PONDBERRY (*Lindera melissifolia*) SEED PREDATORS

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ABSTRACT

Pondberry is an endangered, dioecious, deciduous shrub that grows in periodically flooded forests of the southeastern United States of America. Pondberry is a clonal plant. Each female stem grows up to two meters tall and may produce many red drupes. The probability of dispersed seeds to survive to germination and beyond is unknown in the species. For this study, six locations were chosen in or near the Delta National Forest, Sharkey County, MS, USA. At each location, a one-meter-square plot was established and cleared of forest floor material. Inside the larger plot, a 30-cm square was defined and 25 pondberry seeds were arranged on the soil surface. Video cameras with infrared illumination were set up to monitor animal visitors to the seed plots. Each camera was attached to a video recorder and the batteries and videotape for the camera were exchanged twice weekly and the pondberry seeds were recounted. The animals identified as possible pondberry seed predators were the Northern Cardinal (*Cardinalis cardinalis*), Brown Thrasher (*Toxostoma rufum*), Swamp Rabbit (*Sylvilagus* sp.), Nine-banded Armadillo (*Dasypus novemcintus*) and Gray Squirrel (*Sciurus carolinensis*).

Keywords: Pondberry, *Lindera melissifolia*, seed predators.

PREDADORES DE SEMENTES DE PONDBERRY (*Lindera melissifolia*)

RESUMO

Pondberry é um arbusto decíduo, dióico e em perigo de extinção, que cresce em florestas periodicamente inundadas do sudeste dos Estados Unidos da América. Pondberry é uma planta clonal. Cada fuste cresce até dois metros de altura e pode produzir vários frutos vermelhos. A probabilidade de sobrevivência de germinação das sementes dispersas é desconhecida nesta espécie. Para este estudo, seis locais foram escolhidos dentro ou perto do Delta National Forest, Sharkey County, MS, EUA. Em cada local, uma parcela de um metro quadrado foi medido e limpo. Dentro deste, um quadrado de 30 centímetros foi marcado e 25 sementes de pondberry foram dispostas sobre o solo. Uma câmera de vídeo com iluminação infravermelho foi posicionada para acompanhar os visitantes na área demarcada das sementes.

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Cada câmera foi conectada a um gravador de vídeo e duas vezes por semana foram trocadas as pilhas e a fita de vídeo e as sementes foram contadas. Os animais identificados que podem ser predadores de sementes de pondberry foram o Northern Cardinal (*Cardinalis cardinalis*), Brown Thrasher (*Toxostoma rufum*), Swamp Rabbit (*Sylvilagus* sp.), Nine-banded Armadillo (*Dasypus novemcintus*) e Gray Squirrel (*Sciurus carolinensis*).

Palavras-chave: Pondberry, *Lindera melissifolia*, predadores de sementes.

PREDADORES DE SEMILLAS DE PONDBERRY (*Lindera melissifolia*)

RESUMEN

Pondberry es un arbusto en peligro, dioico y caducifolio que crece en los pantanos del sureste de los Estados Unidos de América. Pondberry es una planta clonal. Cada fuste hembra crece hasta dos metros en altura y pueda producir muchas drupas rojas. La probabilidad de sobrevivencia hasta su germinación se desconoce para semillas diseminadas de esta especie. Para este estudio, seis sitios se escogieron en el Delta National Forest, Sharkey County, MS, EUA. En cada sitio, una parcela de un metro cuadrado se midió y limpio. Dentro de la parcela se delimito un cuadrado de 30 cm y 25 semillas de pondberry fueron disponibilizadas en esta área. Una cámara de vídeo con iluminación infrarroja se instalo para vigilar los visitantes a la parcela. Cada cámara fue conectada a un registrador de vídeo y dos veces por semana se cambiaron las baterías y la cinta de vídeo, y se contaron las semillas. Los animales identificados que podrían ser predadores de las semillas de pondberry fueron Northern Cardinal (*Cardinalis cardinalis*), Brown Thrasher (*Toxostoma rufum*), Swamp Rabbit (*Sylvilagus* sp.), Nine-banded Armadillo (*Dasypus novemcintus*) y Gray Squirrel (*Sciurus carolinensis*).

Palabras claves: Pondberry, *Lindera melissifolia*, predadores de semillas.

INTRODUCTION

Pondberry [*Lindera melissifolia* (Walt.) Blume] is a member of the family Lauraceae and is one of three members of the genus Lindera found in the southeastern United States, the other two species are common spicebush (*L. benzoin*) and bog spicebush (*L. subcoriacea*).

Pondberry is an endangered, dioecious, deciduous shrub that grows in seasonally flooded areas of southeastern forests or along the margins of sinks and ponds (Devall et al., 2001). Pondberry is a clonal plant that grows vegetatively by rhizomes, and it has a tendency to form dense thickets.

Pondberry leaves are oblong-elliptic to narrowly ovate and are 5 to 16 cm in length, 2 to 6 cm in width and release volatile compounds that resemble those of sassafras (*Sassafras albidum*) when the leaf is crushed.

Female stems grow up to two meters tall and may produce pale yellow flowers in late February to mid-March, measuring 5 to 6 mm across, and forming tight, stalkless clusters, that persist no longer than two weeks. From August to early October, pondberry produces many red, ellipsoid to oval-shaped drupes, which measure about one centimeter long and weigh an average of 0.23 grams (Connor et al., 2007). Seeds reach their mature weight in August and peak at 0.18 grams (Connor et al., 2006). Individual stems of pondberry begin flowering by their third year of growth (Tucker, 1984).

It is thought that possibly both water and animals disperse the fruits (Smith et al., 2004). Some birds eat the fruits and regurgitate the seeds, e.g. Hermit Thrush *(Catharus guttatus)*, and are seed dispersers (Smith et al., 2004). Others consume the seeds, e.g. Northern Cardinal (*Cardinalis cardinalis)*, and are seed predators (Smith et al., 2004). Although certain mammals, particularly Swamp Rabbits *(Sylvilagus aquaticus)* have been observed eating pondberry seedlings (Martins, 2006). Detailed information on the probability of seed survival to germination is lacking.

Little is known about pondberry's reproduction, which is apparently aided by insect pollination. Seed production in general is low and few seedlings have been observed in the wild. Flowering often occurs during low temperatures that damage flowers and reduce fruit production.

Pondberry is considered an endangered species (USFWS, 1990, 1993); some causal factors may be the alteration of natural habitat, harvesting practices, local drainage activities and land clearing operations for agricultural, commercial and private development.

Pondberry habitat is highly variable. In general, it occupies forested habitats that are normally flooded or saturated during the dormant season, but infrequently flooded during the growing season for extended periods (Tucker, 1984). Pondberry populations are generally associated with the shade of a mature forest and may be shade dependent (Klomps, 1980; Tucker, 1984).

The known distribution of pondberry populations is located in seven U.S. states and approximately 273 colonies of pondberry are currently known. In Mississippi, 204 colonies have been found in the Delta National Forest.

Knowledge of pondberry ecology, biochemistry and morphology is sparse. Ongoing research may be the key to understanding and solving problems related to the sustainability of this endangered species. This study was implemented to determine additional predators of pondberry seeds and to estimate the survival probability of pondberry seeds to germination.

MATERIALS AND METHODS

All experiments were conducted in or near the Delta National Forest, Sharkey County, Mississippi, from December 2006 through February 2007. Six study locations were chosen and at each location, a one-meter-square plot was established and cleared of leaf litter and twigs. Inside each large plot, a 30-cm square sub-plot was defined and 25 pondberry seeds were arranged on the soil surface. At each sampling site, a continuously operating video camera with infrared illumination (Fuhrman Diversified, Inc.) was set up to monitor animal visitors to the seed plot (Figure 1). Each camera was attached to a videotape recorder operated with 12-volt batteries (Figure 2). Counts of intact, missing and crushed seeds were made twice weekly at each study area and the batteries and video tapes were exchanged. The tapes were viewed to determine the types of animals recorded and the times of day when something visited the plots. Animals were identified as accurately as the videotape record would permit.

Seed plots were paired so that one of each pair was in an area with greater herbaceous cover nearby and the other was in an area with less herbaceous cover. The chosen locations were at the Delta National Forest and Sharkey Large-scale Afforestation Experiment Site.

In the Delta National Forest (a bottomland hardwood forest), three locations were chosen. The study was established in Compartment 7, Compartment 8 and Compartment 16 (GSRC 42 and GSRC 43). This forest is the largest remaining tract of bottomland hardwoods in Mississippi and consists mainly of oaks (*Quercus* sp.), sweetgum (*Liquidambar styraciflua*), tupelo (*Nyssa* sp.), green ash (*Fraxinus pennsylvanica*) and bald cypress (*Taxodium distichum*).

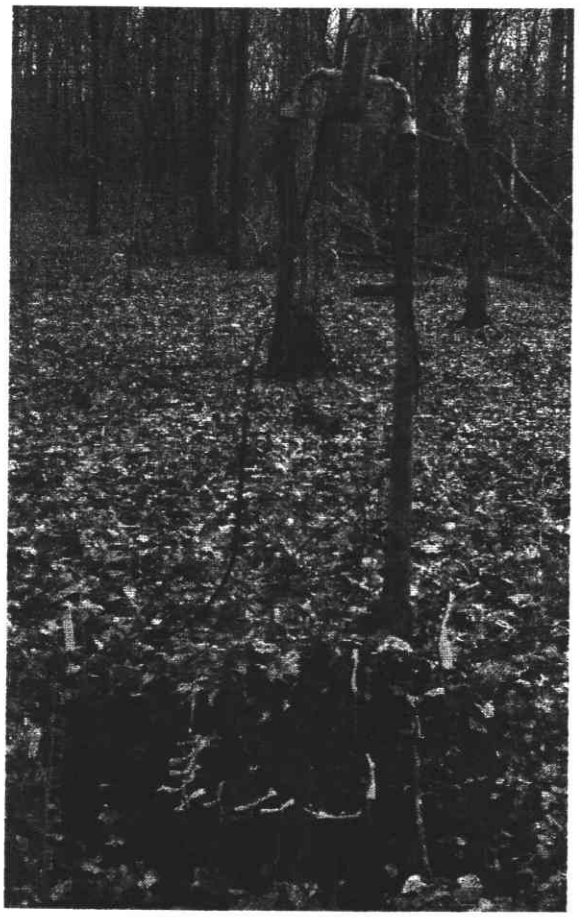

Figure 1 - The video camera with infrared illumination to monitor visitors to the seed plot in Compartment 8 in the Delta National Forest

At the Sharkey Large-scale Afforestation Experiment Site (see Fisher et al., 2002, for more information on the site), the sites chosen were NUR II which is a cottonwood (*Populus deltoides*) and Nuttall oak (*Quercus nuttallii*) mixed plantation, and PLN II with a mainly Nuttall oak plantation, both 12 growing seasons old.

The survival probability of pondberry seeds exposed to predation during this experiment was calculated in the following way. Ratios were determined between the number of seeds remaining at the end of the trial and the original number of seeds (25). The proportion remaining was raised to the inverse power equal to the number of days of the trial, providing an estimate of the daily survival of each seed. Proportions of seeds expected at the end of the 90-day period of exposure were estimated by raising the estimated daily survival probabilities to the 90th power. The average daily and 90-day survival probabilities were calculated for paired plots with higher and lower herbaceous cover at each site.

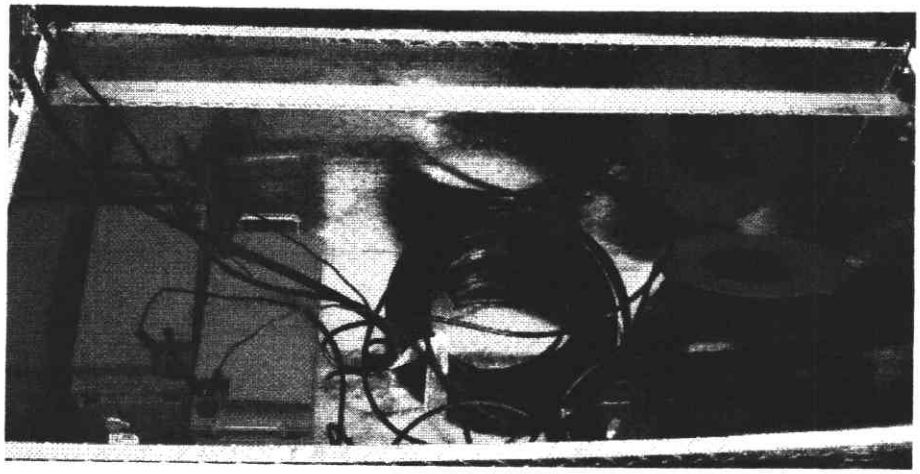

Figure 2 - The equipment to monitor visitors to the seed plot in Compartment 8 in the Delta National Forest

RESULTS AND DICUSSION

Most of the animals recorded by the cameras at the selected study locations were birds. Nineteen bird species were identifiable and four species were not. In addition to birds, Swamp Rabbit, Gray Squirrel (*Sciurus carolinensis*) and Nine-banded Armadillo (*Dasypus novemcinctus*) were recorded by the cameras. Pondberry fruits have characteristics that suggest they are bird-dispersed, including fleshy pulp, high visibility with a red fruit coat, ripeness signaled by change in fruit color, small size and semi-permanent attachment to the stem until removal by a frugivore (Denslow y Moermond, 1985; Ridley, 1930; van der Pijl, 1969; Snow, 1971). The hermit thrush had previously been found to be a pondberry seed disperser and the northern cardinal had been found to be a seed predator (Smith et al., 2004). It is thought that the mammals were possible seed predators because squirrels destroy a large number of seeds (Ridley, 1930), rabbits can be significant depredators (Chapman, 1983), and armadillos eat small fruit (Wetzel, 1983).

The study was conducted for 1,536 hours each in Compartment 7, Compartment 8, NUR II and PLN II, for 840 hours in GSRC 43 and for 240 hours in GSRC 42.

In Table 1 are shown the visitors to each site during the time of observation in and near the Delta National Forest, Sharkey County. In Table 2 are the dates of observation of visits in each plot and the herbaceous cover at each site.

The GSRC 43 plot had the highest activity of animal visitors recorded by the camera. The total number of animals counted was 165 and eight different species were identified. Among these was the Northern Cardinal, a pondberry seed predator.

At the Compartment 7 site, 69 animal visitors were counted in the plot and eleven species were identified, ten birds and one Gray Squirrel. The possible predators visiting the Compartment 7 site included the Northern Cardinal, Brown Thrasher (*Toxostoma rufum*) and Gray Squirrel.

The Compartment 8 seed plot was visited by 71 animals, among these nine were identified, seven species of birds and two species of mammals. The possible predators identified were the Northern Cardinal, the Nine-banded Armadillo and the Swamp Rabbit.

At the NUR II site, only 15 animals were counted, the lowest activity of all the study

locations. Nine species were identified, and the Northern Cardinal and the Swamp Rabbit were the only seed predators.

The established experiment at the PLN II and the GSRC 42 location was not analyzed. Insufficient time was available to review the videotapes, however all the seeds remained at the end of the experiment.

Table 1

Visitors	Scientific names	Compartment 7	Compartment 8	NUR II	GSRC 43
Birds					
American Woodcock	*Scolopax minor*	0	0	2	0
Eastern Phoebe	*Sayornis phoebe*	0	1	0	0
Carolina Chickadae	*Poecole carolinensis*	0	0	0	1
Tufted Titmouse	*Baeolophus bicolor*	1	1	0	10
Carolina Wren	*Thryothorus ludovicianus*	0	0	0	2
Winter Wren	*Troglodytes troglodytes*	1	0	0	0
Golden-crowned Kinglet	*Regulus satrapa*	0	0	1	0
Ruby-crowned Kinglet	*Regulus calendula*	2	1	0	0
Eastern Bluebird	*Sialia sialis*	0	0	1	0
Hermit Thrush	*Catharus guttatus*	38	54	2	53
American Robin	*Turdus migratorius*	0	0 or 1	3	0
Northern Mockingbird	*Mimus polyglottos*	0	0 or 1	0	0
Brown thrasher	*Toxostoma rufum*	7	0 or 1	0	0
Yellow-rumped Warbler	*Dendroica coronata*	1	0	1	3
Pine Warbler	*Dendroica pinus*	1 or 2	0	0	1
Palm Warbler	*Dendroica palmarum*	1 or 2	0	0	0
Field Sparrow	*Spizella pusilla*	0	0	1	0
Song Sparrow	*Melospiza melodia*	0	0 or 1	0 or 1	0 or 1
White-throated Sparrow	*Zonotrichia albicollis*	11	2	0 or 1	93 or 94
Dark-eyed Junco	*Junco hyemalis*	0	1	0	0
Northern Cardinal	*Cardinalis cardinalis*	4	7	1	1
Mammals					
Armadillo	*Dasypus novemcinctus*	0	1	0	0
Swamp Rabbit	*Sylvilagus aquaticus*	0	2	2	0
Gray Squirrel	*Sciurus carolinensis*	1	0	0	0
Total Visits		**69**	**71**	**15**	**165**

Each site consisted of a pair of locations, one with lower and the other with higher herbaceous vegetation cover in the vicinity of the sample plot. Daily and 90-day survival probabilities did not differ between plots with higher and lower herbaceous vegetation cover (Daily proportion surviving: $t=-1.03$, $df=4$, $p=0.36$; Proportion surviving 90 days: $t = -1.06$, $df=4$, $p=0.35$). Given our small sample sizes, we suggest that survival probability in the vicinity of nearby cover for seed predators may be lower than that in areas farther

from such herbaceous cover (Figure 3).

Table 2

Site	Compartment 7	Compartment 8	NUR II	PLN II	GSRC 43	GSRC 42
Start date	12/14/2006	12/14/2006	12/14/2006	12/14/2006	01/12/2007	02/06/2007
End date	02/16/2007	02/16/2007	02/16/2007	02/16/2007	02/16/2007	02/16/2007
Herbaceous cover	Higher	Lower	Lower	Higher	Lower	Higher

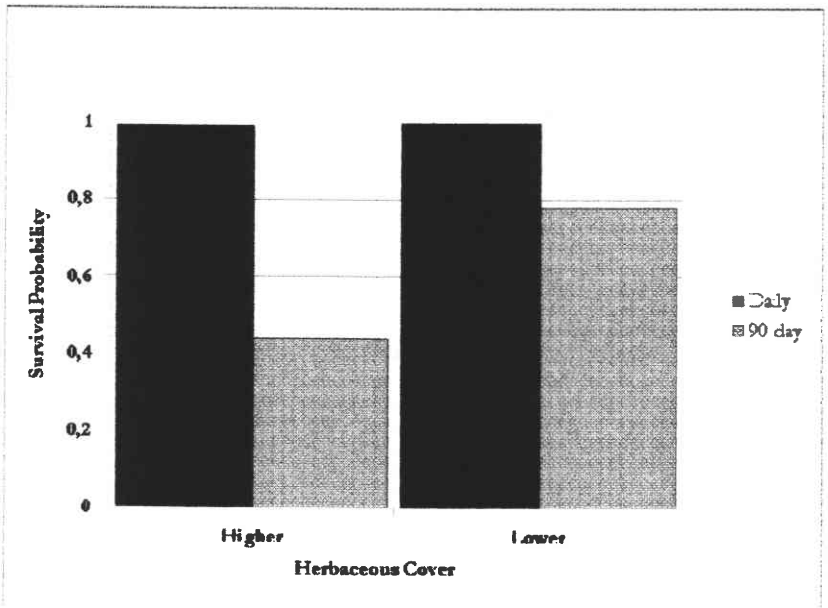

Figure 3 - Daily and 90-day survival probability of pondberry seeds exposed in two levels of herbaceous cover in and near the Delta National Forest, Sharkey County, Mississippi in 2006-2007

CONCLUSIONS

Although our survival probabilities did not differ between plots with higher and lower herbaceous cover, pondberry seed survival may be related to herbaceous cover and the duration of seed exposure to predation in the environment. Survival probability of seeds in higher herbaceous cover may be lower than in areas with lower herbaceous cover. This suggests that animals use forest floor cover to lengthen their foraging time for seeds. However, the seed survival data that we have is very limited and these are preliminary conclusions. The study is continuing.

The animals identified as possible pondberry seed predators were the Northern Cardinal, Brown Thrasher, Swamp Rabbit, Nine-banded Armadillo and Gray Squirrel.

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