Sugar Shack Bugs

Christopher Majka

The collection of maple sap for the production of maple sugar has a long history in North America. Before the arrival of European settlers, native people in the northeast collected maple sap by cutting a diagonal incision in the trunk and inserting a strip of bark at the lower end to serve as a spile. The sap was collected in birch-bark containers, poured into hollowed-out logs, and heated with stones to evaporate the water and concentrate the syrup. European settlers learned the skill from native people, collecting sap in wooden buckets and boiling it in large iron kettles. In the 1880s a significant innovation was the introduction of the forerunner to the contemporary flue pan evaporator. In the 1950s producers began using plastic tubing to gather the sap, easing the work of collection.

Two species of trees, sugar maple and black maple, are utilized in maple sugar production, although sugar maple accounts for the majority of trees tapped. In the Maritime Provinces, red maples are also occasionally tapped. Other trees, such as paper birch and yellow birch have also been utilized for syrup production, although the sugar concentration of birch sap is only half that of maple sap, requiring more boiling and twice as much sap to produce a corresponding amount of syrup.

Canada produces 85% of the world's maple syrup; the United States the other 15%. In 2007 Canadian production was 5.235 million gallons valued at over $168 million. Québec accounts for 91.1% of domestic production, followed by New Brunswick (4.5%), Ontario (3.9%), and Nova Scotia (0.5%). Small volumes are also produced in Prince Edward Island. In the United States, production in 2006 was 1.449 million gallons. A small amount (1,000 gallons) of birch syrup is also produced annually, chiefly in Alaska with even smaller quantities in Canada and (utilizing other species of birch) Russia, Belarus, the Ukraine, and Scandinavia.

In 2006 in Canada, 9,731 maple sugar producers tapped approximately 38,077,400 trees. Two collection methods are used: the traditional bucket system placed on trees, and plastic tube collection. A rough estimate indicates that in Canada

some 2.5 million trees (6.6% of the total) are still tapped using traditional buckets.

Bugs in the Buckets

Despite the long history of maple syrup production, and the very sizeable number of trees that are tapped over a considerable portion of the continent, there has been very little attention paid to the insects attracted to maple sap during extraction and collection. In the traditional bucket collection system, there are considerable opportunities for insects to participate in the harvest as well. Even though maple sap buckets generally have covers (chiefly to keep twigs, bark, and other contaminants from falling into the sap) many insects have a highly developed sense of smell (using chemo-receptors on their antennae), are able to detect the "smell" of various chemical compounds found in maple sap, and then make their way into the containers by crawling under the lids or around the spile.

Maple sap consists of approximately 97.5% water, 2.4% sugars (primarily sucrose with small amounts of glucose), and 0.1% minerals (primarily potassium and calcium, with smaller quantities of zinc and manganese). There are also trace amounts of other organic compounds.

There is a long history of moths being attracted to sap flows on trees. Indeed "sugaring" for moths is an important collection technique. In a poetic essay entitled "Sugaring for Moths" in *The Moth Book*, William Jacob Holland (1848-1932), a pioneering North American lepidopterist (someone who studies butterflies and moths), outlined the technique in a lyrical style now long-vanished from entomological literature.

"The woodland is the haunt of many a joyous thing, which frequents the glades and hovers over the flowers. Tonight the lightning in the air, the suggestion of a coming storm which lurks in the atmosphere, will send a thrill through all the swarms... and they will rise as the dusk gathers. It is just the night upon which to take a collecting trip, resorting to the well-known method of "sugaring."

Here we have a bucket and a clean whitewash brush. We have put into the bucket four pounds of cheap sugar. Now we will pour in a bottle of stale beer and a little rum. We have stirred the mixture well. In our pockets are our cyanide jars. Here are the dark lanterns. Before the darkness falls, while yet there is light enough to see our way along the path, we will pass from tree to tree and apply the brush charged with the sweet semi-intoxicating mixture.

The task is accomplished! Forty trees and ten stumps have been baptized.... Let us wash our sticky fingers in the brook and dry them with our handkerchiefs. Let us sit down on the grass beneath this tree and puff a good Havana. It is growing darker. The bats are circling overhead. A Screech-owl is uttering a plaintive lament, perhaps mourning the absence of the moon, which tonight will not appear. The frogs are croaking in the pond. The fireflies soar upward and flash in sparkling multitudes where the grass grows rank near the water."

Holland goes on to describe returning through the "sugared" forest to find many splendid moths supping at the bait.

Over a hundred years ago, E.J. Smith, a lepidopterist with the Cambridge Entomological Club in Massachusetts, noted the propensity of many moths to be attracted to the sap of trees, particularly that of sugar maples. He highlighted swordgrass moths, sallows, the willow dart (*Cerastis salicarum*), the speckled green fruitworm moth (*Orthosia hibisci*), and the red-winged sallow (*Xystopeplus rufago*) as species particularly attracted to maple sap. In Ohio, Professor Roy W. Rings pointed out that the ashen pinion moth (*Lithophane antennata*), triple-spotted pinion moth *(Lithophane laticinerea*), and the dowdy pinion moth (*Lithophane unimoda*) are all attracted to maple sap and can become a nuisance by accumulating on the surface in collection buckets. All these species (except for the red-winged sallow which occurs north to Maine) are found in the Maritime Provinces.

Amongst beetles, members of Nitidulidae (sap beetles) are well known to be attracted to natural sap flows on a variety of trees. George B. Vogt (1920-1990), a Maryland coleopterist (someone who studies beetles), documented 33 species of this family that he collected at sap flows, primarily on white oaks. Richard Dearborn of the Maine Forest Service, reported that the diurnal firefly often become a pest by falling in large numbers into maple sap buckets. Ross H.

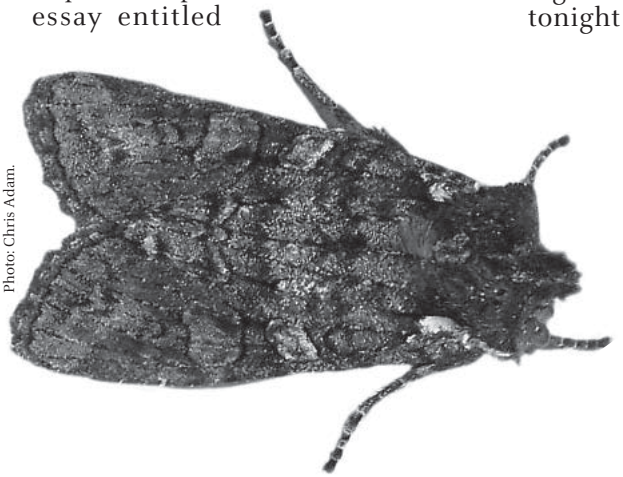

Photo: Chris Adam.

The plush-napped pinion moth Lithophane pexata.

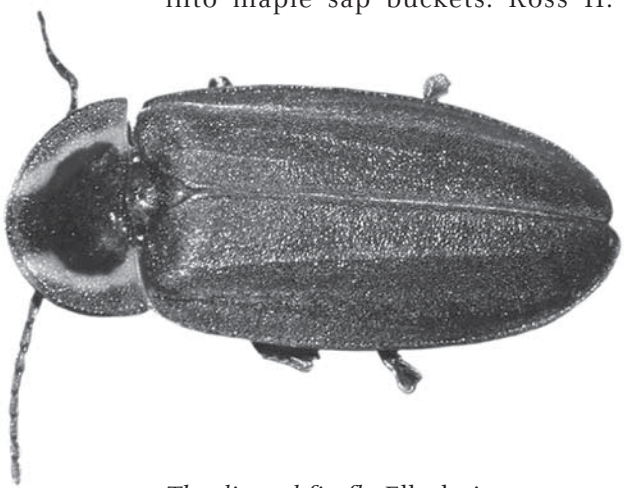

Photo: Tom Murray.

The diurnal firefly, Ellychnia corrusca.

Arnett, Jr. (1919-1999), one of North America's leading experts on beetles, and an inspiration to generations of coleopterists, noted that the common and familiar "snow flea" (*Hypogastrura nivicola*), actually a species of springtail, is attracted to maple sap and can become a pest in buckets during periods of harvest. These insects don't actually harm the sap, but must be filtered out before it is poured into the evaporators.

Maple Syrup production on Prince Edward Island

Bearing this in mind, I decided to investigate the insects that are associated with maple sap on Prince Edward Island. Compared to New Brunswick and Nova Scotia, syrup production in Prince Edward Island is a rather small enterprise with only a handful of producers on the Island. The Hallaig Farm in Belle River, operated by Rob MacLean and Melissa Mullen, has a pipeline operation on a 200 acre woodlot that in some years produces as much as 450 litres of syrup. The Mill River Provincial Park taps just shy of 100 trees for demonstration purposes. Darrell Chaisson taps about 100 maple trees in Tignish. A Little Gift, located in Bonshaw, produces maple syrup and maple wood products, and my friends Richard MacPhee and Max Newby in Woodville Mills tap approximately 430 trees. The PEI Maple Syrup Company, which formerly tapped up to 9,000 trees in Breadalbane, went out of business after several years.

Richard and Max (a.k.a. Woodlands Maple Syrup) have been producing maple syrup for 13 years after Richard bought their first evaporator, transforming what had been a hobby, producing a few litres of syrup on their kitchen stoves, into a partnership which has become the longest running commercial syrup making enterprise on PEI. The 430 trees they tap take between one and three spiles each, producing an annual yield of 300-400 litres of syrup. Syrup output can be highly variable because of yearly weather conditions. While visiting their sugarbush on April 4, 2010, I took the opportunity to inspect approximately 70 of the sap collection buckets, gathering the insects found in them.

What's sucking sap on Prince Edward Island?

In the buckets I found 28 species of insects including 18 beetles, eight moths, and two caddisflies (there were also flies in some of the buckets, but these were not collected and identified). Eighteen of these (all the moths and caddisflies, and ten of the beetles) were newly recorded on Prince Edward Island. This discovery is a contribution in documenting the invertebrate biodiversity of the province. It is not, however, quite as surprising as it might first appear. The insect fauna of Prince Edward Island is the most poorly-documented of any Canadian province so even many common species have not been recorded from the island in the scientific literature. The lack of a provincial natural history museum on PEI is an important reason why research of this kind has been held back in the province.

After examining the biology of these 28 species, it was possible to separate them into two groups: those associated with sap and nectar (21 species), and those that were accidental visitors (7 species). Accidental visitors are insects that are found in forests on trees or under bark, that are not known to be attracted to maple sap, and probably crawled or fell by accident into the collection buckets.

Marsh, Ambrosia, and Sap Beetles

Amongst the beetles, two species were very abundant (more than 100 individuals) in the collection buckets:

The diurnal firefly is a very common beetle throughout the Maritime Provinces found in many forested habitats. It is a member of the firefly family (Lampyride), which are actually beetles and not flies. However, adults of this species are not bioluminescent, so they are less noticeable than their sparkling nocturnal relatives. The reason why these beetles are attracted to sap flows has not been investigated by entomologists. The diurnal firefly is active throughout the year (including early in the spring) and so it may be that they are opportunistically taking advantage of this food at a time when there are few other sources of sugars available to them.

A small marsh beetle called *Cyphon variabilis.* This was a rather surprising discovery since this species (a Holarctic one found in both Europe and North America) has not previously been reported at sap flows. As its name implies, it is a common beetle in marshes, and the maple stand in Woodville Mills is approximately 0.25 km from a small

Photo: Tom Murray.

The marsh beetle, Cyphon variabilis.

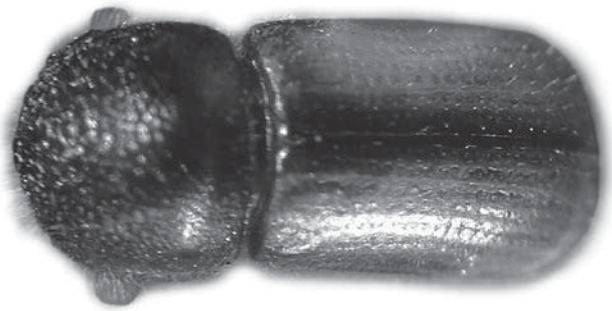

Photo: Christopher Majka.

The ambrosia beetle, Trypodendron retusum.

beaver pond and associated marsh that provide a suitable habitat for it. The large number of specimens attracted to maple sap (and smaller numbers of the related *Cyphon confusus*) is unexpected, apparently reflecting an aspect of the biology of these marsh beetles not previously documented by entomologists.

Three other species found in the maple sap buckets were the ambrosia beetles, *Trypodendron retusum*, *Xyloterinus politus*, and *Xyloborinus alni*. Ambrosia beetles form a grouping within the bark beetles, which in turn are a subfamily of weevils. Ambrosia beetles excavate galleries beneath bark of unhealthy or dying trees. These galleries are inoculated with symbiotic fungi carried in so-called "mycangial" pits, depressions found on the heads of adults. As the beetles excavate the bark they introduce spores in the galleries where the fungi (molds or mildews) grow. Adults and larvae then feed on these fungal hyphae. Bark beetles of all kinds are known to be attracted to chemicals released by trees when they are injured (for example, by having a hole drilled into them) so these bark beetles are attracted to maples through such chemicals signals, and in seeking their source, fall into the maple sap.

Both *Trypodendron retusum* and *Xyloborinus alni* are newly recorded on Prince Edward Island. The former is a native species, widely distributed in eastern Canada and New England, which is associated with poplars. *Xyloborinus alni*, however, is an introduced Oriental species only recently found in North America. It was originally detected in 1995 in British Columbia and 1996 in Washington State, and was later reported in several eastern states in the United States. In North America, it is associated with alders.

The most diverse group of beetles found in the collection buckets, however, were five sap beetles: *Cryptarcha ampla*, *Glischrochilus fasciatus*, *Glischrochilus quadrisignatus*, *Glischrochilus sanguinolentus*, and *Glischrochilus siepmanni*. All sap beetles are attracted to saps and liquids. The two "picnic beetles," *Glischrochilus fasciatus* and *Glischrochilus quadrisignatus,* derive their name from a fondness for sweet and fermenting juices. Put a fruit salad, some pickles, or a glass of beer or wine on a picnic table and in short order these beetles appear and wade right in. *Glischrochilus sanguinolentus*, another member of this genus, is typically found in coniferous forests feeding on sap oozing from broken limbs, torn bark, or recent injuries. The dried-fruit beetle, *Cryptarcha ampla*, frequents sap flows on maple trees. Another widely distributed species in Eastern Canada and New England, it was recorded for the first time on Prince Edward Island.

One final species, a carpet beetle called *Anthrenus castanae*, is a member of the skin and hide beetle family (Dermestidae). Like other species in this family, the larvae feed on dried animal and plants products, however, adult carpet beetles mate in the field and feed on nectar and pollen. Consequently, like other nectar-eating species, they are attracted to sugars found in maple sap. The other six species found in the buckets (single individuals), represented common forest beetles, but not ones associated with sap flows.

Winter Moths: Shivering to Stay Warm

Of the eight species of moths found in the collection buckets, seven were members of the Noctuidae (the owlet moths), one of the most diverse families of moths in North America. They included the grey swordgrass moth, the nameless pinion, the wanton pinion, the plush-napped pinion, the strait-toothed sallow, and the three-spotted sallow. All these moths are known to be attracted to maple sap. Their physiology and behaviour were thoroughly investigated by Bernd Heinrich (1940-) in a pioneering study called "Thermoregulation by winter-flying endothermic moths" published in 1987 in the Journal of Experimental Biology. Heinrich is a professor emeritus at the University of Vermont, well known to many naturalists from his many publications on nature, behaviour, biology, ecology, and evolution such as *Mind of the Raven*, *The Snoring Bird*, *The Trees in My Forest*, and *Why We Run*.

In his research on these moths, Heinrich found that all of them are active during the winter months, whenever ambient temperatures rise above 0ºC. Heinrich found that they are able to be active at such low temperatures because they maintain thoracic temperatures 10ºC higher than other moths. They accomplish this through a combination of behavioural adaptations (shivering to warm the thorax, which commences at temperatures of -2ºC, much lower than other moths) and anatomical features (a thick pile on the head

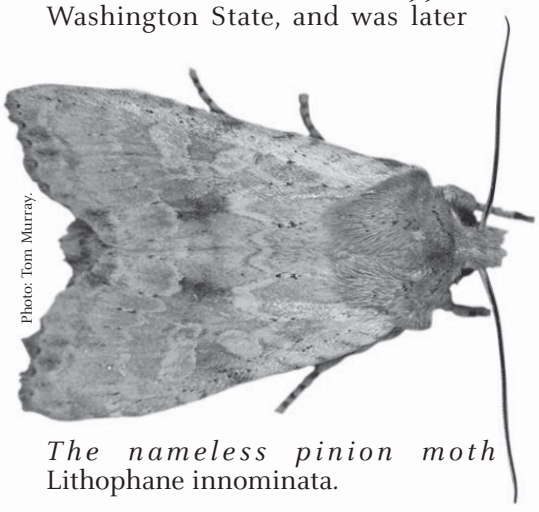

Photo: Tom Murray.

The nameless pinion moth Lithophane innominata.

Photo: Tom Murray.

The strait-toothed sallow moth. Eupsilia vinulenta.

and thorax; a series of abdominal air sacks that act as insulators; and an aortic configuration that acts as a heat exchanger). The moths obtain the energy for these activities by drinking sugar saps. Heinrich observed that, given the opportunity, the moths will bloat themselves by consuming saps, increasing their body weight by up to 95%. Even a much smaller normal meal of maple sap would yield a moth approximately three days of energy reserves. Thus, the presence of these moths in maple sap buckets is not unexpected.

In addition to the owlet moths discussed above, one leafroller moth, the lesser maple leafroller, was abundant in maple sap buckets. This is a widespread species that feeds on apple, beech, birch, maple, and oak. Tortricids are one of the four families of moths that are attracted to natural sap flows. What role such feeding may play in the biology of this species has not been investigated. One other moth, a single specimen of the Norman's Quaker, was found in the study. It is not associated with sap flows and it appears that its presence in the maple sap buckets was accidental.

Caddisflies

Almost all adult caddisflies are liquid feeders, consuming sap and floral nectar. Single individuals of two species, *Glyphopsyche irrorata* and *Limnephilus ornatus* (neither have common names), were found in the collection buckets. *Glyphopsyche irrorata* over-winters as an adult and, like the moths discussed above is regularly active in the winter months at temperatures near 0°C.

What have we learned?

The insect fauna of Prince Edward Island is the most poorly documented of any province province in Canada. Over the past decade, with the assistance of many colleagues, I have been particularly focused on investigating the island's beetle fauna. My collections, coupled with an examination of the excellent collections maintained at the University of Prince Edward Island by Donna Giberson, and those at the

Names of insects collected in maple sap in Woodville Mills, PEI

Scientific Name	Common Name
COLEOPTERA	**BEETLES**
Carabidae	**Ground Beetles**
Dromius piceus Dejean	*no common name*
Coccinellidae	**Lady Beetles**
Anatis mali (Say)	eye-spotted lady beetle
Corylophidae	**Minute Fungus Beetles**
Orthoperus suturalis LeConte	*no common name*
Curculionidae	**Bark Beetles**
Trypodendron retusum (LeConte)	poplar ambrosia beetle
Xyloterinus politus (Say)	beech ambrosia beetle
Xyloborinus alni (Niisima)	an ambrosia beetle
Dermestidae	**Skin and Hide Beetles**
Anthrenus castanae Melsheimer	a carpet beetle
Histeridae	**Clown Beetles**
Euspilotus assimilis (Paykull)	*no common name*
Lampyridae	**Fireflies**
Ellychnia corrusca (Linnaeus)	diurnal firefly
Nitidulidae	**Sap Beetles**
Cryptarcha ampla Erichson	dried fruit beetle
Glischrochilus fasciatus (Olivier)	picnic beetle
Glischrochilus quadrisignatus (Say)	picnic beetle
Glischrochilus sanguinolentus (Olivier)	*no common name*
Glischrochilus siepmanni Brown	*no common name*
Scirtidae	**Marsh Beetles**
Cyphon confusus Brown	a marsh beetle
Cyphon variabilis (Thunberg)	a marsh beetle
Staphylinidae	**Rove Beetles**
Silusa californica Bernhauer	*no common name*
Nudobius cephalus (Say)	*no common name*
LEPIDOPTERA	**MOTHS**
Noctuidae	**Owlet Moths**
Crocigrapha normani (Grote)	Norman's Quaker
Eupsilia vinulenta (Grote)	strait-toothed sallow
Eupsilia tristigmata (Grote)	three-spotted sallow
Lithophane innominata (J.B. Smith)	nameless pinion
Lithophane petulca Grote	wanton pinion
Lithophane pexata Grote	plush-napped pinion
Xylena cineritia (Grote)	grey swordgrass moth
Tortricidae	**Leafroller Moths**
Acleris chalybeana (C.H. Fernald)	lesser maple leafroller
TRICHOPTERA	**CADDISFLIES**
Limnephilidae	**Northern Caddisflies**
Glyphopsyche irrorata (Fabricius)	*no common name*
Limnephilus ornatus Banks	*no common name*

Note: Many species of moths have common names. Beetles (except those considered as pests) generally have not had common names assigned to them.

Agriculture and Agri-Food Canada's Crops and Livestock Research Centre in Charlottetown, maintained by Mary Smith and Christine Noronha, have greatly expanded our knowledge of this group of insects in the province. Whereas, the 1991 Checklist of Beetles of Canada and Alaska contained records of only 341 species from the province, we have now recorded 939 species from Prince Edward Island – 608 new species and a 275% increase!

This is a major step forward, but the process is far from complete and with almost every field study and expedition that I embark on, on Prince Edward Island, I find yet more new species for the province. Furthermore, the moths of Prince Edward Island are even more poorly documented than are the beetles, as evidenced by the fact that all eight species found in this study are newly recorded in the province. It's not that they are rare on the island, just that no previous scientific studies have documented their presence there. So studies that help document the biodiversity of the province continue to be useful.

This isn't just because it is nice to know what the flora and fauna of Prince Edward Island consist of (laudable though this may be), but, such information is indispensable in determining and tracking human impact on the province's environment. If we want to ascertain the effects of pollution, acid rain, the use of biocides (such as herbicides, insecticide, fungicides), clear cutting of forests, climate change, and other impacts of human civilization on the natural world, we first need to know what species are present, and where, and in what numbers. Only then can we monitor to see if they are in decline or changing their distribution – and if so, why. Similarly, if we want to monitor for the introduction of alien species (some of which might become invasive pests), we first need to know what is there, before continuing to look for what might be new. So, contributing to a knowledge of biodiversity is a useful by-product of this study.

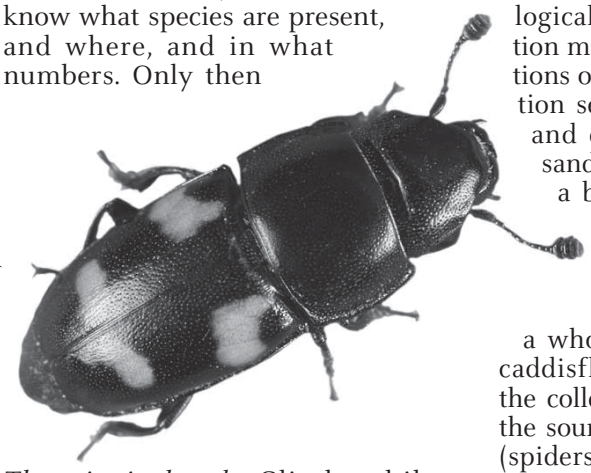

Photo: Tom Murray.

The picnic beetle Glischrochilus quadrisignatus.

Photo: Christopher Majka.

Max Newby of Woodlands Maple Syrup, stoking the fire of the evaporator in the sugar shack.

Beyond this, even though the study I undertook was a preliminary one, it is nonetheless, perhaps the first published study that specifically examines the suite of insects attracted to maple syrup production – not only on Prince Edward Island, but anywhere at all. In maple syrup operations that employ collection buckets, these insects are a small, but significant problem, and entail continually filtering the collected sap to remove their bodies. Beyond that, there is the unanswered question of what ecological impact maple syrup collection might have of the insect populations of maple forests. If a sap collection season lasts for several weeks, and each day hundreds or thousands of insects are being killed as a by product of the operations, will this have an ecological impact on the populations of these species, or indeed on the forest ecosystem as a whole, since the beetles, moths, caddisflies, and flies that drown in the collection buckets are themselves the source of food for other denizens (spiders, birds, squirrels, etc.) of the forest? To answer questions such as these, a much more detailed and quantitative study would need to be done.

Finally, the study has opened a window on this fascinating group of forest insects whose ecology is associated with sap flows. In the ways discussed above, the biology of all of these species is reliant on this energy and nutrient-rich resource and they have evolved various adaptations to take advantage of it. While other moths may hibernate, these moths can be active much earlier in the season, even during warm spells in the winter. Forests are amazingly rich and diverse environments. When we examine them carefully we discover the intricate ecological clockwork that makes them tick and gives them the stability and resilience that they possess.

Sources

The scientific paper on which this article is based is "Insects attracted to maple sap: observations from Prince Edward Island, Canada" by Christopher Majka. It was published in 2010 in ZooKeys: 51: 73-83 and is available online at: http://pensoftonline.net/zookeys/index.php/journal/article/view/478/486. The citations of additional sources are available by checking this paper.

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