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Winter diet, seed preferences and foraging behavior of Henslow's Sparrows (Ammodramus henslowii) in southeastern Louisiana

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WINTER DIET, SEED PREFERENCES AND FORAGING BEHAVIOR OF HENSLOW'S SPARROWS (*AMMODRAMUS HENSLOWII*) IN SOUTHEASTERN LOUISIANA

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ABSTRACT

Henslow's Sparrow (*Ammodramus henslowii*) is a grassland bird whose population is declining throughout its range, mainly due to habitat loss. The Longleaf Pine forest ecosystems in which Henslow's Sparrows spend their winters are reduced to 5% of their former range. The winter ecology of Henslow's Sparrow remains understudied, especially regarding important aspects of diet and foraging behavior. To determine winter diet, I collected fecal samples from Henslow's Sparrows during banding operations in southeastern Louisiana pine savannas from October 2003-March 2004 and October 2004-April 2005. I then analyzed the samples for presence of seeds and arthropod parts, identified them to the lowest classification possible, and then used both multivariate and univariate techniques to look for variations in diet due to a savannas burn history, month of year and their interaction. I also conducted multiple-offer and simple-offer seed preference experiments on captive Henslow's Sparrows in December 2004 and February 2005 to test a variety of seed types found at differing abundances within the study sites.

Commonly consumed seeds included *Scleria* spp., *Rhynchospora* spp., the category including *Dichanthelium* spp. and *Panicum* spp., and the combined category of *Aristida* spp., *Schizachyrium* spp. and *Andropogon* spp. Frequently consumed arthropods included Arachnids and insects from the orders Coleoptera, Hymenoptera, Hemiptera and Orthoptera. Diets varied significantly among months, most likely due to resource availability and timing of seed senescence. Results of seed preference experiments suggest that Henslow's Sparrows preferred *Dichanthelium angustifolium*, *Muhlenbergia expansa* and *Eupatorium leucolepis* while they avoided *Schizachyrium scoparium*. *Ctenium aromaticum* and *Panicum anceps* appeared to be secondarily preferred food items.

CHAPTER 1: INTRODUCTION

Henslow's Sparrows (*Ammodramus henslowii*) winter almost exclusively in Longleaf Pine (*Pinus palustris*) savannahs along the Gulf coast (Herkert et al. 2002). This habitat has been reduced to <5% of its former range (Noss et al. 1995), possibly contributing to the decline in Henslow's Sparrow abundance (Pruitt 1996). Little is known regarding the winter ecology of the Henslow's Sparrow, including important aspects of diet and foraging behavior.

During the breeding season, Henslow's Sparrows forage in the dense litter layer, eating mostly insects with some fruit and seeds (Herkert et al. 2002). Limited data indicate that wintering Henslow's Sparrows eat mostly small seeds of grasses, sedges and forbs as well as some insects (Herkert et al. 2002, Fuller 2004). Also, anecdotal evidence suggests that sparrows pick up fallen seeds from the ground in the winter, which is why litter-free ground may be preferred (Carrie et al. 2002).

My overall objectives were to learn more about the winter diet and foraging behavior of Henslow's Sparrow. Specifically, my first objective was to determine the winter diet of Henslow's Sparrows through fecal analysis (Chapter 2). My second objective was to relate food eaten by Henslow's Sparrows in the wild to what they prefer to eat in captive seed selection trials (Chapter 3). Finally, my third objective was to discover and describe how Henslow's Sparrows forage (Chapter 4).

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CHAPTER 2: WINTER DIET OF HENSLOW'S SPARROWS IN SOUTHEASTERN LOUISIANA

Henslow's Sparrow (*Ammodramus henslowii*) is one of fastest declining grassland birds. Partners in Flight lists Henslow's Sparrow as a watch list species requiring immediate action, with an estimated overall population of 79,000 (Rich et al. 2004). Henslow's Sparrows are classified as Endangered in Canada and listed as "Endangered in 7 states, Threatened in 5 and of Special Concern in 4" (Herkert et al. 2002). Their population is declining at a rate of 7.5% per year, mainly due to habitat loss (Pruitt 1996, Herkert et al. 2002). Longleaf Pine (*Pinus palustris*) forest ecosystems in which Henslow's Sparrows spend their winters have been reduced to <5% of their former range and may be affecting the population decline (Noss et al. 1995, Tucker and Robinson 2003).

Henslow's Sparrows are short distance migrants which breed in the northeastern and northcentral US from April through September, and spend their winters in the southeastern US from October through April (Carrie et al. 2002). The winter habitat of Henslow's Sparrows includes open pine savannahs and pitcher plant (*Sarracenia* spp.) bogs that are characterized by scattered pine trees, tall grasses with little or no litter, low vegetation density near the ground, and low shrub cover (Plentovich et al. 1999, Bechtoldt 2002, Carrie et al. 2002). Pine savanna habitat is characterized by a series of soil moisture gradients ranging from xeric sandhills to seasonally flooded flatwoods (Peet and Allard 1993, Noss et al. 1995). Henslow's Sparrows avoid flying during winter, preferring to remain on the ground beneath grasses. Therefore, sparrows prefer winter habitat that is open on the ground so that they can run under grasses to elude predators and forage for seeds (Carrie et al. 2002).

Dominant understory plants in southeastern Louisiana pine savannas include *Andropogon* spp., *Schizachyrium scoparium*, *Schizachyrium tenerum*, *Dichanthelium* spp., *Panicum* spp.,

Muhlenbergia expansa, *Ctenium aromaticum*, *Aristida* spp., and *Rhynchospora* spp. (Bechtoldt 2002, Bechtoldt and Stouffer 2005). Henslow's Sparrow abundance is positively correlated with high seed abundance (Plentovich et al. 1999, Bechtoldt 2002, Carrie et al. 2002, Tucker and Robinson 2003, Bechtoldt and Stouffer 2005), and in southeastern Louisiana increased abundance of Henslow's Sparrows is correlated with the presence of *Ctenium aromaticum* and *Muhlenbergia expansa* (Bechtoldt 2002, Bechtoldt and Stouffer 2005).

Historically, most of the habitat loss in the Longleaf Pine ecosystem was due to exploitation for tar and turpentine followed by logging (Frost 1993, Peet and Allard 1993, Smith 2004, Engstrom et al. 2005). Fire suppression in the Longleaf Pine forests that survived logging caused encroachment of shrubs and hardwoods (Smith and Shugart 1987, Waldrop et al. 1992, Engstrom et al. 2005). Current threats to Longleaf Pine savannas are development, altered hydrology, fire suppression, and invasion of exotic species (Plentovich et al. 1999).

Habitat suitable for Henslow's Sparrows historically was dependent on regular burning with natural fires occurring as frequently as every 1-3 years in some areas (Tucker and Robinson 2003, Smith 2004, Engstrom et al. 2005). Henslow's Sparrows are most abundant the first winter following a burn (Bechtoldt 2002, Bechtoldt and Stouffer 2005). Frequent burning favors pines and native grasses while suppressing hardwoods (Waldrop et al. 1992, Engstrom et al. 2005). Burns during the growing season are most effective in stimulating vegetative growth and seed production, as this mimics the natural system of fires started by lightning storms in summer (Waldrop et al. 1992, Tucker and Robinson 2003). Not only do savanna plants require fire to produce seeds, but they also need fire to clear litter and shrubs to prevent shading, which also stops seeds from being produced (Buckner and Landers 1979, Waldrop et al. 1992, Smith 2004).

The breeding season diet of Henslow's Sparrows consists of 82% animal matter, including 50% orthoptera and 19% coleoptera, and 18% plant matter (Herkert et al. 2002). However, the winter diet has received far less study. Limited data suggest that Henslow's Sparrows eat small grass seeds, such as wiregrass (*Aristida spp.*), which is more common east of Louisiana (Herkert et al. 2002). One recently completed study, which used crop flushing to determine Henslow's Sparrow winter diet in Mississippi, found that birds commonly eat seeds of sedges such as *Rhynchospora* spp. and *Scleria* spp. as well as grass seeds such as *Panicum* spp., *Paspalum* spp., *Andropogon* spp. and an herb, *Balduina uniflora* (Fuller 2004). Arthropods also were commonly found to be present in the diet of Henslow's Sparrows wintering in Mississippi, but they composed only a small proportion of the total crop contents (Fuller 2004).

Because winter habitat use by many migratory birds is related to habitat quality and abundance of food resources (Pulliam and Enders 1971, Pulliam and Dunning 1987, Johnson and Sherry 2001), specific knowledge of diet has conservation implications when determining how to properly manage pine savannas inhabited by Henslow's Sparrows. Limiting factors for sparrows during winter include food and habitat (Fretwell and Lucas 1970, Fretwell 1972, Pulliam and Mills 1977). It is important to learn which resources need to be present for the birds to survive through the winter and allow for a successful migration back to the breeding grounds.

Fecal analysis is the most reliable non-invasive technique to determine diets of small birds, and this technique has been used for a number of bird species (Ralph et al. 1985, Rosenberg and Cooper 1990, Kalejeta-Summers 1997, Burger et al. 1999, Strong 1999, Deloria-Sheffield et al. 2001, Long 2001). Therefore, I examined fecal samples collected from Henslow's Sparrows with the goal of determining which seeds and arthropods were consumed by birds wintering in southeastern Louisiana pine savannas. I also was interested in determining

if there was a temporal shift in diet throughout the winter, or if time since burn (0 or 1 year) influenced the diet composition of Henslow's Sparrows.

MATERIALS AND METHODS

Study Sites

I studied Henslow's Sparrows during the winter in southeastern Louisiana. My study sites consisted of ten 2.25-hectare plots located in four different management areas in the Florida Parishes in Southeastern Louisiana (Table 2.1, Figure 2.1). Eight of the plots were previously established and are described in detail in an earlier study (Bechtoldt 2002, Bechtoldt and Stouffer 2005). These include five plots at Lake Ramsay Wildlife Management Area, and two plots at Abita Creek Flatwoods Preserve, both managed by The Nature Conservancy. These seven plots represent seasonally flooded flatwoods. One plot at Whispering Pines Girl Scout Camp, managed by The Girl Scouts of America, represents xeric sandhills. Two additional plots representing xeric sandhills were added at Sandy Hollow Wildlife Management Area for this study. These two plots are managed by Louisiana Department of Wildlife and Fisheries. The areas varied greatly in size, so some had fewer plots based on what would fit within the available suitable habitat (Table 2.1).

Sampling for Henslow's Sparrows

I used flush netting to catch Henslow's Sparrows, wherein five to ten people systematically walked transects within a plot to flush birds. My project incorporated a large community of volunteers to help flush birds, including local birders, college and high school students, and anyone from the community that was willing to help. When a suspected Henslow's Sparrow was flushed, a six-meter mist net was set up with one person holding each end. Other members of the team formed an arc around where the bird landed from one side of the net to the other and then

ran towards the net, chasing the bird into the mist net (Chandler and Woodrey 1995, Bechtoldt 2002). All captured Henslow's Sparrows were banded with U. S. Fish and Wildlife Service aluminum bands. Birds also were weighed and wing length, tail length and fat score (furcular fat out of 100%) were measured and recorded (Bechtoldt 2002). We collected blood to determine sex, a tail feather for further analysis of sex and body condition, and a fecal sample if the bird defecated during handling. All aspects of this research including capture, banding, and collecting feathers and blood was conducted with approval of LSU IACUC, Louisiana Department of Wildlife and Fisheries (LADFW) and US Fish and Wildlife Service (USFWS) under the following permits: AEO314 (IACUC), LNHP-05-059 (LADFW), MB0959180 and 22648 (USFWS).

Locations of Study Sites

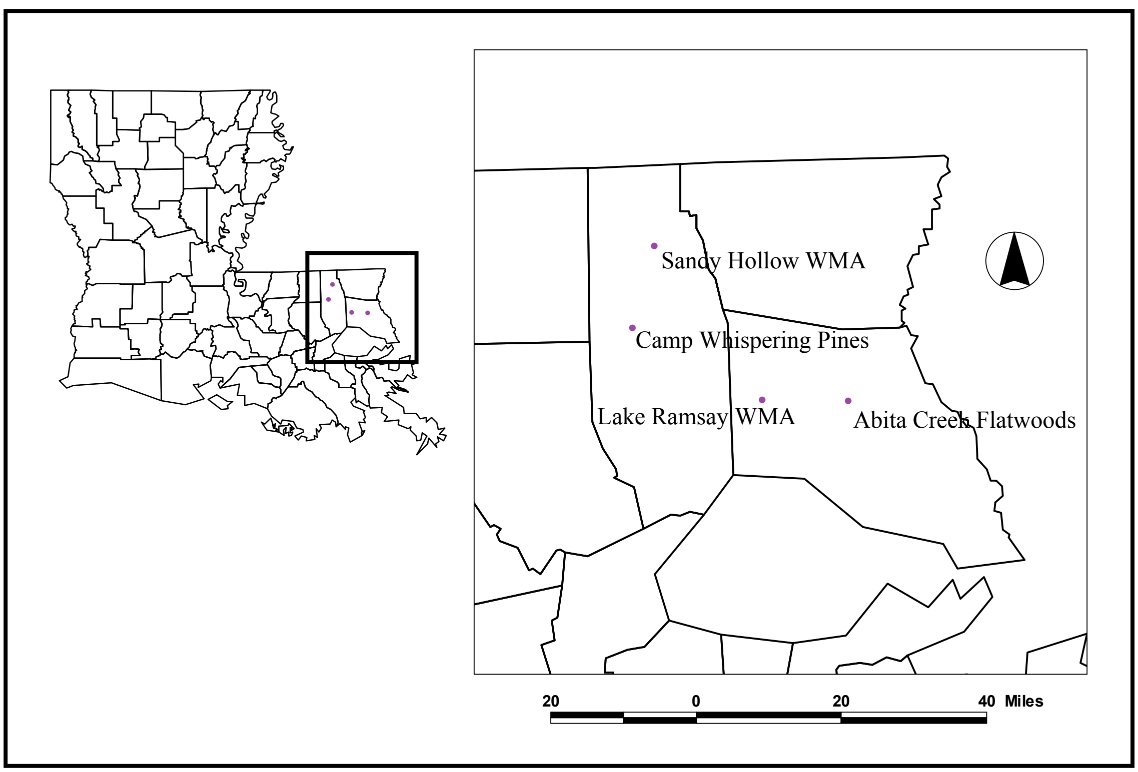

Figure 2.1. Henslow's Sparrows were captured from four study sites in southeastern Louisiana

Table 2.1. Locations of plots and burn histories.

Plot Name (Burn Unit)	Management Area / Site	Site Size (ha)	Most Recent Burn* 2003-2004	Most Recent Burn* 2004-2005	Bechtoldt (2002) Plot Name
LR01 (TNC2)	Lake Ramsay WMA	489.687	May 2003 [Ø]	May 2003 [1]	TNC98
LR02 (TNC4)	Lake Ramsay WMA	489.687	March 2003 [Ø]	March 2003 [1]	RAM01
LR03 (WMA3)	Lake Ramsay WMA	489.687	Jan 2003 [Ø]	Jan 2003 [1]	WMA98
LR04 (WMA1)	Lake Ramsay WMA	489.687	May 2003 [Ø]	May 2003 [1]	RN
LR05 (WMA4)	Lake Ramsay WMA	489.687	April 2003 [Ø]	March 2004 [Ø]	RS
AS03 (AC01)	Abita Creek Flatwoods Preserve	321.332	June 2002 [1]	June 2002 [2]	BU1
AS01 (AC03)	Abita Creek Flatwoods Preserve	321.332	April 2002 [1]	May 2004 [Ø]	BU3
CWP (Area 2A)	Camp Whispering Pines	19.021	spring 2003 [Ø]	spring 2003 [1]	GS01
SH01	Sandy Hollow WMA	1422.47	spring 2003 [Ø]	spring 2003 [1]	*N/A*
SH02	Sandy Hollow WMA	1422.47	spring 2002 [1]	spring 2004 [Ø]	*N/A*

*For fieldwork in winter 2003-2004 or winter 2004-2005
[Ø] Years since burn = 0, [1] Years since burn =1, [2] Years since burn =2

Fecal Analysis

I determined winter diet of the Henslow's Sparrow by identifying seeds and insects present in collected fecal samples. Fecal samples (n=299) were obtained from Henslow's Sparrows by chance during capture; birds often defecated while they were being handled for weight and measurements. I collected fecal samples in the field on filter paper and later transferred them to vials of 70% ethanol for softening and storage.

I used techniques described by Ralph et al. (1985) for analyzing bird droppings in the lab. I examined fecal samples using a 7-30x zoom dissecting microscope to identify food items to the lowest taxonomic classification possible. A reference collection of seeds, identified by Erik Johnson (Graduate Student, Louisiana State University) with the help of Bill Platt (Professor, Louisiana State University) and Glenn Montz (Southeastern Louisiana University), were taken from fields where birds were captured, to assist identification. I identified arthropods to order when possible with the help of Alexey Tishechkin (Post Doctoral Researcher, Louisiana State University Arthropod Museum). To identify arthropod parts, samples that were incidentally

collected during vegetation sampling and vacuuming of seeds (Erik Johnson, unpublished data) were used as reference.

Statistical Analysis

Fecal samples were analyzed for the presence or absence of identified food items. I used EstimateS (Colwell 2005) to produce an accumulation curve of identified food items to determine the effectiveness of my sample size. To determine frequency of occurrence of food items, I divided the total number of samples in which an item was identified by the number of samples collected (n=299), then multiplied by 100. This was done for each month and burn class.

Dissimilarities among observations were calculated utilizing the DISTANCE procedure (SAS Institute Inc. 2004). This procedure assigned a distance to each observation (sample) based on how different it was from all other observations. Only samples with at least one identifiable seed item were used for analysis. The Jaccard coefficient method was implemented to calculate the dissimilarities. Multidimensional scaling (MDS) was used on Jaccard distances of diets of individual birds to look for patterns in relation to time since burn, month of collection, whether the savanna represented a xeric sandhill or seasonally flooded flatwood, and the site and plot where the bird was captured. This technique was used as an illustrative method to display the data and visually check for differences in diet (Davison and Sireci 2000)

A Quasi Latin-Rectangle mixed-model Multivariate Analysis of Variance (MANOVA) with repeated measures on month was conducted using PROC GLM (SAS Institute Inc. 2004) to establish if there was an overall burn and/or month effect on seed types consumed. Three dimension scores obtained from MDS were utilized as the response variables. Because food resource use was likely influenced most by availability, I considered each fecal sample as

independent, regardless of whether it was from a recaptured bird, as long as it was collected on a different sampling event. To check this assumption, I looked at the plot of dissimilarities created with MDS to see if all samples obtained from the same bird clustered together. Plot was the experimental unit, and bird was the sampling unit. Burn, month and their interaction were fixed effects. Year, plot and plot*year*burn were included in the model as random effects. Plot*year*burn was used as the error term to test variables burn and year. Month, month*burn and plot*year*burn were tested with MS(Error). I used the Univariate procedure (SAS Institute Inc. 2004) to test normality of each dimension. Four outliers were removed from the model, and this did not change the results.

Because normality assumptions of the MANOVA were violated, I also conducted a canonical discriminant function analysis (CDFA) on the three dimensions output from MDS using PROC CANDISC (SAS Institute Inc. 2004). This test was used as an attempt to describe characteristics of diets that were distinctive to birds that grouped together (Brown and Wicker 2000). However, CDFA is only able to handle a completely randomized design, so it ignores the design elements of the model that I was able to include in other tests (Tabachnick and Fidell 2001, B. Moser, pers. comm.). Therefore, any p-values obtained from CDFA should be treated with caution as they are not calculated with the correct error terms (B. Moser, pers. comm.).

In order to establish the effect of burn and/or month and their interaction on the probability of a certain seed to be eaten, the GLIMMIX procedure (SAS Institute Inc. 2004) was utilized to perform a Quasi-Latin Rectangle mixed-model Analysis of Variance (ANOVA) with repeated measures on month. The binomial probability distribution and the logit link were utilized. Plot was the experimental unit, and bird was the sampling unit. The presence or absence of the seed in each sample was the dependent variable. The model included fixed

effects of burn, month and their interaction. Plot, year and plot*year*burn were included into the model as random terms. Plot*year*burn was used as the error term to test variables burn and year. Month, month*burn and plot*year*burn were tested with MS(Error).

RESULTS

Food Items Identified

A total of 299 fecal samples were collected from 217 Henslow's Sparrows between October 2003-April 2004 and October 2004-April 2005 (Table 2.2). Samples from savannas that were in the second year after a spring burn were excluded from analysis because there were very few samples (n=7) from 2 year burns. Samples from the months of October and November were lumped together as were those from March and April due to the small number of samples obtained from birds captured in October (n=4) and April (n=11).

I was able to identify 34 different types of food items in the 299 fecal samples (Table 2.2, 2.3). The accumulation curve of identified food items demonstrated that I had an adequate sample size (Figure 2.2). I often was unable to distinguish between fragments of *Dichanthelium* spp. and *Panicum* spp. because of the similar appearance of these seeds; thus, I established a single category to include both seed types, called GRASS, but also counted them in their own categories when I could identify the genus. I also was unable to distinguish among fragments of *Aristida* spp., *Andropogon* spp. and *Schizachyrium* spp.; thus, these also were counted in one category, called ARISTIDA. Additionally, all samples contained debris that I was unable to identify, including grit, seed pieces and arthropod parts.

Scleria spp. was the most commonly identified seed and it was found in 84% of the samples (Table 2.3, Figure 2.3, Figure 2.4). *Rhynchospora* spp. was identified in approximately 55% of samples, the category including *Dichanthelium* spp. and *Panicum* spp. was identified in

48% of samples, and the category of *Aristida* spp., *Andropogon* spp. and *Schizachyrium* spp. was identified in 32% of samples (Table 2.2, Figure 2.3, Figure 2.4).

Arthropod fragments were present in approximately 89% of samples (Table 2.3, Figure 2.1, Figure 2.2). The most commonly found arthropods were Coleopterans and Arachnids, which were in approximately 58% of samples, followed by Hemiptera in 26% of samples, and Hymenoptera in 17% of samples (Table 2.3, Figure 2.3, Figure 2.4).

Table 2.2. Number of fecal samples collected by month and burn

	Burn		
Month	**0**	**1**	**Total**
OCT/NOV	47	26	73
DEC	66	19	85
JAN	30	16	46
FEB	44	14	58
MAR/APR	25	12	37
Total	212	87	299

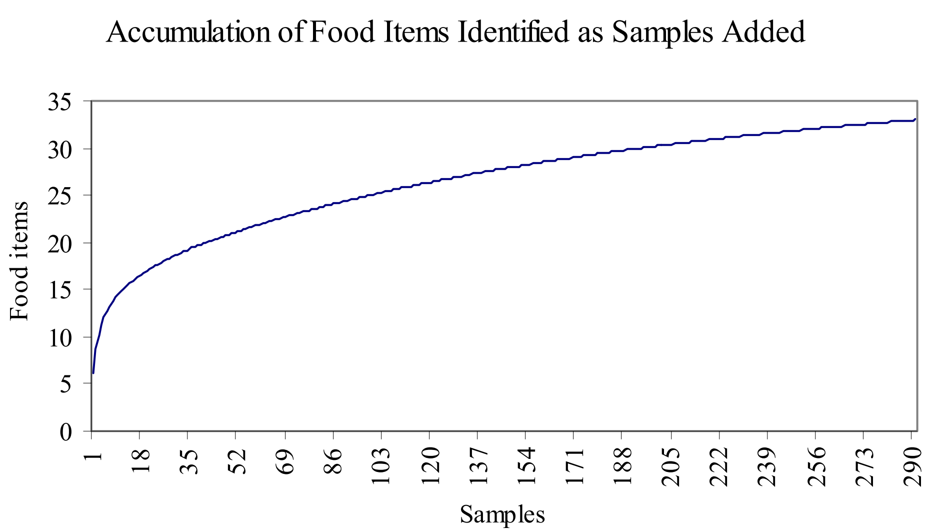

Figure 2.2. Number of different food items identified with increasing sample size.

Table 2.3. Frequency of occurrence of food items by month and burn

		OCT/NOV		DEC		JAN		FEB		MAR/APR	
Consumed Taxa	**% Occurrence**	**Burn 0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**
Scleria spp.	83.95	91.49	80.77	84.85	68.42	96.67	81.25	81.82	100.00	64.00	83.33
Rhynchospora spp.	51.51	59.57	57.69	45.45	57.89	50.00	50.00	40.91	78.57	36.00	75.00
R. chapmanii	4.68	4.26	7.69	1.52	0	6.67	0.00	2.27	14.29	8.00	16.67
R. pusilla	0.67	0	0	1.52	0	0	0	0	0	0	8.33
R. globularis	0.33	0	0	0	0	0	6.25	0	0	0	0
R. elliottii	0.33	0	0	1.52	0	0	0	0	0	0	0
R. gracilenta	0.33	0	0	1.52	0	0	0	0	0	0	0
GRASS	48.16	51.06	53.85	57.58	73.68	30.00	56.25	31.82	71.43	24.00	50.00
ARISTIDA	32.44	29.79	23.08	46.97	52.63	33.33	18.75	22.73	28.57	16.00	41.67
Dichanthelium spp.	9.03	6.38	23.08	9.09	26.32	6.67	12.50	2.27	14.29	0	0
Eragrostis spp.	1.34	0	0	1.52	0	6.67	0	2.27	0	0	0
Xyris spp.	1.34	0	0	1.52	10.53	0	0	2.27	0	0	0
Panicum spp.	1.00	0	0	0	0	3.33	0	0	7.14	4.00	0
P. anceps	0.33	0	0	1.52	0	0	0	0	0	0	0
Linum medium	0.67	0	0	0	5.26	3.33	0	0	0	0	0
Muhlenbergia spp.	0.67	0	0	1.52	0	0	0	0	7.14	0	0
Pityopsis graminifolia	0.33	0	0	0	0	0	0	2.27	0	0	0
PLANT Total	95.32	100.00	96.15	93.94	94.74	93.33	93.75	90.91	100.00	96.00	100.00
ARTHROPOD Total	88.96	95.74	100.00	84.85	89.47	83.33	81.25	88.64	92.86	92.00	75.00
Coleoptera	58.19	76.60	69.23	46.97	42.11	50.00	43.75	54.55	50.00	92.00	41.67
Curculionidae	20.07	23.40	19.23	15.15	15.79	16.67	12.50	13.64	21.43	56.00	8.33
Chrysomelidae	1.00	2.13	3.85	0	0	0	0	2.27	0	0	0
Carabidae	0.67	0	0	0	0	0	0	0	0	8.00	0
Scarabidae	1.34	2.13	0	1.52	0	0	0	2.27	0	4.00	0
Arachnid	57.86	72.34	69.23	46.97	57.89	46.67	43.75	59.09	42.86	80.00	50.00
Araneae	57.53	72.34	69.23	46.97	52.63	46.67	43.75	59.09	42.86	80.00	50.00
Acari	0.33	2.13	0	0	0	0	0	0	0	0	0
Hemiptera	26.09	36.17	34.62	28.79	15.79	23.33	25.00	18.18	14.29	28.00	16.67
Hymenoptera	17.73	17.02	30.77	9.09	5.26	6.67	25.00	20.45	21.43	36.00	25.00
Orthoptera	10.03	19.15	7.69	12.12	15.79	10.00	0	4.55	0	8.00	8.33
Lepidoptera	9.03	14.89	7.69	4.55	5.26	6.67	25.00	11.36	21.43	0	0
Psocoptera	3.01	2.13	3.85	1.52	5.26	0	0	4.55	7.14	8.00	0
Diptera	0.67	0	0	1.52	0	3.33	0	0	0	0	0
Homoptera	0.33	0	0	0	0	0	6.25	0	0	0	0
Thysanoptera	0.33	0	0	1.52	0	0	0	0	0	0	0

Frequency of occurrence of food items by month

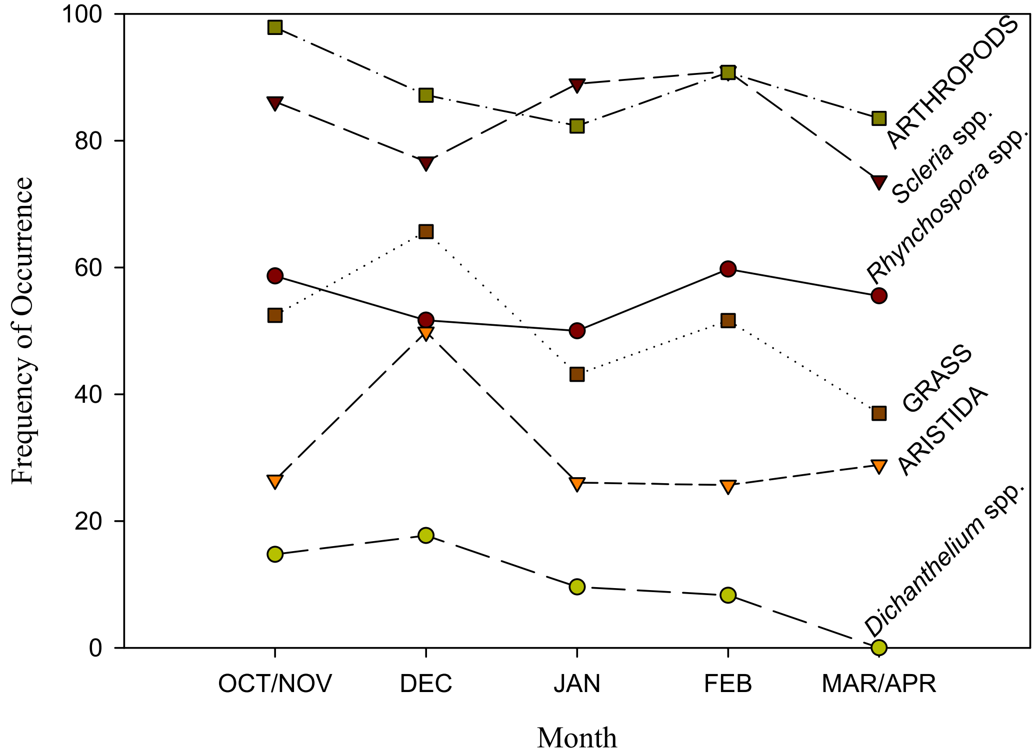

Figure 2.3. Frequency of occurrence of common food items in Henslow's Sparrow fecal samples by month.

Frequency of occurrence of food items by burn

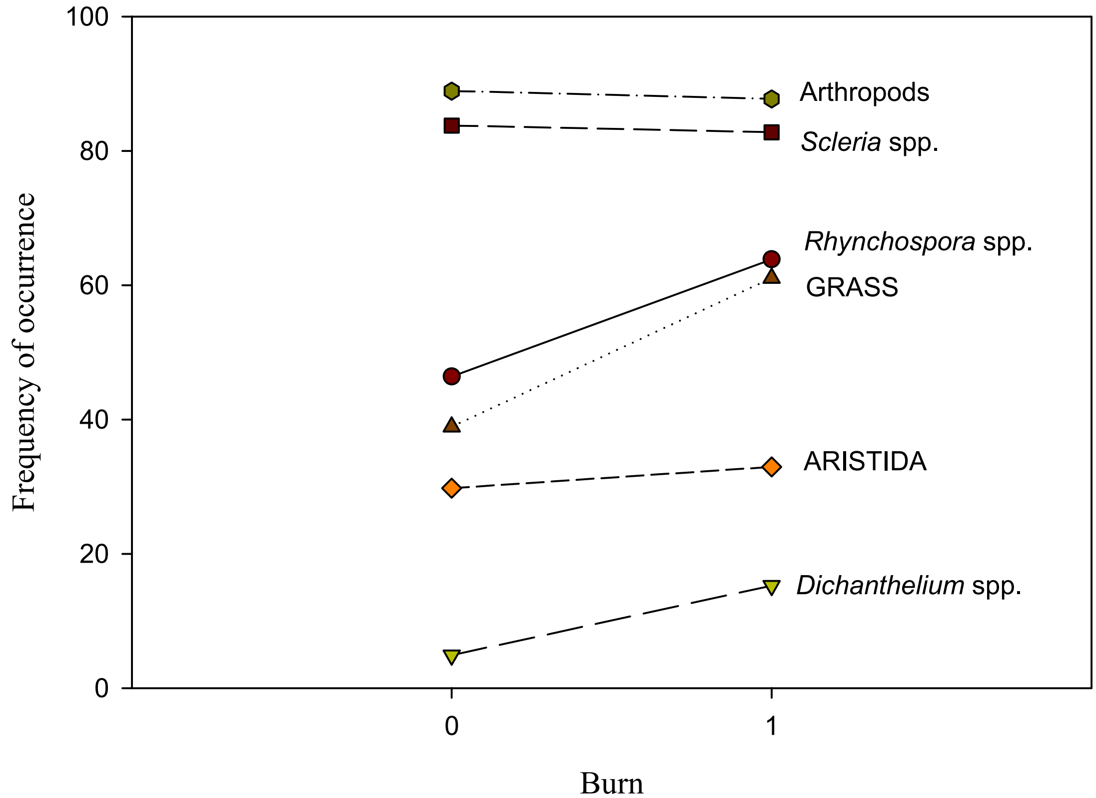

Figure 2.4. Frequency of occurrence of common food items in Henslow's Sparrow fecal samples by burn.

Frequency of occurrence of arthropods by month

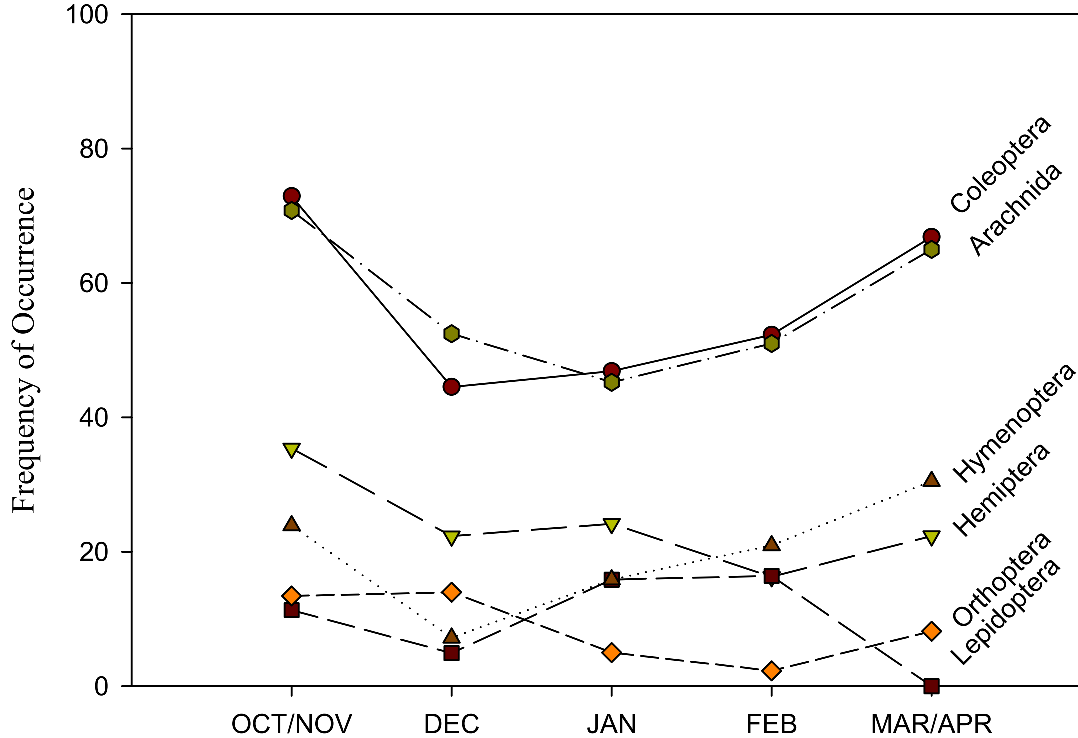

Figure 2.5. Frequency of occurrence of common arthropods in Henslow's Sparrow fecal samples by month.

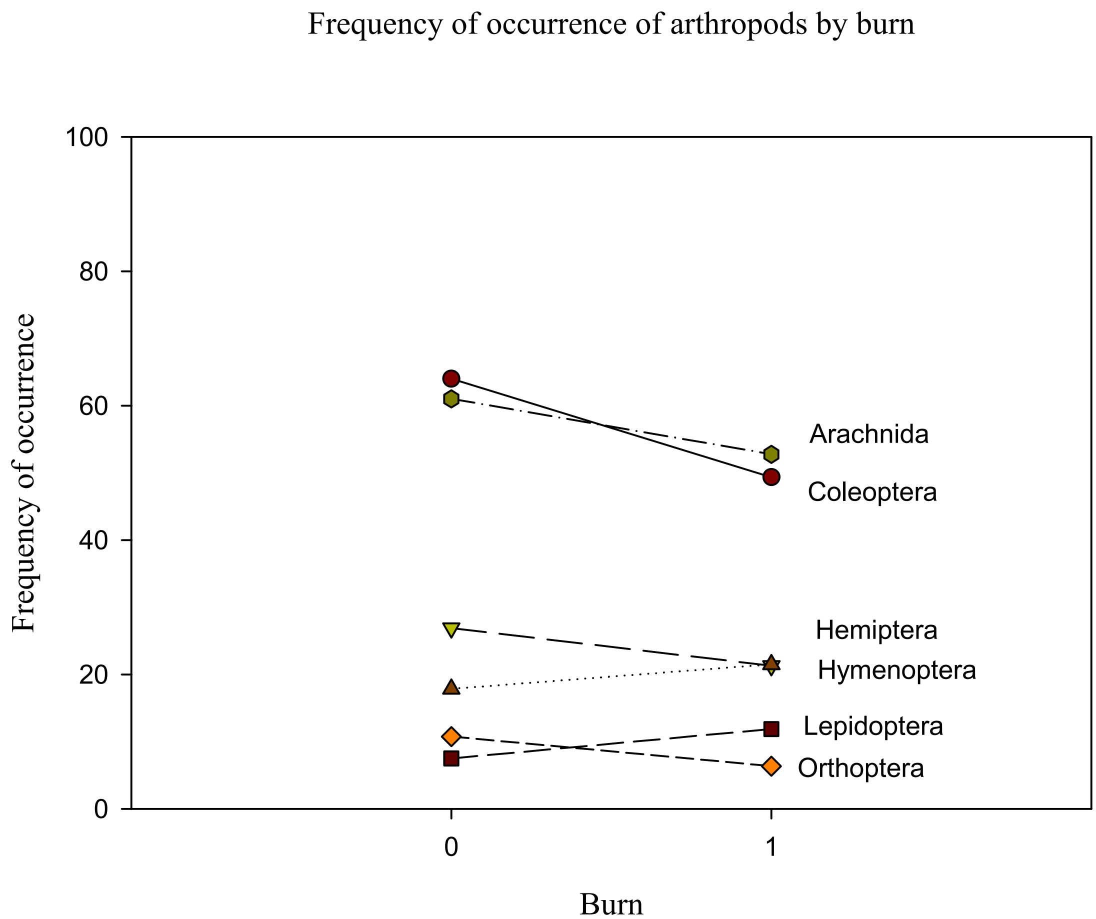

Figure 2.6. Frequency of occurrence of common arthropods in Henslow's Sparrow fecal samples by burn.

Multidimensional Scaling

The information on dissimilarities among observations was captured in 3 dimensions instead of 9 dimensions (the number of different seed types) utilizing Multidimensional Scaling (MDS). The badness-of-fit for 3 dimensions was 0.05. Plots of the data were executed; however, no particular pattern was observed (Figure 2.7, Figure 2.8).

Independence of Samples

I used multiple (2-4) samples from 49 birds in multivariate and univariate analyses. 19 of the 49 (38%) birds had multiple samples cluster together on the MDS plot of dissimilarities;

however, 9 of these birds were represented by additional samples that grouped in different clusters. Overall, 80% of the birds with multiple samples were represented by samples which grouped apart on the MDS plot of dissimilarities; thus, supporting the assumption of independence.

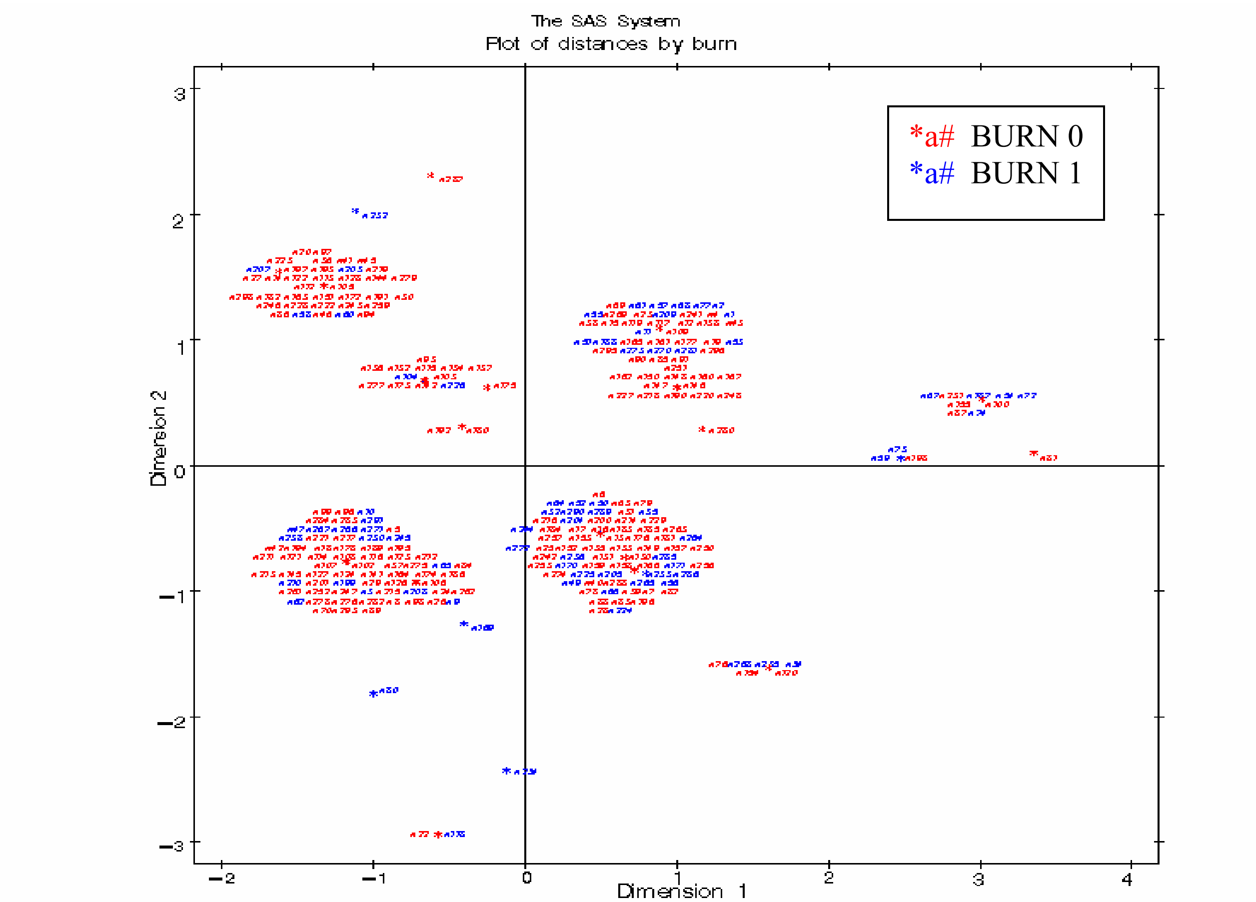

Figure 2.7. Plot of Multidimensional Scaling of distances by burn for Dimensions 1 and 2.

Multivariate Analysis of Variance

Because MANOVA is robust to non-normal distributions as long as there are no outliers, and because of the applicability of Central Limit Theorem due to a large sample size (Tabachnick and Fidell 2001), I proceeded with the analysis even though none of the dimensions fit a normal

distribution (Table 2.4, Figures 2.9, 2.10, and 2.11). Dimension 3 residuals appeared to be the most obviously non-normal, but only due to them being skewed (Figure 2.11). Only the variable month had a significant effect on Henslow's Sparrow diet (Table 2.5).

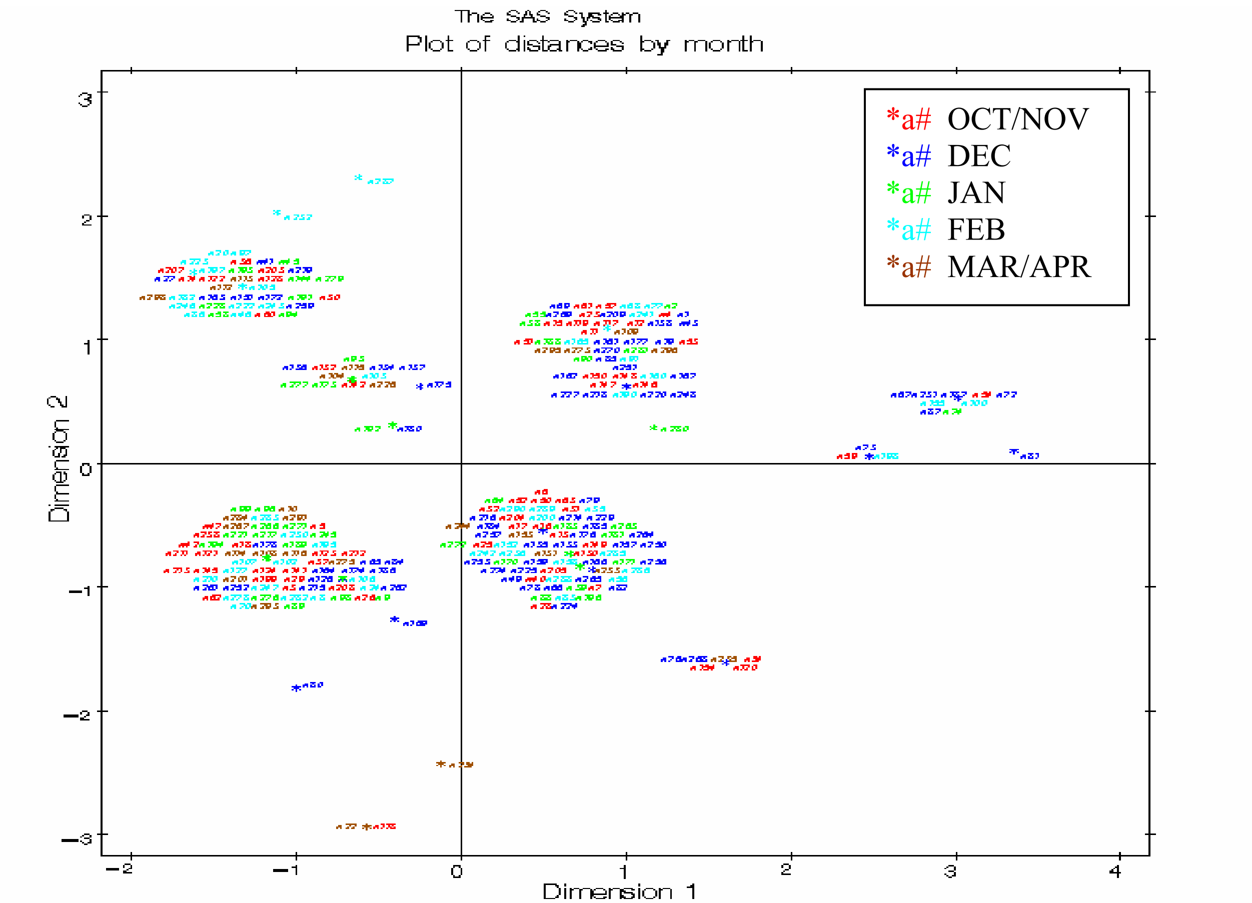

Figure 2.8. Plot of Multidimensional Scaling of distances by month for Dimensions 1 and 2.

Table 2.4. Shapiro-Wilk univariate tests of Normality for each dimension

	Shapiro-Wilk Test Statistic (W)	**Pr < W**
Dimension 1	0.985143	0.0075
Dimension 2	0.976217	0.0002
Dimension 3	0.923875	<0.0001

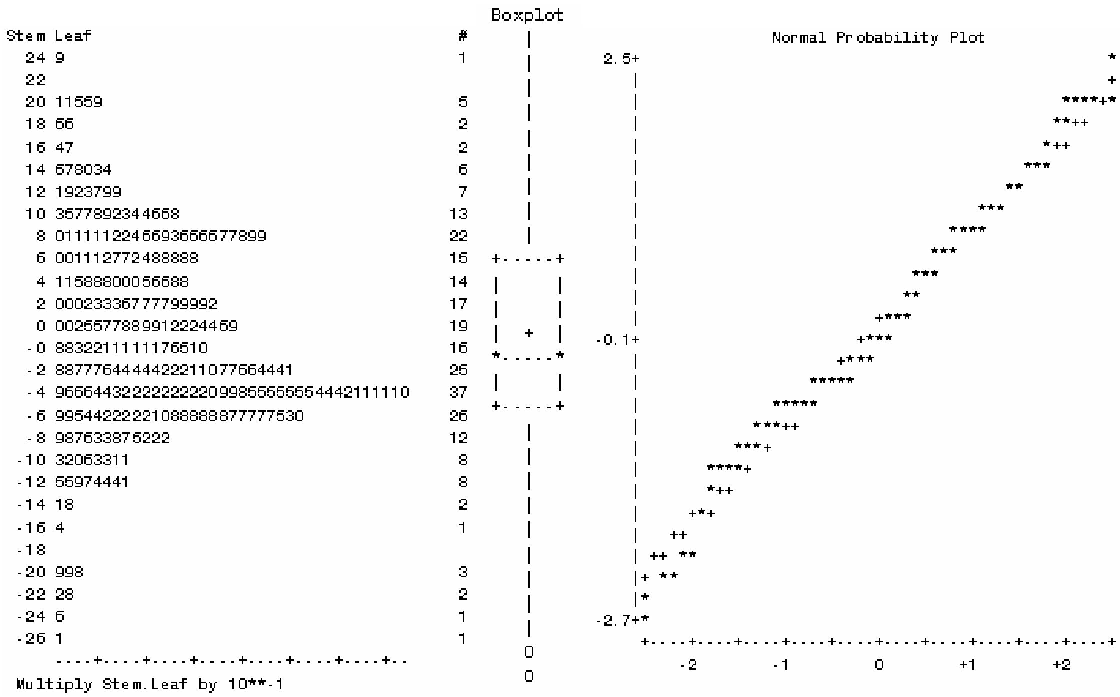

Figure 2.9. Stem leaf plot, boxplot and normal probability plot of dimension 1 residuals.

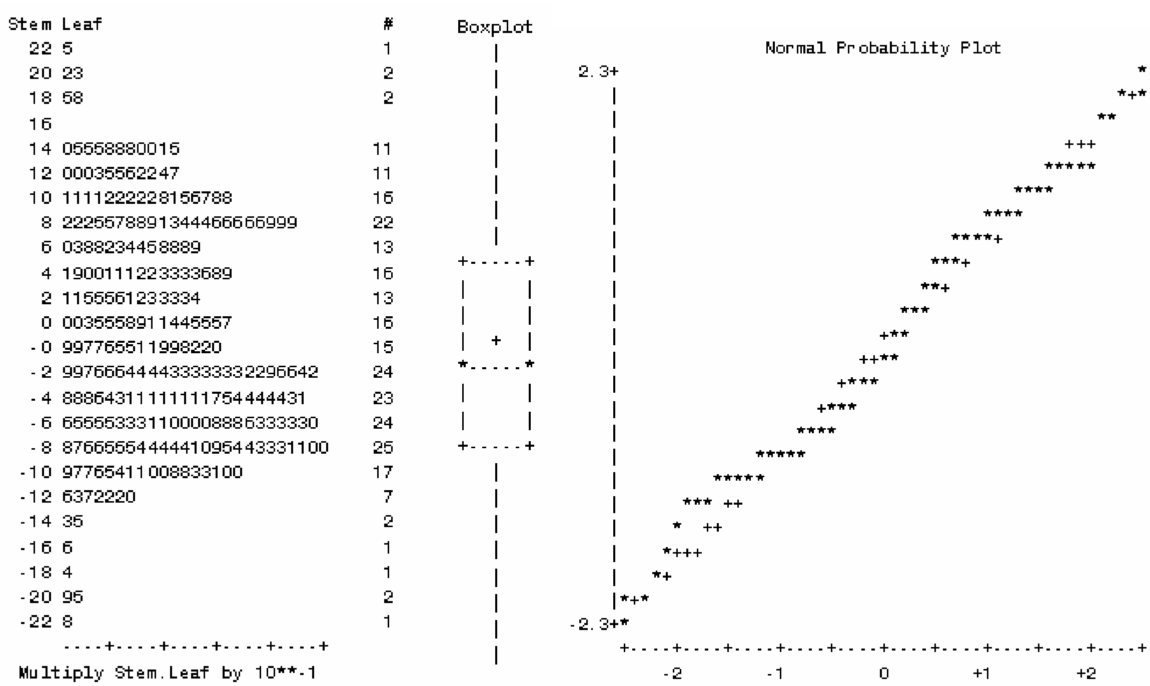

Figure 2.10. Stem leaf plot, boxplot and normal probability plot of dimension 2 residuals.

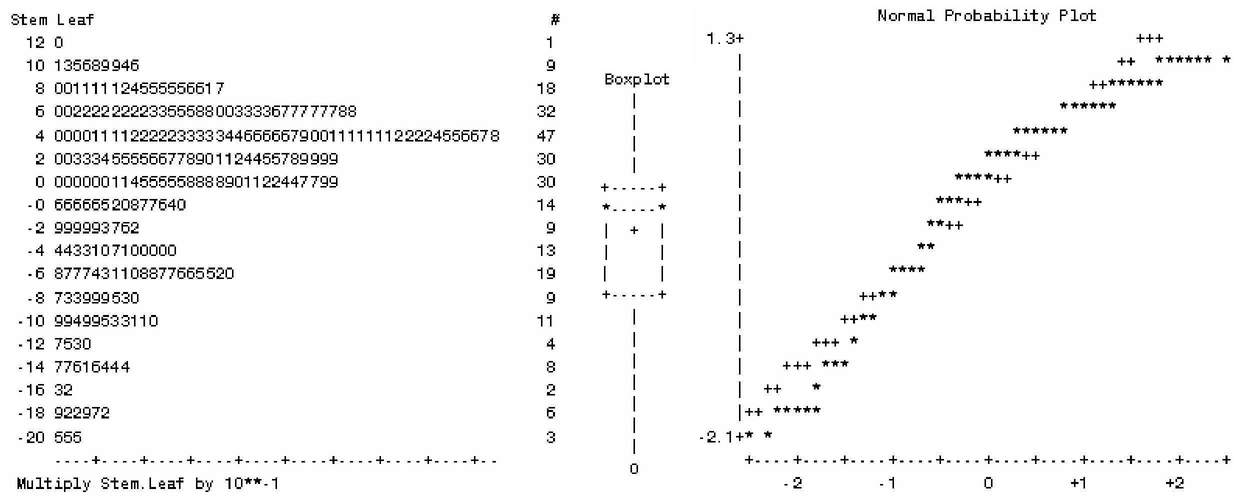

Figure 2.11. Stem leaf plot, boxplot and normal probability plot of dimension 3 residuals.

Table 2.5. Wilks' Lambda tests of no overall effect of treatment variables on composition of diet.

Effect	Value	F Value	Num DF	Den DF	Pr > F
burn	0.911891	0.19	3	6	0.8973
year	0.747616	0.68	3	6	0.5981
month	0.87515	2.68	12	622.04	0.0016
burn*month	0.960274	0.8	12	622.04	0.6504

Canonical Discriminant Function Analysis

Test statistics indicate that only Dimension 1 is statistically significant (Table 2.9). The low squared canonical correlation scores indicate weak relationships between scores on each dimension and group differences (Table 2.10) (Brown and Wicker 2000). Plots of canonical variates by month and burn for each year (Figure 2.12, Figure 2.13) show no groupings of individual bird diets by these variables. Correlations of seed types to the canonical variates show *Scleria* spp. and the grouping of GRASS are separated by Canonical variate 1, the ARISTIDA group is separated by canonical variates 1 and 2, and *Rhynchospora* spp. is separated by canonical variates 1, 2 and 3.

Table 2.6. Pooled Within-Class SSCP Matrix from CDFA.

Variable	Label	Dim1	Dim2	Dim3
Dim1	Dimension 1	283.2639	-2.36922	3.030453
Dim2	Dimension 2	-2.36922	238.8563	0.505315
Dim3	Dimension 3	3.030453	0.505315	167.6769

Table 2.7. Between-Class SSCP Matrix from CDFA.

Variable	Label	Dim1	Dim2	Dim3
Dim1	Dimension 1	65.9057	2.369218	-3.03045
Dim2	Dimension 2	2.369218	22.42344	-0.50531
Dim3	Dimension 3	-3.03045	-0.50531	16.87381

Individual Seed Types using PROC GLIMMIX

Only the variables *Rhynchospora* spp., the combined variable of *Dichanthelium* spp. and *Panicum* spp. (GRASS), and the combined *Aristida* spp., *Schizachyrium* spp. and *Andropogon* spp. (ARISTIDA) were able to converge in the model using PROC GLIMMIX. All other seed types were either too common, such as *Scleria* spp., or were found in too few samples to provide enough variation for the model to work.

The probability of finding ARISTIDA showed a significant month effect (Table 2.17) with greater presence in December (estimated proportion = 0.52) than October/November (estimated proportion = 0.23) (Table 2.18, Figure 2.16, Figure 2.3). There was also a trend for increased presence of GRASS seeds in diets of birds in December (estimated proportion = 0.77) over March/April (estimated proportion = 0.40) (Table 2.19, Figure 2.17).

Table 2.8. Wilks' Lambda Test statistic and F-approximations of CDFA.

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.673628	1.91	54	727.84	0.0001

Table 2.9. Univariate Test Statistics for CANDISC Method of CDFA.

Variable	Label	Total Standard Deviation	Pooled Standard Deviation	Between Standard Deviation	R-Square	R-Square / (1-RSq)	$F_{18,246}$	Pr > F
Dim1	Dimension 1	1.15	1.0731	0.5124	0.1887	0.2327	3.18	<.0001
Dim2	Dimension 2	0.9948	0.9854	0.2989	0.0858	0.0939	1.28	0.1991
Dim3	Dimension 3	0.8361	0.8256	0.2593	0.0914	0.1006	1.38	0.1441

Average R-square	
Unweighted	0.122001
Weighted by Variance	0.132331

Table 2.10. Canonical correlation

	Canonical Correlation	Adjusted Canonical Correlation	Approximate Standard Error	Squared Canonical Correlation
1	0.436821	0.361178	0.049802	0.190812
2	0.300563	.	0.055986	0.090338
3	0.291295	.	0.056323	0.084853

Table 2.11. Eigenvalues and tests of canonical correlations

	Eigenvalue	Difference	Proportion	Cumulative	Likelihood Ratio	Approximate F Value	Num DF	Den DF	Pr > F
1	0.2358	0.1365	0.5512	0.5512	0.673628	1.91	54	727.84	0.0001
2	0.0993	0.0066	0.2321	0.7833	0.832474	1.38	34	490	0.0767
3	0.0927		0.2167	1	0.915147	1.43	16	246	0.13

Table 2.12. Raw Canonical Coefficients

Variable	Label	Can1	Can2	Can3
Dim1	Dimension 1	0.923514	0.119938	-0.03776
Dim2	Dimension 2	0.082614	-0.25590	0.978618
Dim3	Dimension 3	-0.15487	1.159922	0.313047

Table 2.13. Class Means on Canonical Variables

Year	Burn	Month	comb	Can1	Can2	Can3
1	0	Oct/Nov	101	0.021589	0.11261	-0.04176
1	0	Dec	102	0.25312	-0.22978	0.059
1	0	Jan	103	-0.47023	-0.21855	0.056622
1	0	Feb	104	-0.08694	-0.2397	0.375318
1	0	Mar/Apr	105	-0.71203	0.180436	0.241435
1	1	Oct/Nov	111	0.695885	0.580008	0.374875
1	1	Dec	112	1.271546	0.067176	-0.43725
1	1	Jan	113	0.705567	0.601952	0.856261
1	1	Feb	114	0.650257	0.364808	0.280784
2	0	Oct/Nov	201	-0.42294	0.226994	-0.04047
2	0	Dec	202	0.336057	-0.44583	-0.15868
2	0	Jan	203	-0.35377	-0.44888	0.375778
2	0	Feb	204	-0.68804	0.21311	0.1681
2	0	Mar/Apr	205	-0.35892	0.280953	-0.21794
2	1	Oct/Nov	211	-0.72236	0.178487	-0.46127
2	1	Dec	212	0.674922	-0.04832	-0.38735
2	1	Jan	213	-0.12241	0.213766	-0.28413
2	1	Feb	214	-0.10032	0.7306	-0.4676
2	1	Mar/Apr	215	-0.14991	-0.08684	-0.54422

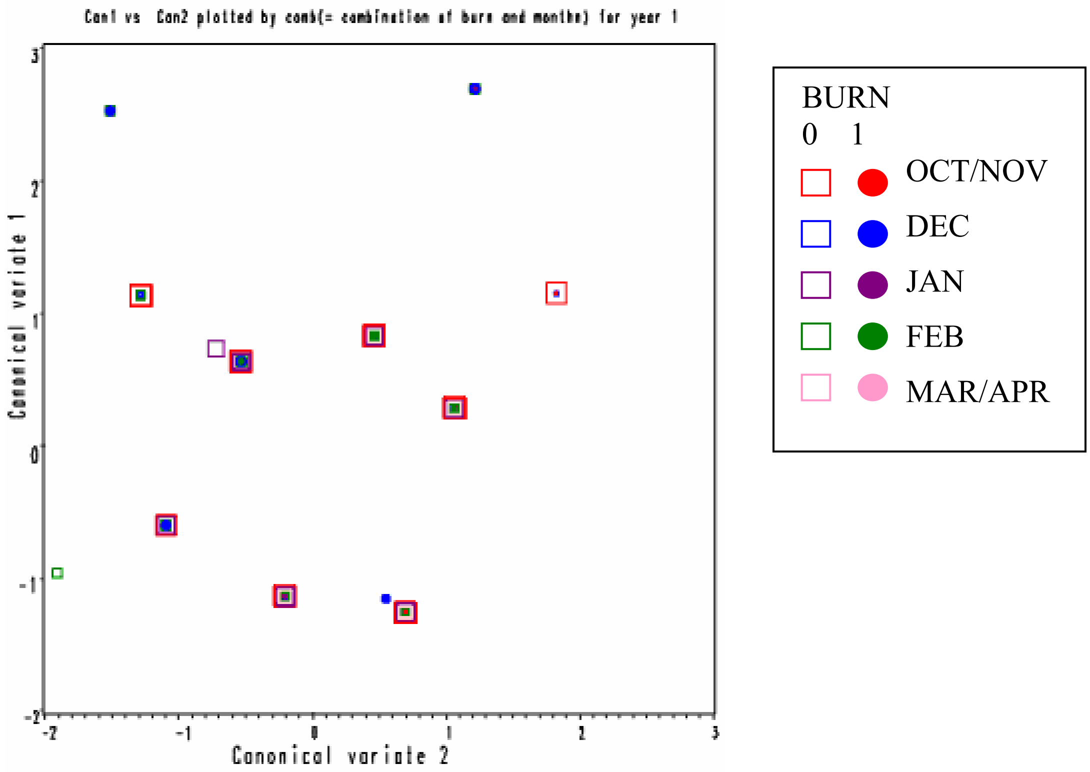

Figure 2.12. A plot of Canonical Variables 1 vs. 2 by burn and month for year 1.

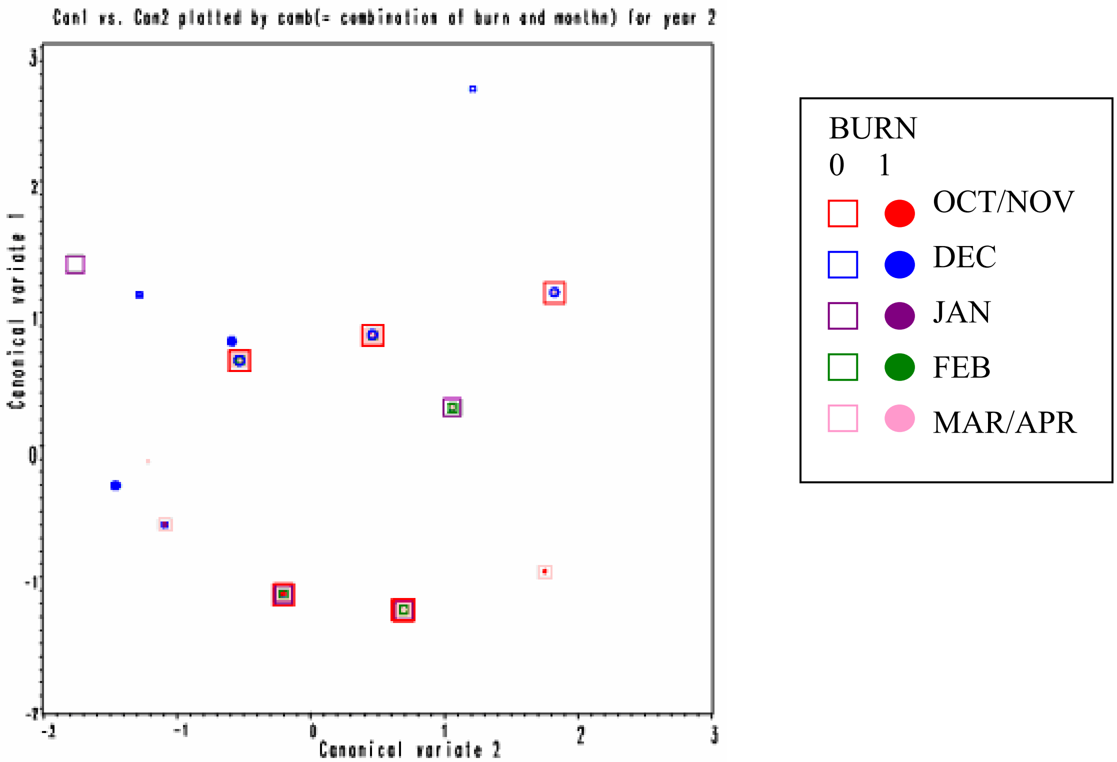

Figure 2.13. A plot of Canonical Variables 1 vs. 2 by burn and month for year 2.

Table 2.14. Pearson Correlation Coefficients correlating month, burn and year to canonical components.

	Can1	**Can2**	**Can3**
burn	0.16343	0.1664	-0.10473
month	-0.15161	-0.0126	0.03360
year	-0.11140	0.01601	-0.16156

Table 2.15. Pearson Correlation Coefficients correlating seeds to canonical components.

	Can1	**Can2**	**Can3**
RHYNC	-0.26321	0.31553	-0.84944
SCLERIA	-0.50938	-0.27221	0.16302
ASTER	-0.01517	-0.13448	0.12173
MUH	-0.00376	-0.17532	-0.02770
ERIGRO	-0.00059	-0.25767	-0.00204
ARIST	0.26870	-0.79326	-0.47194
LINME	0.08789	-0.10157	-0.06130
XYRUS	0.04059	-0.08290	-0.04300
GRASS	0.86783	0.20493	-0.03349

Correlations of Seeds to Canonical Variates

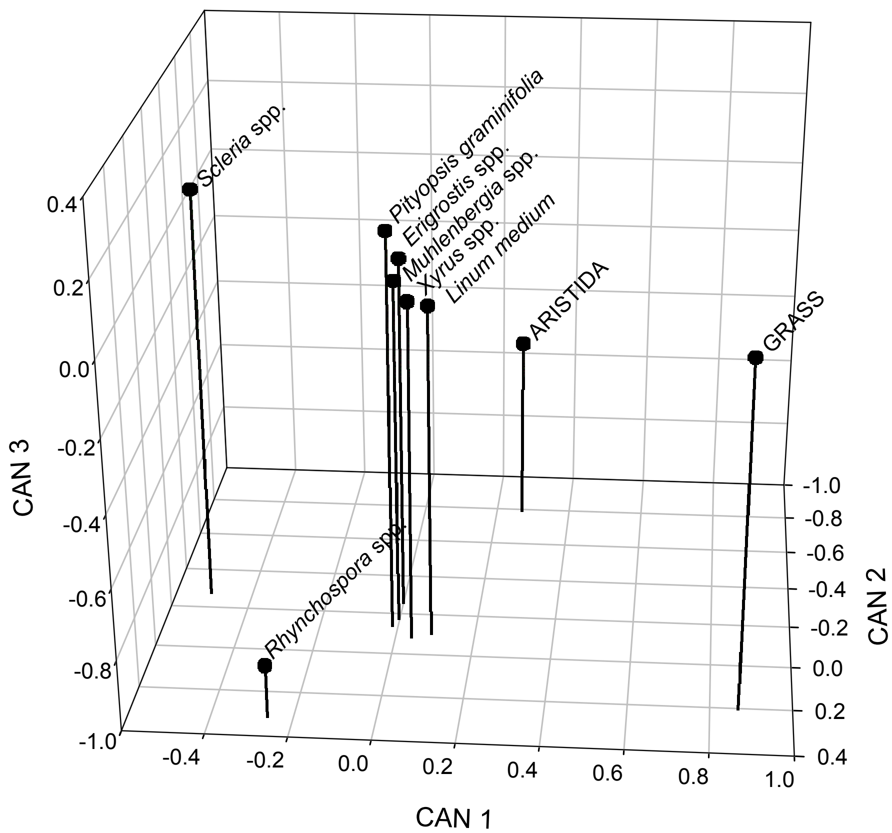

Figure 2.14. Correlations of seed types to the canonical variates.

Table 2.16. PROC GLIMMIX Rhynchospora Type III Tests of Fixed Effects.

Effect	Num DF	Den DF	F Value	Pr > F
burn	1	8	2.77	0.1345
month	4	237	0.70	0.5946
month*burn	4	237	1.32	0.2619

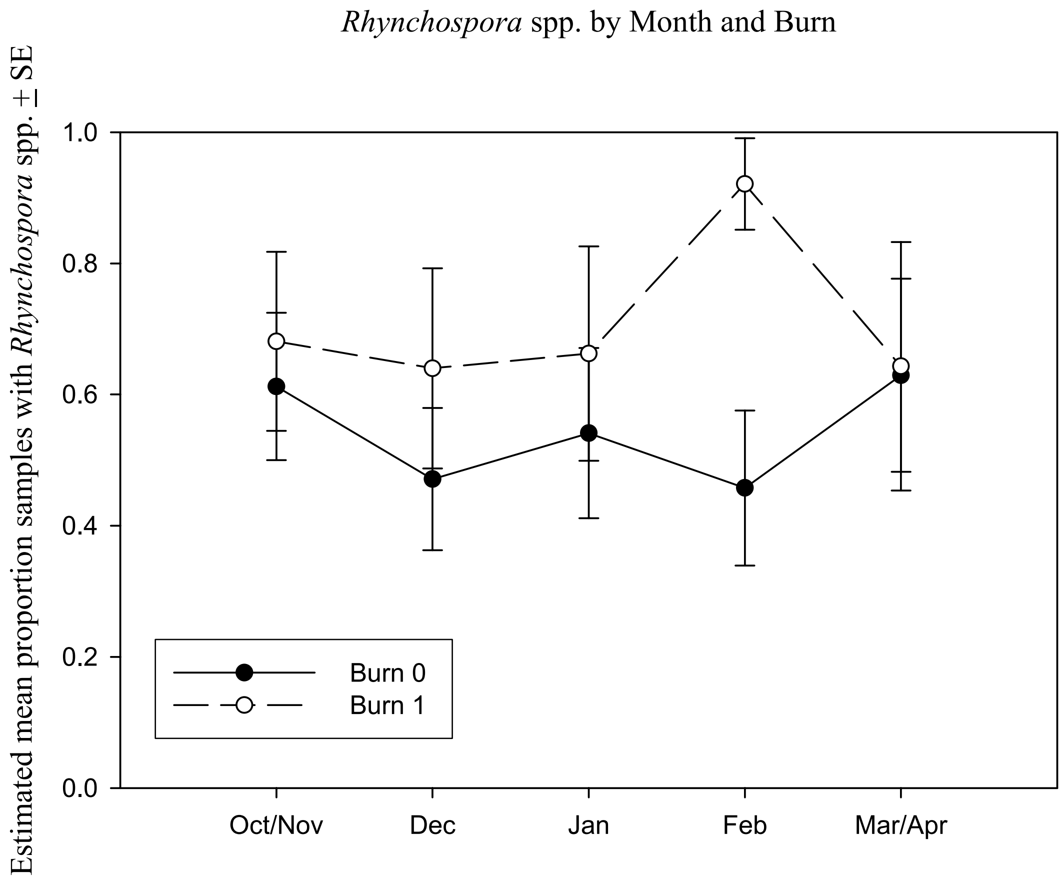

Figure 2.15. Estimated mean proportion of samples containing *Rhynchospora* spp by month burn.

Table 2.17. PROC GLIMMIX ARISTIDA Type III Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
burn	1	8	0.01	0.9213
month	4	237	3.01	0.0190
month*burn	4	237	0.63	0.6402

Table 2.18. Least Square Means and Tukey letter groups for ARISTIDA by month and burn.

month	Estimate	Standard Error of Estimate	Mean	Standard Error of Mean	Tukey Letter Group
Oct/Nov	-1.1776	0.3568	0.2355	0.06423	B
Dec	0.1033	0.3120	0.5258	0.07779	A
Jan	-0.9077	0.4114	0.2875	0.08427	AB
Feb	-1.1327	0.4627	0.2437	0.08526	AB
Mar/Apr	-1.0461	0.4834	0.2600	0.09299	AB

Aristida spp. by Month and Burn

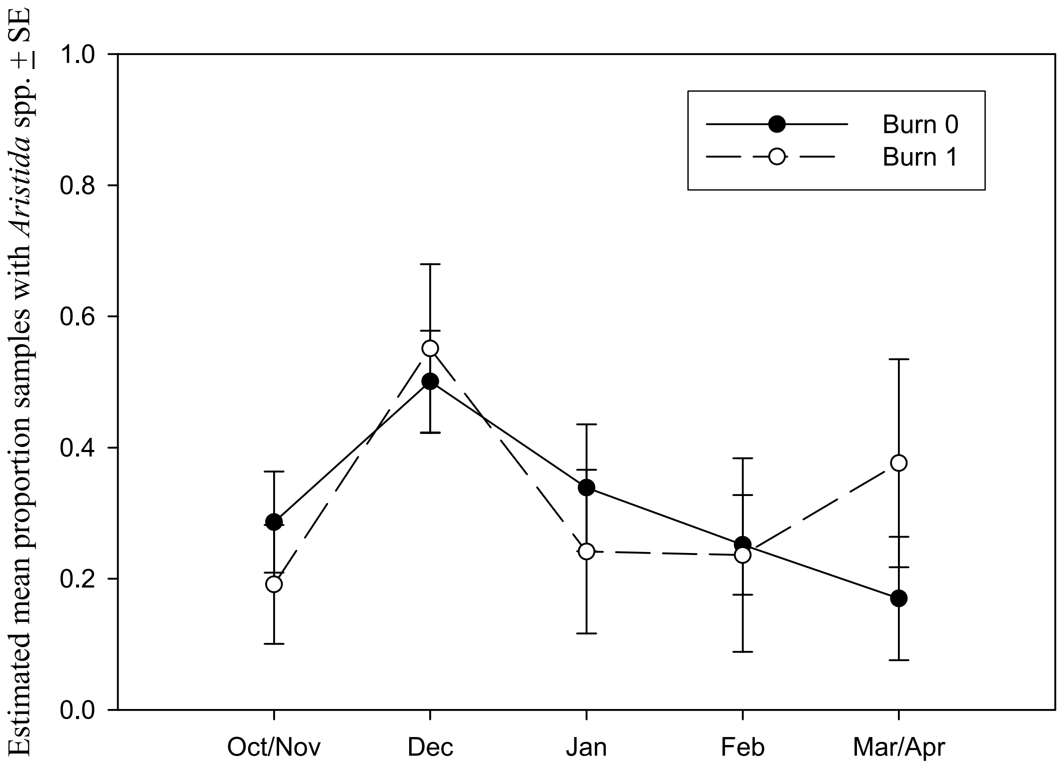

Figure 2.16. Estimated mean proportion of samples containing ARISTIDA group seeds by month and burn.

Table 2.19. PROC GLIMMIX GRASS Type III Tests of Fixed Effects.

Effect	DF	DF	Num F Value	Den Pr > F
burn	1	8	1.52	0.2532
month	4	237	2.28	0.0614
month*burn	4	237	1.48	0.2086

Table 2.20. Least Square Means and Tukey letter groups for GRASS by month and burn.

month	Estimate	Standard Error of Estimate	Mean	Standard Error of Mean	Tukey Letter Group
Oct/Nov	0.1850	0.4560	0.5461	0.1130	A
Dec	1.2193	0.5019	0.7719	0.0884	A
Jan	-0.0714	0.5133	0.4822	0.1282	A
Feb	0.3091	0.5829	0.5767	0.1423	A
Mar/Apr	-0.3806	0.5737	0.4060	0.1384	A

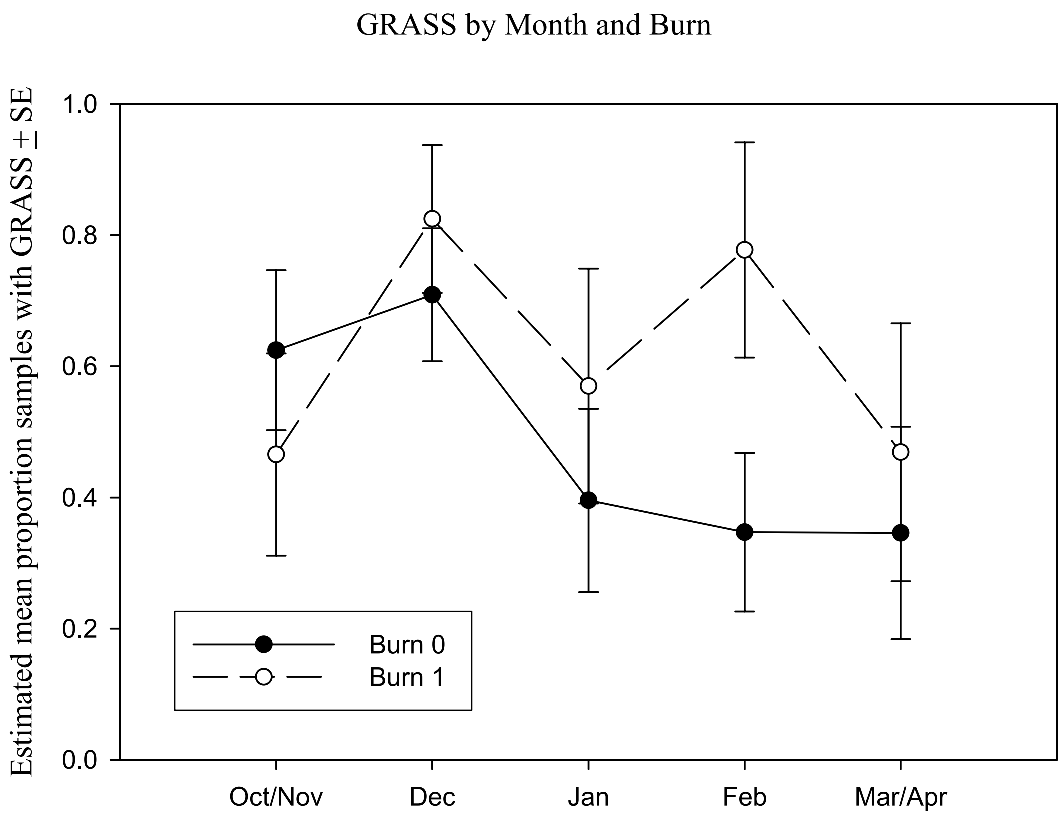

Figure 2.17. Estimated mean proportion of samples containing GRASS seeds by month and burn.

DISCUSSION

My results indicate that Henslow's Sparrows are diet generalists in the winter. They eat a variety of seeds and arthropods which occur in varying abundances in pine savannas. All of the dominant understory plants found in pine savannas, with the exception *Ctenium aromaticum*, were identified as part of the winter diet of Henslow's Sparrows, along with many other less common seeds (Table 1.1). Dominant understory plants include *Andropogon* spp., *Schizachyrium scoparium*, *Schizachyrium tenerum*, *Dichanthelium* spp., *Panicum* spp., *Muhlenbergia expansa*, *Ctenium aromaticum*, *Aristida* spp., and *Rhynchospora* spp. (Bechtoldt 2002, Bechtoldt and Stouffer 2005)

Because frequent burning is necessary for maintaining habitat suitable for Henslow's Sparrows, and abundance of Henslow's Sparrows drops off sharply the second year after a burn, I expected a savanna's burn history to influence the diet of Henslow's Sparrows. However, whether a savanna was burned or unburned the previous spring did not cause significant differences in diet once year was taken into account (Table 2.5). It is important to remember that my research only examined differences in savannas that were burned either during the same year of sampling or one year prior to sampling (Table 2.1). Therefore, further research is necessary to determine if Henslow's Sparrow winter diet changes in savannas with increasing time since burn.

Burning does affect seed availability and production in pine savannas (Streng et al. 1993). Seed production of *Scleria ciliata* in Georgia increased with increases in successional state; burning and soil disturbance suppresses seed production (Buckner and Landers 1979). However, Fuller (2004) found seed abundance of *Scleria* spp. to be highest the first year following a fall burn. *Aristida* spp. seed production increases after a growing season fire (Streng et al. 1993, Mulligan and Kirkman 2002), as does the production of seeds of *Andropogon* spp. (Streng et al. 1993), *Ctenium aromaticum* (MacRoberts and MacRoberts 1992) and *Muhlenbergia expansa* (Main and Barry 2002). Studies also have shown *Rhynchospora* spp., *Dichanthelium* spp., *Panicum* spp., and *Schizachyrium* spp. increase in abundance as time since last burn increases (Bechtoldt 2002, Fuller 2004, Bechtoldt and Stouffer 2005), although *Schizachyrium rhizomatum* seed production in south Florida has been shown to increase the first season following a growing season burn (Main and Barry 2002).

In Mississippi, *Rhynchospora* spp. and *Scleria* spp. were the most commonly occurring diet items, and *Rhynchospora* spp. accounted for the highest composition of Henslow's Sparrow diets (Fuller 2004). Fuller (2004) also found both *Rhynchospora* spp. and *Scleria* spp. to be more common and comprised greater proportions in bird diets as time since the savanna was burned increased. While I detected a trend for increased frequency of *Rhynchospora* spp. in diets of birds in unburned savannas in southeastern Louisiana, this was not significant once the effect of year was taken into consideration (Table 1.17, Figure 1.15). However, *Scleria* spp. was present in a majority of my samples, and thus did not appear to be affected by burning (Figure 1.4). Although there was a lot of overlap in the presence of seed items in the diets of birds in Mississippi and southeastern Louisiana, I also found some differences that probably reflect differences in habitat. For example, the herb *Baldunia uniflora* was frequently in diets of birds in Mississippi (Fuller 2004), but not in Louisiana. Furthermore, grass seeds were more prevalent in Louisiana birds' diets than those of Mississippi, but this probably was attributable to differences in burn seasons and sampling period. Most of the research in Mississippi took place in savannas that were burned in the fall, which does not favor grass seed production (Fuller 2004), as opposed to my sites which were burned during the growing season. Also, birds in Mississippi were only sampled during January and February, whereas I sampled throughout the winter (October through April) and may have picked up different food items that were not available to birds in Mississippi due to timing of seed maturity and senescence. This is supported by the results of the MANOVA showing that month was the only factor influencing variation in the diet of Henslow's Sparrows.

Food availability may be the most important factor in determining winter survival at a population level (Sherry and Holmes 1996). Seed availability is currently being studied by Erik Johnson, which subsequently will allow comparison of usage with availability of seed items. Winter arthropod availability and the importance of burning on diversity and abundance needs further examination to determine how arthropod availability affects the winter diet of Henslow's Sparrows. Arthropod response to fire can vary greatly depending on species, timing of burn, and the substrate with which the arthropods are associated (Folkerts et al. 1993). Just as plant diversity increases with frequent fires, arthropod diversity also can be assumed to increase because arthropod diversity increases with increased plant diversity (Folkerts et al. 1993).

While there is still a great need for more information regarding arthropod availability and diversity in pine savannas (Folkerts et al. 1993), the order Hymenoptera has received some attention recently. Sampling of bee communities in southeast Louisiana occurred from 1999 through 2003 at three of our sample sites: Abita Creek Flatwoods Preserve, Sandy Hollow Wildlife Management Area, and Camp Whispering Pines (Bartholomew 2004). Results showed that bees were more diverse at the upland sites of Sandy Hollow WMA and Camp Whispering Pines than at Abita Creek Flatwoods Preserve (Bartholomew 2004). Also, abundance and species richness of bees increased immediately following a growing season burn at Abita Creek Flatwoods Preserve, likely the result of increases in flowering plants following burn (Bartholomew 2004). Additionally, ant community response to fire was examined in Florida Longleaf pine savannas, with results showing that seasonality played a greater role in ant diversity than

fire (Izhaki et al. 2003). However, the ant community was only measured for six months following a dormant season burn, so the longer term effects of fire are not known.

A benefit of using fecal samples for diet analysis is that I was able to collect a very large sample size (n=299) with very little extra effort and no additional stress to the birds from the normal handling and processing for banding and morphometrics. Almost all samples collected contained at least one identifiable diet item. These samples provided valuable information about what each bird had been eating around the time of capture, since many bird species have a digestion rate ranging between 5 minutes and 2.5 hours, depending on the food item (Rosenberg and Cooper 1990).

One major limitation of using fecal samples to determine diet is that it is limited to only those food items that are able to pass through the digestive tract to be later identified, often by looking at small seed remains and arthropod parts (Ralph et al. 1985, Rosenberg and Cooper 1990). There is a potential bias against finding soft-bodied insects and softer or more non-descript seeds (Ralph et al. 1985, Rosenberg and Cooper 1990). For example, seeds of *Scleria* spp. were the most frequently identified plant food item in the diets of Henslow's Sparrows. These seeds are extremely easy to identify based on hard, basal tubercles and disks and distinctive achenes, even with a very small fragment. Achenes of many *Rhynchospora* spp. are also very easy to identify as belonging to that genus. Therefore, the easy detection of these seeds even from very small fragments may have biased the results.

For example, both *Muhlenbergia expansa* and *Ctenium aromaticum* are associated with preferred habitat and require burning for the production of seeds (Bechtoldt 2002, Bechtoldt and Stouffer 2005). I expected these seeds to be common in the diet of

Henslow's Sparrows. However, *Ctenium aromaticum* seeds were conspicuously absent from fecal samples, and I detected *Muhlenbergia expansa* in only two samples. One possible explanation for this is Henslow's Sparrows are simply not eating these seeds. However, this is highly unlikely, especially given the preference shown for these seeds by captive birds in seed selection trials (Chapter 2). A more likely explanation is that these items are digested to a point where they are not identifiable in samples. This is supported by physical characteristics of the grains of *Muhlenbergia expansa* and *Ctenium aromaticum*, as both are fairly non-descript and neither has a hard, defining outer shell that would pass through the digestive system like the seeds of *Rhynchospora* spp., *Dichanthelium* spp., *Panicum* spp. and *Scleria* spp., which I identified fairly regularly.

Another limitation to using fecal analysis is that I could not identify many items past the genus level or even past a broad grouping level as was the case with *Andropogon* spp., *Schizachyrium* spp. and *Aristida* spp. because they were too digested and missing characteristic features. I was usually dealing with small fragments that were hard to distinguish among these seeds, which have very similar characteristics. All three species have narrow, elongated grains. If the seeds were from crop samples or stomach samples, they would likely have been less digested and perhaps could have been identified to species. This leads to the problem that more inclusive categories of diet items can overestimate the similarities of individual birds diets, leading to an underestimate in diversity in diet (Rosenberg and Cooper 1990). With more information on seed species, I may have been able to detect a difference in diets based on which type of savanna the birds were from, whether they were in xeric pinehills or seasonally flooded flatwoods,

because different plant species are dominant and some are not found in both types of savanna, even though the genus may be present in both habitats (Peet and Allard 1993).

A further limitation of fecal analysis is that I could not quantify food item abundance because fecal samples contained mostly finely ground material and very small pieces of seed. I could only analyze frequency, or percent occurrence. A problem with this measurement is that it can overemphasize the importance of very small food items, or those that remain in the digestive tract longer (Rosenberg and Cooper 1990). I often identified *Scleria* spp. based on its characteristic hard, basal tubercles or by a few small remains of the achenes. However, basal tubercles of *Scleria* spp. seeds may persist in the crops of Henslow's Sparrows for longer periods of time than other food items (Fuller 2004), and therefore may have been over-represented in frequency analyses. Additionally, arthropods were frequently present in fecal samples, and even though abundance was not measured, I rarely observed arthropods to be a large component of a bird's diet. This suggests arthropods are supplementary diet items that do not comprise a large part of the daily energy intake (Rosenberg and Cooper 1990). Fuller (2004) found a similar trend with arthropods in the diets of birds in Mississippi, where arthropods were among the most frequently occurring food items but comprised only 8% of the total crop contents.

There exist fundamental differences between requirements of birds during the breeding season and requirements for winter (Fretwell 1972). Factors that limit sparrow populations over the winter are adequate food and suitable habitat for predator avoidance and self maintenance (Fretwell and Lucas 1970, Fretwell 1972, Pulliam 1975, Pulliam and Mills 1977). Winter habitat quality and resource availability are partly responsible

for determining breeding population size (Fretwell 1972). This difference makes any knowledge of resource requirements for Henslow's Sparrows of utmost importance in efforts to conserve this fast declining species. In southeast Louisiana, Henslow's Sparrows frequently consume sedge seeds including *Rhynchospora* spp. and *Scleria* spp., and grass seeds such as *Dichanthelium* spp., *Panicum* spp., and *Schizachyrium* spp., *Andropogon* spp., and *Aristida* spp. Land managers throughout the state can apply this knowledge of the winter diet of Henslow's Sparrows when restoring and maintaining Longleaf Pine savannas to maximize resource availability.

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CHAPTER 3: SEED PREFERENCES OF WINTERING HENSLOW'S SPARROWS

Henslow's Sparrow (*Ammodramus henslowii*) is a grassland bird whose population is declining throughout its range, mainly due to habitat loss (Pruitt 1996, Herkert et al. 2002). The Longleaf Pine (*Pinus palustris*) ecosystems in which Henslow's Sparrows spend their winters are reduced to 5% of their former range (Tucker and Robinson 2003). The secretive nature of Henslow's Sparrow during winter has caused many aspects of its winter ecology to remain understudied, including diet and foraging behavior. Because winter habitat use by migratory birds has been shown to be related to habitat quality and abundance of food resources (Johnson and Sherry 2001), it is important to learn what food resources are necessary for Henslow's Sparrows to survive through the winter and successfully prepare for spring migration.

Henslow's Sparrows are short distance migrants which breed in the northeastern and northcentral US from April through September, and spend their winters in the southeastern US from October through April (Carrie et al. 2002). The winter habitat of Henslow's Sparrows includes open pine savannahs and Pitcher Plant (*Sarracenia* spp.) bogs that are characterized by scattered pine trees, tall grasses with little or no litter, low vegetation density near the ground and low shrub cover (Plentovich et al. 1999, Bechtoldt 2002, Carrie et al. 2002). Dominant understory plants in southeastern Louisiana pine savannas include *Andropogon* spp., *Schizachyrium scoparium*, *Schizachyrium tenerum*, *Dichanthelium* spp., *Panicum* spp., *Muhlenbergia expansa*, *Ctenium aromaticum*, *Aristida* spp., and *Rhynchospora* spp. (Bechtoldt 2002, Bechtoldt and Stouffer 2005).

The breeding season diet of Henslow's Sparrows consists of 82% animal matter, including 50% orthoptera and 19% coleoptera, along with 18% plant matter (Herkert et al. 2002). However, the winter diet has received far less study. Limited data suggest that Henslow's

Sparrows eat small grass seeds, such as Wiregrass (*Aristida spp.*), which is more common east of Louisiana (Herkert et al. 2002). A recently completed study of Henslow's Sparrow winter diet in Mississippi reported that birds commonly eat seeds of sedges such as *Rhynchospora* spp. and *Scleria* spp., as well as grass seeds such as *Panicum* spp., *Paspalum* spp., *Andropogon* spp. and a herb, *Balduina uniflora* (Fuller 2004). Arthropods also were commonly found in the diet of Henslow's Sparrows wintering in Mississippi, but they composed only a small proportion of the total crop contents (Fuller 2004).

Food resource selection in animals is influenced by a variety of factors. Most importantly, availability dictates what an animal ultimately will consume, with preference determining which available food items are consumed (Frazer and McWilliams 2002). Preference for certain food items over others is determined by many factors including size and handling time (Zach and Falls 1978, Schluter 1982, Diaz 1994), seed chemistry and nutrition (Diaz 1996, Hayslette and Mirarchi 2001, Frazer and McWilliams 2002, Bosque and Calchi 2003, Schaefer et al. 2003), color or appearance (Schmidt and Schaefer 2004), detectability (Getty and Pulliam 1993), food resource density (Wilson 1971, Celis-Diez et al. 2004, Celis-Diez and Bustamante 2005) and seed morphology in relation to mechanical digestion (Diaz 1994). Knowledge of food resource use based solely on foraging observations, sampling of stomach contents, or fecal analysis does not provide a complete picture of which resources animals prefer to utilize, as it only provides a snapshot of what is consumed based on what was available (Cueto et al. 2001) but does not consider temporal variation, habitat quality, or environmental conditions (Marra and Holberton 1998, Strong and Sherry 2000, Johnson and Sherry 2001).

Feeding-preference experiments are an appropriate way to look at food selection under controlled conditions, where availability of food items is known and a preference for presented items can be assessed (Cueto et al. 2001). Two widely-used methods exist for determining preference for different food items in animals. Multiple-offer preference experiments, also known as cafeteria trials, expose a test subject to more than one food item at a time and measure use of each food item to determine a preference for one over the others (Peterson and Renaud 1989, Roa 1992, Manly 1995, Cueto et al. 2001). The reasoning behind this test is that in a natural setting, an animal encounters more than one potential food item simultaneously, and makes a decision on which item to consume after assessing each one, thereby demonstrating a preference (Smallwood and Peters 1986, Peterson and Renaud 1989).

Realistically, however, an animal is likely to encounter many items sequentially, especially when food items are clustered (Smallwood and Peters 1986, Cueto et al. 2001). While foraging, an animal will examine each item it encounters, and then make a decision on whether to consume the item or reject it and continue searching (Smallwood and Peters 1986).

Simple-offer preference experiments are designed to mimic foraging in natural situations when food items are encountered sequentially. In such tests, an animal is given only one food item at a time to determine if the animal will consume the item when no other food is available (Smallwood and Peters 1986, Peterson and Renaud 1989, Cueto et al. 2001). One drawback to simple-offer experiments is that they may reveal a food item to have greater than expected consumption simply because the animal had nothing else available (Cipollini and Levey 1997, Cueto et al. 2001). A benefit of simple-offer experiments is that they can shed light on secondarily preferred food items which may be less preferred, but are consumed in the absence

of preferred food items and may be critical for survival when preferred items are scarce (Cueto et al. 2001).

To gain further understanding of Henslow's Sparrow food resource use during the winter, I used both multiple-offer and simple-offer seed choice trials. Using both testing methods, I was able to determine which seeds Henslow's Sparrows preferred to eat while still accounting for secondarily preferred food items.

MATERIALS AND METHODS

Bird Capture and Care

Henslow's Sparrows were captured at Lake Ramsay Wildlife Management Area using flush-netting techniques with 6m mist nets (Chandler and Woodrey 1995, Bechtoldt 2002). Birds were transported to Baton Rouge in small bird carriers (15 x 20 x 15.5 cm) and held in individual cages (35 x 45 x 50 cm) inside an indoor aviary located at LSU's Ben Hur Aquaculture Facility for the duration of the trial. Sparrows were maintained under natural photoperiods, temperatures and humidity.

Henslow's Sparrows were fed a diet of commercial seed (National Audubon Society, Finch Festival), egg, catfood (Nutro, Max Cat Adult), commercial mealworms (coleopteran larvae) and waxworms (lepidopteran larvae) (Armstrong Cricket Farm, Rainbow Mealworms, Petco), and grit *ad libitum* and provided with fresh water. Many birds did not eat the *ad lib* diet right away and required hand feeding of worm pieces in order to stimulate foraging during the first day or two of captivity.

Birds that did not adapt to captivity (would not eat or would not settle down in cages) were returned to their site of capture, or as close as possible, within a day or two of being captured, if they appeared healthy enough to be released. This included two birds in the December 2004

trial, and two birds in the February 2005 trial. None of these birds were included in seed preference trials. All aspects of this research including capture, banding, captive experiments, and collecting feathers and blood was conducted with approval of LSU IACUC, Louisiana Department of Wildlife and Fisheries (LADFW) and US Fish and Wildlife Service (USFWS) under the following permits: AEO314 (IACUC), LNHP-05-059 (LADFW), MB0959180 and 22648 (USFWS).

Seeds Tested

I studied seed choice in captive Henslow's Sparrows using simple-offer and multiple-offer experiments modeled after techniques and principles described by Cueto et al. (2001). Due to previous problems with captive birds of lower weights in the pilot study, only birds that weighed at least 12.5 g subsequently were brought back to the aviary for seed selection trials. These tests required holding birds captive for a maximum of twelve days, after which I released them as close as possible to sites where they were captured. I waited to begin seed preference trials until two days after birds were captured to allow birds to adjust to captivity.

In winter 2004-2005 (Year 2), I focused tests on eight seeds (Table 3.1). Three birds were tested in November 2004 and five other birds were tested in February 2005. *Ctenium aromaticum* and *Muhlenbergia expansa* were chosen as test seeds because these species have been shown to be important indicators of preferred habitat for Henslow's Sparrows in southeastern Louisiana (Bechtoldt 2002). Anecdotal evidence (M. Woodrey, pers. comm.) and a study by Fuller in 2004 suggested Henslow's Sparrows consume small seeds such as *Rhynchospora* spp. in Mississippi, so these were represented in trials by two ubiquitous species: the low growing *Rhynchospora plumosa* and the taller *Rhynchospora gracilenta*. The other four

seeds were chosen as a representation of seeds from plants commonly found in pine savannas where Henslow's Sparrows were captured.

Table 3.1. Seeds tested in December 2004 and February 2005 (Year 2) simple-offer and multiple-offer seed choice experiments.

Family	**Species**
Poaceae	*Ctenium aromaticum*
	Muhlenbergia expansa
	Schizachyrium scoparium
	Panicum anceps
	Dichanthelium angustifolium
Cyperaceae	*Rhynchospora plumosa*
	Rhynchospora gracilenta
Asteraceae	*Eupatorium leucolepis*

Seed Preference Trials

I modified protocols described by Cueto et al. (2001) for simple-offer and multiple-offer experiments based on the pilot study (Appendix C). For both simple-offer and multiple-offer experiments, all food was removed from individual cages two hours prior to the experiment. For simple-offer experiments, birds were offered 20 seeds of one species at a time in a Petri dish. Twenty minutes were allotted to allow for selection and consumption of seeds before seeds were removed from the cage. This process was repeated daily until all seed types were tested, and the number of each type of seed eaten was recorded. The order and day in which each bird received seed species was randomized so that no birds were tested on the same seed types on a given day or in the same order. In multiple-offer experiments, the same procedure was followed except that birds were presented with twenty of each of the eight seed species at the same time mixed together in one Petri dish.

Statistical Analysis

Simple-offer experiments were analyzed using PROC GLIMMIX (SAS Institute Inc. 2004). The data from the simple offer experiments did not fit a normal distribution, so PROC GLIMMIX was chosen because it can be programmed to fit errors of various distributions and has the capability of fitting random effects (Schabenberger 2005). Data from the simple-offer experiments were analyzed using a logistic generalized linear mixed model as implemented in PROC GLIMMIX (SAS Institute Inc. 2004). The number of seeds eaten out of 20 trials was the binomial response (each seed offered represented one trial in the analysis). Explanatory fixed effects were seed species and day. Birds adjusted to captivity slowly and increased foraging as each day passed; thus, a day effect was included to account for variation in each bird's willingness to forage based on how long it had been in captivity. To account for extra-binomial variation, a bird random effect was included to permit the average proportion of seeds eaten of a particular type to vary among birds. Additionally, an overdispersion constant was included to account for an expected lack of independence among selections of seeds by each bird. This was used to account for the fact that seeds were more likely to be eaten following a clustered distribution. During seed preference experiments, a bird was more likely to eat more than one seed on a foraging bout rather than assess each seed separately as an independent trial. The addition of an overdispersion constant inflated standard errors to a more conservative level (B. Moser, pers. comm.).

The non-parametric Friedman's test has been suggested as a method of testing multiple-offer preference experiments because it can handle data that violates the assumption of normal distribution (Roa 1992, Lockwood 1998, Cueto et al. 2001). However, this model is problematic in that it assumes independence despite food items being offered simultaneously; clearly the

consumption of any given seed is dependent on the other seeds present (Roa 1992, Lockwood 1998). Thus, multiple-offer trial results were analyzed as a multinomial logit utilizing a generalized logit model with PROC LOGISTIC (SAS Institute Inc. 2004). This procedure was utilized because the multinomial logit could better account for both the lack of independence and non-normal distributions as long as none of the food items were depleted in each trial (B. Moser pers. comm.). The number of each seed species eaten (Seed) was the dependent variable, and Bird was considered the aggregate. Data were ordered by Seed in descending frequency, and the seed species with the highest frequency of consumption was used as the reference treatment. Differences in seed choice were determined using multiple comparisons adjusted with the stepdown Bonferroni method of Holm as implemented in PROC MultTest (SAS Institute Inc. 2004).

I performed *a priori* contrasts on both simple-offer and multiple-offer trial results based on known biologically important seed characteristics. Because *Muhlenbergia expansa* and *Ctenium aromaticum* are associated with preferred habitat in Louisiana (Bechtoldt 2002, Bechtoldt and Stouffer 2005), I contrasted proportions of seeds eaten of these two species against each other and these two seeds combined against all other seeds tested. Additionally, because of the increased consumption of *Rhynchospora* spp. by birds in unburned savannas (Fuller 2004) and the dependence of *Muhlenbergia expansa* (Main and Barry 2002) and *Ctenium aromaticum* (MacRoberts and MacRoberts 1992) on fire for seed production, I contrasted *Muhlenbergia expansa* and *Ctenium aromaticum* versus *Rhynchospora gracilenta* and *Rhynchospora plumosa*.

I contrasted proportions of seeds eaten in three different size classes based on published measurements of the lengths of the seeds (Table 3.2) (Radford et al. 1964). I based size classes on whether the grain or spikelet was offered in seed choice experiments to reflect the size of

seeds handled by birds. Size 1 includes *Dichanthelium angustifolium*, *Panicum anceps*, *Rhynchospora plumosa* and *Rhynchospora gracilenta* . Size 2 includes *Muhlenbergia expansa* and *Eupatorium leucolepis*. Size 3 includes *Ctenium aromaticum* and *Schizachyrium scoparium*.

Table 3.2. Grain and Spikelet lengths of seeds tested (Radford et al. 1964).

Seed Species	Spikelet Length (mm)	Grain/Nutlet Length (mm)	Size Class
Rhynchospora plumosa	2.5-4.5	1.5-1.8	1
Rhynchospora gracilenta	4.0-6.0	1.5-2.0	1
Dicanthelium angustifolium	1.5-2.0	1.0	1
Panicum anceps	2.2-3.8	1.5	1
Eupatorium leucolepis	N/A	2.0-2.7	2
Muhlenbergi expansa	3.0-4.2	2.5-3.0	2
Ctenium aromaticum	5.0-6.0	3.0-3.5	3
Schizachyrium scoparium	5.0-8.0	2.0-3.0	3

To compare simple-offer and multiple-offer trial results, I created scatter-plots combining estimated mean proportions of seeds eaten in each type of trial.

RESULTS

Simple-offer

Proportions of seeds consumed by each bird in Year 2 simple-offer trials varied greatly (Figure 3.1). There was a significant difference in probability of consumption by seed type (Table 3.3). Contrasts reveal *Ctenium aromaticum* and *Muhlenbergia expansa* had a higher probability of being eaten than the other tested seeds (Table 3.4). There was no difference in the probability of *Ctenium aromaticum* being eaten versus that of *Muhlenbergia expansa* (Table 3.4). *Ctenium aromaticum* and *Muhlenbergia expansa* had a higher probability of being eaten than the two *Rhynchospora* spp. (Table 3.4). A test of least significant differences using the Tukey adjustment showed no differences among proportions of seeds eaten (Table 3.5, Table 3.7). However, the unadjusted LSD showed that *Muhlenbergia expansa*, *Dichanthelium angustifolium*, *Eupatorium leucolepsis*, *Panicum anceps*, and *Ctenium aromaticum* seeds had

higher probabilities of being eaten than *Schizachyrium scoparium* (Table 3.5, Table 3.6, Figure 3.2). Also, seeds of *Muhlenbergia expansa*, *Dichanthelium angustifolium* and *Eupatorium leucolepsis* had higher probabilities of being eaten than *Rhynchospora plumosa* or *Rhynchospora gracilenta* (Table 3.5, Table 3.6, Figure 3.2). There were no differences in probabilities of consumption for any of the other seeds.

Contrasts of seed size classes reveal Size 2 seeds were preferred over Size 1 seeds and Size 3 seeds (Table 3.8, Figure 3.3). The proportion of seeds eaten from Size 1 was the same as Size 3 (Table 3.8, Figure 3.3).

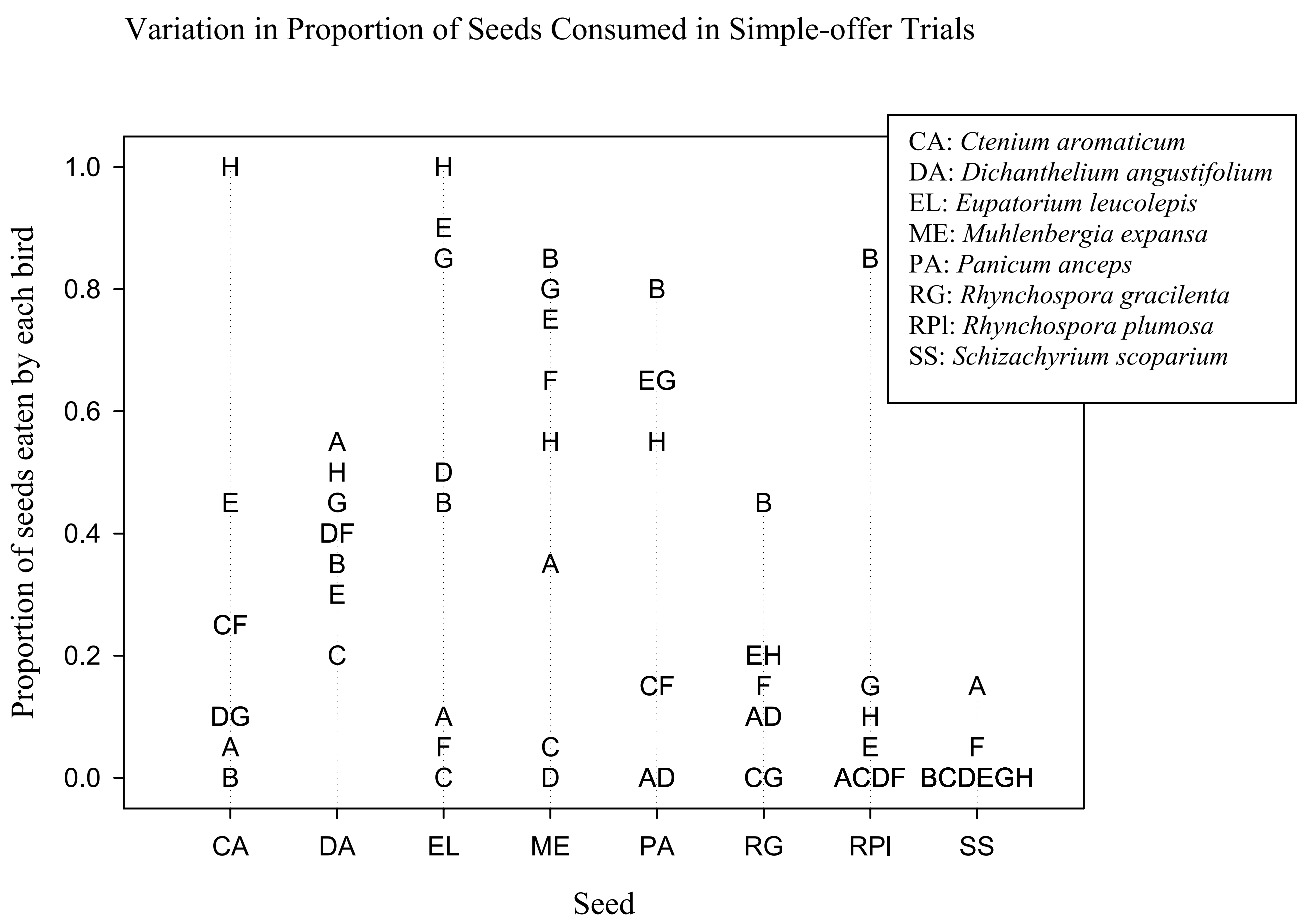

Figure 3.1. The proportion of seeds consumed by individual birds in simple-offer trials (each letter represents one bird).

Table 3.3. Type III Test of Fixed Effects for simple-offer seed preference trials.

Effect	Num DF	Den DF	F Value	Pr > F
seed	7	42	3.1	0.0098
day	7	42	1.0	0.4235

Multiple-offer

The proportions of seeds consumed by individual birds in Year 2 multiple-offer trials was highly variable (Figure 3.4). Results of contrasts reveal *Ctenium aromaticum* and *Muhlenbergia expansa* had a higher probability of being eaten than the other tested seeds (Table 3.10). There was no difference in the probability of *Ctenium aromaticum* being eaten versus that of *Muhlenbergia expansa* (Table 3.10). *Ctenium aromaticum* and *Muhlenbergia expansa* had a higher probability of being eaten than the two *Rhynchospora* spp. (Table 3.10). Multiple comparison probabilities adjusted using the stepdown Bonferroni method of Holm (SAS Institute Inc. 2004) show *Eupatorium leucolepis*, *Dichanthelium angustifolium*, *Muhlenbergia expansa* and *Ctenium aromaticum* were preferred over *Schizachyrium scoparium* (Table 3.11, Figure 3.5). *Eupatorium leucolepis*, *Dichanthelium angustifolium* and *Muhlenbergia expansa* were preferred over *Rhynchospora plumosa* and *Rhynchospora gracilenta*. (Table 3.11, Figure 3.5). *Eupatorium leucolepis* and *Dichanthelium angustifolium* were also preferred over *Panicum anceps* (Table 3.11, Figure 3.5).

Table 3.4. *A priori* contrasts of *Ctenium aromaticum* (CA) and *Muhlenbergia expansa* (ME) vs. all other tested seeds, *Ctenium aromaticum* and *Muhlenbergia expansa* vs. *Rhynchospora plumosa* (RPl) and *Rhynchospora gracilenta* (RG), *Ctenium aromaticum* vs. *Muhlenbergia expansa* for simple-offer trials.

Contrast	Num DF	Den DF	F Value	Pr > F
CA+ME versus RG+RPl	1	42	8.81	0.0049
CA+ME versus rest	1	42	6.95	0.0117
CA versus ME	1	42	2.97	0.092

Table 3.5. Least square mean estimates of seeds eaten on both the logit scale (Estimate) and probability (Mean) scale with associated standard errors and multiple-comparison results for simple-offer trials.

Seed	Estimate	SE Estimate	Mean	SE Mean	LSD	Tukey
ME	0.1496	0.5921	0.5373	0.1472	A	A
EL	-0.229	0.5871	0.443	0.1449	A	A
DA	-0.353	0.5939	0.4126	0.1439	A	A
PA	-0.751	0.619	0.3206	0.1348	AB	A
CA	-1.020	0.6347	0.2651	0.1237	AB	A
RG	-2.058	0.734	0.1133	0.0737	BC	A
RP	-2.095	0.7263	0.1096	0.0709	BC	A
SS	-4.333	1.3859	0.013	0.0177	C	A

Table 3.6. Unadjusted LSD multiple comparison probabilities for simple-offer trials.

	ME	*EL*	*DA*	*PA*	*CA*	*RG*	*RPl*	*SS*
ME	-	-	-	-	-	-	-	-
EL	0.5588	-	-	-	-	-	-	-
DA	0.4341	0.8447	-	-	-	-	-	-
PA	0.1832	0.4258	0.5502	-	-	-	-	-
CA	0.092	0.2384	0.325	0.7017	-	-	-	-
RG	0.0063	0.022	0.0343	0.0988	0.2063	-	-	-
RPl	0.0056	0.0168	0.0274	0.09	0.1746	0.966	-	-
SS	0.0028	0.0054	0.0074	0.0143	0.0249	0.1208	0.1306	-

Table 3.7. Tukey LSD multiple comparison probabilities for simple-offer trials.

	ME	*EL*	*DA*	*PA*	*CA*	*RG*	*RPl*	*SS*
ME	-	-	-	-	-	-	-	-
EL	0.9988	-	-	-	-	-	-	-
DA	0.9928	1	-	-	-	-	-	-
PA	0.8726	0.992	0.9987	-	-	-	-	-
CA	0.6719	0.9286	0.9725	0.9999	-	-	-	-
RG	0.1042	0.2785	0.3792	0.6944	0.8998	-	-	-
RPl	0.0937	0.2272	0.3255	0.6647	0.8607	1	-	-
SS	0.0512	0.0911	0.1186	0.2013	0.3037	0.757	0.7805	-

ME = *Muhlenbergia expansa*, EL = *Eupatorium leucolepis*, DA = *Dichanthelium angustifolium*, PA = *Panicum anceps*, CA = *Ctenium aromaticum*, RG = *Rhynchospora gracilenta*, RPl = *Rhynchospora plumosa* and SS = *Schizachyrium scoparium*

A priori contrasts of proportions of seeds eaten in the three different size classes show Size 2 seeds were preferred over Size 1 seeds and Size 3 seeds (Table 3.12). The proportion of seeds eaten from Size 1 also was greater than those from Size 3 (Table 3.12).

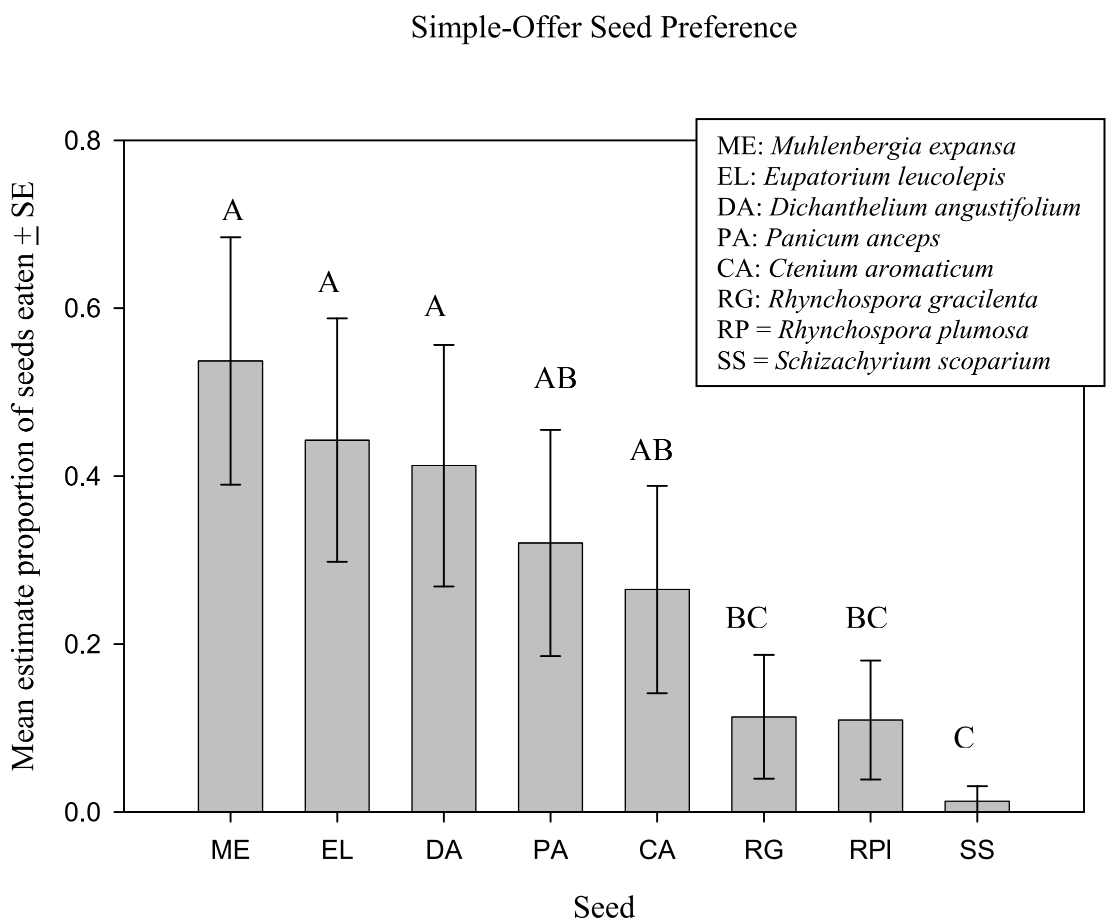

Figure 3.2. Mean estimate proportion of seeds eaten for each species in simple-offer seed preference trials (letters represent differences in multiple-comparisons based on the unadjusted LSD)

Table 3.8. *A priori* contrasts of seeds by size class for simple-offer trials. Size 1 includes *Dichanthelium angustifolium*, *Panicum anceps*, *Rhynchospora plumosa* and *Rhynchospora gracilenta* . Size 2 includes *Muhlenbergia expansa* and *Eupatorium leucolepis*. Size 3 includes *Ctenium aromaticum* and *Schizachyrium scoparium* (Table 3.2).

Contrast	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Size 1 versus 2 Seeds	1	42	9.40	0.0038
Size 1 versus 3 Seeds	1	42	3.31	0.0760
Size 2 versus 3 Seeds	1	42	11.58	0.0015

Simple-offer Seed Preference by Size

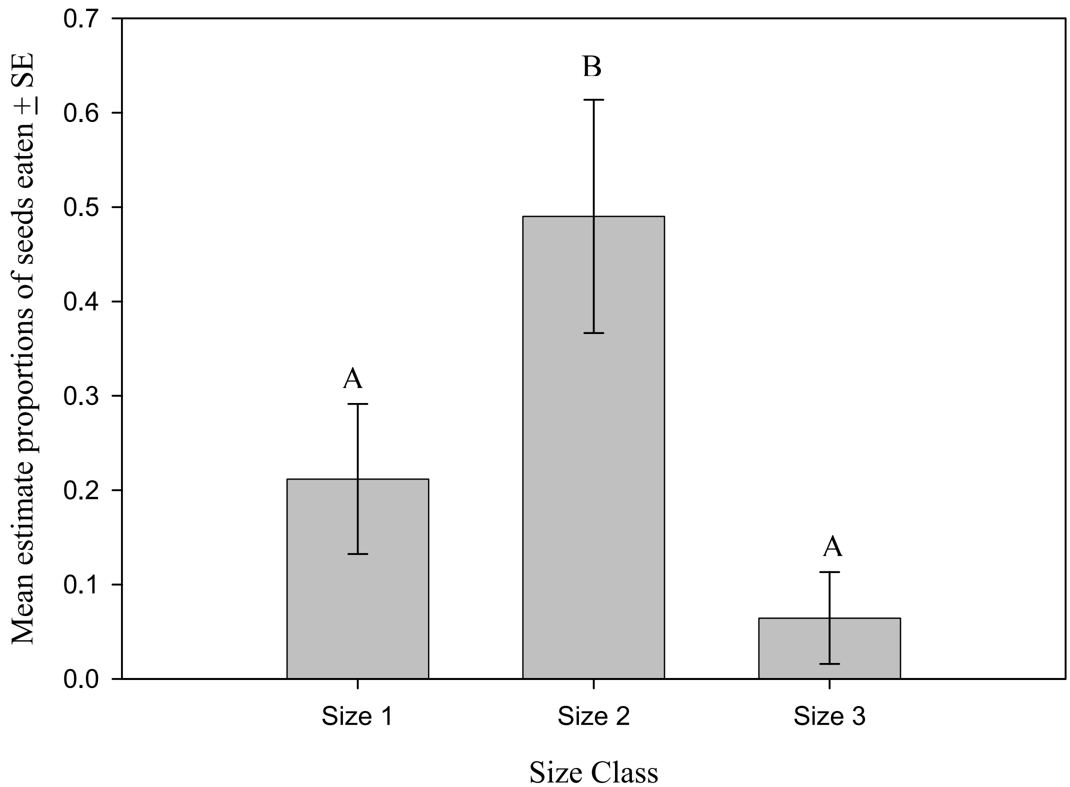

Figure 3.3. Mean estimate proportion of seeds eaten in each size class in simple-offer seed preference trials (letters represent differences in groups based on results of contrasts).

Variation in Proportion of Seeds Consumed in Multiple-offer Trials

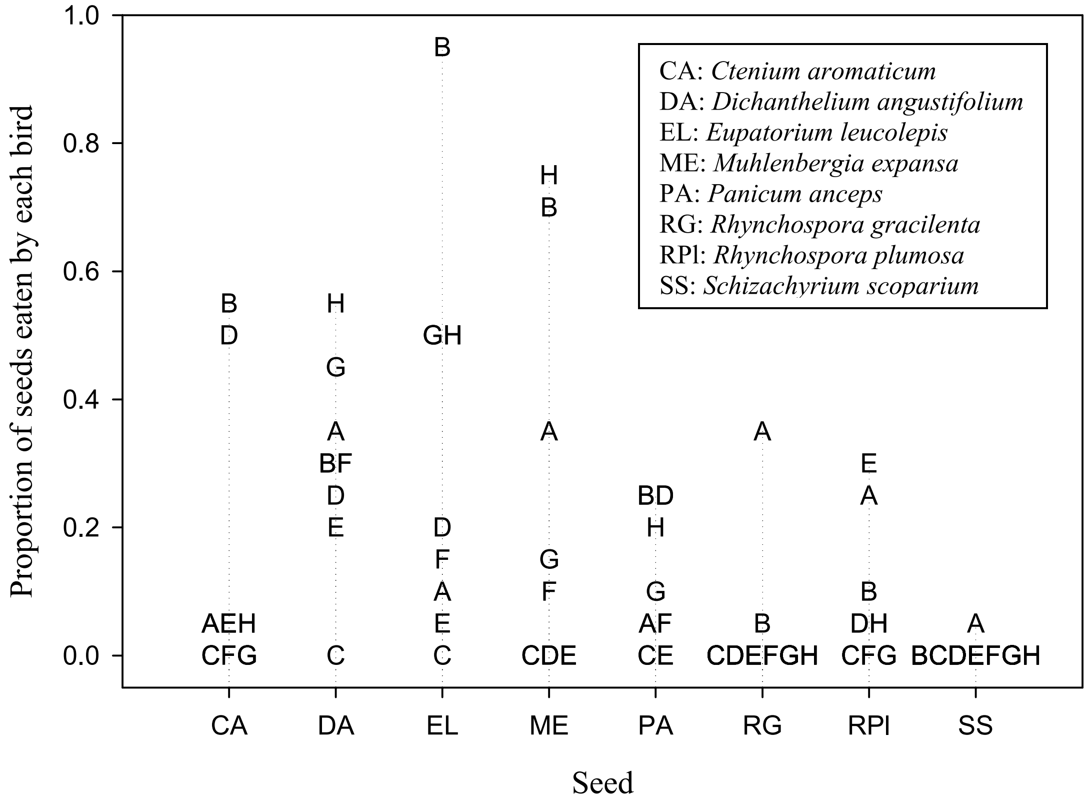

Figure 3.4. The proportion of seeds consumed by individual birds in multiple-offer trials (each dot represents one bird).

Table 3.9. Multinomial logit analysis probabilities (ŷ) with associated confidence limits for multiple-offer trials.

Seed	ŷ	Lower CL	Upper CL
EL	0.2402	0.18157	0.29882
DA	0.23529	0.17709	0.2935
ME	0.20098	0.14599	0.25597
CA	0.11765	0.07343	0.16186
PA	0.08824	0.04931	0.12716
RPl	0.07353	0.03771	0.10935
RG	0.03922	0.01258	0.06585
SS	0.0049	0	0.01449

Table 3.10. *A priori* contrasts of *Ctenium aromaticum* (CA) vs. *Muhlenbergia expansa* (ME), *Ctenium aromaticum* and *Muhlenbergia expansa* vs. all other tested seeds, *Ctenium aromaticum* and *Muhlenbergia expansa* vs. *Rhynchospora plumosa* (RPl) and *Rhynchospora gracilenta* (RG) for multiple-offer trials.

Contrast	Wald Chi-Square	DF	Pr > ChiSq
CA versus ME	0.5494	1	0.4586
CA + ME versus rest	14.5486	1	0.0001
CA + ME versus RPl + RG	17.1788	1	<.0001

Table 3.11. Multiple comparison probabilities adjusted using the stepdown Bonferroni method of Holm (SAS Institute Inc. 2004).

	EL	*DA*	*ME*	*CA*	*PA*	*RG*	*RPl*	*SS*
EL	-	-	-	-	-	-	-	-
DA	1	-	-	-	-	-	-	-
ME	1	1	-	-	-	-	-	-
CA	0.06	0.07	0.37	-	-	-	-	-
PA	0.01	0.01	0.06	1	-	-	-	-
RPl	0	0	0.02	1	1	-	-	-
RG	<.0001	<.0001	0	0.09	0.45	1	-	-
SS	0	0	0.01	0.03	0.07	0.45	0.1	-

EL = *Eupatorium leucolepis*, DA = *Dichanthelium angustifolium*, ME = *Muhlenbergia expansa*, CA = *Ctenium aromaticum*, PA = *Panicum anceps*, RPl = *Rhynchospora plumosa*, RG = *Rhynchospora gracilenta* and SS = *Schizachyrium scoparium*

Multiple-offer Seed Preference

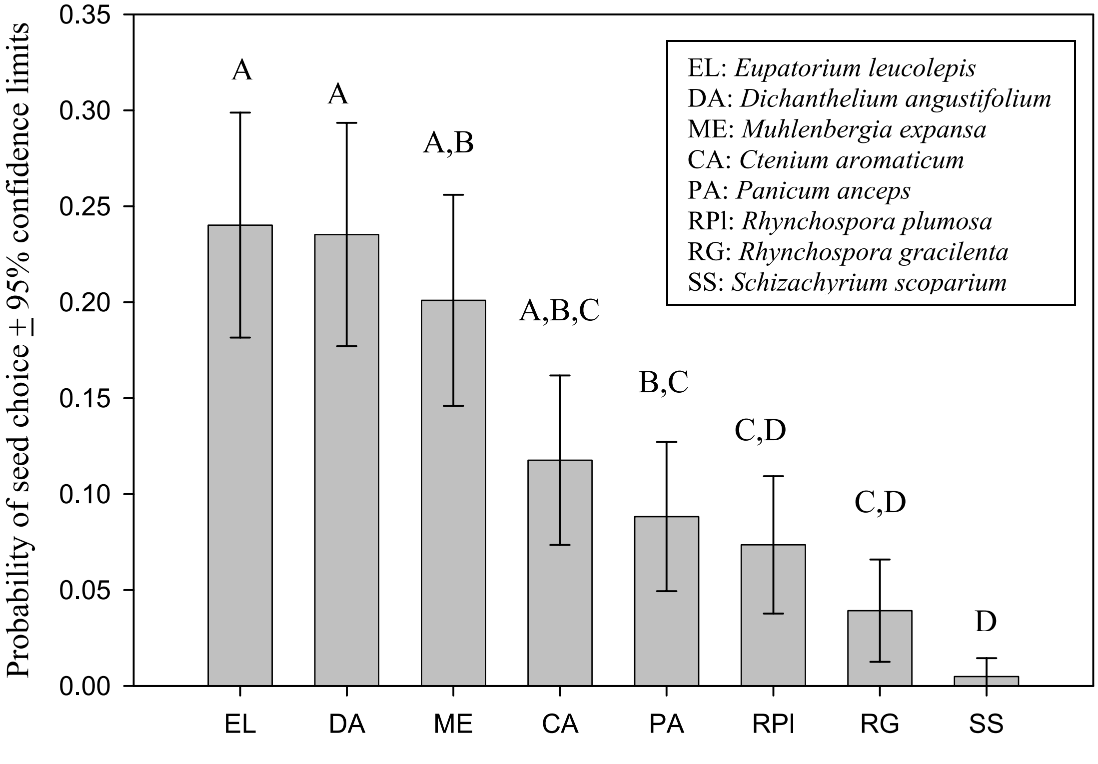

Figure 3.5. Probability of seeds being eaten for each species (letters represent differences in multiple-comparison probabilities).

Table 3.12. *A priori* contrasts of seeds by size class for multiple-offer trials. Size 1 includes *Dichanthelium angustifolium*, *Panicum anceps*, *Rhynchospora plumosa* and *Rhynchospora gracilenta* . Size 2 includes *Muhlenbergia expansa* and *Eupatorium leucolepis*. Size 3 includes *Ctenium aromaticum* and *Schizachyrium scoparium* (Table 2.3).

Contrast	Wald Chi-Square	DF	Pr > ChiSq
Size 1 versus 2 Seeds	29.9792	1	<.0001
Size 1 versus 3 Seeds	6.0808	1	0.0137
Size 2 versus 3 Seeds	18.0414	1	<.0001

Comparison of Simple-offer and Multiple-offer Seed Preference Trials

A scatter-plot comparing the mean proportions of seeds eaten in the simple-offer trial to the multiple-offer trial reveals *Schizachyrium scoparium*, *Rhynchospora plumosa* and *Rhynchospora gracilenta* were avoided while *Ctenium aromaticum* and *Panicum anceps* appear

to be secondarily-preferred food items (Figure 3.6). *Dichanthelium angustifolium*, *Eupatorium leucolepsis*, and *Muhlenbergia expansa* appear to be preferred seeds (Figure 3.6).

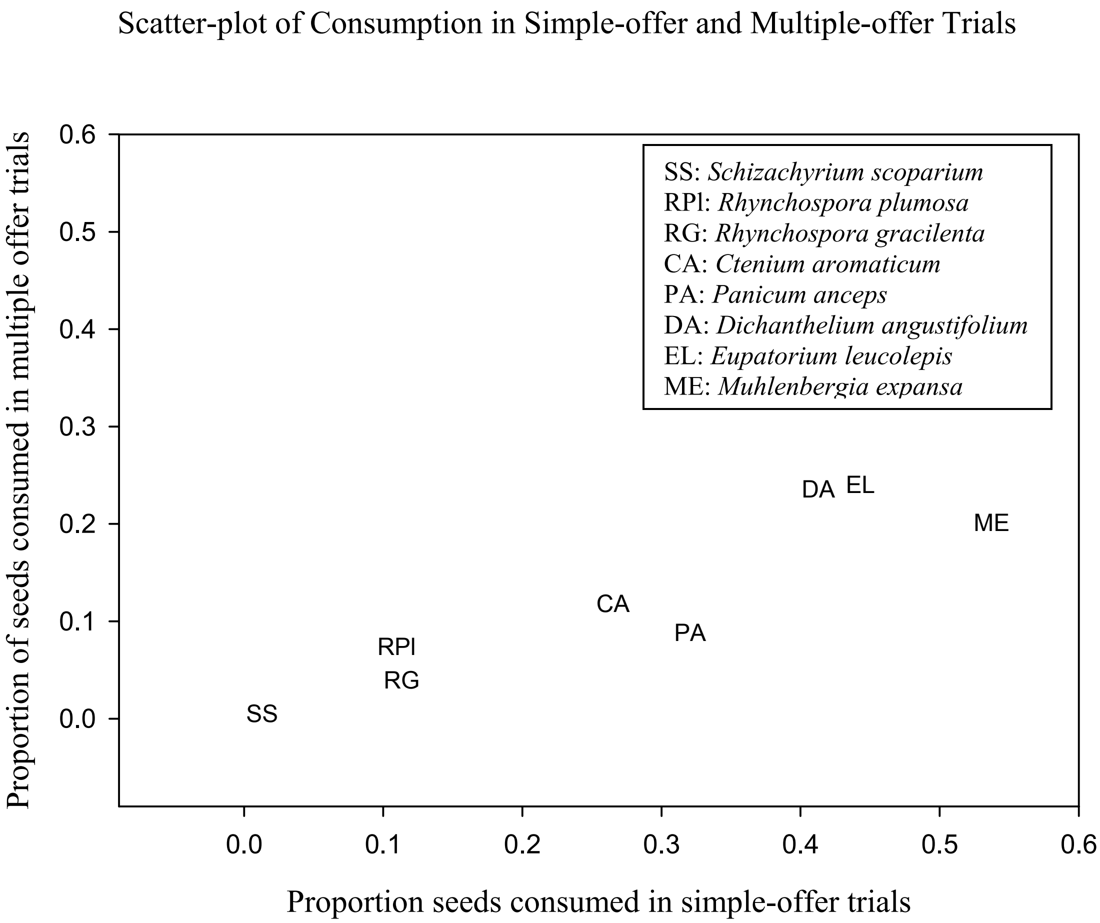

Figure 3.6. Scatter-plot showing combined estimated mean proportions of seeds consumed in simple-offer and multiple-offer seed preference experiments.

DISCUSSION

The combination of small sample sizes and high variability in proportions of seeds eaten by individual birds made it difficult to detect significant differences in seed choice. However, Henslow's Sparrows did exhibit preference for some seeds over others. *Dichanthelium angustifolium*, *Eupatorium leucolepis*, and *Muhlenbergia expansa* appear to be preferred seeds, while *Schizachyrium scoparium*, *Rhynchospora plumosa* and *Rhynchospora gracilenta* were

avoided. *Ctenium aromaticum* and *Panicum anceps* are likely secondarily-preferred food items. All of the seeds presented during the trials were eaten by at least one bird, suggesting Henslow's Sparrows are generalists.

Fire and seed availability are closely related in pine savannas and these food preference experiments provide insight into how Henslow's Sparrows respond to habitat changes resulting from fire. Both *Muhlenbergia expansa* and *Ctenium aromaticum* previously were shown to be indicators of preferred habitat for Henslow's Sparrows in southeastern Louisiana (Bechtoldt 2002, Bechtoldt and Stouffer 2005). Additionally, both species require fire to produce seeds (MacRoberts and MacRoberts 1992, Main and Barry 2002). Both of these seeds had a higher probability of being eaten by Henslow's Sparrows in simple-offer trials, and *Muhlenbergia expansa* was a preferred seed in multiple-offer trials. Studies also have shown *Rhynchospora* spp., *Dichanthelium* spp., *Panicum* spp., and *Schizachyrium* spp. increase in abundance as time since last burn increases (Bechtoldt 2002, Fuller 2004, Bechtoldt and Stouffer 2005). In preference trials, *Dichanthelium angustifolium* was among the more preferred food items, but both *Rhynchospora* spp. offered and *Schizachyrium scoparium* had lower probabilities of being eaten in both simple-offer and multiple-offer trials. Even though Fuller (2004) found grasses such as *Andropogon* spp., *Aristida* spp., *Panicum* spp. and *Paspalum* spp. increased as time since burn increased, this was only for fall burns, which is not a typical management practice at study sites in southeastern Louisiana. Fuller (2004) also found these grasses to be common the first fall following a spring burn. Another seed preference relationship that is not clearly tied to fire is *Scleria* spp., which is more common during the first growing season after a burn (Fuller 2004). *Scleria pauciflora* was not a preferred seed in my pilot study (Appendix C), but it was frequently found in the diet of Henslow's Sparrows regardless of time since burn (Chapter 1, Fuller 2004).

Another factor that may dictate which seeds are preferred is seed morphological characteristics which may result in mechanical constraints (Pulliam and Brand 1975, Diaz 1994) or increased handling times (Zach and Falls 1978, Schluter 1982, Diaz 1994). In both multiple-offer and simple-offer experiments, birds preferred the medium sized seeds over both the larger and smaller ones (Table 8, Figure 3, Table 12). This could reflect the tradeoff between handling time and nutrition gained from choosing medium sized seeds (Diaz 1994). However, the preference for medium sized seeds may just reflect a species preference. Size class 2 represented two of the most preferred seed species, *Eupatorium leucolepis* and *Muhlenbergia expansa*. The lack of preference for larger seeds probably was driven mostly by *Schizachyrium scoparium*, which was avoided in both types of trials. Seeds that have large awns, such as *Schizachyrium scoparium*, may be avoided by the birds because of the difficulty these features may cause in extracting the seeds (Pulliam and Brand 1975). The spikelet of *Schizachyrium scoparium* is fairly tough with awns poking out, so it may not be easy to husk the grain. This may increase handling time such that the effort does not result in a profitable reward (Diaz 1994). *Ctenium aromaticum* spikelets also have awns, but the grains are often found on the ground already husked, so this may be how birds commonly encounter the seeds. For the seed preference experiments, I offered only husked *Ctenium aromaticum* seeds to the birds because it was too difficult to determine if a spikelet contained a grain otherwise. However, this may have impacted the likelihood of *Ctenium aromaticum* being chosen since the morphological characteristics which could be deterrents were eliminated, but this is probably not the case since the seed is often naturally found husked.

Nutrition also is an important factor to consider in determining and explaining preferences for certain food items over others (Diaz 1996, Hayslette and Mirarchi 2001, Frazer

and McWilliams 2002, Bosque and Calchi 2003, Schaefer et al. 2003). Seeds are used by birds in proportion to their profitability; thus, seeds that provide the best sources of specific nutrients may be preferred (Diaz 1994). According to optimal foraging theory, diet selection should maximize the efficiency of nutrient intake, especially with regard to energy (Hayslette and Mirarchi 2001). During winter months, fat plays an increasingly important role in diets of birds, and seeds are the best sources of fatty acids (Diaz 1996). Increased fat intake is expected during winter because fats are a more concentrated energy source (Hayslette and Mirarchi 2001), and Henslow's Sparrows are fattest during mid-winter months (E. Johnson, unpublished data). Hayslette and Mirarchi (2001) predicted selection for energy sources such as carbohydrates and lipids during post-breeding and winter seasons in Mourning Doves. Mourning Doves increased their intake of high carbohydrate foods during periods of decreasing temperature, but they did not switch to seeds high in fat (Hayslette and Mirarchi 2001). Additionally, in studies of fatty acid storage and composition in migratory Red-eyed Vireos, birds selected foods with specific fatty acids to influence the composition of fat stores (Pierce and McWilliams 2005). Future analysis of fat content and total energy of seeds used in Henslow's Sparrow seed preference trials are necessary to determine what role nutrition and seed chemistry plays on selection.

Determining the winter diet of Henslow's Sparrows could have broader importance in slowing the decline of this species. Just like survival and reproductive success on the breeding ground plays a role in determining winter population density, winter habitat quality and resource availability partly are responsible for determining breeding population size (Fretwell 1972). Over the winter, birds have different requirements and needs than those of the breeding season; limiting factors for wintering sparrows are adequate food and suitable habitat for predator avoidance and self maintenance (Fretwell and Lucas 1970, Fretwell 1972, Pulliam 1975, Pulliam

and Mills 1977). Food resource availability may be the most important factor in determining winter survival at a population level (Sherry and Holmes 1996). Therefore, furthering knowledge of winter diet and food preferences should help to explain how Henslow's Sparrow populations distribute themselves according to resource availability (Janzen 1980, Sherry and Holmes 1996). Overall, my experiments suggest that Henslow's Sparrows are generalists in the winter and eat a variety of seeds; they prefer seeds that are common in both recently burned savannas, such as *Muhlenbergia expansa* and *Ctenium aromaticum*, and unburned savannas, such as *Dichanthelium* spp. However, their preference for *Muhlenbergia expansa* and *Ctenium aromaticum* seeds coincides with the indicators of preferred habitat. While the sparrows may be compensating for the lack of more preferred fire dependent seeds in unburned habitats by increasing the frequency of consumption of less preferred food items such as *Rhynchospora* spp., the lack of preferred food items may contribute to a lower density of Henslow's Sparrows in unburned savannas (Bechtoldt 2002, Fuller 2004, Bechtoldt and Stouffer 2005). However, this compensation does not seem to affect body condition, as there appears to be little difference in condition of Henslow's Sparrows between birds captured in recently burned savannas and birds captured in savannas that were burned the previous year (E. Johnson, unpublished data). Further research is necessary to determine if a change in body condition of Henslow's Sparrows is more pronounced in habitats with increasing time since burn.

Henslow's Sparrow abundance in Louisiana is greatest in savannas having high seed abundance and those with tall grass and low vegetation density near the ground (Bechtoldt 2002, Bechtoldt and Stouffer 2005). Additionally, the percent cover of *Muhlenbergia expansa* and *Ctenium aromaticum* is positively correlated with Henslow's Sparrow abundance (Bechtoldt 2002, Bechtoldt and Stouffer 2005). Frequent burning is critical in maintaining all of these

habitat characteristics. However, the correlation of preferred food items with burned habitats suggests that vegetation structure is not the sole factor influencing Henslow's Sparrow abundance. Preference for fire dependent food sources also may play a role in the greater use of recently burned savannas by Henslow's Sparrows.

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CHAPTER 4: FORAGING BEHAVIOR OF WINTERING HENSLOW'S SPARROWS

Differences in habitat and food resources requirements between winter and breeding seasons dictate that Henslow's Sparrows (*Ammodramus henslowii*) have different foraging opportunities and focus on different food items depending on season (Fretwell and Lucas 1970, Fretwell 1972, Pulliam 1975, Pulliam and Mills 1977, Herkert et al. 2002). In the breeding season, their diet consists primarily of arthropods, with some fruit and seeds (Herkert et al. 2002). Henslow's Sparrows forage in the dense litter layer present in the breeding habitat (Herkert et al. 2002). However, during the winter, Henslow's Sparrows prefer habitats with litter-free ground beneath tall grasses (Plentovich et al. 1999, Bechtoldt 2002, Carrie et al. 2002, Tucker and Robinson 2003, Bechtoldt and Stouffer 2005). Anecdotal evidence suggests that sparrows pick up fallen seeds from the ground in the winter, which is why open ground may be preferred (Carrie et al. 2002). Furthermore, depending on whether Henslow's Sparrows take their seeds from stalks or from the ground, there may be a difference in food items eaten. If this is the case, then food availability will greatly depend on timing of senescence and seed dispersal by different species of plants (Pulliam and Brand 1975).

Free-ranging Henslow's Sparrows in winter are too elusive to observe foraging under normal field conditions. In the past, foraging behavior studies have used captive birds in aviaries with a variety of sparrow species, including Savannah Sparrows (*Passerculus sandwichensis*) (Wheelwright and Templeton 2003), Grasshopper Sparrows (*Ammodramus savannarum*) (Joern 1988), Sage Sparrows (*Amphispiza belli*), Black-throated Sparrows (*A. bilineata*) and Dark-eyed juncos (*Junco hyemalis*) (Repasky and Schluter 1996). Additionally, the use of small, portable aviaries has been successful in order to observe birds foraging in their natural habitat (Repasky and Schluter 1996).

I attempted to examine foraging behavior of the Henslow's Sparrow to determine how birds acquire their food. I focused on the research question of whether Henslow's Sparrows pick up seeds from the ground or if they take them directly from stalks.

MATERIALS AND METHODS

In order to observe Henslow's Sparrows foraging, I placed a portable 6ft x 6ft x 6ft aviary (EZ Twist, Large Screen Room) over a patch of pine savannah habitat (Figure 4.1). I observed two birds at Lake Ramsay Wildlife Management Area in February 2005 and two birds at Sandy Hollow Wildlife Management Area in April 2005. After setting up the aviary, vegetation was cleared from the edges and thinned in order to be able to observe the bird as it moved around the aviary. I also added some loose grass and sedge seeds to the ground and a few stalks of common plants containing seeds to provide additional foraging opportunities. Immediately after capture and banding, a sparrow was placed in the tent and observed using a blind for a maximum of two hours in an attempt to determine the method of food retrieval. Any foraging behaviors observed were to be classified following selected criteria described by Remsen and Robinson (1990) (Table 4.1). Upon completion of observations, I released birds back onto their capture site.

Table 4.1. Foraging Behavior Classification

Attack	Surface Maneuvers (glean, reach, lunge) Subsurface Maneuvers (probe, scratch, flake)
Foraging Site	Vertical Position Horizontal Position Substrate
Food Taken	
Food Handling Technique	

Figure 4.1. Portable aviary at Lake Ramsay Wildlife Management Area.

RESULTS AND DISCUSSION

All Henslow's Sparrows remained distressed and nervous during captivity and therefore did not forage. Most of their time was spent either trying to escape from the tent (16%-79%) or hiding beneath the grasses (20%-84%). One bird escaped within the first five minutes of capture. Although one bird did appear to spend some time (13%) searching the ground, I never observed the bird picking up any food items.

Clearly, further development of this technique is necessary for any research to be successful. If a similar study were to be attempted on Henslow's Sparrows, I would recommend

several changes in protocol. First, I recommend that birds be held in captivity for a couple of days in order to allow them to acclimate before beginning foraging trials. My experience with captive Henslow's Sparrows suggests that it takes at least two days for them to adjust to being held captive in small cages and begin foraging, and during the period of adjustment they may require some hand feeding in order to stimulate them to initiate foraging. I had hoped that being held in a more natural setting, such as a portable aviary placed within their home range, would allow them to adjust and begin eating sooner. Based on my results, birds need longer than two hours to adjust to the protable aviary. I also would recommend supplementing the available food with non-sprouting commercial seed and naturally occurring insects to stimulate foraging (Repasky and Schluter 1996, Wheelwright and Templeton 2003). This could be removed prior to observing birds for foraging behavior if it kept birds from eating native seeds.

Foraging behavior has been successfully monitored on captive birds of other species of sparrows, including the Grasshopper Sparrow (Joern 1988). With adjustments, perhaps this procedure could be effective in determining foraging methods utilized by wintering Henslow's Sparrows.

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CHAPTER 5: SUMMARY AND CONCLUSIONS

My results indicate that Henslow's Sparrows (*Ammodramus henslowii*) are generalist foragers. They eat a variety of seeds and arthropods which occur in varying abundances in pine savannas. In southeast Louisiana, Henslow's Sparrows frequently consumed sedge seeds including *Rhynchospora* spp. and *Scleria* spp., and grass seeds such as *Dichanthelium* spp., *Panicum* spp., and *Schizachyrium* spp., *Andropogon* spp., and *Aristida* spp. Arthropods most frequently eaten by Henslow's Sparrows include Arachnids and insects from the orders Coleoptera, Hymenoptera and Orthoptera.

All of the dominant understory plants found in pine savannas, with the exception *Ctenium aromaticum*, were identified as part of the winter diet of Henslow's Sparrows, along with many other less common seeds. Even though I was surprised by the low occurrence of *Muhlenbergia expansa* and absence of *Ctenium aromaticum* from fecal samples, these items probably were just digested too thoroughly to be detected using fecal analysis. This is supported by the seed preference experiments, where both *Muhlenbergia expansa* and *Ctenium aromaticum* were among the preferred food items.

In seed preference experiments, Henslow's Sparrows demonstrated a preference for some seeds over others. *Dichanthelium angustifolium*, *Eupatorium leucolepis*, and *Muhlenbergia expansa* appeared to be preferred seeds, while *Schizachyrium scoparium*, *Rhynchospora plumosa* and *Rhynchospora gracilenta* were avoided. *Ctenium aromaticum* and *Panicum anceps* were likely secondarily-preferred food items. All of the seeds presented during the trials were eaten by at least one bird, further supporting the idea that Henslow's Sparrows are opportunistic feeders.

Foraging behavior experiments did not produce any reliable results, as Henslow's Sparrows remained nervous and distressed during the short time they were in captivity. Further development of technique is necessary.

APPENDIX A: SEED CONTENTS IDENTIFIED IN INDIVIDUAL FECAL SAMPLES

Samples from plots LREXP and LREX01 were included with LR01 in analyses and LREX03 was included with LR05 because they are located in the same burn unit. Samples from plots LREX02, LREX04, LR corner, and LEE (Lee Memorial Forest), and TALI (Talisheek Preserve) were excluded from analyses.

Date	**Plot**	**Burn**	**FWS Band Number**	**Seed parts**	***Rhynchospora spp.***	***R. gracilenta***	***R. elliottii***	***R. pusilla***	***R. globularis***	***R. chapmanii***	***Dichanthelium spp.***	***Panicum spp.***	***P. anceps***	**GRASS**	***Scleria spp.***	**ARISTIDA**	***Pityopsis graminifolia***	***M. expansa***	***Eragrostis spp.***	***Linum medium***	***Xyris spp.***	***Fuirena brevisita***
10/23/03	LREXP	0	228093152	y	x										x							
10/23/03	LREXP	0	228093153	y	x									x	x							
11/1/03	LR05	0	228093301	y												x						
11/2/03	AS?	1	228093158	y										x	x							
11/8/03	AS01	1	228093161	y										x	x							
11/8/03	SH01	0	228093162	y										x	x							
11/8/03	SH01	0	228093163	y	x									x	x							
11/8/03	SH01	0	228093164	y											x							
11/8/03	SH01	0	228093165	y										x	x							
11/9/03	LR04	0	220893174	y										x	x							
11/9/03	LR05	0	228093166	y	x									x	x							
11/9/03	LR05	0	228093167	y	x									x	x							
11/9/03	LR05	0	228093168	y	x										x							
11/9/03	LR05	0	228093169	y										x	x							
11/9/03	LR05	0	228093170	y	x									x	x							
11/9/03	LR05	0	228093171	y	x										x							
11/9/03	LR04	0	228093172	y											x							
11/9/03	LR05	0	228093173	y	x									x	x							
11/13/03	SH02	1	228093175	y	x									x	x							
11/13/03	SH02	1	228093176	y	x									x								

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
11/15/03	LR01	0	228093177	y											x							
11/15/03	LR01	0	228093180	y	x										x	x						
11/15/03	LR01	0	228093182	y	x									x	x	x						
11/15/03	LR02	0	228093184	y	x										x							
11/16/03	AS01	1	228093188	n																		
11/16/03	AS01	1	228093189	y	x									x	x							
11/16/03	AS03	1	228093190	y										x	x							
11/22/03	SH02	1	228093191	y	x						x			x	x							
11/22/03	SH02	1	228093192	y							x			x	x							
11/22/03	SH02	1	228093193	y										x								
11/22/03	SH02	1	228093195	y										x	x							
11/22/03	SH02	1	228093196	y										x		x						
11/22/03	SH02	1	228093197	y											x							
11/22/03	SH02	1	228093198	y										x	x							
11/23/03	LR03	0	228093156	y	x									x	x	x						
11/23/03	LR05	0	228093170	y	x										x	x						
11/23/03	LR03	1	228093199	y	x										x							
11/23/03	LR03	0	228093200	y	x									x	x							
11/23/03	LR05	0	228093304	y	x										x							
11/23/03	LR05	0	228093305	y							x				x	x						
11/23/03	LR05	0	228093306	y	x										x							
11/23/03	LR05	0	228093307	y										x	x	x						
11/24/03	CWP	0	228093308	y										x	x	x						
11/24/03	CWP	0	228093310	y	x									x	x	x						
11/24/03	CWP	0	228093311	y										x	x	x						
11/24/03	SH01	0	228093312	y	x						x			x								

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
12/5/03	CWP	0	228093220	n																		
12/6/03	AS03	1	228093202	y	x										x	x						
12/6/03	AS03	1	228093203	y	x									x	x	x						
12/6/03	CWP	0	228093311	y											x							
12/6/03	CWP	0	228093314	y																		
12/6/03	CWP	0	228093315	y	x									x	x	x						
12/6/03	CWP	0	228093316	y										x	x							
12/6/03	CWP	0	228093317	y							x			x	x	x						
12/6/03	CWP	0	228093318	y											x							
12/6/03	LR03	0	228093321	y	x									x	x	x						
12/7/03	LR02	0	228093182	y											x							
12/7/03	LR01	0	228093184	y										x	x							
12/7/03	LR01	0	228093324	y										x	x	x						
12/7/03	LR01	0	228093326	y											x							
12/7/03	LR02	0	228093367	y	x										x	x						
12/7/03	LR02		228093368	y	x									x	x							
12/7/03	LR02	0	228093369	y										x	x	x						
12/7/03	SH02	1	228093204	y							x			x								
12/7/03	SH02	1	228093205	y										x								
12/7/03	SH02	1	228093206	y										x		x						
12/8/03	LR05	0	228093168	y										x	x							
12/8/03	LR05	0	228093170	y											x							
12/8/03	LR05	0	228093330	y											x	x		x				
12/8/03	LR05	0	228093331	y										x	x							
12/8/03	LR05	0	228093332	y	x										x							
12/11/03	LR04	0	228093210	y	x									x	x	x						

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
12/11/03	LR04	0	228093211	y	x						x			x	x							
12/11/03	SH01	0	228093209	y	x									x								
12/12/03	TALI		228093212	y										x	x	x					x	
12/12/03	TALI		228093213	y	x					x	x			x	x	x						
12/12/03	TALI		228093214	y	x									x	x	x						
12/14/03	AS01	1	228093188	y	x									x	x	x						
12/14/03	AS03	1	228093217	y	x										x						x	
12/15/03	CWP	0	228093218	y										x							x	
12/15/03	CWP	0	228093220	y	x									x	x	x						
12/15/03	CWP	0	228093314	y	x	x	x						x	x	x	x						
12/15/03	CWP	0	228093318	y	x										x							
12/16/03	LR05	0	228093305	y																		
12/16/03	LR05	0	228093328	y	x										x	x						
12/16/03	LR05	0	228093330	y	x									x	x	x						
12/20/03	LR02	0	228093184	n																		
12/20/03	LR01	0	228093222	y	x										x	x						
12/20/03	LR03	0	228093225	y										x	x							
12/20/03	LR02	0	228093333	n																		
12/20/03	LR02	0	228093334	y											x	x			x			
12/20/03	LR04	0	228093336	y	x									x	x							
12/20/03	LR04	0	228093337	y	x									x	x							
12/20/03	LR04	0	228093338	y	x										x	x						
12/20/03	LR02	0	228093369	y											x							
12/20/03	LR02	0	228093370	y										x	x	x						
12/21/03	SH02	1	228093175	n																		
12/21/03	SH01	0	228093230	y							x				x							

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
12/21/03	SH01	0	228093231	y							x			x								
12/21/03	SH02	1	228093339	y										x								
1/16/04	LR04	0	228093232	y	x										x							
1/16/04	LR04	0	228093335	y	x									x	x							
1/16/04	LR03	0	228093341	y	x										x							
1/18/04	SH02	1	228093193	y										x	x							
1/18/04	SH02	1	228093195	y											x							
1/18/04	SH02	1	228093206	y							x			x								
1/18/04	SH02	1	228093208	n																		
1/18/04	SH01	0	228093231	y	x							x		x	x	x						
1/18/04	SH01	0	228093233	y							x			x	x							
1/18/04	SH02	1	228093339	y										x	x							
1/19/04	LR02	0	228093181	y										x	x							
1/19/04	LR01	0	228093184	y											x							
1/19/04	LR02	0	228093235	y											x	x						
1/19/04	LR01	0	228093326	y											x	x						
1/19/04	LR02	0	228093334	y	x									x	x	x						
1/19/04	LR02	0	228093371	y	x										x							
1/24/04	LR05	0	228093170																			
1/24/04	LR05	0	228093237	y											x							
1/24/04	LR05	0	228093239																			
1/24/04	LR05	0	228093240	y	x										x							
1/24/04	LR05	0	228093305	y											x							
1/31/04	LR02	0	228093181	y	x									x	x	x			x			
1/31/04	LR01	0	228093242	y	x					x					x	x						
1/31/04	LR01	0	228093243	y	x										x							

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
1/31/04	LR01	0	228093342	y											x							
1/31/04	LR02	0	228093343	y											x	x			x			
1/31/04	LR02	0	228093344	y											x							
1/31/04	LR02	0	228093345	y	x										x							
1/31/04	LR02	0	228093347	y	x									x	x	x						
1/31/04	LR02	0	228093368	y	x					x	x				x							
1/31/04?	AS01	1	228093201	y	x									x	x							
2/1/04	SH02	1	228093193	y	x									x	x	x						
2/1/04	SH02	1	228093204	y							x			x	x							
2/1/04	SH02	1	228093209	y										x	x							
2/1/04	SH01	0	228093234	y										x	x							
2/1/04	SH01	0	228093245																			
2/1/04	SH01	0	228093312	y										x								
2/7/04	LR04	0	228093156	y	x										x							
2/7/04	LR04	0	228093247	y	x					x					x							
2/7/04	LR04	0	228093248	y											x	x						
2/7/04	LR04	0	228093341	y										x	x	x						
2/8/04	CWP	0	228093220	y	x									x	x	x						
2/8/04	CWP	0	228093311	y	x									x	x	x						
2/8/04	CWP	0	228093315	y										x	x	x						
2/9/04	LR05	0	228093169	y	x										x	x						
2/9/04	LR05	0	228093249	y											x							
2/9/04	LR05	0	228093250	y	x										x							
2/21/04	LR01	0	228093185	y											x							
2/21/04	LR01	0	228093241	y											x							
2/21/04	LR03	0	228093320	y										x	x							

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
2/21/04	LR01	0	228093324	n																		
2/21/04	LR02	0	228093334	y											x							
2/21/04	LR02	0	228093345	y	x										x							
2/21/04	LR02	0	228093348	y											x							
2/21/04	LR02	0	228093371	y											x							
2/21/04	LR02	0	228093372	y											x				x			
2/22/04	SH02	1	228093176	y	x									x	x							
2/22/04	SH01	0	228093234																			
2/22/04	SH01	0	228093244	y										x								
2/22/04	SH01	0	228093350	y										x		x						
2/28/04	LR05	0	228093168	y											x							
2/28/04	LR05	0	228093249	y	x										x	x						
2/29/04	CWP	0	228093314	y	x									x	x	x						
2/29/04	CWP	0	228093352	y	x									x	x							
3/10/04	LREX01	0	228093354	y	x										x							
3/22/04	near LREX02		228093258	y	x										x							x
3/22/04	LREX01	0	228093262	y	x										x							
3/22/04	LREX01	0	228093263	y										x	x							
3/27/04	LR01	0	228093269	y																		
3/27/04	LR01	0	228093271	n																		
3/27/04	LR01	0	228093272	y											x							
3/27/04	LR01	0	228093274	y											x							
3/27/04	LR04	0	228093275	y	x										x							
3/29/04	CWP	0	228093311	y	x							x		x	x							
4/17/04	S of	0	228093276	y											x	x						

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
	LR01																					
4/24/04	SE of LR02	0	228093278	y	x										x							
10/7/04?	SH02	0	228093279	y										x	x							
10/23/04	LR01	1	228093280	y	x																	
11/3/04	LR05	0	228093364	y	x										x							
11/4/04	AS01	0	228093291	y											x							
11/6/04	LR02	1	167174308	y	x										x	x						
11/6/04	LR03	1	228093359	y	x					x	x			x	x	x						
11/7/04	SH02	0	228093281	y										x	x							
11/7/04	SH01	1	228093361	y											x							
11/7/04	SH01	1	228093362	y	x						x				x	x						
11/13/04	LR05	0	228093282	y	x									x								
11/13/04	LR05	0	228093283	y	x										x							
11/13/04	LR05	0	228093284	y											x							
11/13/04	LR05	0	228093285	y	x					x					x							
11/13/04	LR05	0	228093286	y	x										x							
11/13/04	LR05	0	228093287	y																		
11/13/04	LR05	0	228093363	y	x										x							
11/13/04	LR05	0	228093365	y	x					x	x				x							
11/13/04	LR03	1	228093386	y	x										x							
11/14/04	AS01	0	228093292	y	x									x	x	x						
11/14/04	AS01	0	228093295	y											x	x						
11/14/04	AS03	2	228093360	y	x										x	x						
11/14/04?	AS03	2	228093355	y	x									x	x	x						
11/16/04	LR01	1	228093185	y	x					x	x				x							

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
11/16/04	LR01	1	228093351	y	x										x							
11/16/04	LR01	1	228093357	y											x							
11/16/04	LR01	1	228093358	y	x						x			x	x							
11/23/04	LR05	0	228093170	y	x									x	x	x						
12/4/04	CWP	1	167174296	y										x	x							
12/4/04	LREX03	0	228093297	y	x						x			x	x	x						
12/4/04	LREX03	0	228093298	y											x	x						
12/4/04	LREX03	0	228093299	y																		
12/4/04	LREX03	0	236060104	y										x	x	x						
12/4/04	LR corner	0	236060108	y	x																	
12/8/04	LR02	1	228093374	y	x									x	x	x						
12/9/04	SH01	1	228093362	y							x			x	x							
12/9/04	SH02	0	236060128	y							x			x	x							
12/11/04	LREX03	0	228093297	y											x	x						
12/11/04	LR05	0	228093365	y	x									x	x							
12/11/04	LR05	0	236060110	y	x									x	x	x						
12/11/04	LREX03	0	236060112	y										x	x	x						
12/11/04	LREX03	0	236060113	y	x										x							
12/11/04	LREX03	0	236060114	y	x									x	x	x						
12/12/04	AS03	2	236060115	y	x										x	x						
12/12/04	AS01	0	236060116	y	x									x	x	x						
12/12/04	AS01	0	236060117	y	x									x	x	x						
12/12/04	AS01	0	236060118	n																		
12/12/04	AS01	0	236060119	y											x							
12/12/04	AS01	0	236060120	y	x										x							

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
12/12/04	AS01	0	236060121	y	x										x	x						
12/14/04	LR05	0	228093287	y	x					x					x	x						
12/14/04	LREX03	0	228093298	y										x	x							
12/18/04	LR01	1	228093324	y	x						x				x	x					x	
12/18/04	LR02	1	228093374	y	x									x	x	x						
12/18/04	LR02	1	236060125	y	x						x			x	x	x						
12/18/04	LR03	1	236060126	y	x									x	x	x				x		
12/18/04	LR03	1	236060127	y	x									x								
12/19/04	SH02	0	228093204	y							x			x	x							
12/19/04	SH02	0	228093377	y										x	x	x						
12/19/04	SH02	0	228093378	y	x			x						x	x							
12/19/04	SH02	0	228093379	y										x								
12/19/04	SH01	1	236060129	y							x			x	x							
12/21/04	LREX03	0	228093297	y	x									x	x	x						
12/21/04	LREX03	0	236060132	y	x									x	x	x						
1/8/05	LR05	0	236060134	y	x										x							
1/8/05	LR05	0	236060135	y											x	x						
1/9/05	AS01	0	236060121	y	x									x	x							
1/9/05	AS01	0	236060137	y											x							
1/14/05	CWP	1	167174298	y										x	x							
1/15/05	LR03	1	228093156	y	x										x	x						
1/15/05	LR01	1	228093324	y	x									x	x	x						
1/15/05	LR01	1	228093325	y	x									x	x	x						
1/15/05	LR03	1	228093382	y																		
1/15/05	LR03	1	228093881	y	x										x							
1/15/05	LR03	1	236060126	y	x										x							

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
1/16/05	SH02	0	228093377	y											x							
1/16/05	SH01	1	236060129	y	x				x						x							
1/16/05	SH01	1	236060130	y	x						x			x	x							
1/16/05	SH02	0	236060145	y										x	x	x				x		
1/16/05	SH01	1	236060146	y										x	x							
1/20/05	TALI		228093212	y											x							
1/30/05	TALI		236060148	y											x	x						
1/30/05	TALI		236060149	y							x			x	x	x						
1/30/05	TALI		236060150	y	x							x		x								
1/30/05	TALI		236060151	y	x									x	x							
2/11/05	LR05	0	228093168	n																		
2/11/05	LR05	0	236060102	y											x							
2/11/05	LR05	0	236060135	y	x										x							
2/11/05	LR05	0	236060152	y	x										x							
2/11/05	LR05	0	236060154	y	x										x							
2/12/05	LR01	1	228093380	y						x					x			x				
2/12/05	LR03	1	228093381	y	x					x		x		x	x							
2/12/05	LREX04	0	228093387	y						x				x	x	x						
2/12/05	LR03	1	236060156	y	x									x	x							
2/12/05	LR03	1	236060157	y	x									x	x	x						
2/19/05	AS01	0	228093289	y	x										x							
2/19/05	AS01	0	228093291	y																		
2/19/05	AS03	2	228093390	y	x									x	x	x						
2/19/05	AS03	2	228093391	y	x										x	x						
2/19/05	AS01	0	236060158	y											x		x				x	
2/19/05	AS01	0	236060160	y	x									x	x	x						

Date	Plot	Burn	FWS Band Number	Seed parts	*Rhynchospora spp.*	*R. gracilenta*	*R. elliottii*	*R. pusilla*	*R. globularis*	*R. chapmanii*	*Dichanthelium spp.*	*Panicum spp.*	*P. anceps*	GRASS	*Scleria spp.*	ARISTIDA	*Pityopsis graminifolia*	*M. expansa*	*Eragrostis spp.*	*Linum medium*	*Xyris spp.*	*Fuirena brevisita*
2/19/05	LREX04	0	228093387	y	x									x		x						
2/19/05	LREX04	0	228093389	y																		
2/20/05	SH02	0	228093204	y	x										x							
2/20/05	SH01	1	228093362	y	x										x							
2/20/05	SH01	1	228093378	y	x						x				x							
2/20/05	SH02	0	228093392	y										x	x							
2/20/05	SH02	0	228093393	y	x									x	x							
2/20/05	SH01	1	236060161	y	x									x	x							
2/20/05	SH01	1	236060162	y	x									x	x							
2/26/05	near LR05	0	228093395	y											x							
2/26/05	near LREX03	0	236060103	y	x										x							
3/5/05	LR03	1	228093156	y	x										x							
3/5/05	LR04	1	228093248	y											x	x						
3/5/05	LR04	1	228093376	y											x	x						
3/5/05	LR03	1	236060126	y	x										x							
3/5/05	LR02	1	236060163	y	x										x							
3/6/05	SH02	0	228093204	y																		
3/6/05	SH02	0	236060164	y																		
3/6/05	Near SH02	0	236060165	y	x										x							
3/12/05	AS03	2	236060115	y	x					x				x	x	x						
3/12/05	AS03	2	236060167	y	x					x				x	x							
3/12/05	CWP	1	228093396	y	x			x						x	x							
3/13/05	AS01	0	228093293	y	x									x	x	x						
3/13/05	AS01	0	236060119	y																		
3/13/05	LEE		Unbanded	y										x		x						

Date	**Plot**	**Burn**	**FWS Band Number**	**Seed parts**	***Rhynchospora spp.***	***R. gracilenta***	***R. elliotii***	***R. pusilla***	***R. globularis***	***R. chapmanii***	***Dichanthelium spp.***	***Panicum spp.***	***P. anceps***	**GRASS**	***Scleria spp.***	**ARISTIDA**	***Pityopsis graminifolia***	***M. expansa***	***Eragrostis spp.***	***Linum medium***	***Xyris spp.***	***Fuirena brevisita***
3/13/05	LR05	0	228093168	y						x												
3/13/05	LR05	0	236060109	y										x								
3/13/05	LR05	0	236060154	y	x										x							
3/15/05	LR01	1	228093380	y	x									x	x	x						
4/2/05	LR01	1	228093380	y	x											x						
4/3/05	SH01	1	236060130	y										x	x							
4/3/05	SH02	0	236060169	y										x	x							
4/3/05	~SH02	0	236060170	y										x	x							
4/9/05	LR05	0	236060133	y	x										x	x						
4/9/05	LR05	0	236060172	y											x							
4/9/05	LR05	0	236060173	y						x						x						
4/19/05	LR01	1	228093380	y	x									x								
4/19/05	LR05	0	236060171	n																		

APPENDIX B: ARTHROPOD CONTENTS IDENTIFIED IN INDIVIDUAL FECAL SAMPLES

Samples from plots LREXP and LREX01 were included with LR01 in analyses and LREX03 was included with LR05 because they are located in the same burn unit. Samples from plots LREX02, LREX04, LEE (Lee Memorial Forest), and TALI (Talisheek Preserve) were excluded from analyses.

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
10/23/03	LREXP	0	228093152	y						x								x	x	
10/23/03	LREXP	0	228093153	y	x	x				x				x				x	x	
11/1/03	LR05	0	228093301	y	x								x					x	x	
11/2/03	AS?	1	228093158	y	x	x												x	x	
11/8/03	AS01	1	228093161	y	x													x	x	
11/8/03	SH01	0	228093162	y	x													x	x	
11/8/03	SH01	0	228093163	y	x				x				x		x			x	x	
11/8/03	SH01	0	228093164	y	x										x			x	x	
11/8/03	SH01	0	228093165	y										x				x	x	
11/9/03	LR04	0	220893174	y	x															
11/9/03	LR05	0	228093166	y	x								x	x				x	x	
11/9/03	LR05	0	228093167	y	x	x				x								x	x	
11/9/03	LR05	0	228093168	y	x	x							x					x	x	
11/9/03	LR05	0	228093169	y	x	x				x								x	x	
11/9/03	LR05	0	228093170	n																
11/9/03	LR05	0	228093171	y	x	x												x	x	
11/9/03	LR04	0	228093172	y	x													x	x	
11/9/03	LR05	0	228093173	y	x					x				x				x	x	
11/13/03	SH02	1	228093175	y														x	x	
11/13/03	SH02	1	228093176	y	x					x										
11/15/03	LR01	0	228093177	y	x					x								x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
11/15/03	LR01	0	228093180	y						x				x	x					
11/15/03	LR01	0	228093182	y	x					x								x	x	
11/15/03	LR02	0	228093184	y	x		x											x	x	
11/16/03	AS01	1	228093188	y	x															
11/16/03	AS01	1	228093189	y	x															
11/16/03	AS03	1	228093190	y	x													x	x	
11/22/03	SH02	1	228093191	y										x				x	x	
11/22/03	SH02	1	228093192	y	x					x					x			x	x	
11/22/03	SH02	1	228093193	y	x															
11/22/03	SH02	1	228093195	y	x	x									x					
11/22/03	SH02	1	228093196	y	x					x					x			x	x	
11/22/03	SH02	1	228093197	y	x					x					x			x	x	
11/22/03	SH02	1	228093198	y						x								x	x	
11/23/03	LR03	0	228093156	y	x	x												x	x	
11/23/03	LR05	0	228093170	y	x					x								x	x	
11/23/03	LR03	1	228093199	y						x			x	x				x	x	
11/23/03	LR03	0	228093200	n																
11/23/03	LR05	0	228093304	y	x	x				x								x	x	
11/23/03	LR05	0	228093305	y	x									x				x	x	
11/23/03	LR05	0	228093306	y	x					x								x	x	
11/23/03	LR05	0	228093307	y	x					x								x	x	
11/24/03	CWP	0	228093308	y	x								x	x				x	x	
11/24/03	CWP	0	228093310	y	x					x				x				x	x	x
11/24/03	CWP	0	228093311	y	x					x										
11/24/03	SH01	0	228093312	y	x	x				x										
12/5/03	CWP	0	228093220	n																
12/6/03	AS03	1	228093202	y	x					x								x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
12/6/03	AS03	1	228093203	y	x	x								x				x	x	
12/6/03	CWP	0	228093311	y						x				x			x	x	x	
12/6/03	CWP	0	228093314	y														x	x	
12/6/03	CWP	0	228093315	y	x					x								x	x	
12/6/03	CWP	0	228093316	y	x					x								x	x	
12/6/03	CWP	0	228093317	y									x					x	x	
12/6/03	CWP	0	228093318	n																
12/6/03	LR03	0	228093321	y														x	x	
12/7/03	LR02	0	228093182	n																
12/7/03	LR01	0	228093184	y																
12/7/03	LR01	0	228093324	y	x					x								x	x	
12/7/03	LR01	0	228093326	y						x										
12/7/03	LR02	0	228093367	y	x					x								x	x	
12/7/03	LR02		228093368	y	x															
12/7/03	LR02	0	228093369	y						x								x	x	
12/7/03	SH02	1	228093204	y	x	x								x				x	x	
12/7/03	SH02	1	228093205	y														x	x	
12/7/03	SH02	1	228093206	y														x		
12/8/03	LR05	0	228093168	y														x	x	
12/8/03	LR05	0	228093170	y						x										
12/8/03	LR05	0	228093330	y						x				x	x			x	x	
12/8/03	LR05	0	228093331	y	x					x										
12/8/03	LR05	0	228093332	y	x				x									x	x	
12/11/03	LR04	0	228093210	y	x															
12/11/03	LR04	0	228093211	y										x						
12/11/03	SH01	0	228093209	n																
12/12/03	TALI		228093212	y	x	x									x			x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
12/12/03	TALI		228093213	y	x	x								x				x		x
12/12/03	TALI		228093214	y						x								x	x	
12/14/03	AS01	1	228093188	y									x							
12/14/03	AS03	1	228093217	y	x	x				x										
12/15/03	CWP	0	228093218	y						x				x						
12/15/03	CWP	0	228093220	n																
12/15/03	CWP	0	228093314	y	x					x								x	x	
12/15/03	CWP	0	228093318	n																
12/16/03	LR05	0	228093305	n																
12/16/03	LR05	0	228093328	y	x	x												x	x	
12/16/03	LR05	0	228093330	y											x			x	x	
12/20/03	LR02	0	228093184	y																
12/20/03	LR01	0	228093222	y	x					x			x					x	x	
12/20/03	LR03	0	228093225	y	x	x														
12/20/03	LR02	0	228093333	n																
12/20/03	LR02	0	228093334	n																
12/20/03	LR04	0	228093336	y	x									x						
12/20/03	LR04	0	228093337	y	x					x										
12/20/03	LR04	0	228093338	y						x				x				x	x	
12/20/03	LR02	0	228093369	n																
12/20/03	LR02	0	228093370	y	x	x														
12/21/03	SH02	1	228093175	y	x									x		x		x	x	
12/21/03	SH01	0	228093230	y	x								x							
12/21/03	SH01	0	228093231	y	x					x										
12/21/03	SH02	1	228093339	y														x	x	
1/16/04	LR04	0	228093232	y	x	x				x										
1/16/04	LR04	0	228093335	n																

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
1/16/04	LR03	0	228093341	y	x								x					x	x	
1/18/04	SH02	1	228093193	y	x					x			x					x	x	
1/18/04	SH02	1	228093195	y						x										
1/18/04	SH02	1	228093206	y	x								x					x	x	
1/18/04	SH02	1	228093208	n																
1/18/04	SH01	0	228093231	y	x	x														
1/18/04	SH01	0	228093233	y										x				x	x	
1/18/04	SH02	1	228093339	y	x					x					x					
1/19/04	LR02	0	228093181	y	x													x	x	
1/19/04	LR01	0	228093184	y						x										
1/19/04	LR02	0	228093235	y														x	x	
1/19/04	LR01	0	228093326	y	x													x	x	
1/19/04	LR02	0	228093334	y	x	x												x	x	
1/19/04	LR02	0	228093371	y	x													x	x	
1/24/04	LR05	0	228093170	n																
1/24/04	LR05	0	228093237	y						x										
1/24/04	LR05	0	228093239	n																
1/24/04	LR05	0	228093240	y						x			x							
1/24/04	LR05	0	228093305	y						x								x	x	
1/31/04	LR02	0	228093181	y	x															
1/31/04	LR01	0	228093242	y								x		x	x					
1/31/04	LR01	0	228093243	y						x										
1/31/04	LR01	0	228093342	y	x	x				x								x	x	
1/31/04	LR02	0	228093343	y	x	x												x	x	
1/31/04	LR02	0	228093344	y	x															
1/31/04	LR02	0	228093345	y	x									x				x	x	
1/31/04	LR02	0	228093347	y														x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
1/31/04	LR02	0	228093368	y	x															
1/31/04?	AS01	1	228093201	y	x	x									x			x	x	
2/1/04	SH02	1	228093193	y	x								x		x	x		x	x	
2/1/04	SH02	1	228093204	y									x							
2/1/04	SH02	1	228093209	n																
2/1/04	SH01	0	228093234	y	x	x							x					x	x	
2/1/04	SH01	0	228093245	y									x					x	x	
2/1/04	SH01	0	228093312	y											x			x	x	
2/7/04	LR04	0	228093156	y											x			x	x	
2/7/04	LR04	0	228093247	y														x	x	
2/7/04	LR04	0	228093248	y												x		x	x	
2/7/04	LR04	0	228093341	y										x						
2/8/04	CWP	0	228093220	y										x	x			x	x	
2/8/04	CWP	0	228093311	y					x									x	x	
2/8/04	CWP	0	228093315	y	x													x	x	
2/9/04	LR05	0	228093169	y	x					x			x					x	x	
2/9/04	LR05	0	228093249	y	x					x								x	x	
2/9/04	LR05	0	228093250	y	x	x														
2/21/04	LR01	0	228093185	y	x													x	x	
2/21/04	LR01	0	228093241	y	x													x	x	
2/21/04	LR03	0	228093320	y	x															
2/21/04	LR01	0	228093324	n																
2/21/04	LR02	0	228093334	y																
2/21/04	LR02	0	228093345	y						x										
2/21/04	LR02	0	228093348	y	x										x			x	x	
2/21/04	LR02	0	228093371	n																
2/21/04	LR02	0	228093372	y	x													x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
2/22/04	SH02	1	228093176	y	x															
2/22/04	SH01	0	228093234	y	x															
2/22/04	SH01	0	228093244	y	x													x	x	
2/22/04	SH01	0	228093350	n																
2/28/04	LR05	0	228093168	y											x	x				
2/28/04	LR05	0	228093249	y						x					x			x	x	
2/29/04	CWP	0	228093314	y																
2/29/04	CWP	0	228093352	y	x	x				x								x	x	
3/10/04	LREX01	0	228093354	y	x	x												x	x	
3/22/04	Near LREX02		228093258	y	x	x				x										
3/22/04	LREX01	0	228093262	y	x	x										x		x	x	
3/22/04	LREX01	0	228093263	y	x	x				x								x	x	
3/27/04	LR01	0	228093269	y											x					
3/27/04	LR01	0	228093271	n	x															
3/27/04	LR01	0	228093272	y	x	x				x								x	x	
3/27/04	LR01	0	228093274	y	x	x				x								x	x	
3/27/04	LR04	0	228093275	y	x	x		x						x		x		x	x	
3/29/04	CWP	0	228093311	y	x			x							x			x	x	
4/17/04	S of LR01	0	228093276	y	x	x												x	x	
4/24/04	SE of LR02	0	228093278	y	x					x										
10/7/04?	SH02	0	228093279	y	x					x								x	x	
10/23/04	LR01	1	228093280	y	x					x								x	x	
11/3/04	LR05	0	228093364	y	x													x	x	
11/4/04	AS01	0	228093291	y	x															
11/6/04	LR02	1	167174308	y	x	x									x			x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
11/6/04	LR03	1	228093359	y	x	x				x								x	x	
11/7/04	SH02	0	228093281	y	x										x			x	x	
11/7/04	SH01	1	228093361	y														x	x	
11/7/04	SH01	1	228093362	y	x		x								x					
11/13/04	LR05	0	228093282	y	x	x														
11/13/04	LR05	0	228093283	y	x	x									x	x				
11/13/04	LR05	0	228093284	y	x	x				x								x	x	
11/13/04	LR05	0	228093285	y	x															
11/13/04	LR05	0	228093286	y									x	x	x			x	x	
11/13/04	LR05	0	228093287	y														x	x	
11/13/04	LR05	0	228093363	y														x	x	
11/13/04	LR05	0	228093365	y											x			x	x	
11/13/04	LR03	1	228093386	y												x		x	x	
11/14/04	AS01	0	228093292	y	x										x					
11/14/04	AS01	0	228093295	y	x															
11/14/04	AS03	2	228093360	y	x	x				x										
11/14/04?	AS03	2	228093355	y	x													x	x	
11/16/04	LR01	1	228093185	y	x										x			x	x	
11/16/04	LR01	1	228093351	y	x	x							x							
11/16/04	LR01	1	228093357	y														x	x	
11/16/04	LR01	1	228093358	y											x					
11/23/04	LR05	0	228093170	y																
12/4/04	CWP	1	167174296	y																
12/4/04	LREX03	0	228093297	y	x	x								x	x			x	x	
12/4/04	LREX03	0	228093298	y	x	x												x	x	
12/4/04	LREX03	0	228093299	y														x	x	
12/4/04	LREX03	0	236060104	y														x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
12/4/04	LRcorner	0	236060108	y	x								x		x			x	x	
12/8/04	LR02	1	228093374	y																
12/9/04	SH01	1	228093362	y	x													x	x	
12/9/04	SH02	0	236060128	y	x													x	x	
12/11/04	LREX03	0	228093297	y	x								x		x					
12/11/04	LR05	0	228093365	y												x		x	x	
12/11/04	LR05	0	236060110	y														x	x	
12/11/04	LREX03	0	236060112	y	x															
12/11/04	LREX03	0	236060113	y	x	x				x								x	x	
12/11/04	LREX03	0	236060114	y	x	x												x	x	
12/12/04	AS03	2	236060115	n																
12/12/04	AS01	0	236060116	y	x													x	x	
12/12/04	AS01	0	236060117	y														x	x	
12/12/04	AS01	0	236060118	n																
12/12/04	AS01	0	236060119	y	x															
12/12/04	AS01	0	236060120	y										x						
12/12/04	AS01	0	236060121	y																
12/14/04	LR05	0	228093287	y	x															
12/14/04	LREX03	0	228093298	y	x	x														
12/18/04	LR01	1	228093324	y											x					
12/18/04	LR02	1	228093374	y														x	x	
12/18/04	LR02	1	236060125	y																
12/18/04	LR03	1	236060126	y	x													x	x	
12/18/04	LR03	1	236060127	n																
12/19/04	SH02	0	228093204	y														x	x	
12/19/04	SH02	0	228093377	y											x					
12/19/04	SH02	0	228093378	y	x							x						x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
12/19/04	SH02	0	228093379	y						x					x					
12/19/04	SH01	1	236060129	y	x					x								x	x	
12/21/04	LREX03	0	228093297	y	x	x				x										
12/21/04	LREX03	0	236060132	y	x															
1/8/05	LR05	0	236060134	n																
1/8/05	LR05	0	236060135	y																
1/9/05	AS01	0	236060121	y	x															
1/9/05	AS01	0	236060137	n																
1/14/05	CWP	1	167174298	y									x					x	x	
1/15/05	LR03	1	228093156	y	x	x									x					
1/15/05	LR01	1	228093324	y	x										x			x	x	
1/15/05	LR01	1	228093325	y														x	x	
1/15/05	LR03	1	228093382	n																
1/15/05	LR03	1	228093881	y	x					x										
1/15/05	LR03	1	236060126	y							x		x							
1/16/05	SH02	0	228093377	y	x													x	x	
1/16/05	SH01	1	236060129	n																
1/16/05	SH01	1	236060130	y																
1/16/05	SH02	0	236060145	y											x			x	x	
1/16/05	SH01	1	236060146	y														x	x	
1/20/05	TALI		228093212	n																
1/30/05	TALI		236060148	y						x								x	x	
1/30/05	TALI		236060149	y	x					x					x					
1/30/05	TALI		236060150	n																
1/30/05	TALI		236060151	y																
2/11/05	LR05	0	228093168	n																
2/11/05	LR05	0	236060102	y	x															

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
2/11/05	LR05	0	236060135	y	x								x					x	x	
2/11/05	LR05	0	236060152	y	x										x			x	x	
2/11/05	LR05	0	236060154	y	x															
2/12/05	LR01	1	228093380	y						x										
2/12/05	LR03	1	228093381	y											x					
2/12/05	LREX04	0	228093387	y											x					
2/12/05	LR03	1	236060156	y									x					x	x	
2/12/05	LR03	1	236060157	y																
2/19/05	AS01	0	228093289	y	x					x								x	x	
2/19/05	AS01	0	228093291	y	x	x	x			x										
2/19/05	AS03	2	228093390	y	x	x														
2/19/05	AS03	2	228093391	y	x	x												x	x	
2/19/05	AS01	0	236060158	y	x	x												x	x	
2/19/05	AS01	0	236060160	y	x	x									x			x	x	
2/19/05	LREX04	0	228093387	y	x					x								x	x	
2/19/05	LREX04	0	228093389	y														x	x	
2/20/05	SH02	0	228093204	y						x					x			x	x	
2/20/05	SH01	1	228093362	y														x	x	
2/20/05	SH01	1	228093378	y	x										x			x	x	
2/20/05	SH02	0	228093392	y														x	x	
2/20/05	SH02	0	228093393	y	x													x	x	
2/20/05	SH01	1	236060161	y	x	x				x										
2/20/05	SH01	1	236060162	y	x													x	x	
2/26/05	Near LR05	0	228093395	n																
2/26/05	Near LREX03	0	236060103	y	x															

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
3/5/05	LR03	1	228093156	y	x										x					
3/5/05	LR04	1	228093248	n																
3/5/05	LR04	1	228093376	y																
3/5/05	LR03	1	236060126	n																
3/5/05	LR02	1	236060163	y	x													x	x	
3/6/05	SH02	0	228093204	y	x										x					
3/6/05	SH02	0	236060164	y	x					x					x			x	x	
3/6/05	Near SH02	0	236060165	y	x													x	x	
3/12/05	AS03	2	236060115	y	x					x								x	x	
3/12/05	AS03	2	236060167	y	x	x									x			x	x	
3/12/05	CWP	1	228093396	y	x													x	x	
3/13/05	AS01	0	228093293	y	x	x												x	x	
3/13/05	AS01	0	236060119	y	x	x									x			x	x	
3/13/05	LEE		Unbanded	y	x					x					x			x	x	
3/13/05	LR05	0	228093168	y	x													x	x	
3/13/05	LR05	0	236060109	n																
3/13/05	LR05	0	236060154	y	x	x									x			x	x	
3/15/05	LR01	1	228093380	y						x				x	x					
4/2/05	LR01	1	228093380	y														x	x	
4/3/05	SH01	1	236060130	n																
4/3/05	SH02	0	236060169	y	x	x												x	x	
4/3/05	Near SH02	0	236060170	y	x													x	x	
4/9/05	LR05	0	236060133	y	x	x			x	x					x			x	x	
4/9/05	LR05	0	236060172	y	x	x									x			x	x	
4/9/05	LR05	0	236060173	y	x	x				x				x	x			x	x	

Date	Plot	Burn	FWS Band Number	Arthropod parts	COLEOPTERA	Curculionidae	Chrysomelidae	Carabidae	Scarabidae	HEMIPTERA	HOMOPTERA	DIPTERA	LEPIDOPTERA	ORTHOPTERA	HYMENOPTERA	PSOCOPTERA	THYSANOPTERA	ARACHNID	Araneae	Acari
4/19/05	LR01	1	228093380	y														x	x	
4/19/05	LR05	0	236060171	y	x													x	x	

APPENDIX C: PILOT SEED PREFERENCE EXPERIMENTS

I conducted a pilot study during the spring of 2004 in which I tested a variety of seed species found in varying abundances in the study sites to get an idea of what the birds would eat (Table C.1). I preformed simple-offer and multiple-offer seed preference experiments on captive Henslow's Sparrows using techniques and principles described by Cueto et al. (2001).

MATERIALS AND METHODS

Bird Capture and Care

Henslow's Sparrows were captured at Lake Ramsay Wildlife Management Area using flush-netting techniques with 6m mist nets (Bechtoldt 2002; Chandler & Woodrey 1995). Birds were transported to Baton Rouge in small bird carriers (15 x 20 x 15.5 cm) and held in individual cages (35 x 45 x 50 cm) inside an indoor aviary located at LSU's Ben Hur Aquaculture Facility for the duration of the trial. Sparrows were maintained under natural photoperiods, temperatures and humidity.

Henslow's Sparrows were fed a diet of commercial seed (National Audubon Society, Finch Festival), egg, catfood (Nutro, Max Cat Adult), commercial mealworms (coleopteran larvae) and waxworms (lepidopteran larvae) (Armstrong Cricket Farm, Rainbow Mealworms, Petco), and grit *ad libitum* and provided with fresh water. Many birds did not eat the *ad lib* diet right away and required hand feeding of worm pieces in order to stimulate foraging during the first day or two of captivity.

Birds that did not adapt to captivity (would not eat or would not settle down in cages) were returned to their site of capture, or as close as possible, within a day or two of being captured, if they appeared healthy enough to be released. This included one bird in each group during the pilot study. Additionally, one bird in the first group of birds did not eat, and

eventually died after two days in captivity. None of these birds were included in seed preference trials. All research was conducted with approval of LSU IACUC, Louisiana Department of Wildlife and Fisheries (LADFW) and US Fish and Wildlife Service (USFWS).

Seeds Tested

A total of seven birds, divided into two groups, were tested in seed choice trials during March of 2004, with four birds tested on the first group of seeds and the *Rhynchospora* spp. trials, and three other birds tested on the second group of seeds. Problems with seeds made it necessary to exclude *Ctenium aromaticum* from analysis for group 1, while *Tridens ambiguus* and *Andropogon virginicus* were excluded from analysis in group 2. I excluded *Ctenium aromaticum* and *Tridens ambiguus* because I was not confident that all spikelets I offered to the birds contained grains. I excluded *Andropogon virginicus* because it blew out of cages during trials. I began seed preference trials one day after capture for group 1 and two days after capture for group 2 to allow birds to adjust to captivity.

Table C.1. Seeds tested in the March 2004 pilot simple-offer and multiple-offer seed choice experiments.

GROUP 1 (n=4)[a]	**RHYNCHOSPORA (n=4)[a]**	**GROUP 2 (n=3)[a]**
Poaceae	*R. fascicularis*	Poaceae
Ctenium aromaticum	*R. elliottii*	*Paspalum setaceum*
Dichanthelium angustifolium	*R. chapmanii*	*Andropogon virginicus*
Muhlenbergia expansa	*R. plumosa*	*Tridens ambiguus*
Panicum anceps	*R. pusilla*	
Schizachyrium scoparium	*R. inexpansa*	Cyperaceae
		Rhynchospora elliottii
Cyperaceae		*Rhynchospora fascicularis*
Rhynchospora plumosa		*Rhynchospora pusilla*
Scleria pauciflora		
		Asteraceae
Asteraceae		*Helianthus angustifolius*
Eupatorium leucolepis		

[a] number of birds tested

Seed Preference Trials

For both simple-offer and multiple-offer experiments, all food was removed from individual cages two hours prior to the experiment. For simple-offer experiments, birds were offered one species of seed at a time in equal numbers in a small food dish. During the pilot study, 50 seeds were offered to the first group of birds, but for the second group, this was reduced to 20 seeds because of the low numbers of seeds eaten. Twenty minutes were allotted to allow for selection and consumption of seeds before seeds were removed from the cage. This process was repeated daily until all seed types were tested, and the number of each type of seed eaten was recorded. The order and day in which each bird received seed species was randomized so that no birds were tested on the same seed types on a given day or in the same order. In multiple-offer experiments, the same procedure was followed except that birds were presented with 20 of each of the eight seed species at the same time mixed together in one food dish.

Statistical Analysis

Data from the simple-offer experiments were analyzed using a logistic generalized linear mixed model as implemented in PROC GLIMMIX (SAS Institute Inc. 9.1.2). The number of seeds eaten out of 20 trials was the binomial response. Explanatory fixed effects were seed type and day. To account for extra-binomial variation, a bird random effect was included to permit the average proportion of seeds eaten of a particular type to vary among birds. Additionally, an overdispersion constant was included to account for an expected lack of independence among selections of seeds by each bird.

Multiple-offer trial results were analyzed as a multinomial logit utilizing a generalized logit model with PROC LOGISTIC (SAS Institute Inc. 9.1.2). The number of each seed species eaten (Seed) was the dependent variable, and Bird was considered the aggregate. Data were

ordered by Seed in descending frequency, and the seed species with the highest frequency was used as the reference treatment. Differences in seed choice were determined using multiple comparisons adjusted with the stepdown Bonferroni method of Holm as implemented in PROC MultTest (SAS Institute Inc. 9.1.2).

To compare simple-offer and multiple-offer trial results, I created scatter-plots combining estimated mean proportions of seeds eaten in each type of trial.

RESULTS

Simple-offer

The number of seeds eaten by each bird in Pilot simple-offer trials was highly variable (Figure C.1, Figure C.2). There was no significant difference in probability of consumption by seed type in group 1 (Table C.2, Figure C.3). For those seeds tested in group 2, there was no difference in probability of consumption by seed type (Table C.4, Figure C.4).

Table C.2. Type III Test of Fixed Effects for simple-offer seed preference trial of group 1 seeds.

Effect	Num DF	Den DF	F Value	Pr > F
seed	6	7	0.9	0.5428
day	7	7	0.7	0.6738

Table C.3. Least square mean estimates of seeds eaten on both the logit scale (Estimate) and probability scale (Mean) with associated standard errors for the simple-offer preference trial of group 1 seeds.

Seed	Estimate	SE Estimate	Mean	SE Mean
ME	-0.478	0.8331	0.3826	0.1968
DA	-0.695	0.8369	0.333	0.1859
EL	-0.87	1.1672	0.2952	0.2428
SS	-1.9	0.806	0.1302	0.0913
SP	-1.947	0.8809	0.1249	0.0963
PA	-2.075	1.0309	0.1116	0.1022
RP	-2.297	1.0492	0.0913	0.0871

ME = *Muhlenbergia expansa*, DA = *Dichanthelium angustifolium*, EL = *Eupatorium leucolepis*, SS = *Schizachyrium scoparium*, SP = *Scleria pauciflora*, PA = *Panicum anceps* and RPl = *Rhynchospora plumosa*

Variation in Consumption in Group 1 Pilot Simple-offer Trials

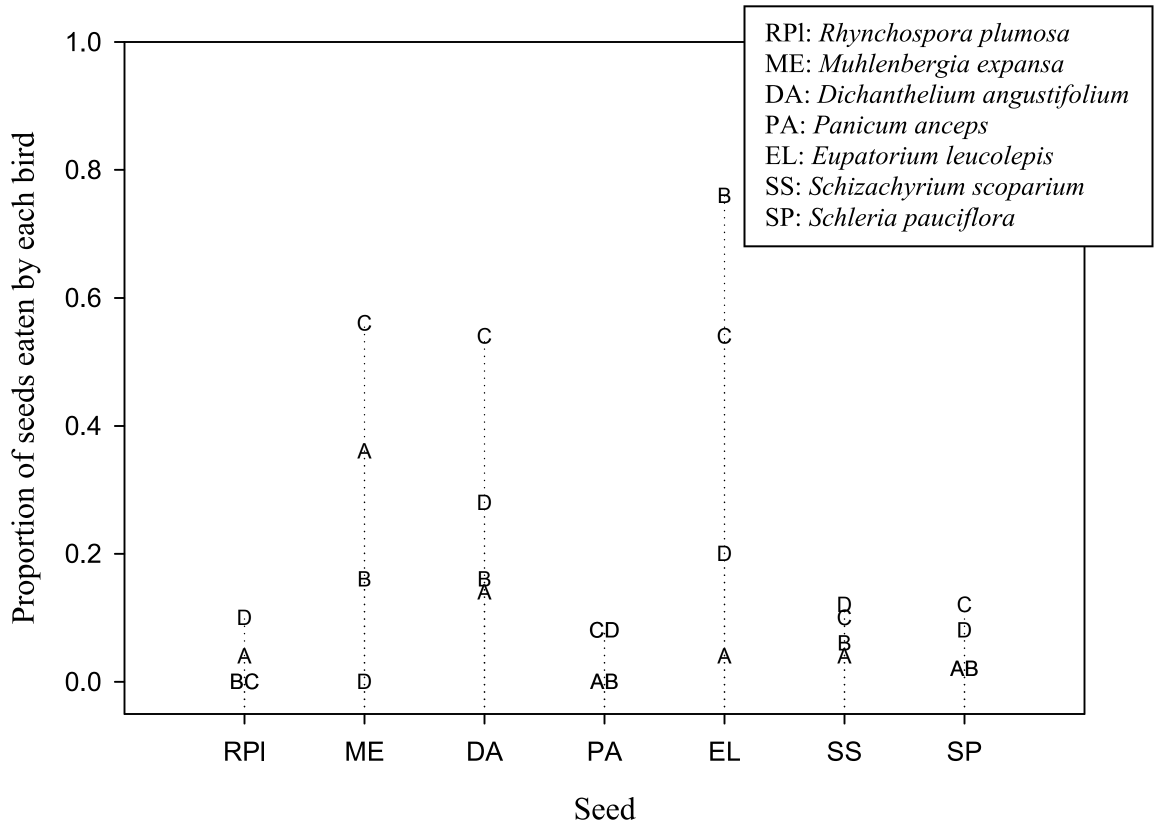

Figure C.1. Individual bird consumption of seeds in Group 1 Pilot simple-offer trials (each letter represents one bird).

Variation in Consumption in Group 2 Pilot Simple-offer Trials

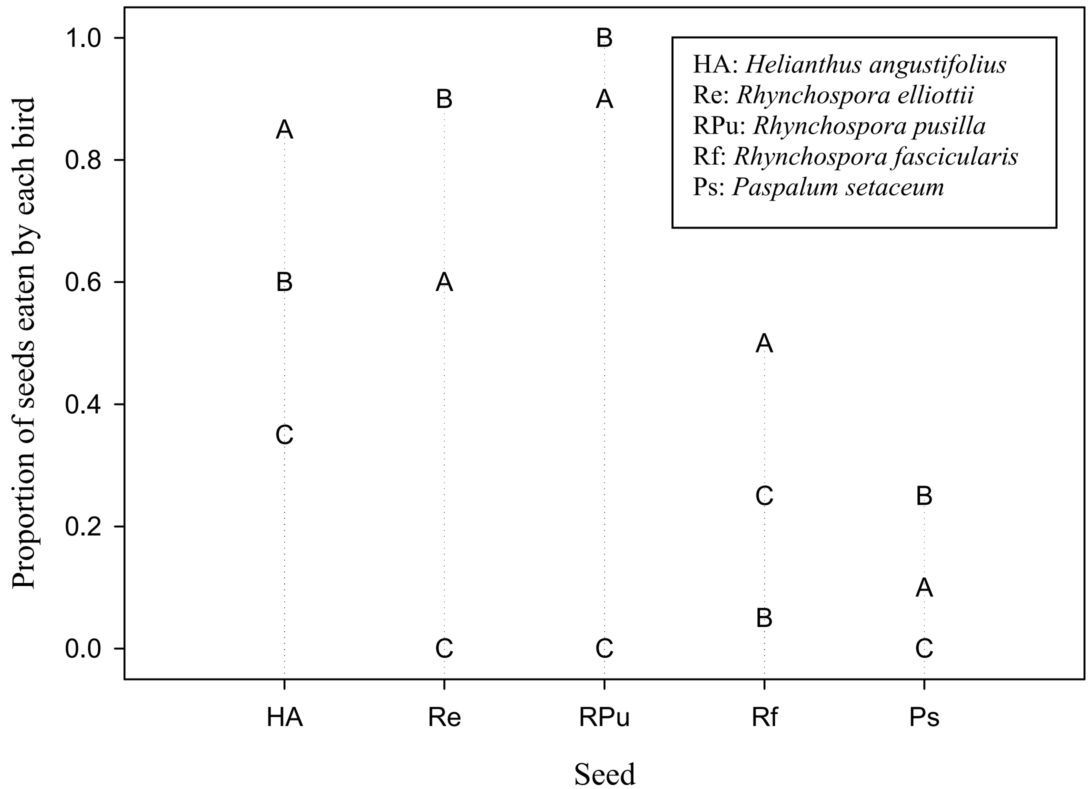

Figure C.2. Individual bird consumption of seeds in Group 2 Pilot simple-offer trials (each letter represents one bird).

Multiple-Offer

Proportions of seeds consumed by each bird in the pilot multiple-offer trials varied greatly (Figure C.5, Figure C.6). For group 1 seeds, *Muhlenbergia expansa* and *Eupatorium leucolepis* were preferred over *Schizachyrium scoparium*. *Muhlenbergia expansa* also was eaten proportionally more than *Rhynchospora plumosa* (Table C.6, Table C.7, Figure C.7). Because no *Schizachyrium scoparium* seeds were eaten during the experiment, an observation of one seed eaten was added to the results for one bird so that *Schizachyrium scoparium* was not dropped from the analysis by PROC LOGISTIC due to a total frequency of zero. For group 2 seeds,

Rhynchospora pusilla and *Helianthus radula* were preferred over *Rhynchospora elliottii* and *Paspallum setaceum* (Table C.8, Table C.9, Figure C.8). The *Rhynchospora* spp. trial results showed no difference of consumption for the different seed types (Table C.10, Table C.11, Figure C.9).

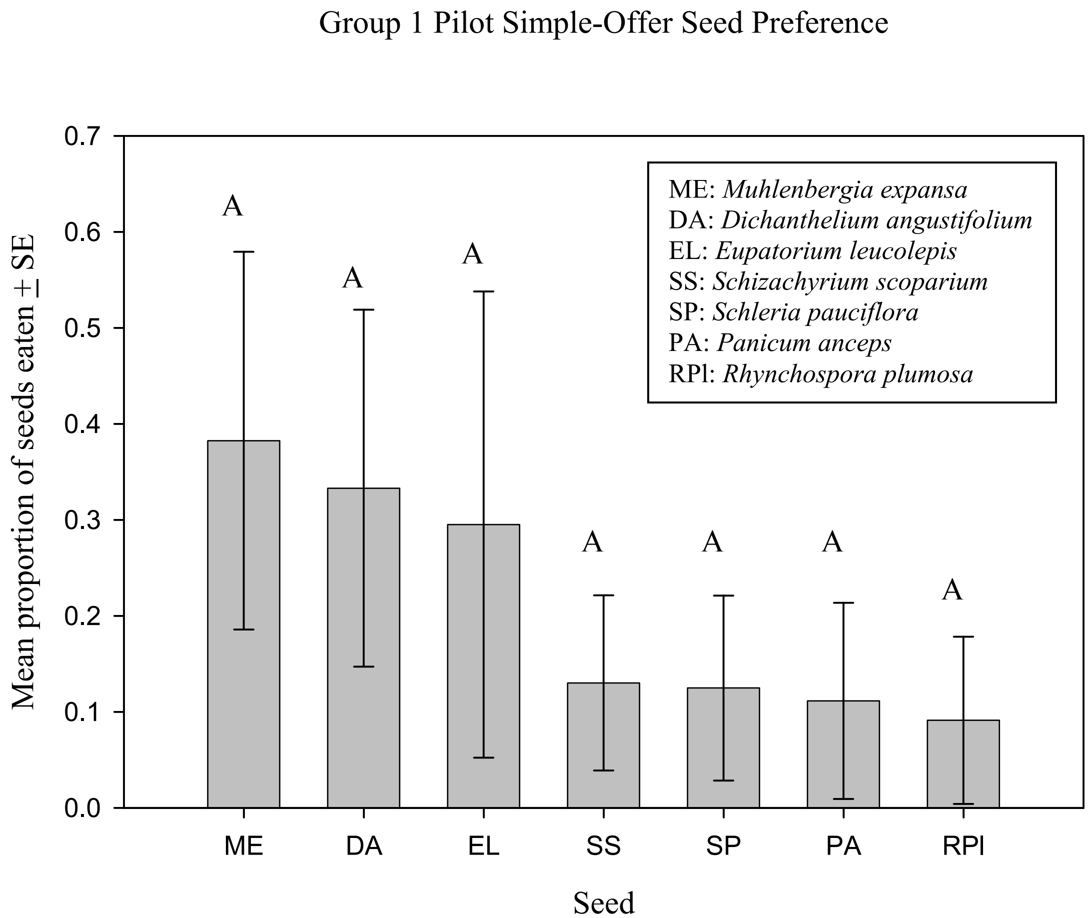

Figure C.3. Estimated mean proportion of seeds eaten for each seed species in Pilot simple-offer trials of group 1 seeds (letters represent differences in proportions of seeds eaten).

Table C.4. Preliminary simple-offer seed preference trial of group 2 seeds Type III Test of Fixed Effects.

Effect	Num DF	Den DF	F Value	Pr > F
seed	4	2	1.39	0.4585
day	6	2	0.52	0.7751

Table C.5. Least square mean estimates of seeds eaten on both the logit scale (Estimate) and probability scale (Mean) with associated standard errors for simple-offer group 2 seeds.

seed	Estimate	SE Estimate	Mean	SE Mean
HA	1.5832	1.9149	0.8297	0.2706
RPu	0.5561	2.188	0.6356	0.5068
Re	-0.371	1.8734	0.4084	0.4526
Rf	-1.381	1.7017	0.2009	0.2731
PS	-4.444	2.3539	0.0116	0.027

HA = *Helianthus angustifolius*, PS = *Paspalum setaceum*, RPu = *Rhynchospora pusilla*, Re = *Rhynchospora elliottii*, Rf = *Rhynchospora facicularis*

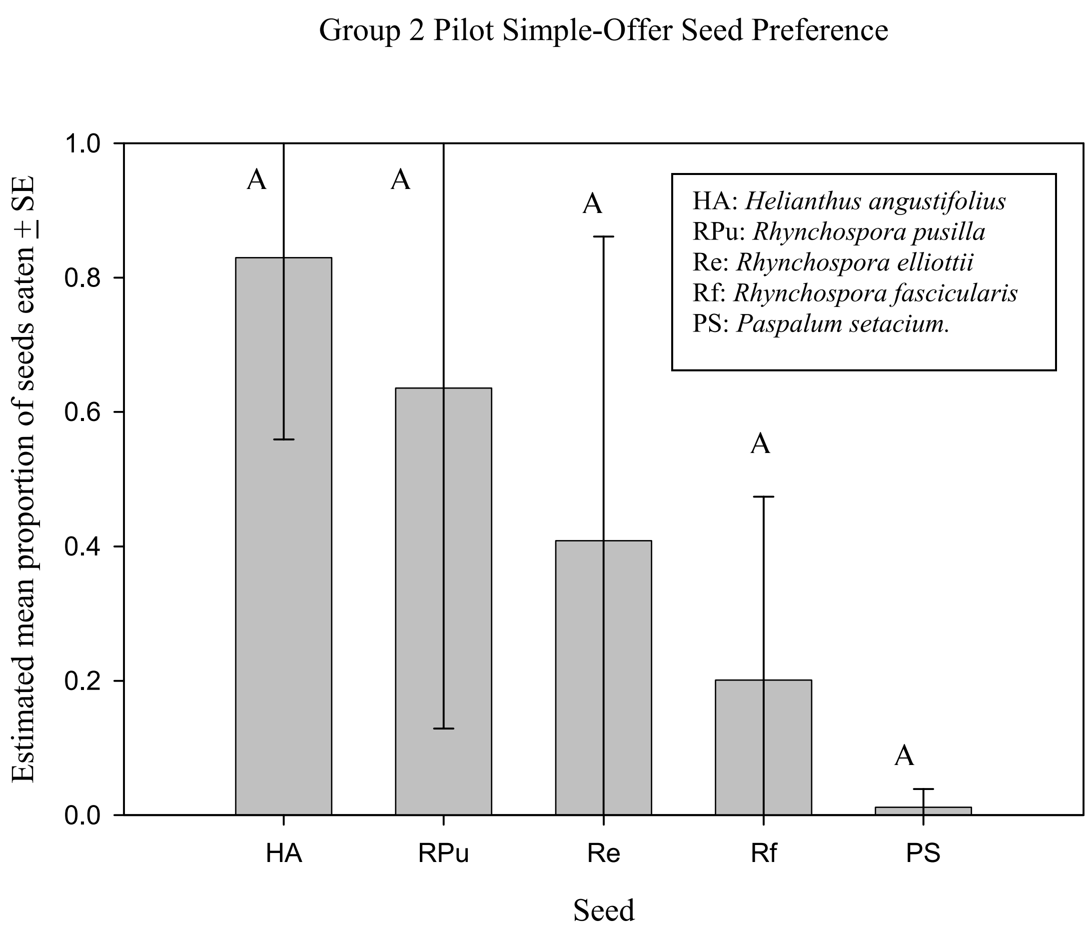

Figure C.4. Estimated mean proportion of seeds eaten for each seed species in Pilot simple-offer trials of group 2 seeds (letters represent differences in proportions of seeds eaten).

Variation in Consumption in Group 1 Pilot Multiple-offer Trials

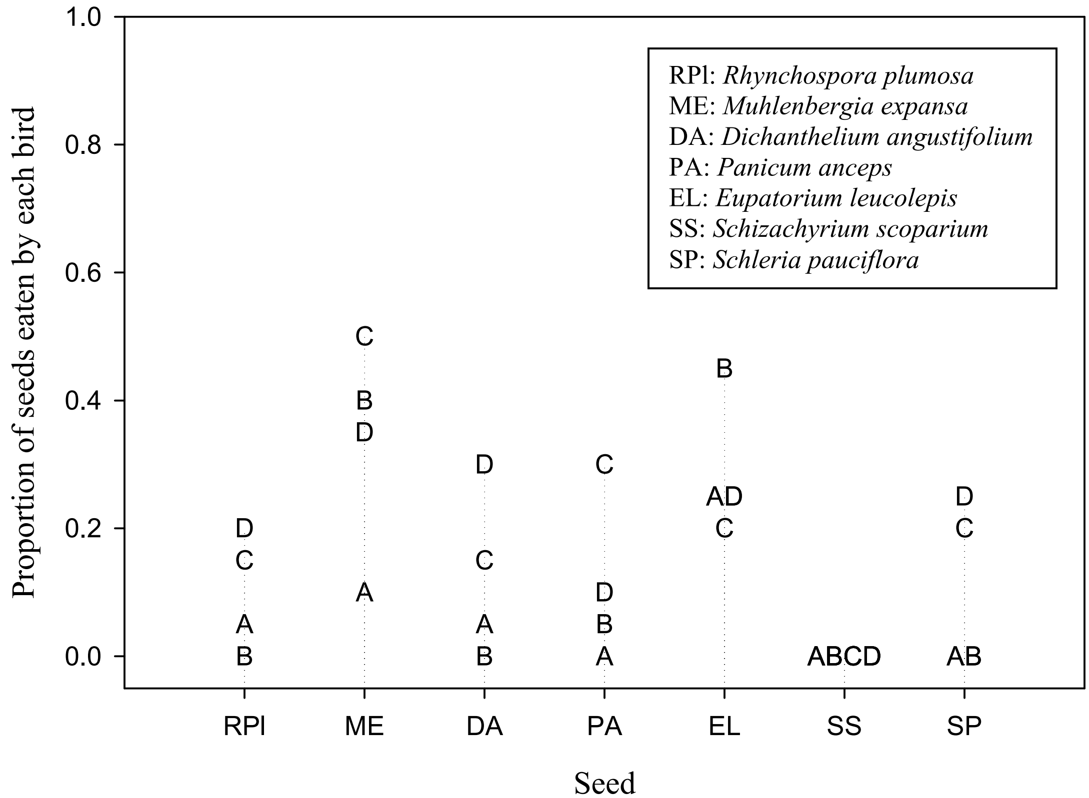

Figure C.5. Individual bird consumption of seed species in group 1 Pilot multiple-offer seed preference trials (each letter represents one bird).

Variation in Consumption in Group 2 Pilot Multiple-offer Trials

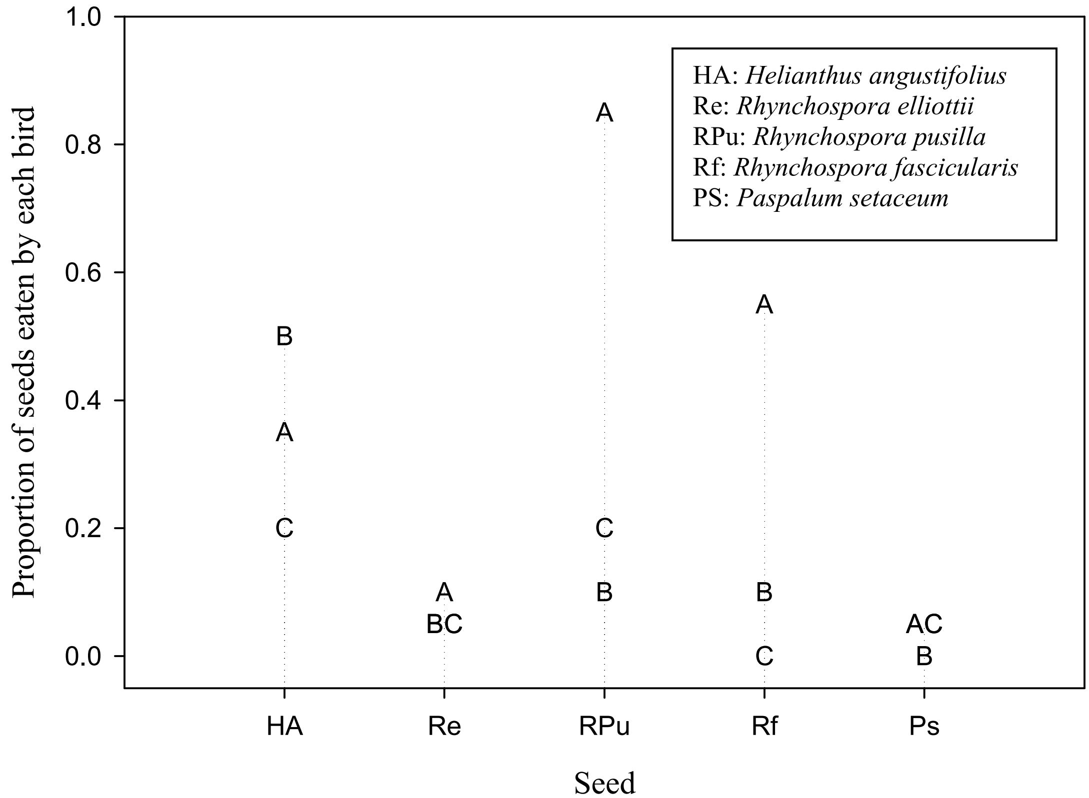

Figure C.6. Individual bird consumption of seed species in group 2 Pilot multiple-offer seed preference trials (each letter represents one bird).

Table C.6. Multinomial logit analysis probabilities for group 1 seeds in multiple-offer trials.

Seed	**ŷ**	**Lower CL**	**Upper CL**
ME	0.31034	0.21313	0.40756
EL	0.26437	0.1717	0.35703
DA	0.11494	0.04792	0.18196
PA	0.10345	0.03945	0.16744
SP	0.10345	0.03945	0.16744
RPl	0.09195	0.03123	0.15267
SS	0.01149	0	0.03389

Table C.7. Multiple comparison probabilities adjusted with the stepdown Bonferroni method of Holm (SAS Institute Inc. 2004) for group 1 seeds in multiple-offer trials.

	ME	*EL*	*DA*	*PA*	*SP*	*RPl*	*SS*
ME	-	-	-	-	-	-	-
EL	1	-	-	-	-	-	-
DA	0.1167	0.3346	-	-	-	-	-
PA	0.0776	0.2382	1	-	-	-	-
SP	0.0776	0.2382	1	1	-	-	-
RPl	0.0477	0.1513	1	1	1	-	-
SS	0.0254	0.0429	0.3346	0.3712	0.3712	0.3995	-

ME = *Muhlenbergia expansa*, EL = *Eupatorium leucolepis*, DA = *Dichanthelium angustifolium*, PA = *Panicum anceps*, SP = *Scleria pauciflora*, RPl = *Rhynchospora plumosa* and SS = *Schizachyrium scoparium*

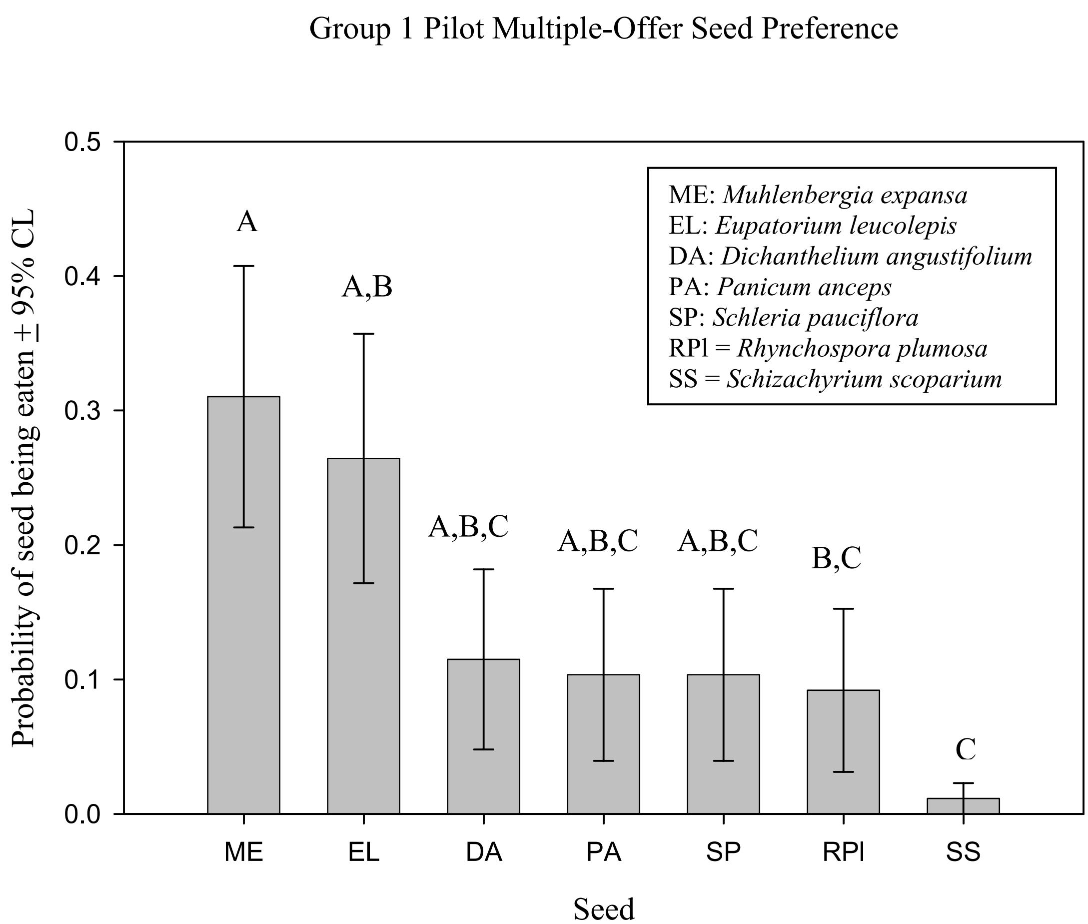

Figure C.7. Probability of seeds being eaten for each seed species in multiple-offer trials of group 1 seeds (letters represent differences in multiple-comparison probabilities)..

Table C.8. Multinomial logit analysis probabilities for group 2 seeds in multiple-offer trials.

Seed	$\hat{y}$	Lower CL	Upper Cl
RPu	0.36508	0.24619	0.48397
HA	0.33333	0.21693	0.44974
Rf	0.20635	0.10642	0.30628
Re	0.06349	0.00328	0.12371
PS	0.03175	0	0.07504

Table C.9. Multiple comparison probabilities adjusted with the stepdown Bonferroni method of Holm (SAS Institute Inc. 2004) for group 2 seeds in multiple-offer trials.

	RPu	*HA*	*Rf*	*Re*	*PS*
RPu	-	-	-	-	-
HA	1	-	-	-	-
Rf	0.801	1	-	-	-
Re	0.0236	0.0379	0.4319	-	-
PS	0.0185	0.0267	0.1922	1	-

Group 2 Pilot Multiple-Offer Seed Preference

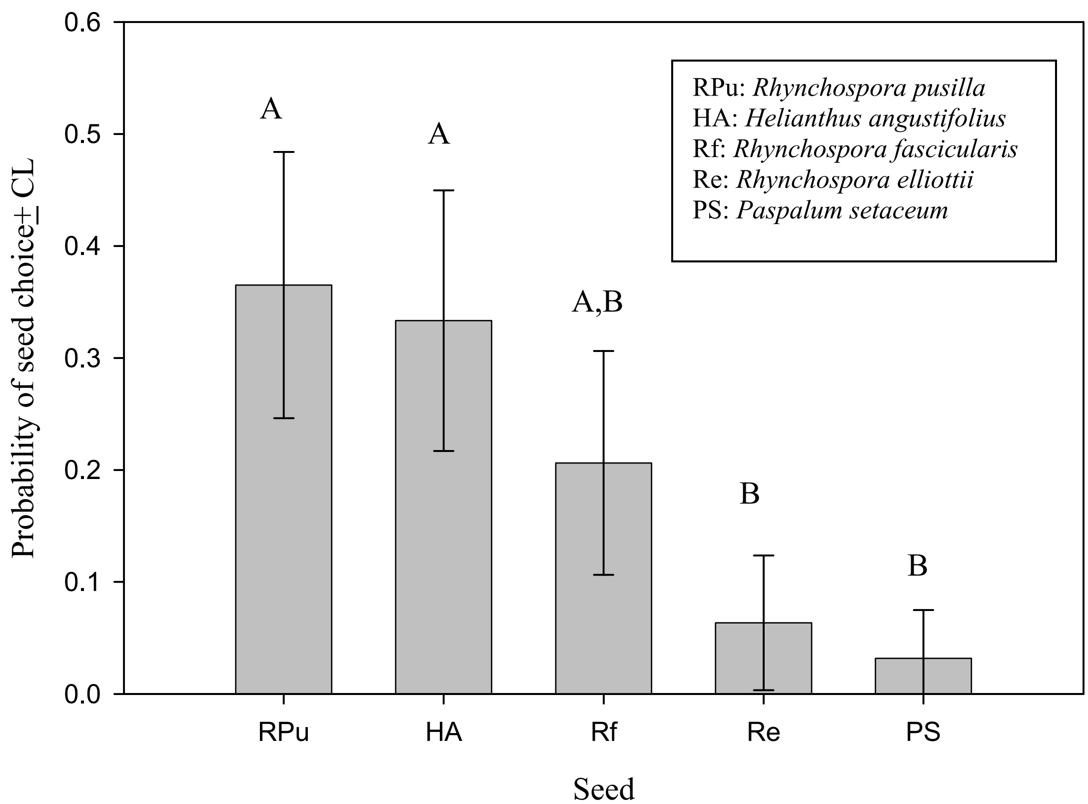

Figure C.8. Probability of seeds being consumed for each seed species in multiple-offer trials of group 2 seeds (letters represent differences in multiple-comparison probabilities).

Table C.10. Multinomial logit analysis probabilities for *Rhynchospora* spp. seeds in multiple-offer trials.

Seed	**ŷ**	**Lower CL**	**Upper CL**
Rpu	0.29032	0.13054	0.45011
Ri	0.22581	0.07862	0.37299
Rf	0.19355	0.05447	0.33262
Rpl	0.16129	0.03182	0.29076
Re	0.09677	0	0.20085
Rch	0.03226	0	0.09445

Rpu = *Rhynchospora pusilla*, Ri = *R. inexpansa*, Rf = *R. fasicularis*, Rpl = *R. plumosa*, Re = *R. elliottii*, Rch = *R. chapmanii*.

Table C.11. Multiple comparison probabilities adjusted with the stepdown Bonferroni method of Holm (SAS Institute Inc. 2004) for *Rhynchospora* spp. seeds.

	Rpu	*Ri*	*Rf*	*Rpl*	*Re*	*Rch*
Rpu	-	-	-	-	-	-
Ri	1	-	-	-	-	-
Rf	1	1	-	-	-	-
Rpl	1	1	1	-	-	-
Re	1	1	1	1	-	-
Rch	0.5568	0.9621	1	1	1	-

Rpu = *Rhynchospora pusilla*, Ri = *R. inexpansa*, Rf = *R. fasicularis*, Rpl = *R. plumosa*, Re = *R. elliottii*, Rch = *R. chapmanii*

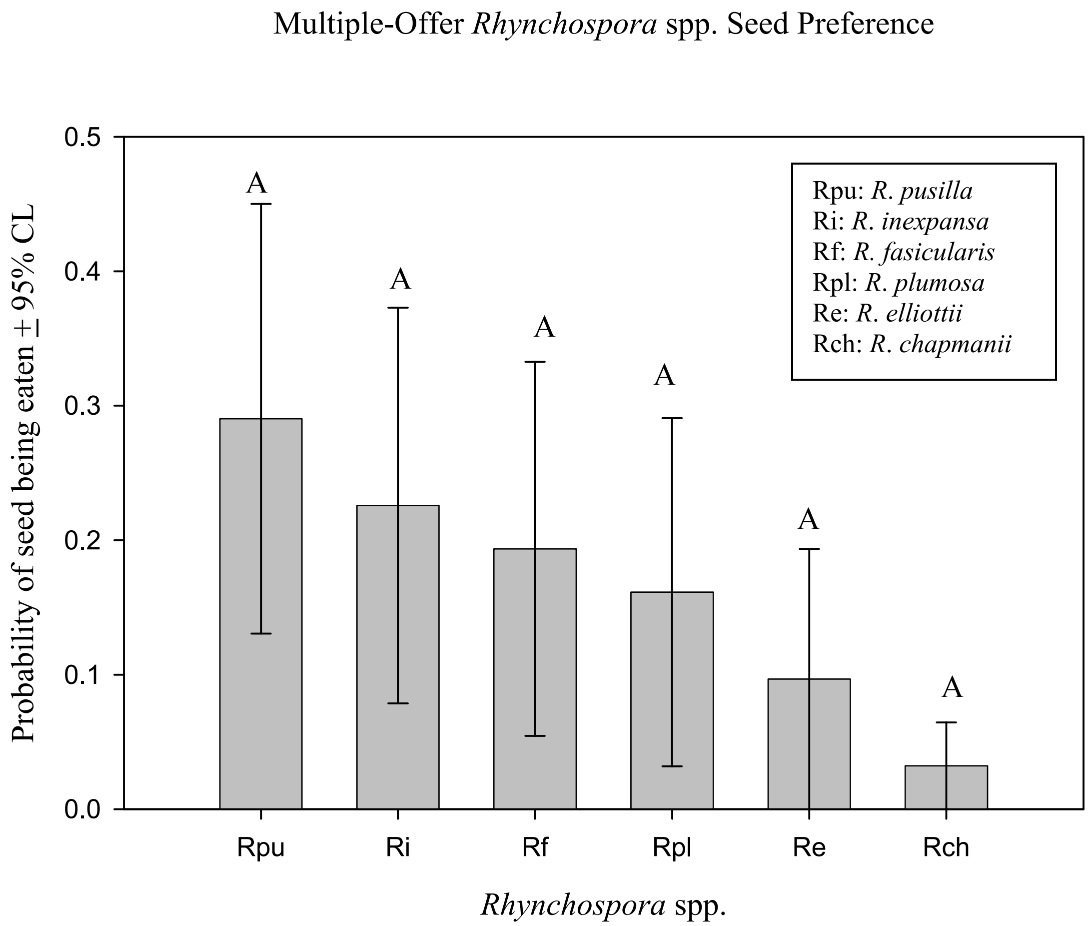

Figure C.9. Probability of seeds being eaten for each species in multiple offer *Rhynchospora* spp. seed preference trials (letters represent differences in multiple-comparison probabilities)..

Comparison of Simple-offer and Multiple-offer Seed Preference Trials

For group 1 seeds, *Schizachyrium scoparium*, *Panicum anceps*, *Scleria pauciflora* and *Rhynchospora plumosa* all appear to be avoided in both multiple-offer and simple-offer trials (Figure C.10). *Dichanthelium angustifolium* appears to be a secondarily preferred item with higher consumption in simple-offer trials than in multiple-offer trials (Figure C.10). *Muhlenbergia expansa* and *Eupatorium leucolepis* appear to be preferred seeds with high consumption in both types of trials (Figure C.10). For group 2 seeds, *Paspallum setaceum* appears to be avoided, while *Rhynchospora elliottii* appears to be a secondarily-preferred seed and *Helianthus angustifolius* and *R. pusilla* appear to be preferred seeds (Figure C.11).

Scatter-plot of Consumption in Group 1 Pilot Seed Preference Trials

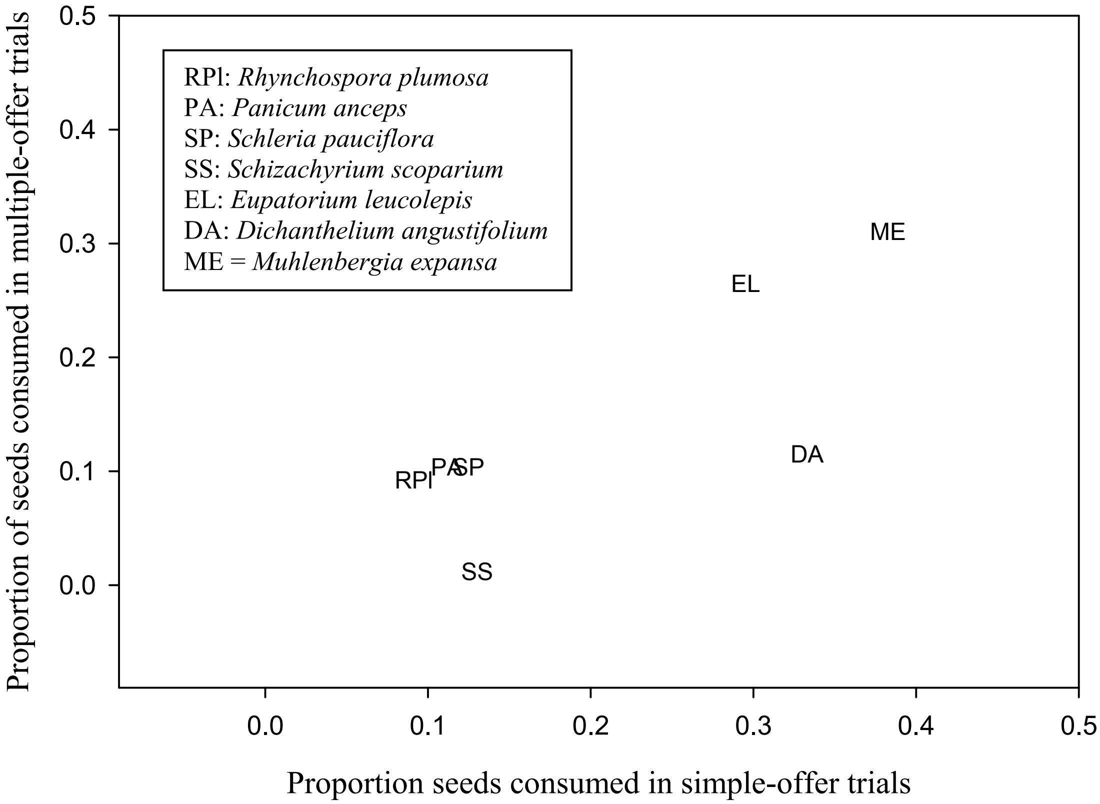

Figure C.10. Scatter-plot showing combined estimated mean proportions of seeds consumed in preliminary simple-offer and multiple-offer seed preference experiments for group 1 seeds.

Scatter-plot of consumption in Group 2 Pilot Seed Preference Trials

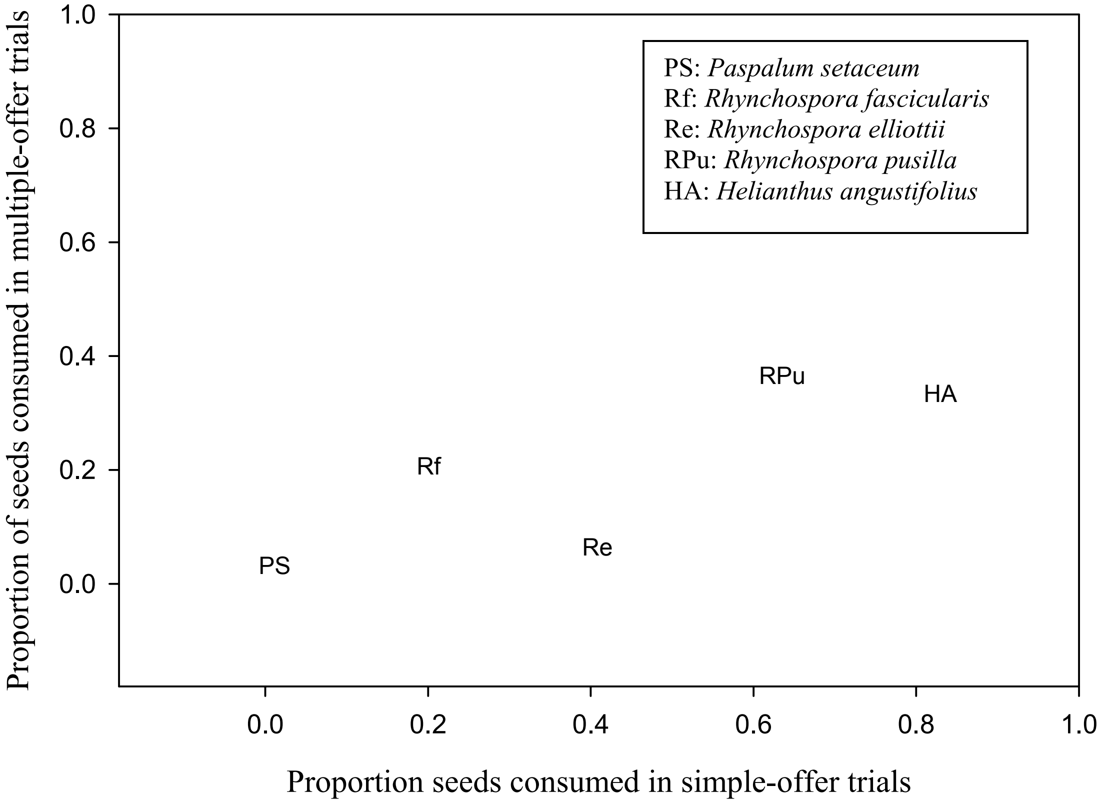

Figure C.11. Scatter-plot showing combined estimated mean proportions of seeds consumed in preliminary simple-offer and multiple-offer seed preference experiments for group 2 seeds.

DISCUSSION

All of the seeds presented during the trials were eaten by at least one bird, suggesting Henslow's Sparrows are generalists in the winter. *Muhlenbergia expansa* and *Eupatorium leucolepis* were preferred seeds in group 1 trials, *Helianthus angustifolius* and *Rhynchospora pusilla* were preferred seeds in group 2 trials.

The pilot study provided an opportunity to modify my protocol to for seed preference trials and bird care. First, the combination of small sample sizes and high variability in proportions of seeds eaten by individual birds made it difficult to detect differences in seed

choice. Because of this, I determined it was necessary to sample more birds on the same group of seeds in the Year 2 trials. Additionally, based on problems with birds not eating in the first group of birds tested, I determined that birds needed two days to adjust to captivity and begin foraging regularly before beginning trials. Lastly, I was able to work out problems with seeds to be used in trials. Some seeds require extra care or some modification before being offered in trials to keep them from blowing away when birds move. For example, I had to exclude *Andropogon virginicus* from my analysis because I could not reliably determine if the birds ate any of the seeds or if they blew out of the cages. I had similar problems with seeds of *Eupatorium leucolepis*, but I was able to modify the pappus to prevent the seeds from blowing away. To solve the problem of offering seed containing grains, I offered only husked *Ctenium aromaticum* seeds to birds in future trials because it was too difficult to determine if a spikelet contained a grain otherwise.

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VITA

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