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EFFECTS OF ABIOTIC FACTORS ON THE ABUNDANCE OF EASTERN SKUNK CABBAGE (*SYMPLOCARPUS FOETIDUS*) IN TWO CENTRAL PENNSYLVANIA SPRINGS

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ABSTRACT

This study investigated the abundance of the skunk cabbage (*Symplocarpus foetidus*) at Warm Spring and Cold Spring. We tested whether abiotic factors such as spring water pH, spring water temperature, soil pH, soil moisture, and soil temperature affected the abundance of skunk cabbage. We examined ten plots at each site, five on each side of each spring brook and conducted total counts within each plot. We found that skunk cabbage abundance was significantly positively correlated with soil moisture along both Warm Spring ($r_2 = 0.5971$, $P < 0.009$) and Cold Spring ($r_2 = 0.5993$, $P < 0.009$). Soil moisture appeared to have a stronger effect on skunk cabbage abundance than did the other abiotic factors examined.

Key words: abiotic factors, pH, soil moisture, springs, Symplocarpus foetidus

INTRODUCTION

Winters in central Pennsylvania are taxing on the flora and fauna of the region and few species have been able to adapt to rise from the ground before the traditional spring bloom. During the harsh winter months, plants encounter the problems of water loss through transpiration and difficulty photosynthesizing due to weak, limited sunlight. Many plants overcome these difficulties by becoming dormant during these winter months, essentially hibernating, until spring. Low growing plants are more likely to have the ability to survive in warm depressions created under the snow. The plants then wait for the snow to melt so that they can begin their growth period (Fish and Wildlife).

Another, rarer adaptation of plants is thermogenesis. Thermogenesis is where a plant has the ability to produce its own heat internally. Even more uncommon, is the physiological regulation of flower temperature, where heat production increases at lower environmental temperatures. This type of regulation is known in only two species (Seymour 1998). One of the unique native species that is able to perform this type of regulation is *Symplocarpus foetidus*, known as skunk cabbage, and is the topic of our study.

Skunk cabbage, from the family Arum (Araceae), is typically found in wet woods, marshes, and streamsides (Connecticut 2005). The spathe, which protects the floral spike, begins to poke through the snow and ice covering the ground in late winter. This is due to the endothermic nature of the skunk cabbage, which releases heat from the flower head (Holdrege 2000). At two local springs, Warm and Cold, we observed the skunk cabbage poking through the snow in late February.

In observing the blooming of this plant, we noticed that the areas where skunk cabbage is most prevalent appeared to be in relatively water-saturated areas near the springs. This led us to investigate the correlation of abiotic factors with skunk cabbage abundance. The abiotic factors studied were soil moisture, temperature and pH, in addition to the spring water temperature and pH. We hypothesized that the greatest abundance of skunk cabbage should be found where the environmental conditions indicate high soil moisture and the pH is 4 and 7.

FIELD SITE

For this study, we concentrated on two springs located in Huntingdon, Pennsylvania. Both Warm Spring and Cold Spring are located just off of Cold Springs Road. Warm spring is aptly named because the average temperature is slightly higher than that of a typical spring in central Pennsylvania. The average water temperature is 18.5° C and the average water pH is 6.80. This spring is both wider and deeper at the source than at Cold Spring. At the source of Cold spring, you can see that it has been altered by man, lining the banks with rocks most likely to prevent erosion if the water level was to rise. The average water temperature at Cold Spring is 12.4° C with an average pH of 5.06. Both springs have wet and dry sections along their banks, with most of the drier sections occurring where the ground level is well above the height of the surface waters of the spring. Vegetation at both springs is similar, with a mix of trees, mosses, and thorny plants.

METHODS AND MATERIALS

At both Warm Spring and Cold Spring, we divided the springside area using a 5-m by 5-m grid system. After the five 25-m^2 plots were marked out along each side of each spring brook, we marked every other plot as our sample sites, alternating on the other side. Out farthest plot reached back 60 m from the source with a five plots along each bank and a total of ten plots at each spring. See Fig. 1 for clarification of sample site setups.

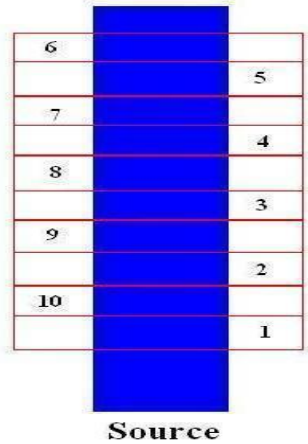

Figure 1. Layout of sampling plots for both springs.

To gather environmental data, we used a probe thermometer for soil temperature, a mercury thermometer for water temperature, and a Markson Model 88 pH meter for water and soil pH. Soil pH was estimated from equal samples of soil from each plot that had been mixed with 100mL of de-ionized water. Soil-moisture data were gathered by taking samples from each plot and packing them evenly into equal sized containers and weighing them. After drying in the oven for a week, the samples were weighed again and after subtracting the mass of the container, the soil moisture could be calculated.

Population counts were gathered by using a total count technique where every plant in the plot was counted. We defined one plant by looking at the main stem. Everything that branched off of the one main stem was considered one plant.

RESULTS

Fig. 2 shows the abundance of the skunk cabbage at the two springs examined. Skunk cabbage was present in all of the ten plots at Warm Spring, though it was missing from plots 6 and 7 at Cold Spring. The total number of skunk cabbage at Warm Spring is on average much higher than that at Cold.

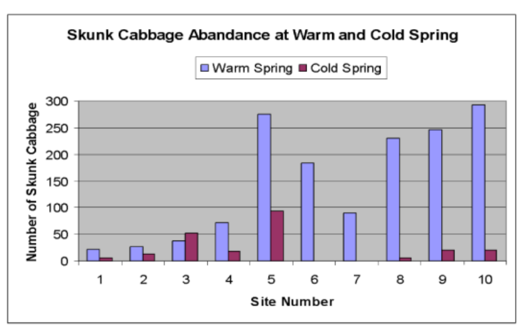

Figure 2. Graph of the abundance of skunk cabbage at the ten sampling sites from Warm and Cold Springs.

Fig. 3 shows the percentage of soil moisture from the ten plots at both springs. On average, the soil moisture is higher at Warm Spring than Cold Spring (55.66% versus 40.83%). The soil moisture peaks at 81.76% for Warm Spring and at 71.44% for Cold Spring and has a minimum of 27.84% at Warm Spring and 22.20% at Cold Spring.

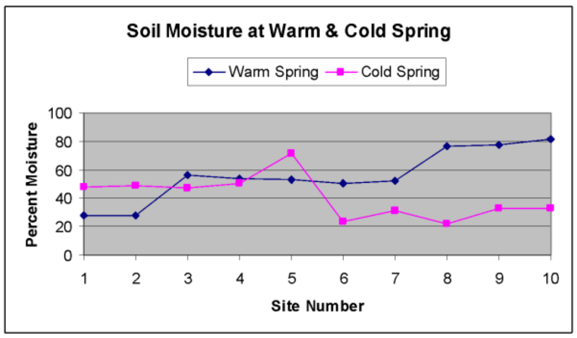

Figure 3. Graph of the soil moisture percentage at the ten sampling sites from Warm and Cold Springs.

Fig. 4 shows the soil pH from the ten plots at both springs. On average, the soil pH is slightly higher at Warm Spring than Cold Spring (4.66 versus 4.57). The soil pH peaks at 5.90 for Warm Spring and at 5.75 for Cold Spring and has a minimum of 3.98 at Warm Spring and 4.13 at Cold Spring.

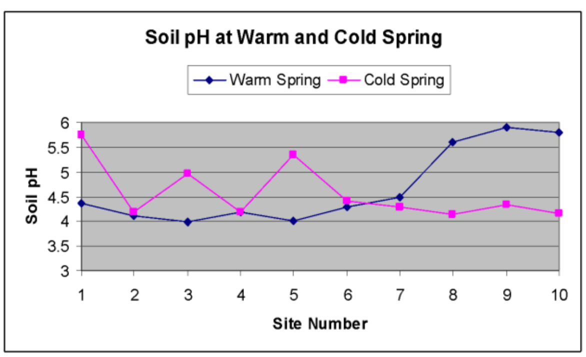

Figure 4. Graph of the soil pH at the ten sampling sites from Warm and Cold Springs.

Fig. 5 shows the correlation between the percentages of soil moisture and the number of skunk cabbage at each of the 10 sample sites for both springs. On average, Warm Spring has a higher percentage of soil moisture and a greater number of plants, but this does not necessarily correspond to a greater correlation. The r^2 value for cabbage number in relation to percentage soil moisture at Warm Spring is 0.5971 ($P = 0.009$). The r^2 value for Cold Spring is 0.5993 ($P = 0.009$).

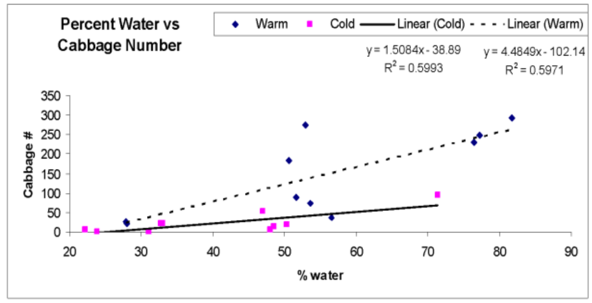

Figure 5. Graph of number of skunk cabbage plants versus soil moisture percentage at the ten sampling sites from Warm and Cold Springs.

Fig. 6 shows the correlation between the soil pH and the number of skunk cabbage at each of the 10 sample sites for both springs. On average, Warm Spring had a higher soil pH and a greater number of organisms. The r^2 value for Warm Spring is 0.4256 ($P = 0.041$). The r^2 value for Cold Spring is 0.2195 ($P = 0.172$).

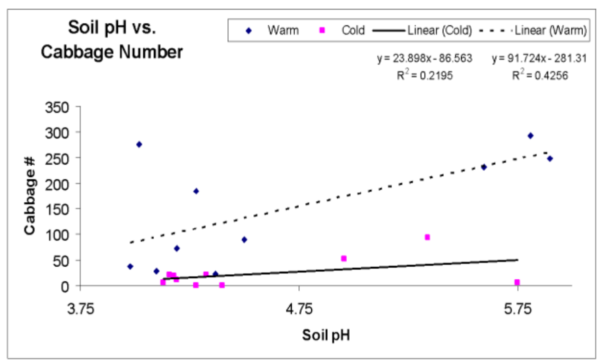

Figure 6. Graph of number of cabbage versus soil pH at the ten sampling sites from Warm and Cold Springs.

Table 1 shows the variation in the water temperature at the two springs, average 18.5° C (range 17 to 19° C) at Warm Spring and 12.4° C (range 12 to 14° C) at Cold Spring. The water pH of Warm Spring ranges from 6.59-7.02 with an average of 6.797, and the pH of Cold Spring ranged from 4.97-5.20 with an average of 5.055. Both the soil temperatures for Warm and Cold Springs ranged from 11 to 13° C with an average of about 12° C.

Table 1. Other environmental factors examined at both springs

Environmental Factors	Spring	Min	Max	Average
Water temperature	Warm	17 °C	19° C	18.5°C
	Cold	12°C	14° C	12.4 °C
Water pH	Warm	6.59	7.02	6.797
	Cold	4.97	5.20	5.055
Soil Temperature	Warm	11°C	13° C	12°C
	Cold	11°C	13° C	12.1°C

DISCUSSION

We found that the environmental factors of soil temperature, water temperature, and water pH of the springs had no significant effects on the abundance of skunk cabbage due to their relatively unchanging nature between both springs (Table 1). Soil moisture and pH were the most variable factors, and they both appeared to affect the abundance of skunk cabbage. Skunk cabbage density was statistically significantly positively correlated with soil moisture percentage at both Warm and Cold Springs. Skunk cabbage density was also correlated positively with soil pH, but the correlations were weaker and at Cold Spring it was nonsignificant.

To tease out the relative importance of soil moisture and pH, we performed a multivariate regression analysis on the abundance of skunk cabbage versus both soil moisture percentage and soil pH. The *P*-value of this test was 0.001, which is close to the *P*-value of the regression analysis for soil moisture percentage alone. Therefore, there is no better fit when soil pH is taken into account, thus the soil pH data has virtually no affect on the significance of the data. From these regression tests we can conclude that soil moisture is probably the environmental factor which most greatly affects the abundance of skunk cabbage.

The literature describes the range of pH tolerance for skunk cabbage as being between 4 and 7 (USFWS). The overwhelming majority of our pH values occurred within that projected range so even though there is variation in pH along the ten test sites at each spring, this variation can be tolerated by skunk cabbage and should therefore not have a large effect on their abundance.

The range of soil-moisture values tolerated by skunk cabbage is not well documented in the literature, but most sources state that saturated, marshy areas are the most suitable location for this species. Thus, soil moisture is a key factor in the abundance of skunk cabbage, just as we had suspected.

Our findings could be verified by performing further replicates of our test. We only obtained one set of data at each spring due to timeline and weather constraints. This accounts for possible sources of error within our findings.

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