

A World of Opportunists: The Parasitic Plants

by Sydne Record

One of the rarest wild plants in Massachusetts belongs to a group that must tap into the roots of nearby host plants in order to survive. Research reveals that the health of the parasite depends on the origins and life forms of the host species that are available.

When we hear the word ‘parasite,’ our minds conjure up images of animals feeding on our own flesh. We might think of the recent bedbug outbreak in New York City or of the ticks that we hope do not latch onto us as we stroll through the woods. Perhaps less likely to come to mind is a whole other world of equally interesting and important opportunists, the parasitic plants. With nearly 4,500 species spread across the globe, parasitic plants are one of the largest and most widespread groups of plants. Though unfamiliar to many, there is an entire taxonomic family devoted to parasitic plants: Orobanchaceae.

Unlike bedbugs and ticks, whose nourishment comes from mammals, the numerous parasitic plants acquire mineral nutrients, sugar, and water by sucking on the roots or stems of other plants. All plants have an intricate series of pipes called the *xylem* and *phloem* that distribute water and food, respectively, from one part of the plant to another. These tissues mirror the plumbing system in a house that brings water from the well to the tap. To steal resources from their hosts, parasitic plants form *haustoria* – special disc-shaped structures that resemble the round rubber end of a toilet plunger (see photo on facing page). The haustorium grows into and engulfs the stem or root of the host plant, then creates a direct connection between the pipes of the parasite and those of the host.

Once this connection is made between the plumbing systems of the two plants, the haustoria, operating much like toilet plungers, generate a uni-directional flow. Instead of pushing nutrients down the drain, however, the haustorial plunger

sucks food and water up through the handle from the host to the parasite.

Parasitic plant species vary in the degree to which they depend upon their host plants. Holoparasitic plants rely completely on their host plants for obtaining carbohydrates because they are unable to convert water, nutrients, and sunlight into sugars by performing photosynthesis. This inability to photosynthesize is apparent in the coloration of the stems and leaves of holoparasites, which lack chlorophyll. Dodder, for instance, is also known as “love vine,” because it is often bright red-orange and wraps itself tightly around its hosts.

Hemiparasitic plants are green and capable of performing photosynthesis, but they require additional water, mineral nutrients, or sugars from their host plant to reach reproductive maturity. Both holoparasites and hemiparasites may also vary in their reliance on any particular host species. Specialist parasitic plants only form haustoria with a single host species, whereas generalist parasitic plants have a mixed diet comprised of resources acquired from connections to several different species of hosts.

The curious relationships between parasitic plants and their hosts pique the interest of Congress, farmers, and conservation agencies across the world for various reasons. For instance, Witch Weeds (*Striga* species) parasitize several important crop species such as corn, sugarcane, and sorghum. In the mid-1950s, the United States Congress budgeted funds for the Department of Agriculture to study the infestation of Witch Weeds, which led to a nationwide eradication effort that significantly reduced the



Parasitic plants suck on their host plants' roots with disc-shaped structures called haustoria. This picture depicts Swamp Lousewort haustoria attached to the roots of Common Rush.

hemiparasite's impact on American crop production. Unfortunately, in Africa, where subsistence farmers cannot afford Witch Weed control methods, these plants continue to ravage harvests. In contrast to the ubiquitous Witch Weeds, other parasitic plants are extremely rare. For instance, Corpse Flower (*Rafflesia arnoldii* R. Br.) is an elusive species that grows in the jungles of Borneo. With no leaves or stems, Corpse Flower is only detectable for the short time when its gigantic, three-foot-diameter flowers emerge. (The plant, which relies on flies for pollination, was so named because it produces the fly-attracting aroma of rotting flesh.) Sustaining these species' populations and the host plants that they rely upon is a primary objective of parasitic plant conservationists.

Rare Parasitic Plants in New England

New England is home to several species of parasitic plants that span a diversity of habitats ranging from sandy

coastal beaches to alpine meadows. Many parasitic plants in New England are considered rare by federal and/or state agencies. Furbish's Lousewort, *Pedicularis furbishiae*, a federally Endangered hemiparasite that grows only on the border of the United States and Canada along the banks of the St. John River in Maine, is perhaps the most famous parasitic plant found in the northeast.

The story of Furbish's Lousewort is best told by Roy Gardner, a youthful white-haired man who has lived on the shores of the St. John River for most of the 20TH and all of the 21ST centuries. A couple of summers ago, my husband and I had the opportunity to visit Roy while researching the louseworts. Listening to Roy as we sat watching the sun set over the river on the front porch of the house he grew up in was like taking a trip in a time machine.

He recalled his mother selling loaves of bread for a nickel along the street during the Great Depression, the subsequent paving of the road, and Franklin Roos-



One of the rarest parasitic plants in the United States, Furbish's Lousewort, perhaps the most famous parasitic plant found in the northeast, grows along the St. John River in Maine.

Photo © Noah Charney

velt's New Deal that eventually landed him a job working on various hydroelectric projects around the country. In the mid-1970s, there was an opportunity for Roy to work on a proposed hydroelectric project just upstream from his home. Simultaneously, a botanist working on an environmental impact assessment for the proposed dam, Dr. Richards, rented a riverside cabin on Roy's property.

At the time, Furbish's Lousewort had not been seen for years along the St. John and was deemed extinct, but while Dr. Richards was looking out across the river from his cabin porch he rediscovered the rare plant. The Gardners embraced the presence of the rare species. They housed the many researchers who came to study the plants in their riverside cabins and set up a sign that proudly proclaimed, "Home of Furbish's Lousewort." The construction of the proposed

dam came to a standstill and was quite controversial given the then relatively recent passage of the Endangered Species Act. Today, Furbish's Lousewort remains one of the rarest parasitic plants in the United States.

One of the rarest plants in Massachusetts is also a hemiparasitic species of the same genus as Furbish's Lousewort: Swamp Lousewort (*P. lanceolata*). Swamp Lousewort is a late-blooming plant that grows in open sunny areas that experience flooding in the late fall through early spring. The documented range of Swamp Lousewort spans from Massachusetts to Georgia on the east coast of the United States, and west to Missouri and Manitoba, Canada. The species is listed as rare by most states along the eastern seaboard, but it is considered common by many states in the Midwest. Historic records indicate that Swamp Lousewort

used to be more common in Massachusetts, with several populations scattered across the state. Yet today, there is only one extant population. Although there is no evidence to determine precisely how these populations became extinct, given their documented localities, many of them were likely lost as a result of habitat destruction due to development. For instance, the site of one historical population now lies beneath the waves of the Quabbin Reservoir, which supplies drinking water for the city of Boston. Currently, the management of the single population of Swamp Lousewort in Massachusetts by the DFW's Natural Heritage and Endangered Species Program relies upon understanding what the major threats are to the population so that its extinction can be averted.

An Academic-Agency Partnership for Swamp Lousewort

In 1991, the New England Wildflower Society (NEWFS) founded the New England Plant Conservation Program (NEPCoP), a group of over 65 organizations, to prevent the extinction of the region's Endangered plants. Together, NEWFS and NEPCoP coordinated the production of non-regulatory conservation and research plans for New England's Endangered flora written and reviewed by academics and conservation professionals. By proposing interesting research questions relevant to the region's rare plants, these plans encouraged collaborations between students, professors, state



Photo © Noah Charney

The flowers of the Swamp Lousewort spring from spires of buds at the apex of the plant's stems and do not open until quite late in the season. Several populations were once scattered across the state, but only one remains today.



Photo © Noah Charney

A wild Swamp Lousewort in bloom. Looking at the plant, few would realize it is a parasite that cannot live without crucial root connections to a host species.

and federal agencies, and conservation professionals. Several success stories resulted from this program where academic-agency partnerships have formed around species with a conservation and research plan.

In 2001, Dr. Dorothy Allard wrote a NEP-CoP conservation and research plan for Swamp Lousewort that identified probable threats to existing populations of Swamp Lousewort in Massachusetts and Connecticut. Some of the possible threats to the species mentioned by Allard included deer or beetle herbivory, competition with invasive species, shading by woody native plants, and habitat modification as a result of activities such as grazing, mowing, or drainage of wetlands. In 2007, the Massachusetts Natural Heritage and Endangered Species Program followed up on Allard's plan by updating the state-specific management plan for Swamp Lousewort. To do this, the now-retired state botanist, Paul Somers, assembled a team consisting of Elizabeth Farnsworth (New England Wildflower Society), Karro Frost (environmental consultant), and myself (University of Massachusetts Amherst graduate student).

As we reviewed all of the existing information about Massachusetts' sole population of Swamp Lousewort, it was evident that there were several unanswered questions about the biology of the plant that, if answered, would help us to develop the best management practices for the species. These questions became the focus of my doctoral dissertation research. For instance, the Massachusetts population of Swamp Lousewort occurred at a site where there were also several non-native invasive species. In particular, Reed Canary Grass (*Phalaris arundinacea*) and Smooth Brome (*Bromus inermis*), plants brought over from Asia to provide fodder for livestock, grew in abundance.

Removing highly competitive, non-native invasive species growing with rare native plants is a common management practice, but given the hemiparasitic nature of Swamp Lousewort, eradicating such species could potentially have taken out important host plants. From previous studies by other researchers, we knew that as a generalist hemiparasite, Swamp Lousewort was capable of

forming connections with multiple host species including Reed Canary Grass. We did not, however, know whether or not these non-native grasses were high quality hosts for Swamp Lousewort.

As a generalist hemiparasitic species that both photosynthesized and parasitized for resources, the value of any particular host plant depended on the degree to which the hemiparasite benefited from water and nutrients acquired from the host, versus the amount that the host plant shaded out the hemiparasite, thereby preventing it from photosynthesizing. To determine whether or not non-native invasive species growing near Swamp Lousewort should be removed, I conducted greenhouse and field experiments.

In the greenhouse, I grew Swamp Lousewort with native, non-native invasive, or a mixture of native and non-native invasive graminoids (grasses). The native graminoids were Woolgrass (*Scirpus cyperinus*) and Common Rush (*Juncus effusus*). The non-native invasive graminoids were Reed Canary Grass and Smooth Brome. I also clipped the host plants in half of the pots evenly distributed across the different combinations of hosts to see how a clipping management treatment would affect the hemiparasites.

Swamp Lousewort grew significantly larger, produced more flowers, and had higher survival rates when grown with native host plants compared to when it was grown with non-native invasive host plants in monocultures or in mixtures with natives. Further, clipping the host plants, regardless of whether they were natives or non-native invasives, negatively impacted the size and flowering of Swamp Lousewort. This evidence suggested that the removal of Reed Canary Grass and Smooth Brome from around the Massachusetts population was warranted, but that the removal method should not also harm nearby native host plants.

The greenhouse experiment was useful in that it provided a controlled setting for exploring host-hemiparasite relationships, but Swamp Lousewort growing wild outdoors experiences multiple other stressors, such as fluctuations in weather, that also required investigation. The next step after the greenhouse experiment

was to see how native versus non-native invasive plants performed as host plants at the site of the Massachusetts population of Swamp Lousewort.

In the field, I tagged several hundred Swamp Lousewort individuals in invaded and uninvaded patches, and measured the tagged plants' survival, growth, and reproduction for 3 consecutive years. I was then able to use this data in a mathematical model to see how the growth rates of the invaded portion of the population differed from the uninvaded portion of the population. During the first half of the study, Swamp Lousewort growing in uninvaded patches had higher population growth rates than plants growing in invaded patches. However, in the second half of the study, the population growth rates of Swamp Lousewort growing in the uninvaded patches were lower than plants in the invaded patches.

Over the course of the 3-year study, native woody shrubs called alders (*Alnus* species) grew and began to cast heavy shade onto the Swamp Lousewort. Many management plans emphasize the removal of non-native invasive plants growing around native rare plants, but this field study stressed the importance of considering the growth forms of co-occurring species, in addition to their origins. In this case, the natural growth of native species (alders) appeared to have a direct, negative effect on a rare native species.

Another potential threat to Swamp Lousewort that we identified in the state management plan was the

effect of beaver activity on the plants. The population of Swamp Lousewort in Massachusetts grew in several patches along a small stream that was also home to beavers. When we wrote the state management plan there was



One of the focus areas of the author's research was determining if Swamp Lousewort would grow better with invasive, non-native species, or with native hosts. In the controlled environment of a greenhouse, she demonstrated that Swamp Lousewort grew larger, had better survival, and produced more flowers when growing with native as opposed to non-native invasive host grasses. Above, growing with the non-native grass Smooth Brome, and right, with our native Woolgrass.

no prior information on the effects of beaver flooding on the hemiparasites. In addition to tagging and measuring plants in uninvaded and invaded areas for 3 years, I also followed the fates of individuals in all of the patches along the stream.

In year one of the study, flooding caused by beaver dams nearly wiped out two of the patches of Swamp Lousewort. Simulating the potential fate of Swamp Lousewort based on these data showed that the frequency of beaver flooding had a strong influence on the population's risk of extinction. Although beaver flooding

had a negative effect on the population size of Swamp Lousewort during the study, beaver also played an important long-term role in maintaining the open, sunny habitat needed by the hemiparasites. As such, management activities directed at conserving the plants needed to acknowledge this tenuous dynamic in which beaver act as both creators and destroyers of Swamp Lousewort's habitat.

The results of this research are now being used by the Massachusetts Natural Heritage and Endangered Species Program to inform the best management

practices for Swamp Lousewort. As a graduate student, I found that the academic-agency partnership formed to answer the questions needed for the management of Swamp Lousewort led to a number of invaluable resources. Because of the "directly applied" aspect of my work, the project was more competitive for grants from a variety of sources, including funds from the university, state programs, and the private sector. Also, I developed contacts with people who had diverse perspectives on topics ranging from theoretical to practical issues, which enriched the context of the studies. One purpose of the NEWFS and NEPCoP conservation and research plans was to bridge the academic-agency divide, and they fulfill this goal. There are many intriguing plants with conservation and research plans that are still in need of study. Spread the word – the opportunities are out there!



Sydne Record is a postdoctoral research fellow at the Harvard Forest Long Term Ecological Research Site in Petersham, Massachusetts. She would like to thank NC for his help in editing this article.

Photos © Noah Charney

