THE KINGLET'S WINTER FUEL

I'm searching for kinglets in a stand of red spruces and balsam firs on the north side of Alder Stream [near the author's cabin in Maine -- SLB] on a morning in mid-January. It is dark in these woods even in the summertime because the dense tree crowns shut out the sunlight. So little light gets through that only moss grows like a green velvet carpet on the brown springy humus. Yellow and purple mushrooms erupt there after summer rains. In spring the blackburnian, yellow-rumped, and magnolia warblers sing and build their nests here.

The warblers are gone now, and it is a different world. The snow packed onto the dark-needled branches above me excludes even more light than it did before, while the snow covering the mossy ground reveals tracks. Deer have recently been crossing the brook and their worn path through this patch of woods continues on to their food in more open hardwoods beyond. A porcupine has worn a tunnel-like groove through the snow from its shelter under a pile of rocks to a lone hemlock where it feeds at night. Few snowshoe hares cross this area, because there are no twigs within reach for them to eat. The woods seem almost devoid of birds and the gray sky promises even more silence and more snow and the dull crunching of my footsteps muffles the few remaining faint sounds.

Sitting down on the trunk of a fallen balsam fir, I listen for the light but steady tapping of a black-backed woodpecker. Black-backs come here only in the winter, and sometimes I can hear one. They specialize in feeding on bark-beetle larvae found in recently dead spruce and balsam fir trees. Lightly tapping on the bark as if palpating the tree trunk for possible hollow sounds where a larva might reside, these woodpeckers work like a physician tapping a chest for infirmities. No black-backed woodpecker is near today, but I hear a pileated's vigorous hammering. The bird is probably excavating a deep vertical groove into the base of a balsam fir trunk to reach the hibernating carpenter ants deep within the core of the tree. It takes brute force and specialized talents for these insect-eating birds to make a living while remaining in these winter woods. One of the insect-eating birds that seems to be without a visible means of support is the golden-crowned kinglet. This spruce-fir grove is where I go most often to try to find them.

Kinglets have thin voices that are barely audible in the human range of hearing, and they are neither seen nor heard unless you really tune in. Golden-crowned kinglets do not eat the seeds of the various trees that sustain the finches that stay here all winter, nor do they eat the plentiful tree buds, like the squirrels and

grouse do. They cannot reach grubs under bark or buried deep in wood. Yet they obviously fuel their raging metabolism to keep warm. They hover at the tips of branches, hop nonstop in dense spruce thickets, and pick at seemingly invisible prey.

The kinglets' tiny bills are suited for gleaning insects from twigs. But what insects could there possibly be about in the winter? How do these gold-crowns manage to find up to three times their own body weight of food each short winter day, as they predictably must to have enough fuel to keep warm? If kinglets are without food for only one or two hours in the daytime, they starve (and freeze) to death. Yet, some of their population clings to the north woods, despite the fifteen-to twenty-hour-long winter nights. Since the birds don't forage at night, and since they have not been observed to cache or store food in the day, what saves them from dying ten times over during the night?

Is that a conversation of barely audible *tsees* in the spruce thicket? No doubt about it. Finally I hear it. And they are coming closer. The sounds are as unobtrusive as a gentle breeze, and they just as easily go unnoticed. There among the thick branches, I finally see one of probably several tiny callers hop and hover hummingbird-like near the end of a branch. A kinglet never holds still for more than a second. Nonstop foraging. Try as I might, I cannot see them actually catching and eating anything, even as I get within three or four feet of them on those rare occasions when they came out of the spruce tops. They feed on prey too tiny for me to see.

What kinglets eat in the winter had long been a mystery, and researchers had relied on speculation to try to decipher what food these insectivorous birds might find in the winter. They reasoned, on the basis of anatomy and behavior, that the birds are springtail (Collembola) specialists. A species of these primitive almost microscopic insects commonly known as "snow fleas" (*Hypogastrura tooliki*, formerly *H. nivicola*) at times pepper the snow in these New England woods. I have seen millions of them gathering in track depressions in the snow, almost blackening the sides and bottom due to the sheer numbers of individuals. They color the snow gray to almost black, depending on their collective numbers. You see the individuals as almost stationary dots that creep about slowly on tiny stubby legs. But when you look closer, you are apt to see some of them hurtle off and disappear in flealike leaps, hence their name of snow fleas. But unlike fleas,

they don't jump using their legs. The power for their explosive leaps comes from a muscle-powered spring mechanism attached to a stout tail that is folded under them and then released to strike against the substrate and that tailkick propels them up and away.

Although I have seen almost solid mats of snow fleas on the snow, neither I nor anybody else seems to know where they come from or where they go. Snow fleas appear mysteriously in isolated patches, sometimes within hours after the snow begins to melt. They are on the snow only in the daytime (to absorb sunlight?). Perhaps they burrow directly through the snow, but they also retreat to tree trunks in the evening and radiate out from them in the morning. I have never seen kinglets pay any attention to the snow fleas that are so conspicuous to us on the ground. That is surprising, if kinglets are indeed specifically adapted to forage for springtails, and in Europe Collembola were reported to be their main prey in winter—the manna that provides them the calories and fuels their metabolism to survive the night. Snow fleas appear to be palatable. Bill Barnard, a biologist from Norwich College who studies gray jays in Victory Bog in Vermont, has seen the jays scooping up snow laden with snow fleas like kids eating maple syrup on snow at spring sugaring parties. Do golden-crowns take advantage of this bounty? If so, why had I never seen it happen? Are the springtails up in the trees where the kinglets spend most of their time and where they feed on them unobtrusively? However, as I'll indicate shortly, I doubted that snow fleas spent much time up in the trees.

Kinglets are, as far as I know, the only birds that routinely hover at twig ends to pluck off microscopic mites, aphids, and aphid eggs that probably no other bird could see, nor a human would ever find unless assisted with a hand lens. It would be difficult, but important to know what the birds' lives depend on. Knowing what a bird eats is fundamental if not central to understanding the mysteries of its survival. But knowledge is never without costs to acquire. Sometimes one has to do whatever it takes. To find out what kinglets eat, I had to do the most direct thing. I had to examine kinglets' stomach contents.

I may invite censure for setting a bad example by hunting tiny birds. Nature writer Jim Harrison (1996) warns: "I have noticed lately that hunting, tobacco, and wife-beating are being lumped together in the feel-good quadrant of yuppiedom, that ghastly, fluorescent hell of the professionally sincere that makes one long for the

sixties." I'm not insensitive to his observation and need to at least address the hunting rap, given also my upbringing by a father who was a professional bird collector (hunter) for museums. I'll never forget the rhyme he taught me: "*Quale nie ein Tier zum Scherz denn es fühlt wie du den Schmerz*" [Never do something to torture an animal because it feels the pain like you]. He drilled the ethics of hunting into me, and the only time when I ever saw him show anger toward me was when as a preteen in the 1950s I tried to kill a skunk with my slingshot to impress my peers. That was not all right. It was disgusting. He felt justified to kill birds for a museum where they would be preserved forever, as some feel justified to eat fish, chicken, or other meat that is digested in hours. Which is more justified? And even if necessary, how do you justify? Those who are familiar with ancient folklore, or are up above the rest of us a moral notch or two, kill "respectfully" by offering prayers or apologies, in the hope that animals will "offer themselves" up to be voluntarily killed. However, it is a sad fact that no animal cares if those who might eat them invent reasons to justify their acts (to make themselves feel good). But if any animals did offer themselves up for the greater good, then none as small as a kinglet would ever consider the value of its meager body to man as sufficient recompense for its own life. So, yes, I killed several kinglets (after getting the appropriate state and federal permits), really only because of curiosity and a hunger for knowledge. And with regrets but no prayers.

I shot the first kinglet at dusk when the bird's stomach would presumably be full. Wanting to maximize the information that it might yield, I took its body temperature as soon as it hit the ground. As mentioned previously, it was an astonishing 44°C (111°F), which is about 2° to 3°C higher than that of most birds. My fingers were rapidly cooling and in danger of numbing, and I then opened the kinglet quickly to see golden yellow fat among the intestines and around its bean-sized gizzard. As I pried open the tiny gizzard to put the contents into a vial of alcohol, I found it filled to capacity. But this gizzard did not contain springtails, as the literature had led me to believe. Not a one. Instead, it contained a total surprise: the partially digested remains (mostly skins) of thirty-nine geometrid ("inchworm") caterpillars. They were a species that neither I nor an entomologist, Ross T. Bell, who made a minute analysis of the stomach contents, could identify. Nobody would ever have predicted caterpillars on trees in the depth of winter, much less in a kinglet's stomach. I would not have been more surprised if I'd have found earthworms.

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Geometrid caterpillars of most species are well known to over-winter as pupae, safe from frost in the subnivian zone or deep underground. Nobody had ever reported finding caterpillars on *trees* in the northern winter before. But this bird and subsequent birds, were proof of something new and unexpected.

If birds could find caterpillars, so could we. So, later on in January 1995, after temperatures had again been near -30°F for a few nights, I went out into the woods with four students (Jeremy Cohen, Kristian Omland, Lauri Freedman, and Mike Tatro) on a caterpillar hunt. Having wielded a gun earlier, I now carried a club —a six-foot-long thick trunk from a freshly felled maple tree. The club was heavy, and when I banged trees (up to six inches diameter) as hard as I could, they vibrated from the shock and released a shower of bark and other debris and the tree's crop of overwintering insects onto the snow.

The operation was a big success. I hit fifteen each red spruce, balsam fir, beech, and red and sugar maples and the yield from the seventy-five trees was thirteen tiny geometrid caterpillars (and two small spiders). No springtails. The caterpillars were visible on the snow, but hard to distinguish from needles and debris. They were gray and brown and very small, matching the remains of those I had found in the kinglet's gizzard.

That caterpillars apparently exist on open branches in winter, and that they serve as winter food for kinglets was not known before. But that meant little unless they could be identified. After some checking around I determined that possibly only one man in the world could do it: Douglas Ferguson, at the Systematic Entomology Laboratory of the National Museum of Natural History of the Smithsonian Institution in Washington, D.C. I sent Ferguson some of the larvae I had collected. He examined them and speculated on what they might be, but said that they didn't seem to be a precise match with any he knew. "The only way of identifying such larvae beyond doubt is to rear out adults, which are easy to identify," he said. He had indeed tried to rear the larvae I had sent him but they had all succumbed, probably because they had not fed. There was no way of feeding them until one knew what their food plant is, and there is usually no way of knowing what the food plant is until one knows what the insect's species is!

On another survey—January 1—I banged a total of 224 trees (102 conifers and 122 deciduous trees, 10 species in all). This yielded only eleven caterpillars, all

geometrids, and all but four of them were from sugar maples. I decided to try to rear some of these larvae myself. After collecting them at my winter retreat in the Maine woods, I put the frozen caterpillars into glass vials and left them outside the cabin in the snow. Days later when I went back to Vermont, I stuck them into our freezer and, unfortunately, due to other diversions that soon intervened, I forgot about them until July, six months later. When I thawed them, to my great surprise I found five of them still very much alive. Not knowing what to feed them, I put them into a plastic lettuce crisper with sprigs of potential food plants; those found where I had collected them, including spruce, balsam, fir, maple, and beech. On the very next day I was pleasantly surprised when I found five caterpillars, all hungrily feeding. But even though I had collected them on maple twigs, they were feeding on balsam fir needles! So I added more fir twigs, expecting to finally rear moths. No such luck. A few days later all the caterpillars were wrinkled and dead. The cause was a small but by then plump spider that I had inadvertently introduced on a fir twig. Spiders inject digestive juices through their fangs, then suck out the insects' contents, leaving only dry husks. This spider had, apparently, been a very hungry spider.

The "outbreak" of caterpillars on sugar maples that year was apparently unusual, and it did not go unnoticed by kinglets who otherwise forage exclusively on conifers. On the fourth, fifth, and seventh of January, after cold (-24° to -34°C) and windy nights, I followed two separate pairs of kinglets (for 93 and 75 minutes, respectively), and all four individuals spent the entire time foraging in my young sugar maple grove. I saw them pick off and eat several caterpillars of the same kind that I had also collected. The birds foraged tirelessly, without pause. I timed them at an average of 45 hop-flights per minute, without any apparent change of pace. They bypassed conifers repeatedly (the grove was bordered by balsam, fir, red spruce, and white pines on three sides). Given the windy and cold nights that must have produced a chill factor of near -50°C, I marveled not only that they were alive, but that they switched from spruce/fir to maple, apparently having learned to associate food with specific trees.

[Here I've cut two longish paragraphs wherein the author describes two more winters of failed attempts to rear larvae -- SLB]

Getting close to an identification (I hoped), I tried again the next year. I reared a number of the larvae that I again collected on sugar maple but fed on balsam fir,

to adulthood. Beautifully gray-mottled moths variously marked with subtle browns and cream emerged, and Ferguson identified them as the well-known, one-spotted variant, *Hypagyrtis unipunctata*. The food plant of this species is reported to be extremely variable, including alders, willows, birches, oaks, and balsam firs. Charles V. Covell's book *Eastern Moths* describes the variant as "extremely variable sexually, geographically and seasonally." It had not previously been known where the larvae overwinter.

It had been difficult to identify the caterpillars. We were poor taxonomists, even of trees, as my exam of the students proved. But the kinglets had apparently learned what I'd been trying to teach my students, generally less successfully. Are they intelligent? Kinglets, being small, cannot have large absolute brain size. Nevertheless, on a per-body-weight basis, their brain mass is massive. It accounts for an incredible 6.8 percent of their whole body weight (as opposed to ours of about 1.9 percent). Thus although a kinglet's total brain mass does not amount to much in absolute terms, it does represent an enormous commitment to neurons given the size of the bird.

A brain is metabolically expensive, and kinglets live on an energy edge in winter and have no energy to spare. In humans the 1.9 percent of body tissue that is devoted to brain mass reputedly accounts for 20 percent of our energy drain. There is much debate about what *our* energy base could have been in order for us to evolve to support such a large brain and why we should have it.

In kinglets, the energy drain of the brain could be triple ours, and we now have the answer to the energy source question: caterpillars. Turtles are successful because the brain drain has been reduced to a minimum—a barely enlarged bump on the nerve cord—helping them to survive up to a year without food. When all is said and done, chances are we'll never know why the kinglets' brain size scales large. However, we can be reasonably sure that if their brain is not part of the problem of energy balance, then it is likely to be part of the solution. We don't know how kinglets decide what to eat in the winter, what else they eat, and hence what their flexibility is. But finding out they eat moth caterpillars in the winter is not only a satisfying accomplishment for all of us who took part, but it is also the discovery of a link in their survival. To care for the welfare of kinglets, it is necessary to care for moths.