The Relationship Between *Pleopeltis polypodioides* (Polypodiaceae) and Associated Mosses

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Observations of 56 populations in Oklahoma and 180 herbarium sheets revealed *Pleopeltis polypodioides* (L.) E.B. Andrews & Windham to typically grow with mosses. Experiments examining the role of the moss in hydration and growth of the fern indicated that *P. polypodioides* relies on the moss associated with it.

INTRODUCTION

A member of *Polypodiaceae, Pleopeltis polypodioides* (L.) E.B. Andrews & Windham is well known for two characteristics. One is its habit as an epiphyte on trees or an epilith on rocky outcrops, and the other is its ability to resume growth after periods of desiccation, hence its common name of "resurrection fern."

During herbarium and field studies of this species, another factor caught my attention, the presence of moss growing with the fern. When herbarium sheets were carefully examined, moss could often be found intertwined in the stolons and adventitious roots of the fern, yet its presence was not mentioned on the herbarium labels. These mosses may have been overlooked or ignored, because of a general lack of knowledge of bryophytes. Moreover, descriptions of *P. polypodioides* in several fern treatments and floras, including: *Ferns of Southeastern States (1), Ferns of Tennessee (2), Flora of North Central Texas (3), Ferns and Fern Allies of Texas (4), A Field Guide to the Ferns (5), Field Guide to the Ferns and other Pteridophytes of Georgia (6), Arkansas Ferns and Fern Allies (7), Ferns of Alabama (8)*, did not mention the presence of moss. This lack of comment clearly contradicted my personal observations in the herbarium and field. The only references to the moss were in the *Flora of North America* (*9*) in which the authors described the resurrection fern as living on mossy banks, and *Floristic Investigations of the Flora of Oklahoma* (*10*), in which Smith described *P. polypodioides* as living on mossy granite and sandstone. Thus, the objective of this study was to examine the relationship between *Pleopeltis polypodioides* and the moss associated with it.

METHODS

My investigation began with a review of the literature, followed by a detailed study of herbarium specimens. This work led to observations in the field that were the basis for two laboratory experiments. The library work began in early October, 1999. Information about *P. polypodioides* was gathered from books (*1-10*) in the libraries of Oklahoma State University and McLoud High School. As noted above, this literature search provided little information about the relationship of the moss and the ferns. Examination of herbarium sheets of *P. polypodioides*, however, indicated a possible relationship. One hundred eighty specimens were examined at the Bebb Herbarium University of Oklahoma (OKL), the Botanical Research Institute of Texas (BRIT), and Oklahoma State University (OKLA).

I gathered label information and inspected the sheets for the presence of mosses. I recorded from each herbarium label the name of the collector, date of collection, state and county in which collected, the variety, associated species, and the description of the habitat. Most labels lacked adequate habitat descriptions and lists of associated species.

To determine whether the fern had been growing with a moss, the mount was closely examined with either a hand lens or dissecting microscope. Notes were made about the moss, if present. Some of the fern stolons and adventitious roots appeared to have been carefully cleaned before they were pressed. On rare occasions only the fronds were mounted.

Fifty-six populations of *P. polypodioides* at three sites in Oklahoma were examined in 1999 and 2000 (Table 1). With permission, plants were collected at Robber's Cave State Park and Whip-poor-will Resort. Only the specimens collected from the resort were used in the experimental studies. Information recorded at each site included the name of the host tree, its diameter at breast height, relative abundance of the moss, height above the ground at which the fern appeared, relative abundance of the fern, and appearance of the fern.

An experiment to determine if the moss contributed to the fern's hydration and resumption of growth from a dormant stage was conducted in a cold frame (125 x 33 x 95 cm) at McLoud High School. Twenty ferns without a substrate, fifteen with bark as a substrate, and twenty with moss and bark as a substrate were compared. Using nylon string, the dormant ferns were suspended from two strings that ran lengthwise inside the cold house. Ferns with a substrate were hung on one string and ferns without a substrate on the other.

First, using a spray bottle, every fern was misted with 5.32 mL of tap water. This process was repeated three more times at 2 hr intervals. It became apparent that misting was not going to be enough to hydrate the ferns. They were then completely saturated with tap water. The ferns were completely submersed in a tray (53 x 25 x 6 cm) for sixty seconds. This process was repeated four more times at 2 hr intervals. The appearance of the plants was observed 1 hr after each saturation, and one of four stages assigned: (1) Plants dormant, fronds and lobes completely curled; (2) Plants partially hydrated, fronds slightly curled but lobes still tightly curled; (3) Plants partially hydrated, fronds open and lobes slightly curled; (4) plants fully hydrated, fronds and lobes fully open.

A second experiment was conducted to determine if the moss contributed to the fern's ability to remain hydrated and in a non-dormant stage. The cold frame was converted into a green house, subdivided into three chambers. Each chamber had a different growing environment. Chamber One (45.5 x 33 x 95 cm) contained 1 tray (30 x 21.5 x 6 cm) of wet rocks and a humidifier with fan and humidity control set on high. Chamber Two (38.5 x 33 x 95 cm) had two bowls of wet rocks as a source of humidity. Chamber Three (45.5 x 33 x 95 cm) contained a heater set on low and no trays of water. At the beginning of the experiment, all fifty-five fern plants were fully hydrated and actively growing. Three ferns with and without a substrate were placed in the water-filled trays of Chamber One and Two. In Chamber Three, six were placed in the dry tray. Every chamber also had a clothes hanger suspending a combination of twelve ferns with and without the substrate.

Observations of the ferns were made on February 7-11, 2000. Every 24 hrs, a humidistat recorded the percent humidity and temperature in each chamber (Table 2). Concurrently, one of the four previously described stages was assigned to the plants.

RESULTS

Of the 180 herbarium sheets examined, 122 had mosses associated with *P. polypodioides*. Label information indicated that the ferns grew on trees, rocks, and soil (Table 3). Of the plants in the 56 populations observed in the field, 49 populations were on trees and the other seven were on rocks. All populations consisted of moss(es) and *P. polypodioides* (Table 4).

In the experiment to determine if the moss contributed to the fern's hydration and resumption of growth, both the ferns with and without the substrate remained dormant

TABLE 1. Locations of *Pleopeltis* populations examined in 1999-2000.

Population Number	Date	Site Name	RTS	Locality Notes	Moss	Tree/Rock
			<u>Pennington Creek Johnston County</u>			
1,2	6/22/99	Nature Conservancy Site	Southside of Creek		+	Pre-Cambrian Granite
			<u>Robber's Cave State Park Latimer County</u>			
3-7	10/22/99	Rough Canyon	R 18E T 6N Sec. 12	Boulder Canyon	+	Sandstone
			<u>Beaver's Bend State Park McCurtain County</u>			
8-12	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Bottom of Trail	+	*Carya texana*
13-20	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Bottom of Trail	+	*Juniperus virginiana*
21	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Bottom of Trail	+	*Quercus alba*
22	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Bottom of Trail	+	*Quercus stellata*
23-25	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Bottom of Trail	+	*Ulmus sp.*
26	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Mid-Slope	+	*Carya texana*
27	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Mid-Slope	+	*Juniperus virginiana*
28-30	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Mid-Slope	+	*Quercus stellata*
31-33	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Mid-Slope	+	*Ulmus sp.*
34	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Ridgeline	+	*Carya texana*
35	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Ridgeline	+	*Quercus stellata*
36	1/22/100	Cedar Bluff Trail	R 25E T 5S Sec 4	Ridgeline	+	*Ulmus sp.*
37	1/23/100	Campsite	R 25E T 5S Sec 10	Mt. Fork River Bottom	+	Dead tree
38	1/23/100	Campsite	R 25E T 5S Sec 10	Mt. Fork River Bottom	+	*Liquidambar styraciflua*
39	1/23/100	Campsite	R 25E T 5S Sec 10	Mt. Fork River Bottom	+	*Quercus alba*
40,41	1/23/100	Campsite	R 25E T 5S Sec 10	Mt. Fork River Bottom	+	*Quercus nigra*
42-47	1/23/100	Campsite	R 25E T 5S Sec 10	Mt. Fork River Bottom	+	*Ulmus sp.*
49	1/23/100	Beaver Lodge Nature Trail	R 25E T 5S Sec 4	Streamside	+	*Acer saccharum*
50	1/23/100	Beaver Lodge Nature Trail	R 25E T 5S Sec 4	Streamside	+	*Carya texana*
51	1/23/100	Beaver Lodge Nature Trail	R 25E T 5S Sec 4	Streamside	+	*Juniperus virginiana*
52	1/23/100	Beaver Lodge Nature Trail	R 25E T 5S Sec 4	Streamside	+	*Ostrya virginiana*
53,54	1/23/100	Beaver Lodge Nature Trail	R 25E T 5S Sec 4	Streamside	+	*Quercus stellata*
55,56	1/23/100	Beaver Lodge Nature Trail	R 25E T 5S Sec 4	Streamside	+	*Ulmus sp.*
			<u>Whip-poor-will Resort McCurtain County</u>			
	1/23/100		R 24E T 4S Sec 22	Pine/Hardwood Forest	+	*Carya texana*
	1/23/100		R 24E T 4S Sec 22	Pine/Hardwood Forest	+	*Quercus stellata*
	1/23/100		R 24E T 4S Sec 22	Pine/Hardwood Forest	+	*Ulmus sp.*

TABLE 2. Environmental conditions in growth chambers

Condition	Chamber 1	Chamber 2	Chamber 3
Average Humidity (%)	85	84	82
Humidity Range (%)	84-86	77-89	73-83
Average Temperature (ºC)	26.9	28.2	29
Temperature Range (ºC)	26.6-27.7	25.5-27.7	25.5-32.2

TABLE 3. Herbarium sheets of *Pleopeltis polypodioides* with or without associated moss from different habitats

Habitat	Number of Sheets	Percent
Tree		
Ferns with moss	59	67.8
Ferns without moss	28	32.2
Rocks		
Ferns with moss	26	65.0
Ferns without moss	14	35.0
Soil		
Ferns with moss	6	100.0
Ferns without moss	0	0.0
Unspecified		
Ferns with moss	31	66.0
Ferns without moss	16	34.0
Total		
Ferns with moss	122	67.8
Ferns without moss	58	32.2

TABLE 4. Populations of *Pleopeltis polypodioides* with or without associated moss from different habitats

Habitat	Number of Populations	Percent
Trees		
Ferns with moss	49	100
Ferns without moss	0	0
Rocks		
Ferns with moss	7	100
Ferns without moss	0	0
Soil		
Ferns with moss	0	0
Ferns without moss	0	0
Total		
Ferns with moss	56	100
Ferns without moss	0	0

TABLE 5. Stages of hydration of ferns misted and soaked.

Treatment	No Substrate	Bark Substrate	Bark & Moss Substrate
Misting	1	1	1
Soaking #1	1	1	2
Soaking #2	1	1	2
Soaking #3	1	2	3
Soaking #4	1	2	4

Stage 1. Plants dormant, fronds and lobes are completely curled. Stage 2. Plants partially hydrated, fronds slightly curled but lobes still tightly curled. Stage 3. Plants partially hydrated, fronds open and lobes slightly curled. Stage 4. Plants fully hydrated, fronds and lobes fully open.

TABLE 6. Maintenance of fern hydration in different humidity and temperature conditions

	Chamber #1			Chamber #2			Chamber #3		
	N	B, M	T	N	B, M	T	N	B, M	T
Day 1	1	4	4	3	4	4	2	4	4
Day 2	1	3	4	1	3	4	1	2	4
Day 3	1	2	4	1	2	4	1	1	3
Day 4	1	2	4	1	1	4	1	1	1
Day 5	1	2	4	1	1	4	1	1	1

N = No Substrate; B,M = Bark and Moss Substrate; T = Tray; Stages 1-4 as in Table 5.

throughout the misting. After four soakings ferns without a substrate also remained dormant. The ferns with bark as a substrate reached only stage 2. The fronds were slightly curled but lobes still tightly curled. Ferns with both bark and moss as a substrate exhibited Stage 4 (Table 5).

In the experiment to determine if the moss contributed to the fern's ability to remain hydrated, the ferns without bark and moss in Chamber One reached Stage 1, the dormant stage, in one day, whereas those in Chambers Two and Three became dormant by day two. By the third day, the ferns with moss and bark in Chambers One and Two had reached Stage two, with the lobes curled and the fronds beginning to curl. Those in Chamber Three became dormant. The ferns in the trays of Chambers One and Two stayed fully hydrated during the entire period. In Chamber Three the ferns on the trays became dormant on the fourth day (Table 6).

DISCUSSION

On the basis of my herbarium and field studies it is evident that there is a definite association between *P. polypodioides* and moss. If all of the herbarium labels had been complete in describing habitat and associated species, they would have most likely paralleled the results of my field studies and, the fern would have been observed to be growing with moss 100% of the time. In the field, the moss(es) formed a thick carpet on rocks. It is hypothesized that this carpet enables the fern to grow on rock where water is scarce. The experimental results confirmed that bark does absorb water, which permits partial hydration, but not enough water is available to sustain full resurrection of the fern. Experiment two showed that the ferns stay resurrected longer in the presence of both moss and bark. This study indicates that *P. polypodioides* relies on the moss associated with it.

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