AN ABSTRACT OF THE THESIS OF

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Title: BIOENERGETICS OF WINTERING GREATER PRAIRIE-CHICKENS

Abstract approved: Edward C. Rowe

The purpose of this study was to determine how efficiently greater prairie-chickens (*Tympanuchus cupido pinnatus*) would utilize ten different seeds, three different commercial feeds and western wheat grass under simulated winter conditions. The ten seeds were sunflower (*Helianthus* sp.), Blackwell switchgrass (*Panicum virgatum*), soybean (*Glycine max*), pearlmillet pennisetum (*Pennisetum glaucum*), amaranth (*Amaranthus hypochondriacus*), buckbrush (*Symphoricarpos orbiculatus*), milo (*Sorghum vulgare*), corn (*Zea mays*), wheat (*Triticum* spp.) and Korean lespedeza (*Lespedeza stipulacea*). The three commercial feeds were Cole soy pellets, Purina chick starter/grower and a maintenance mix. Using variables of body weight change, assimilated energy and energy utilization efficiency, individual seed diets were classified as extremely poor, very poor, poor, or good to excellent energy sources for wintering prairie-chickens. Western wheat grass and buckbrush were rated extremely poor and very poor, respectively, while Blackwell switchgrass and amaranth were rated poor energy sources for wintering prairie-chickens. Korean lespedeza, soybean, pearlmillet pennisetum, wheat, sunflower, corn and sorghum were rated good to excellent energy sources for wintering greater prairie-chickens.

BIOENERGETICS OF WINTERING GREATER PRAIRIE-CHICKENS

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the Division of Biological Sciences

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by

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INTRODUCTION

The environmental conditions of winter are known to be a period of high stress for game and nongame avian species. These stresses have been shown to create losses in weight and fat reserves, which result in a greater mortality by game birds such as quail during late winter (Robel 1965, 1969, 1972; Robel et al. 1974; Robel and Fretwell 1970; Case 1982). It has been suggested that an increase in the winter supply of easily assimilated food would increase the survival of quail and other game birds during the extremes of winter weather (Robel et al. 1979*a*,*b*). How well a specific food is being assimilated by an animal can best be determined through a study of bioenergetics. Bioenergetics is the science, or means, of determining the amount of energy that is obtained from a food source by an animal (Saunders and Parrish 1987).

Knowledge of the bioenergetics of avian species has long been considered essential information for the management of game and nongame birds (Kendeigh 1934; Hart 1957). Early research utilized nongame birds to demonstrate the importance of studying bioenergetics in avian management (Kendeigh 1949; West 1960; Zimmerman 1965; Kontogiannis 1968; Martin 1968). Techniques introduced in these studies have been applied in studying the bioenergetics of various game birds such as ring-necked pheasants, *Phasianus colchicus* (Breitenbach et al. 1963; Solomon 1986); California quail, *Callipepla californica* (Brush 1965); willow ptarmigan, *Lagopus lagopus*

(West 1968); northern bobwhites, Colinus virginianus (Case 1973; Case and Robel 1974; Robel et al. 1979a; Robel and Arruda 1986); Canada geese, Branta canadensis (Williams and Kendeigh 1982); capercallies, Tetrao urogallus (Linden 1984), and scaled quail, Callipepla squamata (Saunders and Parrish 1987).

Although several studies of food utilization have been performed on several other Phasianids, none had been carried out on the greater prairie-chicken, Tympanuchus cupido pinnatus (Johnsgard 1983), a popular Kansas game bird. The present study measured the ability of the greater prairie-chicken to assimilate fourteen different diets under the simulated photoperiod and temperature conditions of Kansas winters. These diets included some seeds which are known to be eaten by greater prairie-chickens in their natural habitat (Martin et al. 1951; Baker 1953; Korschgen 1962; Horak 1985). These data will provide information helpful in making food sources available for populations of wintering greater prairie-chickens throughout their ranges in Colorado, North and South Dakota, Nebraska, Kansas, Oklahoma, Minnesota, Iowa, Missouri and Illinois. This study has the additional possibility of serving as a model for research on the bioenergetics of the lesser prairie-chicken (Tympanuchus pallidicinctus) and the sharp-tailed grouse (Tympanuchus phasianellus), two other members of the grouse family that are closely related to greater prairie-chickens.

MATERIALS AND METHODS

Seventeen greater prairie-chickens were utilized during this investigation. Nine of the birds were trapped on a lek near Reading, Kansas, during November, 1987 and eight were provided by Clifford Steinhauer, RR2, Box 141A, Thief River Falls, Minnesota. Each bird was housed in an individual 61 cm X 61 cm X 91.4 cm (24" X 24" X 36") wire cage obtained from Bass Equipment Co., Monett, Missouri (Appendix 1). To prevent self-inflicted injury to the birds, the top and sides of each cage were lined with standard fiberglass window screen (Parrish and Saunders 1989). During all nontesting periods the prairie-chickens were maintained on a diet of approximately 50 percent Purina game bird startena and 50 percent Cole soybean pellets. This "maintenance mix" provided approximately 35 percent total crude protein.

Throughout the study all birds were kept under a constant photoperiod of 10L:14D and temperature range of 1 to 5 C. Feeding trials for each diet consisted of two consecutive, 2-day trials carried out on six birds. Two days before the start of each feeding trial the feed to be tested and the maintenance diet were mixed approximately 1:1. This allowed each bird to become familiar with the test feed prior to the feeding trials.

At the start of each 2-day trial heavy duty aluminum foil was weighed and placed below the wire floor of each cage to collect excreta and spilled feed. To assure that none of the feed was consumed before weighing took place, all feed was removed the night before the initial weighing. Each bird was weighed to the nearest 0.5 gram at the beginning and end of each 2-day trial and the weight change determined by subtraction. The birds were weighed at approximately the same time each morning to obtain consistent data (Kontogiannis 1967). Each trial began and ended with either six Kansas or six Minnesota prairie-chickens. Feeding trials were discontinued for individual birds if body weight loss exceeded 10 percent of pre-trial stabilized weight.

The ten seed diets tested were oil type sunflower chips (Helianthus sp.), obtained from Hanson Kimmal Fertilizer Service, Emporia, KS; Blackwell switchgrass (Panicum virgatum), obtained from Sharp Brothers Seed Co., Healy, KS; soybean (Glycine max), donated by Bunge Corp., Emporia, KS; pearlmillet pennisetum (Pennisetum glaucum) and amaranth (Amaranthus hypochondriacus), supplied by the Kansas State University Experiment Station, Hays, KS; buckbrush (Symphoricarpos orbiculatus), supplied by the Kansas Department of Wildlife & Parks, Emporia, KS; and milo (Sorghum vulgare), corn (Zea mays), wheat (Triticum spp.) and Korean lespedeza (Lespedeza stipulacea), obtained from Emporia Elevator, Emporia, KS. The three commercial diets tested were Purina chick starter/grower; Cole soy pellets, donated by Hanson Kimmal Fertilizer Service, Emporia, KS; and the maintenance mix previously described. A feeding trial with western wheat grass (Agropyron smithii) was discontinued when the test birds lost more than 10 percent of their body weight during the first 2-day trial. All diets, along with water and grit, composed of a 1:1 mix of oyster shell (Pilot Brand) and crushed granite (North Carolina Granite Corp.), were provided ad libitum during each trial and maintenance period. The Kansas birds were fed Korean lespedeza, sorghum, corn, milo, wheat, Cole soy pellets and the maintenance mix, while Minnesota birds were fed Blackwell switchgrass, amaranth, pearlmillet pennisetum, sunflower, buckbrush, Purina chick starter/grower and the maintenance mix.

Data were recorded on a standard form for each bird and each diet (Appendix 2). At the end of each 2-day trial, excreta and spilled feed were collected, separated and weighed to the nearest 0.1 gram. The collected feed and excreta were then dried at 90 C for five days. After drying, samples were reweighed to the nearest 0.1 gram to determine the moisture content. Immediately before caloric analysis, dried feed and dried excreta samples were separately ground with a mortar and pestle, brushed through a 0.058 cm (0.023 inch) mesh screen and weighed to the nearest 0.1 mg. Caloric analyses were performed in a Parr (Model 1351) oxygen bomb calorimeter. Duplicate analyses were performed on all feed and excreta samples. When the caloric content of duplicate excreta samples varied by more than five per cent, a third sample was analyzed and substituted for the extreme sample.

A computer spread-sheet program (Reflex 1985) was used in calculating the caloric values (Tables 2A,B,C,D and 3). Gross energy intake, GE = caloric content of the feed x grams consumed; excretory energy output, EE = caloric content of the excreta x grams excreted; assimilated energy, AE = GE - EE; and energy utilization efficiency, UE = (AE/GE) x 100, were all calculated using data obtained from the caloric analyses. Because there were no significant differences between the first and second 2-day trials for body weight change, food consumption and excreta production, data were combined and analyzed for the entire four days of feeding.

Statistical analyses were performed on a Zenith Z-150 microcomputer. The HOMOV test for homogeneity of variances was run on the raw data using the program BIOM-PC (Rohlf 1985). Comparison among the means was tested with a two-tiered nested analysis of variance using the program BIOSTAT 1 (Pimentel and Smith 1986). The range among all of the subsets of means was tested using the Student-Newman-Keuls Multiple Range Test (Zar 1984). The utilization efficiency values, expressed as percentages, were transformed to arc sine values for statistical analysis (Sokal and Rohlf 1981). Differences among the means were considered statistically significant when the calculated value was equal to or greater than the table value at the 0.05 level.

RESULTS

Body Weight Changes

Mean pre-trial body weights ranged from 930 to 1058 grams per bird (Table 1). Mean body weight changes per trial ranged from 104 grams lost for birds on a diet of buckbrush to 30.9 grams gained for birds fed Purina chick starter/grower (Table 1). Birds fed buckbrush exhibited significantly greater weight loss per trial than did birds fed all other diets. Birds fed Purina chick starter/grower, Cole soy pellets, pearlmillet pennisetum and maintenance mix showed significantly greater weight gain per trial than birds fed Blackwell switchgrass and buckbrush (Table 1).

Feed Consumption and Combustible Energy Content of Feed

The mean caloric content per gram of dried feed used in this study varied from 4.0 kcal for wheat to 6.6 kcal for sunflower (Tables 2A,B,C,D). The dry weight of feed consumed per day per bird ranged from 15.6 grams for birds fed amaranth (Table 2A) to 61.1 grams for birds on a diet of Purina chick starter/grower (Table 2D). Amaranth, buckbrush (Table 2A) and sunflower (Table 2C) were consumed in amounts significantly lower than all other diets. Purina chick starter/grower, Cole soy pellets and maintenance mix (Table 2D) were consumed in amounts significantly greater than any of the seed diets.

Table 1. Mean pre-trial body weights and weight changes, ± SEM, for greater prairie-chickens fed various diets (n=6 per diet). ($\bar{x}$'s in the same column followed by the same capital letter did not differ significantly [P > 0.05]).

Diet	Pre-trial weight (g)	Body weight change (g/trial)
Commercial diets:		
Purina chick starter/grower	964.4 ± 10.6 A	30.9 ± 5.7 C
Cole soy pellets	938.1 ± 9.7 A	26.2 ± 2.4 C
Maintenance mix	965.9 ± 6.3 A	25.2 ± 2.4 C
Seed diets:		
Pearlmillet pennisetum	930.0 ± 8.8 A	10.9 ± 2.8 C
Sunflower	956.2 ± 9.7 A	9.4 ± 2.3 BC
Corn	948.3 ± 5.5 A	8.9 ± 4.5 BC
Korean lespedeza	961.4 ± 6.0 A	3.5 ± 5.3 BC
Soybean	964.4 ± 7.8 A	- 2.5 ± 1.9 BC
Wheat	955.4 ± 5.7 A	- 3.5 ± 2.4 BC
Sorghum	960.4 ± 4.8 A	- 10.1 ± 1.0 BC
Amaranth	951.7 ± 10.6 A	- 24.4 ± 2.9 BC
Blackwell switchgrass	947.8 ± 7.1 A	- 32.4 ± 2.1 B
Buckbrush[a]	1058.0 ± 18.5 B	-104.0 ± 7.1 A

[a] Birds fed diet only one day; body weight changes extrapolated to two days.

Table 2A. Mean energetic values, ± SEM, for greater prairie-chickens fed buckbrush, Blackwell switchgrass and amaranth (n=6 per diet). ($\bar{x}$'s in same rows followed by same capital letters did not differ significantly [$P > 0.05$].)

Energetic variable	Buckbrush	Blackwell switchgrass	Amaranth
Consumption (grams/day)	18.5 DE ± 2.0	29.2 CD ± 1.2	15.6 E ± 1.5
CE[a] (kcal/gram)	4.6	4.4	4.5
GE[a] (kcal/bird/day)	84.8 BC ± 9.1	128.1 BCD ± 8.5	69.9 B ± 6.5
GE (kcal/gram body weight/day	0.083 B ±0.008	0.139 BC ±0.010	0.075 B ±0.007
Excrement (grams/day)	16.9 A ± 1.0	18.6 A ± 0.6	8.2 B ± 0.3
Excrement (kcal/gram)	3.49 ± 0.07	3.67 ± 0.07	3.56 ± 0.06
EE[a] (kcal/bird/day)	58.8 AC ± 2.5	68.1 AC ± 3.1	29.0 B ± 1.5
EE (kcal/gram) body weight/day)	0.059 AD ±0.003	0.074 ABD ±0.004	0.031 C ±0.002
AE[a] (kcal/bird/day)	26.0 E ± 8.4	60.0 BCE ± 6.3	40.9 CE ± 6.74
AE (kcal/gram body weight/day)	0.025 E ±0.008	0.065 BCE ±0.007	0.045 CE ±0.007
UE[a] (%)	18.7 B ± 10.15	42.0 AB ± 3.38	42.2 AB ± 9.4
Weight change (%)	- 9.8	- 3.4	- 2.6

[a] CE = combustible energy, GE = gross energy intake, EE = excretory energy loss, AE = assimilated energy (AE = GE - EE), and UE = energy utilization efficiency (UE = [AE/GE] X 100).

Table 2B. Mean energetic values, ± SEM, for greater prairie-chickens fed Korean lespedeza, pearlmillet pennisetum, soybean and wheat (n=6 per diet). ($\bar{x}$'s in same rows followed by same capital letters did not differ significantly [P > 0.05].)

Energetic variable	Korean lespedeza	Soybean	Wheat	Pearlmillet pennisetum
Consumption (grams/day)	41.3 ABC ± 2.0	50.0 AB ± 2.8	35.7 BC ± 1.6	45.2 AB ± 2.1
CE[a] (kcal/gram)	5.1	5.2	4.0	4.7
GE[a] (kcal/bird/day)	208.8 A ± 10.3	235.7 A ± 14.5	144.3 CD ± 6.6	211.8 A ± 9.9
GE (kcal/gram body weight/day	0.216 AD ±0.01	0.245 AD ±0.016	0.151 C ±0.011	0.227 AD ±0.007
Excrement (grams/day)	23.4 AC ± 1.2	20.8 A ± 1.2	12.2 B ± 1.1	18.9 A ± 0.9
Excrement (kcal/gram)	3.53 ± 0.02	4.13 ± 0.07	3.76 ± 0.07	3.85 ± 0.11
EE[a] (kcal/bird/day)	82.7 A ± 4.4	85.7 A ± 5.4	45.9 BC ± 4.1	73.1 A ± 4.6
EE (kcal/gram) body weight/day)	0.086 AB ±0.005	0.089 B ±0.006	0.048 CD ±0.004	0.078 AB ±0.005
AE[a] (kcal/bird/day)	126.1 AB ± 8.6	150.1 AD ± 10.4	98.3 ABC ± 3.5	138.7 AD ± 10.2
AE (kcal/gram body weight/day)	0.131 AB ±0.008	0.156 AD ±0.011	0.103 ABC ±0.004	0.149 AD ±0.011
UE[a] (%)	59.6 A ± 1.7	63.5 A ± 1.4	69.1 A ± 1.5	64.2 A ± 2.6
Weight change (%)	+ 0.4	- 2.6	- 0.4	+ 1.2

[a] CE = combustible energy, GE = gross energy intake, EE = excretory energy loss, AE = assimilated energy (AE = GE - EE), and UE = energy utilization efficiency (UE = [AE/GE] X 100).

Table 2C. Mean energetic values, ± SEM, for greater prairie-chickens fed sunflower, corn and sorghum (n=6 per diet). ($\bar{x}$'s in same rows followed by same capital letters did not differ significantly [P > 0.05].)

Energetic variable	Sunflower	Corn	Sorghum
Consumption (grams/day)	20.5 DE ± 1.6	30.3 BCD ± 1.4	30.8 BCD ± 1.7
CE[a] (kcal/gram)	6.6	4.2	4.2
GE[a] (kcal/bird/day)	135.9 BCD ± 10.2	127.2 BCD ± 5.8	130.0 BCD ± 7.3
GE (kcal/gram of body weight/day)	0.143 BC ±0.012	0.133 BC ±0.006	0.136 BC ±0.007
Excrement (grams/day)	7.1 B ± 0.3	7.4 B ± 0.5	7.6 B ± 0.6
Excrement (kcal/gram)	3.2 ± 0.1	3.7 ± 0.1	3.6 ± 0.1
EE[a] (kcal/bird/day)	23.0 B ± 1.2	27.2 B ± 1.9	27.5 B ± 2.4
EE (kcal/gram of body weight/day)	0.024 C ±0.0	0.029 C ±0.002	0.029 C ±0.003
AE[a] (kcal/bird/day)	112.9 AB ± 10.2	99.9 ABC ± 4.8	102.5 ABC ± 5.8
AE (kcal/gram body weight/day)	0.119 AB ±0.011	0.105 ABC ±0.005	0.107 ABC ±0.006
UE[a] (%)	78.3 A ± 3.18	78.4 A ± 1.2	79.0 A ± 1.3
Weight change (%)	+ 1.0	+ 0.9	- 1.1

[a] CE = combustible energy, GE = gross energy intake, EE = excretory energy loss, AE = assimilated energy (AE = GE - EE), and UE = energy utilization efficiency (UE = [AE/GE] X 100).

Table 2D. Mean energetic values, ± SEM, for greater prairie-chickens fed maintenance mix, Purina chick starter/grower and Cole soy pellets (n=6 per diet). ($\bar{x}$'s in same rows followed by same capital letters did not differ significantly [P > 0.05].)

Energetic variable	Maintenance mix (KS)	Cole soy pellets	Maintenance mix (MN)	Purina chick starter/grower
Consumption (grams/day)	52.1 AF ± 3.3	55.9 AF ± 3.3	45.6 AB ± 3.0	61.1 F ± 2.4
CE (kcal/gram)	4.3	4.3	4.3	4.3
GE[a] (kcal/bird/day)	222.4 A ± 14.1	242.2 A ± 13.0	194.7 AD ± 12.9	263.6 A ± 10.2
GE (kcal/gram body weight/day)	0.232 AD ±0.014	0.254 AD ±0.014	0.194 CD ±0.012	0.271 A ±0.012
Excrement (grams/day)	26.6 CD ± 1.1	28.9 D ± 1.1	22.1 AC ± 1.4	19.8 A ± 0.3
Excrement (kcal/gram)	2.81 ± 0.02	2.71 ± 0.02	2.95 ± 0.03	3.13 ± 0.04
EE[a] (kcal/bird/day)	74.7 A ± 3.0	78.2 A ± 3.2	65.2 AC ± 4.3	62.0 AC ± 0.9
EE (kcal/gram) body weight/day)	0.078 ABC ±0.003	0.082 AB ±0.004	0.065 AB ±0.004	0.063 ABD ±0.0
AE[a] (kcal/bird/day)	147.7 AD ± 12.4	164.1 AD ± 11.8	129.4 AB ± 12.3	201.6 D ± 10.6
AE (kcal/gram body weight/day)	0.154 AD ±0.012	0.172 AD ±0.012	0.129 AB ±0.012	0.208 D ±0.012
UE[a] (%)	64.6 A ± 1.6	64.7 A ± 3.1	65.2 A ± 2.0	75.2 A ± 1.6
Weight change (%)	+ 2.7	+ 2.8	+ 2.5	+ 3.2

[a] CE = combustible energy, GE = gross energy intake, EE = excretory energy loss, AE = assimilated energy (AE = GE - EE), and UE = energy utilization efficiency (UE = [AE/GE] X 100).

<u>Energy Value of Diet</u>

Gross energy intake per bird per day ranged from 69.9 kcal for birds fed amaranth (Table 2A) to 263.6 kcal for birds on a diet of Purina chick starter/grower (Table 2D). Gross energy intake per bird per day and per gram body weight per day were significantly lower for birds on diets of amaranth, buckbrush and Blackwell switchgrass (Table 2A) than for birds fed Korean lespedeza, pearlmillet pennisetum and soybean (Table 2B). Birds fed Korean lespedeza, pearlmillet pennisetum, soybean (Table 2B), maintenance mix, Cole soy pellets and Purina chick starter/grower (Table 2D) had gross energy intake values that were significantly greater than birds fed corn, sorghum and sunflower (Table 2C).

<u>Energy Value of Excreta</u>

Excrement per bird per day ranged from 7.1 grams for birds fed sunflower (Table 2C) to 85.7 grams for birds on a diet of Cole soy pellets (Table 2D). Birds fed sunflower, corn, sorghum (Table 2C), amaranth (Table 2A) and wheat (Table 2B) produced significantly smaller amounts of excrement than those on all other diets. Birds fed maintenance mix and Cole soy pellets (Table 2D) produced significantly greater amounts of excrement than those on all other diets.

Caloric value of excrement per gram ranged from 2.7 kcal for birds fed Cole soy pellets (Table 2D) to 4.1 kcal for birds on a diet of soybean (Table 2B). Birds fed Cole soy pellets, maintenance mix, Purina chick starter/grower (Table 2D) and sunflower (Table 2D) had excreta with caloric contents significantly lower than birds fed all other diets. The caloric content of excrement from birds fed pearlmillet pennisetum and soybean (Table 2B) was significantly greater than from birds fed all other diets.

Excretory energy per bird per day ranged from 23 kcal for birds fed sunflower (Table 2C) to 85.7 kcal for birds on a diet of soybean (Table 2B). Excretory energy per bird per day was significantly lower for birds fed sunflower, corn, sorghum (Table 2C) and amaranth (Table 2A) than for birds fed all other diets. Maintenance mix, Cole soy pellets (Table 2D), pearlmillet pennisetum, Korean lespedeza and soybean (Table 2B) had excretory energy values per bird per day that were significantly higher than birds fed all other diets.

Excretory energy per gram body weight per day ranged from 0.024 kcal for birds on a diet of sunflower (Table 2C) to 0.089 kcal for birds fed soybean (Table 2B). For birds fed sunflower, corn, sorghum (Table 2C) and amaranth (Table 2D) excretory energy per gram body weight per day was significantly lower than for birds fed all other diets. On diets of Blackwell switchgrass (Table 2A), maintenance mix, Cole soy pellets (Table 2D), pearlmillet pennisetum, Korean lespedeza and soybean (Table 2B) the excretory energy per gram body weight per day was significantly higher than for birds fed all other diets.

Energy Assimilation

Assimilated energy per bird per day ranged from 26 kcal for birds on a diet of buckbrush (Table 2A) to 201.6 kcal for birds fed Purina chick starter/grower (Table 2D). Birds fed diets of buckbrush and amaranth (Table 2A) had significantly lower assimilated energy values both per bird per day and per gram body weight per day than birds fed all other diets. Birds fed Purina chick starter/grower (Table 2D) had significantly the highest assimilated energy both per bird per day and per gram body weight per day.

Energy Utilization Efficiency

Energy utilization efficiency values ranged from 18.7 percent for birds fed a diet of buckbrush (Table 2A) to more than 78 percent for birds on diets of sunflower, corn and sorghum (Table 2C). Birds fed buckbrush, Blackwell switchgrass and amaranth (Table 2A) had appreciably lower energy utilization efficiency values, less than or equal to 42 percent. Birds fed Korean lespedeza (Table 2B) had an energy utilization efficiency of 59.6 percent. Birds on all other diets (Tables 2B,C,D) had appreciably higher energy utilization efficiency values, equal to or greater than 64 percent.

Energy Values for Wild-caught vs. Pen-raised Prairie-Chickens

A comparison between wild-caught Kansas birds and pen-raised Minnesota birds fed the maintenance mix showed that feed consumption per bird per day was 52.1 and 45.6

grams, respectively (Table 2D). The Kansas and Minnesota birds had the following energetic values: gross energy per bird per day was 222.4 and 194.7 kcal, respectively; excretory energy per bird per day was 74.7 and 65.2 kcal, respectively; assimilated energy per bird per day was 147.7 and 129.4 kcal, respectively; and energy utilization efficiency was 64.6 and 65.2 percent, respectively.

DISCUSSION

Efficacy of Maintenance Diet

Ideally, a maintenance diet should provide adequate calories, crude protein, essential amino acids, fat, crude fiber, vitamins and minerals for an animal. Purina game bird startena was used in this study because it has consistently been shown to provide these nutritional factors in sufficient amounts to the domestic chicken (*Gallus gallus*), a close relative of the prairie-chicken. The startena diet contains 30 percent crude protein, assumed to be adequate for greater prairie-chickens since Bump (1947) showed that young ruffed grouse (*Bonasa umbellus*) thrived best on diets that contained 27 to 30 percent protein. However, Cole soy pellets, containing 41 percent crude protein, were added to increase the available protein for the prairie-chickens during the additional stress of low temperature, confinement and experimentation.

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Average body weight change for birds fed maintenance mix was a gain of 25.2 grams per bird per 2-day feeding trial (Table 1), which was an average increase of 2.6 % per bird (Table 2D). For birds fed maintenance mix, average gross energy per bird was 208.6 kcal per day, average assimilated energy per bird was 138.6 kcal per day and average energy utilization efficiency was 64.9 percent (Table 2D). Average body weight gain and all energy values resulting from maintenance mix feeding trials support use of this mixture as a standard maintenance diet for prairie-chickens during the adverse conditions of low temperature, confinement and experimentation.

Energetic Variables of Diets fed Prairie-Chickens

Since all diets were provided *ad libitum* to the prairie-chickens, the amount of feed consumed by each bird most likely reflected acceptability of that diet (Ault and Stormer 1983; Robel et al. 1974). The significantly smaller consumption of buckbrush, amaranth (Table 2A) and sunflower (Table 2C) compared to all other diets implied that those seeds were less acceptable to prairie-chickens. Since sunflower contained the highest energy content of all seeds tested (Table 2A,B,C,D) and a relatively large percent of protein, the birds were able to obtain their caloric and protein requirements on less of this seed. An attempt was made to feed western wheat grass to the birds, but they refused to consume more than a minimal amount, which indicated it was highly unacceptable. The consumption of corn, sorghum (Table 2C), pearlmillet pennisetum, soybean, Korean lespedeza (Table 2B) and Blackwell switchgrass (Table 2A) was not significantly different among birds on those diets. This suggested similar acceptability of those seeds. Purina chick starter/grower, Cole soy pellets and maintenance mix (Table 2D) were consumed in amounts significantly larger than all seed diets. This suggested high acceptability of the commercial diets by prairie-chickens.

Gross energy represents the total amount of energy contained in the food consumed by animals such as prairie-chickens. The significantly smaller amount of amaranthh and buckbrush (Table 2A) consumed by the birds resulted in gross energy, excretory energy and assimilated energy values per bird per day that were significantly smaller than all other diets. Even though sunflower was eaten in significantly smaller amounts than most other diets, the high caloric content of that seed kept its gross energy value (Table 2C) at a level not significantly different from corn, sorghum (Table 2C), Blackwell switchgrass (Table 2A), and wheat (Table 2B). The significantly higher gross energy values for Korean lespedeza, pearlmillet pennisetum, soybean (Table 2B), maintenance mix, Cole soy pellets and Purina chick starter/grower (Table 2D) must be attributed to their significantly greater consumption by the prairie-chickens.

Excretory energy represents that energy which was not assimilated from the food consumed by the bird. When it is subtracted from gross energy, the difference gives the assimilated energy, which is the quantity of energy actually used by the bird. Thus, assimilated energy is an excellent indication of the energy value of a food to an animal. Assimilated energy values for pearlmillet pennisetum, soybean (Table 2B), maintenance mix, Cole soy pellets and Purina chick starter/grower (Table 2D) were significantly higher because of the relatively large difference between their gross energy and excretory energy values. Cost prohibits the use of commercial diets for wintering prairie-chickens, but pearlmillet pennisetum and soybean should be considered valuable energy sources for wintering greater prairie-chickens.

Energy utilization efficiency represents the amount of energy assimilated compared to the amount of energy consumed by an animal and provides a valuable indication of the nutritional value of a food to that animal. Since buckbrush, Blackwell switchgrass and amaranth (Table 2A) yielded energy utilization efficiency values that were significantly lower than all other diets, they should be viewed as unimportant energy sources for wintering greater prairie-chickens. In contrast, Korean lespedeza, soybean, pearlmillet pennisetum, wheat (Table 2B), sunflower, corn, sorghum (Table 2C), Cole soy pellets, maintenance mix and Purina chick starter/grower (Table 2D) possessed significantly higher energy utilization efficiency values. Korean lespedeza, soybean, pearlmillet pennisetum, sunflower, corn and sorghum should be considered valuable energy sources for wintering greater prairie-chickens.

Value of Test Diets to Prairie-Chickens

Assimilated energy per bird per day has been used as an index value for seeds fed to northern bobwhites because that value took into account both food quality and digestibility (Robel et al. 1979a). A similar index value based on assimilated energy per gram body weight per day has more recently been used for seeds fed to scaled quail (Saunders and Parrish 1987). This second index value is thought to be a more realistic representation of the actual value of a seed to a bird than the more often used metabolizable energy value (combustible energy x utilization efficiency) of a seed (Saunders 1986). For example, from Table 3 it can be seen that metabolizable energy per gram of soybean (3.33 kcal) is almost identical to metabolizable energy per gram of sorghum (3.34 kcal). However, assimilated energy per gram body weight per day for soybean (0.156 kcal) is about 45 percent greater than assimilated energy per gram body weight per day for sorghum (0.107 kcal). Those data imply that metabolizable energy values tend to overestimate the value of relatively poorly assimilated and utilized seeds. Therefore, based on assimilated energy per gram body weight per day the diets can be rated as extremely poor, very poor, poor, good or excellent sources of energy for wintering greater prairie-chickens. Western wheat grass was consumed in such small quantities and caused such a significant weight loss (10 %) that it must be considered extremely poor. Buckbrush (Table 2A) yielded very low assimilated energy values and must be rated as very poor. Blackwell switchgrass and amaranth (Table 2A) yielded values that were significantly lower and should be classified as poor. Wheat, Korean lespedeza (Table 2B), corn, sorghum and sunflower (Table 2C) should be considered good, while pearlmillet pennisetum and soybean (Table 2B) should be considered

Table 3. Mean assimilated energy values and mean metabolizable energy values for greater prairie-chickens fed various diets (n=6 per diet).

Diet	Assimilated energy[a] (kcal/g body weight/day)	Metabolizable energy[b] (kcal/g seed)
Commercial diets:		
Purina chick starter/grower	0.21	3.24
Cole soy pellets	0.17	2.81
Maintenance mix	0.14	2.14
Seed diets:		
Soybean	0.16	3.33
Pearlmillet pennisetum	0.15	3.01
Korean lespedeza	0.13	3.01
Sunflower chips	0.12	5.18
Sorghum	0.11	3.34
Corn	0.10	3.29
Wheat	0.10	2.79
Blackwell switchgrass	0.06	1.84
Amaranth	0.04	1.89
Buckbrush	0.02	0.86

[a] Assimilated energy (AE = GE - EE)

[b] Metabolizable energy (ME = CE X UE)

excellent energy sources for wintering prairie-chickens. Except for pearlmillet pennisetum, all seeds that were well assimilated and efficiently utilized by prairie-chickens in this study have previously been reported in the crops of wild greater prairie-chickens (Korschgen 1962; Horak 1985).

Factors Affecting Seed Selection by Prairie-Chickens

Availability, acceptability, assimilated energy values and energy utilization efficiency percentages are significant in food selection by all animals. Availability of preferred food is possibly the most important determining factor of food selection (Robel et al. 1974). Failing to consider availibilty of food may give a false impression of the real value of a specific food to an animal. Food highly preferred but not readily available will not be as important as less preferred foods that are more readily available. Those seeds which were considered good or excellent energy sources for greater prairie-chickens and are available during Kansas winters are soybean, wheat, corn and sorghum (Horak 1985).

Acceptability of a food to an animal is a second factor which should be considered. The quantity of seed eaten by a prairie-chicken should indicate acceptibility of that seed to the bird. All seeds considered either good or excellent, based on assimilated energy per gram body weight per day, were consumed in adequate amounts to maintain body weights of the birds during feeding trials (Table 1).

Assimilated energy represents the net quantity of energy actually available to an animal from a consumed food. Seeds that had assimilated energy values considered good were wheat, Korean lespedeza (Table 2B), corn, sorghum and sunflower (Table 2C). Pearlmillet pennisetum and soybean (Table 2B) had assimilated energy values considered excellent. Those ratings suggest that those seven seeds should be considered good to excellent energy sources for wintering greater prairie-chickens.

A fourth factor that should be considered is energy utilization efficiency, which is an indication of the percent of energy an animal can obtain from the food it consumes. Korean lespedeza, soybean, pearlmillet pennisetum, wheat (Table 2B), sunflower, corn and sorghum (Table 2C) had energy utilization efficiency values that statistically were similar and should be considered good to excellent energy sources for wintering greater prairie-chickens.

In addition, such factors as protein and amino acid content, calorie-to-protein ratio, mineral and vitamin content of seeds are important to the overall nutrition of an animal. These are factors that should be addressed in future nutritional studies involving the greater prairie-chicken.

Wild-caught vs. Pen-raised Prairie-Chickens.

Since prairie-chickens used in this study were obtained from two different geographical locations and habitats, Kansas/wild-caught and Minnesota/pen-raised, a comparison of their food utilization capabilities was conducted. Both Kansas and Minnesota birds were fed maintenance mix diets under the same environmental conditions for four days. The net result was a nonsignificant difference in body weight change, gross energy intake, excretory energy loss, assimilated energy and energy utilization efficiency between the Kansas and Minnesota birds (Table 2D). Furthermore, energy utilization efficiency values for Kansas (64.6 %) and Minnesota birds (65.2 %) were almost identical. Those very similar energy values show that prairie-chickens utilize food the same regardless of geographical location or habitat. Thus, either pen-raised or wild-caught prairie-chickens can be used for bioenergetics studies without concern for any differences in their food utilization capabilities.

Food Utilization among Prairie-Chickens and other Phasianids

Different studies examining the bioenergetics of several grouse during winter conditions have found that grouse can be remarkably omnivorous birds. For example, the heath hen was found to consume 93 different species of plants (Gross 1928). However, some species such as ruffed grouse tend to be nutritional specialists, depending on one or two species of vegetation (Doerr et al. 1974).

Ruffed grouse, having mean body weights of 644 grams, had assimilated energy values per bird per day of 46.1 kcal while consuming mostly aspen buds and twigs (Rasmussen and Brander 1973). Rock ptarmigan (*Lagopus mutus*), having mean body weights of 432 and 390 grams, had assimilated energy values per bird per day of 70.8 kcal (West 1972) and 100 kcal (Moss 1973), respectively, while consuming primarily birch buds and twigs. Willow ptarmigan, having mean body weights of 490, 574 and 590 grams, had assimilated energy values per bird per day of 105 kcal (Moss 1973), 117 kcal (West 1968) and 70.5 kcal (West 1972), respectively, while consuming mostly willow buds and twigs. Willow ptarmigan also had an energy utilization efficiency value of 68.5 percent, while maintaining relatively constant assimilated energy values througout the year (West 1968).

Excluding the prairie-chickens in the buckbrush trial, birds in this study had a mean body weight of 953.7 grams and a mean assimilated energy value per bird per day of 109.4 kcal, while consuming ten different seeds. While prairie-chicken weights were as much as twice those of the ruffed grouse, rock ptarmigan and willow ptarmigan studies, assimilated energy values for all four species were similar enough to be considered comparable among these grouse. Excluding the buckbrush trial, the mean energy utilization efficiency value for greater praire-chickens in this study was 64.1 percent. This value was slightly lower than the 68.5 percent reported for willow ptarmigan but should be viewed as similar, especially when considering that completeness of digestion and absorption decreases as mass of ingested food increases (Brody 1945; Kendeigh 1949). In undernourished red-necked pheasants the gut lengthened and the utilization efficiency increased (Breitenbach et al. 1963), while in red grouse fed highly digestible diets the caecal length and utilization efficiency decreased (Moss 1972). These two different feeding conditions could be compared to "northern" grouse consuming harder-to-digest buds and twigs, while prairie-chickens consumed presumably easier to digest seeds or grains.

No other study to date has examined the utilization of individual seeds by other grouse. However, comparable seed utilization studies have examined other members of the avian family Phasianidae, such as northern bobwhites (Clement 1970; Robel et al. 1974, 1979a,b) and scaled quail (Saunders and Parrish 1987). Some of the same seed species used in those studies were examined in this study. Since prairie-chickens are 4 to 5 times larger than quail, a comparison of most of their energy values is difficult. However, since energy utilization efficiency is a percentage measurement, it can be used as a fair estimate for comparing food utilization among these birds.

Energy utilization efficiency values (UE's) for Korean lespedeza were nearly identical (approximately 60 %) among the three bird species (Robel et al. 1979a,b; Saunders and Parrish 1987, Table 2B). The UE's for sorghum were very similar, those of the two quail species being approximately 86 percent, while that for prairie-chickens was 79 percent.

Prairie-chickens had similar UE's for sunflower (78 %) and Purina chick starter/grower (75 %) as did scaled quail (86 % and 75 %, respectively). Northern bobwhites and prairie-chickens had almost identical UE's for amaranth, with both being approximately 40 percent. Therefore, energy utilization efficiency for those diets was similar among these three bird species.

Some noticeable differences did exist between scaled quail and prairie-chickens when Blackwell switchgrass, pearlmillet pennisetum and amaranth were compared. Scaled quail consuming amaranth had UE's almost twice as high as those for prairie-chickens (82 % and 42, respectively). For Blackwell switchgrass and pearmillet pennisetum, UE's were almost 50 percent higher for scaled quail (65 % and 84 %, respectively) compared to prairie-chickens (42 % and 64 % respectively). Another difference between UE's for bobwhites (61 %) and prairie-chickens (78 %) existed for birds fed sunflower.

Overall, UE's for quail are larger than those for prairie-chickens. While this can not as yet be completely explained, the distinctly different size of the birds could possibly play a role in the difference between their UE's.

Significance for Managers

Availability of food has been shown to be the primary determining factor in food consumption by wild birds (Ault and Stormer 1983; Doerr et al. 1974; Jones 1963; Korschgen

1962; Robel et al. 1974). Northern bobwhites showed no significant correlation between volume of food consumed and its energy content, assimilated energy and energy utilization efficiency (Robel et al. 1974). All species of seed examined in this study have been found in crops of wild greater prairie-chickens, except buckbrush, Blackwell switchgrass and pearlmillet pennisetum. Coincidentally, Blackwell switchgrass and buckbrush, along with amaranth, were the three test seeds that ranked the lowest in quantity of seed consumed and the energetic categories of gross energy, assimilated energy and energy utilization efficiency. Thus, these three seeds and western wheatgrass should not be considered valuable energy sources for wintering greater prairie-chickens.

None of the remaining seven seeds consistently ranked superior to the others in all measures, but did rank good to excellent in most categories. Korean lespedeza, soybean, pearlmillet pennisetum, wheat, sunflower, corn and sorghum should be viewed as valuable sources of energy for greater prairie-chickens during the adverse conditions of winter. This agrees with Korschgen (1962), who ranked the following crops in decreasing importance to prairie-chickens: corn, soybean, sorghum, Korean lespedeza and wheat.

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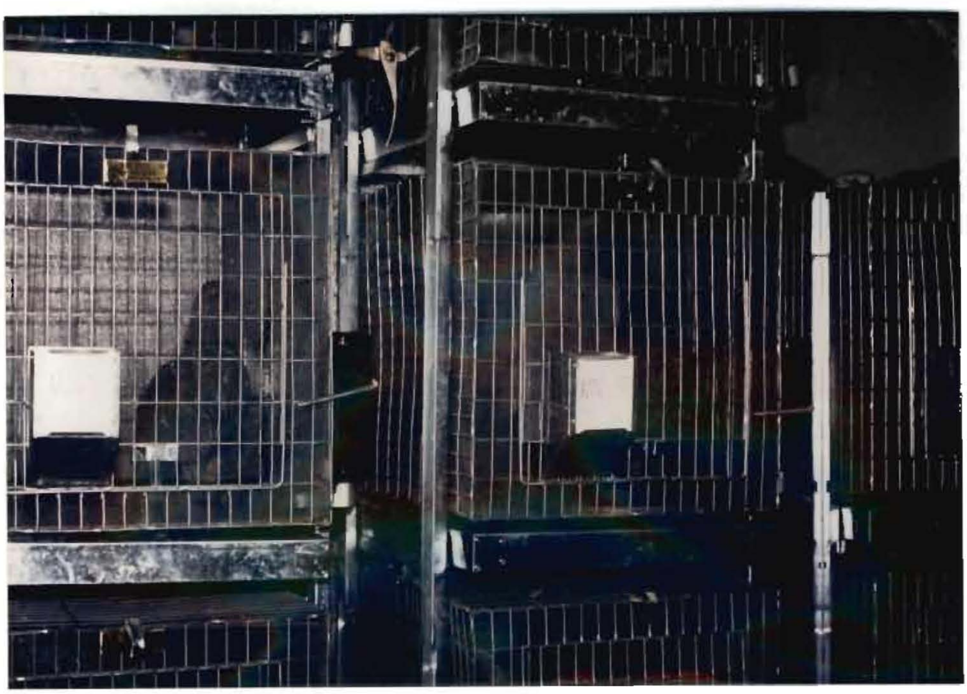
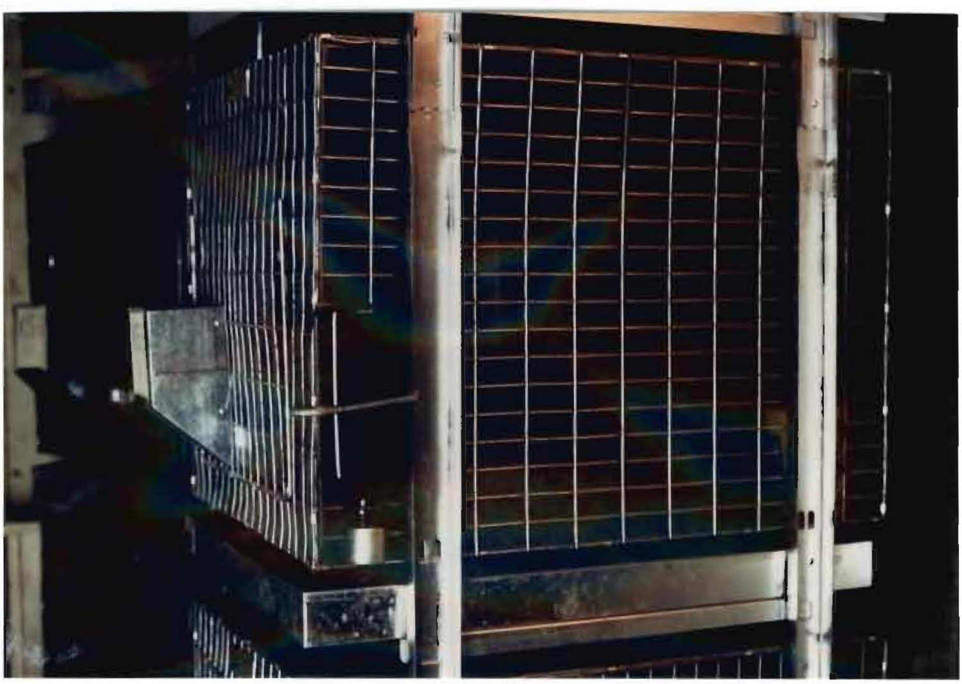
APPENDIX 1

Front view of bird cage

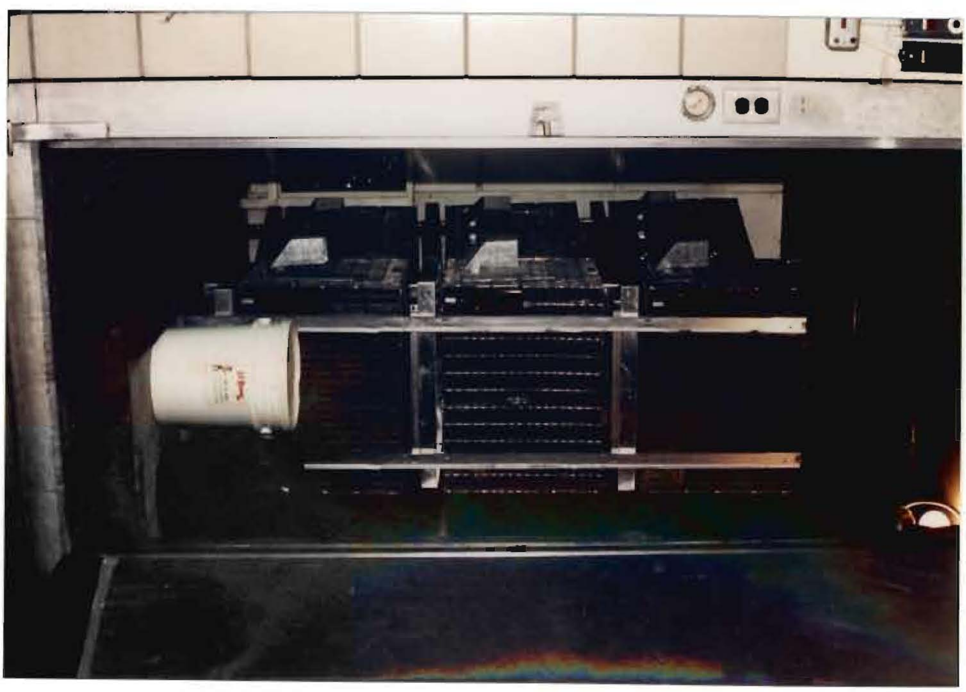

MN-8



Side view of bird cage



Environmental chamber



Experimental set-up

APPENDIX 2

Data collection card
(front)

Species_______________________ No.__________ Card No._________

Date begin trial __________________ Begin wt.___________.____g

Date ending trial__________________ End wt. ___________.____g

Length trial _______________________ Wt. change__________.____g

Temperature: Max. ___________C; Min. ___________C

Photoperiod: _________L:_________D (hrs); Fat class: _______

Molt record:

Notes:

Data collection card
(back)

Wet weight of feed__________.____g Dry wt. feed_________.____g

%moisture feed _______________% Protein content feed ________%

Caloric value dry feed ____________.____kcal/g

Oven dry wt old feed___________.____g; feces_____________.____g

Wt. of tare of feed____________.____g; feces_____________.____g

Net dry wt. old feed___________.____g; feces_____________.____g

Weight of tare (foil) next period feces____________.____g

EXCRETA ANALYSIS:

Calories _______________.____kcal/g; Nitrogen________.____mg/g

Protein________%; Ether extract__________mg/g; Ash________mg/g