# Long-term effects of woody vegetation management on seasonal body condition of northern bobwhites

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### **Abstract**

We investigated effects of season and brush management on body condition of northern bobwhites (Colinus virginianus) in the Cross Timbers ecosystem of central Oklahoma. Quail were collected seasonally and body condition assessed by necropsy and analysis of percent fat, protein, and ash in the carcass. Brush management by herbicide, herbicide + fire, and mechanical removal had minimal long-term effects on body condition. However, we found significant seasonal differences in weights of the gizzard, gizzard fat, liver, and lipid reserves (body and gizzard fat). With respect to condition, we concluded that northern bobwhites derived no long-term benefits from brush management programs in the Cross Timbers ecosystem of central Oklahoma.

Key Words: Colinus virginianus, herbicide, nutrition, prescribed burning

The Cross Timbers vegetation type is characteristic of central Oklahoma. Because of the dense overstory, forage availability for livestock and wildlife is often limited. Reduction of woody overstory cover to increase forage for livestock can be achieved by burning and herbicide treatments (Engle et al. 1991), which affect habitat structure, forage availability, and dietary quality for northern bobwhites (Colinus virginianus) as well (Baumgartner 1945, Ellis et al. 1969, Minser and Byford 1981, Wilson and Crawford 1981, Wiseman and Lewis 1981, Webb and Guthery 1982).

Removal of woody vegetation with application of fire and herbicide can have direct and indirect effects on the nutritional ecology of quail. Prescribed burning benefits bobwhites by (1) increasing biomass of forb seeds and insects (Stoddard 1963, Hurst 1972, Renwald et al. 1978); (2) removing mulch and dead vegetation near the ground surface, allowing for increased access to feeding areas (Lang 1954, Hurst 1972); and (3) stimulating new growth with a higher nutrient content (Dewitt and Derby 1955, Bogle et al. 1989). Likewise, applications of herbicide may benefit quail by removing woody vegetation, which increases grass and forb production (Guthery et al. 1987) and crude protein content of important quail foods such as common sunflower (Helianthus annuus L.) (Pletscher and Robel 1979) and croton (Croton spp.) (Wood et al. 1986).

However, research results on long-term benefits to bobwhites

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from brush management programs are equivocal. For example, several studies revealed that high herbicide application rates (>1.1 kg/ha of tebuthiuron) resulted in a decline of forb biomass and diversity (Pletscher and Robel 1979, Meyer and Bovey 1985, Guthery et al. 1987) and improvement of crude protein content of forage was limited only to the growing season following treatment (Masters and Scifres 1984, Biondini et al. 1986).

Recent studies in the Cross Timbers demonstrated that removal of woody vegetation with herbicides and periodic burning increased forb production (Engle et al. 1991) and produced forage with higher concentrations of crude protein and digestibility (Bogle et al. 1989, Soper 1992). As a result, we hypothesized that quail would benefit by improved body condition from these management practices. The purpose of our study was to evaluate the long-term (up to 7 years after treatments) effects on northern bobwhites of 3 brush management strategies (including prescribed burning, herbicide, or mechanical removal of woody vegetation) commonly used in the Cross Timbers of central Oklahoma and document seasonal changes in body condition of bobwhites in treated and untreated areas.

## Methods

The Cross Timbers Experimental Range (CTER) is in the Payne County, Okla. (36°2' to 36°4'N, 97°9' to 97°11'W) in the Cross Timbers land resource area (Garrison et al. 1977). Detailed descriptions of the study area have been published previously (Engle et al. 1991, Lochmiller et al. 1991, Stritzke et al. 1991). Vegetation on CTER is dominated by post oak (Quercus stellata Wang.) and black-jack oak (Q. marilandica Muenchh.) in the overstory interspersed with tallgrass prairie (Ewing et al. 1984). For each of the 4 treatments bobwhites were collected from the interior of 1 to 8 replicated sample plots (one 128-ha replication of mechanicaltreated, three 64-ha replications of burned, eight 32-ha replications of herbicide-burned, and four 64-ha replications of untreated sample plots). Distance between replicated sample plots ranged from 0.8 to 5.0 km. Herbicide treatment involved use of either tebuthiuron (N-[5-(1,1-dimethylethyl)-1,3,4-thiakiazol-2-yl]-N, N'-dimethylurea; Elanco Product Co., Division of Eli Lilly and Co., Indianapolis, Ind. 46285) or triclopyr ([(3,5,6-tricloro-2-pyridinyl)oxy] acetic acid; Dow Chemical Co., Miland, Mich. 48674) applied aerially at 2.2 kg/ha in March and June 1983. Burned sample plots were burned annually with strip headfires during late spring from 1985 to 1990 to reduce post-herbicide increase of woody vegetation. Mechanical removal of woody vegetation was accomplished in 1988 by bulldozing. The untreated sample plots were not

sprayed or burned. All sample plots were grazed by yearling cattle from April to September with stocking rate set each year relative to expected levels of forage production to result in 50% utilization as measured by end-of-season residue of herbaceous standing crop (Stritzke et al. 1991).

## Sampling Intensity

Northern bobwhites were collected seasonally 6 and 7 years following initial herbicide applications (May 1989 and 1990, Sep. 1990 and 1991, Feb. 1989 and 1990). Line-transect flush counts were attempted on the study areas but quail numbers were too low to derive quantitative estimates of density. Approximate relative abundance of birds was lower among treated sample plots (0.5 bird/hour) compared to untreated sample plots (1 bird/hour) based on collection efforts. The low densities complicated collection efforts during some seasons, necessitating pooling of samples between years within; 67, 62, and 37 birds were collected during spring (May), fall (September), and winter (February), respectively.

# **Body Condition Analysis**

Postmortem examination included weights of the whole body, liver, gizzard, gizzard fat, spleen, adrenal glands, and reproductive organs. The small intestine was flushed to remove contents and returned to the carcass. The carcass was dried by lyophilization and ground to a fine powder with a food processor and a microgrinding mill. Body fat was assessed by ether-extraction with a Soxhlet Apparatus (Sawicka-Kapusta 1975) and ash content was determined by combustion in a muffle furnace at 600° C for 6 hours. Percent body protein was determined by subtracting percent fat and ash from 100 (Cambell and Leatherland 1980).

#### Statistical Analysis

Because of low sample sizes of quail on several treatments, birds were pooled among replicates before statistical analysis of treatment effects. All data were tested for normality before statistical analysis with the F-max text (Sokal and Rohlf 1969). Variances of treatment means for spleen and adrenal gland weights were heterogeneous so values were transformed (log). Differences in body condition indices related to age of birds collected during fall was tested by 2-way analysis of variance with treatment type and age as main factors (PROC GLM, SAS 1988). Differences in body condition indices among the 3 collection times, 4 treatment types, and between untreated and treated (brush treatments were pooled) sample plots were tested by 3-way analysis of variance with treatment type, season, and sex as main factors (PROC GLM, SAS 1988). Interactions of treatment type, season, and sex were examined. We used Least Significant Difference test to determine differ-

ences ( $P \le 0.05$ ) among means in the presence of a significant F-test

### Results

All birds collected in spring and winter were adults ( $\geq$ 14 weeks old) whereas 51 of the 62 birds collected in fall were immatures (4-14 weeks old). Seasonal differences in mean body weight resulted from different age classes of birds collected during the 3 collection periods. Eighty-two percent of the birds from fall were smaller immatures which resulted in a sample reduction in mean body weight. Weights of the whole body (P = 0.05), liver (P = 0.02), adrenal glands (P = 0.01) and reproductive organs (P = 0.05) were greater for adults than for immatures; percent body protein was greater (P = 0.05) in immatures.

Season  $\times$  treatment interactions were significant ( $P \le 0.05$ ) only for weights of gizzard and gizzard fat. Season  $\times$  sex interactions for weights of the whole body, liver, gizzard fat, and percentage fat and protein in the carcass were significant (P < 0.05). Weights of the whole body, liver, gizzard, gizzard fat, and percent body fat were greater (P < 0.05) in females than males during spring; percent body protein was significantly greater in males than in females. There were no sex related effects during fall or winter (P < 0.05). The only significant season  $\times$  treatment  $\times$  sex interaction was for percent body protein.

Seven of the 10 body condition indices differed seasonally (Table 1). Whole body weights were greater for quail collected in spring and winter compared with those from fall. Liver weights were significantly greater in spring birds compared with fall and winter birds. Weights of the gizzard were greater in winter birds compared with spring or fall birds; however, relative weights were significantly greater (P < 0.01) in fall birds followed by winter and spring birds, respectively. Weights of gizzard fat and percent body fat were higher in birds collected in winter compared with spring and fall. Protein composed a lower percentage of total body dry mass in the winter birds compared to the spring and fall birds. A positive correlation (P < 0.01) existed between body weight and body fat (r = 0.30.).

Three of the 11 body condition indices differed among treatments (Table 2). Weights of the whole body, liver, and relative gizzard fat (P = 0.04) were greater in birds collected from the untreated sample plots compared with birds from areas subjected to mechanical treatment. Relative weights of gizzard fat also were influenced by a significant interaction between season and treatment, with lower weights in birds from mechanical treatments than untreated sample plots in spring. Specific comparisons indicated that birds from untreated sample plots had greater  $(P \le 0.05)$  body

Table 1. Seasonal effects on selected body condition indices of northern bobwhites ( $\bar{x} \pm SE$ ), Cross Timbers Experimental Range, Oklahoma, 1989-91.

Indices	Spring (n = 67)	Fall (n = 62)	Winter (n = 37)	(P>F)	
Whole body, g	181.24 ± 1.96A1	157.14 ± 4.20B	185.27 ± 3.29A	0.0001	
Liver, g	$3.25 \pm 0.12A$	$2.57 \pm 0.09B$	$2.75 \pm 0.17B$	0.0001	
Gizzard, g	$7.59 \pm 0.14B$	$7.64 \pm 0.22B$	$8.35 \pm 0.26A$	0.0079	
Spleen, mg	$4.96 \pm 0.98$	$4.91 \pm 0.45$	$2.19 \pm 0.49$	0.1820	
Adrenal gland, mg	$1.26 \pm 0.06$	$1.23 \pm 0.15$	$1.15 \pm 0.10$	0.5644	
Gizzard fat, mg	$7.99 \pm 1.29B$	$4.78 \pm 0.54B$	$25.36 \pm 3.35A$	0.0001	
Body fat, %	$7.47 \pm 0.36B$	$7.76 \pm 0.41B$	$19.79 \pm 1.25A$	0.0001	
Body protein, %	$83.26 \pm 0.36$ A	$81.81 \pm 0.44A$	$71.96 \pm 1.19B$	0.0001	
Ash, %	$9.35 \pm 0.18B$	$10.44 \pm 0.24$ A	$8.25 \pm 0.20$ C	0.0001	
Water, %	$64.94 \pm 0.36B$	$67.70 \pm 0.31A$	$60.43 \pm 0.52$ C	0.0001	

<sup>&</sup>lt;sup>1</sup>Row means with same letter were not different ( $P \ge 0.05$ ).

Table 2. Treatment effects on selected body condition indices of northern bobwhites  $(\bar{x} \pm SE)$ , Cross Timbers Experimental Range, Oklahoma, 1989-91.

Indices	Herbicide	Herbicide + Fire $n = 21$ )	Mechanical (n = 44)	Control ( <i>n</i> = 27)	(P>F) $(n=74)$
Whole body, g	171.96 ± 4.33AB <sup>1</sup>	165.87 ± 4.87B	166.13 ± 5.90B	180.35 ± 2.69A	0.0403
Liver, g	$2.95 \pm 0.15$ AB	$2.84 \pm 0.16AB$	$2.54 \pm 0.14B$	$3.01 \pm 0.12A$	0.0042
Gizzard, g	$7.61 \pm 0.27$	$7.67 \pm 0.27$	$7.15 \pm 0.36$	$8.12 \pm 0.14$	0.2709
Spleen, mg	$5.49 \pm 2.31$	$3.37 \pm 0.35$	$3.90 \pm 0.98$	$4.70 \pm 0.62$	0.6131
Adrenal gland, mg	$1.08 \pm 0.10$	$1.13 \pm 0.06$	$1.25 \pm 0.10$	$1.31 \pm 0.13$	0.5986
Gonad/Ovary, mg	$116.72 \pm 28.05$	$42.85 \pm 10.44$	$84.24 \pm 17.93$	$65.68 \pm 15.69$	0.5596
Gizzard fat, my	$08.00 \pm 2.03$	$10.64 \pm 3.16$	$6.21 \pm 1.44$	$13.24 \pm 1.53$	0.1056
Body fat, %	$7.49 \pm 0.74$	$9.43 \pm 1.01$	$9.27 \pm 1.03$	$12.06 \pm 0.88$	0.9199
Body protein, %	$82.89 \pm 0.66$	$80.93 \pm 0.93$	$80.71 \pm 0.98$	$78.82 \pm 0.82$	0.8723
Ash, %	$9.62 \pm 0.46$	$9.65 \pm 0.31$	$10.06 \pm 0.25$	$9.20 \pm 1.20$	0.5263
Water, %	$64.80 \pm 0.70$ BC	$65.45 \pm 0.61B$	$66.92 \pm 0.52A$	$64.01 \pm 0.47$ C	0.0474

<sup>&</sup>lt;sup>1</sup>Row means with same letter are not different (P>0.05).

weights (180.4  $\pm$  2.7 and 167.0  $\pm$  3.1 g, respectively) and liver weights (3.01  $\pm$  0.12 and 2.78  $\pm$  0.09 g, respectively) than those from treated sample plots collectively.

# Discussion

Applications of herbicides initially resulted in suppression of the dominant overstory woody vegetation (blackjack oak and post oak) on the Cross Timber Experimental Range. However, suppression of woody vegetation was short-lived (5 years) from the inability to control other hardwood species (Stritzke et al. 1991). Herbaceous forage production (including forbs and grasses) increased following herbicide treatments and effects persisted through the study (Engle et al. 1991). Prescribed burning following herbicide application had little effects on grass and forb production compared with unburned herbicide plots (Engle et al. 1991). Mechanical removal of woody vegetation resulted in the complete removal of woody vegetation followed by a high forb density relative to grasses.

Previous studies indicated that prescribed burning and herbicide application may increase quail densities and body condition by increasing feeding areas, nesting cover, and forb biomass; however, our data suggest that these brush management techniques did not alter, in a long-term sense, the nutritional condition of bobwhites in the Cross Timber ecosystem. Despite alterations in the structure and composition of vegetation immediately following brush management, long-term benefits as measured by several body condition indices were not evident in bobwhites collected from treatment sample plots. Slightly larger body weights, liver weights, and gizzard fat (relative) weights of quail on untreated sample plots compared with those subjected to the mechanical treatment suggested that brush management treatments may have even decreased body condition to birds over the long-term. Because herbaceous forage production was greater on brushtreated plots than on untreated sample plots, we suggest that nutrient composition of vegetation, forage cover, and forage efficiency perhaps differed among study sites as well.

Body condition of birds traditionally has been assessed through composition measures such as the amount of protein and fat reserves (Robel 1972, Kirkpatrick 1980, DuBowy 1985, Sears 1988). Two studies indicated a significant positive relation between body weight and percent body fat (Dabney and Dimmick 1977, Koerth 1988), which also was documented by this study. We found >50% difference in percent body fat and gizzard fat weight from winter to spring, which supported findings of Koerth and Guthery (1987). Seasonal changes in percent body fat and gizzard fat weight undoubtedly reflected changes in dietary intake levels. During

winter quail relied heavily on seeds such as common sunflower (Helianthus annuus) and western ragweed (Ambrosia psilostachia), which are high in fat and low in useable protein, to meet their dietary requirements (Peoples 1992); however, in spring and fall they consume large quantities of insects, which are lower in fat and higher in protein (Hurst 1972, Peoples 1992). Body protein also was higher during spring and fall.

Dynamics in the size of the gizzard among collection times in this study were pronounced. Gizzard weight was greatest for birds collected in winter compared with spring and fall, probably in response to seasonal changes in feeding strategies (Peoples 1992). Depressed gizzard weights during the prebreeding and breeding period (spring and fall) may reflect increase in the availability of foods, such as insects and water-softened seeds (Anderson 1972, DuBowy 1985), which resulted in atrophy of the gizzard. Relative organ weights of the digestive system are greatest in birds during rapid body growth (14 weeks) because of increased food consumption and digestive activity (Kirkpatrick 1944), which may explain why relative gizzard weight was elevated in quail collected in fall.

The liver also changes size with altered nutritional states, reflecting physiological adaptation to changes in circulating nutrient levels (Anderson 1972, Pendergast and Boag 1973). Increased liver weight of quail during spring, compared with winter, was probably a response to increased dietary protein and estrogen and secretion in hens, which is at maximum levels at this time (Anderson 1972). Estrogen promotes accumulation of fat and protein in the liver (Common et al. 1948, Ljunggren 1968).

Although we found significant seasonal differences in body condition indices, we concluded that with regard to body condition, northern bobwhites derived no long-term benefits from the vegetative changes from brush management programs in the Cross Timbers area of central Oklahoma.

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