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Effect of Supplemental Feeding on Winter Diet and Body Mass of Northern Bobwhites

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Supplemental feeding by spreading grain is a common management practice on private lands managed for northern bobwhites (*Colinus viginianus*), but its effect on diet of bobwhites is not well documented. We examined crop contents from 160 northern bobwhites collected in January and February of 2002 and 2003 from Tall Timbers Research Station, Tallahassee, FL, and Pebble Hill Plantation, Thomasville, GA. Sorghum seed (*Sorghum vulgare*) was spread bi-weekly on approximately half of each study area along a dedicated feed trail through the cover. Dry mass of crop contents from harvested bobwhites averaged 2.51g (SE = 0.171) and was composed primarily of seeds ($\bar{\chi}$ = 2.44 g; SE = 0.171), with minor invertebrate ($\bar{\chi}$ = 0.052g; SE = 0.021) and vegetation ($\bar{\chi}$ = 0.016g; SE = 0.004) matter. Dry mass of crop contents for bobwhites averaged 2.94 g (SE = 0.280) for birds from fed sites and 2.09g (SE = 0.187) from reference sites. On fed sites 67.5% of bobwhites had used sorghum and sorghum accounted 71% of food items by weight. Diet varied annually, primarily with changing use of acorn, (*Quercus* spp.) pine (*Pinus* spp.) mast, and partridge pea (*Cassia* spp.). Adult bobwhites captured in January averaged 169.9g (SE = 0.970; n = 181) on reference sites and 174.8g (SE = 0.896; n = 237) on fed sites. Supplemental feeding by spreading sorghum was an effective method of providing seeds with high metabolizable energy to bobwhites.

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Introduction

Food supplementation has a long history in bobwhite management (Frye 1954) and supplemental feeding has since replaced food plot planting on many private lands managed for bobwhites. Unlike food plot plantings, supplemental feeding is not dependent on soil or weather conditions, can be made available to the bobwhites year-round, provides food for many wildlife species, and is applicable where disking ground or using agrichemicals to plant crops is not possible (e.g., erosion potential or wet conditions) nor acceptable (e.g., disrupting sensitive or threatened plant communities). For these reasons and others (Sisson et al. 2000), landowners managing for bobwhites are adopting food supplementation.

A few studies have investigated the use of sorghum by bobwhites and the effects of supplemental feeding on bobwhite demographics. In Georgia, Michael and Beckwith (1955) showed that sorghum was the most preferred food of native and planted species tested. Robel and Arruda (1986) reported that bobwhites maintained body weight on sorghum, but not some natural foods prevalent in winter diets. In Kansas, Robel (1969), Robel et al. (1974) studied bobwhite use of food plots and reported those near food plots weighed more and contained a higher percentage of body fat than birds without food plot available to them. Frye (1954) demonstrated population increases on a portion of a wildlife management supplementally fed using feeders. Sisson et al. (2000) reported higher winter survival rates and smaller home ranges when bobwhites were provided supplemental feed through spreading in high quality habitat. Finally, Townsend et al. (1999) reported bobwhites in Oklahoma used

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sorghum from feeders even when food plots were available, exhibited higher survival in 2 of 4 years of their study, and were more resistant to severe weather events. However, Guthery (1999) found little support for the food-limitation hypothesis in quail management.

Few studies have compared the relative importance of supplemental feed in the diet of bobwhites relative to control bobwhites. Frye (1954) found heavy use of supplemental feed from feeders during a year with low natural foods in Florida. Robel et al. (1974) reported sorghum was 27.9% of crop contents for bobwhites near food plots. Townsend et al. (1999) reported percent sorghum of bobwhites harvested during winter from an area with supplemental feeders was 28.2% relative to 5.5% for bobwhites from a control area. No studies have reported the diet of bobwhites on areas supplementally fed by spreading feed, which is becoming a common practice on managed properties in the southeast. Therefore, we determined the effect of supplemental feeding on diet and body mass of bobwhites on 2 areas during late winter.

Study Area

We studied bobwhites during January and February on Tall Timbers Research Station (1,568 ha) (TTRS), Leon County, Florida and Pebble Hill Plantation (1,246 ha) (PH), Thomas and Grady Counties, Georgia. These study areas, which are 12 km apart, were located in the Red Hills physiographic region in the Gulf Coastal Plain of northern Florida and southern Georgia. Our study areas consisted of upland pine forests (80%) dominated by loblolly pine (*P. taeda*) and shortleaf pine (*P. echinata*) with associated "old-field" ground cover vegetation on TTRS. On PH, approximately 30% of the study area is longleaf pine (*P. palustris*) with associated wiregrass (*Aristida stricta*) ground cover. Intermixed throughout the study sites were hardwood drains and hammocks and annually disked fallow fields. Basal area of overstory trees in upland areas managed for bobwhites averaged 9.2 m^2/ha on TTRS and 10.5 m^2/ha on PH. Approximately 60-70% of each site was burned annually to promote herbaceous ground cover and reduce the stature of hardwood shrubs and saplings.

Methods

Supplemental Feeding

The northern portion of TTRS (445 ha) and the southern portion of PH (532 ha) were supplied with sorghum once every 2 weeks on a year-round basis. Sorghum was spread from a tractor along a specified route through the uplands. The feeding route covered 19 km on TTRS and 14 km on PH. Difference in length of feeding routes between study areas resulted from differences in landscape characteristics between the study sites. Pebble Hill has more hardwood drains than TTRS which limited tractor access to some areas. Sorghum was spread continuously along the route at the rate of approximately 95 kg of sorghum per km of feeding route. For example, this amounts to 107 kg of sorghum per ha per year (1.7 bushels of sorghum/acre/year) for the TTRS study area. Sorghum was used because it is preferred by bobwhites (Michael and Beckwith 1955) and has excellent energetic properties for bobwhites (Robel and Arruda 1986).

Data Collection

We collected 160 hunter-shot bobwhites during January - February, 2002 - 2003. Forty bobwhites were collected from the fed area and reference area of TTRS and PH each year of the study. Each bobwhite was aged and weighed to the nearest 0.1 g. Crops were removed from bobwhites and placed individually in plastic bags and marked by study area, date, age, sex, and band history. Crops were frozen until further analyses.

Crops were thawed then their contents emptied into a #25 sieve. Contents were washed to separate vegetation, insects and seeds. We placed all of the vegetation in a dish for drying. We then removed the insects and placed them in a tube containing a 70% ethanol solution. We transferred the remaining contents, which were now composed only of seeds, to a dish and oven-dried seeds and vegetation at 80°

C for a period of 24 hours.

We separated seeds from each crop by genus, according to Landers and Johnson (1976), using a magnifying lamp and a dissection microscope. Once all of the seeds were separated, we counted and weighed the dried seeds. We also dried and weighed the insect and vegetation matter collected. Using this data, we calculated mean crop weight, mean seed weight, mean % of seed per crop, and mean number of seeds per crop.

We weighed captured bobwhites to determine their body mass on TTRS and PH during January in baited-funnel traps. Details on hunting procedures and capturing procedures are published elsewhere (Palmer et al. 2002). Bobwhites were weighed to the nearest 0.1 g on an electric balance. Bobwhites on both fed and reference sites were captured in traps baited with sorghum, therefore, mass estimates are biased high, but the comparison among fed and reference sites should not be biased.

Results

Crop Contents

Dry weight of crop contents averaged 2.51g (SE = 0.171) and was composed primarily of seeds ($\bar{\chi}$ = 2.44 g; SE = 0.171), with lesser amounts of invertebrate ($\bar{\chi}$ = 0.052 g; SE = 0.021) and vegetation ($\bar{\chi}$ = 0.016 g; SE = 0.004) matter. Dry weight of crop contents for bobwhites from fed sites was 2.94 g (SE = 0.280), whereas mean mass of crop contents from bobwhites from reference sites was 2.09 g (SE = 0.187). Bobwhites from fed sites ate slightly less vegetation ($\bar{\chi}$ = 0.0064 g; SE = 0.0032) than bobwhites from reference sites ($\bar{\chi}$ = 0.0261 g; SE = 0.0073).

Mass of crop contents also varied by year, averaging 2.66 g (SE = 0.236) per crop in 2003 and 2.36 g (SE = 0.248) per crop in 2002. Mass of crop contents varied more among years for bobwhites from reference sites than fed sites. Bobwhites on reference sites averaged 1.82 g (SE = 0.274) in 2002 and 2.35 g (SE = 0.251) in 2003. Whereas, mean mass of crop contents for bobwhites on fed sites was 2.90 (SE = 0.399) in 2002 and 2.98 (SE = 0.397) in 2003.

Relative Use Of Sorghum

We found 32 species of seeds in the 180 quail crops analyzed. There were 8 species of seeds found from bobwhites in reference sites that were not present in bobwhites from fed sites (Table 1). Of bobwhites with some crop contents, 67.5% of bobwhites harvested on fed areas had sorghum in their crops which accounted for 65.9% (95% CI = 56.2 - 75.7) of the crop contents mass. Including only bobwhites that had sorghum in their crops, sorghum comprised 91.5% of the crop contents, averaging 2.94 g (SE = 0.351) per crop. The most sorghum found was in a single crop was 9.8 g in a juvenile female, which also happened to be the heaviest crop contents of the 80 bobwhites harvested from fed sites.

Annual Variation

Bobwhites used different foods each year. Mass of acorn meat in crops was 16.7x greater in 2002 ($\bar{\chi}$ = 0.50 g, 95% CI = 0.243 - 0.749) than 2003 ($\bar{\chi}$ = 0.03 g, 95% CI = -0.035 - 0.103). Pine mast also was more prevalent in crops in 2002 ($\bar{\chi}$ = 0.14 g, 95% CI = 0.045 - 0.024) than 2003 ($\bar{\chi}$ = 0.05 g, 95% CI = 0.024 - 0.071). In 2002, when pine and oak mast use was relatively high, bobwhites on fed sites utilized these foods ($\bar{\chi}$ = 0.32 g, 95% CI = 0.079 - 0.560), but less so than on reference sites ($\bar{\chi}$ = 0.99g, 95% CI = 0.481 - 1.497). In 2003, partridge pea was the most prevalent native seed in crops of bobwhites ($\bar{\chi}$ = 1.18g, 95% CI = 0.828 - 1.53), and it was used significantly less in 2002 ($\bar{\chi}$ = 0.17 g, 95% CI = 0.061 - 0.263). In 2003, partridge pea was utilized more on reference areas ($\bar{\chi}$ = 1.62g, 95% CI = 1.17 - 2.07) than fed areas ($\bar{\chi}$ = 0.70g, 95% CI = 0.183 - 1.210). One bobwhite had 1287 partridge pea seeds in its crop. Mass of all other legumes combined did not vary from reference ($\bar{\chi}$ = 36g, 95% CI = 0.199 - 0.512) and fed sites ($\bar{\chi}$ = 0.33 g, 95% CI = 0.088 - 0.568). All other seed types combined accounted for an average of 0.075 g (SE = 0.023) per crop.

Body Mass

Adult bobwhites captured in January averaged 169.9 g (SE = 0.970; n = 181) on reference sites and 174.8 g (SE = 0.896; n = 237) on fed sites and the 95% CI's did not overlap. Similarly, captured juvenile

Table 1: Percent use and dry mass (g) of seeds in crops (when present) of northern bobwhites (n = 80) collected from sites with sorghum (*S. vulgare*) spread along dedicated feeding trails and reference sites (n = 80) on Tall Timbers Research Station, Florida, and Pebble Hill Plantation, Georgia, in January and February, 2002−2003.

	Supplementally-fed						Reference				
Seed type	n	Use %	Dry mass	Min	Max		n	Use (%)	Dry mass	Min	Max
Sorghum vulgare	54	67.5	2.939	0.037	9.768		9	11.3	1.579	0.017	3.476
Desmodium spp.	32	40	0.092	0.002	1.425		37	46.3	0.143	0.003	1.294
Lespedeza spp.	23	28.7	0.281	0.003	5.668		39	48.8	0.181	0.002	4.439
Chamaecrista spp.	35	43.8	0.894	0.004	6.155		49	61.3	1.451	0.008	4.915
Pinus spp.	30	37.5	0.129	0.004	1.156		41	51.2	0.251	0.006	3.204
Galactia volubilus	23	28.7	0.63	0.006	5.694		37	46.3	0.212	0.006	1.577
Acorn (*Quercus* spp.)	6	7.5	1.491	0.039	2.856		19	23.8	1.577	0.043	5.515
Zea mays	3	3.8	0.302	0.14	0.494		2	2.5	2.039	1.375	2.703
Geranium spp.	0	-	-	-	-		2	2.5	0.005	0.005	0.006
Centrosema virgininanum	12	15	0.059	0.011	0.168		36	45	0.175	0.001	1.35
Panicum spp.	9	11.3	0.024	0.002	0.141		9	11.3	0.007	0.001	0.017
Tephrosia virginica	1	1.3	0.01	0.01	0.01		6	7.5	0.031	0.004	0.067
Trichostema dichotomum	12	15	0.052	0.002	0.366		25	31.3	0.042	0.002	0.206
Juncus spp.	9	11.3	0.01	0.005	0.018		15	18.8	0.017	0.002	0.06
Ambrosia artemisiifolia	4	5	0.021	0.007	0.039		6	7.5	0.129	0.003	0.733
Helianthus spp.	1	1.3	0.018	0.018	0.018		5	6.3	0.018	0.006	0.052
Acalypha spp.	5	6.3	0.004	0	0.008		12	15	0.005	0.001	0.021
Cercis canadensis	0	-	-	-	-		1	1.3	0.025	0.025	0.025
Liquidambar styraficula	0	-	-	-	-		4	5	0.14	0.007	0.312
Polygonum spp.	0	-	-	-	-		1	1.3	0.001	0.001	0.001
Rumex acetosella	0	-	-	-	-		1	1.3	0.003	0.003	0.003
Parthenocissus quinquefolia	0	-	-	-	-	1	1.3	0.034	0.034	0.034	
Prunus serotina	0	-	-	-	-		2	2.5	0.66	0.053	1.267
Richardia scabra	1	1.3	0.062	0.062	0.062		4	5	0.047	0.002	0.167
Diodia teres	1	1.3	0.007	0.007	0.007		1	1.3	0.015	0.015	0.015
Bouteloua curtipendula	0	-	-	-	-		1	1.3	0.012	0.012	0.012
Unknown	4	5	0.007	0.002	0.016	7		8.8	0.028	0.001	0.161

bobwhites averaged 167.3 g (SE = 0.486; n = 820) on reference sites and 171.5 g (SE = 0.464; n = 1004) on fed sites and these 95% CI's also did not overlap. The mean difference in body mass between fed and reference sites averaged 4.3 and 4.8 g for adult and juvenile bobwhites, respectively. Body mass was consistently lower on reference sites each year at TTRS, however, on PH, body mass was lower in 2003 than in 2002 on the reference site (Figure 1).

Discussion

Bobwhites on our study areas used sorghum greater than any other seed when it was available. This was not surprising given that the supplementation program was designed make sorghum available to most bobwhites on our study areas and sorghum is a highly preferred bobwhite food (Michael and Beckwith 1955). Studies reporting use of food plots and feeders reported lower use than our study. Robel et al. (1974) reported that 27.9% crop contents was sorghum for bobwhites living near food plots. Townsend et al. (1999) reported sorghum from feeders composed 28.2% (Range 20.7 - 45.2%) of crop contents from bobwhites harvested during winter. These compare to 71% of crop contents, by weight, in this study. The relatively high use of sorghum in our study suggests that supplemental feeding by spreading along dedicated trails is more effective at provided sorghum to bobwhites than feeders or food plots.

Diets of bobwhites were diverse on both the fed and reference areas, although some minor diet items were found only on the reference areas. The most important native foods included partridge pea, acorn mast, pine mast, lespedeza, milk pea (*Galactia volubilis*) and beggar-tick (*Desmodium* spp). Therefore, while bobwhites made heavy use of sorghum seeds, this did not result in complete reliance on supplemental feed. Similar results were found by Robel et al. (1974) and Townsend et al. (1999).

Robel et al. (1974) compared the metabolizable energy (ME) per crop for bobwhites near and far from food plots and reported ME of 7514 cal/crop for birds utilizing food plots and 5653 for bobwhites not using food plots. We developed an estimate of ME per crop for bobwhites in this study using energy content and ME values provided by Robel et al. (1974, pg. 660). For species lacking data on ME, we used the reported overall mean ME for the species they tested. For bobwhites on the fed portion of the study area, the mean crop contained roughly 9720 cal versus 5531 cal for bobwhites on the reference sites. The ME per crop for reference bobwhites in this study was similar to that reported by Robel et al. (1974) for bobwhites not utilizing food plots. However, ME per crop for bobwhites on the fed portion of our study areas was $\sim$2500 cal higher than those utilizing food plots in Robel et al.'s study due to double the sorghum content in crops from this study. On fed sites in this study, 76% of the energy per crop came from sorghum versus 42% in Robel et al.'s study. Collectively these results suggest that supplemental feeding through spreading is more effective at providing high energy foods to a bobwhite population than food plots.

Some insights may be gained from evaluating ME of bobwhites with full crops, as most bobwhites were harvested during feeding activity. For instance, a juvenile female had 385 sorghum seeds in her crop which is approximately 36,280 cal. This amount of sorghum indicates bobwhites could feed 1 to 2 times per day to meet daily ME needs at 2° C (Robel et al. 1979). This compares to 1287 partridge pea seeds in the crop of a juvenile male on the unfed site, approximately 21,420 cal. Differences in diet and energy content suggest total feeding time may be as much as 3 to 4 times greater on the unfed sites than fed sites. Sisson et al. (2000) reported smaller home ranges and higher survival for bobwhites with access to supplemental feed during some winters and suggested that observed lower mortality was an artifact of decreased foraging activity and predation risk. Similarly, Townsend et al. (1999) suggested supplemental feeding may reduce exposure of bobwhites to predation. Home ranges on our study areas were 50% smaller on fed sites than unfed sites and Kaplan-Meier winter survival was significantly higher on fed sites in some years (Palmer and

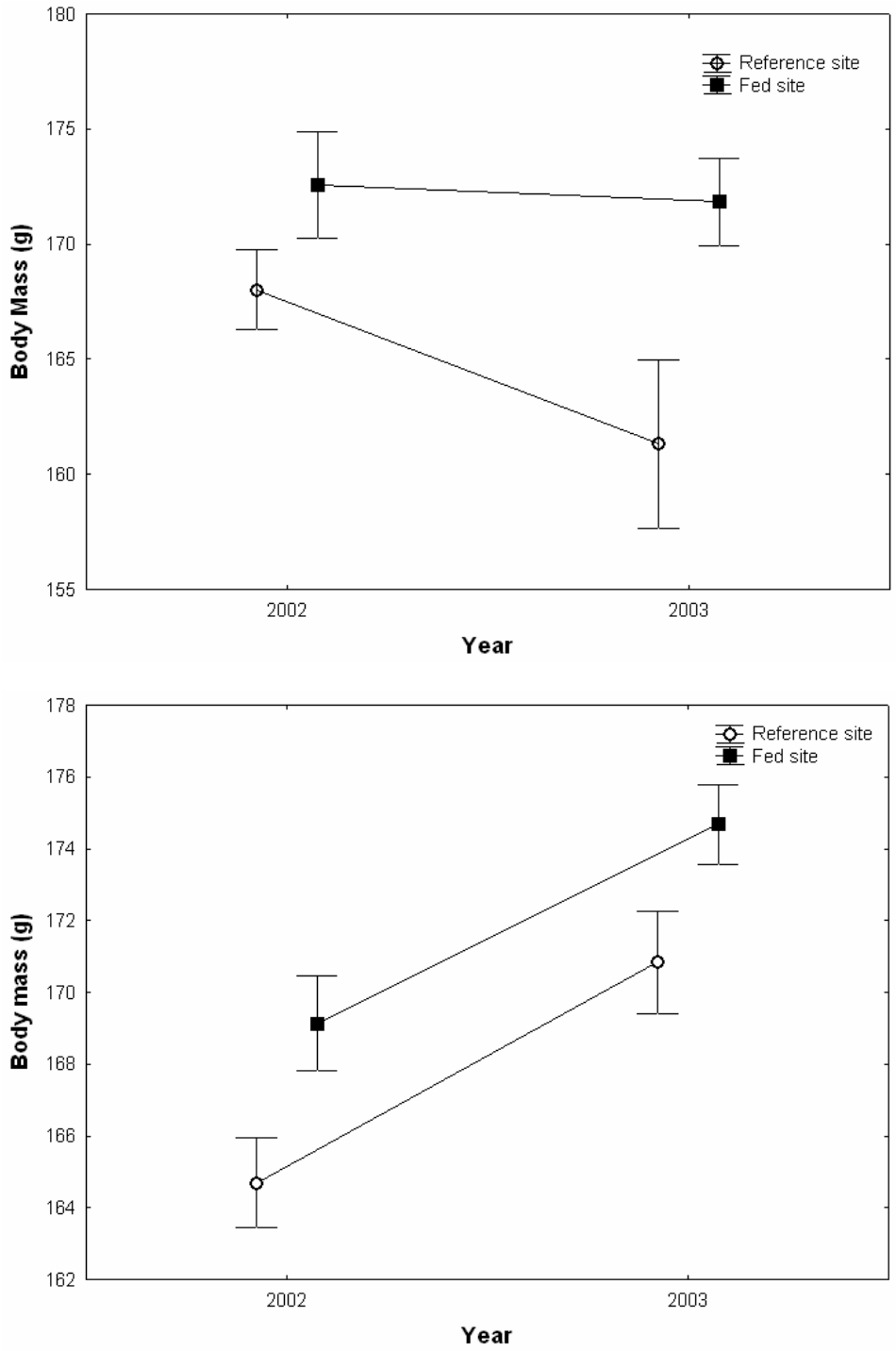

Figure 1: Average mass (g) and associated 95% confidence intervals for northern bobwhites (n = 852) captured on fed and reference areas on Pebble Hill (top graph), Grady County, Georgia and Tall Timbers Research Station (lower graph), Leon County Florida, 2002−2003.

Wellendorf, unpublished data). Robel and Kemp (1997) suggested higher survival for birds with access to food plots was due to improved resistance to severe winter weather. Guthery (1999) countered that increased lipid loads in bobwhites with access to food plots would provide marginal improvement in resistance to periods of severe weather. In the deep south, where winter weather is almost never severe (e.g., extended periods of snow cover) and natural food supplies are adequate in good habitat (Guthery 1999), we hypothesize that supplemental feeding may lessen predation on bobwhites by reducing foraging time and/or modifying foraging behaviors. Future studies of supplemental feeding should consider the effect of foraging time and foraging behavior on bobwhite survival.

Greater body mass of bobwhites on fed areas in this study was consistent with other studies (Robel 1969, Robel et al. 1974) although the difference was lower than that reported by Robel et al. (1974) in Kansas. In addition to sustaining higher body weight, body weight varied little each year on supplementally-fed sites. In contrast weights varied annually on reference sites and were relatively low in 2003 on the reference portion of PH. We suspect low acorn and pine mast availability during 2003 resulted increased use of partridge pea in 2003. On reference sites in 2003, 71% of the dry mass of crop contents for bobwhites with >1 g of seeds in their crops (n = 30) was partridge pea. This contrasts with 7% of crop contents for birds similarly sampled in 2002. Partridge pea is a relatively poor food energy source for bobwhites because of its low metabolizable efficiency (Robel et al. 1974). Robel et al. (1974) also reported relatively heavy use of low energy foods during January and February, including sumac and partridge pea. Bobwhites may adjust for lower energy foods by increasing volume ingested (Giuliano et al. 1996). In our study bobwhites on reference sites had slightly heavier crops in 2003 than 2002 suggesting increased weights were a result of reliance on seeds with lower energy content.

Management Implications

Supplemental feeding of bobwhites by spreading sorghum seed along feeding routes through properly managed habitat reduced annual variation in diet composition and ME and resulted in increased body mass during late winter. Our results suggest that supplemental feeding reduces reliance on poor quality foods (e.g., low ME) in late winter, even in an area in the "deep south" that had a diverse plant community and abundant native foods that support bobwhites (Stoddard 1931).

Providing high energy foods for bobwhites likely reduces foraging time to meet daily energy needs. In this study, bobwhites on fed sites had roughly 50% more energy per crop suggesting feeding time was reduced by at least that amount. Other studies have suggested that providing high energy foods through supplemental feeding (Townsend et al. 1999, Sisson et al. 2000) or food plots (Robel and Kemp 1997) resulted in higher over winter survival rates in at least some years. Reducing over-winter mortality is an important management objective for sustaining bobwhite populations.

Supplemental feeding as a food management technique is preferred over food plantings because it does not depend on suitable growing conditions to produce, can be adapted quickly to changing conditions (flooding, habitat changes etc.) and does not result in soil disturbance nor require the inputs such as fertilizers and pesticides, and is more effective at delivering high energy foods to bobwhites. While we did not directly measure the costs associated with supplemental feeding, we suspect it is not outside the budget of many wildlife management programs on public or private lands. Further research is needed to determine if population level responses accrue from changes to demographic parameters as a result of supplemental feeding in areas of good to excellent habitat.

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