Transactions of the Illinois State Academy of Science
(2000), Volume 93, #4, pp. 271-277

received 3/21/00
accepted 8/1/00

The Relationship of Inflorescence Size to Reproductive Output and Pre-dispersal Seed Predation in a Population of *Baptisia leucophaea* (Fabaceae)

Chris E. Petersen*, Neda Eftekhar, Richard Wadda, Tanya Zaya, and Matthew Cote
Natural Sciences
College of DuPage
Glen Ellyn, IL 60137

*Corresponding author

ABSTRACT

Baptisia leucophaea Nutt. is a clustering species native to tallgrass prairie of the Midwest. The legume is most conspicuous during spring when sprawling plants produce cream-colored flowers. Selective advantages and disadvantages to larger inflorescence size per cluster and individual *B. leucophaea* were investigated over a 3-year study in a 1.5 ha tall grass plot that was reconstructed in 1984 in northeastern Illinois. *B. leucophaea* within the tallgrass plot were infested by the weevil, *Apion rostrum*, which develops inside the pods, consuming seeds as a single source of nutrition. Fourteen clusters of *B. leucophaea* were selected for study in 1997. In 1998 and 1999, 11 clusters were added to the original 14. Sampling protocol was the same for all three years. Flower count provided a measure of inflorescence size. Larger flower count per cluster and per plant failed to indicate advantages in the number of inflated pods and matured seeds on a per flower basis. However, the numbers of inflated pods and matured seeds per plant were higher during two of three study years among clusters and plants which produced more flowers. Higher reproductive output among clusters and plants having larger inflorescences is notable when considering the few pollinators observed when *B. leucophaea* blooms. Larger inflorescence size did not appear to have great cost to flowers pollinated, but instead possible rewards in seeds matured. *A. rostrum* counts/plant were highest among clusters and plants having more flowers except during 1999 when the weevil was less abundant. Predatory pressure by *A. rostrum* may act as a constraint to inflorescence size in *B. leucophaea*.

Key words: *Baptisia leucophaea*, inflorescence size, *Apion rostrum*, seed number, predispersal seed predation, tallgrass prairie.

INTRODUCTION

Baptisia leucophaea Nutt. (Fabaceae)(cream wild indigo) is a prolific flowering native of mesic prairie throughout the Midwest (Ladd, 1995; Swink and Wilhelm, 1994). The legume is most conspicuous during spring when the sprawling racemes radiate outward from clusters which commonly exceed two dozen plants. The 1 m tall plants typically have single racemes of over 15 cm long lined with pale yellow flowers. Bumblebees (*Bombus* spp.), the major pollinators of *B. leucophaea* (Petersen, 1996) tend to forage from the distal staminate flowers of the indeterminate racemes to the basal pistillate flowers (Haddock and Chaplin, 1982). This foraging behavior enables a degree of self pollination, an advantage when spring pollination activity is unreliable in the Midwest (Haddock and Chaplin, 1982). Despite prolific flowering and the success of pollination as indicated by inflated pods, many pods may fail to ripen. Pre-dispersal seed predation by insects and subsequent pod abortion can explain a portion of the loss, but even plants having little or no seed predator infestation lose pods (Petersen et al, 1998). With respect to these losses in reproductive yield, we questioned why this clustering species produces so many flowers.

In this study, selective advantages and disadvantages to larger inflorescence size per cluster and individual *B. leucophaea* were investigated over a 3-year study in a reconstructed tallgrass plot located in northeastern Illinois. Populations of flowering plants often cluster with high variation in the number of individuals per cluster (Watt, 1947). Larger inflorescence size is associated with higher pollination activity in clusters as well as in individuals (Jennersten, 1988; Jennersten and Nilsson, 1993; Menges, 1988). However, larger sizes may also promote herbivory and seed predation (Ehrlen, 1997; Hainsworth et al, 1984; Jennersten and Nilsson, 1993; Molau et al, 1989).

In the reconstructed tallgrass prairie under study, the only observed seed predator of *B. leucophaea* was the weevil, *Apion rostrum* Say (Curculionidae). It is unknown what attracts the weevil to *B. leucophaea*, although overwintering adults appear as the newly emergent shoots of *B. leucophaea* begin to bloom (Petersen et al, 1998). Weevils insert eggs into pods as they inflate during June and early July. The larval progeny consume the seeds of the pods as their single source of nutrition. Pupation occurs during July with maturation completed by early August. Adults disperse as the above-ground tissues of the *B. leucophaea* senesce and as pods dehisce during late summer.

METHODS

The study site was a 1.5-ha tallgrass prairie which was reconstructed in 1984 on the campus of College of DuPage, DuPage County, IL. The plot has been burned annually during spring and is dominated by *Andropogon gerardii* Vitman (big bluestem), *Sorghastrum nutans* (L.) Nash (Indian grass), and *Sporobolus heterolepis* Gray (prairie dropseed). Forbs in the plot which overlap in flowering time with *B. leucophaea* include *Baptisia leucantha* T.&G. (white wild indigo), *Dodecatheon meadia* L. (shooting star), and *Zizia aurea* (L.) Koch (golden Alexanders). A comprehensive listing of plants found within the plot is provided by Kirt (1989).

Sampling protocol was the same for the three year study which began in 1997, with the exception being the number of clusters examined. Beginning in 1997, fourteen clusters of *B. leucophaea* which were farther than 1 m from the edge of the plot were randomly selected for study. Eleven more clusters were randomly selected for study the following two years. A cluster was defined as a discrete unit of *B. leucophaea* where plants were no further than 10 cm apart from one another. Clusters were separated by a minimum distance of 1 m. The flower count per plant was recorded during June of each year to serve as the measure of inflorescence size. Inflated pods were counted on each plant during early July and used as a measure of successful pollination (Haddock and Chaplin, 1982). Counts of ripened pods per plant were recorded during August.

Five sealed pods were then collected from racemes and sampled for counts of matured seeds and weevils. These pods included the most proximal, distal, and three spaced evenly between. If a raceme had less than 5 pods, all were sampled. The number of matured seeds/plant was computed as the product of the mean number of seeds/ripened pod and the ripened pod count of the plant. Weevil count/plant was computed as the product of the mean number of weevils/pod and inflated pods/plant. This count was possibly an underestimate in the event of weevil mortality. Inflated pod count was used as a variable in order to account for weevils present in pods that were lost or aborted from plants prior to the enumeration of weevils. Mean numbers of flowers, inflated pods, ripened pods, and matured seeds per plant within clusters provided grand mean counts/plant for the respective variables. Matured seeds and weevil counts per cluster were estimated as the sums of matured seeds/plant and weevils/plant within the cluster.

The Kruskal-Wallis test was used to compare median rank measurements of plant reproductive yield and weevil counts among the study years. Spearman rank correlation was used to test for relationships between inflorescence size and other parameters of reproductive yield, and inflorescence size to weevil count.

RESULTS

Plant density per cluster, mean flower production and inflated pods per plant did not differ significantly over the three years (Table 1). However, mean ripened pods, matured seeds, and weevil counts per plant did vary significantly. Mean ripened pods and matured seeds per plant were low in 1998 when weevil densities per plant were high.

Clusters with higher flower counts tended to contain more individual plants and also plants with greater mean numbers of flowers and inflated pods (Table 2). The relationship of flowers/cluster to ripened pods/plant was less conclusive. However, flower count/cluster was significantly correlated to the mean number of matured seeds/plant during the years 1997 and 1999 when plant densities of weevils were relatively low. Advantages of large inflorescence size were not exponential as flower count/cluster did not show positive correlations to mean plant ratios of inflated pods/flower and matured seeds/flower. Flower count/cluster and weevils/plant were positively correlated although failing in significance during 1999 when weevil infestation was lowest.

Mean flower counts/plant were positively correlated to mean plant numbers of inflated pods, ripened pods, and except during 1997, to matured seeds during each year of the study, indicating the advantage of a larger inflorescence at the level of the individual plant (Table 2). As with clusters, the advantages of larger inflorescence size/plant were not evident in mean plant ratios of inflated pods/flower and matured seeds/flower. Weevil counts were positively correlated to plants having more flowers, although again failing in significance during 1999 when weevil infestation was lowest.

DISCUSSION

Higher reproductive yield among plants having more flowers, or which belong to clusters having more flowers, is expected if a larger inflorescence confers an advantage. Larger flower count per cluster and per plant failed to indicate an advantage in inflated pods and seed production on a per flower basis. However, the numbers of inflated pods and matured seeds per plant were higher during two of three study years among clusters and plants which produced more flowers. This reproductive output among clusters and plants having larger inflorescences is notable in respect to when the entomophilous species blooms. Over a dozen forbs in the restored prairie under study, as well as one-third of the prairie species of Illinois, bloom during spring when pollinators tend to be few and limited to bumblebees (Howe, 1994; Pearson, 1933; Petersen, 1996). Larger inflorescence size did not have a great cost in flowers pollinated per plant, but instead, possible rewards in seeds matured despite added predatory pressure from *A. rostrum*.

Predatory pressure by *A. rostrum* may act as a constraint to inflorescence size. Weevil counts/plant were highest among clusters and plants having more flowers except in 1999 when the mean weevil count was lowest. Future studies may investigate how foraging and oviposition behaviors of pollinators and the weevil vary in the choice of clusters to that of individual plants within clusters. In addition, future studies could examine the genetic relatedness shown by plants within and between clusters. A degree of self pollination, the likelihood of pollen coming from members of the same cluster versus from different clusters and the dispersal of seeds by gravity would seemingly support a high degree of genetic relatedness of plants within clusters. If so, the results of our study has greater relevance where inflorescence size is linked to the success of a genetic type of *B. leucophaea* at the level of the cluster.

ACKNOWLEDGEMENTS

Appreciated is extended to B. Petersen for providing valuable comments in preparation of the manuscript.

LITERATURE CITED

Ehrlen, J. 1997. Risk of grazing and flower number in a perennial plant. Oikos 80:428-434.

Haddock, R. C. and S.J. Chaplin. 1982. Pollination and seed production in two phenologically divergent prairie legumes (*Baptisia leucophaea* and *B. leucantha*). American Midland Naturalist 108:175-186.

Hainsworth, F.R., L.L. Wolf, and T. Mercier. 1984. Pollination and pre-dispersal seed predation: net effects on reproduction and inflorescence characteristics in *Ipomopsis aggregata*. Oecologia 63:405-409.

Howe, H. F. 1994. Managing species diversity in tallgrass prairie: assumption and implications. Conservation Biology 8:691-704.

Jennersten, O. 1988. Pollination in *Dianthus deltoides* (Caryophyllaceae): effects of habitat fragmentation on visitation and seed set. Conservation Biology 2:359-366.

Jennersten, O. and S.G. Nilsson. 1993. Insect flower visitation frequency and seed production in relation to patch size of *Viscaria vulgaris* (Caryophyllaceae). Oikos 68:283-292.

Kirt, R.R. 1989. Prairie Plants of Northern Illinois: Identification and Ecology. Stipes Publishing Company, Champaign, Illinois, USA.

Ladd, D. 1995. Tallgrass Prairie Wildflowers. Falcon Press Publishing Co., Inc., Helena, Montana, USA.

Menges, E.S. 1988. Seed germination percentage increases with population size in a fragmented priarie species. Conservation Biology 5:158-164.

Molau, U., B. Eriksen, and J.T. Knudsen. 1989. Pre-dispersal seed predation in *Bartsia alpina*. Oecologia 81:181-185.

Pearson, J.F.W. 1933. Studies on the ecological relations of bees in the Chicago region. Ecological Monographs 3:383-441.

Petersen, C.E. 1996. Bee visitors of four reconstructed tallgrass prairies in northeastern Illinois. Paper presented at the 15th North American Prairie Conference, St. Charles, Illinois, USA.

Petersen, C.E., S. C. Lindsey, D.M. Dudgeon, and R. A. Pertell. 1998. The effect of seed predation on pod abortion by the prairie legume, *Baptisia leucophaea*. Transactions of the Illinois Academy of Science 91:47-52.

Swink, F. and G. Wilhelm. 1994. Plants of the Chicago region, 4th ed. Indiana Academy of Science, Indianapolis, Indiana, USA.

Watt, A.S. 1947. Pattern and process in the plant community. Journal of Ecology 35:1-22.

Table 1. Mean ± standard deviation counts of *Baptisia leucophaea* per cluster, and also per plant counts of flowers, initiated pods, ripened pods, seeds matured, and weevils (*Apion rostrum*). Measurements are ordered according to year. Sample size = 14 for 1997 and 25 for 1998 and 1999. Kruskal-Wallis values (H) and associated probabilities from parameter comparisons among study years are given.

Parameter	1997	1998	1999	H	p
Baptisia leucophaea/cluster	12.4±9.2	6.8±4.5	9.0±7.9	4.39	0.11
Flower count/plant	17.4±10.0	17.4±13.6	24.8±17.8	3.66	0.16
Inflated pods/plant	11.4±6.4	16.6±13.4	17.2±15.3	1.33	0.51
Ripened pods/plant	10.5±5.7	3.4±3.7	16.4±14.2	24.58	<0.01
Matured seeds/plant	25.7±31.5	1.4±3.4	83.3±91.8	29.62	<0.01
Weevils/plant	4.5±5.0	11.2±17.	3.6±9.1	6.56	0.04

Table 2. Results of correlation testing between flower counts and other components of *Baptisia leucophaea* reproductive yield as well as counts of weevils (*Apion rostrum*). Spearman rank correlation coefficients (R) and probabilities (P) are presented according to comparison and year of sampling. Seed counts are based on seeds matured.

Variable 1	Variable 2	Year					
		1997		1998		1999	
		R	P	**R**	P	**R**	P
Flower count/cluster	Plant count/cluster	**0.83**	<0.01	**0.37**	0.07	**0.45**	0.02
	Flower count/plant	**0.72**	<0.01	**0.72**	<0.01	**0.63**	<0.01
	Inflated pods/plant	**0.69**	<0.01	**0.69**	<0.01	**0.45**	0.02
	Ripened pods/plant	**0.66**	<0.01	**0.27**	0.18	**0.36**	0.08
	Matured seeds/plant	**0.54**	<0.05	**0.31**	0.13	**0.43**	0.03
	Weevils/plant	**0.64**	0.01	**0.42**	0.04	**0.37**	0.07
	Inflated pods/flower	**0.13**	0.66	**-0.23**	0.29	**-0.43**	0.03
	Matured seeds/flower	**0.30**	0.29	**0.26**	0.22	**-0.08**	0.69
Flower count/plant	Plants/cluster	**0.35**	0.22	**-0.28**	0.17	**-0.29**	0.17
	Inflated pods/plant	**0.98**	<0.01	**0.99**	<0.01	**0.80**	<0.01
	Ripened pods/plant	**0.98**	<0.01	**0.54**	<0.01	**0.77**	<0.01
	Matured seeds/plant	**0.40**	0.16	**0.40**	<0.05	**0.69**	<0.01
	Weevils/plant	**0.60**	0.02	**0.60**	<0.01	**0.15**	0.48
	Inflated pods/flower	**0.19**	0.51	**-0.14**	0.52	**-0.18**	0.38
	Matured seeds/flower	**0.17**	0.56	**0.27**	0.20	**-0.04**	0.85