PREFERENCE AND NUTRITION OF QUAIL BREEDER 16™, COMMON AGRICULTURAL FEEDS, AND A MIX OF NATIVE SEEDS AS NORTHERN BOBWHITE FOOD

Jon A. Larson[1]
Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, TX 78363, USA

Timothy E. Fulbright
Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, TX 78363, USA

Leonard A. Brennan
Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, TX 78363, USA

Fidel Hernández
Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, TX 78363, USA

Fred C. Bryant
Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, TX 78363, USA

ABSTRACT

Agricultural feeds are commonly dispersed along roads or in openings as an attractant or dietary supplement for northern bobwhites (*Colinus virginianus*). Quail Breeder 16™ is a pelletized ration specifically developed by Lyssy & Eckel Feeds for breeding bobwhites to maximize nutritive content of diets. Captive bobwhites were used to examine relative preference of the pellets, sorghum, corn, soybean, and a mix of seeds of 8 native plant species. Protein, fat, acid detergent fiber, gross energy, and mineral content of the feeds were measured and we examined changes in body mass of bobwhites fed exclusive diets of each of the five feeds. A Latin rectangle experimental design with single and multiple-offer treatments was used to compare feed preference. Sorghum was most highly preferred in both the single and multiple offering experiments. Soybeans and the pelletized ration were least preferred. The native seed mix and corn were intermediate in preference. Nutritionally, soybeans had the highest protein (40%), highest fat (19%), and highest gross energy (21 kJ/g). Bobwhites fed exclusive diets of the native seed mix exhibited the greatest increase in body mass (40%), and birds fed the sorghum diet had the greatest decrease in body mass (–8%). Providing supplements (pelletized rations and agricultural feeds) should not take precedence over managing bobwhite habitat to produce a variety of native grasses and forbs when improving bobwhite nutrition is a management objective.

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Key words: *Colinus virginianus*, Latin rectangle, northern bobwhite, nutrition, Quail Breeder 16™, relative preference, supplement

INTRODUCTION

Many landowners and wildlife managers use commercially available foodstuffs as a nutritional supplement or to attract northern bobwhites (Doerr 1988, Guthery et al. 2004). This practice is widespread in Texas (Guthery et al. 2004). The concept behind supplemental feeding via feeding stations or scattered seeds and pellets is to provide a food source additional to the natural foods available to bobwhites. The objective of supplemental feeding is often to increase survival or reproduction, thus increasing bobwhite density via improved body condition (Doerr 1988). Dispersing feed along roadsides or in openings to attract bobwhites also is used with the goal of concentrating and making locating bobwhites easier, thus providing hunters with more opportunities for harvest (Guthery et al. 2004).

Supplemental feeding may be advantageous as a management tool when food is limiting. Survival rates of bobwhites in western Oklahoma were greater (6-fold and 2-fold, respectively, for 1992–1993 and 1993–1994) in areas with supplemental feeders than in areas without supplemental feeders during 2 winters (Townsend et al. 1999). Population densities were also greater for bobwhites (fed sites averaged 3.8 ha less/bird than unfed sites) in Florida offered supplemental feed when natural food supplies were limiting (Frye 1954). Bobwhite hen survival (8% greater), chick production (0.2 more hatches/

[1] *dlarson79@hotmail.com*

hen), and fall densities (1.7 more birds/ha) were greater on sites with supplemental food than sites without feed from 2001 through 2006 in southwest Georgia and northwest Florida (W. E. Palmer, Tall Timbers Research Station, unpublished data). Supplemental feeding may be effective during periods of limited food availability, such as during drought or colder months, in increasing survival of bobwhites (Frye 1954, Townsend et al. 1999, Doerr and Silvy 2002). However, results of other studies (Kane 1988, DeMaso et al. 2002) in Texas have shown no increase in abundance of bobwhites with access to supplemental feed, and supplemental feeding had little or no effect on survival or abundance.

Quail Breeder 16™ is a pelletized feed developed by Lyssy & Eckel Feeds (Poth, TX, USA) to provide breeding bobwhites (i.e., laying hens) with supplemental nutrition to maximize reproduction. Our objectives were to examine: (1) relative use of Quail Breeder 16™ compared to other common supplemental feeds and a mix of native forb and grass seeds, (2) nutritional quality of Quail Breeder 16™ compared to other common supplemental feeds and a mix of native forb and grass seeds, and (3) temporal changes in body mass of hatchery-produced bobwhites fed exclusive diets of Quail Breeder 16™, other common supplemental feeds, and a mix of native forb and grass seeds.

STUDY AREA

The research was conducted in the Duane M. Leach Research Aviary at the Tio and Janell Kleberg Wildlife Research Park, Texas A&M University-Kingsville, Texas, USA.

METHODS

Pre-experimental Period

We selected five feed types (treatments) for this experiment: whole corn, sorghum, soybeans, Quail Breeder 16™, and a mixture of native forb and grass seeds. The native mix was comprised of seeds of pigweed (*Amaranthus palmeri*), common sunflower (*Helianthus annuus*), wooly croton (*Croton capitatus*), partridge pea (*Chamaecrista fasciculata*), red prickly poppy (*Argemone sanguinea*), switchgrass, (*Panicum virgatum*), plains bristlegrass (*Setaria leucopila*), and Texas signaltop (*Urochloa texana*). We selected these species because they are commonly eaten by bobwhites in southern Texas (Lehmann and Ward 1941, Campbell-Kissock et al. 1985, Wood 1985, Larson et al. 2010) and were commercially available. These seeds were mixed at a rate of 3:1 forb to grass seeds (Fig. 1).

We purchased 125 adult bobwhites from a privately-owned hatchery in San Antonio, Texas, USA. Hatchery-produced birds, fed only commercial diets, were used so there was no prior exposure to any of the feeds used in the experiment (Barras et al. 1996). Each bird was weighed, banded with tarsal leg bands, and housed communally in groups of 10–12 by gender. We provided the birds with a commercial, pelletized upland gamebird feed *ad libitum* for 4 weeks before the first feeding trial (Barras et al. 1996). Fresh water and grit were provided *ad libitum* during the pre-experimental period. All protocols for this research were approved by the Texas A&M University-Kingsville Animal Care and Use Committee (# 2007-10-26).

We randomly selected 30 of the 125 bobwhites (15 males and 15 females) for the feeding trials and randomly selected 6 (3 males and 3 females) of those 30 birds for each of 5 experimental groups. We measured and recorded body mass of each bobwhite before assigning them to pens. Birds were housed individually in $1.5 \times 1.8 \times 2.1$-m pens, alternating male and female by pen, and consecutively by pen, according to group assignment. Pens were cleaned daily and disinfected with a bleach solution weekly.

Experimental Period

Feed Preference.—We used a Latin rectangle design for each of 3 blocks (repetitions in time) in which each group of 6 birds experienced each treatment once in each block (Barras et al. 1996). We provided each of 5 groups of bobwhites with 5 randomly assigned, single-offering treatments (5 diets $\times$ 5 groups of bobwhites $\times$ 3 24-hr repetitions in time) and 5 randomly assigned, multiple-offering treatments once for each block (5 combinations of 4 feeds $\times$ 5 groups of bobwhites $\times$ 3 repetitions in time). Single-offering treatments consisted of 25 g of 1 feed type. The subsequent multiple-offering treatment was comprised of 25 g of each of the 4 feed types not offered during the previous single-offering treatment. We placed each of the food containers used during the multiple-offerings in the pens spaced evenly apart to provide unhindered availability and access from all sides of the container.

We alternated single and multiple-offerings daily (24 hrs). Maintenance rations to prevent malnutrition were provided to all groups upon collection of multiple-offerings for 24 hrs, after which the next treatment was provided. Each group received a different treatment during each trial (24-hr feeding period). We provided feed in $3.5 \times 12.5 \times 12.5$-cm plastic containers. We offered treatments at 0700 hrs during each feeding period. We collected all remaining feed after 24 hrs elapsed from the time feed was provided and stored it for reweighing. Subsequent treatments were offered immediately following the collection. The feed that was collected after treatment offerings was reweighed and differences from the original mass were recorded, providing the amount consumed. We weighed each bird weekly to monitor body mass and to protect against malnutrition (Barras et al. 1996). Any loose bird waste was collected and removed during collection of feed. The floors of each pen were cleaned with water and a mild bleach solution during collection times every 7 days from the start of the feeding trials.

A graduated cylinder (mL), fine sand, and feeds provided in the experiment were used to convert mass of seed to volumes (Inglis and Barstow 1960). We weighed

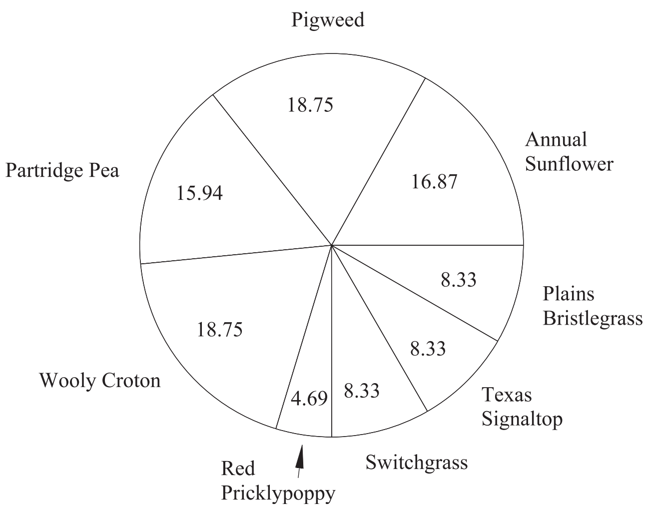

Fig. 1. Percentage of each seed species by mass (g) in a native seed mix fed during northern bobwhite feeding preference trials.

10 samples of each feed to obtain samples of 1 g each to calculate means for the 10 sample volumes of each feed to calculate average volume for 1 g of each species. The graduated cylinder was filled with 10 mL of sand and a 1-g sample of feed was placed in the graduated cylinder. The sand and feed were thoroughly mixed to ensure the sand occupied all interstitial space. The difference between the total volume of the sand and feed mixture and the initial 10 mL of sand was recorded. We repeated this process 9 times for a total of 10 volumes for each feed. We converted the mass of feed consumed in each feeding trial using the corresponding 1-g conversion factors and statistically compared volumes consumed. Volumes are expressed as cubic centimeters (cc) (1 mL = 1 cc).

We analyzed data with a repeated measures analysis of variance using the PROC MIXED procedure in SAS Version 9.1 (SAS Institute 2006). The dependent variable was daily consumption of food (g and cc) and the independent variable was diet (single feed or combinations of seeds of 4 feeds). Diet was the fixed factor and the birds were random factors. Tukey's Studentized Range (HSD) test was used to compare consumption means (SAS Institute 2006).

We measured gross energy, fat content, protein, and acid detergent fiber (ADF) for each feed. We randomly selected 25 subsamples (5 g) of feed from each source (bag) and thoroughly mixed each one. We ground the subsamples from each feed and thoroughly mixed the ground contents. We randomly took subsamples (5 g) of the mixed, ground contents until we had 50 g of each feed and then oven-dried the samples for the assays. Duplicates for each feed were tested in each assay and the mean was used. Gross energy of each feed was obtained using a Parr oxygen bomb calorimeter (Parr Instrument Company, Moline, IL, USA). Fat content was measured using an ANKOM XT10 Extractor© (Ankom 2010). Protein and mineral content (Appendix) were measured by the Soil, Water, and Forage Testing Laboratory of the Department of Soil and Crop Sciences of the Texas AgriLife Extension Service in College Station, Texas, USA (Soil, Water, and Forage Testing Laboratory 2010). Acid detergent fiber (ADF) was measured following Goering and Van Soest (1970). Inferences regarding chemical composition of each feed are limited to those feeds used in this study because only one source of each feed was used.

Body Mass Change.—We examined body mass changes of birds fed exclusive diets of each feed type after preference trials were completed. We randomly selected 60 birds, 30 males and 30 females, not used in the previous preference trials for use in this experiment. We randomly assigned 2 birds of the same gender to each of 30 pens and weighed each bird before pen assignment. We randomly assigned each pen with a feed type so there were 6 pens assigned to each of the 5 treatments. Each pen received the assigned diet twice daily. The first portion was provided *ad libitum* at 0700 hrs and removed at 0900 hrs. The second portion was provided *ad libitum* at 1700 hrs and removed at 1900 hrs. We provided fresh water *ad libitum* daily. We weighed each bird every third day after the start of the feeding, until 12 masses were recorded for each bird. We calculated percent difference in mass from the previous mass recorded for each bird. Number of eggs laid by each treatment group was recorded.

We analyzed body mass change data with analysis of variance using the PROC MIXED procedure in SAS Version 9.1 (SAS Institute 2006). The dependent variable in analyses was overall body mass change and the independent variable was diet. Tukey's Studentized Range (HSD) test was used to compare treatment means (SAS Institute 2006).

RESULTS

Relative Preference of Agricultural Feeds Based on Mass

Sorghum was the most highly consumed feed for the single and multiple offering experiments, based on mass, with 81 and 193% greater consumption, respectively for single and multiple offering experiments, than the second most consumed feed, the native seed mix (Figs. 2, 3). Consumption of sorghum was 109% greater than corn consumption, 149% greater than Quail Breeder 16™ consumption, and 373% greater than soybean consumption for single-offering experiments. Quail Breeder 16™ and soybeans were the least consumed feeds while native mix and corn were intermediate in consumption; mean consumption of these 2 feeds was similar for single-offering experiments. Consumption of sorghum was 285% greater than corn consumption, and >1,000% greater than Quail Breeder 16™ and soybean consumption for multiple-offering experiments. Quail Breeder 16™ and soybeans were the least consumed feeds, while native mix and corn were intermediate in consumption; mean consumption of these 2 feeds was similar for multiple-offering experiments.

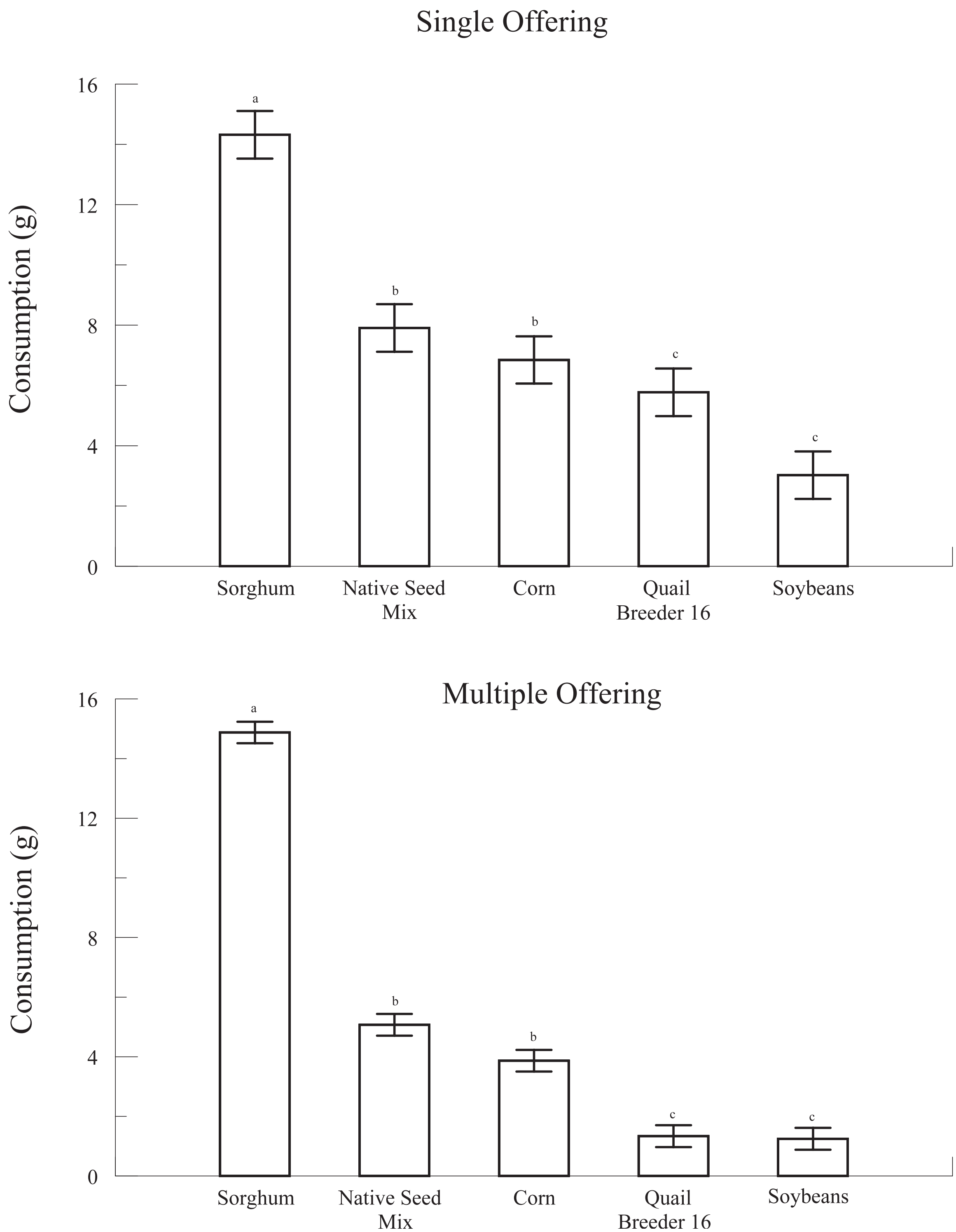

Fig. 2. Mass (g) (mean ± 95% confidence intervals) of sorghum, native mix, corn, Quail Breeder 16™, and soybeans eaten by 30 northern bobwhites during 3 single (top) and 3 multiple-offering (bottom) feeding trial periods between 26 November 2007 and 8 January 2008, Kingsville, Texas, USA. Means with unlike letters differ ($P \leq 0.05$) based on Tukey's test.

Relative Preference of Agricultural Feeds Based on Volume

Sorghum and native mix were the most highly consumed feeds when comparing diets based on volume for single-offering experiments, while soybeans were least consumed (Figs. 4, 5). Consumption of the native mix was 57% greater than Quail Breeder 16™, 66% greater than corn, and 329% greater than soybeans for single-offering experiments. Quail Breeder 16™ and corn were intermediate in consumption and mean consump-

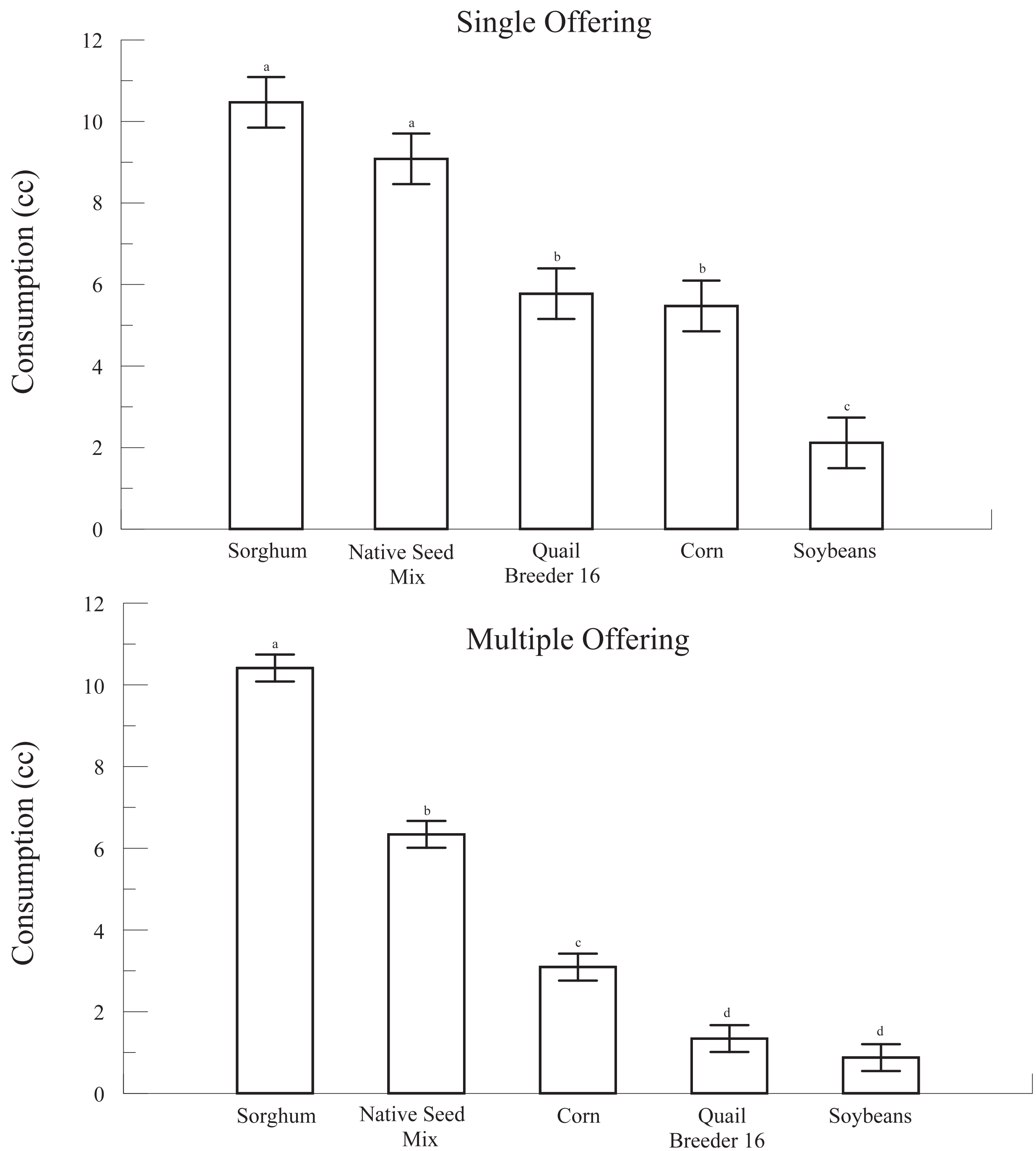

Fig. 3. Volume (cc) (mean ± 95% confidence intervals) of sorghum, native mix, corn, Quail Breeder 16™, and soybeans eaten by 30 northern bobwhites during 3 single (top) and 3 multiple-offering (bottom) feeding trial periods between 26 November 2007 and 8 January 2008, Kingsville, Texas, USA. Means with unlike letters differ ($P \leq 0.05$) based on Tukey's test.

tion of these species was similar for single-offering experiments. Sorghum was the most highly consumed feed when comparing diets based on volume for multiple-offering experiments. Consumption of sorghum was 64% greater than native mix, 237% greater than corn, 677% greater than Quail Breeder 16™, and 1,089% greater than soybeans for multiple-offering experiments. Native mix and corn were intermediate in consumption, and soybeans and Quail Breeder 16™ were least consumed feeds.

Nutritional Quality of Diets

Protein ranged from 8% in corn to 40% in soybeans (Table 1). Fat content ranged from 9% in Quail Breeder 16™ to 19% in soybeans. ADF ranged from 24% in soybeans to 29% in the native seed mix. Gross energy

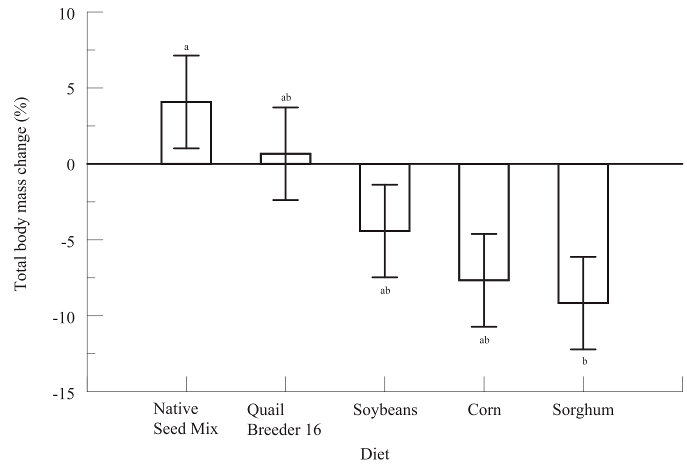

Fig. 4. Mean total body mass change (%) of 60 northern bobwhites fed exclusive diets of corn, soybeans, sorghum, a native seed mix, and Quail Breeder 16™ from 1 March to 3 April 2008, Kingsville, Texas, USA. Means with the same letter did not differ ($P \leq 0.05$) based on Tukey's test.

ranged from 14.9 kJ/g in Quail Breeder 16™ to 21 kJ/g in soybeans.

Body Mass Changes of Bobwhites Fed Exclusive Diets and Eggs Laid

Only mean body mass change for the native seed mix and sorghum differed significantly (Fig. 4). Body mass changes for bobwhites offered each treatment followed similar trends (Fig. 5). Body mass of birds in all treatments initially decreased, but increased by the second week after the experiment was initiated. Body mass then decreased but continued to increase after the third week of the experiment. Bobwhites fed exclusive diets of the native seed mix and the Quail Breeder 16™ increased in body mass compared to the first weighing period. Bobwhites fed exclusive diets of corn, sorghum, and soybeans weighed less overall than at the first weighing period. Fifteen eggs were laid for all diet treatment groups combined. Birds fed Quail Breeder 16™ laid 7 eggs while those fed the native mix laid 0. Birds fed soybeans, corn, and sorghum laid 3, 3, and 2 eggs, respectively.

DISCUSSION

Quail Breeder 16™ pellets were low to moderate in diet preference based on consumption. Lower relative preference of Quail Breeder 16™ may be explained, in part, based on its nutrient content if bobwhites in our study selected Quail Breeder 16™ to meet their nutritional requirements. Nonbreeding adult bobwhites need to consume about 250 kJ/day of metabolizable energy (ME) (Case and Robel 1974) and 11–12% protein (Nestler

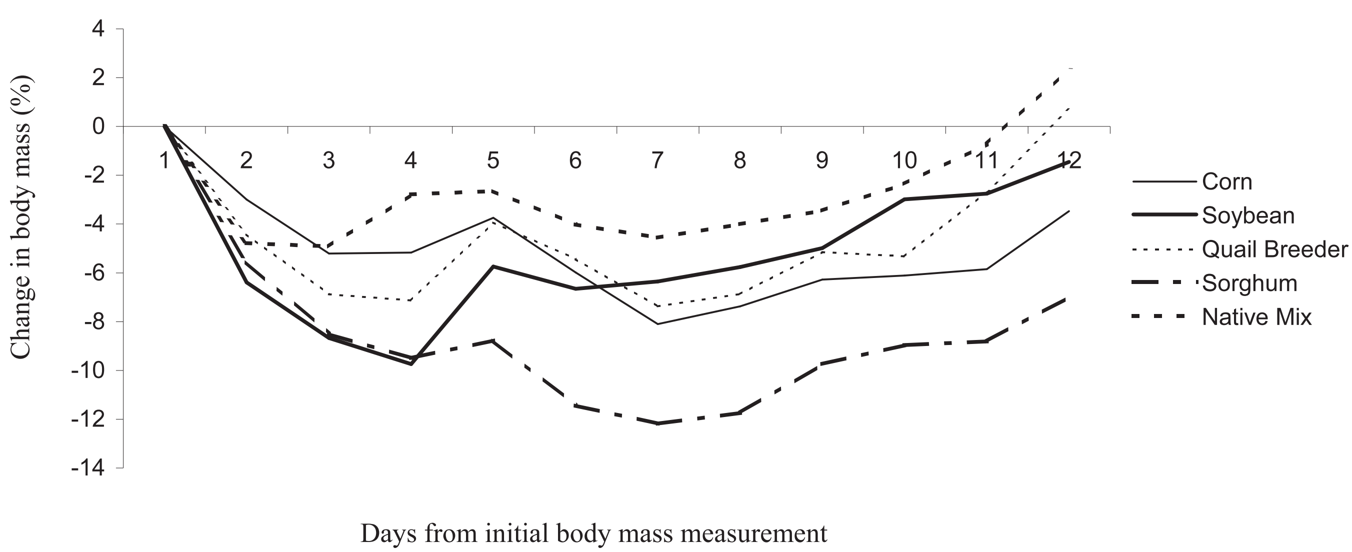

Fig. 5. Mean body mass change (%) over time for 5 groups of 12 northern bobwhites fed exclusive diets of corn, soybeans, sorghum, a native seed mix, and Quail Breeder 16™ from 1 March to 3 April 2008, Kingsville, Texas, USA.

Table 1. Protein, fat, acid detergent fiber (ADF), and gross energy for sorghum, corn, a native seed mix, soybeans, and Quail Breeder 16™.

Diet	Protein (%)	Fat (%)	ADF (%)	Gross energy (kJ/g)
Sorghum	10	11	27	16.32
Corn	8	12	26	16.74
Native seed mix	22	11	29	19.83
Soybeans	40	19	24	21.00
Quail Breeder 16™	18	9	25	14.89

1949) at 15 °C. Quail Breeder 16™ meets this protein demand, but contains the lowest gross energy value of all diets offered. A bobwhite would need to consume ~ 17 g/day of Quail Breeder 16™ even if all of the gross energy of Quail Breeder 16™ could be metabolized. Quail Breeder 16™ had the lowest gross energy and bobwhites likely consumed some other feed types in greater quantity to meet energy demands.

Bobwhite preferences for the other feeds in our experiment may be explained in part by their nutrient content. Soybeans were least preferred, based on consumption, but overall had the highest protein, fat, and gross energy. Bobwhites assimilated only 45% of energy consumed in soybeans in previous feeding trials (Robel and Arruda 1986). Bobwhites in the same study assimilated nearly 85% of energy consumed from sorghum. Similarly, bobwhites assimilated 86% of energy consumed from sorghum and 68% of energy consumed from soybeans (Robel et al. 1979). Metabolic efficiency (ME) was greater for sorghum than soybeans, but ME was greater in soybeans because gross energy was greater in soybeans (Robel et al 1979, Madison and Robel 2001). Bobwhites consumed more sorghum than soybeans (9%) in a similar study (Madison and Robel 2001). If bobwhites also exhibited greater metabolic efficiency consuming sorghum than soybeans in our study, it may explain why sorghum consumption was greater than soybean consumption based on mass for multiple-offerings.

The native seed mix was also relatively nutritious, but contained the greatest ADF. Perhaps more energy was needed to soften the native seed mix while in the crop than with other feeds, requiring bobwhites to consume more of it to meet energy demands. The relatively low nutritional value of corn may be a reason why consumption of this feed type was low to moderate, because bobwhites may have needed to consume more corn than other diets to meet energy requirements.

Palatability and relative size of each feed type may also affect preference. Sorghum was the most highly preferred food by bobwhites of 53 different foods (Michael and Beckwith 1955). The authors indicate that differences in palatability are important in food selection and olfactory senses of bobwhites aid in detecting palatability. Short-billed (mean bill length < 9.6 mm) species of North American sparrows (*Melospiza georgiana*, *Spizella arborea*, and *S. pusilla*) consumed more small seeds than large seeds (Willson 1971). All species (*Cardinalis cardinalis, Passerella iliaca, Melospiza melodia, M. georgiana, Zonotrichia albicollis, Junco hyemalis, Spizella arborea,* and *S. pusilla*) studied (mean bill length up to 14.2 mm) selected mostly small seeds (Willson 1971). Bobwhites 17 months of age and older have bill lengths ranging from 7.4 to 9.2 mm (Thompson and Robel 1968). The relatively large size of soybeans, corn, and Quail Breeder 16™ compared to sorghum and the native seed mix, may have caused bobwhites to choose diets comprised of smaller seeds. Sorghum seeds were larger than most of the seeds in the native mix, yet generally smaller than those of the other diets, resulting in a higher rate of intake efficiency.

Two parts of this study addressed the nutritional aspect of feed types used in the preference studies. First were laboratory analyses of nutrition, and second was the experiment in body mass change. Changes in body mass of bobwhites fed exclusive diets are likely due to the nutritional characteristics of each diet. Bobwhites fed the native seed mix and Quail Breeder 16™ exhibited an overall increase in body mass, while bobwhites fed sorghum exhibited the greatest overall decrease in body mass at the end of the study period. The native seed mix and Quail Breeder 16™ were the most nutritious diets based on our laboratory analyses. Birds offered the relatively low in nutrition corn and sorghum diets had the highest decreases in body mass. Factors other than nutrition that could have affected body mass changes include competition within pens, differing stress levels of birds, pen location, and initial overall health of birds studied. However, bobwhites were limited to 2 birds per pen and all birds used were in good initial general body condition to reduce potential variability of mass changes due to these other factors.

Our findings that soybeans, corn, and sorghum produced negative body mass changes at the conclusion of our study are consistent with previous research. Bobwhites fed exclusive diets of soybeans (Robel and Arruda 1986, Madison and Robel 2001), and corn and sorghum (Michael and Beckwith 1955) also had an overall decrease in body mass. An exclusive sorghum diet fed to bobwhites (Robel and Arruda 1986) resulted in an overall positive change in body mass, although it was only a 1-g increase over a 3-day period for 5 birds. Corn and grain sorghum are the most commonly supplemented feeds in south Texas for bobwhites (Brennan 2007:291), but these feeds do not possess adequate calcium, protein, or phosphorus for laying hens (Guthery 1986:53).

Female bobwhites fed only Quail Breeder 16™ laid 7 eggs during the 34-day body mass change study, which was 1 fewer than all other diets combined. This suggests Quail Breeder 16™ provides ample nutrition for the laying requirements of bobwhite hens in captivity. Egg production and differences in egg production among treatments may have been due, at least in part, to captivity bias (Lambrechts et al. 1999). Bobwhites fed only Quail Breeder 16™ had an overall increase in mass by the end of the 34-day mass change study, even with the increased energy demands of egg production for those hens that laid eggs. Hen bobwhites were likely carrying some of these eggs during weighing intervals, and body mass changes due to increased energy demands for egg production may be partially offset by the increased body mass due to the eggs. Female bobwhites fed soybeans, corn, and sorghum also laid at least 2 eggs per treatment group, and changes in body mass may have also been due to additional mass of eggs in these birds when weighed. Fresh mass of bobwhite eggs range from 8.2 to 8.8 g (Case and Robel 1974). Ovary mass in bobwhites can also increase during reproduction and has been shown to be affected by protein and energy in diets (Giuliano et al. 1996). Mean ovary mass for female bobwhites fed a high quality diet was 3% of total body mass (Giuliano et al. 1996). The effect on body mass could be significant for a 167-g hen with a 5-g ovary and an egg just prior to laying.

MANAGEMENT IMPLICATIONS

Providing Quail Breeder 16™ to supplement bobwhite nutrition when food availability is limiting could potentially increase reproduction in wild bobwhites, if they consume it in the wild. Corn, sorghum, and the native seed mix were generally more highly preferred than Quail Breeder 16™ in our study, but quail may select Quail Breeder 16™ in the wild to acquire minerals not highly available in the other 2 feeds and native food sources. Only 8 species of seeds were used in the native seed mix, whereas south Texas habitats have a greater variety of species of seed producing plants for bobwhites (Wood 1985). Bobwhites may be able to acquire nutrients or minerals lacking in the 8 native seeds used in these trials with a greater variety of foods available in the wild. Managing landscapes in South Texas to produce diverse native plant communities that provide bobwhites with ample nutritious food sources as well as the nesting, loafing, and protective cover they require, should take priority over providing supplemental feeding.

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APPENDIX. Mineral content (% and micrograms per milliliter [ug/ml]) of soybeans, sorghum, corn, Quail Breeder 16™, and a native seed mix used in a supplemental feed preference study with northern bobwhites.

Diet	Phosphorus (%)	Potassium (%)	Calcium (%)	Magnesium (%)	Sodium (ug/ml)	Zinc (ug/ml)	Iron (ug/ml)	Copper (ug/ml)	Manganese (ug/ml)
Soybeans	0.76	1.82	0.22	0.24	1,123	53	75	10	31
Sorghum	0.33	0.37	0.05	0.15	1,004	26	49	3	24
Corn	0.27	0.39	0.04	0.09	996	21	36	3	16
Quail Breeder 16™	0.77	0.87	4.04	0.18	2,264	128	94	22	208
Native seed mix	0.45	0.62	0.4	0.27	1,139	52	66	11	59