ABSTRACT

SAVAGE, AMELIA LEE. Prey Selection by Swainson's Warblers on the Breeding Grounds. (Under the direction of Dr. Christopher Moorman).

Swainson's Warbler (SWWA), *Limnothlypis swainsonii*, is a migratory songbird that breeds in bottomland hardwood forests across the southeastern United States. It is believed to be one of the least abundant breeding songbird species in the region. While nest-site selection has been well studied, little is known about SWWA foraging habits except that the species is insectivorous, with a large bill used to flip fallen leaves on the forest floor. We captured and crop-flushed SWWA to determine diet, and sampled leaf litter arthropods and vegetation at each SWWA capture location. We compared the proportion of arthropod orders detected in crop-flush samples to the proportion of arthropods collected in the leaf litter to determine which orders were eaten by SWWA more or less than their proportional availability. Although Acari (mites and ticks) and Chilopoda (centipedes) were the most abundant arthropods recorded in the leaf litter samples (51% and 18%, respectively), these orders rarely occurred in crop flush samples. Conversely, Araneae (spiders) and Coleoptera (beetles) were uncommon in leaf litter samples (2% and 5%, respectively) but were the most abundant arthropod orders in SWWA crop flush samples. We conducted binary logistic regressions with the presence or absence of Aranids as the dependent variable and habitat measures as the independent variables. The probability that spiders were present in the leaf litter increased as leaf litter depth increased. To promote SWWA foraging habitat leaf litter depth should be preserved by maintaining patches of closed canopy forests, and natural flooding regimes should be restored.

Prey Selection by Swainson's Warblers on the Breeding Grounds

by
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A thesis submitted to the Graduate Faculty of
North Carolina State University
in partial fulfillment of the
requirements for the degree of
Master of Science

Fisheries and Wildlife Sciences

Raleigh, North Carolina

2009

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DEDICATION

I dedicate this work to my sisters Amanda, Alice and Abigail.

BIOGRAPHY

Amelia Lee Savage was born January 1, 1984 at the Air Force Academy in Colorado Springs, Co. She grew up in Merritt Island, Fl and attended Cocoa Beach Jr/Sr High School where she graduated in May 2002. She began her college career at the University of Florida, Gainesville. She had the opportunity to study abroad in Australia through the School for Field Studies, Boston College, where she studied the populations of birds in different aged rainforest. This experience is where she discovered her love of birds. She worked in a reproductive endocrinology lab studying the effects of toxins on the reproductive development of American Alligators. She spent the summer of 2005 and 2006 searching for and monitoring songbirds on hog farms in NC and urban areas in Gainesville, Fl, respectively. Amelia graduated *Cum Laude* with a Bachelor of Science in zoology in May 2006. She began her graduate school career in August 2006 and obtained a Master of Fisheries and Wildlife Sciences in May 2009. She plans on pursuing a career in Wildlife Biology and management with an emphasis on non-game species.

ACKNOWLEDGMENTS

Financial support for this project came from the South Carolina Department of Natural Resources, North Carolina Museum of Natural Sciences, and North Carolina State University. We thank International Paper and South Carolina Department of Natural Resources for allowing access to the study site. We are grateful for all the field support provided by Sarah Green, Sharna Tollfree, Becky Desjardins, Leah Fuller, Georgann Savage, Robert Savage, Sara Jaquith, Corey Shake, Charlotte Matthews, Keith Jensen, and Elise Corliss. Statistical advice was provided by Dr. Consuelo Arelleno. A special thanks to my committee members, Dr. Moorman, John Gerwin, Dr. Sorenson, and Dr. Lancia for helping me with this project.

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INTRODUCTION

Swainson's Warbler (SWWA), *Limnothlypis swainsonii,* winters in the Caribbean basin and breeds primarily in bottomland hardwood forests of the southeastern United States (Hunter et al. 1993). SWWA is thought to be one of the least abundant breeding songbirds in the southeastern United States (Hunter et al. 1993, 1994; Smith, et al. 1993), and the bird has disappeared entirely from its historical ranges in Maryland, Delaware, Missouri, and Illinois (Graves 2001). Because no adequate estimate of the SWWA population exists, it generally is given high conservation priority (Hunter et al. 1993, 1999, Morton 1992, Ruth 2004).

Forests inhabited by SWWA typically are situated on or near a floodplain and have a high canopy cover, dense undergrowth with little or no herbaceous ground cover, and relatively deep leaf litter (Meanley 1966, Eddleman et al.1980, Thomas et al. 1996). Additionally, SWWA often breed in association with switchcane (*Arundinaria gigantea*) habitats or vine tangles (Graves 2001, 2002, Thompson 2005). Most efforts to manage or create SWWA breeding habitat have emphasized restoration of switchcane and gap creation in mature bottomland hardwood forests (Hunter et al. 1993, 1999). Recent studies showed that a heterogeneous understory may be the principal consideration in SWWA selection of breeding habitat (Graves 2001, 2002).

Although researchers have investigated SWWA nesting habitat selection (Graves 2002, Peters 2005), limited information is available on the species' diet or foraging habitat. SWWA are insectivores, foraging almost solely in leaf litter by lifting dead leaves with their large bill (Strong 2000, Graves 1998). The bird forages in the top layer of leaf litter, so arthropods found in the lower decaying leaf litter are unavailable (Meanly 1971).

The species' reclusive nature and formidable breeding habitat composed of dense vegetation make direct observations of SWWA difficult. Therefore, we crop-flushed birds captured in mist nets, a more practical way of retrieving information about the SWWA diet (Major 1990, Moorman et al. 2007). We captured and crop-flushed SWWA during the 2007 and 2008 breeding seasons and compared the proportion of arthropod orders in crop-flushes to the proportion of arthropod orders available in the leaf litter. We also modeled the habitat characteristics that best predicted the presence of leaf litter arthropods selected by SWWA.

METHODS

STUDY SITE

We studied the SWWA diet on the 8 000-ha Woodbury Wildlife Management Area (Woodbury) (33° 52′ N, 79° 22′ W), which is owned and managed by the South Carolina Department of Natural Resources. Woodbury is located at the confluence of the Great and Little Pee Dee rivers near Britton's Neck, South Carolina. Elevation ranges from 0m to 25m above sea level. Woodbury floods irregularly during the spring and summer months and includes isolated wetlands, bottomland hardwood forests, and stands of planted loblolly (*Pinus taeda*) and longleaf pine (*Pinus palustris*) (Peters 2005).

Much of the hardwood forest on Woodbury naturally regenerated following clearcutting with a shearing blade between 5 and 30 years ago. During shearing, all trees, saplings, and stumps were removed, but most drainage areas and other water-filled low-lying areas were not harvested (Peters 2005). The uncut mature hardwood forests, regenerated forest, and sparsely vegetated areas that received heavy soil compaction (e.g., logging roads and decks) during logging created a heterogeneous vegetation structure preferred by SWWA on Woodbury (Thompson 2005).

DIET IDENTIFICATION

From 15 April to 31 July in 2007 and 2008, we captured SWWA individuals in mist nets. We used four mist net arrays of 12 nets each to passively catch SWWA in areas of high SWWA density, and each array was operated for six hours, one out of every ten days. We captured additional SWWA by target netting individuals that responded to song and chip note broadcasts. We targeted SWWA by systematically broadcasting recorded SWWA songs and chip notes along all roads that intersected potential SWWA habitat on Woodbury. For portions of the property far from roads, we broadcast SWWA songs as we walked through the woods. We attempted to capture all SWWA that responded to broadcast calls by luring the birds into mist nets placed near low vegetation where the bird was heard or sighted.

Each newly captured and recaptured SWWA was banded, weighed, and crop-flushed. Crop-flushing occurred as soon as we removed each bird from the net because of the high digestibility rates of prey items. To avoid excessive stress, we did not crop-flush any bird recaptured within one week of a previous crop-flush (Major 1990). We flushed crops by inserting a 2-mm diameter plastic catheter down the throat into the crop through which we gently squirted warm water, while slowly removing the catheter (Moorman et al. 2007). We collected crop contents into a clean plastic bowl. We preserved crop contents in 75% ethanol in plastic vials for later identification (Major 1990). When handling SWWA individuals, we followed all protocols set by the NCSU Institutional Animal Care and Use Committee. A dissecting microscope was used to count and identify, to the order, arthropod fragments found in the crop contents. We could not identify arthropods beyond order because the small fragments made it difficult to be any more specific. The fragmentary nature of the crop contents made it difficult to count the exact number of individual arthropods found in each crop sample; therefore, we estimated conservatively, and multiple individuals of the same order were counted only if we observed fragments of the same kind (e.g. legs, antennae, and eyes) in excess to what is normally found on an individual arthropod (Moorman et al. 2007).

MICROHABITAT

Vegetation and leaf litter were removed from the immediate vicinity during set-up of mist nets. Therefore, we moved approximately 20m away from each SWWA capture location, and established two concentric circular microhabitat sampling plots (5-m radius plot located in the center of an 11.3-m radius plot). When SWWA were captured using call broadcasts, the plots were located in the direction the SWWA was initially heard before capture. For SWWA captured during passive netting, we used a random direction. If the plot center fell in areas where the SWWA were known not to forage, i.e. in a body of water or light gap, we relocated the plot to the nearest edge of the body of water or light gap (Personal Com. John Gerwin).

Within the 5-m radius plot, we visually estimated ground cover as % switchcane cover, % other grass cover, % other herbaceous cover, % vine cover, % woody debris, % bare ground, % standing water, and % herb-free litter. We used a convex densiometer to estimate canopy cover at the center of the plot. Within the 11.3-m radius plot, we counted and measured the diameter at breast height (dbh) of all trees. Trees were separated into five categories based on dbh: # saplings (<2.5-cm dbh and >30-cm tall); # poles (2.5-8-cm dbh); # small trees (8–23-cm dbh); # medium trees (23–38-cm-dbh); and # large trees (>38-cm dbh). Additionally, understory vegetation density was assessed by standing in the center of the plot and reading a density board positioned at 11.3m in four cardinal directions. Immediately adjacent to leaf litter samples (described below) we recorded % soil moisture, soil pH (Kelway soil pH and moisture meter), and leaf litter depth in mm.

ARTHROPOD COMMUNITY IDENTIFICATION

To quantify the arthropods available to SWWA, we hand-collected leaf litter and associated litter-dwelling arthropods within a 0.25-m^2 frame placed in a random location within each of the four quadrants of the 5-m plot. Arthropods from the 4 sub-sampling plots were combined for each plot. We collected all leaf litter from the top surface of leaf litter to bare earth and stored each sample in a plastic bag until placing it in a Berlese funnel for 24 hours to extract the arthropods (Barberena-Arias and Aide 2003). If the leaf litter was not completely dry after 24 hours it was left in the funnel until it was dry.

Arthropods were preserved in 75% ethanol, and later identified to order and counted.

We checked for seasonal changes in the litter-dwelling arthropod community by collecting leaf litter samples after 15 June 2007 from locations immediately adjacent to leaf litter samples previous collected before 15 June 2007. Also, to assess the portion of the arthropod community actually available to SWWA, we separated 28 leaf litter samples collected in 2008 into the upper, dry portion of leaf litter and the lower, decaying leaf litter near the soil. The lower, decaying portion of the leaf litter was distinguished from the upper, dry portion by the presence of decaying leaves. The dry and decaying leaf litter samples were processed in the manner detailed above.

STATISTICAL ANALYSES

We analyzed data from 2007 and 2008 separately because there was a dramatic difference in flooding patterns between the wetter 2007 season and the drier 2008 season. We compared each arthropod order found in the crop-flush samples between adult male and adult female birds using two-tailed t-tests and between early and late arthropod availability in the 2007 breeding season using paired two-tailed t-tests (SASv.9.1.3, Cary, NC).

The arthropod orders within the dry and decaying leaf litter layer samples were summarized as percentages of the 28 samples. Then, the percentage of the arthropods from each order found in the upper dry portion of the 28 leaf litter samples was multiplied by the total number of individuals in each order for all samples. We then recalculated the proportion of arthropods in each order that were available to SWWA.

We used the Jacobs Index (1974) to determine if arthropods were being consumed in proportion to their availability: $D_{hb} = (r\text{-}p)/(r+p\text{-}2rp)$, where D_{hb} was the index of arthropod use, r was the fraction of an arthropod order in the crop-flush sample, and p was the fraction of a particular arthropod order in the total arthropod sample. D_{hb} values ranged from -1 to 1. SWWA selection and avoidance of arthropods was determined using Morrison's (1982) D_{hb} categorization, where -1 to -0.81 = strong avoidance, -0.80 to -0.40 = moderate avoidance, -0.40 to -0.16 = slight avoidance, -0.15 to 0.15 = no selection, 0.16 to 0.40 = slight selection, 0.41 to 0.80 = moderate selection, and 0.81 to 1= strong selection.

We used SAS JMP to run a Pearson's Correlation Matrix to identify highly correlated habitat variables (r>0.6), and we removed what we considered the less biologically relevant correlated habitat variable (SAS 2003). We used 13 habitat variables in subsequent analyses (TABLE 1). Aranids appear to be the most important prey for SWWA based on this study (see results) and previous studies (Meanly 1971, Strong 2000, and Eaton 1953). Therefore, we conducted binary logistic regressions (Proc Logistic) with the presence or absence of Aranids as the dependent variable and habitat measures as the independent variables (SAS Institute 2003). Few leaf litter samples contained no Aranids, but many had either one or more individuals. Therefore, Araneae was considered absent if 0 or 1 individual was recorded and present if more than one individual was recorded in a plot. All combinations of all habitat variables were run in binary logistic regression models. Regression models were then compared using Akaike's

Information Criterion for small sample sizes (AIC*c*; Cody and Smith 1997, Burnham and Anderson 2002) and an AIC*c* weight was calculated for each model. Only models within two Δ AIC*c* were considered.

RESULTS

DIET IDENTIFICATION

In 2007, we obtained 96 crop samples from 74 individuals (58 adult males, nine adult females, and seven hatch-year birds) and 22 within-season recaptures. The crop samples that contained arthropod fragments in 2007 included: 27 adult males, 4 adult females, and five hatch-year birds. In 2008, we obtained 100 crop samples from 78 individuals (64 adult males, 14 adult females, and zero hatch-year birds) and 22 within-season recaptures. The crop samples that contained arthropod fragments in 2008 included: 31 adult males, and 6 adult females. Notably, 12 of the individuals flushed in 2008 were originally captured in 2007. Seventy-six (39%) of the 196 crop samples contained no arthropod fragments. Crop samples collected in 2007 had 155 individual prey items representing 12 arthropod orders, and the 2008 crop samples contained 227 individual prey items representing 12 arthropod orders (FIGURE 1). The orders found in the highest proportion were Araneae (35%) and Coleoptera (25%) in 2007, and Araneae (57%) and Coleoptera (16%) in 2008 (TABLE 2). Collembola and Thysanoptera were only recorded once in the crop samples. Because so few females were captured, we combined samples for 2007 and 2008 to compare arthropod orders found in adult male and adult female SWWA diets. The proportion of each arthropod order in crop samples did not differ between adult male and adult female SWWA ($P > 0.05$ for all arthropod orders, $n_{Female}=10$, $n_{Male}=58$).

ARTHROPOD COMMUNITY IDENTIFICATION

We detected 23 arthropod orders and 31,040 individual arthropods from 384 leaf litter samples collected in 2007. In 2008, we recorded 17 arthropod orders and 36,753 individual arthropods from 400 leaf litter samples. Approximately 37% of leaf litter arthropods were unavailable to SWWA because they were in the decaying leaf litter (TABLE 3). In 2007, only Diplopoda ($n=44$, $t_{88}=-2.18$, $P=0.032$) and Orthoptera ($n=44$, $t_{88}=2.12$, $P=0.037$) abundance differed between the early and late sampling periods. Diplopoda increased in abundance as the breeding season progressed, and Orthoptera decreased in abundance later in the breeding season.

ARTHROPOD USE vs. AVAILABILITY

Acari was the most abundant arthropod order found in the leaf litter, but it was one of the least detected arthropod orders in crop samples (TABLE 2). Araneae, the most abundant arthropod found in the crop samples in both 2007 and 2008, was one of the least abundant arthropods in the leaf litter. In 2007 SWWA selected Araneae, Hemiptera, Lepidoptera, Coleoptera, Diplopoda and Chilopoda in proportions greater than their availability, while Collembola, Acari, and Diptera were avoided (TABLE 2). In 2008 SWWA selected Araneae, Hemiptera, Coleoptera, Lepidoptera, and Diptera in proportions greater than their availability, while Acari, Chilopoda and Thysanoptera were avoided (TABLE 2).

HABITAT MODELS

The two models that best predicted the presence of Aranids for the 2007 season included: 1) leaf litter depth (positive relationship), and 2) leaf litter depth (positive relationship) and % other grass cover (positive relationship) (TABLE 4). The model that best predicted the presence of Aranids in 2008 included five variables: leaf litter depth (positive relationship), % other grass cover (positive relationship), % woody debris cover (positive relationship), % other herbaceous plant cover (negative relationship), and % soil moisture (positive relationship) (TABLE 5). The top 10 habitat models from both 2007 and 2008 had lower Δ AIC*c* than the intercept-only model.

DISCUSSION

On Woodbury, SWWA strongly selected Araneae, Chilopoda, Hemiptera, and Lepidoptera in 2007 and strongly selected Araneae and Hemiptera in 2008. In Georgia, four stomach samples from breeding SWWA contained primarily Orthopterans, Hymenopterans, Aranids, and larval Lepidopterans (Meanly 1971). Strong (2000) and Eaton (1953), using emetics and stomach sampling, respectively, determined SWWA selected Araneae, Coleoptera, Lepidoptera, and Hemiptera on their wintering grounds. In all cases, Aranids composed the preponderance of SWWA diets.

There are several possible explanations why Araneae occurs so commonly in SWWA diet. First, Aranids may offer some unique nutritional value. Schowalter et al. (1981) determined that predatory arthropods such as Aranids possessed higher sodium content than other arthropods. Second, SWWA could have evolved prey selection behaviors and physical characteristics uniquely adapted to Araneae size or movements. SWWA may select spiders because they are easily seen because of high activity of the spiders. Thirdly, SWWA may select soft-bodied arthropods because they might require less energy to digest than hard-bodied arthropods (Major 1990).

Although Araneae were present in crop samples in proportions greater than their availability, the order still could be under-represented in crop samples because Aranids are digested so rapidly. Soft-bodied arthropods, such as larval and adult Lepidopterans and Aranids, are digested more rapidly than hard-bodied arthropods like adult Coleopterans (Wheelwright 1986, Major 1990). We generally crop-flushed birds immediately after capture, which helped reduce bias associated with differential digestion rates of hard and soft-bodied arthropods.

SWWA might not consume all potentially available arthropods because arthropod life stage, size, location, and activity patterns of the arthropods could limit their availability to foraging birds (Cooper and Whitmore 1990). There were several arthropod orders that SWWA did not eat or select, including Collembola, Acari, Thysanoptera, Mollusca, Isopoda, Orthoptera, and Pscoptera. Isopoda is an arthropod order that mainly lives in damp decaying leaf litter, in which SWWA do not forage. Acari, although common leaf litter arthropods, were not selected by SWWA. This might be because they are small hard-bodied arthropods that possess little nutritional value, the nutrition is difficult to extract, or because they aren’t seen due to their size.

Araneae occurred most commonly in areas with deeper leaf litter. SWWA foraging habitat typically has a closed canopy and open understory with little or no herbaceous ground cover (Eddleman et al 1980), where leaf litter depth likely would be high. Few studies have identified leaf litter depth as an important determinant of SWWA foraging habitat, although in Arkansas SWWA presence was correlated with leaf litter depth and % leaf litter ground cover (Brown 2008). Arthropod diversity and abundance increases as leaf litter depth increases (Uetz 1976); it is likely that prey availability for both SWWA and spiders also increases as litter depth increases. The best predictive models for 2007 and 2008 suggest that spider presence was higher where grass cover was highest. SWWA typically forage in areas of exposed leaf litter free of grass and other herbaceous cover (Eddleman et al 1980). Although % grass was positively correlated with spider presence, the average values for grass cover were relatively small (3.7%). Also, % cover of other herbaceous plants was negatively correlated with spider presence in 2008, which is consistent with what has been previously observed. Although the arthropod community changed relatively little within a season, the leaf litter arthropod community changed more significantly between the 2007 and 2008 seasons, especially for some orders such as, Chilopoda. These changes appear to be dictated by differences in flooding patterns. Though both 2007 and 2008 saw mid-April floods, the flood of 2007 receded much more slowly than that of 2008. In Illinois, flooding and differences in leaf litter depth explained 99.3% of variation in abundance and diversity of spiders (Uetz 1976). Because upstream efforts to control flooding can alter habitat conditions downstream like leaf litter depth and arthropod diversity and abundance, these management activities should be monitored closely where SWWA is a priority species.

Graves (2001) suggested that during times of prolonged flooding SWWA will abandon inundated areas due to the loss of their critical foraging habitat. Flooding can scour, concentrate, disperse, and cover with silt much of the food-bearing leaf litter (Bell and Sipp 1975, Uetz et al. 1979). Further, flooding might delay the start of the breeding season (Thompson, 2005). Also, the timing, depth, and duration of flooding affect plant and arthropod species (Wharton et al. 1982). Arthropod diversity and abundance might be higher in higher elevation areas that do not experience long-term flooding (Uetz et al. 1979). Because the natural flooding regime of most rivers has changed due to floodplain alteration and damming of rivers (Askins 2000), SWWA likely would benefit from restoration of water levels consistent with the natural flooding regime.

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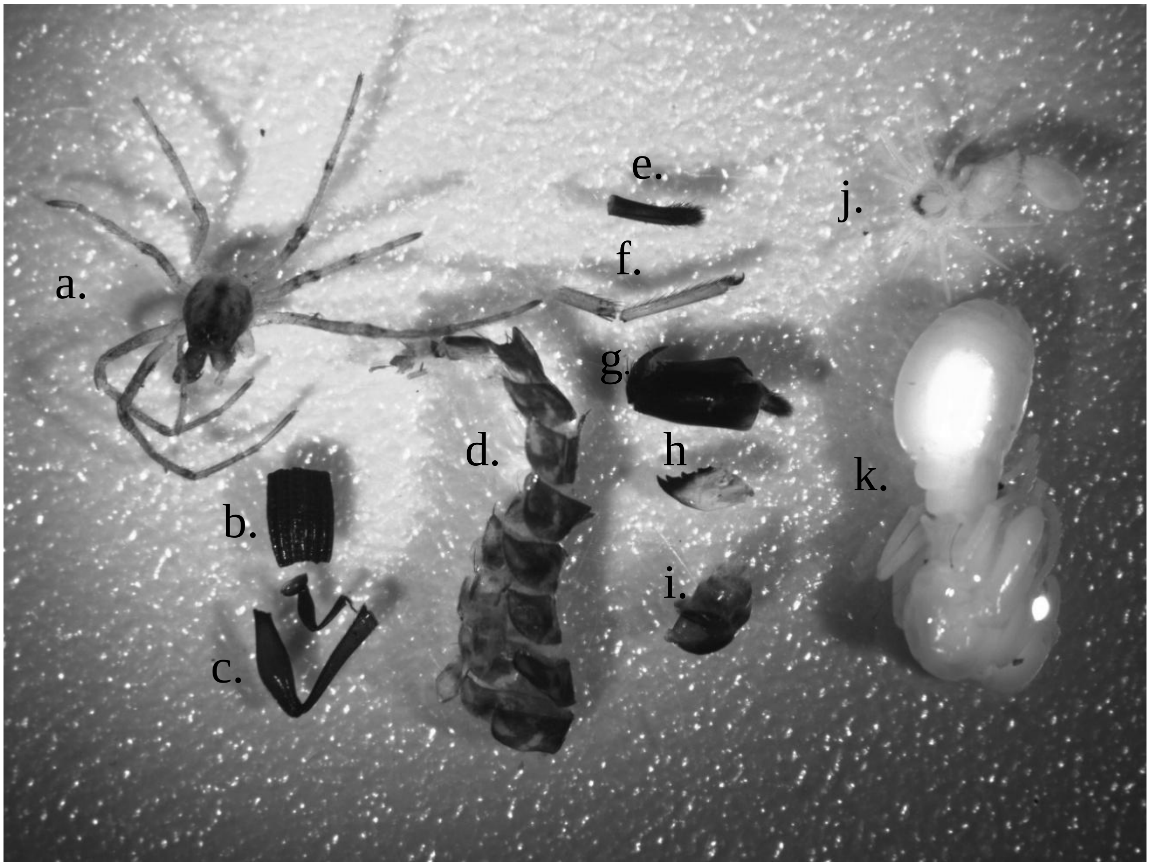

FIGURE 1. Arthropod fragments found in crop samples of Swainson’s Warblers captured at Woodbury Wildlife Management Area, SC (2007 and 2008).

a. Whole Araneae; b. Elytra of Coleoptera; c. Legs of Coleoptera; d. Body of Chilopoda; e. Palp of Araneae; f. Leg of Araneae; g. Chelicereae of Araneae; h. Mandible of Lepidoptera; i. Metasomsa of Hymenoptera; j. Whole Araneae; k. Hymenoptera Pupa.

TABLE 1. Habitat variables included in regression models to predict presence/absence of Aranids at Woodbury Wildlife Management Area, SC (2007 and 2008).

VARIABLE	DESCRIPTION
LLD	Leaf litter depth in mm from surface to earth
%Moist	% Soil moisture measured with moisture meter
%Canopy	% Open canopy cover measured with a convex densiometer
%Leaf	% Leaf litter cover
%Wood	% Woody debris cover
%Grass	% Other grass cover
%Other	% Other herbaceous plant cover
%Vines	% Vine cover
Sap	# Saplings trees >30cm tall, and <2.5cm dbh
Pole	# Pole trees 2.5-8cm dbh
Sm	# Small trees 8cm-23cm dbh
Med	# Medium trees 23-38cm dbh
Veg	% Vegetation density measured with a density board at 11.3m

TABLE 2. Arthropod prey selection by breeding SWWA on the Wildlife Management Area, SC (2007 and 2008).

Arthropod order	2007				2008			
	Arthropod in crop (proportion)	Arthropod in leaf litter (proportion)	Jacobs' index	Selection	Arthropod in crop (proportion)	Arthropod in leaf litter (proportion)	Jacobs' index	Selection
Acari	0.05	0.53	-0.91	Strong Avoidance	0.04	0.36	-0.88	Strong Avoidance
Araneae	0.35	0.02	0.93	Strong Selection	0.57	0.02	1.00	Strong Selection
Collembola	<0.01	0.18	-0.94	Strong Avoidance	-	0.09	-	-
Diplopoda	0.02	<0.01	0.58	Moderate Selection	0.01	<0.01	0.04	No Selection
Chilopoda	0.01	<0.01	0.90	Strong Selection	0.02	0.32	-0.87	Strong Avoidance
Hemiptera	0.06	<0.01	0.83	Strong Selection	0.03	<0.01	0.87	Strong Selection
Thysanoptera	-	0.02	-	-	0.01	0.04	-0.65	Moderate Avoidance

TABLE 2. Continued

Coleoptera	0.25	0.05	0.50	Moderate Selection	0.16	0.04	0.50	Moderate Selection
Hymenoptera	0.08	0.10	0.03	No Selection	0.05	0.03	0.22	Slight Selection
Lepidoptera	0.09	<0.01	0.90	Strong Selection	0.07	0.01	0.66	Moderate Selection
Diptera	0.02	0.05	-0.66	Moderate Avoidance	0.03	0.02	0.41	Moderate Selection

TABLE 3. Proportion of arthropods in dry and decaying leaf litter (n=28) and corrected proportion of available arthropods at Woodbury Wildlife Management Area, SC (2007 and 2008).

Arthropod Order	Proportion in Dry Leaf Litter	Proportion in Wet Leaf Litter	Uncorrected Abundance (Proportion) 2007	Corrected Abundance (Proportion) 2007	Uncorrected Abundance (Proportion) 2008	Corrected Abundance (Proportion) 2008
Mollusca	0.68	0.32	<0.01	<0.01	0.03	0.04
Worm	0.44	0.56	<0.01	<0.01	0.02	0.01
Isopoda	0.32	0.68	<0.01	<0.01	<0.01	<0.01
Diplopoda	0.63	0.37	<0.01	<0.01	<0.01	<0.01
Chilopoda	0.88	0.12	<0.01	<0.01	0.26	0.32
Acari	0.67	0.33	0.54	0.53	0.38	0.36
Araneae	0.73	0.27	0.02	0.02	0.02	0.02
Collembola	0.75	0.25	0.18	0.20	0.08	0.09
Orthoptera	0.70	0.30	<0.01	<0.01	<0.01	<0.01
Pscoptera	0.95	0.05	<0.01	<0.01	<0.01	<0.01
Hemiptera	0.58	0.42	<0.01	<0.01	<0.01	<0.01
Thysanoptera	0.72	0.28	0.02	0.02	0.04	0.04
Coleoptera	0.50	0.50	0.07	0.05	0.06	0.04
Lepidoptera	0.63	0.38	<0.01	<0.01	0.01	0.01
Hymenoptera	0.72	0.28	0.09	0.10	0.03	0.03
Diptera	0.54	0.46	0.06	0.05	0.03	0.02

TABLE 4. Comparison of regression models used to predict the presence of Aranids at Woodbury Wildlife Management Area, SC (2007).

Model	n	K	AIC_c	$\Delta AICc$	w_i	Concordance %	P-value
LLD(+)	93	2	109.68	0.00	0.50	72	<0.01
LLD(+),%Grass(+)	93	3	110.64	0.96	0.31	74	<0.01
LLD(+),%Grass(+),%Wood(+)	93	4	112.55	2.86	0.12	74	<0.01
LLD(+),%Grass(+),%Wood(+),%Other(-)	93	5	114.70	5.02	0.04	74	<0.01
LLD(+),%Grass(+),%Wood(+),%Other(-),%Vine(+)	93	6	116.99	7.30	0.01	75	<0.01
LLD(+),%Grass(+),%Wood(+),%Other(-),%Vine(-), %Leaf(-), Med (+),Poles(+),Sap(+),Sm(+),Canopy(+)	93	12	118.51	8.83	<0.01	81	<0.01
LLD(+),%Grass(+),%Wood(+),%Other(-),%Vine(-), %Leaf(-),Med(+)	93	8	119.00	9.32	<0.01	76	0.01
LLD(+),%Grass(+),%Wood(+),%Other(-),%Vine(-),%Leaf(-)	93	7	119.05	9.36	<0.01	74	0.01
LLD(+),%Grass(+),%Wood(+),%Other(-),%Vine(-), %Leaf(-),Med(+),Pole(+)	93	9	120.11	10.43	<0.01	75	0.01
%Leaf(-),Med(+)	93	3	120.34	10.66	<0.01	63	0.06
Null(Intercept only)	93	1	121.77	12.09	<0.01		

Sign in parentheses indicates the direction of relationship

TABLE 5. Comparison of regression models used to predict the presence of Aranids at Woodbury Wildlife Management Area, SC (2008).

Model	n	K	AIC_c	ΔAIC_c	w_i	Concordance %	P-value
LLD(+),%Grass(+),%Wood(+),%Other(-),%Moist(+)	99	6	128.41	0	0.50	71	0.07
LLD(+),%Grass(+),%Wood(+),%Other(-),%Moist(+), %Vine(-)	99	7	130.72	2.31	0.16	71	0.11
LLD(+),%Grass(+),%Wood(+),%Other(-),%Moist(+), %Vine(-),%Leaf(-)	99	8	131.71	3.30	0.10	72	0.14
LLD(+),%Grass(+),%Wood(+),%Other(-), %Moist(+), %Vine(-),%Leaf(-),Med(+)	99	9	134.12	5.71	0.03	72	0.20
LLD(+), %Grass(+)	99	3	132.83	4.42	0.05	66	0.09
%Moist(+)	99	2	132.71	4.30	0.06	54	0.40
%Other(-),%Moist(+)	99	3	133.60	5.19	0.04	58	0.40
LLD(+), %Grass(+),%Wood(+)	99	4	133.90	5.48	0.03	67	0.06
%Wood(+),%Other(-),%Moist(+)	99	4	134.46	6.04	0.02	60	0.37
LLD(+),%Grass(+),%Wood(+),%Other(-),%Moist(+), %Vine(-),%Leaf(-),Med(-),#Pole(-)	99	10	136.42	8.01	<0.01	71	0.26
Null	99	1	137.00	8.59	<0.01		

Sign in parentheses indicates the direction of relationship