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Baseline Study of the Hooded Pitcher Plant (Sarracenia minor): Its Utility as an Indicator Species of Freshwater Wetland Habitats

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Baseline Study of the Hooded Pitcher Plant (*Sarracenia minor*): its utility as an indicator species of freshwater wetland habitats

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Abstract

The hooded pitcher plant, *Sarracenia minor*, is an important member of bog and seepage savanna communities of the southeastern United States. Unfortunately these wetland communities have been damaged and are disappearing at an alarming rate. The goal of this study was to collect baseline data, which will be ultimately used to develop a model of the survivorship, growth rate, morphology and population dynamics of four populations of *Sarracenia minor*. The model will assess the effects of several environmental factors on changes in the morphology and population dynamics of *S. minor* on the UNF campus. Measurements on the survival, growth and morphology of *S. minor* from four populations were collected monthly. In addition, population-level changes in survival and recruitment were also monitored monthly using permanent field plots.

Introduction

Wetlands are crucial ecosystems that serve several important functions for surrounding habitats. Wetlands provide nurseries for many fish species, aid in flood control, purify water that percolates through their soils, serve as a habitat for a unique flora and fauna (including several endangered species) and they generally enhance the landscape. However, bogs and seepage savannas are very fragile ecosystems that are highly susceptible to human disturbances. Because most wetlands serve as collection sites for larger drainage basins, human activities well beyond the borders of the wetland can cause irreversible damage. In addition to outright destruction, humans have impacted wetlands by altering their hydrology, introducing pollutants from point and non-point sources, and facilitating the establishment of exotic species, which may out compete native plants and animals.

Unfortunately, wetlands (which occupy approximately 1% of the Earth's surface) have been destroyed or degraded to an alarming degree. Between 1780-1980 approximately 53% of all U.S. wetlands were lost. In 1984, in an effort to limit their further exploitation and destruction, Florida officially recognized the importance of wetlands with the passage of the Warren S. Henderson Wetlands Protection Act, which regulates construction and dredge or fill activities conducted in the waters of Florida.

An important step in protecting remaining wetlands is regular long-term monitoring. Traditional wetland monitoring programs, which utilize physical and chemical sampling, can be time consuming and expensive to implement. However, one inexpensive monitoring technique involves the use of indicator species to assess ecosystem health. Indicator species are typically plant or animal species that are sensitive to changes in environmental conditions and, as a result, can be very effective in monitoring the long-term stability of an ecological community (Primack 1998). Indicators can be used independently or in conjunction with other assessment methods. Before a species can be used as an indicator, conservationists must first describe its life history and ecological requirements.

The goal of this study was to collect baseline data on the natural history of the hooded pitcher plant, *Sarracenia minor*, and determine if this species is suitable as an indicator species for freshwater wetlands in the southeastern United States. Plants often make very good indicator species because they are sessile, which greatly facilitates long-term monitoring because their exact location is known to the researcher.

Methods

Sarracenia minor

Although bog soil is typically low in available nitrogen (which is often the limiting element for growth in plants), the hooded pitcher plant, *S. minor*, is carnivorous and, as a result, it can supplement its nitrogen intake by capturing and digesting invertebrate prey (Gotsch and Ellison 1998). Although several orders of insects are captured by pitcher plants, including Orthoptera (crickets and grasshoppers), Diptera (flies), Coleoptera (beetles); Hymenoptera (in particular ants) were numerically the most abundant prey item (Jaffe et al. 1992). Once captured by the pitcher, enzymes secreted by the plant as well as those produced by bacteria found in the pitcher digest the prey. Because the enzymes breakdown the soft, inner tissues of invertebrates, but do not digest the resistant, chitinous exoskeleton, a detailed assessment of prey items can be made by dissection of the pitcher. Nutrients obtained from the digested prey are absorbed from the pitcher and translocated to the rest of the plant (Jaffe et al. 1992).

Sarracenia minor has a highly variable growth rate and morphology, both of which are affected by environmental conditions. The pitcher of *S. minor* is a modified leaf, and pitchers of a healthy plant are erect. The pitcher is shaped into a funnel with the anterior end covered by a hood. The lip of the funnel is thicker than the rest of the pitcher and is referred to as the nectar roll because it secretes a sweet substance, which attracts insects (its main prey). The external ventral side of the pitcher is called the wing or ala and it runs from the tip of the nectar roll to the base of the pitcher. Opposite the nectar roll on the dorsal side of the hood are special non-pigmented spots called areolae. Light enters the pitcher through the areolae, apparently causing prey caught inside to become confused. Insects and other prey, which attempt to exit the pitcher through the areolae, continue to bump into the back of the hood until they tire and fall into the funnel of the pitcher. Once inside the funnel, small invertebrate prey are unlikely to escape because the inner walls are covered with downward pointing "hairs" that cause the insects to slip down into funnel which contains a small volume of water. Eventually the prey will become exhausted and drown in the water held in the base of the funnel where they are digested.

Pitcher plants also produce non-pitcher (exclusively photosynthetic) leaves called phyllodia, which are generally shorter than the pitchers. The growth morphology of *Sarracenia minor* is highly variable; some plants only have pitchers, while some only have phyllodia; others possess both pitchers and phyllodia. Leaves sprout from underground rhizomes and the total number of leaves per plant ranges from one to several hundred. Rhizomes produce small rosettes (clumps of leaves) that are often located a few centimeters from each other and the "parent" plant (Schwaegerle 1983). Although most reproduction appears to be through the spread of vegetative rhizomes, seeds can also add new recruits to a population.

Study Site

Demographic and morphological data were collected from randomly sampled plants from four populations of *S. minor* in the UNF nature preserve. Three of these populations designated as North, East, and Soccer Field are relatively close in proximity at the northern end of campus. The East and North sites are under a partial tree canopy and have light groundcover; however, the Soccer Field site has few trees and the ground receives much more incident light and it is mostly covered with grasses. The fourth population (designated as South) is located near the southern edge of the campus and is situated in a much drier habitat. A road built for the Golf Management and Learning Center (GMLC) is less than 10 m away from the South population in some places. Large pines and loblolly bay trees, which have encroached on this site, have covered the ground with a deep layer of leaf litter (up to 30 cm deep in some locations). All four sites are seasonally flooded a few months each year.

Morphological Data Collection

Morphological data was collected each month beginning in March of 1999. The sample size for each population used in the morphological study was 35, 34, 35, and 34 for the North, East, Soccer Field, and South sites, respectively. For each individual, measurements of several morphological characters were collected including: number of pitchers, height of the tallest pitcher (cm), number of flowers per plant, and percent damage, which was determined by estimating the percentage damaged (to the nearest 5%) of the tallest pitcher.

Pitcher Dissection

Ten pitcher plants were randomly collected from the Soccer Field site, returned to the lab and dissected to determine prey composition and abundance. Each pitcher was opened and its contents were emptied into a petri dish. Using a dissecting microscope (10X magnification), the prey were counted, separated according to order, and placed into vials containing 70% ethanol.

Most of the prey had been partially degraded and only parts of arthropods (primarily insects) remained. The abundance of insects such as wasps, bees, and ants (Hymenoptera) was determined by counting the number of easily distinguishable highly sclerotized heads, which are resistant to enzymatic digestion. Moreover, the elytra, which are highly sclerotized protective forewings of beetles (Coleoptera), were also very resistant to decomposition. The number of elytra in each pitcher was counted and, since each beetle has two, the number of elytra was halved to estimate the number of beetles. Dipterans were also commonly found in pitchers, but they were mostly whole when found and could be directly counted. Other prey items were noted and identified when possible.

Soil Moisture

Soil moisture data has been collected each month beginning in May of 1999. The soil samples from the North and Soccer Field sites were collected using transects and soil samples were collected at 10-m intervals. However, at the South site, individuals were so dispersed that transects were not feasible. In the areas where transects could not be used, permanent sampling stations were established within 1 m of individual plants. The number of soil sampling stations in each pitcher plant population ranged from 6 (East) to 13 (South). Soil samples were obtain using a metal corer, which was pushed approximately 14 cm (average root depth) into the substrate, and the lower 5 cm of soil was placed into a metal container, returned to the lab for weighing. Soil samples were dried in an oven at 60°C for 72 hours and re-weighed. The water percentage of each sample was then determined from the difference in weights.

Population Dynamics

Since September 2000 , population mortality and recruitment rates have been estimated monthly with permanent sampling plots. These plots (2-m^2) were constructed using 5.1 cm (diameter) polyvinylchloride (pvc) pipes. Each plot 2 x 2 m plot frame was supported approximately 1 m above the substrate by pvc legs in each corner and an additional support between each corner, resulting in a total of eight supports per plot frame. A 4 cm wood screw (four per side) was inserted along each side of the frame at 0.20, 0.40, 0.6, and 0.80 m. The heads of each screw were left approximately 2 cm above the surface of the frame and served as attachment points for a grid of 0.25-cm (diameter) twine. The frame was strung by connecting a taut length of twine from each screw along the frame to its partner screw on the opposite side of the frame, dividing each sampling plot into 25 sections (each accounting for 40 cm^2 or 4% of the total area of a plot). These small sections could be easily surveyed for pitcher plants. Each individual inside the plots was flagged and given a unique number. Every month the survivorship of marked individuals was recorded and new recruits were flagged, numbered, and recorded. All individuals were located on a hand-drawn grid that represented the sampling plot. This allowed for the exact placement of each plant, which may prove useful in determining flower rate spatial trends within the populations of *S. minor*. Percent change (+ or -) for each population was calculated monthly to investigate long-term trends in persistence of *S. minor* on the UNF campus.

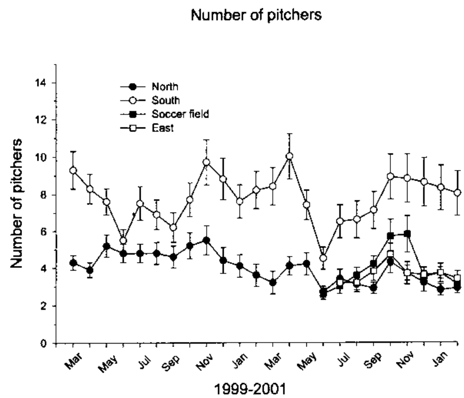
The permanent sampling plots were placed so that at least three plants were inside each plot. Five of these sampling plots were placed in the North, East, and Soccer Field Sites; however, owing to the small population size and the highly dispersed arrangement of individuals in the South population only three plots were used. Data were only collected from the East and Soccer Field populations since November 2000 (when the populations were first discovered).

Results

Morphology of *S. minor*

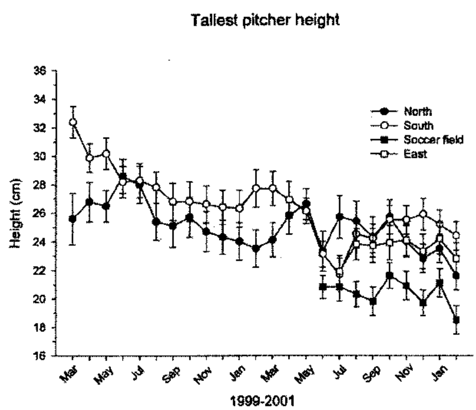
The mean number of pitchers per plant (pitcher density) varied by approximately 100% over the course of the study for all four populations, although plants in the South population always had the highest pitcher density per plant. Pitcher density ranged from 3 – 6 per plant for the North, East and Soccer Field sites, but varied from 5 – 10 per plant in the South population

Fig. 1. Mean (± sem) number of *S. minor* pitchers from four populations on the UNF campus.



For all four populations, pitcher density tends to be highest from March – May and September – November. Plants from the North and East sites (which are geographically closest) are similar in size, while pitchers from the Soccer Field site are consistently the shortest. In addition, the South population also had the tallest pitchers, but mean pitcher height in the South population has been steadily decreasing over the last two years (Fig. 2).

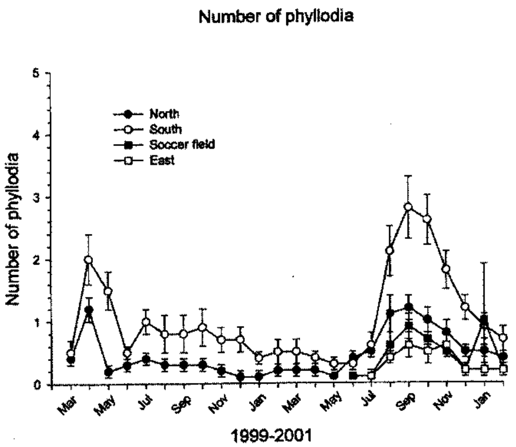
Fig. 2. Mean (± sem) height (cm) of the tallest S. minor pitcher from four populations on the UNF campus.



While plants from all four populations exhibit seasonal differences in pitcher height, the long-term decline in the height of plants in the South population is statistically significant ($r = -.789$; $P < .001$; N = 23).

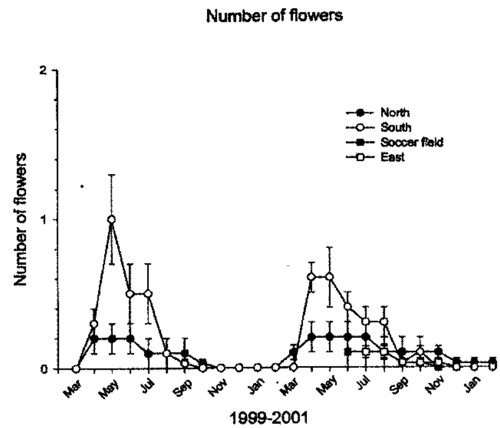
Although plants in the South population also had the highest number of phyllodia per plant on nearly every sampling date, all four populations exhibited similar seasonal peaks in the number of phyllodia during the spring and fall (Fig. 3).

Fig. 3. Mean (± sem) number of *S. minor* phyllodia from four populations on the UNF campus.



In addition, plants in the South population generally had the highest number of flowers per plant, but rates flowering were very low at all four sites — typically much lower than one flower per plant on average (Fig. 4).

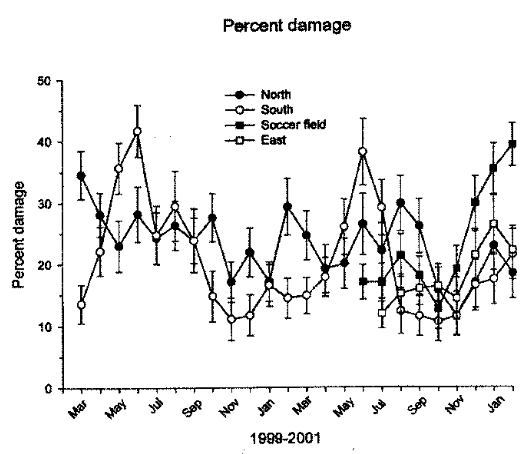
Fig. 4. Mean (± sem) number of flowers per individual *S. minor* from four populations on the UNF campus.



However, our data did reveal a distinct flowering season for *S. minor*, which is between the months of April and August. Plants in the North population usually have the most herbivore damage (primarily caused by insects), but the South population exhibited a steep increase in damage from May – July (Fig. 5).

Data from the most recent census indicated a rapid increase in damage to plants at the Soccer Field Site, although all four populations showed a great deal of variation in percent damage.

Fig. 5. Mean (± sem) percent herbivore damage to *S. minor* from four populations on the UNF campus.



Soil Moisture

Although the temporal trends in soil moisture at all four sites followed similar patterns, which were correlated with the seasonal wet and dry periods in north Florida, soil in the South site always had the lowest water content. The East site, which often maintains standing water even during the dry season, had a soil water content that was 3-5X greater than soil samples from the South site. The North site, which straddles a drainage slough, and the Soccer Field site, which occupies a bog habitat, had a mean soil water content of that ranged from 30-55% (Fig. 6).

Population Dynamics

Although data on population growth rates has only been collected for five months, changes in population size were highly variable. The North population remained virtually unchanged over this period, while the East and Soccer Field populations increased by almost 20% from September – October; however, this gain was lost by November (Fig. 7).

Fig. 6. Mean (± sem) percent water content of soil samples from four *S. minor* populations on the UNF campus.

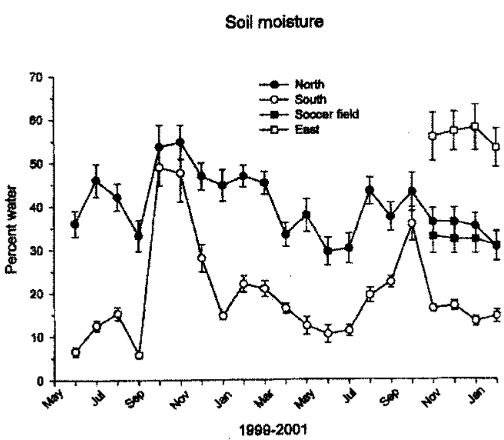


Fig. 7. Mean (± sem) percent change of four populations of *S. minor* on the UNF campus.

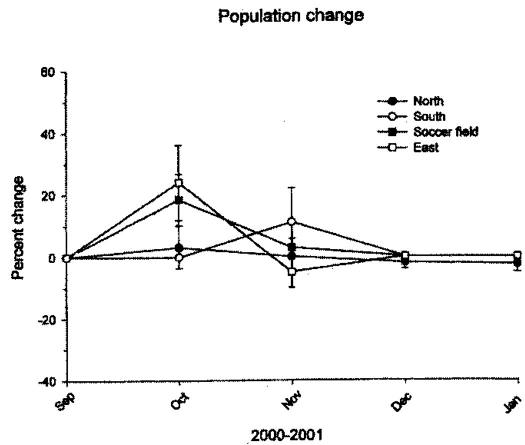
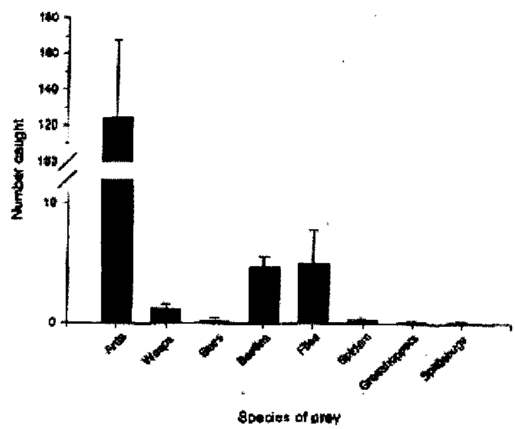


Fig. 8. Mean (± sem) number of prey captured by pitchers of *S. minor*.



Pitcher Contents

By far the most numerically abundant prey captured in the pitchers of *S. minor* were ants; plants had a mean of approximately 125 ants per pitcher (Fig. 8). The next most abundant prey were flies and beetles, both of which averaged five per pitcher. Other arthropods, including spiders, were much less commonly found in pitchers of *S. minor*.

Discussion

Morphological measurements of *S. minor* consistently revealed that plants in the South population are structurally different from plants in the other three populations. Plants from the South population typically had twice as many pitchers, which were generally taller than those from the other populations, although this population has exhibited a significant decline in height over the course of the study. Plants from the South site also tended to have more phyllodia and flowers than plants from the other sites. These differences could be due to the South population's location on campus, which is much closer to areas of campus development.

Differences in abiotic factors such as soil moisture, leaf litter and amount of shading appear to have a direct effect on the growth morphology of *S. minor*. Plants in the South population have twice as many pitchers as plants from the other populations, and, although we don't have data on soil nutrient levels, our results suggest that the soil in the South site is significantly lower in available nitrogen. If so, it is not surprising that plants at this site should produce more pitchers per plant because more pitchers should increase prey captures and supplement deficiencies in soil nitrogen. Moreover, plants in the South population have taller pitchers than those from the other populations, which may be an adaptation to the deeper layers of leaf litter at this site. Pitchers may grow taller at the South site to keep the opening of the pitcher above the surface of the leaf litter. However, while plants in the South population were almost 30% taller than plants in the North population (the only other site for which we have comparable data) at the beginning of the study (March 1999), they were less than 10% taller by January 2001.

This decrease in mean height of plants in the South population was significant over this twenty-two month period and suggests that the South site was initially of better quality than the North site, but soil fertility and/or soil moisture have also declined over this same period. Although it is unlikely that the soil fertility (such as soil nitrogen) was greatly reduced at the South site over this short period of time, it does seem likely that reduced water availability, owing to increased development and construction of retention ponds around this site, has caused this population to decline.

Specifically, the South population is isolated on three sides by paved roads and/or retention ponds, which often cause damage to nearby wetlands by altering the natural hydrology of the surrounding landscape. As a result, the South site may be experiencing more rapid dry downs because run-off from the surrounding wetlands is either diverted to manmade retention ponds, or may leach through the soil into nearby retention ponds. In addition, the South site has a largely closed tree canopy and, as a result, it has a much deeper layer of leaf litter (up to 30 cm deep in some areas) and it receives much less incident sunlight than the other three sites.

The higher number of phyllodia (or photosynthetic leaves) of plants from the South population is probably an adaptation to lower incident sunlight reaching the ground at this site. As a result, plants in the South population must produce a higher number of phyllodia (photosynthetic leaves) to generate adequate levels of carbohydrates via photosynthesis in order to sustain growth and reproduction. Rates of flowering were very low for *S. minor*, but all four populations exhibited similar temporal trends. This surprisingly low production of flowers by *S. minor* suggests that populations of this plant, at least on the UNF campus, may have very few sexual recruits. In other words, we suspect that most new recruits to these populations of *S. minor* are vegetative offspring produced by budding of underground rhizomes or the separation of plant culms. Recent attempts to grow *S. minor* from seeds under greenhouse conditions have been unsuccessful (this was also true for seeds that had vernalized for three weeks in a dark freezer). We are not sure whether these seeds of *S. minor* are non-viable or if they simply require very specific environmental conditions to stimulate germination. Initial results suggest that *S. minor* may serve as a useful indicator species for freshwater wetland ecosystems. Morphology of the hooded pitcher plant was very consistent and populations exhibited distinguishable differences in growth form influenced by differences in microhabitat between the four populations. Moreover, because this plant is listed by the state of Florida as "threatened," use of the hooded pitcher plant, which is a unique member of our natural heritage as an indicator species, would certainly increase its long-term chances of survival in the wild.

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