Seeley Swan PATHFINDER

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Eye on the Environment

Honey Bees: Cranking Up The Heat

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Some friends have been staying with us since May. We fixed them up a simple place next door to the house: nothing fancy, no electricity or wood stove.

We're piling extra butter on our pancakes and wearing thicker sweaters in our drafty old house now that winter's set in. Our guests? They've set their thermostat to TROPICAL – it's going to be 75 to 95 degrees in their place all winter long. I might be annoyed if we had to pay for that heating bill – but they're taking care of it themselves. They're honeybees. And unlike most other insects, they can crank up the heat in the winter.

Tiny bags of water that they are, all insects seem ridiculously ill-equipped to avoid freezing solid. Yet every summer, they're back, buzzing and stinging and pollinating. The peculiar winter survival strategy of honeybees is among the most unique in the insect world. To understand why, it helps to know how the rest of them manage to make it through until spring.

Consider the mountain pine beetle: that tiny insect which attacks and lives in all the pine species of the western U.S. and Canada. Like most of our local insects, the distinct life stages (egg, larva, pupa, adult) of the pine beetle operate at peak performance at different times of the year.

While the adults take center stage to disperse and grow the population, they are not designed for cold weather. Their duties are best carried out in the heady days of mid-summer. The task of winter survival thus falls to the larval life stage, and that period is spent safely bedded down in galleries under a protective layer of bark, possibly even blanketed for months under a deep snowpack.

When you think "mountain pine beetle," an image of a grub should spring to mind, because an individual beetle spends most of its twelve months of life as a larva - the form most adapted to our extended winter season, as we shall see.

Honeybees have a different life history altogether. It makes sense that our image of the honeybee is that of a flying adult. While an individual pine beetle's life expectancy of one year is mostly spent as a larva, the life span of any given honeybee (3 months in the summer, with "winter bees" living for 6 months or so) is spent largely in the adult phase.

You won't see them flying around in the middle of winter - but put your ear up to the side of any healthy hive and the contented hum of the colony tells a clear story of active adults' rapidly moving wings. Open a hive on most days of the year and you'll find eggs, larvae, pupae and adults, whereas for most months of the year, only the hardy larvae of the pine beetle can be found.

So why don't our beetles and bees freeze solid in winter? If the water in their cells freezes, ice crystals form which dehydrate and puncture their fragile cell walls – not a survivable condition. Each of the two species takes a different approach to the problem.

In addition to jettisoning the fragile adults back in August, pine beetle larvae spend weeks developing cold hardiness, adjusting their physiology to avoid freezing. One of their tactics relies on a fascinating physical property of water. Pure water can "supercool," or drop in temperature well below its freezing point without actually freezing if it doesn't contain "ice nucleating agents" - which translates as anything an ice crystal can get a foothold on to begin growing.

In the process of becoming acclimated to the cold, the pine beetle larvae work to eliminate any ice nucleating substances; they cease feeding and rid their bodies of minute particles around which ice might form, including bacteria and dust, by voiding or even molting part of their gut. In this sense, pine beetles' spring cleaning happens in the fall.

Pine beetle larvae have also perfected the recipe for a cocktail of biochemicals called cryoprotectants which they begin manufacturing as the temperatures drop. Their cells become highly concentrated with this concoction over the course of the winter, which further enables them to supercool.

The cocktails are composed of certain sugars, the biological equivalent of the ethylene glycol in automotive antifreeze, that enable their cellular fluids to stay liquid even below 32F. Another set of ingredients in the cocktail are unique antifreeze proteins, which latch onto ice crystals, inhibiting their growth.

How about honeybees? How can the species keep everybody, including the winged, leggy adults, alive all winter? Physiologists use the term ectothermic ("external energy") to describe creatures like insects whose body temperature relies principally on an external heat source: the sun or, indirectly, a warm patch of ground, or a spot deep enough in the earth to remain above freezing. (Endotherms, by comparison, are animals like birds or mammals whose high metabolism helps them to maintain high levels of activity regardless of ambient temperatures.)

Activity levels of typical ectotherms rise and fall with the mercury in the thermometer. Pine beetle larvae may not freeze solid, but they're not exactly sweating it out on the Nordic-track either. Honeybees, on the other hand, have opted to keep everybody doing aerobic workouts right through the winter.

A honeybee adult is something like an on-demand hot water heater: ostensibly ectothermic, but possessing the ability to turn on endothermic reactions to generate heat when air temperatures are low. This might not produce much benefit for any individual bee.

A single honeybee trying to make a go of it in a pine beetle's winter gallery wouldn't stand a chance. But a healthy hive is 50,000 strong going into winter. The mass of bees in their winter cluster flex their flight muscles without flying anywhere to create heat. Those on the outer fringes of the cluster act as living insulation, until getting fed up and elbowing their way in to that 95 degree spot in the center, whereupon the toasty bees in the middle get shoved to the periphery.

An individual bee's heat production only lasts several minutes at a time, interspersed between long bouts of ectothermic rest, but the sum total of 50,000 bees periodically generating minute amounts of heat elevates the hive's internal temperature dramatically above air temperature in winter. There's no need for them to deplete their bodies of ice-nucleating agents or create costly cryoprotectants; there's very little temperature variation in the hive at all.

A swarm of honeybees arrived unexpectedly at our place in July two years ago – they flew around the house for a few hours then poured single file into a tiny hole in the cedar shakes, ready to start up a new life in some protected spot under the siding. We asked several beekeepers what they thought of the situation; one invoked the old rhyme, “A swarm in July ain’t worth a fly.” Which turned out to be true. That colony didn’t make it through the winter, and we’re not sure what to do with the pile of dead bees that accumulated in an unreachable spot under the shakes.

Why weren’t they worth a fly? There simply wasn’t enough time left in the season to store up their own winter provisions. All that endothermically generated heat requires lots of fuel and while a beekeeper robs excess honey from a hive in fall, the colony relies on the rest to get through the lean times between October and March when there will be no food coming in. A hive’s hundred pounds of stored honey are like venison in the freezer and several cords of firewood stacked up outside the door. Without it, the colony will starve and freeze over the winter. And to think our old friend the pine beetle is on a starvation diet all winter just to keep ice from collecting in its guts.

Many of our insects are like the pine beetle – the adults die in late summer and leave the kids to fend for themselves. The offspring, in turn, have come up with all kinds of ingenious methods to resist the ravages of winter. Honeybees choose to keep the home fires burning. Think about that next time you swirl a spoonful of honey into your tea this winter.