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The distribution of Sarracenia purpurea (pitcher plant) in Southeastern Wisconsin fens: The influence of pH and nutrients

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THE DISTRIBUTION OF *SARRACENIA PURPUREA* (PITCHER PLANT) IN SOUTHEASTERN WISCONSIN FENS: THE INFLUENCE OF pH AND NUTRIENTS

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ABSTRACT

Temperature, pH, alkalinity, total-N, total-P, K, Na, Ca and Mg levels were measured in groundwater at the Pickerel Lake and Ottawa Lake calcareous fens and the Cedarburg Bog patterned fen. The two calcareous fens were similar in all chemical characteristics. Alkalinity, pH and Mg were significantly lower in the patterned fen when compared to the calcareous fens, while the other chemical parameters were similar.

Each of these southeastern Wisconsin fens supported Sarracenia purpurea (pitcher plant). When the characteristics of the groundwater of the areas that supported S. purpurea were compared with those of areas that did not support S. purpurea, it was evident that distribution of S. purpurea was not correlated with the measured groundwater characteristics.

Eleocharis rostellata (spike rush) was dominant in the calcareous fens, while Rhynchospora alba (beak rush) was the dominant plant of the patterned fen. S. purpurea often occurred in association with various mosses and, in the two calcareous fens, usually grew near spring seeps.

INTRODUCTION

Pitcher plants, members of the genus Sarracenia, form a distinctive group with several species in North America. The leaves of these plants are fused along much of their length, forming a long tube or pitcher that terminates at the open end in wings and an upright hood. Pitcher plants are commonly found in bogs and fens and several species occur in the Middle Atlantic states and along the Southern Coastal Plain (Folkerts, 1982). The pitcher plant of our bogs, Sarracenia purpurea, has the most extensive geographic range and is the only species found in the northern U.S. and Canada. The plant is an herbaceous perennial that develops from a short vertical stem and may live for 20 to 30 years (Taylor, 1980). Leaves measure 10 to 20 cm in length; they are usually curved and evergreen, although sometimes turning purple or dying during winter. A single plant may have one or many pitchers of various sizes. During the summer, the plant produces a solitary magenta flower on a tall stem, and the seed ripens in the late fall.

Pitcher plants are carnivorous plants; insects and other prey trapped in the liquid accumulated in the hollow leaves are digested, perhaps by enzymes secreted by the leaf or by bacterial action. In contrast to other species, S. purpurea

leaf enzymes are weak and it appears to depend largely on bacterial digestion of its prey (Mellichamp, 1978).

Sarracenia purpurea may grow in either alkaline or acidic wetlands, from calcareous fens to acid sphagnum bogs. It appears to have no consistent association with other vascular bog species, nor apparently with any particular substrate (Mandossian, 1965a,b). Sundews (Drosera rotundifolia and D. linearis) are often found in similar sites in Wisconsin (Stromberg-Wilkins, 1984). In southeastern Wisconsin, pitcher plants grow in only three of 28 calcareous fens (i.e., Pickerel Lake, Ottawa Lake and Vernon Marsh Fens). They are also found in the wet flarks or depressions in the patterned fen of the Cedarburg Bog.

The limited distribution of pitcher plant, combined with the lack of knowledge of the chemistry of Wisconsin calcareous fens, led to this study. The purpose was twofold: to document water chemistry of calcareous fens and to determine if distribution of Sarracenia purpurea was related to pH and nutrient availability.

The field investigation included vegetation sampling, measurement of pitcher plant morphological features, and analysis of water chemistry. One site was studied in each of three fens: Pickerel Lake Fen (Walworth Co.), Ottawa Lake Fen (Waukesha Co.) and Cedarburg Bog (Ozaukee Co.). In an associated study (Golembiewski, 1984), seed germination and seedling growth were investigated in relation to nutrient levels under controlled laboratory conditions.

Vegetation Relationships

Calcareous fens in southern Wisconsin are generally found on lower slopes or at the base of escarpments where a continuous flow of mineral rich water is available (Curtis, 1959). Reed defined calcareous fens as wetlands "characterized by a mixture of grasses, sedges, and low shrubs that colonize wet sites having an internal flow of groundwater rich in the bicarbonates, and occasionally sulphates, of calcium and magnesium". The calcareous fens of southern Wisconsin receive groundwater that originates in either the dolomitic bedrock or in dolomitic glacial deposites (Reed, 1985).

The calcareous fen community is dominated by spike rush (Eleocharis rostellata), shrubby cinquefoil (Potentilla fruticosa), and beak rush (Rhynchospora capillacea). In contrast, the patterned fen at Cedarburg Bog consists of low, wet areas, or flarks occupied by various sedges including cotton grass, (Eriophorum sp.), wiregrass (Carex lasiocarpa), beak rush and other bog species, interspersed between slightly raised "strings", that support woody vegetation such as white cedar, tamarack, and several shrubs (Reinartz, 1985, 1986).

Vegetation was sampled in transects consisting of 25 by 50 cm quadrats, spaced at 1.5 or 2 m intervals. Species of vascular plants were recorded with the canopy coverage for each species. Canopy coverage is defined as ground

surface (percentage of quadrat) included under the area of vertical projection of the plant foliage. The sampling objective was to determine relationships of pitcher plant colonies to other fen vegetation.

In the calcareous fens, the areas supporting pitcher plants were relatively small. There were two patches at Pickerel Lake, one 10 m by 20 m located on a thick vegetation mat dominated by spike rush overlaying a loose dark peat, and the second in a large open area associated with spring seeps and supported by a weak and treacherous sedge mat. At Ottawa Lake, the pitcher plants were also found in two patches; one was a zone on the northeast, about 9 m by 30 m, where spring seeps parallel the junction of the fen and upland. The second patch occurred in a calcareous fen on the northwestern side of Ottawa Lake, again associated with spring seeps. At Cedarburg Bog the plants studied occurred in the patterned fen. Other plants are found in the Bog at the east edge of Mud Lake and in a marshy area at the eastern end (Salamun, 1970).

The vegetation associated with pitcher plants is similar in the two fens (Table 1) while that in the Cedarburg Bog comprised a different group of associates. In both fens, the pitcher plants are associated with mosses particularly of the family Amblystegiaceae (Table 2); at Ottawa Lake fen the dominant moss was Drepanocladus revolvens. They were also associated with spring seeps, either in the open fen or near the junction of the calcareous fen and the shrubby upland border. In the Cedarburg Bog, pitcher plants in the string bog occurred both in the open, sedge mat and along the edges of the hummocks, ridges and islands, again often associated with mosses.

Water Chemistry

Water samples were obtained using wells 43 cm long and 5 cm in diameter constructed of PVC pipe. Narrow slits cut in the upper half of the tube permitted sampling the shallow groundwater just below the surface of the peat. The wells inserted in the peat, remained in place throughout the study and were sampled at least three times during the summer and autumn of 1982. Fourteen wells were used at Pickerel Lake and seven each at Ottawa Lake and Cedarburg Bog. At Pickerel Lake Fen seven wells were placed in the pitcher plant area and seven outside of that area, while at both Ottawa Lake and the Cedarburg Bog, 3 and 4 wells were used respectively. Before each sampling, the well was bailed and allowed to refill. Samples were drawn by pumping and were returned to the laboratory. pH and alkalinity were measured in the laboratory within six hours after sampling. K, Na, Ca and Mg were determined at the Center for Great Lakes Studies using standard techniques and atomic absorption spectrometry while total N and total P were determined with a technitron autoanalyzer (Golembiewski, 1984).

Water chemistry showed some seasonal variation, presumably related to precipitation and groundwater movement (Table 3). The pH of shallow groundwater at Pickerel and Ottawa Lake varied only slightly, with mean values ranging from

7.1 to 7.4 while pH in the Cedarburg patterned fen was slightly lower, from mean values of 6.0 in fall to summer means of 6.7. Perhaps the greatest difference between the patterned fen and the calcareous fens was in alkalinity, with the patterned fen averaging between 125 and 145 mg/l and the calcareous fens from 277 to 306 mg/l. Concentrations of mineral nutrients varied but showed no particular pattern; total N and total P were present only in low concentrations at all three sites. The differences between the three sites were largely lower pH, alkalinity and Mg values at the patterned bog as compared to the calcareous fens.

Table 1. Common vascular plants in and near the pitcher plant colonies of the Ottawa Lake and Pickerel Lake Fens. Mean percentage cover and frequency and percentage of bare ground as determined from 30, 25 x 50 cm quadrats at each site.

Species	Ottawa Lake Fen		Pickerel Lake Fen	
	Cover	Frequency	Cover	Frequency
Eleocharis rostellata (spike rush)	59.3	97	49.3	84
Scirpus acutus (great bulrush)	3.2	45	10.0	60
Potentilla fruticosa (shrubby cinquefoil)	1.4	18	22.8	64
Carex aquatilis & lasiocarpa (sedge and wire grass)	2.4	47	0.3	22
Sarracenia purpurea (pitcher plant)	4.1	45	2.1	16
Carex spp. (sedge species)	1.7	25	1.2	29
Utricularia intermedia (bladderwort)	1.9	45	0.3	19
Pedicularis lanceolata (swamp lousewort)	--	--	3.0	13
Typha spp. (cattail species)	--	--	1.0	12
Bare ground	12.2	52	2.1	13

Common plants in low areas (flarks) of the patterned fen at the Cedarburg Bog: Rhynchospora alba (beak rush), Carex lasiocarpa (wire grass), Sarracenia purpurea (pitcher plant), Menyanthes trifoliata (bog bean), Equisetum fluviatile (horse tail), Utricularia spp. (bladderworts), Triglochin maritima (arrow grass) and Drosera linearis (Linear-leaved sundew).

Table 2. Bryophyte species found in and near areas of high pitcher plant density at the Pickerel Lake and Ottawa Lake calcareous fens.[a,b]

Pickerel Lake Fen	Ottawa Lake Fen
AMBLYSTEGIACEAE	AMBLYSTEGIACEAE
Amblystegium serpens	Campylium stellatum
Calliergon giganteum	Cratoneuron filicinum
Calliergonella cuspidata	Drapanocladus revolvens
Campylium polygamum	BARTRAMIACEAE
Campylium stellatum	Philonotis fontana
Cratoneuron fillicinum	
Drepanocladus revolvens	
BRACHYTHECIACEAE	
Brachythecium rivulare	
Brachythecium salebrosum	
BRYACEAE	
Bryum pseudotriquetrum	
MARCHANTIACHEAE	
Marchantia polymorpha	
MNIACEAE	
Plagiomnium ellipticum	
SPHAGNOPSIDA	
Sphagnum squarrosum	
Sphagnum teres	

[a]Species identified or checked by John A. Christy and Dr. Frank Bowers. Voucher specimens deposited in the UWM Herbarium.

[b]No quantitative data are available for the patterned fen.

Analysis of the fen water as illustrated in data obtained from the Ottawa and Pickerel Lake fens indicated no significant differences in the nine groundwater characteristics measured between the areas that support pitcher plants and nearby areas not supporting pitcher plants (Table 4). These data characterize the chemistry of the surface groundwater, but provide no specific clue to the distribution of pitcher plants within the fens. In the patterned fen, although there were some small differences between sites with, and those without, pitcher plants late in the season (Na, Ca, Mg and K), these differences are not adequate to explain pitcher plant distribution.

Field Observations

Observation of the pitcher plants provides some basis for speculation. In both Ottawa Lake and Pickerel Lake fens, the pitcher plants were concentrated near or along spring seeps where there was continuous groundwater upwelling. In

Table 3. Chemical characteristics of shallow groundwater at the Pickerel Lake and the Ottawa Lake calcareous fens and the Cedarburg Bog patterned fen. Values are means with standard deviations in parentheses. Where sample size of individual tests varies, n's are given in the table.

Site	Sampling Date	n	pH	Alkalinity mg/l as $CaCO_3$	Total-N ppb	Total-P ppb	K ppm	Na ppm	Ca ppm	Mg ppm
Pickerel Lake calcareous fen	7/7/82	16	7.4(0.2)	306(19)	780(470)	44(41)	0.9(0.5)	4.7(1.1)	27(9)	30(2)
	8/15/82	14			1000(600)	82(97)	1.3(1.0)	6.2(1.2)	25(6)	35(4)
	9/23/82	14	7.1(0.2)	298(14)	960(530)	44(42)	1.6(0.6)	5.7(1.0)	31(6)	36(4)
	10/31/82	14	7.2(0.2)	277(9)	750(420) (n=10)	130(130)	1.3(0.6)	6.1(1.3)	17(5)	33(2)
Ottawa Lake calcareous fen	8/8/82	7			1700(890) (n=5)	120(99)	1.3(0.7)	4.4(1.4)	24(5)	34(1)
	9/12/82	7	7.1(0.1)	290(10)	650(390)	42(63)	1.0(0.2)	3.9(1.5)	27(6)	33(3)
	10/25/82	7	7.2(0.1)	266(11)	310(300) (n=5)	5(11) (n=5)	1.4(0.5)	4.4(1.3)	36(20)	35(1)
Cedarburg Bog patterned fen	7/25/82	7	6.6(0.1)	145(12)		74(26)	1.0(0.4)	4.7(0.6)	27(5)	18(2)
	9/2/82	7	6.6(0.1)	120(29)	1500(400)	55(30)	1.2(0.9)	5.5(0.8)	32(4)	17(2)
	10/6/82	5	6.0(0.2)	125(26)	1400(240) (n=4)	33(38)	1.6(1.0)	5.6(1.0)	34(6)	17(3)

Table 4a. Chemical characteristics of shallow groundwater in areas supporting Sarracenia purpurea and nearby areas not supporting S. purpurea at the Pickerel Lake calcareous fen. Values are means with standard deviations in parentheses. Where sample size of individual tests varies, n's are given in the table. Differences in the means were tested using a two-tailed t-test. The significance levels of significant T statistics are noted (*, p <0.05). All others are not significant.

Sampling date	S. purpurea occurrence	n	pH	Alkalinity mg/l as $CaCO_3$	Total-N ppb	Total-P ppb	K ppm	Na ppm	Ca ppm	Mg ppm
7/7/82	present	2	7.6(0.1)	288(6)	480(7)	50(40)	1.0(0.5)	4.4(1.0)	21(4)	28(3)
	absent	14	7.4(0.2)	309(19)	830(490)	8(0)	0.8(0.5)	4.7(1.0)	28(9)	30(2)
	T		0.78	1.51	0.99	1.40	0.61	0.37	1.10	1.11
8/15/82	present	7			1200(590)	95(85)	1.8(1.1)	6.4(1.3)	23(4)	36(4)
	absent	7			810(610)	69(110)	0.7(0.6)	5.9(1.1)	28(6)	35(3)
	T				1.35	0.48	2.23*	0.88	1.93	0.44
9/23/82	present	7	7.1(0.2)	298(16)	710(320)	18(17)	1.4(0.8)	5.6(1.0)	30(5)	37(4)
	absent	7	7.1(0.2)	298(13)	1200(600)	70(44)	1.7(0.4)	5.9(1.2)	32(7)	34(3)
	T		0.54	0.02	1.93	2.97*	0.61	0.47	0.70	1.65
10/31/82	present	7	7.2(0.2)	278(6)	840(360) (n=3)	200(160)	1.2(0.6)	6.4(1.1)	17(6)	33(2)
	absent	7	7.2(0.2)	276(13)	710(470)	65(34)	1.3(0.5)	5.8(1.5)	16(4)	33(2)
	T		0.40	0.33	0.41	2.13	0.42	0.84	0.11	0.00

Table 4b. Chemical characteristics of shallow groundwater in areas supporting Sarracenia purpurea and nearby areas not supporting S. purpurea at the Ottawa Lake calcareous fen. Values are means with standard deviations given in parentheses. Where sample size of individual tests varies, n's are given in the table. Differences in the means were tested using a two-tailed t-test. The significance levels of significant T statistics are noted (**, p <0.01). All others are not significant.

Sampling date	S. purpurea occurrence	n	pH	Alkalinity mg/l as $CaCO_3$	Total-N ppb	Total-P ppb	K ppm	Na ppm	Ca ppm	Mg ppm
8/8/82	present	3			1500(840)	140(100)	1.4(0.4)	2.9(1.2)	23(8)	34(1)
	absent	4			2000(1200) (n=2)	110(110)	1.2(0.9)	4.8(1.5)	24(4)	34(0)
	T				0.60	0.36	0.25	0.78	0.29	1.43
9/12/82	present	3	7.2(0.0)	284(5)	580(370)	53(92)	0.9(0.1)	3.1(1.7)	24(6)	34(1)
	absent	4	7.0(0.1)	295(12)	700(450)	33(45)	1.0(0.2)	4.5(1.2)	30(6)	33(4)
	T		4.39**	1.47	0.40	0.40	0.55	1.32	1.12	0.19
10/25/82	present	3	7.2(0.1)	263(13)	96 (n=1)	1(1) (n=2)	1.1(0.6)	3.9(1.5)	23(1)	34(2)
	absent	4	7.2(0.1)	268(12)	360(320)	8(14) (n=3)	1.6(0.3)	4.8(1.3)	46(22)	35(1)
	T		0.38	0.48		0.68	1.37	0.78	1.70	0.45

these areas, moss growth appeared to form a suitable substrate for germination and early growth of pitcher plants without excessive competition. Bare peat areas in the patterned fen may serve the same purpose. Seedlings are small and grow slowly (Golembiewski, 1984). Under favorable laboratory conditions, seedlings weigh only about 0.23 grams (dry wt) after 28 weeks compared to average seed weight of 0.15 g. The first pitcher (true leaf) becomes visible at 5-6 weeks and after eight weeks is only 10-11 mm long.

Plant characteristics were recorded for 10 randomly selected individuals in each size category at Ottawa Lake and in the patterned fen. Identity of individuals was difficult to determine in the calcareous fens where the plants grew tightly together (Table 4). In the patterned fen at the Cedarburg Bog, it was possible to detect individual plants with short rooted stems and associated rosettes of leaves (pitchers).

Where present in the calcareous fens, the pitcher plants were usually relatively abundant and small (<5 to 10 cm) in diameter, while in the patterned fen, they tended to be fewer and larger. (10 to 30 cm). Seedlings and small plants were particularly abundant at the Ottawa Lake fen. Large, dense clumps developed at the calcareous fens but were not observed at the patterned fen. Two clumps more than 50 cm in diameter, that contained 365 and 400 pitchers, occurred at Ottawa Lake. In the Pickerel Lake fen several clumps were even larger.

Although plants in the calcareous fens appeared to have shorter and narrower leaves than those in the patterned fen, measurements did not substantiate this impression. There was a clear difference in growth form between plants in the patterned fen in which the pitchers tended to spread out horizontally from the rooting point and were fewer in number per individual, compared to the vertical pitchers found in the calcareous fens where pitchers were crowded together in clumps.

CONCLUSIONS

Water chemistry (i.e., alkalinity, pH, Ca, Na, Mg, Total N and Total P) appears to have little influence on the distribution of pitcher plants within the calcareous fens. Pitcher Plants are concentrated in small areas associated with patches of moss and with spring seeps that provide the fen with a continuous water supply. Pitcher plant seedlings were observed mainly on the moss mat, suggesting that mosses may be more than just frequent associates and may promote seedling survival. Mosses were not common in the patterned fen, but open peat areas and the edges of ridges and island with sphagnum moss did support pitcher plants. It appears likely that availability of a suitable substrate for germination and early growth is a prime determinant of the location of pitcher plant colonies in fens.

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