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During late winter, 1994 and 1995, we investigated food habits and preferences of northern bobwhites (*Colinus virginianus*; hereafter, bobwhites) collected on forested lands in east Texas. Crops for bobwhites were collected from areas under 3 management regimes, namely intensively managed for bobwhites (QMA) (i.e., tree basal area reduced, annually burned, numerous multi-stage food plots, etc.), extensively managed for timber and wildlife (NBS) (i.e., burned every 3-5 years, scattered 2-stage food plots with corn feeders), and unmanaged for wildlife (i.e., burned every 5-7 years). With years pooled, partridge pea (*Cassia fasciculata*), Hercules club (*Zanthoxylum clava-herculis*), and pine (*Pinus* spp.) seeds, and clover leaflets (*Trifolium* spp.) comprised 93% by weight of foods of 79 bobwhites foods on QMA. On NBS, 81% of 40 bobwhite diets was butterfly pea (*Centrosema virginianum*), browntop millet, pine, wild bean (*Strophostyles* spp.), and corn seeds and clover leaflets; millet and corn were from food plots and feeders, respectively. For unmanaged areas, 79% of 19 bobwhite diets was butterfly pea, rush (*Juncus* spp.), pine, partridge pea, and American beautyberry (*Callicarpa americana*) seeds, and clover leaflets. Top-ranked food items on QMA were pine, hairy vetch, and Hercules club seeds in 1994 and butterfly pea, partridge pea, and wax myrtle (*Myrica cerifera*) seeds in 1995 ($P < 0.05$). On NBS, hawthorn (*Crataegus* spp.) and beautyberry seeds were top-ranked in 1994 as were kobe lespedeza, wild bean, and butterfly pea seeds in 1995. On unmanaged areas, butterfly pea and partridge pea seeds and clover leaflets were highest ranked in 1995. On forested lands, activities (e.g., disking, burning, establishing food plots) which provide seed-bearing plants, especially legumes, and clover greenery benefit bobwhites.

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Introduction

Northern bobwhite populations have been declining for at least 50 years (Brennan 1991, Church et al. 1993). Loss of habitat is the primary factor contributing to this decline (Goodrum and Reid 1954, Landers and Mueller 1986). Management practices targeted toward increasing bobwhite populations should include providing year round food for the species (Stoddard 1931); winter food supplies, however, are often scarce (Landers and Mueller 1986). Therefore, providing such foods is an important aspect of managing the species (Stoddard 1931, Lay 1965, Jackson et al. 1987).

Although biologists and land managers regularly plant food plots to meet winter food needs, literature on the subject is contradictory. Both Stoddard (1931) and Rosene (1969) pointed out successful managers who utilized food plots, yet both clearly stated that bobwhites prefer seeds of native plant species rather than those of introduced species. Robel et al. (1974) and Landers and Mueller (1986) suggested that food plots served as a safeguard against native food scarcities. They believed that bobwhites are opportunistic feeders and select what is most readily available. However, in central Florida, bobwhites selected slough-grass seeds (*Scleria muhlenbergii*) over those of wax myrtle (Laessle and Frye 1956). Slough-grass seeds had a much higher nutritional value than wax myrtle seeds, and since both were available, the authors reasoned that

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bobwhites selected items that best met their dietary needs.

Stoddard (1931) was the first biologist to study food habits of bobwhites. His studies and those of others (Lay 1965, Rosene 1969) were based on analyses of bobwhite crops from hunter-killed birds. Other studies examined food availability by collecting food items from the litter and surface soil (Haugen and Fitch 1955, Ault and Stormer 1983). However, no known studies have compared food utilization to food availability and thus developed food preferences of bobwhites. The objectives of this study were to compare winter food habits, availabilities, and preferences of bobwhites on 3 forested areas, each subjected to a different management regime. One area was intensively managed for bobwhites and another was extensively managed for wildlife and timber production. The third area was forested lands generally managed for timber production; for the purpose of this study, these lands will be referred to as unmanaged. All areas were similar in terrain, elevation, soil type, and timber type (Dietz 1999), but differed in the management objectives applied to them. Our null hypothesis was that bobwhites showed no preferences among foods consumed, regardless of management regime.

Study Areas

The Pineywoods of east Texas are generally comprised of pure pine and mixed pine-hardwood types. Soils are primarily alfisols, ultisols, and vertisols in the uplands (Gould 1962). In stands where bobwhites were collected, pines contributed $>$70% of both canopy cover and basal area. In natural stands, overstory pines were 50 to 60 years old and average basal area was about 22 m^2/ha. Dominant pine species were loblolly (*Pinus taeda*) and shortleaf (*P. echinata*), and dominant hardwood species were bitternut hickory (*Carya cordiformis*), black hickory (*C. texana*), post oak (*Quercus stellata*), southern red oak (*Q. falcata*), white oak (*Q. alba*), and sweetgum (*Liquidambar styraciflua*). Flowering dogwood (*Cornus florida*) was a common midstory tree.

The intensively managed study area, known as the Quail Management Area (QMA), consisted of 607 ha in the South Boggy Slough Hunting and Fishing Club. The club was in Trinity County, 16 km southwest of Lufkin, Texas. The QMA was established in 1989 by Temple-Inland Forest Products Corporation as a northern bobwhite research area. Parsons et al. (2000) described habitat modification on the QMA in detail.

There were 69 permanent food plots on the QMA, totaling 81 ha; size of the plots ranged 0.8-2.0 ha. Mean distance between plots was 296 m. Each plot contained a fall/winter section, a spring/summer section, and a border of 3- to 5-year-old rough. Larger plots had first-year fall/winter fallow and second-year fall/winter fallow sections. Seed mixes planted during the fall included crimson clover, red clover, winter wheat, hairy vetch, kobe lespedeza, and partridge pea. Spring seed mixes included Egyptian wheat, browntop millet, pearl millet, joint vetch, and cowpeas. Roadsides were planted to similar species (Dietz 1999).

The extensively managed study area was North Boggy Slough Hunting and Fishing Club (NBS). This club was approximately 13 km north of the QMA. It was managed for timber, white-tailed deer (*Odocoileus virginianus*), eastern wild turkeys (*Meleagris gallapavo*), and red-cockaded woodpeckers (*Picoides borealis*) (RCW). The habitat included 1,215 ha of hardwood bottoms and 2,025 ha of pine and mixed pine-hardwood uplands. In natural upland stands, basal areas ranged 21-28 m^2/ha. However, in RCW clusters and foraging areas, stands had been thinned to approximately 14 m^2/ha and the hardwood midstory removed. There were 50 permanent food plots on NBS, totaling 162 ha. Food plots on NBS had spring/summer and fall/winter sections, but most had no surrounding rough. Each food plot had a feeder which distributed 45 kg of corn per week during fall and winter. Seed mixes for food plots and roadsides were similar to those used on the QMA, but lacked partridge peas (Dietz 1999).

There were 3 primary differences in habitat management on the QMA and NBS. Nearly 15% of the QMA was planted annually whereas only 5% of NBS

was so planted. Most of the QMA was on an annual burning cycle whereas NBS was on a 3- to 5-year cycle. Also, fallow disking took place in the woods on the QMA, but not on NBS.

Unmanaged areas were comprised of both private and United States Forest Service (USFS) lands. Forests on these large tracts (>500 ha) ranged from young pine plantations to mature mixed pine-hardwood stands; the tracts were primarily managed for pine sawlog and pulpwood production. Generally, little wildlife management had been implemented in these lands. The exception was the protection and management of RCW clusters. These cluster sites, most of which occurred on USFS lands, had been thinned to approximately 14 m^2/ha basal area and the hardwood midstory had been reduced or removed. Some stands were also on a 5- to 7-year burning cycle.

Methods

Bobwhites were harvested over pointing bird dogs during January and February 1994 and 1995. Upon harvest, all birds from a covey were placed in a bag marked with the covey identification number. Prior to leaving the area, the location where the covey was first contacted was flagged.

In the lab, each bird was weighed, sexed, and aged, then dissected and its crop and proventriculus removed. Contents of the crop and proventriculus were sorted, and each plant and animal food item identified to the lowest possible taxon using guides and keys by Landers and Johnson (1976), Rosene and Freeman (1988), and a personal seed collection. Once identified, each taxon was dried at 38° C for 48 hours and weighed to the nearest 0.0001 g using an electronic balance.

Food availability data were collected as soon as possible after each bird was bagged. If more than 1 bird was collected from a covey on the same day, only 1 food availability sample was gathered. On both the QMA and NBS, food available to each bobwhite (or covey) was sampled in a forested area (woods sample) and in 2 food plots. If the first contact with a covey occurred in the forest, the 2 food plots nearest the point of covey contact were sampled. If the first contact occurred in a food plot, the woods sample was initiated 30 m from the food plot edge which was nearest the point of covey contact.

In forested areas, food availability was sampled at 5 points (i.e., subsamples). The first subsample was taken at the point at which the covey was initially contacted. Each of the other 4 subsamples was collected 20 m from the first in a randomly selected direction. For each subsample, a 21.6-cm diameter ring was placed on the ground, then leaf litter, bark, and other large debris removed from within it. Next, the ground surface within the ring was vacuumed for 30 seconds using a hand-held, battery operated wet/dry vacuum (Worthington et al. 2004). Finally, herbaceous vegetation (i.e., greenery) within 15 cm of ground level was gathered. All potential food items, soil, debris, and green vegetation collected during the 5 subsamples were placed in a labeled paper bag.

Food plots were sampled in a manner similar to that of the woods samples. Each section of each food plot was sampled, but with only 2 subsamples. Potential food items gathered in each section of the 2 food plots were pooled (thus 4 subsamples per section), allowed to air dry, then temporarily stored in labeled plastic bags containing moth balls. Thereafter, potential food items were sorted, identified to the lowest possible taxon, and dried and weighed using the same methods as used for foods consumed.

Data Analyses

Thomas and Taylor (1990) referred to field studies that compared resource use and availability as selectivity studies. Their evaluation of study designs and tests for studies such as ours suggested the use of the Chi-square test of homogeneity, the Johnson rank method (i.e., the program PREFER), the Friedman test, or the Quade test. We chose the Johnson rank method (Johnson 1980) because it is less sensitive to the subjective inclusion or exclusion of resources (Alldredge and Ratti 1986, Thomas and Taylor 1990), does not require usage and availability to

be estimated without error (Johnson 1980), ranks the order of individual components, and permits statistical comparisons. Because this method ranks the components, potential food items that are abundant but scarcely consumed are not dismissed as having little or no value (Johnson 1980). In this study, we included all consumed foods that comprised $\geq 1.0\%$ by weight. However, potential foods in availability samples not consumed by any bird were not tested. All statistical tests were made at $\alpha = 0.05$.

Results

During January - February 1994, 39 bobwhites were collected, 26, 11, and 2 from the QMA, NBS, and unmanaged lands, respectively. In 1995, 101 bobwhites were collected, 54 from the QMA, 29 from NBS, and 18 from unmanaged areas. However, 2 digestive tracts from 1995 were unusable, 1 from the QMA and the other from unmanaged areas. There were digestive tracts from 25, 19, 49, and 45 adult males, adult females, subadult males, and subadult females, respectively.

Foods Consumed

Digestive tracts of 138 bobwhites collected during the winters of 1994 and 1995 contained 78 identifiable plant foods. Sixty taxa were seeds and 18 were greenery; 12 taxa occurred as both seeds and greenery, thus 66 identifiable plant food items. Animal matter from 12 orders was also recorded. Excluding grit, bobwhites collected on the QMA consumed 35 and 54 different food items in 1994 and 1995, respectively (Dietz 1999, pgs 35-39). Twenty-six and 55 identifiable food items were consumed in 1994 and 1995, respectively, by birds collected on NBS. Birds collected on unmanaged areas yielded 8 different foods in 1994 and 37 in 1995. However, sample size was only 2 birds in 1994.

1994 - Pine seeds made up the major portion (56%) of bobwhite diets in 1994. On the QMA, pine, partridge pea, and Hercules club seeds and clover leaflets comprised the bulk (93%) of foods consumed (Table 1). Partridge pea was the only planted species with seeds that comprised >10% of the digestive tract weight. Leaflets from planted clovers comprised 91% of greenery weight; no other taxa of greenery contributed $\geq$1% to the total weight. Beetles and butterfly (Lepidoptera) pupae each occurred in approximately 15% of the digestive tracts, but contributed <1% to the digestive tract weight (Dietz 1999). For bobwhites on NBS, seeds of pine, planted browntop millet, and corn from feeders made up 87% of the total digestive tract weight. Planted clovers contributed most of the greenery (Table 1). Butterfly pupae and snails occurred in 36 and 27% of the digestive tracts, respectively, but comprised <1% of the total weight. The 2 birds from unmanaged areas consumed American beautyberry and pine seeds (93%) and greenery of yaupon (*Ilex vomitoria*) and American beautyberry (Dietz 1999).

1995 - In the second winter, pine seeds made up a much smaller portion (9%) of bobwhite diets. Seeds of native wax myrtle, butterfly pea, and pine and planted partridge pea and kobe lespedeza comprised approximately 59% of QMA bobwhite diets. The most used food item was leaflets from planted clovers which comprised 26% of the total weight, 96% of the greenery weight, and occurred in 50 of the 53 birds (Table 1). Animal matter consumed by bobwhites included beetles (Coleoptera), true bugs (Hemiptera), and ants (Hymenoptera) (Dietz 1999). Important food items on NBS were seeds of native wild bean, butterfly pea, pine, partridge pea, and planted browntop millet and kobe lespedeza, and clover greenery (Table 1). Although animal matter made up a very small part of what NBS bobwhites ate (Table 1), beetles and snails each occurred in $\geq$20% of the digestive tracts (Dietz 1999). For bobwhites from unmanaged areas, butterfly pea seeds made up the greatest total weight and occurred in 41% of digestive tracts. Partridge pea, pine, rush, and snake root (*Psoralea psoralioides*) seeds and greenery from wild clover were also important food items (Table 1). Beetles and butterfly pupae were the most frequently consumed animal foods, but both occurred in small amounts (Dietz 1999).

Table 1: Number of northern bobwhites and mean percent composition by weight of planted and wild food items in digestive tracts of 138 bobwhites collected in east Texas, winters 1994 and 1995, from areas intensively (QMA), extensively (NBS), and unmanaged for wildlife. Species planted in food plots on the QMA and NBS are indicated by PI and PE, respectively. Values $< 0.05\%$ are shown as trace (tr.).

	1994			1995			
Taxon	QMA ($n = 26$) Count (%)	NBS ($n = 11$) Count (%)	Unmanaged ($n = 2$) Count (%)	QMA ($n = 53$) Count (%)	NBS ($n = 29$) Count (%)	Unmanaged ($n = 17$) Count (%)	Pooled ($n = 138$) Count (%)
Seeds							
Partridge pea (PI)	7 (13.4)			19 (24.9)	6 (5.8)	5 (11.5)	37 (15.3)
Butterfly pea		1 (0.1)		20 (4.6)	10 (9.5)	7 (27.3)	38 (4.4)
Lespedeza (PI, PE)	2 (tr.)			13 (5.6)	16 (5.8)	3 (1.1)	34 (2.9)
Wax myrtle				11 (13.0)			11 (3.9)
Browntop millet (PI, PE)		2 (16.6)			3 (15.4)		5 (4.5)
Pine	21 (61.7)	8 (43.4)	2 (57.1)	16 (11.2)	12 (7.0)	6 (7.5)	65 (30.6)
Wild bean				8 (1.7)	9 (24.7)	5 (3.5)	22 (5.5)
Hairy vetch (PI, PE)	6 (2.7)	1 (0.1)		1 (tr.)		2 (1.0)	10 (1.2)
Hercules club	11 (10.4)	2 (0.5)		11 (2.3)	9 (2.6)	2 (0.2)	35 (4.5)
Corn	1 (tr.)	3 (26.8)		3 (1.3)	1 (0.7)		8 (3.0)
Others (n=50)	(1.8)	(3.9)	(39.9)	(6.7)	(4.0)	(21.9)	(5.6)
Subtotal	(90.0)	(91.4)	(97.0)	(71.3)	(75.5)	(74.0)	(81.4)
Greenery							
Clovers (PI, PE)	23 (7.9)	3 (0.2)		50 (26.2)	26 (21.1)	13 (21.7)	115 (15.3)
Others (n=17)	(0.7)	(2.9)	(2.0)	(1.1)	(1.6)	(2.1)	(1.3)
Subtotal	(8.6)	(3.1)	(2.0)	(27.3)	(22.7)	(23.8)	(16.6)
Animal (n=12)	(1.0)	(1.9)	(0.1)	(0.8)	(1.0)	(1.5)	(1.0)
Grit (Rock and Shot)	4 (0.4)	5 (3.6)	1 (0.9)	9 (0.6)	8 (0.8)	2 (0.7)	(1.0)
Total	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Avg. Weight of Digestive Tract Contents (g)	1.8465	2.0305	1.0477	1.3905	1.6396	0.5963	1.4715

Table 2: Number of samples and mean percent composition by weight of food items available to northern bobwhites on areas intensively (QMA), extensively (NBS), and unmanaged for wildlife during the winters of 1994 and 1995. Species planted in food plots on the QMA and NBS are indicated by PI and PE, respectively. Values $< 0.05\%$ are shown as trace (tr.).

	1994			1995			
Taxon	QMA ($n = 12$) Count (%)	NBS ($n = 7$) Count (%)	Unmanaged ($n = 1$) Count (%)	QMA ($n = 20$) Count (%)	NBS ($n = 12$) Count (%)	Unmanaged ($n = 6$) Count (%)	Pooled ($n = 58$) Count (%)
Seeds							
Wooly croton	10 (4.7)	2 (0.7)		4 (0.1)	2 (0.1)	3 (0.6)	21 (1.3)
Browntop millet (PI, PE)	9 (0.4)	3 (0.2)		20 (3.3)	11 (6.3)		43 (2.5)
Pine	11 (1.2)	6 (0.8)	1 (9.9)	17 (0.7)	9 (1.0)	4 (1.9)	48 (1.0)
Oak		1 (3.2)		3 (1.2)	2 (3.7)		6 (1.7)
Egyptian wheat (PI, PE)	10 (9.2)	2 (1.0)		16 (1.3)	1 (0.2)		29 (2.9)
Others (n=52)	(3.9)	(0.9)	(12.7)	(5.4)	(4.9)	(4.1)	(4.0)
Subtotal	(19.4)	(6.8)	(22.6)	(12.0)	(16.2)	(6.6)	(13.4)
Greenery							
Pigweed	9 (2.3)	6 (1.9)	1 (4.0)	16 (1.2)	8 (1.7)	3 (0.6)	43 (1.6)
Brome grass	4 (0.9)	3 (0.4)		4 (1.9)		2 (32.5)	13 (2.4)
Ryegrass (PI, PE)	6 (1.8)	1 (1.7)		11 (4.9)	4 (0.3)		22 (2.5)
Panic grass	9 (2.9)	2 (0.3)	1 (67.8)	13 (8.1)	4 (1.3)	4 (47.2)	33 (6.3)
Blackberry	11 (10.3)	2 (1.1)		14 (3.2)	5 (0.3)	2 (1.6)	34 (3.9)
Nightshade	4 (0.9)	2 (0.2)		13 (2.2)	6 (0.8)	2 (0.6)	27 (1.2)
Clovers (PI, PE)	12 (23.4)	7 (38.9)	1 (1.6)	20 (24.7)	12 (33.6)	2 (4.1)	54 (27.5)
Winter wheat (PI, PE)	12 (29.3)	7 (39.2)		19 (33.9)	11 (41.5)		49 (33.6)
Hairy vetch (PI, PE)	12 (4.4)	5 (6.8)		14 (2.5)	3 (0.3)	1 (1.2)	35 (3.3)
Others (n=42)	(4.4)	(2.7)	(4.0)	(5.3)	(4.0)	(5.6)	(1.3)
Subtotal	(80.6)	(93.2)	(77.4)	(87.9)	(83.8)	(93.4)	(86.6)
Animal (n=3)	(tr.)			(0.1)			(tr.)
Total	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)
Avg. wt of sample	5.8714	7.4760	1.3672	5.3310	4.8484	2.2696	5.2191

Table 3: Mean differences and groups of preference rankings of foods consumed by northern bobwhites on areas intensively (QMA) and extensively (NBS) managed for wildlife in east Texas, 1994. Groups with the same capital letters are not different ($P > 0.05$). Seeds and greenery are referenced as s and g, respectively.

Management Regime	Food	Difference	Group
QMA^a	Pine (s)	4.27	A
	Hairy vetch (s)	3.79	A
	Hercules club (s)	2.98	AB
	Partridge pea (s)	2.6	BC
	Hawthorn (s)	2.42	BC
	Rye grass (g)	0.98	C
	Clover (g)	-1.19	D
	Hairy vetch (g)	-1.77	D
	Panic grass (g)	-2.33	DE
	Wooly croton (s)	-3.52	E
	Egyptian wheat (s)	-4.13	E
	Winter wheat (s)	-6.73	F
NBS^a	Hawthorn (s)	1.18	A
	American beautyberry (g)	1.14	A
	Corn (s)	0.77	AB
	Pine (s)	0.68	AB
	Oak (s)	0.64	AB
	Browntop millet (s)	0.05	AB
	Hairy vetch (g)	-1.05	BC
	Clover (g)	-3.41	C

[a] Critical value for Waller-Duncan: QMA = 1.92, NBS = 2.87

Foods Available

Food availability samples were collected for each covey contact. On the QMA, 12 and 20 samples were gathered for 26 and 54 birds collected in 1994 and 1995, respectively. On NBS, 7 availability samples gathered in 1994 and 12 in 1995 represented the potential foods for 40 birds collected there. For 20 birds collected from the unmanaged areas (2 in 1994 and 18 in 1995), 7 availability samples were gathered, 1 in 1994 and 6 in 1995.

1994 - As expected, greenery from species planted in food plots dominated food availability weights on the QMA and NBS; greenery from planted clovers and winter wheat exceeded 50% of the weight on each area each year. On the QMA, seeds of native wooly croton (*Croton capitatus*), pine, and nightshade (*Solanum* spp.) and planted Egyptian wheat comprised 15% of the weight of foods available. Browntop millet seeds occurred in 75% of samples but contributed little to the total weight of potential food items. Greenery from native pigweed (*Amaranthus* spp.), panic grass (*Panicum* spp.), and blackberry (*Rubus* spp.) comprised 16% of the weight and each occurred in $\geq$75% of the samples (Table 2). Oak mast comprised the greatest weight of seeds on NBS, but occurred in only a single sample. Pine, panic grass, and paspalum (*Paspalum* spp.) seeds occurred in most samples but contributed little weight (Dietz 1999). Native greenery made up $<$5% of total food availability weight. On unmanaged lands, pine, smartweed (*Polygonum* spp.), and

Table 4: Mean differences and groups of preference rankings of foods consumed by northern bobwhites on areas intensively (QMA), extensively (NBS), and unmanaged for wildlife in east Texas, 1995. Groups with the same capital letters are not different ($P > 0.05$). Seeds and greenery are referenced as s and g, respectively.

Management Regime	Food	Difference	Group
QMA^a	Butterfly pea (s)	4.72	A
	Partridge pea (s)	4.11	A
	Wax myrtle (s)	3.86	A
	Lespedeza (s)	2.07	BC
	Oak (s)	1.35	CD
	Hercules club (s)	1.24	CD
	Ryegrass (g)	0.61	DE
	Pine (s)	-0.23	DE
	Clover (g)	-0.27	E
	Hairy vetch (g)	-0.9	EF
	Beggarweed (s)	-1.38	F
	Egyptian wheat (s)	-2.38	F
	Panic grass (s)	-4.57	G
	Winter wheat (g)	-6.86	H
NBS^a	Lespedeza (s)	3.68	A
	Wild bean (s)	3.65	A
	Butterfly pea (s)	2.93	AB
	Partridge pea (s)	1.94	BC
	Hercules club (s)	1.41	BCD
	Ryegrass (g)	0.37	CDE
	Oak (s)	-0.13	DEF
	Pine (s)	-0.26	DEF
	Dogwood (s)	-0.33	EF
	Carolina jessamine (g)	-0.41	EF
	Egyptian wheat (g)	-0.7	EF
	Panic grass (s)	-1.56	F
	Browntop millet (s)	-3.98	G
	Winter wheat (g)	-6.61	H
$Unmanaged^a$	Butterfly pea (s)	2.25	A
	Clover (g)	2.18	A
	Partridge pea (s)	2.07	A
	Yaupon (g)	0.71	AB
	Rush (s)	0.61	AB
	Snake root (s)	0.5	AB
	Carolina jessamine (g)	-1.25	BC
	Pine (s)	-1.32	BC
	Panic grass (s)	-1.79	C
	Panic grass (g)	-3.96	C

[a] Critical values for Waller-Duncan: QMA = 1.79, NBS = 1.94, Unmanaged = 3.05

wild sorghum (*Sorghum* spp.) comprised the bulk of seeds in the single sample. Pigweed, yaupon, panic grass, and wild clovers provided most greenery (Table 2).

1995 - On the QMA, seeds made up 12% of the available foods. Only acorns and seeds of native beggarweed (*Desmodium* spp.) and Hercules club and planted Egyptian wheat and browntop millet comprised weights ≥1%. Native greenery with weights ≥1% were blackberry and panic grass. On NBS, seeds made up approximately 16% of the total weight of potential foods (Table 2). Browntop millet and acorns comprised the majority of the seed weight; acorns occurred in only 2 samples, however. Seeds of wild panics, beggarweed, and smartweed were relatively common but made up small proportions of available foods (Dietz 1999). Native greenery from panic grass, pigweed, nightshade, and chickweed (*Stellaria media*) each made up a small part of the weight, but each occurred in ≥33% of samples. On unmanaged areas, pine seeds made up the greatest biomass and were the most available food item (Table 2). Panic grass and wooly croton seeds also were common, but contributed little to the total weight. Greenery from panic grass, brome grass (*Bromus* spp.), Carolina jessamine (*Gelsemium sempervirens*), and wild clover was also relatively common (Table 2, Dietz 1999).

Food Preferences

In 1994, bobwhites on the QMA selected pine, hairy vetch, and Hercules club seeds over all other foods ($P < 0.05$). Partridge pea and hawthorn seeds ranked second in importance. Seeds of panic grass and Egyptian wheat and greenery of winter wheat were ranked lowest (Table 3). Highly ranked seeds on the NBS in 1994 were hawthorn, pine, oak, browntop millet, and corn from feeders. American beautyberry was the green vegetation selected; leaves of hairy vetch and clover were rated lowest (Table 3). As only 1 food availability sample was collected on an unmanaged area, preference was not tested.

In 1995, seeds selected by bobwhites on the QMA were butterfly pea, partridge peas, and wax myrtle. Seeds of kobe lespedeza, Hercules club, oak, pine, and beggarweed and greenery of planted ryegrass, hairy vetch, and clover were centrally ranked, while seeds and greenery of other planted species ranked lowest. For NBS bobwhites, seeds of planted kobe lespedeza and 4 native species were in the 2 highest ranked groups. Seeds of 3 native tree species and greenery from 2 planted and a native species were centrally ranked. Seeds of planted browntop millet and greenery of winter wheat were included in the lowest groups. Bobwhites from unmanaged areas selected butterfly pea, partridge pea, rush, and snake root seeds and clover greenery. Pine seeds were ranked mid-range, and panic seeds and panic greenery ranked lowest (Table 4).

Discussion

Foods Consumed

Pine seeds and clover greenery were the foods most utilized by bobwhites in this study. Stoddard (1931) found that pine seeds constituted 32.5% of bobwhite diets in the winter months of 1924, but only 4.2% for the same months the following years of a 5-year study. He pointed out that 1924 was an exceptional year for pine mast production. Likewise, during this study, there apparently was an exceptional pine seed crop in east Texas in the fall of 1993. Although this was not reflected in weights from 1994 availability samples, it was evident in the frequencies; pine seeds were recorded in 18 of the 20 samples.

Although equally available each year, clover greenery on the QMA and NBS was consumed in greater quantities and more frequently in 1995 than in 1994. It was also an important food component for bobwhites on unmanaged areas in 1995. Landers and Mueller (1986) wrote that planted foods increase in importance when native foods become scare. If so, bobwhites may have utilized clover in 1995 in the absence of pine seeds. Other researchers have reported similar shifts (Stoddard 1931, Reid and Goodrum 1959).

Seeds of partridge pea were consumed on the

QMA at much higher rates than on NBS or unmanaged areas. It was planted and grew wild on the QMA and grew wild on NBS and unmanaged areas. In the absence of an abundant supply of partridge pea seeds, NBS bobwhite focused on seeds of wild bean, butterfly pea, and brown millet; although browntop millet seeds were equally available on the QMA, they were not consumed there. On unmanaged areas, bobwhite did not benefit from planted foods, thus consumed available native foods, including seeds of butterfly pea, wild partridge pea, and wild bean.

Foods Available

On the QMA, food availability samples contained fewer taxa of seeds (44) than greenery (48). The relationship was reversed on the other 2 areas, with 35 and 23 taxa of seeds and greenery on NBS and 20 and 12 on unmanaged areas. Although unequal numbers of availability samples may have contributed to these differences, the multi-sectional make up of food plots on the QMA was probably most important. Stoddard (1931), Lay (1965), and Rosene and Freeman (1988) reported that bobwhites prefer the first and second stages of succession and that disking stimulates the abundance and diversity of weed species. Buckner and Landers (1979) found that ground which lay fallow for up to 2 years after disking had more herbaceous weeds than did ground which was untouched or burned. These findings suggest that 1- and 2-year fallow sections of food plots on the QMA increased the number of herbaceous species.

Food Preferences

On both the QMA and NBS, consumption rates and preference rankings of pine seeds were much higher in 1994 than in 1995. Subjectively, pine seed were much more abundant in fall 1993 than in fall 1994. However, the sampling technique we used showed little difference in abundances between years. It is unclear why, but pine seeds may have been localized under and around specific trees and missed by the sampling technique. Alternatively, pine seeds are an important food to many species and may have been consumed as soon as they fell. Regardless, the combination of high consumption and relatively low apparent availability resulted in a high preference ranking in 1994. Conversely, moderate consumption and low apparent availability resulted in a moderate preference ranking in 1995.

In the absence of an abundant pine mast crop in fall 1994, bobwhites shifted food preferences to native and planted legumes in winter 1995. Researchers have long recognized the importance of legumes as a food source for bobwhites (Stoddard 1931, Lay 1965, Peoples et al. 1994). In an investigation of 1,400 bobwhite digestive tracts, 12 of the 14 most frequently consumed foods were legumes; greenery and pine seeds were the remaining 2 items (Rosene 1969). Stoddard (1931) noted that partridge peas occurred in $\geq$70% of the digestive tracts of nearly 3,000 bobwhites. Lay (1965) recognized partridge pea as the most important wild legume and kobe lespedeza as the most important planted legume in east Texas.

Greenery from species planted on food plots on the QMA and NBS generally ranked in the mid-to-low ranges of preference. Such greenery was readily available, thus its low rankings are not surprising. However, the high ranking of clover on unmanaged areas demonstrates the importance of greenery to bobwhites. Baldwin and Handley (1946) found clover greenery in 149 of 495 bobwhite digestive tracts and Landers and Mueller (1986) reported greenery as the most frequently consumed food in early spring. Our results suggest that in the absence of greenery in food plots, bobwhites utilized greenery from wild clover if available, or yaupon, American beautyberry, and other species if not.

Management Implications

This study suggested that food plots benefit bobwhites in forested areas of east Texas. The birds readily consumed seeds of planted partridge pea, lespedeza, and hairy vetch and greenery of planted clover. Goodrum and Reid (1954) suggested planting legumes to supplement native food supplies for

bobwhites in eastern Texas and western Louisiana. They pointed out that populations in forested areas were limited by often unpredictable native food supplies. The unpredictable nature of native foods and the value of foods from planted species were clearly demonstrated in this study wherein diets of birds from the QMA and NBS were dominated by pine seeds in 1994 and by seeds and greenery of planted species in 1995. Managers concerned with bobwhite populations should consider supplemental food plots which include partridge pea, kobe lespedeza, hairy vetch, and clover for greenery.

Other species that may warrant planting, as indicated by this study, are browntop millet and Egyptian wheat. In the absence of partridge peas, NBS birds consumed relatively high proportions of browntop millet each year. Planted on fertile, well-drained soils, Egyptian wheat will exceed 2 m in height. It offers value as a nurse crop to planted legumes and the strong stalks easily supported twining vines of hairy vetch. It also provides cover for bobwhite hens with broods.

Finally, improvement harvests which open canopies in pine stands encourage seed production by overstory trees and increase accessibility to seeds on the ground by bobwhites. In east Texas, however, such harvests must be coupled with regular prescribed burning or disking to prevent encroachment by woody species.

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