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The Competition of Pityopsis ruthii with Liatris microcephala and Andropogon temarius

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The Competition of *Pityopsis ruthii*
with *Liatris microcephala* and *Andropogon ternarius*

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ABSTRACT

Pityopsis ruthii (Small) Small, currently listed as an endangered species by the State of Tennessee and the U.S. Fish and Wildlife Service, is a perennial plant belonging to the family Asteraceae. The distribution of *P. ruthii* is limited to soil that has accumulated in cracks and crevices of phyllite or graywacke boulders along the Ocoee and Hiwassee Rivers. Analysis of both the soil and the boulders indicate neither the absence nor the presence of any unusual nutrient. *P. ruthii* is most likely restricted to this habitat mainly because of its inability to compete with other more vigorously growing associates. The construction of dams along both rivers, resulting in lower frequency of flooding and reduced water flow, may have complicated the situation by creating a more favorable habitat for competitors, specifically *Liatris microcephala* L. and *Andropogon ternarius* Michx. In order to study the competition between *P. ruthii* and its two main competitors, *L. microcephala* and *A. ternarius*, the natural environment has been simulated in the greenhouse, using concrete blocks to create 1/4" cracks filled with sand. Six treatments were devised with different combinations of *P. ruthii*, *L. microcephala*, and *A. ternarius*, planted at a density of one plant per inch.

INTRODUCTION

Pityopsis ruthii, commonly known as Ruth's golden aster, is currently listed as an endangered species by the State of Tennessee and the U. S. Fish and Wildlife Service (Gunn 1). It belongs to the family Asteraceae and has yellow flowering heads that strongly resemble dandelions but are only about half the size, 5-8 mm wide and 6-8 mm high. Characteristic of the Asteraceae family, the yellow flowering heads consist of ray florets and disk florets, 8-14 yellow ray florets and up to 45 yellow disc florets per head (Wofford 5).

The flowers are borne on leafless stalks covered with tiny yellowish gland-tipped hairs. The clustered and upright stems grow 1-3 dm tall and have one to several inflorescences per stem. A great portion of the stems is covered by numerous leaves. The narrow, silvery, gray-green, grass-like leaves are alternate and sessile with entire margins. The basal and stem leaves are similar in size, and the roots are fibrous (Cronquist 114). (See Figure 1).

The distribution of this rare plant is restricted to short stretches along the Ocoee River and the Hiwassee River (Gunn 1). It grows in the soil that has accumulated in cracks and crevices of phyllite or graywacke boulders. Analysis has been done on both the soil and the boulders, and the results show no indication of the presence of any unusual nutrient that might cause *P. ruthii* to favor this environment nor the absence of any essential nutrients (Gunn 3).

The question that arises is why is it restricted to this area? One of the highly probable explanations that has been proposed is the inability of *P. ruthii* to compete with other more vigorously growing associates. Since its competitors require greater soil depths to grow, *P. ruthii* would be relatively safe growing in the small amount of soil that accumulates in the cracks and crevices of the boulders. According to research done by Wofford and Smith, "adaptation to barren boulder habitats does not appear to be a nutritional limitation; rather, an inability to compete with other more vigorously growing species of the river gorges which occupy adjacent sites of greater soil accumulation" (7).

In years past, periodic flooding and the high level of water flow in both rivers have kept the soil build-up in the cracks and crevices to a minimum (Gunn 7). However, dam constructions along both rivers, upstream from the populations, have diverted the main flow of water. The outcome is reduced water flow and a lower frequency in flooding along both the Ocoee and the Hiwassee, which in turn has resulted in greater soil accumulation. This additional build-up of soil creates a more favorable habitat for the gradual establishment of more competitive species (Wofford 16). *P. ruthii* may never reach a state of stability if it is slowly being displaced by other species.

Two species frequently associated with *P. ruthii* are *Liatris microcephala*, commonly known as Blasting Stem, and *Andropogon ternarius*, commonly known as Big Bluestem Grass or Silvery Beard-Grass (Wofford 17). *L. microcephala* is a member of the Asteraceae family with four to six flowers terminating the slender stem in a loose raceme. It stands 3 to 8 dm high with numerous linear leaves. The basal leaves are only 0.5 to 1 dm long. *L. microcephala* can be found in exposed, rocky places, glades, open woods, and sandy shores in Tennessee, Georgia, Kentucky, North Carolina, and South Carolina (Cronquist 206). (See Figure 2).

A. ternarius, on the other hand, is a member of the grass family, Gramineae. It stands erect between 8 to 12 dm tall. It is simple at the base and generally much branched above with purplish leaves about 2 to 4 mm wide. *A. ternarius* grows in dry sandy soil and open woods. It is found in the Coastal Plain, from Delaware to Kentucky and Kansas, and even as far south as Florida and Texas (Chase 760). (See Figure 3). The two species, *L. microcephala* and *A. ternarius*, may be "secondary invaders," outcompeting *P. ruthii* as soil depths increase.

METHODS AND MATERIALS

In order to study the competition between *P. ruthii* and its two main associates, *L. microcephala* and *A. ternarius*, the natural environment was simulated in the greenhouse. Two concrete blocks were placed in such a manner that a quarter inch crack was created in between. Wooden sticks that were a quarter inch wide were placed along the sides and down at the bottom of the crack in order to ensure a quarter-inch crack. The cracks were then filled with sand obtained along a creek. (See Figure 4).

Six treatments were devised with different combinations of *P. ruthii*, *L. microcephala*, and *A. ternarius*, planted at a density of one plant per inch. The first treatment consisted of only *P. ruthii* seedlings. The second treatment had all *L. microcephala* seedlings, and the third had all *A. ternarius* seedlings. These three treatments were to function as controls, and each treatment had two replicates.

In the fourth treatment, *P. ruthii* seedlings were planted in between *L. microcephala* seedlings. The fifth treatment had *P. ruthii* seedlings planted in between *A. ternarius* seedlings. The last treatment had all three species alternated. These three treatments had three replicates each. (See Figure 5). A small sample size of replicates was used so that too many seeds would not be taken out of the field site since *P. ruthii* is an endangered species.

To obtain the seeds for this project, a trip was taken to the Hiwassee River in the fall of 1995. *P. ruthii*, *A. ternarius*, and *L. microcephala* were observed growing in their natural habitats, and seeds from all three species were collected for the greenhouse experiment. (See Figure 6).

The seeds were cleaned and prepared for germination by carefully separating them from dirt, leaves, petals, and other plant parts. The seeds were placed on a double layer of filter paper in petri dishes, and a small amount of distilled water was added to moisten the filter paper. The petri dishes were then placed in the incubator at a light intensity of 1500 [m^{-2} sec^{-1}] and watered daily with distilled water.

After the seeds germinated, the seedlings were transplanted to the greenhouse and planted in the blocks according to the treatment plans. The seedlings were watered daily with distilled water. After the seedlings became established within the blocks, weekly measurements of each seedling were taken for plant height, number of leaves, and the length of the longest leaf.

RESULTS

The greenhouse experiment was initiated on January 18, 1996, when the germinated seedlings were transferred to the concrete blocks. Almost immediately, problems occurred in keeping the seedlings alive. The extreme cold conditions of the winter made it difficult to regulate the temperatures for the plants to establish. The seedlings of all three species exhibited high mortality rates, and many of them had to be replaced.

A. ternarius had no problem establishing and had a very low mortality rate although some of the leaf tips began to yellow after a few weeks. *L. microcephala* did pretty well for about two weeks, and then the seedlings started looking weak and unable to stand up and support their shoots. Eventually, they began to die off one by one, and many of them had to be replaced. *P. ruthii* had a very difficult time getting established and had to be replaced with more seedlings for the next nine weeks.

Because of the high mortality rate of the seedlings, only six block sets survived to the end of the experiment. (See Figure 7). Weekly measurements were taken for plant height, the number of leaves, and the length of the longest leaf, and the final measurements are recorded in Table 1.

To see how well *P. ruthii* established in other settings, seedlings were also planted in pots with both regular soil and vermiculite. Once again, there was a low establishment rate of only about 25 percent.

DISCUSSION

The poor performances of the plants in the blocks can be attributed to a number of possible reasons. One is the lack of nutrients in the sand. In order to see if the lack of nutrients was the limiting factor, the three main nutrients—nitrogen, phosphorus, and potassium—were added to the soil in a dilute solution of NPK fertilizer [1 tsp/L]. However, this resulted in no significant differences. Due to time restrictions, experiments were not conducted for all nutrients, and no other hypotheses were tested.

Although the plants were still small at the end of six weeks, the results clearly indicate that *A. ternarius* has an edge over *P. ruthii* and *L. microcephala*. The death rate of *A. ternarius* was significantly smaller than the other species, and it did quite well in becoming established in the blocks. With soil accumulation in the cracks along the Ocoee River and the Hiwassee River allowing *A. ternarius* to grow more readily, *P. ruthii* could be in danger of being displaced by this more vigorous species.

As for *L. microcephala*, the results do not indicate any advantages it may have over *P. ruthii*. Both species struggled with becoming established in the blocks, and the death rates for both were fairly high. The results of the greenhouse experiment suggest that *L. microcephala* may be a codominant of the boulders along with *P. ruthii*, with neither being capable of forcing the other out of existence. However, *L. microcephala* is not threatened with extinction, since it is readily found in other habitats of southern and eastern United States.

The competition of *P. ruthii* with *L. microcephala* and *A. ternarius* is an important factor in the decreasing stability of *P. ruthii*. Because of soil build-up in the cracks of the boulders, *P. ruthii* is in danger of being displaced by the competition, specifically *A. ternarius* if not *L. microcephala*.

Figure 1. A sketch of *Pityopsis ruthii.*

Figure 2. A sketch of *L. microcephala*.

Figure 3. A sketch of *A. ternarius*.

BLOCKS (14" x 4")

1	2	3	4	5	6	7	8	9	10	11	12	13

Density: 1 plant per inch
Crack: ¼ inch

Figure 4. Simulation of natural environment using blocks in greenhouse.

P = *Pityopsis ruthii* (Small) Small
L = *Liatris microcephala* L.
A = *Andropogon ternarius* Michx.

Treatment 1:

P	P	P	P	P	P	P	P	P	P	P	P	P

Treatment 2:

L	L	L	L	L	L	L	L	L	L	L	L	L

Treatment 3:

A	A	A	A	A	A	A	A	A	A	A	A	A

Treatment 4:

L	P	L	P	L	P	L	P	L	P	L	P	L

Treatment 5:

A	P	A	P	A	P	A	P	A	P	A	P	A

Treatment 6:

A	P	L	A	P	L	A	P	L	A	P	L	A

Figure 5. Treatment plan with different combinations of plants. The first three were to function as controls with two replicates each. The last three had three replicates each.

Figure 6. Observing the plants in their natural habitat along the Hiwassee River.

P = *Pityopsis ruthii* (Small) Small
L = *Liatris microcephala* L.
A = *Andropogon ternarius* Michx.

Treatment 1:

P				P	P	P			P	P	P	P

Treatment 2:

L	L		L	L	L	L	L	L	L	L	L	L

Treatment 3:

A	A	A	A	A	A	A	A	A	A	A	A	A

Treatment 4:

L		L	P	L		L		L		L		L

Treatment 5:

A		A	P	A	P	A	P		P	A		A

A		A		A	P	A		A		A	P	A

Figure 7. Surviving plants in the salvaged blocks.

(1)	P	(P)	(P)	(P)	P	P	P	(P)	(P)	P	P	P	P
plant height	0.3				0.7	0.6	0.9			0.6	0.6	0.4	0.4
# of leaves	4				4	6	7			8	6	6	5
leaf length	0.3				0.4	0.7	0.7			0.4	0.6	0.4	0.5

(2)	L	L	(L)	L	L	L	L	L	L	L	L	L	L
plant height	3.0	3.4		1.2	2.6	1.8	5.5	2.4	1.1	2.5	1.2	3.3	2.4
# of leaves	4	4		3	4	2	4	3	4	4	3	3	4
leaf length	3.3	3.4		1.4	2.4	1.8	5.4	2.2	1.1	2.7	1.7	3.0	2.1

(3)	A	A	A	A	A	A	A	A	A	A	A	A	A
plant height	3.1	5.5	4.8	5.8	4.9	6.1	5.6	4.8	5.7	2.9	2.6	5.2	3.5
# of leaves	3	5	4	5	5	5	5	5	6	3	3	5	3
leaf length	3.6	7.9	5.5	8.6	8.0	6.6	8.5	5.0	6.5	4.0	4.4	7.2	3.7

(4)	L	(P)	L	P	L	(P)	L	(P)	L	(P)	L	(P)	L
plant height	2.2		2.6	0.3	2.8		3.5		3.4		2.2		1.0
# of leaves	4		3	2	3		3		4		3		5
leaf length	2.2		2.1	0.3	2.8		3.6		3.1		2.2		3.3

(5a)	A	(P)	A	P	A	P	A	P	(A)	P	A	(P)	A
plant height	4.9		3.6	0.7	5.4	0.6	6.1	0.4		0.6	4.7		3.1
# of leaves	5		5	7	6	8	3	3		5	4		3
leaf length	6.2		5.0	0.7	6.5	0.6	7.6	0.4		0.7	6.8		4.2

(5b)	A	(P)	A	(P)	A	P	A	(P)	A	(P)	A	P	A
plant height	2.5		3.8		3.3	1.0	2.2		2.2		3.3	0.7	3.3
# of leaves	4		5		5	8	5		6		5	7	3
leaf length	3.6		4.1		4.6	0.8	4.5		4.4		4.6	0.5	4.1

Table 1. Measurements taken on April 9, 1996, the final day of the experiment. (plant height and leaf length in cm).

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