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THE NATIVE ORCHID CONFERENCE JOURNAL

VOLUME 19, ISSUE 3 : TABLE OF CONTENTS

APLECTRUM HYEMALE, (MUHL EX WILLD.) TORR.
A BOTANICAL EXAMPLE OF APOSEMATIC COLORATION

By John H. Horner, PhD, JHorner@addisoncw.com

What do Monarch Butterflies and *Aplectrum* leaves have in common? I believe that both are aposematic. That is, the bright coloration of Monarch Butterflies and the stripes marking an *Aplectrum* leaf serve to inform predators that they are unpalatable, and to move along and find a meal elsewhere.

Aplectrum hyemale is a unique and unmistakable orchid species, found exclusively in the deciduous forests of eastern North America. The western limit of its distribution extends from Minnesota to eastern Oklahoma. From there the range extends eastward to northern Georgia and southern Quebec. A winter leaf is produced in autumn, from an underground corm, as the trees comprising the deciduous overstory shed their leaves in preparation for winter dormancy. Like several other members of the subtribe Calypsoinae; for example *Calypso* or *Tipularia*, *Aplectrum* leaves are adapted to photosynthesize from late fall, through winter, to mid-spring, until the deciduous forest canopy again closes. A wintergreen leaf phenology such as this likely minimizes insect predation, but makes the leaf and the associated underground corm more susceptible to mammalian predation. Few other plant species bear leaves during the winter months, making *Aplectrum* both more visible and more appealing to hungry deer.

The leaves of *Aplectrum* are plicate, typically 6-10 cm in length, but can reach 17 cm. They vary in shape from broadly lanceolate, to ovate, to obovate, to almost round. The dorsal surface is marked by distinct white to silvery gray longitudinal stripes that serve to draw attention to the leaves, making them unmistakable to passing humans or potential herbivores. These stripes are not merely decorative. They mark the position of tough fibrous veins that run from the base of the leaf to the tip (Figure 2). This property was observed when the author attempted to tear a fresh *Aplectrum* leaf. The leaves are easily torn longitudinally (parallel to the veins), but are extremely difficult to tear across the veins. This characteristic has, as far as I can discern, never been noted before in botanical literature. For comparison, a leaf of a nearby *Tipularia discolor* was easily torn across.

The only relevant reference dealing with the internal leaf anatomy of *Aplectrum* is a study authored by Stevens and Dill, who noted that the leaves were stiff, a property they attributed to the presence of strands of elongated sclerenchyma cells above and below the vascular bundles (Stevens and Dill, 1942).

Aposematic coloration is a biological defense mechanism whereby an unpalatable or even dangerous organism advertises its undesirable nature to potential predators. In most cases, aposematic coloration involves highly distinct, contrasting visual patterns which serve to increase visibility and distinguish them

Figure 1. Leaf of *Aplectrum hyemale* emerging from corm, showing prominent white stripes.

Figure 2. Dorsal surface showing small tear with fibrous veins.

from more edible species. The unpleasant experiences suffered by predators which ignore these warnings trains them to avoid similarly colored individuals, thus deterring future predation. In the case of *Aplectrum*, the fibrous veins present in each leaf serve to increase fracture toughness and minimize cracking as it's chewed. In theory, this would be unpleasant for large herbivores and discourage them from targeting other *Aplectrum*.

Plants of the deciduous forest of the eastern United States face predation from three primary sources: insects, Whitetail Deer (*Odecoileus virginianus*), and small mammals such as rabbits, squirrels or chipmunks (Fletcher et al., 2001). By studying the Turk's Cap Lily (*Lilium superbum*), Fletcher et al. (2001) were able to observe and record its predators. Like *Aplectrum*, lily species (Liliaceae) store food reserves underground, in this case in bulbs, rather than corms. The herbivores presented two distinct threats: deer and insects targeted aboveground foliage, while rodents targeted the underground bulbs during fall, winter, and spring. They found that insects damaged, but did not kill, 35% of the plants in the study; likewise deer damaged, but did not kill 28% of unprotected plants. Rodents, however, dug up and killed 9% of the underground bulbs. Since Turk's Cap Lily grows in the same eastern deciduous forest as *Aplectrum*, it seems likely that *Aplectrum* must also deal with these three groups of herbivores.

Whigham (1988) studied predation on the leaves and corms of *Tipularia discolor*, an orchid also in the Calypsoinae subtribe that often co-occurs with *Aplectrum* and likewise produces a winter-leaf. Over a ten year period between 20% and 40% of the plants in a given year suffered leaf predation. Destructive corm predation by rodents ranged from zero to a few percent in any given year to about twenty percent, and was correlated with the size of the rodent population. Whether or not *Aplectrum* is less or more susceptible than *Tipularia* or *Lilium* to predation is unknown.

The common name Puttyroot is a reference to the observation that the corms, when crushed, produce a mucilaginous substance that was once used as an adhesive in colonial America. Numerous authors anecdotally repeat this and it is likely true, but as far as I can determine no scientific study has ever been performed on the adhesive properties of *Aplectrum* mucilage. I was, however, able to locate a single blog post which stated that macerating an *Aplectrum* corm produces a sticky mass. After 30 minutes, the mass became viscous and stringy to the point that it could actually be used to repair a clay-dough statue (Diehn, 2018).

Underground storage structures (corms and roots) are often chemically defended, sometimes by being highly toxic (e.g. Death Camas, *Zigadenus*), or by just being obnoxious enough to make herbivores think twice about consuming them (e.g. Onions, *Allium*). This is only a conjecture, but I believe the high mucilage content of *Aplectrum* corms serves to deter herbivory by small mammals, much like how the tear-producing compounds released by onions deter herbivores. Biting into a corm and ending up with a

mouthful of sticky mucilage is likely not a pleasant experience, but this is only a supposition on my part. If the corm of *Aplectrum* were favorably palatable, the highly visible striped leaf should act like a beacon to attract chipmunks and other small rodents looking for an easy meal. Instead, I believe it serves to send them on their way, to look for a meal elsewhere.

Numerous examples of aposematic coloration exist in the animal kingdom. The best known example is the Monarch Butterfly (*Danuaus plexippus*) (Figure 3). The caterpillars feed on Milkweed (*Asclepias*), and accumulate cardenolide glycosides, which are passed on to the adults (Brower et al., 1982). When birds attempt to feed on either the caterpillars or adult butterflies, the glycosides produce an intense emetic effect which causes the bird to release the insect. Birds possess excellent color vision, and the traumatic memories of attacking this highly colored, easily recognized, unpleasant insect serves to deter future predation.

Figure 3. Aposematic coloration. Monarch Butterfly (*Danaus plexippus*) on Common Milkweed (*Asclepias syriaca*). Baraboo, WI (July 2021)

Highly conspicuous species of neotropical frogs of family Dendrobatidae (commonly known as poison dart frogs), accumulate and store alkaloid toxins, often at levels lethal to potential predators (Santos et al., 2016). Velvet Ants, (Hymenoptera: Family Mutillidae), are colorful flightless wasps that possess a vicious sting (Gall et al., 2018). Like the Monarch Butterfly, these species do not need to avoid predation by camouflage or by being nocturnally active, but are able to expose themselves to potential predators in broad daylight.

Botanical examples of aposematic coloration are less well known. Plants commonly defend themselves physically, by being spiny, tough, or both. Thorns, spines or prickles are often, but not always, highly visible.

One of the most prolific authors writing on the topic of aposematic coloration in plants is Simcha Lev-Yadun of the University if Haifa, who has written extensively about defensive structures and their coloration found in Israeli desert plants (Lev-Yadun, 2001, 2003, 2006, 2015; Ronel, 2012). He concluded that the thorns and spines presented by many desert species are aposematic, since herbivores, once wounded, come to associate the highly visible thorns with an unpleasant experience, and consequently avoid the thorn-bearing plants. Aposematic individuals will as a consequence suffer fewer attacks, while non-aposematic plants will preferentially be sampled.

Among the many plants discussed in his publications are *Silybum marianum* and *Agave americana*. As a result of human activity these two plants have spread around the world. I spent part of the great COVID lockdown of 2020-2021 in southern California, and had the opportunity to seek out and make the acquaintance of both species. These spiny denizens of the California flora are visually striking, and well armed to deter predation.

Agave americana, is a large succulent native to the deserts of the southwestern United States and Mexico, now naturalized in the Mediterranean. Plants can grow up to two meters tall, and up to four meters in diameter. These imposing and impressive plants bear leathery, sword-like, bluish-white leaves, the margins of which are armed with stiff, sharp, highly visible, blackish- brown, spines. Each leaf is tipped with a dark rigid spine up to 3 cm in length. The apical spines are quite capable of inflicting painful injuries on unwary passersby (Figure 4). This species is widely used as a landscaping plant in southern California. Gardeners sometimes clip the apical spines of plants in high traffic areas, so that their employers will not be impaled if they fail to heed the aposematic warning.

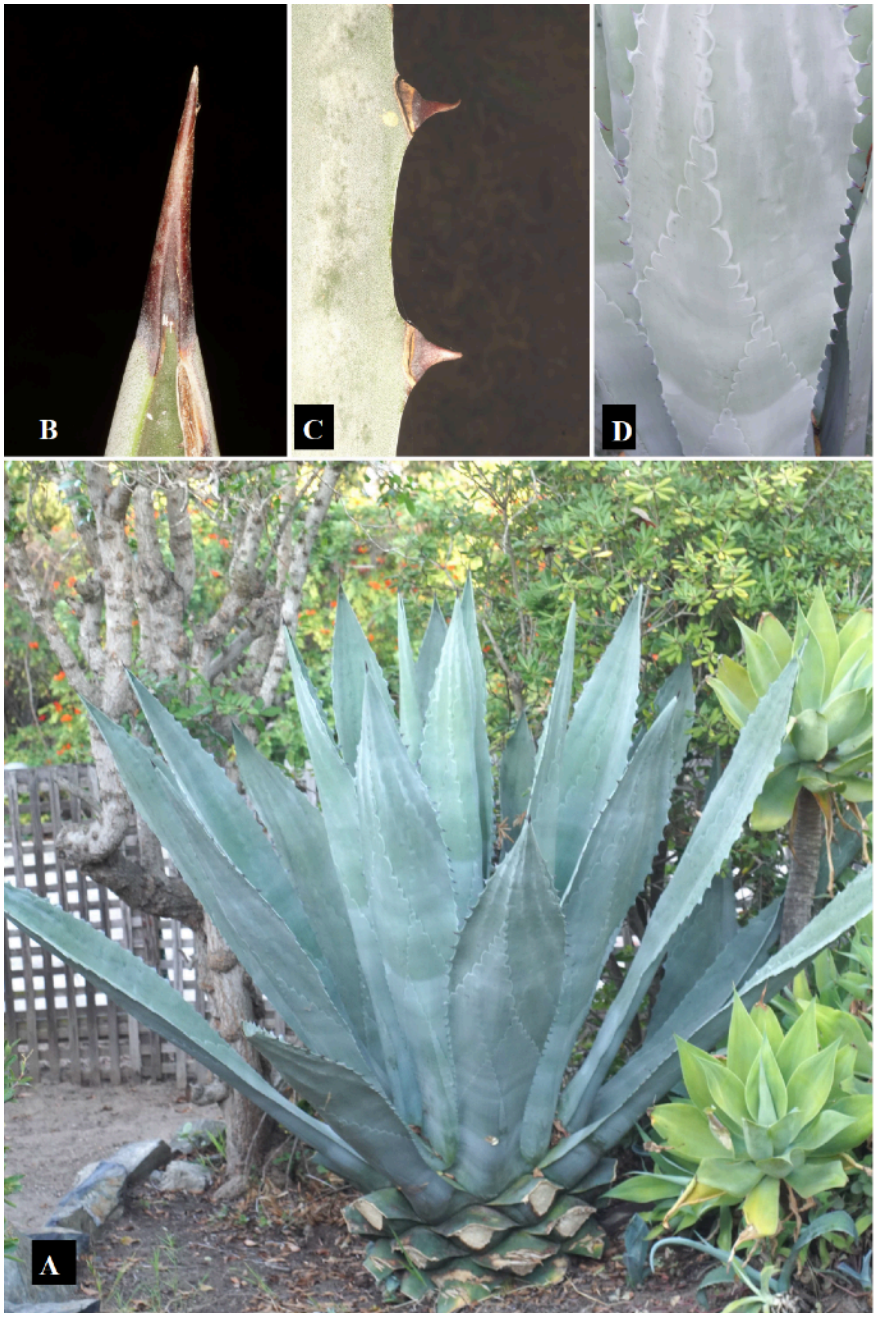

Figure 4 *Agave Americana*, (A) Entire plant. (B) Stiff apical spine (length 3 cm), (C) Marginal spines, (D) Closeup of white patterning on leaves. North County, San Diego

A second plant discussed by Lev-Yadun as an example of aposematic coloration is *Silybum marianum*, commonly known as Milk Thistle (Lev-Yadun, 2003). Originally native to southern Europe, North Africa, and the Middle East, it has become widely naturalized in warm and temperate climates around the world.

Milk Thistle is a formidable plant that one quickly learns to avoid. It produces distinctive green leaves marked by a reticulated pattern of white stripes (Figure 5). Milk Thistle has become naturalized in southern California, and I quickly learned to avoid touching any part of this plant. All parts are covered in incredibly sharp, stiff spines. The high contrast between the stripes and green background make the leaves visible from several meters away. After a first encounter, the distinctive leaves serve as a warning to passing humans to not touch, and to potential herbivores to look elsewhere for a meal.

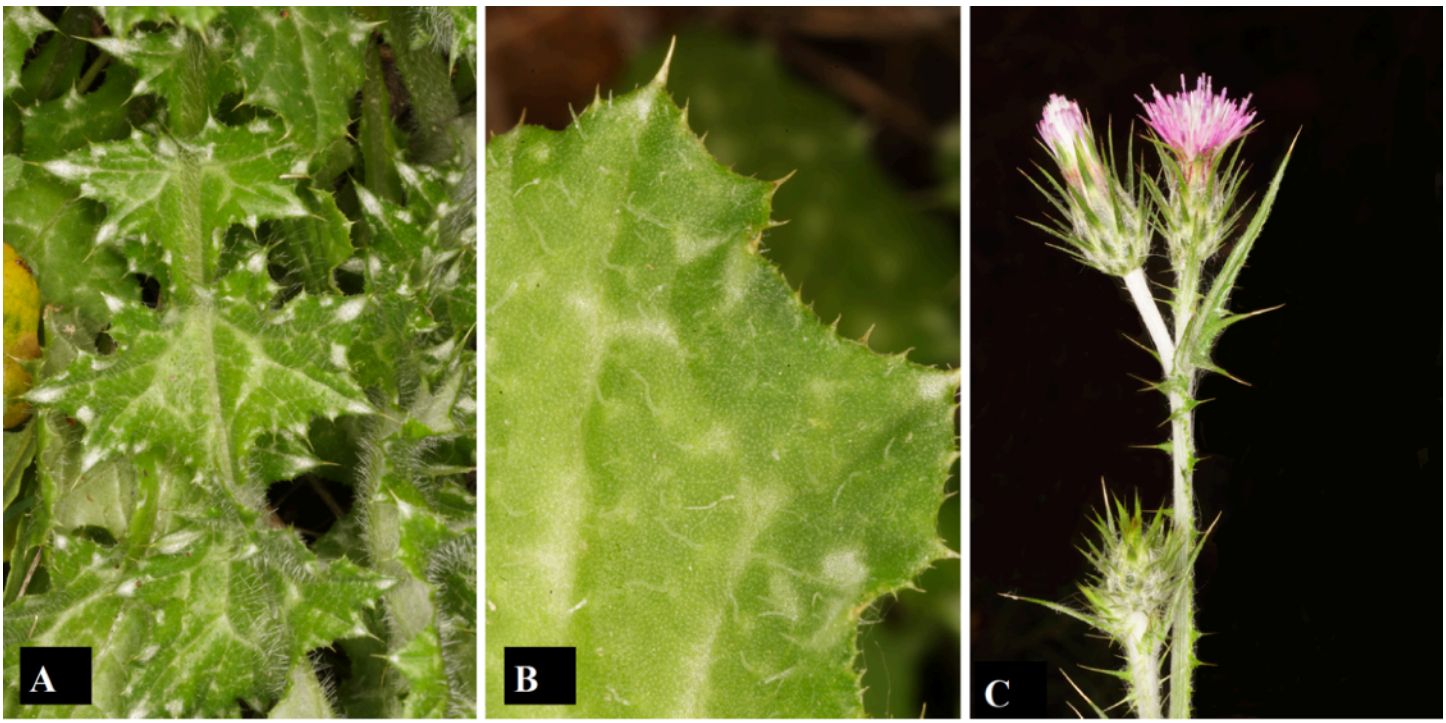

Figure 5. Photos of of *Silybum marianum* (A) Leaves showing white veins and spotting. (B) Closeup of leaf showing spines and variegated surface. (C) Stems and flowers showing spines. San Elijo Lagoon Ecological Reserve, North County San Diego, CA, March, May, 2021.

On several occasions I encountered aposematic cacti while in southern California. One of the most striking was *Opuntia phaeacantha*, a species that bears highly visible bicolored spines up to 5 cm in length (Figure 6). The spines are stiff, needlelike, and easily inflict a painful wound. A study by McCarthy of Ohio University, identified that 49 species growing in southeastern Ohio, bore aposematic thorns, spines or prickles (Rubinio, 2004). Prominent among the aposematic species were roses and blackberries, which each bear highly colored prickles.

Figure 6. *Opuntia phaeacantha*, showing aposematic bicolored spines.
North County San Diego.

In terms of defense, *Aplectrum hyemale* has not adopted the in-your-face, full throated roar of a spiny agave or thistle, but simply being tough (sclerophyllous), is a well-known deterrent to herbivory (Hanley, 2007; Sanson, 2006). In order to be digested, herbivores must macerate leaves into small pieces, so as to release cellular contents. Large herbivores are faced with the task of grinding leaf material into small pieces so as to maximize nutrient extraction in their digestive tract. For ungulates such as deer, sheep, or cattle the intake rate of forage declines with increasing fiber content due to the increase in time needed for reduction to digestible size (Laca, 2001). Resistance to chewing or fracture slows herbivores down and makes the plant less desirable.

In material science, fracture toughness measures the ability of a crack to propagate through a material. If sufficient force to fracture a material is applied, a crack will initiate, often at a preexisting zone of weakness. Once initiated, a lower level of force is needed to propagate the crack through the material. Most readers who have opened items wrapped in plastic film, are already familiar with this phenomenon. The wrapping is initially highly resistant to tearing, but if it is punctured or nicked it can be easily torn, as the tear can now be propagated with the application of minimal force.

One of the common ways to minimize tear propagation is to introduce a fibrous material, which results in a fiber-reinforced composite. After initiation, the tear only propagates as far as the closest fiber, and must then be reinitiated. All leaves to some extent can be described as naturally occurring fiber composites. Depending on the species the veins vary greatly in strength relative to the surrounding mesophyll. *Aplectrum* has carried this to an extreme by producing sclerophyllous fibers that should impede crack propagation, and thus increase the time required for the herbivore to grind the leaf down to digestible size.

All, or almost all examples of botanical aposematic coloration reported thus far both in arid or temperate climates involve physical defense in the form of spines, thorns or prickles. This work is apparently the first to propose aposematism as a warning to leaf sclerophylly but as noted above it may also signal distasteful associated corms.

A reviewer suggested that I mention an alternate theory of leaf variegation. Except for most primates, mammals are color blind. They lack a long wavelength, red sensitive, opsin pigment in their retinal cone cells. As a result red, orange, and green blend together as shades of yellow. It has been suggested that white variegation can act to camouflage leaves (Givnish, 1990). His hypothesis is that in a forest understory, where mottled sunshine reaches the forest floor, leaf variegation serves to disrupt the perception of leaf outline, thus making the leaf less obvious to colorblind herbivores.

It has been suggested that white variegation can either provide camouflage, or aposematic warning, depending on environmental lighting; camouflage in a shaded forest understory, aposematic in bright sunlight (Lev-Yadun, 2015). It is possible that the white patterns on the leaves of many *Goodyera* species serve as camouflage. *Goodyera* leaves are evergreen and occur as rosettes which grow in forests with dappled sunshine. Deer apparently find that the leaves of *Goodyera pubescens* are quite palatable, in that deer herbivory has been reported to be a major cause of population decline (Reddoch, 2012). (Ed. A reviewer notes that there has been discussion of leaves of *Goodyera* mimicking poisonous snakes, but a comprehensive review of this subject is not available.)

The case of *Aplectrum* is somewhat different from *Goodyera*. Although *Aplectrum* is classified as a temperate, forest understory herb, its leaf presents itself in winter when the forest floor is bathed in bright sunlight (when not covered by snow). Although it is not completely clear how a colorblind herbivore perceives an *Aplectrum* leaf against the forest background, it seems likely that the white stripes should be highly visible.

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CYPRIPEDIUMS OF THE PACIFIC NORTHWEST

By Ron Hanko, ronaldhhanko@outlook.com

Depending on whether or not we count the natural hybrid of *Cypripedium montanum* and *Cypripedium parviflorum* and the three varieties of *Cypripedium parviflorum* there are between five and eight *Cypripediums* that grow in the Pacific Northwest, arbitrarily limited in this article to the coastal states of California, Oregon and Washington and the province of British Columbia. Two of these *Cypripediums* are indigenous to the area and not found elsewhere. In Washington, where I reside, we have five of the eight, including the natural hybrid, but we are too far north for *Cypripedium californicum* and too far south for *Cypripedium passerinum*.

The following table lists these Cypripediums and shows their distribution.

	California	Oregon	Washington	B. Columbia	Beyond
C. californicum	X	X			
C. fasciculatum	X	X	X		X
C. montanum	X	X	X	X	X
C. parviflorum var. *exiliens*				X	X
C. parviflorum var. *makasin*			X	X	X
C. parviflorum var. *pubescens*		X	X	X	X
C. passerinum				X	X
C. ×columbianum			X	X	

The **California Lady's-slipper**, *Cypripedium californicum,* is found only in northern California and southern Oregon and only in serpentine soils that have a high concentration of heavy metals. Where it grows it can be quite abundant and is often found with the carnivorous Cobra Lily, *Darlingtonia californica,* and another orchid, the Sparse-flowered Bog Orchid, *Platanthera sparsiflora*. It is the tallest Lady's-slipper in the USA, as tall as 120 cm (4 feet) and has more flowers than any of the others, as many as twenty per stem. It grows in wet areas and the flower color varies from brownish green to yellow-green. The lip is always white but can be pink around the opening of the lip, as evident in one of the photos.

California Lady's-slipper, *Cypripedium californicum*

Cobra Lily, *Darlingtonia californica* and habitat (top) and
Few-flowered Bog Orchis, *Platanthera sparsiflora* (bottom) commonly grows with
California Lady's-slipper, *Cypripedium californicum*

The **Clustered** or **Brownie Lady's-slipper**, *Cypripedium fasciculatum,* is the smallest of our Lady's-slippers and produces two (occasionally three) broad plate-like leaves that are very close to the ground. Due to its stature and the coloration of its flowers, this species is very hard to find, even in places where it is known to grow and that may in part explain its perceived rarity. As a testament to this, we have looked for it unsuccessfully in locations where we know populations occur or even in places where we have found plants before. Each plant is at most only 25 cm tall and the flowers are dull mahogany to green. Flowers are produced in clusters and tend to droop, which makes them all the more difficult to photograph or spot in the field. There are two named forms, f. *purpureum*, with uniform dark mahogany flowers, and f. *viride*, which has clear green flowers. This species is the least showy of our native Slippers, but charming nonetheless.

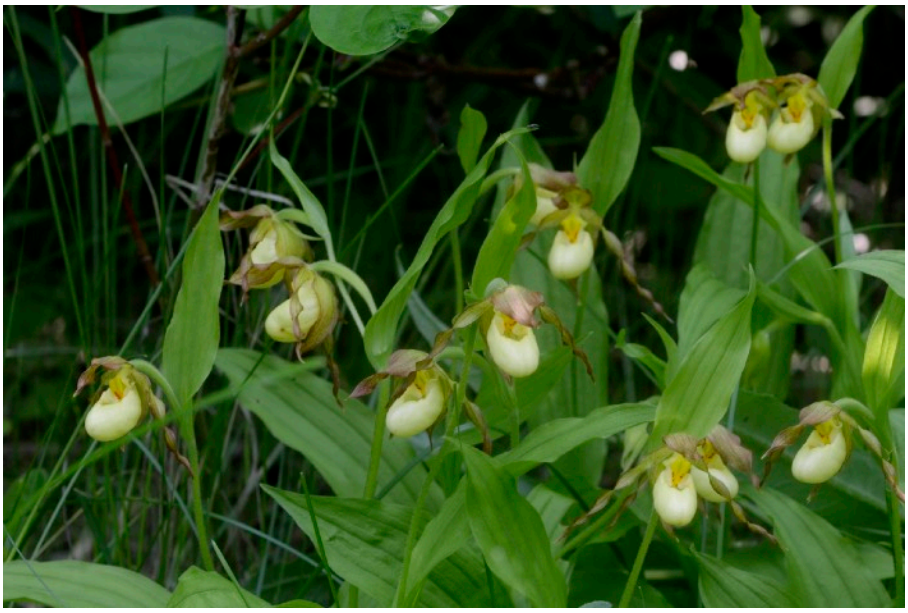
The **Sparrow's-egg Lady's-slipper** or **Franklin's Lady's-slipper,** *Cypripedium passerinum,* is not found south of the Canadian border in our area, though it is known from Montana. Plants of this species can reach a height up to 50 cm (nearly 2 feet) tall, but the solitary flower each bears is only a few centimeters in size. The flowers do not open widely, with the dorsal sepal often nearly obscuring the opening of the lip, which is almost filled by a very large staminode. The lip is usually white, rarely off-white, and is dotted on the inside with purple. Where we have found this species, plants are always growing in damp areas in open woodlands, often with Yellow Lady's-slipper, *Cypripedium parviflorum*.

The **Mountain Lady's-slipper**, *Cypripedium montanum,* is a variable species, which ranges in height from 30-75 cm (1-2.5 feet), with flowers that are quite uniform in size but run the gamut from very dark mahogany-purple to a pale green. The lip is always white and usually has lines of purple spotting on the lower surface of its interior and sometimes purple blotching around the rim. This species is quite common in some areas. There are two named forms: f. *welchii*, with a crimson-edged lip (and very dark flowers, bottom left), and f. *praetertinctum*, a white-flowered form which lacks any purple or red coloring on the petals, the staminode, or the lip (bottom right).

The **Yellow Lady's-slipper**, *Cypripedium parviflorum*, is very rare in Oregon and Washington but quite common in northern British Columbia, where we have seen plants by the thousands. Generally speaking, this species becomes increasingly frequent northward. Interestingly, this species is rather variable in height. Plants growing in strong sunlight tend to be less than 30 cm (1 foot) tall, while those in more shaded areas reach 60 cm (2 feet). The lip is usually an intense yellow and the petals and sepals range from very dark mahogany to paler green with mahogany patterning. This species has three named varieties, var. *exiliens,* var. *pubescens* and var. *makasin*. The flowers of var. *pubescens* are the largest of the three varieties (pictured below). Variety *makasin* and var. *exiliens* both have a strong fragrance, but the sepals and petals are usually very dark in color in var. *makasin*, and dull green tan with small clusters of rust colored spots in var. *exiliens* (Coleman 2018). Another difference is the hairiness of the distalmost sheathing bract, which is very hairy in var. *pubescens* and almost smooth in var. *exiliens* and var. *makasin*. The varieties are very difficult to distinguish in the wild, however, and most people do not even try to do so.

In Washington state, *Cypripedium parviflorum* grows only in a few places whose locations are closely guarded secret to protect the plants from collectors. In June 2013 we visited one of these places with the Washington Native Orchid Society, each of us promising that we would not give away the location.

Not only did we see over a hundred plants of *Cypripedium parviflorum* in the area, we found a mixed population of plants, some of whose flowers closely resembled *Cypripedium parviflorum*, others *Cypripedium montanum*, as well as plants whose flowers were clearly intermediate between the two species, which we identified as the natural hybrid, *Cypripedium ×columbianum* (pictured below).



Cypripedium ×columbianum, resembles its parents in both plant and flower size, as well as flower form, but the lip is off-white or cream-colored, not the white of *Cypripedium montanum* nor the yellow lip of *Cypripedium parviflorum.* Its sepals and petals are greenish, more or less marked with mahogany, which distinguishes it from neither parents. Where we've found it, this hybrid was growing with *Cypripedium montanum* or both parents.

Because these plants were growing and flowering together, it is doubtful that any individuals in this population were pure *Cypripedium montanum* or *Cypripedium parviflorum,* and very likely that they were all hybrids, even though evidence of hybridization was more evident in some plants than others. In other words, what we found was most likely a hybrid swarm with no pure plants, even if some hybrids bore a close resemblance to one of their presumed parents.

The flowers that resembled *Cypripedium parviflorum* were small, about 8 cm, and were scented. The sepals and petals ranged from a solid mahogany brown to greenish with varying amounts of spotting. The lips ranged from short and blunt to elongated, some with purplish markings around the rim of the lip, and others without. Many had purple veining on the inside of the lip at the bottom, some did not. In some the exterior of the lip was smooth, in others it was veined.

Those flowers that resembled *Cypripedium montanum* seemed quite typical for that species, with greenish sepals and petals which were more or less heavily spotted and marked with mahogany. The lips were white and each generally had purple markings around its opening in addition to purple veining in the bottom of the interior. The petals did seem shorter and more tightly spiraled than what I am used to seeing in that species, however.

There were also quite a number of flowers that were clearly intermediate between the two parents. The lip coloration of these plants was the most noticeable feature, ranging from an off white to a cream color. Flowers that on their own would probably pass for *Cypripedium parviflorum* or *Cypripedium montanum* were often slightly off-color, a paler yellow in the case of *Cypripedium parviflorum*, and an off-white in the case of *Cypripedium montanum*. These oddly colored flowers all had purple veining at the base of the pouch, but sepals and petals ranged from mahogany to green with varying amounts of spotting and other markings. These fit the description of the natural hybrid, *Cypripedium ×columbianum*. The accompanying photos show this variation in lip color, which often differs between plants growing side by side.

We have seen something similar to this in British Columbia and have also seen photos of a similar hybrid swarm near our home in eastern Washington, though to date we have not been able to see the latter plants in person. We have talked to those who are skeptical of the possibility that these plants represent the natural hybrid, *Cypripedium ×columbianum*, but having seen populations both of *Cypripedium parviflorum* and *Cypripedium montanum* growing on their own, we need no convincing.

We usually do not reveal locations for native orchids, but are especially careful in the case of the *Cypripediums* since they are the most likely to be dug up and collected from the wild. This reluctance to reveal locations was strengthened by a bad experience a year ago: our returning to the location of a rare white Fairy Slipper (*Calypso bulbosa*) and finding only a hole where someone had removed it.

This second table compares the different species and shows their flowering times. Flowering times, of course, vary with the season, the latitude and the elevation, but mid to late June is usually the best time to see these native beauties in bloom.

Species	**Plant height**	**Flower count**	**Flower size**	**Flower season**
C. californicum	to 120 cm	5-20	4 x 4 cm	May-June
C. fasciculatum	to 25 cm	1-10	4 x 4 cm	April-June
C. montanum	to 75 cm	1-4	12 x 15 cm	May-July
C. parviflorum var. *exiliens*	to 25 cm	1-2	4 x 8 cm	June-July
C. parviflorum var. *makasin*	to 40 cm	1-2	4 x 10 cm	June-July
C. parviflorum var. *pubescens*	to 60 cm	1-3	10 x 12 cm	June-July
C. passerinum	to 50 cm	1	4 x 6 cm	June-July
C. ×columbianum	to 70 cm	1-2	8 x 12 cm	May-June

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VALMONT BOG UPDATE- PART II:
THE NATIVE ORCHID CONFERENCE AT VALMONT

By Robert Sprague, bobsatcyndal@aol.com

It would be a gross understatement to suggest that the Valmont Bog in West Hazleton, PA is an anomaly; it most certainly is. Located in an old (1950's vintage) industrial park, it's surrounded by shopworn factories and warehouses, narrow roads and an abandoned rail line. Even more bizarre, it sits within a utility right-of-way (ROW) and underneath high-voltage, electrical transmission lines. Why would scientists, naturalists and wildflower aficionados flock there? Mention the word "bog" to nature enthusiasts and thoughts immediately turn to remote, wild places surrounded by pristine forest with a meandering stream, abundant wildlife and a plethora of unique flora nearby… flora such as sphagnum moss, cranberry, insectivores and orchids. *ORCHIDS? In an industrial park? In West Hazleton, PA? Yes, yes and yes!*

The Valmont Industrial Park is showing signs of its 70 year age [top left]; High voltage transmission lines hoover over the orchids [bottom left]; Ragged-fringed Orchid (*Platanthera lacera*) occurs in small numbers near the power line right of way [right].

Valmont Bog's rise to national prominence in the world of botany began shortly after the turn of the century (i.e. the year 2000). As discussed in Part I, a Natural Areas Inventory confirmed the presence of several native orchids as well as other rare plants and insects. That survey, prompted in part by the Hazleton Rails to Trails organization, was originally intended to help establish a pedestrian walking trail. An abandoned rail line adjacent to the bog was (and may still be) under consideration for inclusion in that as yet unfinished project. As of this writing a very fine five mile trail terminates approximately three miles from the bog.

Abandoned railroad right-of-way may be added to the Rails to Trails project.

Amateur botanists and natural history enthusiasts had known about Valmont's orchids for many years. As is often the case, however, in order to prevent accidental damage by the uninformed or exploitation by the unscrupulous, very little was said outside a tight circle of interested and carefully vetted individuals. All that changed when Rick Koval, then Land Protection Specialist for the North Branch Land Trust (NBLT), undertook an effort to involve the Directors of Can Do, Inc. (the original owner/developer of the Valmont Industrial Park) in a conservation project. He set his sights on the bog, and the undeveloped acreage surrounding it, in order to protect the many species of rare flora and fauna found therein.

The road to land acquisition would prove to be paved with skepticism on the part of the Pennsylvania Department of Conservation and Natural Resources (DCNR). DCNR was the most likely source of funds for such projects, but department officials were not immediately impressed by the rare Odonata (the Order of insects that includes dragonflies and damselflies) which inhabit the bog… not enough "Wow" factor, perhaps. They did, however, indicate support for projects that would provide public access and recreational opportunities so the Rails to Trails project became their focus. Thus, NBLT also became involved in the trail proposal. But Koval recognized that the "wow factor" of orchids constituted another arrow in the quiver of ammunition that could help in the struggle to raise funds for land acquisition. He discovered the fledgling Native Orchid Conference (NOC) which had been incorporated in North Carolina in 2002. It was in 2005 that the NOC was apprised of the trail project and the possibility that it could bring hikers uncomfortably close to the orchids. The following year I was asked to help lobby DCNR and gladly joined that effort. Koval asked me to write a letter of support on behalf of the NOC and to emphasize the botanical and scientific importance of this hidden gem located in the heart of anthracite country.

And with that, the proverbial cat was out of the bag. It was thought by many that trying to put that genie back in the bottle would be an impossible task. Unfortunately, or fortunately depending on your point of view, the orchids of Valmont would no longer be a closely held "secret." I vacillated for several years trying to decide how much publicity might be enough and conversely, how much would be too much. That decision was clearly not within my control. It wasn't really within anyone's control because Valmont had become the rock star du jour in the world of native wildflowers. Word had spread rapidly. Isn't the internet wonderful? Perhaps it is… or perhaps not so much.

It became apparent that a carefully orchestrated public education campaign had become appropriate, even necessary, and that it could be effective with regard to long-term preservation… but where to begin? NBLT efforts to acquire upland acreage surrounding the bog continued at the expected bureaucratic snail's pace. Utility company work continued, but not always with "orchid safety" top of mind. Visitors continued to visit… occasionally via all terrain vehicles which obliterated orchids.

Tom Mirenda, in addition to being a prolific writer, world traveler and opera singer, was formerly the Smithsonian Gardens Orchid Specialist. In August, 2009 I invited Tom to visit Valmont. Also in our group were Australian scientist Zoe Smith, PhD. who was working at the Smithsonian Environmental Research Center (SERC), Howard Wood, MD (author of *The Dendrobiums* as well as several articles on native terrestrial orchids), and Amy Levengood (my wife, field companion, bird and wildflower spotter extraordinaire and NOC webmaster). Each would play a role in publicizing Valmont.

Dr. Smith took an interest in the hybrid orchids growing in considerable numbers at Valmont and began extensive DNA analysis and germination studies. Dr. Wood noted that not one, but two varieties of *Platanthera blephariglottis* might be present. He wrote an article comparing the hybrid swarm to similar swarms in Newfoundland that he had studied extensively in prior years. That article was featured in *Orchids,* the monthly publication of the American Orchid Society, in August, 2010. Meanwhile, Tom Mirenda continued to write, sing opera and promote orchid conservation worldwide… all things at which he is very accomplished and which occupy his time to this day.

Dr. Zoe Smith (left) began her research at Valmont in 2009.
Dr. Howard Wood (right) admires Narrow-leaved Gentian (*Gentiana linearis*)

In July, 2011 the NOC held its annual, four-day symposium at Mount Cuba Center in Hockessin, DE. One of the featured field trips during that gathering was a visit to the Valmont Bog which afforded attendees an opportunity to see firsthand what their organization had been supporting for several years. Then, in 2012 it finally happened. NBLT acquired title to 59 acres of upland forest which abut the bog on the north and west sides and they were ready to blow their own horn. Of course the orchids actually "belong" to the utility company (PP&L of Allentown, PA), but the NBLT acquisition provided access and a bit of a buffer. By this time word had spread far and wide. Kent Jackson, a reporter for the Standard Speaker, developed a special interest in the project. (Yes… there are actually still a few local newspapers with at least one traditional reporter). Kent published several articles on the Valmont Bog… his interest and involvement is on-going.

Because of my orchid related activities and relative proximity, I was asked to help NBLT with its horn blowing effort. I penned an article which offered a possible explanation as to the formation of the bog and background information on the development of the industrial park. It enumerated the orchids as well as other rare plant and insect species which occur there. In addition, we solicited input from former Agriculture Canada researcher and University of Ottawa adjunct professor Paul Catling, PhD. Paul wrote an article which explained, in scientific terms, the conservation value of preserving Valmont's orchids as well as the potential economic benefit which might accrue to the local community. Both articles appeared in the July, 2013 edition of *Orchids*. Each season (pre-Covid) NBLT sponsored an event for members and friends. My forty-five minute PowerPoint presentation about the bog and its unique flora was followed by a group walk to the site and an up close view of blooming orchids.

Attracted by the extraordinary spectacle of the *Platanthera ×bicolor* hybrid swarm, folks flocked to Valmont like so many swallows to Capistrano. Individuals and small groups, some representing orchid or native plant societies, came to see and photograph the orchids. Most were from the mid-Atlantic region but a few came from as far as California. As word spread, orchid societies became increasingly interested in native orchids and in November, 2012 I made a presentation about Valmont to the Delaware Orchid Society. That was the first of what would become more than a dozen such presentations. In subsequent years I visited numerous orchid societies, garden clubs and native plant societies. (NOTE: The best refreshment table can be found at the monthly meeting of the Fishing Creek Herb Guild in Bloomsburg, PA)

Yellow-fringed Orchid (*Platanthera ciliaris*) [top left] and White-fringed Orchid (*Platanthera blephariglottis)* [top right] are the parent species responsible for the extraordinary hybrid swarm Bi-colored Orchid (*Platanthera ×bicolor*) [bottom left and right] showing characteristics of both parents.

The Good, the Bad and the Ugly

Clearly, the land acquisition by NBLT and the extraordinary cooperation displayed by PP&L (see Part I) may be counted among the good things at Valmont. But, not everything about the bog is exactly a bed of roses for the orchids. On more than one occasion some folks thought it might be a good idea to drive through the bog on the aforementioned all-terrain vehicles. The ATV's, and the tow trucks needed to extract them, were distressingly destructive. In 2015, a routine PP&L maintenance project included the use of aminocyclopyrachlor. This extremely powerful herbicide was inadvertently sprayed on sensitive habitat and hundreds (perhaps thousands) of orchids were destroyed forever. One of the few remaining Yellow-fringed Orchids (*Platanthera ciliaris*) was among the casualties.

Dr. Smith's blue flag marks the location of one of the last Yellow-fringed Orchids which was destroyed by herbicide in 2015.

Two years later, concerned about deterioration of the dirt access road used to monitor and manage their ROW, the utility company installed rip rap in the wet ditches that parallel the road. And with that, the last known Loesel's Twayblade (*Liparis loeselii*) was buried. That species hasn't been seen at Valmont since. In addition, the material that is used for roadbeds and other construction projects in this part of the country is typically limestone. That's what was used at Valmont and it has the potential to increase the pH of the surrounding soil which doesn't bode well for several acid-loving plants nearby. In addition to *L. loeselii*, those include *Spiranthes cernua, Drosera rotundifolia*, *Calopogon tuberosa*, three Platanthera taxa and sphagnum ssp. Those unfortunate incidents were wake-up calls for NBLT and the NOC.





Limestone rip-rap [left] installed to stabilize the access road covered the last known Loesel's Twayblade [right] in 2017. Especially robust (10-15 flowers per inflorescence) Grass Pink Orchids (*Calopogon tuberosus*) populate Valmont [left]. Fragrant Nodding Ladies-tresses (*Spiranthes cernua*) graces Valmont in September [center]. Club-spur Orchid (*Platanthera clavellata*) occurs in a wet woodland on NBLT property [right].

Even though PP&L owns the property and can wreak havoc at will, its corporate philosophy includes a certain respect for the environment. The company devotes considerable personnel and resources to environmental issues. Although some of that effort is likely driven by regulatory oversight and public relations concerns, it is effective nonetheless. We advised PP&L of the aforementioned "disasters" and they listened. From that point forward the three entities have communicated effectively and, as described in Part I, worked together to protect the unique orchid habitat on their property.

However, the Valmont Bog is doing exactly what bogs do. It's trying desperately to become a forest. Absent some significant intervention, whether natural or man-made (intentional or otherwise), bogs tend to fill in from the bottom up. Eventually they become a meadow and ultimately a forest. This process, known as natural succession, may take decades or even centuries depending on the size of the bog and other environmental circumstances. Regardless of its original size, age and other features (all things we have yet to determine) Valmont Bog is well on its way to drying out and losing its remarkable orchid flora.

The overarching questions now are these: can we stop (or at least delay) the natural succession process? If so, should we… and in this case, "may" we? Those questions, recent developments and future possibilities at Valmont, will be addressed in Part III.

A healthy section of the bog prior to infiltration by woody plants.

[Back cover] A Valmont hallmark species White-fringed Orchid (*Platanthera blephariglottis*) puts on a dazzling display in July.

HYPOTHESES BORNE OF THE OLYMPIC PARK CONFERENCE: TREE INCUBATORS AND CONSERVATION STRATEGIES

By Laura Juszczak, PhD, laurajust54@gmail.com

During one of the seminar days at the 2022 Olympic National Park, Port Angeles Native Orchid Conference in Washington State, neophytes like myself were urged to write about their first encounter of a native orchid in its natural habitat. I impulsively raised my hand, remembering an instant later that I had witnessed a *Cypripedium* in flower in the Delaware Water Gap decades earlier.

Nevertheless, the fresher image that has endured from the Olympic meeting is of a floral tapestry along the steep embankment of Old Deer Park Road. A plethora of other species was interwoven with *Goodyera oblongifolia* and *Calypso bulbosa.* The effect was subtle; as if the display had been orchestrated. Yet this was only the visible surface layer! The seminars elaborated on the interplay of flora, fungi and subsoil fauna. These would seem to partake in dynamic interactions where the role of each player is promoted yet controlled. No single element dominates.

My second, previous "wild encounter" was more recently with *Epipactis helleborine* (Figure 1) at Paul Smith's College in the Adirondacks in August 2019. This sighting shouldn't really "count" as *E. helleborine* is nonnative and invasive. My trip to Paul Smith's was actually for the North American Mycological Association's annual foray, but my off-topic goal was to locate *E. helleborine* as it had been reported there. The College features extensive trails emanating from its Visitors Interpretive Center. Apropos for an invasive, I did not find the orchid along any of the trails but in a wood chip-lined tree pit outside a campus building, a mass of stems, complete with multiple seed pods.

Figure 1.
Epipactis helleborine (Photo courtesy of Dave Taft)

E. helleborine is native to Eurasia, found in a broad swath from Scandinavia to Siberia and into the Himalayas (Kolanowska 2013). Its first documented North American sighting was in 1879 near Syracuse, NY; it is now considered an invasive in Pennsylvania and Wisconsin and is widespread to the Pacific Coast (Tenney and Hill 2022). Rumor has it that *E. helleborine* was introduced by colonists as a cure for gout. I would guess that it first entered North America through the New York City area, introduced by Dutch or English colonists, who planted it in backyard gardens as a medicinal herb. It can now be found all over the New York metropolitan area---in tree pits and poking through asphalt---as documented on the web app, iNaturalist (iNaturalist 2021), and in *The New York Times* (Taft 2013). Its 1879 official sighting near Syracuse may be a function of *E. helleborine's* wind borne spread out of the City, and the fact that looking for native wildflowers is generally an ex-urban activity. At the end of the nineteenth century, the New York City populace had its collective eye entrained on imported exotic tropical orchids, flaunted by uber-rich collectors, and displayed at the Eden Musée's Winter Garden (Hannickel 2022). In brief, urban eyes weren't focused on the ground looking for native terrestrials.

That image of *E. helleborine*, a nonnative flourishing in garden wood chips, was an "Ah ha" moment for me, bringing to mind a similar finding regarding the spread of nonnative fungi in wood chips. Stamets reports that active (psychedelic) mushrooms in the genus "*Psilocybe* are rarely found in the woods in the Pacific Northwest" but are found in abundance in masses of wood chips about public buildings (Stamets 1996). Is it a coincidence that the dust-like size of both fungal spores and orchid seeds, carried by the wind, are readily entrapped in the labyrinthine crevices of tree bark? If so, wood bark entrapment of minuscule orchid seeds and the equally tiny spores of its fungal symbiont offers a solution to a paradox: many orchids have evolved an extremely elaborate pollination scheme involving one specific pollinator yet seed dissemination seems profligate—millions of seeds thrown to the wind with the expectation that somehow some fraction will encounter the necessary fungal partner to initiate germination. This tree bark entrapment scenario would seem to have some merit, especially for epiphytes that are often found in association with specific trees and require a specific fungus for germination. Could it be that tree trunks with their creviced bark act like some giant, high efficiency particulate air (HEPA) filter for minuscule mycorrhizal fungal spores and the equally tiny seeds of their orchid symbiont? Is there any evidence that tree bark acts as an atmospheric particulate filter?

I posed this question to Google, the all-knowing search engine. Voila! Indeed, in a study of the particulate filtering function of five tree species in Beijing, China, the bark of the trees was found to accumulate 90% of larger particulate matter, over leaf accumulation for a density of 1719.9 $\mu g/cm^3$ for insoluble particulate matter (Xu et al. 2019). Yet is there any evidence that these accumulated larger insoluble particulates include fungal spores, which fall in this size range?

Trees---both their bark and upper canopy---capture organic nutrients and inorganic particulate matter as well as microscopic organisms and fungal asexual spores (conidia), microbes, and seeds in large quantities (Magyar et al. 2021), possibly even orchid seed. The washing of this captured material by rainfall from the tree canopy to the ground is known as *throughfall* while the flow of particulate matter along the bark is called *stemflow* (Figure 2). Throughfall can generate a particulate flow on the order of 150 kg /ha-yr (Lequy et al. 2014). Conidia are so efficient at adhering to bark that an annual flux of 10^9 per hectare per year can stick to a single tree (Magyar et al. 2021). Over 50 species of fungal spores have been identified in throughfall and stemflow (Ponette-Gonzalez et al. 2020). Magyar et al. also note that the transport of pollen and seed by throughfall and stemflow has not been studied but that this method of distribution has significance for epiphytic plants with easily transported seed, like orchids (Ponette-Gonzalez et al. 2020).

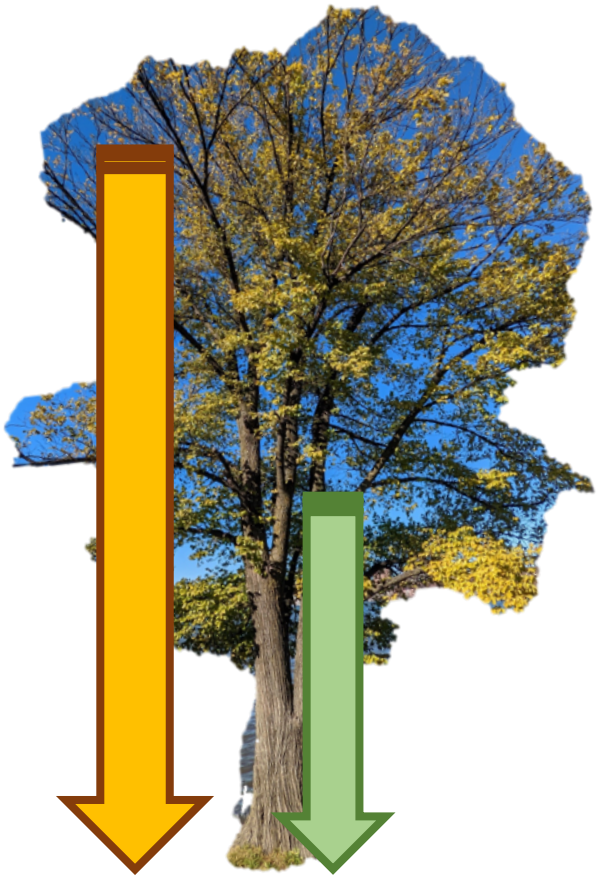

Figure 2. Direction of flow of particulates suspended in rain water through a tree: left, orange arrow represents *throughfall* while the right, green arrow represents *stemflow* (image adapted from Magyar et al. 2021; photo by the author)

The demonstrated abundance of fungal spores in arboreal water flow suggests that water movement through trees creates the essential germinative opportunity for orchids seed and their fungal partner, be it on the ground for terrestrials or on trees for epiphytes. Indirect evidence for the possible significance of canopy throughfall to terrestrial orchid germination lies in the fact that populations of terrestrials can be found under tree drip lines. For example, *Platanthera pallida* is found under *Pinus rigida* and associated trees (Chapman 1997). In the case of epiphytic orchids, successful seed germination on nonsterile bark has been demonstrated by Thomas Ederer, propagator at Orchideenvermehrung Ederer, Austria, and Carlos Cruz, grower at Sunset Valley Orchids, California (Schiff 2018). In recent field germination experiments in Susua State Forest, Puerto Rico, *Psychilis kraenzliinii* protocorms formed in seed packets attached to *Coccoloba microstachya* tree trunks (Gonzalez-Orellana et al. 2022). Thus, nascent evidence suggests that trees have a dual supporting role in orchid physiology: as incubators for orchid seed and their symbiont fungus and as phorophytes (supports) for the mature epiphyte. Water stemflow and throughfall has a potential role in spore, seed and/or protocorm distribution extending even to terrestrial orchids.

Like the orchestrated balance of established native orchids seen at the Olympic Park Native Orchid Conference, the scenario described above of the interplay of rainfall, trees, orchid seed and fungal spores is one of an orchestrated, dynamic process. Yet what happens to the life-in-balance of a natural living system when a nonnative species is introduced? Taken out of their native habitat, where their promiscuity may be limited, checks and balances are few or missing. Foreign species have free-reign to invade, especially if they are self-pollinating, or nonspecific with regard to pollinator or fungal symbiont. Like *E. helleborine* (Tenney and Hill 2022), the South African orchid terrestrial, *Disa bracteata* (Figure 3), more commonly known as the South African weed orchid, has invaded Australia (Weedsofmelbourne.org 2021, Nillimbik Shire Council 2019). Discovered in 1944 near Albany in southwestern Australia, this self-pollinating *Disa* has spread profusely across the continent. It is believed to have been accidentally introduced via the sacking covering goods unloaded at Albany, Southwestern Australia (Hoffman et al. 2019). *D. bracteata* seed remains viable for seven years (Muyt 2001), and proliferates---*like E. helleborine* (Tenney and Hill 2022)---if its tubers are disturbed and not completely removed (Weedsofmelbourne.org 2021). One Australian shire council reports that "If this plant is allowed to invade unchecked the consequences could be devastating to sensitive environments containing native orchids and other wildflowers (Nillimbik Shire Council 2019)."

Figure 3. *Disa bracteata* inflorescence (Andrew Massyn - Own work, CC BY-SA 3.0, https://commons.wiki media.org/w/index. php?curid=5065469)

The examples of *E. helleborine and D. bracteata* certainly leave the impression that introduction of nonnative orchid species can only end in an environmental disaster. Some evidence exists, however, that in the absence of a required specific pollinator, an introduced orchid species will not necessarily become invasive. *Vanilla planifolia* vines were first introduced into Madagascar in the mid-nineteenth century yet are contained because the requisite pollinator, a euglossine bee, is not resident, and a surrogate does not exist. *Vanilla* still requires hand-pollination after nearly two centuries.

To ensure the long-term survival of a native orchid species whose habitat has been decimated, a possible strategy that follows from the above observation is to propagate orchid seedlings or mericlones that have a specific pollinator requirement (like *Vanilla* vines) in a suitable nonnative ecological niche, where the lack of pollinator safeguards against invasiveness; *i.e*., a species cannot become invasive if it cannot reproduce. This strategy for orchid species conservation may become necessary as climate change irrevocably alters the environment and perhaps decimates the pollinator specific to an orchid species.

Calypso bulbosa var. *occidentalis* (left), *Monotropa hypopity*s and *Goodyera oblongifolia (*right) found along Deer Park Road, Olympic National Park. Photos by Chelsea Kieffer

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