Northern Woodlands
A NEW WAY OF LOOKING AT THE FOREST

Nitrogen Pollution Empties the Pitcher Plant

by Kent McFarland | May 30th 2011 |

Illustration by Adelaide Tyrol

Find yourself a sphagnum-covered bog in Vermont or New Hampshire, and you're likely to find a pitcher plant. Peer a little closer, and you'll find a miniature food web living within each leafy pitcher.

Northern pitcher plants (*Sarracenia purpurea*) grow as many as a dozen new leaves each season in a rosette pattern, meaning that each leaf grows up from the base of the plant. Some of these leaves are flat and face the sun to capture light for photosynthesis, as is the case with most plants. Some leaves, however, are curled into the shape of a pitcher that collects and holds rainwater.

Small insects are attracted to a sugary secretion on the lip of the pitcher, as well as to the pitcher's color and scent. Because of a waxy, slippery coating on the lip of the pitcher, the insects sometimes fall into the water within. Very fine, downward-angled hairs on the inside walls of the pitcher then make it difficult for these insects – primarily ants and flies – to climb out. Eventually they drown.

Pitcher plants have evolved this elaborate strategy for catching insects because it enables them to grow in rain-fed (technically called ombrotrophic) bogs that are extremely nutrient poor and acidic. Although they take up some nutrients with their roots, the pitcher plants absorb most of their nutrients from the prey that fall into their traps. Consequently, carnivorous plants in general have about five times more leaf biomass than root biomass, the opposite of many plants.

New pitchers produce digestive enzymes during their first year to help break down trapped prey, but as the pitchers grow older they produce fewer enzymes and, instead, digestion is aided by a complex web of life living within each pitcher. The heart of this food web is comprised of the rotting insects, which are shredded and partially consumed by the pitcher plant midge and the pitcher plant fly larvae. The shredded prey are further digested by a host of bacteria and protozoa. These are, in turn, prey to a filter-feeding rotifer called *Habrotrocha rosi* and the mite *Sarraceniopus gibsonii*. Larvae of the pitcher plant mosquito feed on bacteria, protozoa, and rotifers. Older mosquito larvae eat rotifers as well as younger, smaller mosquito larvae. Ultimately, the pitcher plant absorbs the nutrient debris produced by this intricate ecosystem.

Nitrogen is the key nutrient that the pitcher plants are after, since there is very little available in bogs for uptake by plant roots. About 80 percent of their nitrogen comes from the prey digested in the pitchers and only 20 percent from the root system. Recently, researchers from Harvard Forest in Petersham, Massachusetts, discovered that bacteria are the primary agents for transforming nitrogen into a form that the pitcher plants can absorb, while the mosquito and fly larvae regulate the abundance and diversity of the bacteria.

Though Earth's atmosphere is comprised primarily of nitrogen, most of it is an inert gas that is not directly available to plants and animals. Plants generally use nitrogen that soil-associated bacteria have converted into a form they can use, though the pitcher plant's bacteria are aquatic. Over the last century, however, nitrogen availability has increased dramatically from the manufacture of synthetic fertilizer, use of fossil fuels for combustion, and the planting of nitrogen-harnessing crops, all of which lead to increased amounts of nitrate and ammonia in the environment. While this has given us greater crop yields and higher energy production, it has also led to reduced air quality and, most importantly for pitcher plants, the over-enrichment of wetlands such as bogs. There is now more reactive nitrogen circulating in the environment than most microbes, plants, and animals need.

Here in the Northeast, where excess nitrogen in rainwater is now relatively common, pitcher plants seem to be adapting to absorb it. Nicholas Gotelli from the University of Vermont and Aaron Ellison from Harvard University had an idea: if more nitrogen is available to pitcher plants, are the plants responding by producing fewer pitcher-shaped leaves and instead growing more flat leaves for photosynthesis?

The answer is yes. The researchers experimentally increased the amount of nitrogen that the pitcher plants received, and within just a single growing season, the plants receiving excessive nitrogen produced no pitchers at all.

Out in the environment, excess nitrogen deposition generally decreases across New England as air travels farther away from major emission sources in the Midwest. It also increases in New Hampshire and Vermont with increased elevation. Gotelli and Ellison found that pitcher plant growth reflects these trends, with fewer pitchers being formed in southwestern valleys and more in the northeastern hills. It turns out that this carnivorous plant is also a proverbial canary in a coalmine.

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