REGIONAL VARIATION IN THE NUTRITIONAL ECOLOGY OF RUFFED GROUSE

by

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(ABSTRACT)

Three experiments with captive ruffed grouse (Bonasa umbellus) demonstrated that dietary metabolizable energy (ME) can be predicted from neutral detergent solubles, total phenols, and percent acorns of grouse diets. The weight of the fat attached to the gizzard was highly correlated with percent carcass fat in 82 grouse and was judged a useful index of body condition.

Crop contents of 1005 grouse collected during fall and winter 1981-84 in Maine, New York, Wisconsin, Washington, Virginia, West Virginia, Indiana, Ohio, North Carolina, and Georgia were used to make regional comparisons of food habits and diet quality. The ME of crop contents was predicted from chemical composition. Evergreen leaves of woody plants were the most common late winter forages of grouse in southeastern states, whereas buds, twigs, and catkins were the most common late fall and winter forages in

diets of grouse in northern states. Winter diets in the Southeast tended to have higher levels of predicted ME than diets in the North; however, southeastern diets tended to have higher levels of total phenols and lower levels of protein than typical northern diets. Evergreen leaf forages had higher levels of tannin phenols than buds, twigs, and catkins. Dietary ME appeared adequate in both the North and the Southeast, but low levels of protein and high levels of tannins may result in poorer quality winter diets along the southeastern edge of the range of the ruffed grouse.

Acorns comprised 63% of the crop contents of 22 grouse collected in Virginia in March and April 1982, the spring following a year of high acorn production. Leaves and flowers of herbaceous forbs were the primary forages of 41 grouse collected in spring 1983 and 1984. Body fat levels were greater for females than males and declined from March to April. Fat declines appeared to be related to breeding activities.

Evergreen leaves were the most abundant forages available to grouse in late winter on a study site in southwestern Virginia. Biomass of high quality herbaceous leaves was insufficient to meet estimated energy requirements of grouse in late winter, indicating a need for a dietary shift to low quality evergreen leaves.

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helped with the laboratory work. assisted with field work, and helped with metabolism trials. The following biologists coordinated collections of ruffed grouse crops: of the U.S. Forest Service, of the Maine Department of Inland Fisheries and Wildlife, of the Ohio Department of Natural Resources, of the Georgia Department of Natural Resources, of the Indiana Department of Natural Resources, of the Washington Department of Game, and of the University of Wisconsin-Stevens Point. Also, large contributions of crop

samples were made by

and the Maine Ruffed Grouse Society. of the Virginia Commission of Game and Inland Fisheries arranged for collection permits and spring collections of ruffed grouse in Virginia. and of the VCGIF made collections of ruffed grouse in Virginia. Most of all, I would like to express my thanks and appreciation to my wife my parents, and sisters for their love, support, and encouragement.

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INTRODUCTION

The southeastern edge of the range of the ruffed grouse extends along the Appalachian Mountains into Georgia, North Carolina, Virginia, and Tennessee. Grouse are not as abundant in this region as in the northern U.S. and Canada (Bump et al. 1947). Ruffed grouse ecology in the southern Appalachian Mountains has not been extensively studied. Other than food habits studies, the few studies done in the Southeast have been on spring and summer habitat use (Harris 1981, Hale et al. 1982), fall and winter habitat use and survival of grouse transplanted from Wisconsin to Tennessee (White and Dimmick 1978, Gudlin and Dimmick 1984), and seasonal changes in body condition and diet quality (Norman and Kirkpatrick 1984). Also, Weber and Barick (1963) reported on eleven years of census data in North Carolina.

Factors that may be responsible for the lower population densities of grouse in the Southeast have not been identified, although low recruitment in southern states has been noted (Davis et al. 1973, Harris 1981:109) and may be a contributing factor. Fall and winter food habits of ruffed grouse in the Southeast have received considerable study (see review in Chapter 3) and are known to differ markedly from the food habits of grouse from northern regions. Grouse in northern areas feed primarily on buds,

twigs, and catkins of trees in winter, whereas grouse in the Southeast feed primarily on leaves of shrubs, vines, and herbaceous plants. The nutritional significance of this regional difference in food habits is unknown because little is known about the nutritional quality of these forages.

Regional differences in food habits likely occur during the spring season also. Gullion (1970) stated that the availability of staminate flower buds of quaking aspen (Populus tremuloides) and bigtooth aspen (Populus grandidentata) largely determines the distribution of breeding grouse in Minnesota. The food habits of ruffed grouse in the Southeast during the breeding season are not well documented, but aspen is relatively uncommon in the southern Appalachians. Food habits data for nine grouse collected in April in Virginia (Norman and Kirkpatrick 1984) are the only published information for the Southeast. These grouse primarily fed on leaves of woody and herbaceous plants. More detailed study of the food habits of grouse in the spring season is needed.

Lower population levels of grouse in the Southeast may be related to regional differences in food habits, diet quality and/or food abundance. The present study was undertaken to gain a better understanding of the nutritional ecology of ruffed grouse in the Southeast during the fall,

winter, and spring seasons and to compare the nutritional quality of diets of the ruffed grouse from southeastern and northern parts of its range. The development of techniques for measuring body condition and dietary metabolizable energy of ruffed grouse was a major part of the study. Specific objectives of the study were

1. to develop an equation for predicting the metabolizable energy in forages of ruffed grouse from forage chemical composition,
2. to evaluate wing fat and gizzard fat as indices of carcass fat in ruffed grouse,
3. to determine the relationships between food habits and the metabolizable energy, crude protein, and total phenols in the diet of ruffed grouse,
4. to determine the regional variation in the metabolizable energy, crude protein, and total phenol levels of the fall and winter diets of ruffed grouse,
5. to determine levels of tannin phenols in selected winter forages of ruffed grouse,
6. to determine the interrelationships among food habits, diet quality, and carcass fat levels of ruffed grouse during the early part of the breeding season in southwestern Virginia, and

7. to measure forage and cover availability and habitat use in fall and winter for a ruffed grouse population in southwestern Virginia.

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CHAPTER 1

PREDICTING THE METABOLIZABLE ENERGY IN THE DIET OF RUFFED GROUSE FROM VAN SOEST AND TOTAL PHENOL ANALYSES

Ruffed grouse food habits are well documented (Brown 1946, Bump et al. 1947, Korschgen 1966, Phillips 1967, Svoboda and Gullion 1972, Woehr and Chambers 1975, Smith 1977, Stafford and Dimmick 1979, Seehorn et al. 1981), but the relationships between food habits and diet quality are still largely unknown. Progress has been slow because of the lack of accurate, efficient, and tested methods for measuring the metabolizable energy (ME) in the natural diet of ruffed grouse. Studying all forages individually in conventional metabolism trials is impractical because of the varied diet of grouse. In addition, one-time measurements of forage quality from metabolism trials would not account for variation in quality among seasons, years, or locations.

Predicting the metabolizable energy of forages of ruffed grouse from forage chemical composition is a promising alternative. Large numbers of forages could be studied much more efficiently using this method. Also, crop contents could be chemically analyzed to study the ME of the diet of grouse, which eliminates the bias between hand-picked forages and forages selected by wild birds.

The Van Soest method of forage chemical analysis (Goering and Van Soest 1970) has proven to be reliable for predicting forage digestion in ruminant and monogastric species (Van Soest 1967, Mould and Robbins 1982, Servello et al. 1983, MacPherson et al. 1985). The objective of the present study was to determine the relationship between forage chemical composition as measured by the Van Soest method and forage ME for ruffed grouse and to develop a predictive equation for estimating ME based upon this relationship.

High levels of phenolic compounds in forages may complicate prediction of forage digestion when using the Van Soest analysis (Mould and Robbins 1981a, 1982). Depending on their size and structure, phenols, which include the more commonly known tannins, may interfere with digestive enzymes and nutrient absorption processes and reduce protein digestibility by forming strong complexes with plant proteins (McLeod 1974, Mould and Robbins 1981b). Simple phenols and portions of hydrolyzable tannins may be absorbed through the gut wall. However, the absorbed phenols require detoxification and can cause liver and kidney disorders (McLeod 1974). In general, phenols have a negative effect on forage quality and digestion. However, in the Van Soest analysis, phenols are extracted as part of the theoretically

highly digestible neutral detergent soluble fraction. Therefore, the influence of phenolic compounds on prediction of forage ME in ruffed grouse also was determined.

Storage and drying treatments can influence measured chemical constituents of forages, especially highly reactive phenols (Mould and Robbins 1981a). The effects of a number of commonly used storage and drying treatments on prediction of forage ME also were examined in the present study.

METHODS

Experiment 1. Initial Metabolism Trials

The ME (%) in 14 diets fed to captive ruffed grouse was determined in metabolism trials by the total collection method. Six male and two female ruffed grouse, 2-4 years old, were used in these trials. All birds were raised from eggs collected from wild grouse in Virginia or West Virginia. Grouse were kept in outdoor enclosures and maintained on a high fiber diet (31% neutral detergent fiber) consisting of a 50:50 mix of Purina Gamebird Chow and Purina Horse Chow-100 for at least 3 months prior to the trials.

Mixed diets composed of commercial feeds and natural forages were used in metabolism trials because of difficulties encountered in feeding single forage diets. Six diets fed in fall trials (20 Sep-20 Nov 1982) consisted

of mixtures of 58% of either gamebird chow or horse chow and 40% of one of six dried and ground (2mm) natural forages of ruffed grouse: cinquefoil (Potentilla spp.) leaves, strawberry (Fragaria spp.) leaves, autumn olive (Elaeagnus umbellata) fruit, quaking aspen (Populus tremuloides) leaves, grape (Vitis spp.) fruit, or black chokeberry (Pyrus melanocarpa) fruit. Gamebird chow and horse chow also were fed as two additional diets. All diets contained 2% corn oil to improve palatability.

Six diets fed during winter trials (10 Jan-12 Mar 1982) consisted of 48% of either gamebird chow or horse chow and 50% of 1 of 6 dried and ground (2mm) winter forages: quaking aspen flower buds, yellow birch (Betula alleghaniensis) buds, mountain laurel (Kalmia latifolia) leaves, apple (Malus spp.) buds, Christmas fern (Polystichum acrostichoicles) fronds, and black oak (Quercus velutina) fruit, Gamebird and horse chow again were fed as additional diets, and all diets contained 2% corn oil. Strawberry leaves, aspen buds, chokeberry fruit, and birch buds all were collected in New York. All other forages were collected in Virginia. All forages were oven-dried (50 C) prior to grinding except for leaves or fronds of cinquefoil, strawberry, laurel, Christmas fern, and aspen, which were air-dried for 5 days.

The metabolism trials for the eight diets fed during each of the fall and winter experiments were conducted in two 4x4 Latin square designs with each Latin square having four diets, four grouse, and four time periods. Each metabolism trial consisted of a 6-day acclimation period and a 4-day collection period. The test diet was fed as 50% of the diet for the first 3 days of the acclimation period and as 100% of the diet for the second 3 days. Uneaten food and feces were collected daily during the 4-day collection period, dried at 55 C for 48 hours, and weighed. There were 7 days between trials.

Percentages of neutral detergent solubles (NDS), acid detergent solubles (ADS), lignin, cellulose, and cutin levels in the diets were measured by the methods of Goering and Van Soest (1970) as described by Servello et al. (1983). Cellulose was determined by the 72% sulfuric acid method after lignin determination with potassium permanganate. Cutin was then determined by ashing the residue at 500 C for 3 hours. Sodium sulfite was not used in the determination of neutral detergent solubles as recommended by Mould and Robbins (1981a). Acid detergent solubles is defined as the dry matter of the sample soluble in sequential treatments with neutral detergent and acid detergent solutions. Percent total phenols in the diets was measured

colorimetrically (Singleton and Rossi 1965) after a 3-day extraction in acetone/water (70:30), using a gallic acid standard. Gross energy in diets and feces was determined with a Parr adiabatic bomb calorimeter.

Simple, multiple, and stepwise regression procedures of SAS (Ray et al. 1982) were used to determine the relationships between the chemical composition of the diets and diet ME.

Experiment 2. Validation Metabolism Trials

Eight diets were fed to ruffed grouse in metabolism trials conducted in fall 1983 to test prediction equations developed in Experiment 1. Each diet was composed of 2-3 forages of ruffed grouse. Based on preliminary chemical analyses of forages, diets were formulated to cover a wide range of NDS and total phenol levels and still have an acceptable palatability (specific composition of diets is presented in Table 1.3). Forages used included leaves of clover (Trifolium spp.), dandelion (Taraxacum officinale), mountain laurel, greenbrier (Smilax spp.), Japanese honeysuckle (Lonicera japonica), strawberry, and cinquefoil, fruits of hawthorne (Crataegus spp.), autumn olive, sweet cherry (Prunus avium), grape, staghorn sumac (Rhus typhina), and corn, and fronds of Christmas fern. Seeds were removed from sweet cherry and only the fleshy portion was used.

Forages were either air-dried, oven-dried, or freeze-dried and ground to pass a 2mm screen. All diets were supplemented with a poultry vitamin-mineral mix (Diamond Shamrock, Nopcosol R-3) at the manufacturer's recommended rate, and 2% corn oil was added to improve palatability.

Six adult male grouse used in Experiment 1 and 12 juvenile ruffed grouse (7 males, 5 females) raised from eggs collected from nests in Virginia were used in these metabolism trials. Juveniles were maintained for 6 weeks prior to the trials on the high fiber maintenance diet fed routinely to adults. Metabolism trials were conducted as in Experiment 1 except there was only a 3-day collection period. Trials were conducted in a randomized block design. Diets were chemically analyzed as in Experiment 1. Observed ME values (from metabolism trials) and predicted ME values (from equations) of the eight diets were compared. Data from Experiments 1 and 2 were tested for differences in regression coefficients using dummy variable regression techniques (Neter and Wasserman 1974).

Experiment 3. Acorn Metabolism Trials

Prediction of the ME of diets containing acorns was studied in this experiment which was conducted in late fall, 1983. Nine diets were formulated, each composed of a basal diet mixed with acorn meat from one of three species of

oaks: red oak (Quercus rubra), white oak (Quercus alba), and chestnut oak (Quercus prinus). Acorn meat of each species was substituted for the basal diet at levels of 70, 50, and 30% in the diets. The basal diet was the maintenance diet described in Experiment 1 and also was fed as one diet. All diets contained 2% added corn oil. Acorn meat was oven-dried (50 C), ground (2mm), and supplemented with the vitamin-mineral mix used in Experiment 2 prior to mixing into diets. The ME of the diets for grouse was determined in metabolism trials as in Experiment 2. Diets were chemically analyzed as described in Experiment 1. In addition, the percent ether-extract (estimate of fat content) of each diet was measured with a Soxhlet apparatus. Observed ME values of the diets for grouse (based on metabolism trials) and predicted ME values using equations developed in Experiment 1 and 2 were compared.

Effect of Forage Treatment on ME Prediction

The effects of various methods of storage and drying on measured chemical composition of forages and prediction of ME for grouse were studied. Fresh-collected mountain laurel leaves, Christmas fern fronds, Japanese honeysuckle leaves, cinquefoil leaves, and strawberry leaves collected in February and/or May were split into uniform lots and either oven-dried (50 C for 48 hours), freeze-dried (3 days), air-

dried (20-24 C for 5 days), or frozen (2 days). Frozen samples were removed from the freezer and kept at room temperature for 8 hours. Samples thawed within 30 minutes. After 8 hours, one-half of each previously frozen sample was freeze-dried (3 days) or oven-dried (50 C, 48 hours). Forages in each treatment were analyzed for levels of NDS and total phenols.

RESULTS AND DISCUSSION

Experiment 1. Initial Metabolism Trials

The ME of the 14 diets varied from 32.2 to 69.4% (Table 1.1). Diet ME and chemical composition varied sufficiently to examine their relationships using linear regression procedures. Fall and winter ME values for each of the two commercial feeds were similar; therefore, fall and winter data for these diets were combined. Also, lignin and cutin values of the diets are reported as a lignin+cutin fraction (Table 1.1). Values for the one diet containing acorns were eliminated from the regression analyses because the actual ME of the acorn diet was substantially underpredicted (11-12 percentage units) by all regression equations. Prediction of the ME of diets containing acorns was studied in greater detail in Experiment 3.

Both NDS and ADS had strong linear relationships ($P=0.0001$) with ME in ruffed grouse (Table 1.2). However,

Table 1.1. Metabolizable energy and chemical composition of 14 diets fed to ruffed grouse in Experiment 1.

Diet[1]	Metabolizable energy (%)			NDS[2] (%)	ADS[3] (%)	Cellulose (%)	Lignin+ cutin (%)	Total phenols (%)
	$\bar{x}$	SE	N					
Gamebird chow (G)	69.4	0.6	7	81.9	92.7	4.5	2.7	0.7
Horse chow (H)	36.5	1.6	7	45.1	61.5	24.8	14.7	1.2
G-strawbery l.	57.3	2.0	4	80.0	89.1	5.5	5.3	5.9
G-cinquefoil l.	56.9	1.9	4	73.3	83.5	7.0	9.3	2.8
G-autumn olive f.	65.3	0.9	4	75.7	84.6	5.3	9.6	0.7
H-grape f.	43.4	1.2	4	53.2	66.7	16.0	17.2	3.0
H-chokeberry f.	38.3	1.6	4	50.4	63.0	19.2	17.8	1.4
H-aspen	35.0	1.8	4	53.4	65.9	17.8	15.9	5.5
G-birch b.	42.9	1.4	3	62.8	74.2	8.6	17.5	4.7
G-aspen b	38.4	1.1	4	65.4	76.7	8.5	14.8	4.0
G-laurel l.	45.6	5.0	3	73.8	82.2	6.6	11.2	9.5
H-apple b.	32.2	0.6	3	52.9	65.4	16.5	17.8	6.1
H-acorn	52.2	1.2	3	56.9	69.9	17.2	13.0	3.3
H-fern l.	34.9	0.2	3	52.8	67.3	20.0	12.3	6.8

[1]Plant part abbreviations: f.=fruit, l.=leaves, b.=buds.

[2]NDS=neutral detergent solubles.

[3]ADS=acid detergent solubles.

Table 1.2. Relationships between percent metabolizable energy (ME) and percent neutral detergent solubles (NDS), acid detergent solubles (ADS), and total phenol levels in 13 diets fed to ruffed grouse in Experiment 1.

Independent variables			
X_1	X_2	R^2	Equation[1]
NDS		0.75	$ME = 0.85X_1 - 7.73$
NDS - Phenols		0.88	$ME = 0.90X_1 - 7.14$
NDS	Phenols	0.93	$ME = 0.85X_1 - 1.92X_2 - 0.18$
ADS		0.79	$ME = 1.03X_1 - 30.98$
ADS - Phenols		0.91	$ME = 1.06X_1 - 29.10$
ADS	Phenols	0.93	$ME = 1.01X_1 - 1.73X_2 - 22.69$

[1]All relationships significant at P=0.0001. Single diet containing acorns was excluded from regression analyses. See text for explanation.

subtracting phenol values from NDS and ADS values greatly improved the R^2 values. Theoretically, NDS is the highly digestible fraction of feeds and forages (Van Soest 1967). However, phenols, which are extracted as NDS, have little or no nutritional value and can decrease the digestibility of other NDS constituents (McLeod 1974, Mould and Robbins 1981a,b, 1982). Because phenols constituted a major portion of the NDS of some diets, correcting NDS and ADS values for levels of total phenols improved the accuracy of ME prediction. Inclusion of phenols as a separate variable in a multiple regression equation slightly improved R^2 values over phenol-corrected NDS (NDS - P) and phenol-corrected ADS (ADS - P) variables (Table 1.2). Stepwise regression analysis using all variables produced a model which only included ADS - P.

Experiment 2. Validation Metabolism Trials

The ME of these diets varied from 38.4 to 75.2% (Table 1.3). The ME, NDS, ADS, and phenol levels of the diets varied sufficiently to test ME prediction equations from Experiment 1. Slope and intercept values of equations (of the form shown in Table 1.2) derived from Experiment 2 data were not different ($P>0.05$) than those from Experiment 1. The NDS - P equation developed in Experiment 1 had the lowest sum of squared errors of prediction (error of

Table 1.3. Percent metabolizable energy, neutral detergent solubles (NDS), acid detergent solubles (ADS), and total phenols of eight diets fed to ruffed grouse in Experiment 2.

Diet composition[1]	Metabolizable energy $\bar{x}$	SE	N	NDS	ADS	Total phenols
1. Cherry f. (58), Clover l. (40)	63.0	1.8	4	84.7	88.4	3.3
2. Corn (73), Dandelion l. (25)	75.2	1.6	4	86.6	94.1	1.0
3. Hawthorn f. (38), Strawberry l. (40), Cinquefoil l. (20)	38.4	1.2	3	67.5	76.2	10.0
4. A. olive f. (28), Clover l. (40), Dandelion l. (30)	50.0	0.6	3	74.9	81.4	1.8
5. A. olive f. (73), Honeysuckle l. (25)	58.4	0.8	4	75.7	78.8	3.0
6. Grape f. (58), Laurel l. (25), Christmas fern (15)	40.8	2.9	3	61.6	67.9	8.1
7. Grape l. (58), Greenbrier l. (40)	42.7	1.1	3	66.3	71.4	6.4
8. Sumac f. (50), A. olive f. (24), Grape f. (24)	48.2	1.5	3	56.4	69.1	6.0

[1]Percent composition is in parentheses. All diets also contain 2% corn oil by weight. Plant part abbreviations: f.=fruits, l.=leaves.

prediction equals observed ME minus predicted ME) for the diets in Experiment 2, suggesting that it was a slightly more accurate equation. Values for sum of squared errors of prediction for equations based on NDS - P, NDS and P, ADS - P, and ADS and P were 270, 281, 283, and 342, respectively. The actual and predicted ME values were highly correlated for the NDS - P equation ($r=0.88$, $P=0.004$, Figure 1.1). Therefore, based on the data from these trials, which included 8 new forages and 12 new grouse, it was concluded that the equations developed in Experiment 1 provided good prediction of ME and that the NDS - P equation was just slightly more accurate than the other equations tested. The equations based on NDS also have an additional practical advantage in that the measurement of NDS is considerably faster and easier than ADS determination. The data from the two experiments were combined and the following equation produced:

$$ME = 0.87\ (NDS - P) - 5.76 \qquad R^2=0.85$$

The type of phenolic compounds in forages may explain much of the remainder of the variation in the relationship between NDS - P and ME. For example, tannin phenols, a constituent of total phenols, can have a two-fold effect of being an indigestible component of NDS and reducing the digestibility of other NDS constituents. Additional study

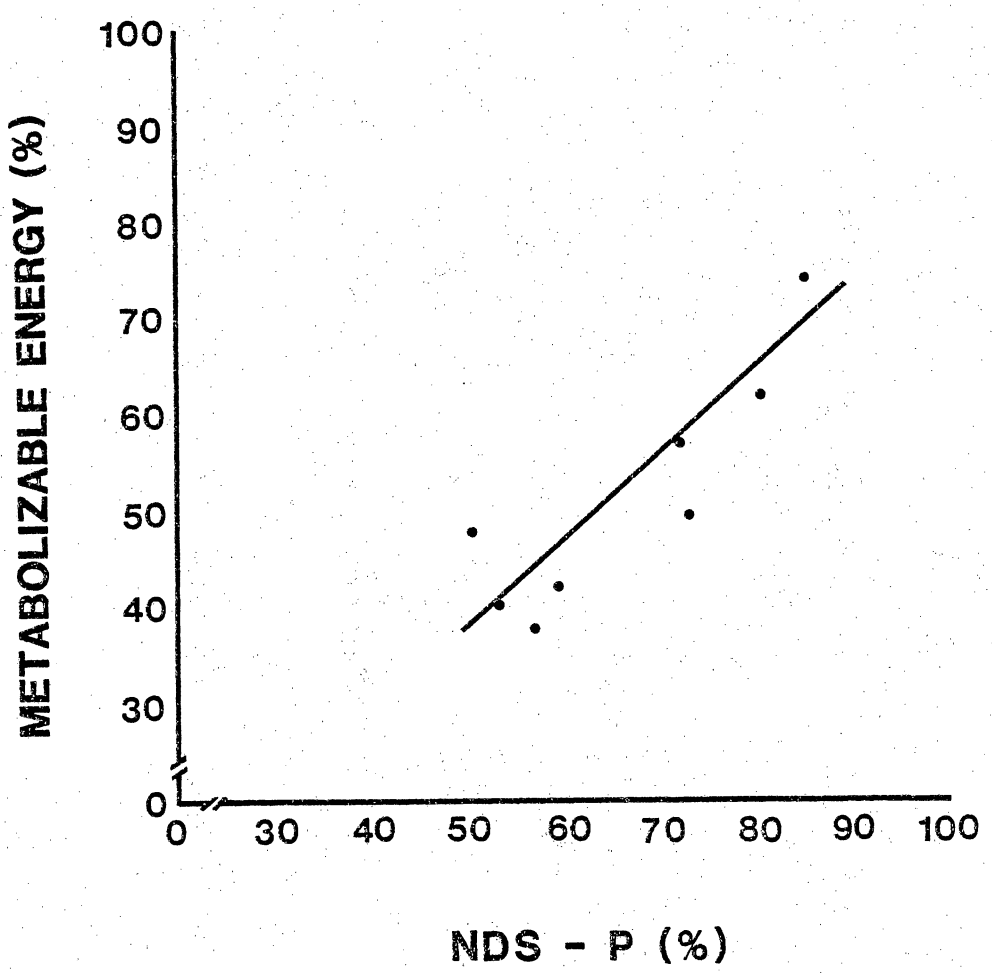

Fig. 1.1. Observed (•) and predicted (——) metabolizable energy values of eight diets fed to ruffed grouse in Experiment 2 as a function of the phenol-corrected neutral detergent soluble (NDS - P) content of the diets.

is needed in this area and on the effects of other non-nutritive plant constituents (e.g. essential oils, resins) on forage ME.

Experiment 3. Acorn Metabolism Trials

The acorn meat diets varied in levels of phenols and ether-extract, but had relatively similar NDS levels (Table 1.4). As was found in the first two experiments, a knowledge of total phenol levels in the diets clarifies the observed relationship between NDS levels of the diet and diet ME. For example, both the 70% white oak acorn diet and 70% chestnut oak acorn diet had NDS values of 78%, but the lower ME of the chestnut oak acorn diet was the result of its higher phenol content.

The observed ME values of the acorn meat diets were greater than predicted from the NDS - P values of the diets (Table 1.4), which was consistent with the observation for the diet containing black oak acorns fed in Experiment 1. The predicted ME of the basal diet was underestimated by 4.3 percentage units, which was consistent with data for previously fed diets of gamebird and horse chow. The amount of underestimation of ME in the acorn diets was related ($P=0.007$, $r=0.82$) to the percent acorn meat of the diets, but was not related ($P=0.43$) to the percent ether-extract of the diets.

Table 1.4. Percent ether extract (EE), neutral detergent solubles (NDS), total phenols, predicted metabolizable energy (ME), observed ME, and difference between observed and predicted ME values of ten diets fed to ruffed grouse in Experiment 3.

Diet (% acorn meat)	EE	NDS	Total phenols	Predicted ME(%)	Observed ME			Difference (predicted - observed)
					$\bar{x}$	SE	n	
Red oak (70)	18.3	84.4	8.8	60.0	72.2	1.6	3	-12.2
Red oak (50)	14.6	79.6	6.6	57.7	68.4	0.7	3	-10.7
Red oak (30)	11.3	75.9	3.9	56.9	64.0	1.1	3	- 7.1
White oak (70)	7.9	78.2	2.8	59.9	76.7	0.6	3	-16.8
White oak (50)	7.5	75.6	2.0	58.2	72.8	0.7	3	-14.6
White oak (30)	6.8	73.2	1.4	56.7	66.0	0.4	3	- 9.3
Chestnut oak (70)	7.7	78.3	6.0	57.1	70.2	2.0	3	-13.1
Chestnut oak (50)	7.5	76.7	4.4	57.1	67.9	1.4	3	-10.8
Chestnut oak (30)	7.3	73.9	2.8	56.1	61.9	0.4	3	- 5.8
Basal diet (0)	6.2	68.7	0.7	53.4	57.7	0.7	3	- 4.3

Multiple regression analysis was used to develop an equation for predicting the ME of diets containing acorns from values of NDS - P and percent acorn meat in the diets. Data for the 30 diets in the 3 experiments (21 diets from Experiments 1 and 2, which did not contain acorns, plus the 9 acorn diets from Experiment 3) were used in this analysis. A small part of the underestimation of the ME of each acorn diet was due to the slight underprediction of the ME of the basal diet. To remove the influence of the basal diet used in Experiment 3 on the regression analysis, the percentage units of underprediction contributed by the basal diet (proportion basal diet x 4.3) in each acorn diet was subtracted from the respective observed ME values of the acorn diets.

Multiple regression analysis produced the following equation ($P=0.0001$, $R^2=0.92$) for the prediction of the ME (%) of the diets of ruffed grouse:

$$ME = 0.87(NDS - P) + 0.18(\%\ \text{acorn meat}) - 5.76$$

where: % acorn meat = percent acorn meat in the diet.

Stepwise regression analysis indicated that percent acorn meat added significantly ($P<0.05$) to the prediction provided by the NDS - P equation. Predicted ME values for 100% acorn

meat samples reported in Chapter 3 appear to fall into a reasonable range, suggesting that the relationship between ME and percent acorn meat is linear to 100% acorn meat. When percent acorn meat equals zero, the above equation is identical to the prediction equation developed for diets without acorns in Experiments 1 and 2. However, the high R^2 value of 0.92 for the multiple regression equation is not representative of the variation for both diets with acorns and diets without acorns. The prediction equation for diets without acorns (Experiments 1 and 2) had an R^2 value of only 0.85. Metabolizable energy can be expressed as kcal/g of dry matter by measuring the gross energy (GE) of the sample and making the appropriate calculations.

Effect of Forage Treatment on ME Prediction

Treatment of forages prior to drying and choice of drying methods had a substantial effect on measured NDS and total phenol levels (Tables 1.5 and 1.6). Immediate freeze-drying of fresh forages produced the highest NDS and phenol values, which are probably the most representative of the true values. Values for air-dried fresh forages were closer to values for fresh freeze-drying than any of the other treatments; however, lower NDS and/or phenol levels were observed for air-dried honeysuckle and Christmas fern. Oven-drying fresh forages consistently resulted in lower

Table 1.5. Percent neutral detergent solubles (NDS), total phenols (P), NDS - P, and metabolizable energy (ME) of mountain laurel leaves and Christmas fern fronds collected in Virginia in February and subjected to various storage and drying treatments.

	Mountain laurel				Christmas fern			
Treatment	NDS	P	NDS - P	ME	NDS	P	NDS - P	ME
Fresh								
Freeze-dry (3 days)	69.6	17.0	52.6	40.0	63.9	13.3	50.6	38.3
Oven-dry (24h @ 50 C)	66.1	11.9	54.2	41.4	60.9	10.8	50.1	37.8
Air-dry (5 days)	69.4	16.2	53.2	40.5	62.3	11.9	50.4	38.1
Frozen and thawed[1]								
Freeze-dry (3 days)	70.8	16.7	54.1	41.3	62.0	12.2	49.8	37.6
Oven-dry (24h @ 50 C)	65.0	11.5	53.5	40.8	55.9	8.5	47.4	35.5

[1]Forages were frozen for 2 days and thawed at room temperature for 8 hours prior to drying.

Table 1.6. Percent neutral detergent solubles (NDS), total phenols (P), NDS - P, and metabolizable energy (ME) of selected forages (leaves or fronds) collected in Virginia in May and subjected to various storage and drying treatments.

Treatment	Mountain laurel				Strawberry				Cinquefoil				Japanese honeysuckle				Christmas fern			
	NDS	P	NDS-P	ME	NDS	P	NDS-P	ME	NDS	P	NDS-P	ME	NDS	P	NDS-P	ME	NDS	P	NDS-P	ME
Fresh																				
Freeze-dry (3 days)	71.0	13.8	57.2	44.3	81.7	17.0	64.7	50.5	70.8	11.9	58.9	45.5	81.5	6.7	74.8	59.3	64.5	13.4	51.1	38.7
Oven-dry (24h @ 50 C)	61.7	10.6	51.1	38.7	79.5	17.4	62.1	48.3	70.6	12.5	58.1	44.8	78.5	4.3	74.2	58.8	53.9	9.6	44.3	32.8
Air-dry (5 days)	70.8	13.9	56.9	43.7	80.6	18.3	62.3	48.4	71.3	12.1	59.2	45.7	78.3	5.8	72.5	57.3	60.0	14.0	46.0	34.3
Frozen and thawed[1]																				
Freeze-dry (3 days)	65.1	11.3	53.8	41.0	79.0	13.6	65.4	51.1	65.5	8.5	57.0	43.8	73.3	1.1	72.2	57.1	48.0	5.5	42.5	31.2
Oven-dry (24h @ 50 C)	58.5	6.3	52.2	39.7	77.2	10.6	66.6	52.2	59.4	6.4	53.0	40.4	68.4	1.1	67.3	52.8	38.8	2.2	36.6	26.1

[1]Forages were frozen for 2 days and thawed at room temperature for 8 hours prior to drying.

values for both NDS and total phenols compared to fresh freeze-dried samples. NDS and phenol values of forages also were lower after freezing and thawing for all respective drying treatments. Some frozen samples turned brown or black in color within a few hours after thawing. This was probably caused by the oxidation of some phenolic constituents (Mould and Robbins 1981a, Ribereau-Gayon 1972:37). Most forages tested also developed a brown or black coloration during over-drying. Freezing and thawing and/or heating probably disrupts intracellular vacuoles allowing the oxidation of some phenols and/or the complexing of tannins and protein (McLeod 1974, Mould and Robbins 1981a). Phenols complexed with substrates are probably insoluble in neutral detergent solution and would explain in part the lower NDS values. Phenol levels of both Christmas fern and laurel appeared to be affected by freezing and thawing and heating to a lesser extent in the winter than in the spring. More protein and/or tannin may be present in new growth or more phenols may be susceptible to oxidation at that time.

With the exception of the Christmas fern collected in the spring, the percentage unit decreases (from fresh freeze-dried values) in NDS and phenols as a result of the various treatments were similar. Therefore, NDS - P values

and predicted ME values of forages prepared by each treatment were much less affected by forage treatment than were NDS and phenol values separately (Tables 1.5 and 1.6).

APPLICATION

The strong relationship between phenol-corrected NDS and ME provides a reliable and efficient method for studying diet quality in ruffed grouse populations. Unlike conventional metabolism trials, only a small amount of forage is needed for ME determination. In these studies, a 0.40g sample was routinely used for NDS and phenol analyses and as little as one half that amount can be used when the amount of forage material is limited. The small amount of forage required allows for the analysis of crop contents and, therefore, the estimation of the ME of forages actually selected by wild grouse.

To use the prediction equation, the percent acorn meat in the crop contents must be measured on a dry matter basis prior to chemical analysis in order that the appropriate CF can be computed. However, this requires little additional effort if food habits data are collected for comparison with ME values. Like acorns, the ME of beechnuts (Fagus grandifolia) also may be underestimated by the prediction equation. Until more information is available on the metabolizability of beechnuts, percent beechnut meat could

be substituted for percent acorn meat in the prediction equation.

There may be additional problems in predicting the ME of soft fruits that contain hard seeds. Beer and Tidyman (1942) reported that they could find no evidence that seeds of Smilax spp., Rhus spp., and Rose spp. were being ground by the gizzard of grouse. However, Korschgen (1966) states that hard seeds are ground by the gizzard of ruffed grouse and based this conclusion on his observation that few entire seeds were found during fecal analysis. However, only grape (Vitis spp.) and rose (Rosa spp.) fruits were found in substantial quantities in that study. The gizzard contents of 120 ruffed grouse collected in fall and winter in North Carolina were examined for evidence of seed digestion in the present study. There was evidence (numerous seed fragments) that seeds of grape and rose were being ground in the gizzard, but very few broken seeds of greenbrier and sumac were found even though these seeds were numerous. I also have observed whole seeds of fruits of flowering dogwood (Cornus floridanus), black gum (Nyssa sylvatica), and greenbrier (Smilax) spp. in the feces or large intestines of wild ruffed grouse. Mechanical grinding and chemical analyses of hard seeds not normally ground by the gizzard may overestimate the actual ME of those particular fruits.

Also, finely grinding seeds that normally are only broken into large pieces by gizzard action may result in overestimated ME values. This problem is difficult to resolve because grinding of hard seeds by the gizzard probably depends on the fruit species and on the amount of fruit consumption. High fruit consumption may increase rates of seed passage. When analyzing crop contents, ME estimates would be most effected in the fall when fruits often form a large part of the diet of grouse.

An alternative to grinding and analyzing seeds of soft fruits is to remove them from the crop contents and analyze the seed and nonseed portions of the crop contents separately. A range of ME estimates could then be calculated using the ME estimates for the seed and the nonseed portions of the crop contents and the known proportion of hard seeds in the crop contents. Minimum values are for the case when seeds are undigested (ME of zero used for seeds in calculations of the ME of the crop contents) and maximum values are for the case when seeds are completely ground (predicted ME values of ground, analyzed seeds used in calculations of the ME of the crop contents).

Proper care of forages prior to chemical analyses is important for obtaining accurate NDS and phenol values. Fortunately, changes in NDS and total phenol levels that may

occur during storage and drying are offsetting to a large extent in the ME prediction equation and reduce the error in predicted ME values. Immediate freeze-drying is recommended whenever possible. Some amount of NDS and phenol complexing probably takes place in the crops of grouse because of warm, moist conditions. However, care in drying crop contents can minimize chemical changes. Freeze-dried crop contents retain their natural color to a much greater extent than oven-dried crop material, suggesting a lesser degree of chemical change.

In summary, chemical analyses and prediction equations have numerous advantages over other methods of measuring metabolizable energy in the diet of ruffed grouse. By analyzing crop contents, direct comparisons of food habits and diet quality of grouse can now be made. This information will be a major step towards a better understanding of the relationships among food habits, diet quality, and population levels of ruffed grouse.

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CHAPTER 2

WING FAT, GIZZARD FAT, AND BODY WEIGHT AS INDICES OF CARCASS FAT IN RUFFED GROUSE

In the only two studies on seasonal body fat dynamics in wild ruffed grouse, whole carcasses were analyzed for fat content (Thomas et al. 1975, Norman and Kirkpatrick 1984). Carcass analysis is the most accurate method of fat determination; however, whole grouse are usually difficult to obtain, and the analysis is time-consuming. Norman and Kirkpatrick (1981) recently reported that wing fat was correlated with carcass fat in ruffed grouse collected in Virginia. However, the correlations between wing fat and carcass fat were weaker in the spring and summer than in the fall and winter, indicating some potential problems with the technique. The advantage of wing fat as an index is that wings can be easily collected from hunters for analysis. The weight of fat attached to the gizzard of ruffed grouse may have a similar advantage as a carcass fat index because gizzards also can easily be collected from hunters. Various measures of abdominal or visceral fat deposits have been shown to be strongly correlated with body fat in waterfowl (Woodall 1978, Bailey 1979, Chappell and Titman 1983, Thomas et al. 1983). The objective of the present study was to determine the reliability of wing fat and gizzard fat as

indexes of carcass fat in ruffed grouse. The relationship between fresh body weight and carcass fat content also was examined because body weight is frequently used as a measure of body condition.

METHODS

Sixty-two ruffed grouse were collected in the months of March and April from 1982 to 1984. A total of 20 grouse was collected between 1 November and 1 January from 1981 to 1984 in Virginia (N=8) and New York (N=12). Whole body weights were measured after removing crop contents. Grouse were plucked, and lower legs were removed at the tibio-tarsus-tarsometatarsus junction. Reproductive and digestive tracts were removed, but mesentary fat was stripped from the organs and replaced in the body cavity. The weight of the fat adhering to the gizzard (GFW) was weighed after lightly blotting surface moisture, and the fat was returned to the body cavity. The empty gizzard was weighed and a gizzard fat index (GFI) was calculated by dividing the weight of the fat attached to the gizzard by the gizzard weight.

Norman and Kirkpatrick (1980) analyzed the fat content of the entire wing (removed at the humerus-scapular junction). I tested three different sections of the wing that would be more representative of the amount of wing

material that could be consistently collected from hunters. For the 42 grouse collected in spring 1982 and 1983 and the 20 fall-collected grouse, 1 wing from each bird was removed at the humerus-radius-ulna junction (complete radius-ulna [CRU]) and the other wing was removed at a point midway on the radius-ulna (half radius-ulna [HRU]). For the 20 grouse collected in spring 1984 the skin and muscle along the radius-ulna (RUM) bones of 1 wing were removed for analysis. The other wing was cut at both the humerus-radius-ulna junction and midway on the radius-ulna. Both sections of this wing were analyzed resulting in a directly measured fat value for HRU and a computed value for CRU calculated from the fat content and weight of each section.

Carcasses and wings were freeze-dried and ground with a Waring blender. Wing samples and carcass subsamples were oven-dried (50 C) for 24h prior to fat extraction. Fat levels were measured in a Soxhlet apparatus using ethyl ether. Wing dry weight and fat were mathematically added to carcass values. Fat levels were calculated both as a percentage of carcass dry matter and as a lipid index ([g fat/g fat-free carcass dry matter] x 100).

Carcass and wing fat means were tested for differences with paired t-tests. Pearson's product-moment correlation and least-squared regression analyses were used to examine

relationships among condition indices. Slope and intercept values of regression lines were tested for differences between sexes and seasons using dummy variable regression techniques (Neter and Wasserman 1974).

RESULTS

Carcass fat and lipid index values ranged from 1.9-30.0% and 1.9-43.6, respectively, in the spring-collected grouse and from 4.9-35.1% and 5.2-54.0 in the fall-collected grouse. In males, paired t-tests showed that CRU wing fat and HRU wing fat were greater ($P<0.01$) than carcass fat in both the spring and fall (Table 2.1). There were no differences ($P>0.10$) between carcass fat and CRU or HRU wing fat in females in either season. The fat content of the RUM wing was not different ($P>0.10$) from carcass fat in males or females in the grouse collected in spring 1984, even though both CRU and HRU wing fat in the same grouse was greater than carcass fat in males ($P<0.01$), but not females ($P>0.20$).

Values for carcass fat and lipid index were highly correlated ($r=0.99$, $P=0.0001$). As a result, relationships between fat indices and carcass fat and lipid index were similar. Both CRU and HRU wing fat was correlated ($P<0.01$) with carcass fat and lipid index in the spring (Table 2.2). The correlation coefficients were higher for males

Table 2.1. Carcass fat, CRU wing fat, HRU wing fat, and RUM wing fat of ruffed grouse collected in Virginia (N=62) in spring 1982-84 and in Virginia (N=8) and New York (N=12) in fall 1981-1984.

	Spring						Fall					
	Female			Male			Female			Male		
	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N
Carcass fat (%)	17.7	1.1	39	7.5	1.0	23	17.1	3.6	8	14.6	1.7	12
CRU wing fat (%)	17.9	0.6	39	[1]15.1	1.7	23	22.5	0.8	8	[1]20.2	1.2	11
HRU wing fat (%)	19.1	0.6	39	[1]14.8	1.7	23	22.2	0.6	8	[1]20.7	1.2	12
RUM wing fat (%)[2]	12.1	1.2	10	7.5	1.7	10						

[1] Different from carcass fat mean at $P<0.05$.

[2] Mean $\pm$ SE) carcass fat, CRU wing fat, and HRU wing fat, respectively, for corresponding 20 grouse: females (15.7 $\pm$ 2.8, 16.9 $\pm$ 1.2, 18.6 $\pm$ 1.2), males (6.2 $\pm$ 1.5, 12.4 $\pm$ 2.8, 12.8 $\pm$ 3.0).

Table 2.2. Ranges of fat indexes and correlations with carcass fat and lipid index of ruffed grouse collected in Virginia (N=62) in spring 1982-84 and in Virginia (N=8) and New York (N=12) in fall 1981-84.

Fat index[1]	N	Range	Correlation coefficients: Carcass fat	Correlation coefficients: Lipid index
Spring				
CRU wing fat (%)				
males	23	1.7-24.7	0.83 *	0.80 *
females	39	10.3-25.2	0.63 *	0.62 *
HRU wing fat (%)				
males	23	1.6-25.1	0.83 *	0.81 *
females	39	11.3-26.0	0.60 *	0.59 *
RUM wing fat (%)	20	1.4-18.6	0.81 *	0.78 *
Body weight (g)				
males	23	535-773	0.74 *	0.74 *
females	39	561-711	0.43 *	0.43 *
Log (GFW+1)	62	0-1.52	0.87 *	0.86 *
Log (GFI+1)	62	0-0.21	0.84 *	0.85 *
Fall				
CRU wing fat (%)	20	11.2-26.0	0.58 *	0.55 *
HRU wing fat (%)	20	9.9-25.0	0.46 *	0.42 *
Body weight (g)	20	529-784	0.20 NS	0.17 NS
Log (GFW+1)	20	0.22-1.31	0.91 *	0.88 *
Log (GFI+1)	20	0.01-0.17	0.87 *	0.85 *

[1] Data for males and females are pooled in this table when slope and intercept values for relationships did not differ (P>0.05) between sexes and correlation coefficients for sexes were similar. See text for specific results.

* Correlated with dependent variable (P<0.01)

NS Nonsignificant correlation with dependent variable (P>0.05)

(r=0.80-0.83) than females (r=0.59-0.63), and the slope values of the least-square regression lines for these relationships were greater (P<0.05) for females than males. Intercept values did not differ (P>0.05). Percent fat in the RUM wing was correlated (P<0.01) with carcass fat and lipid index, but regression coefficients (slope and intercept values) did not differ (P>0.05) between sexes. Body weight was correlated (P<0.05) with carcass fat and lipid index in the spring for both sexes. The relationships were stronger for males (r=0.74) than females (r=0.43), but the regression coefficients did not differ (P>0.05) by sex.

Both CRU and HRU wing fat were weakly correlated (P<0.05) with carcass fat (r=0.46-0.58) and lipid index (r=0.42-0.55) in the fall (Table 2.2). Regression coefficients did not differ (P>0.05) between sexes. Body weight was not correlated (P>0.05) with carcass fat or lipid index in the fall for males or females or for pooled data of both sexes.

For all data pooled (N=82), there were curvilinear relationships (P=0.0001) between gizzard fat weight and carcass fat (Figure 2.1) and lipid index. A logrithmic model was used to describe the relationships (P=0.0001), which tended to have less variability at lower fat levels (e.g. carcass fat<15%). Correlation coefficients between

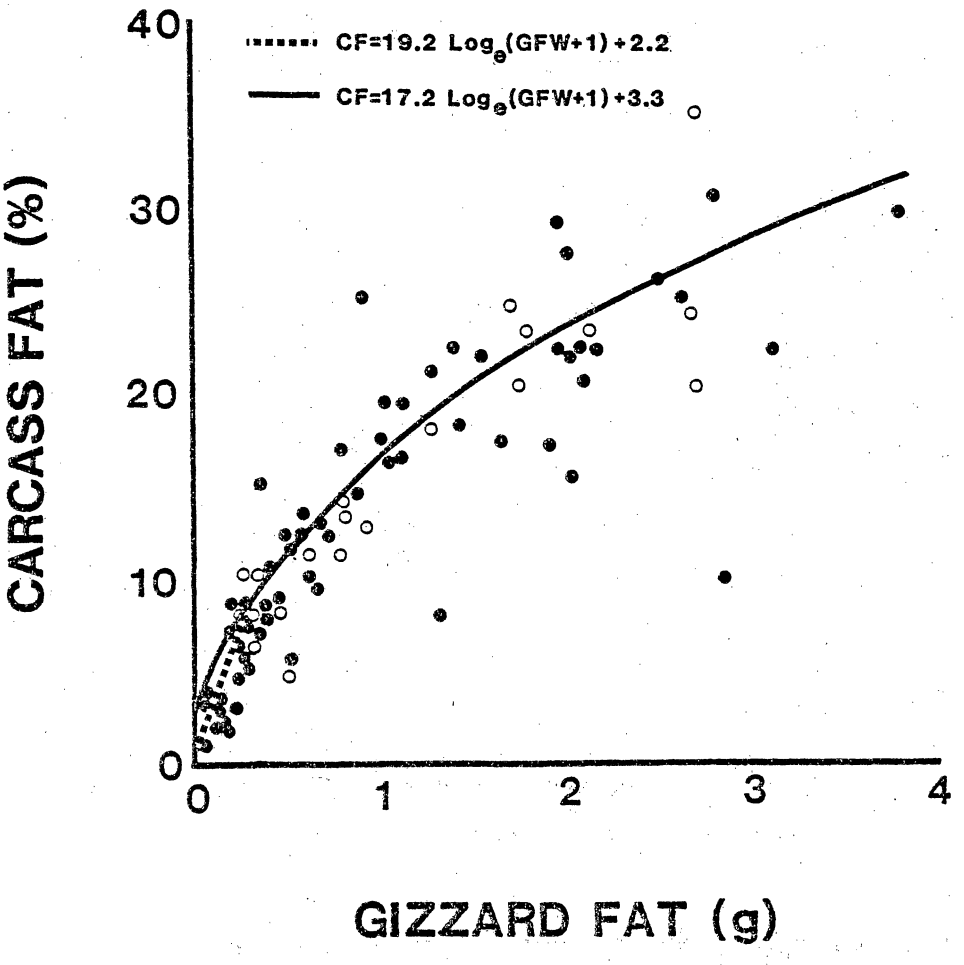

Fig. 2.1. Relationship between carcass fat (CF) and gizzard fat in ruffed grouse collected in the spring in Virginia (N=62) and in the fall in New York (N=12) and Virginia (N=8). Lines represent weighted (·····) and unweighted (——) least-squared regression equations. See text for explanation.

$\log_e$(GFW+1) and carcass fat and lipid index varied from 0.86 to 91 (Table 2.1). Regression coefficients did not differ (P>0.05) by sex or between spring samples from Virginia and fall samples from New York and Virginia. Weighted regression was used to obtain a better fit of the least-squared regression line at lower levels of carcass fat and lipid index where variability was lower. The weight values were proportional to the reciprocal of the variances of carcass fat or lipid index at each observation of GFW, which provided the best linear unbiased estimates of regression coefficients. The following equations were produced and are considered the most accurate for prediction of carcass fat (Fig. 2.1) and lipid index from GFW:

$$\text{Carcass fat} = 19.2[\log_e(\text{GFW} + 1)] + 2.2$$

$$\text{Lipid index} = 25.7[\log_e(\text{GFW} + 1)] + 1.1$$

The GFI was highly correlated with GFW (r=0.98, P=0.0001); therefore, relating GFW to gizzard weight did not improve the accuracy of GFW as a predictor of carcass fat and lipid index. Correlation coefficents of carcass fat and lipid index with $\log_e$(GFI+1) were similar to correlation coefficients with $\log_e$(GFW+1) (Table 2.2).

DISCUSSION

The weight of the fat attached to the gizzard appeared to be the most useful index of carcass fat for ruffed

grouse. There was no evidence that the relationship was affected by sex, season, or location. However, because of the curvilinear nature of this relationship, gizzard fat weight must be transformed to carcass fat estimates for comparative purposes.

Positive correlations between body fat and fat deposits also have been reported for waterfowl (Woodall 1978, Bailey 1979, Chappell and Titman 1983, Thomas et al. 1983); however, nonlinear relationships were not found in these previous studies. At higher body fat levels in grouse, fat may accumulate around the gizzard at a faster rate than in other parts of the body, resulting in a nonlinear relationship. Most grouse with high levels of body fat and gizzard fat were females collected in the spring. These females could have been rapidly storing or utilizing fat prior to or during egg-laying, which may have contributed to the high variability in the gizzard fat-carcass fat relationship at high body fat levels.

Typical body fat levels of ruffed grouse in the fall and winter probably would be in the range (0-20%) where prediction of carcass fat is the most accurate. For example, 114 of 118 gizzards collected from ruffed grouse in fall and winter in North Carolina had gizzard fat weights of less than 1.6g and predicted carcass fat levels of less than

21% (see Chapter 3). Thomas et al. (1975) found that mean carcass fat levels of grouse in Ontario, Canada in January and February were only 7 and 8%, respectively, also in the range where prediction from gizzard fat weight is the most accurate.

Fat levels of the CRU and HRU wings do not appear to be satisfactory as indexes of body fat. Correlations were weak and relationships differed for sexes in the spring. Carcass fat levels in females were greater than in males in the 63 spring-collected grouse (see Chapter 4). Therefore, differences in regression lines between sexes may have been the result of different body fat levels and not sex *per se*.

The lowest mean CRU and HRU wing fat levels were observed for males in the spring. However, these levels were still twice mean carcass fat levels. Wing fat (CRU and HRU) levels of <10% were observed in only seven grouse (all males) in the present study, and these grouse had mean ($\pm$SE) carcass fat of 2.8$\pm$0.3%. Fat levels in wings may remain high until carcass fat levels have decreased to a low level.

Hutchinson and Owen (1984) recently reported that wing bones of many species of waterfowl contain fat laden marrow, and that marrow fat was one of the last fat reserves to be used as body fat declined. The presence of marrow in wing bones of ruffed grouse was observed in some specimens of

ruffed grouse obtained after the present study. If ruffed grouse have a similar pattern of marrow fat depletion in wing bones as described for ducks that would explain the high mean wing fat relative to carcass fat found in the present study and the observation that the mean fat content of the muscle and skin (bone excluded) along the radius-ulna (RUM wing fat) did not differ from mean carcass fat.

Body weight was not an accurate predictor of body fat levels even when accounting for sex differences. Thomas et al. (1975) also found that there was not a simple relationship between weight and fat content for ruffed grouse. The lower correlation coefficient for females than males in the spring was probably due to large changes in weights of reproductive organs and the presence of partially developed eggs in the oviducts of females (see Chapter 4). Age information may improve prediction in the fall to some degree.

In summary, gizzard fat weight has good potential as a predictor of carcass fat in ruffed grouse, while wing fat and body weight were only weakly related to body fat. Large numbers of samples of gizzards and attached fat could easily be collected from hunters to monitor fat levels in ruffed grouse populations.

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CHAPTER 3

REGIONAL VARIATION IN THE NUTRITIONAL ECOLOGY OF RUFFED GROUSE IN FALL AND WINTER

The southeast edge of the range of the ruffed grouse extends along the Appalachian mountains into the states of Georgia, North Carolina, Virginia, and Tennessee (Aldrich 1963). Ruffed grouse are not as abundant in this region as in the northern U.S. and Canada (Bump et al. 1947:55). The causes of this regional difference in grouse abundance have not been identified.

Low population densities of ruffed grouse in the Southeast may be related to regional differences in diet quality or food abundance. Fall and winter food habits of ruffed grouse differ distinctly between southeastern and northern regions. Buds, twigs, and catkins of trees are the most common winter foods of grouse in the northern U.S. and Canada (Brown 1946, Bump et al. 1947, McGowan 1973, Vanderschaegan 1970, Svoboda and Gullion 1972), whereas the winter diet of grouse in the southern Appalachians is composed of fruits, ferns, and leaves of herbaceous and woody plants (Stafford and Dimmick 1979, Seehorn et al. 1981, Norman and Kirkpatrick 1984).

The nutritional significance of this difference in food habits is unknown because there have been few studies on the

nutritional quality of forages and diets of ruffed grouse. Previous research only consisted of proximate analyses of grouse forages (Bump et al. 1947, Korschgen 1966). While providing some useful information (e.g. protein content), the proximate system of feed analyses has limited value for describing forage quality (Robbins 1983:244). Basic to an understanding of the nutritional ecology of any species is information on the metabolizable energy (ME) content of forages. However, with one exception (Hill et al. 1968), there is no published information on the ME of forages or diets of ruffed grouse.

Information on levels of phenolic compounds also may be important when evaluating the nutritional quality of forages of grouse (Byrant and Kuropat 1980, Sinclair et al. 1982, Lindroth and Batzli 1984, Sinclair and Smith 1984). Byrant and Kuropat (1980) proposed that food selection by ruffed grouse was related more to the avoidance of protective plant chemicals than to the selection for nutrient-rich foods. Phenolic compounds, which include simple phenols, nontannin flavans, hydrolyzable tannins, and condensed tannins (Peri and Pompei 1971), have a variety of adverse physiological and nutritional effects on herbivores. Tannins may reduce protein digestibility and digestive enzyme activity because of their ability to bind strongly with protein (McLeod 1974,

Mould and Robbins 1981a). Large amounts of absorbed tannins can cause liver and kidney disorders in rabbits and rats (Arheleger et al. 1965, Boler et al. 1966, Camp et al. 1967). Dietary tannin also has been shown to reduce growth rates in chickens (Vohra et al. 1965, Fuller et al. 1967, Conner et al. 1969, Armstrong et al. 1974, Kubena et al. 1983). Quercetin (a flavonoid) and tannic acid (a hydrolyzable tannin) reduce growth rates of prairie voles, and quebracho, a condensed tannin, causes mortality in prairie voles by reducing food intake (Lindroth and Batzli 1984). Concentrations of total phenols are known to be substantial (17% of dry matter) in some forages of ruffed grouse (see Chapter 1), but data on tannin levels in grouse forages are not available.

To gain a better understanding of ruffed grouse nutritional ecology, more information on the nutritional quality of forages is needed as well a better understanding of the relationships between food habits and diet quality. In addition, there is a need for direct comparisons of the quality of the diets of ruffed grouse from northern and southeastern populations in order to determine the significance of regional differences in food habits. The objectives of the present study were (1) to determine the relationships between food habits and ME, protein, and total

phenols in the diet of ruffed grouse; (2) to determine levels of tannin phenols in selected winter forages of ruffed grouse; and (3) to determine the regional variation in the ME, protein, and total phenol levels of the fall and winter diets of ruffed grouse. Also, carcass fat levels of ruffed grouse collected in North Carolina during the fall and winter were measured to examine the relationship between diet quality and body condition.

METHODS

Crop contents of hunter-killed ruffed grouse were collected by cooperators in Virginia, North Carolina, and Georgia during the 1981-82, 1982-83, and 1983-84 hunting seasons and in Maine, New York, Wisconsin, and Washington during the 1982-83 and 1983-84 hunting seasons. Crops were collected in West Virginia during the 1981-82 hunting season and in Indiana and Ohio during the 1983-84 season only. Hunters were instructed to freeze crop contents as soon as possible in plastic bags and collection envelopes and to record the date and county of kill. Most samples were shipped to VPI&SU by an express mail service. Generally this involved one shipment from each state at the end of the hunting season because one individual usually coordinated collections for each state. Crops were frozen when mailed, but thawed during shipment. All samples arrived in <24h

(usually 16h) except one container of crops from New York in 1982 that arrived in approximately 30h. Most shipments were still cool on arrival and crop contents were generally in excellent condition. Collections from New York in 1983 and from Maine in 1982 were kept on ice and transported directly to VPI&SU by automobile. Crop collections in Virginia were made in the vicinity of VPI&SU and did not require shipment. Upon arrival at VPI&SU, crop contents were frozen and later freeze-dried (without thawing) for approximately 48h.

Food Habits

After freeze-drying, crop contents were separated into the following forage classes: leaves of deciduous woody plants, leaves of evergreen woody plants, leaves of nonwoody herbaceous plants other than ferns, ferns, hard fruits, soft fruits, buds and twigs, catkins, animal matter, and grit. Grit was excluded from all food habits calculations and analyses. The deciduous leaf class included such species as apple, aspens, and greenbrier (all scientific names of plants appear in Appendix Table 3.1). Honeysuckle leaves were included in this forage class because they often partially change in color in late winter. The evergreen leaf class only included broad-leaf woody species that typically remained green throughout the entire year. Common forages in this class were mountain laurel, wintergreen, and

trailing arbutus. Hard fruits included those forages from which the principal source of nutrients for grouse was derived from the seed. This forage class included acorns, maple samaras, and small seeds of numerous species. Soft fruits were defined as forages from which nutrients are principally derived from the pericarp surrounding the seed. Besides such typical soft fruits as apple, grape, and greenbrier, fruits of sumac were included here.

Estimates of the major forage species in the collected crops were made by identifying at least the four most common species for each month of each state-wide collection (except for Washington). Then, for each crop, the percentage by volume of each identified species in its respective forage class was ocularly estimated. Crop contents were then freeze-dried for 24h and weighed by forage class. Then, for each crop, the estimated percentage of each identified and measured species in its respective forage class was multiplied by the weight of the forage class to obtain an estimate of the dry weight of that species in the crop. The weight to volume ratios of forages in a forage class were assumed to be similar. For 77% of the ocular measurements made, one species made up 100% of the forage class; therefore, most weight estimations were exact. Monthly percentages of forage classes and forage species in crop

contents were calculated by the aggregate volume method (Martin et al. 1946), except that dry weight was used.

Seeds of soft fruits, and the meat of acorns and beechnuts were removed from crop contents and weighed separately. A knowledge of the percentage of acorn and beechnut meat in the crop contents is necessary for predicting the ME of the crop contents by the prediction equation to be described later. Seeds of soft fruits were removed from the crop contents because the extent to which grouse grind hard seeds of soft fruits is not known. Although some hard seeds are apparently ground in the gizzard (Korschgen 1966), information for many fruit species is lacking (see Chapter 1). Finely grinding and chemically analyzing hard seeds that are not ground or only broken into large fragments in the gizzard may overestimate the nutritional value of those seeds for grouse. Seed weight data were used to calculate minimum and maximum estimates of ME and other nutritional variables in crop contents, which will be described later.

Nutritional Analyses of Crop Contents

Separated crop contents were recombined (except seeds of soft fruits) and ground in a Wiley mill to pass a 30-mesh screen. Crop contents were analyzed for percent neutral

detergent solubles (NDS) by the method of Goering and Van Soest (1970), except sodium sulfite was not used (Mould and Robbins 1981b). Amylase treatment was used as described by Robertson and Van Soest (1977). Percent total phenols were measured colorimetrically using gallic acid as a standard (Singleton and Rossi 1965) after a 3-day extraction in an acetone/water solution (70:30). Gross energy was measured with a Parr adiabatic bomb calorimeter. The percent ME of the ground crop material (excludes seeds of soft fruits) was calculated from the NDS, total phenols, and the percentage of acorn and/or beechnut meat in the crop contents using the following equation (see Chapter 1):

$$ME = 0.87(NDS - \text{total phenols}) + 0.18(\%\ \text{acorn meat}) - 5.76$$

The kcal of ME per gram of dry matter was calculated from %ME and GE(kcal/g). Percent nitrogen of crop contents was measured by the VPI&SU Agronomy Laboratory with a Technicon autoanalyzer after digestion in concentrated sulfuric acid at 450 C. Crude protein was calculated as percent nitrogen times 6.25. When there was insufficient crop material for all analyses, priority was assigned in the following order: NDS, total phenols, GE, and nitrogen.

The lack of information on seed digestion by grouse was circumvented in the present study by calculating minimum and

maximum estimates of predicted ME, total phenols, and protein for crop contents that contained seeds of soft fruits. Estimates were calculated using values of the above nutritional variables for the seed and nonseed portions of the crop contents and the known proportion of seeds in the crop contents. Minimum values for predicted ME, total phenols, and protein were calculated from respective values for the nonseed portion of the crop contents, the proportion of seeds of soft fruits in the crop contents, and assuming that the contribution of ME, total phenols, and protein by seeds was zero (seeds undigested). To calculate maximum values, measurements of predicted ME, total phenols, and protein for ground seeds were made by species. Maximum values for the predicted ME, total phenols, and protein in crop contents (seeds included) then were calculated from the respective values of ME, total phenols, and protein of the nonseed portion of the crop contents, the respective values of ME, total phenols, protein of seeds in the crop contents, and the proportion of seeds of soft fruits in the crop contents. Average values of nutritional variables for species of seeds were used because most crops contained insufficient amounts of seeds for analyses. Calculating minimum and maximum values not only gave a range of estimates for nutritional variables for crop contents that

contained soft fruits, but also provided useful information for evaluating the nutritional contribution of soft fruits to the diet of grouse.

The predicted ME, total phenols, and protein in ground seeds of soft fruits were determined by grinding the seeds through a 30-mesh screen and measuring NDS, total phenols, GE, and nitrogen. All seeds were from the crops of wild grouse. ME was predicted from NDS and total phenols with the equation described earlier. These data were used to calculate maximum values of ME, total phenols, and protein in crop contents as described above. Greenbrier seeds and parts of the outer seed coats of dogwood and blackgum were difficult to grind in a Wiley mill and were only ground fine enough to pass a 20-mesh screen. Seeds of some fruits occurred in crops in quantities too small to chemically analyze. For those crops, seeds of unanalyzed species were assigned the values of predicted ME, total phenols, and protein of the nonseed portion of the crop contents when calculating maximum values. However, unanalyzed seeds constituted only a small percentage of the seeds of soft fruits found in crops and an even lower percentage of the total crop contents. Therefore, these seeds had little effect on estimates of nutritional variables. However, any effect of unanalyzed seeds would tend to be conservative

(calculated maximum values would include the true maximum predicted value) because the predicted ME, protein, and total phenol content of the nonseed crop contents typically were greater than values for most hard seeds.

Food habits data for each month were expressed as percentages of forage classes in the aggregate weight of all crop contents for each month. Therefore, monthly values of ME (% and kcal/g), total phenols, and protein were calculated as percentages or kcal/g of the aggregate total crop content weights or gross energy (equivalent to a weighted mean with heavier crops having a greater influence on results) for each month in order that food habits and nutritional variables would be directly comparable.

Standard errors (SE) of these weighted means were calculated as follows (Hal Wilson, Statistical Consulting Center, Virginia Polytechnic Institute and State University, pers. comm.):

$$SE = \left[\frac{\sum W_i^2 \times S^2}{(\sum W_i)^2} \right]^{\frac{1}{2}}$$

where: SE = standard error of the weighted mean.

W_i = the proportion of the dry weight of crop content i in the aggregate weight of crop contents in a monthly sample. Note: $(\sum W_i)^2=1$ for these calculations because weights were proportions.

S^2 = sample variance for the unweighted mean.

The SE of the weighted mean is greater than the SE of the unweighted mean when all W values are not equal.

Dietary protein levels were evaluated with respect to the ME content of the diet because dietary energy levels largely determine dry matter intake (Maynard et al. 1979, Scott et al. 1982) and, therefore, influence protein intake. A protein-energy (P/E) ratio (g protein per 100 kcal ME) of the diet was calculated for each month using the aggregate monthly protein and ME (kcal/g) values. The P/E ratio provides a basis for comparing the crude protein intake of grouse on diets or forages of differing ME content. Ratios were similar within a month, regardless if they were calculated using corresponding minimum or maximum values of ME and protein because ME and protein estimates of soft fruit diets were both dependent on the degree of digestion of hard seeds.

Nutritional Analyses of Individual Forages

Estimates of the predicted ME, total phenol, and protein content of individual forages selected by grouse were made by analyzing forage samples obtained from crops. Except for clover, individual species of herbaceous plants

were not found in crops in sufficient amounts for chemical analyses. Crops that contained 100% herbaceous leaves (typically containing many species) were analyzed as samples of mixed herbaceous leaves. No attempt was made to determine the species composition of these samples.

Levels of tannin and nontannin phenols in selected hand-collected winter forages of grouse also were measured. Because phenols are affected by forage storage and drying treatments (see Chapter 1), only fresh, hand-collected forages were used for tannin analyses in order to obtain the most accurate measurements possible. Tannin phenols were measured by determining total phenols (Singleton and Rossi 1965) before and after precipitation of tannins with cinchonine sulfate at pH 7.0-8.0 (Brugirard and Travernier 1952, Peri and Pompei 1971). The aqueous-acetone solution used to extract phenols from forage samples blocked the precipitation of tannins by cinchonine sulfate. This problem was circumvented by evaporating the acetone from 25ml aliquots of the forage extract using a steady stream of filtered air just prior to phenol analyses and tannin precipitation. The extract was restored to original volume with distilled water. Removal of acetone during a 4-hour period just prior to analyses did not affect total phenol values.

Forages of grouse from southeastern states were collected for tannin analysis in November and December in southwestern Virginia. Samples were immediately freeze-dried and stored dessicated at 5 C. Forages of grouse from northern states were collected in December in central New York and frozen. Frozen samples were transported to VPI&SU (without thawing) within 48h of collection and immediately freeze-dried. Forages also were analyzed for NDS to compare predicted ME values of hand-collected forages with forages from crops.

Carcass Fat Analysis

Gizzards, wings, and central tail feathers of ruffed grouse were collected with crop contents from North Carolina. Percent carcass fat for these grouse was predicted from the weight of the fat attached to gizzard (GFW) using the equation described in Chapter 2:

$$\text{Carcass fat} = 19.2[\log (GFW+1)] + 2.2$$

Grouse were aged by the shape of the contour of the 9th and 10th primaries. Sex was determined by the length of the central tail feather using classification criteria published for Ohio (Davis et al. 1969). To improve the accuracy of sex classification, data for grouse with tail lengths that fell between classification division points (3% of observations) were not used. Sex, age, and month

differences in predicted carcass fat were tested by ANOVA using SAS (Ray et al. 1982).

RESULTS

A total of 1005 crops was collected, including 395 crops from the southeastern states of Virginia, North Carolina, and Georgia, 490 from the northern states of Wisconsin, New York, Maine, and Washington, and 120 from West Virginia, Indiana, and Ohio. Thirteen crops collected in southeastern West Virginia were included as part of the Virginia sample, because these crops were collected in counties adjacent to the Virginia collection sites. One hundred and sixty (16%) collected crops did not contain food material. The distribution of collections by county is summarized in Appendix Table 3.2.

Forage Quality

Analyses of Forages from Crops--Soft fruit flesh had relatively low total phenol levels and high, but variable ME content (Table 3.1). With the exception of rose and viburnum, soft fruit flesh had ME levels greater than or equal to 50% and 2.50 kcal/g. Mean protein levels of fruit ranged from 4.4-10.2%, and protein levels and P/E ratios of fruit were generally lower than other forages.

Table 3.1. Neutral detergent solubles (NDS), total phenols, metabolizable energy, crude protein, and protein-energy (P/E) ratio (g protein/100 kcal ME) of selected forages obtained from crop contents of ruffed grouse. The number (N) of crop samples analyzed precedes values for nutritional variables.

Forage	N	NDS (%) $\bar{x}$	NDS (%) SE	Total phenols (%) $\bar{x}$	Total phenols (%) SE	Metabolizable energy (%) $\bar{x}$	Metabolizable energy (%) SE	N	Gross energy (kcal/g) $\bar{x}$	Gross energy (kcal/g) SE	Metabolizable energy (kcal/g) $\bar{x}$	Metabolizable energy (kcal/g) SE	N	Crude protein (%) $\bar{x}$	Crude protein (%) SE	P/E[2] ratio
Fruits[1]																
Apple	4	81.1	1.9	2.6	0.9	63	1.7	4	4.06	0.01	2.54	0.06	4	4.8	1.0	1.89
Grape	8	78.8	1.8	2.7	0.4	60	1.6	5	4.11	0.06	2.49	0.05	6	8.7	0.6	3.49
Greenbrier	4	76.1	2.9	1.2	0.2	59	2.5	4	4.53	0.06	2.68	0.08	4	7.7	1.0	2.87
Dogwood	4	65.9	1.1	2.0	0.3	50	1.2	4	5.27	0.23	2.63	0.16	4	10.0	1.7	3.80
Viburnum	3	60.4	5.0	0.7	0.1	46	4.2	3	4.63	0.11	2.13	0.15	3	4.6	0.6	2.15
Blackgum	1	82.7		2.5		64		1	4.93		3.16		1	8.1		2.56
Hawthorn	1	80.7		3.7		61		1	4.09		2.50		1	4.4		1.76
Rose	3	66.2	1.8	2.3	0.4	50	1.9	3	4.32	0.04	2.15	0.06	3	10.2	0.3	4.74
Mountain ash	2	82.3	2.1	3.0	0.0	63	1.8	2	4.39	0.10	2.77	0.02	2	6.6	0.3	2.38
Maple	5	65.4	2.2	14.9	2.3	38	1.8	5	5.27	0.04	2.01	0.09	5	19.7	3.3	9.80
Acorn (w/o shells)	2	89.4	3.4	11.1	2.5	78	0.2	2	4.54	0.31	3.55	0.18	2	8.0	1.1	2.25
Acorn (w/shells)	2	66.6	1.3	7.9	0.6	57	1.9	2	4.95	0.18	2.80	0.10	2	7.0	0.2	2.50
Beechnut (w/shells)	3	56.7	5.0	1.4	0.2	53	4.3	1	5.50		2.70		2	15.3	1.0	5.67
Leaves, woody plants																
Apple	6	75.5	1.2	5.5	0.6	55	1.2	5	4.74	0.03	2.64	0.06	6	13.9	0.8	5.27
Quaking aspen	2	72.6	0.4	5.5	1.1	53	1.3	1	5.00		2.70		1	12.7		4.70
Greenbrier	8	72.4	1.0	6.7	0.5	51	0.6	7	4.74	0.03	2.44	0.02	7	13.1	0.5	5.37
Laurel	4	70.7	1.9	15.5	0.6	42	1.3	3	4.99	0.13	2.11	0.05	3	9.2	0.4	4.36
Leaves, herbaceous plants																
Clover	4	74.6	1.5	2.1	0.3	57	1.3	4	4.28	0.07	2.57	0.08	4	29.1	0.6	11.32
Mixed-N. Carolina	3	82.1	1.1	3.7	1.6	63	1.0	2	4.32	0.04	2.74	0.02	2	21.2	3.6	7.74
Mixed-Virginia	6	81.8	2.4	2.9	0.3	63	2.3	4	4.28	0.02	2.78	0.11	3	24.5	3.9	8.81
Mixed-Maine	8	77.0	1.0	2.6	0.6	59	1.0	5	4.49	0.05	2.69	0.09	6	27.1	1.7	10.07
Mixed-New York	3	79.8	2.3	6.2	5.0	58	5.9	1	4.16		2.77		2	23.1	2.1	8.34
Mixed-Wisconsin	2	72.2	1.3	3.4	1.6	54	0.3	1	4.36		2.37		1	26.1		11.01

Table 3.1. Continued.

Forage	NDS (%) N	NDS (%) $\bar{x}$	NDS (%) SE	Total phenols (%) $\bar{x}$	Total phenols (%) SE	Metabolizable energy (%) $\bar{x}$	Metabolizable energy (%) SE	Gross energy (kcal/g) N	Gross energy (kcal/g) $\bar{x}$	Gross energy (kcal/g) SE	Metabolizable energy (kcal/g) $\bar{x}$	Metabolizable energy (kcal/g) SE	Crude protein (%) N	Crude protein (%) $\bar{x}$	Crude protein (%) SE	P/E[2] ratio
Ferns																
Christmas fern	2	47.7	1.0	2.2	0.6	34	0.4	1	4.26		1.45					
Buds and twigs																
Cherry	3	50.2	0.6	3.6	0.5	35	0.5	4	4.73	0.38	1.65	0.03	4	16.4	2.0	9.93
Birch	3	48.9	7.7	6.2	1.5	31	5.9	3	5.03	0.28	1.59	0.33	3	11.0	0.9	6.91
Aspen	1	42.8		4.4		28		1	4.98		1.38		1	15.4		11.16
Hazelnut	1	47.2		9.4		27		1	4.87		1.32		1	9.9		7.50
Catkins																
Birch	6	57.8	1.5	7.6	0.7	38	0.8	6	5.47	0.48	2.06	0.05	6	11.9	0.4	5.78
Hazelnut	6	60.9	1.3	6.9	0.6	41	0.8	6	4.58	0.39	1.89	0.04	6	14.7	0.6	7.78
Hophornbeam	1	56.0		6.4		37		1	4.86		1.82		1	14.0		7.69

[1]Values for soft fruits are for the fruit flesh only (i.e. seeds excluded).

[2]Calculated from mean ME (kcal/g) and crude protein values.

Seeds from the nine species of soft fruits in Table 3.2 constituted 88% by weight of the seeds of soft fruits found in all crops in the study and 92-99% of the seeds of soft fruits in crops from southeastern states where fruit use was most common. The predicted ME of ground seeds of soft fruits was low, ranging from 12% and 0.53 kcal/g for dogwood to 48% and 2.44 kcal/g for honeysuckle (Table 3.2). Levels of total phenols in seeds were generally low (<4%), except for viburnum (8.9%) and honeysuckle (5.1%). Protein levels in seeds were variable and ranged from 3.1% for hawthorn to 12.7% for greenbrier. The low ME of seeds substantially lowers the overall ME content of soft fruits. For example, seeds of greenbrier, dogwood, grape, and rose compose approximately 50% of the fruit dry matter. The range in ME values for these fruits is 31-43% when the contribution of seeds is included, compared to a range of 50-60% for the fruit flesh.

Acorn meat had the highest ME (78% and 3.55 kcal/g) of all forages analyzed (Table 3.1). With shells included, the ME of acorn and beechnut samples were within the range of ME values of soft fruits flesh. Acorns were not identified to species, but are known to be variable in phenol content (Ofcarcik and Burns 1971) and may be variable in ME. Beechnut had the highest GE (5.50 kcal/g) of all forages

Table 3.2. Neutral detergent solubles (NDS), total phenols, metabolizable energy, gross energy, and crude protein content of seeds of selected soft fruits collected from crops of ruffed grouse. The number of crop samples analyzed precedes values for nutritional variables.

	NDS (%)		Total phenols (%)		Metabolizable energy (%)			Gross energy (kcal/g)		Metabolizable energy (kcal/g)			Crude protein (%)	
Seed	N	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	N	$\bar{x}$	SE	$\bar{x}$	SE	N	$\bar{x}$	SE
Greenbrier	5	31.3	2.9	0.2	0.1	21	2.5	5	5.00	0.04	1.06	0.12	5	12.7	0.7
Dogwood	5	20.8	1.6	0.7	0.1	12	1.4	5	4.58	0.05	0.53	0.06	5	5.7	0.5
Grape	5	39.1	0.7	3.7	0.3	25	0.8	5	5.56	0.06	1.39	0.05	5	10.0	0.6
Hawthorn	5	25.8	4.7	0.6	0.1	16	4.1	3	4.70	0.06	0.55	0.25	2	3.1	0.5
Sumac	5	25.4	1.9	1.9	0.2	15	1.8	4	4.87	0.07	0.75	0.12	5	8.2	0.9
Rose	5	46.9	1.4	2.5	0.2	33	1.3	4	4.36	0.05	1.46	0.07	5	8.5	0.8
Viburnum	5	46.4	1.3	8.9	0.9	27	0.5	4	5.42	0.07	1.48	0.03	3	8.8	0.3
Japanese honeysuckle	2	66.9	0.3	5.1	1.8	48	1.3	1	4.94		2.44				
Black gum	1	29.4		1.1		19		1	5041		0.95				

tested and a relatively high protein content (15.3%). Maple fruit had the second highest total phenol content (14.9%), of all forages tested and the highest protein content (19.7%) of all fruits. However, the ME of maple fruit was low (38% and 2.01 kcal/g) due to a combination of low NDS and high total phenols.

The deciduous leaves of apple, aspen, and greenbrier had ME values that ranged from 51-55%, which was less than most soft fruit flesh (Table 3.1). However, the relatively high GE content of deciduous leaves resulted in ME (kcal/g) values similar to most soft fruit flesh. Mountain laurel, a woody evergreen forage, had a lower ME (42%, 2.11 kcal/g) than the leafy deciduous forages and the highest total phenol level (15.5%) of all forages analyzed. Leaves of woody plants tended to have higher P/E ratios than most fruits.

Clover was relatively high in ME (57%, 2.57 kcal/g) and had the highest protein content (29.1%) and P/E ratio of all forages analyzed (Table 3.1). Samples of mixed herbaceous leaves were similar to clover in both ME and protein. The P/E ratios for herbaceous leaves were higher than most fruits, woody leaves, ferns, some buds and twigs, and some catkins. Christmas fern had the lowest ME of all leafy forages. Christmas fern contained a little more than one-half the ME (kcal/g) of the mixed herbaceous leaf samples.

The ME of buds and twigs (27-35%, 1.32-1.65 kcal/g) was lower than all other forage classes, with the exception of Christmas fern and some soft fruits with seeds. The protein content and P/E ratios of buds and twigs were variable, but moderately high. Total phenol levels in bud and twig samples were variable, ranging from 3.6% for cherry to 9.6% for hazelnut. The ME of catkins (37-41%, 1.82-2.06 kcal/g) tended to be slightly higher than buds and twigs, but lower than deciduous leaves and some fruits. Birch catkins (5.47 kcal/g) had the highest GE of all forages analyzed. Phenol levels in catkins were moderate. Mean protein levels ranged from 11.9% for birch catkins to 14.7% for hazelnut catkins. Ratios of protein to energy in catkins were greater than fruits and leaves of woody plants, but less than most herbaceous leaves and some buds and twigs.

Analyses of Hand-Collected Forages--Evergreen leaf forages had higher levels of total phenols (12.5-16.3%) and tannin phenols (6.5-7.8%) than all other forages with the exception of maple fruit (Table 3.3). Maple fruit contained an exceptionally high 16.4% tannin. All soft fruit flesh contained <2% tannins. Tannin levels in greenbrier and honeysuckle leaves were less than in apple and bigtooth aspen leaves. Tannins in buds and twigs were variable ranging from 0.6% for aspen twigs to 4.3% for quaking aspen

Table 3.3. Percent neutral detergent solubles (NDS), total phenols, tannin phenols, nontannin phenols, and metabolizable energy (ME) of hand-collected winter forages of ruffed grouse in New York or Virginia.

Forage[1],[2]	NDS	Total phenols	Tannin phenols	Non-tannin phenols	ME
Fruits					
Apple	90.9	1.5	0.2	1.3	72
Grape	86.2	4.3	1.8	2.5	66
Greenbrier	77.6	6.6	0.1	6.5	56
Flowering dogwood	72.3	4.5	1.9	2.6	53
Multiflora rose	75.1	2.9	1.6	1.3	57
Striped maple	60.8	18.3	16.4	1.9	31
Deciduous leaves					
Apple	77.2	9.8	1.3	8.5	53
Bigtooth aspen	70.5	10.2	4.3	5.9	47
Greenbrier	75.2	9.9	0.4	9.5	51
J. honeysuckle	79.7	5.3	0.0	5.3	59
Evergreen leaves					
Mountain laurel	67.9	16.3	6.7	9.6	39
Trailing arbutus	62.7	13.0	7.8	5.2	37
Wintergreen	69.1	12.5	7.4	5.1	43
Christmas fern	64.6	13.1	6.5	6.6	39
Buds and twigs					
Yellow birch b.	44.7	8.3	2.9	5.4	26
Black cherry b.	76.4	6.4	2.4	4.0	55
Quaking aspen lb.	44.6	7.7	3.1	4.6	26
Quaking aspen fb.	57.3	10.1	4.3	5.8	35
Yellow birch t.	52.5	8.1	1.8	6.3	33
Black cherry t.	52.3	8.3	3.7	4.6	33
Quaking aspen t.	65.9	6.3	0.6	5.7	46
Catkins					
Yellow birch	64.3	9.0	1.8	7.2	42
Gray birch	65.6	8.9	3.4	5.5	44
Speckled alder	65.4	11.4	1.5	9.9	41

[1]Values for soft fruits are for the fruit flesh only (i.e. seeds excluded).

[2]Plant part abbreviations: b.=buds, lb.=leaf buds, fb.=flower buds, t.=3-5 cm of twigs proximal to buds, l.=leaves.

flower buds. Tannin levels in catkins were low and within the range of values for buds and twigs.

Total phenols, NDS, and predicted ME values of selected forages from crops and hand-collected samples were compared with paired-t tests to determine if nutritional characteristics of crop and hand-collected forage samples were different. Comparisons were made with fruits of apple, grape, greenbrier, flowering dogwood, rose, and maple; leaves of apple, greenbrier, and mountain laurel; Christmas fern fronds; and yellow birch catkins. Buds and twigs were not used in these comparisons because of unknown ratios of buds to twigs in crops. Total phenols and NDS levels were 3.0 and 5.0 percentage units, respectively, greater ($P<0.02$) in hand-collected samples than crop samples (Tables 3.1 and 3.3). However, ME was not different ($P=0.28$) because differences in NDS and total phenols were nearly offsetting (i.e. total phenols are subtracted from NDS) in the ME prediction equation.

Regional Food Habits and Diet Quality

Georgia, North Carolina, Virginia--The monthly changes in the foods found in the crops of grouse from these three states were similar (Table 3.4), with only a few notable exceptions. Soft fruits made up 40-90% of the crop contents

Table 3.4. Foods from crops of ruffed grouse collected in ten states during the fall and winter between November 1981 and February 1984. Values are frequency of occurrence (number of crops) and percent dry weight by forage class.[1]

Month	No. of crops with food	Leaves: Deciduous woody plants Freq.	Leaves: Deciduous woody plants %	Leaves: Evergreen woody plants Freq.	Leaves: Evergreen woody plants %	Leaves: Herbaceous plants Freq.	Leaves: Herbaceous plants %	Ferns Freq.	Ferns %	Hard fruits Freq.	Hard fruits %	Soft fruits Freq.	Soft fruits %	Buds and twigs Freq.	Buds and twigs %	Catkins Freq.	Catkins %	Animal matter Freq.	Animal matter %
Georgia																			
Nov	5	2	1.1	1	0.1	4	6.9	1	t	1	0.4	3	89.8	1	t	1	1.0	0	0
Dec	14	6	12.3	9	18.4	9	14.3	6	4.7	1	7.2	4	40.7	6	2.3	0	0	0	0
Jan	34	11	10.8	14	10.8	22	20.8	15	9.9	5	33.4	5	11.8	12	1.5	3	1.0	0	0
Feb	15	4	29.7	7	32.1	9	8.2	7	11.3	2	8.1	0	0	7	5.2	1	t	0	0
N. Carolina																			
Nov	43	7	3.2	4	2.6	24	8.3	9	2.7	8	5.8	26	68.8	9	6.1	0	0	1	t
Dec	42	13	5.8	12	11.3	32	15.9	22	10.7	2	0.3	19	48.7	23	6.5	0	0	0	0
Jan	26	12	5.0	6	13.3	19	5.2	13	5.3	5	8.6	15	58.7	18	3.1	1	t	0	0
Feb	28	10	2.6	11	44.4	18	18.0	13	16.2	5	5.0	5	9.7	9	3.1	0	0	2	t
Virginia																			
Nov	32	10	3.9	6	1.5	17	2.2	5	1.1	12	15.9	25	72.2	9	2.4	2	t	0	0
Dec	48	25	17.1	5	0.7	34	14.1	8	1.1	10	3.9	29	47.9	27	12.0	7	2.8	0	0
Jan	43	20	12.4	7	9.7	26	7.4	16	3.3	3	0.6	21	53.3	26	9.6	4	1.1	1	t
W. Virginia																			
Dec	9	0	0	1	t	2	1.8	2	0.6	1	0.3	5	29.5	6	66.4	1	1.2	0	0
Jan	8	1	6.6	2	3.8	2	5.6	6	10.2	1	0.2	3	18.1	7	55.1	0	0	0	0
Feb	9	3	0.6	2	0.2	3	3.9	2	0.2	1	3.2	8	90.2	4	1.5	0	0	0	0
Ohio																			
Nov	4	2	0.4	0	0	1	0.3	0	0	0	0	4	99.3	0	0	0	0	0	0
Dec	11	4	2.5	0	0	3	0.2	5	4.3	0	0	7	92.5	2	0.3	0	0	0	0
Jan	23	5	2.1	0	0	16	9.8	10	8.3	1	t	18	69.2	13	2.1	3	5.5	0	0
Feb	13	3	2.9	0	0	9	36.2	5	12.6	1	t	7	38.5	6	2.0	0	0	0	0
Indiana																			
Oct	3	0	0	0	0	0	0	0	0	0	0	2	99.6	1	t	0	0	0	0
Nov	8	3	0.6	0	0	2	0.4	0	0	0	0	6	97.2	4	1.9	0	0	0	0
Dec	3	0	0	0	0	3	7.3	2	5.4	0	0	2	86.3	0	0	0	0	0	0
Jan	3	1	3.0	0	0	1	14.1	1	5.8	1	30.8	2	15.4	1	0.7	1	30.3	0	0

Table 3.4. Continued.

Month	No. of crops with food	Leaves: Deciduous woody plants Freq.	Leaves: Deciduous woody plants %	Leaves: Evergreen woody plants Freq.	Leaves: Evergreen woody plants %	Leaves: Herbaceous plants Freq.	Leaves: Herbaceous plants %	Ferns Freq.	Ferns %	Hard fruits Freq.	Hard fruits %	Soft fruits Freq.	Soft fruits %	Buds and twigs Freq.	Buds and twigs %	Catkins Freq.	Catkins %	Animal matter Freq.	Animal matter %
New York																			
Sep	4	1	12.7	0	0	1	0.7	0	0	4	21.9	2	64.6	0	0	0	0	1	0.2
Oct	31	8	20.3	1	0.2	13	7.9	3	0.5	8	4.0	17	32.7	11	26.0	2	3.1	6	2.6
Nov	20	0	0	0	0	14	8.1	8	0.6	3	9.1	5	12.8	11	21.3	5	47.5	6	0.3
Dec	17	2	1.2	0	0	12	7.2	3	0.8	11	32.9	4	18.6	15	29.7	1	6.2	5	3.0
Jan	14	1	t	0	0	4	1.7	2	0.9	1	11.8	4	42.4	9	37.1	2	5.2	0	0
Feb	9	0	0	0	0	3	2.6	1	0.6	0	0	3	6.3	8	62.2	4	28.2	3	t
Wisconsin																			
Sep	27	2	0.3	0	0	2	0.3	1	t	10	72.7	11	19.7	0	0	1	0.8	1	t
Oct	42	6	3.4	1	t	22	6.3	5	1.3	6	16.2	13	38.3	19	4.2	20	28.2	0	0
Nov	11	1	1.2	0	0	10	22.1	4	2.2	1	2.6	4	17.4	6	5.6	7	43.8	1	t
Washington																			
Sep	19	5	4.0	0	0	13	15.9	0	0	1	0.2	16	76.1	2	t	0	0	3	0.4
Oct	2	0	0	0	0	1	1.5	0	0	1	18.2	2	52.6	1	11.4	0	0	0	0
Nov	4	0	0	0	0	2	5.8	0	0	0	0	4	54.9	0	0	0	0	1	0.1
Maine																			
Oct	178	80	25.5	1	t	90	10.3	9	t	59	15.8	69	25.6	65	8.1	50	11.7	19	t
Nov	19	4	1.9	1	0.2	12	6.4	1	t	7	29.4	16	55.5	14	5.0	1	t	5	t
Dec	14	1	2.1	0	0	9	10.6	3	1.8	6	15.0	5	4.0	12	27.3	5	39.0	2	t

[1]Difference between the sum of percentages in a month and 100% equals the percentage of unidentified foods from crops.

from November to January in all three states, except for January in Georgia. In that month hard fruits were used heavily in Georgia (33.4%). Fruits of grape, greenbrier, flowering dogwood, and oak were the most commonly used fruits (see Appendix Table 3.3 for data on species composition of forages identified in crops). In Georgia and North Carolina, the leaves of evergreen woody plants, ferns, and leaves of herbaceous species tended to increase in crops as fruits decreased. Evergreen leaves (93% and 56% mountain laurel in Georgia and North Carolina, respectively) and ferns (96% and 53% Christmas fern in Georgia and North Carolina, respectively) made up 43.4% of the crop contents in Georgia and 60.2% in North Carolina in February. Buds and twigs were more common in crop contents from Virginia than in those from Georgia and North Carolina.

The ME of crop contents from Georgia increased as soft fruits declined in importance and reached a high of 54-55% and 2.49-2.56 kcal/g in January when acorns and herbaceous leaves were the most common food items (Figures 3.1 and 3.2). In months when soft fruits composed >50% of the crop contents in Virginia and North Carolina, ranges of monthly ME estimates varied from lows of 33-40% and 1.59-1.89 kcal/g to highs of 39-45% and 1.77-2.08 kcal/g. In February, when evergreen leaves and ferns were commonly eaten, the ME of

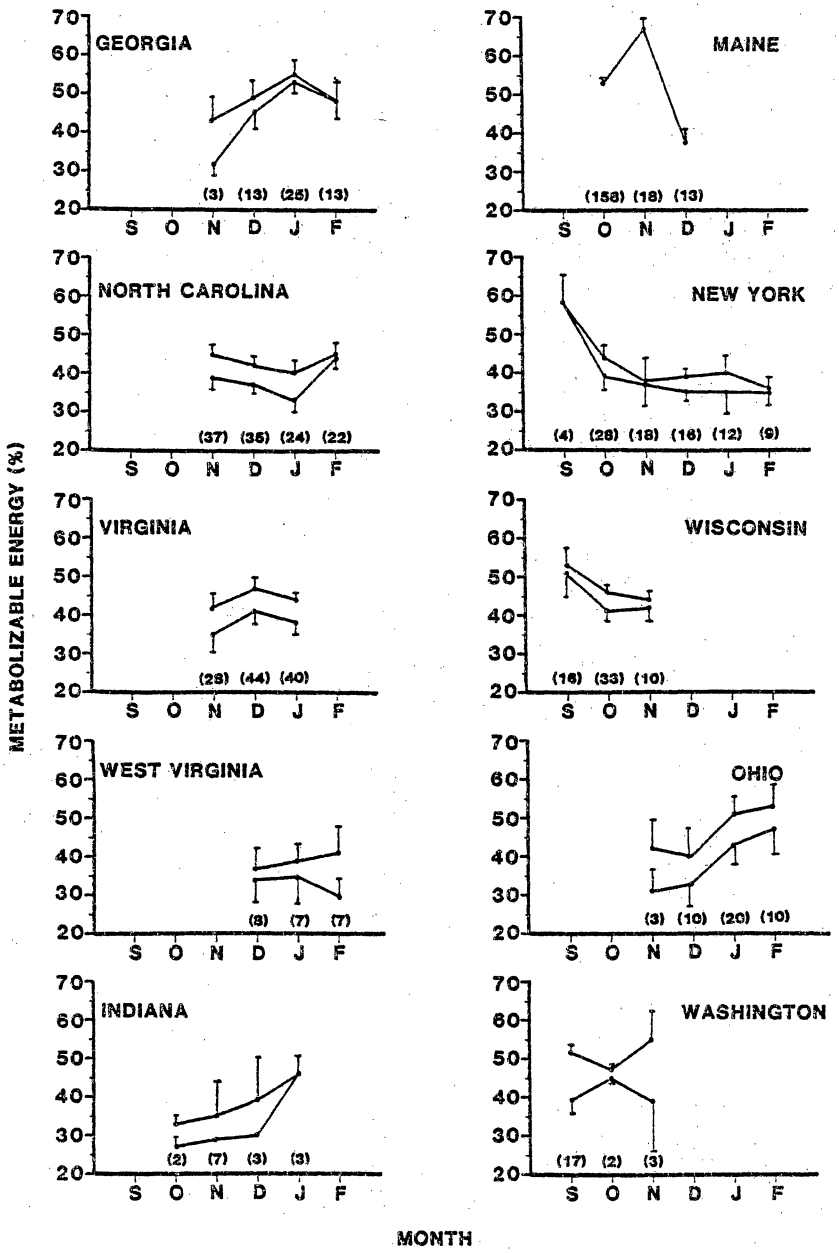

Fig. 3.1. Minimum and maximum estimates of predicted metabolizable energy (%) in foods from crops of ruffed grouse collected in ten states from 1981 to 1984. Values are weighted means and standard errors of weighted means. Number of crops analyzed is in parentheses.

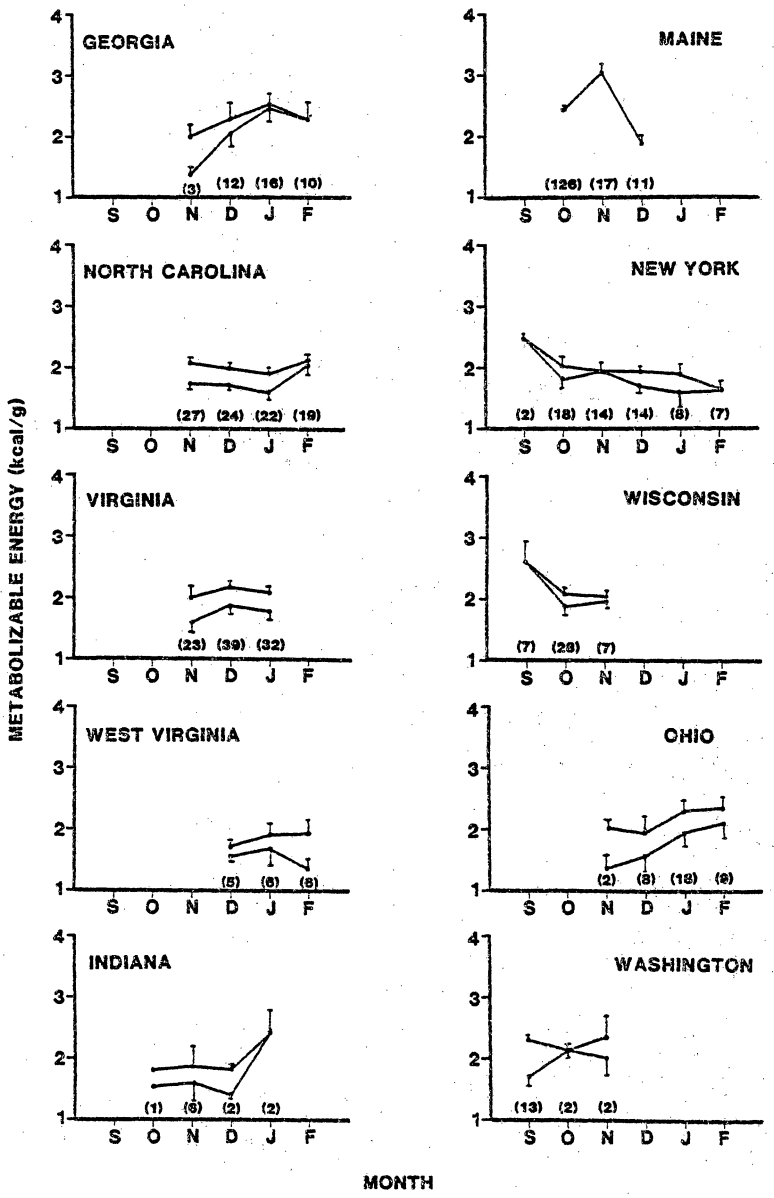

Fig. 3.2. Minimum and maximum estimates of predicted metabolizable energy (kcal/g) in foods from crops of ruffed grouse collected in ten states from 1981 to 1984. Values are weighted means and standard errors of weighted means. Number of crops analyzed is in parentheses.

diets in Georgia (48%, 2.26 kcal/g) and North Carolina (44-45%, 2.03-2.10 kcal/g) were similar. The decline in estimated ME in North Carolina from November to January can be attributed in part to the greater use of dogwood fruit in December and January. The seeds of dogwood have a low ME (12%). The low dietary ME during the fall in all three states is largely the result of the low ME of seeds of soft fruits. However, the monthly ME values of the nonseed portion of the crop contents were relatively high (49-57%, 2.26-2.65 kcal/g) and tended to remain fairly constant or decline slightly from November to January in Georgia, North Carolina, and Virginia (Appendix Tables 3.4 and 3.5).

Total phenol levels in crop contents increased from November to January as a result of the dietary shift from soft fruits which are low in phenols to evergreen leaves, which are high in phenols (Figure 3.3). The 8.1% total phenol levels found in Georgia and the 9.1-9.6% level for North Carolina in February were the highest monthly estimates for all states. Total phenols were <5% in Virginia because soft fruits predominated in the diet in all months.

Protein (%) levels (Figure 3.4) in crop contents and ratios of protein to ME (Table 3.5) were relatively similar among months from December to February in all 3 states.

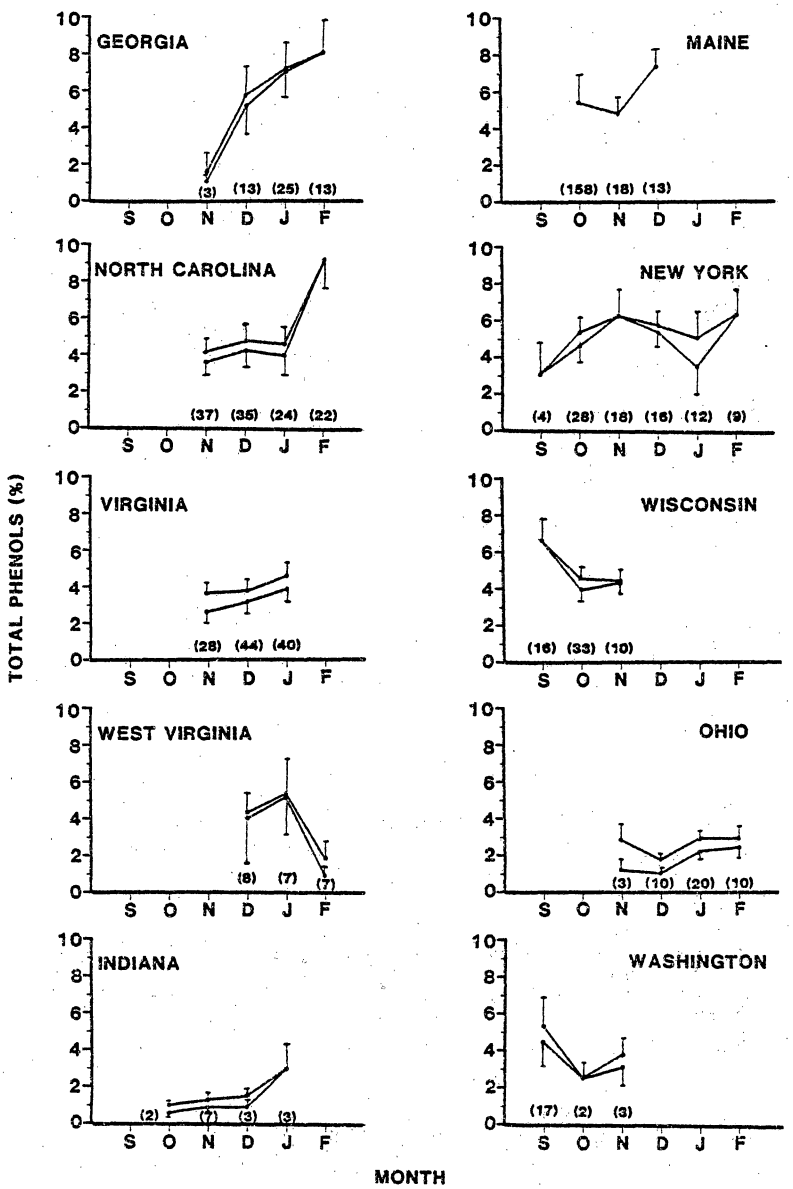

Fig. 3.3. Minimum and maximum estimates of total phenols (%) in foods from crops of ruffed grouse collected in ten states from 1981 to 1984. Values are weighted means and standard errors of weighted means. Number of crops analyzed is in parentheses.

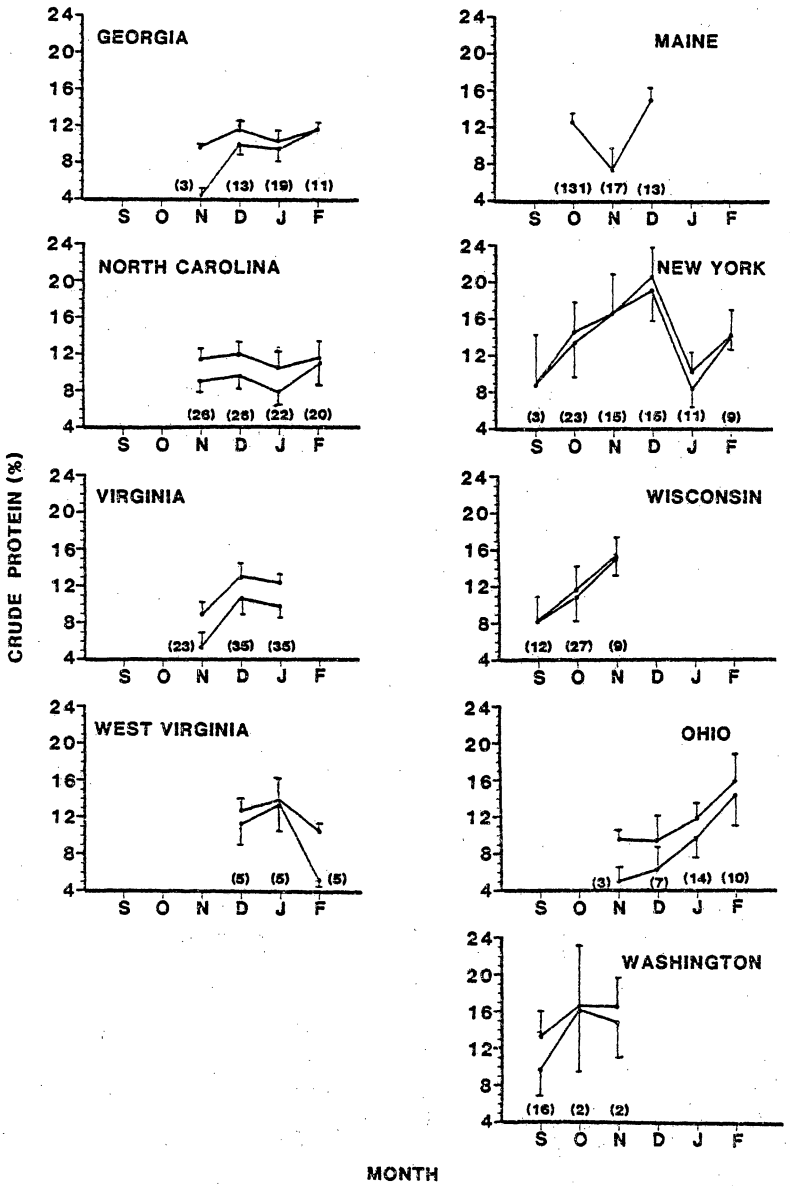

Fig. 3.4. Minimum and maximum estimates of crude protein (%) in foods from crops of ruffed grouse collected in ten states from 1981 to 1984. Values are weighted means and standard errors of weighted means. Number of crops analyzed is in parentheses.

Table 3.5. Ranges of ratios of crude protein to metabolizable energy (g protein/100 kcal ME) in foods from crops of ruffed grouse collected in nine states between November 1981 and February 1984.

State	Sep	Oct	Nov	Dec	Jan	Feb
Georgia			3.1-4.9	4.9-5.1	3.8-4.0	5.1
North Carolina			5.1-5.5	5.6-6.0	4.9-5.5	5.3-5.5
Virginia			3.3-4.4	5.7-6.0	5.5-5.9	
West Virginia				7.2-7.4	7.3-8.0	3.8-5.5
Ohio			3.7-4.7	4.0-4.9	5.0-5.1	6.8-6.9
New York	3.5	7.2-7.3	8.5	10.6-11.2	5.2-5.4	8.4-8.5
Wisconsin	3.0-3.1	5.6-5.8	7.5-7.6			
Washington	5.5-5.7					
Maine		5.1-5.2	2.5	8.0		

February values for protein were 11.6% and 10.8-11.5% in Georgia and North Carolina, respectively, when evergreen leaves were the most common foods eaten.

New York, Wisconsin, Maine, and Washington-- In New York, buds, twigs, and catkins made up the major portion of the winter diet (Table 3.4). Birch, aspen, hazelnut, and cherry buds occurred in relatively similar amounts except for February when cherry made up 89% of the buds and twigs. Yellow birch made up 79% of the catkins found in November, whereas hazelnut made up 100% of the catkin forage class in February. Apple and/or viburnum were the most common soft fruits found in September and December. The 42.4% value for soft fruit in January was largely the result of two crops that contained large amounts of viburnum fruit. Evergreen leaves and ferns were found in only trace amounts (Table 3.4).

The ME in crop contents from New York declined from 58% and 2.49 kcal/g in September to approximately 36% and 1.67 kcal/g in February (Figures 3.1 and 3.2). Phenol levels were highest in November (6.3%) when maple seeds (14.9% phenols) were common and in February (6.3-6.4%) when buds, twigs, and catkins made up 90.4% of the diet (Figure 3.3). Protein increased from 8.7% in September to >19% in December and was low in January (Figure 3.4). The high protein level

of December was largely the result of maple fruit (protein=19.7%), and the low level in January was the result of the low protein content of soft fruit. The protein content of the buds, twigs, and catkin diet of February was relatively high (13.8-14.3%).

In Wisconsin, hard fruits (90% acorns) made up 72.7% of the crop contents in September (Table 3.4). Catkins and herbaceous leaves became more important in the diet as fruits decreased. Hazelnut made up 76% of the catkin forage class in October and 87% in November. Dietary ME (53-54% and 2.70 kcal/g) was highest in September when acorns were common in crops (Figures 3.1 and 3.2). Total phenol levels decreased slightly from September to November. Protein levels in November (14.9-15.4) were nearly double those of September (Figure 3.4).

Soft fruits (68% apple) and deciduous leaves (85% apple) were of equal importance (>25%) in the diet of grouse in October in Maine (Table 3.4). Hard fruits (77% acorn) and soft fruit (99% apple fruit) made up a total of 85% of the crop contents collected in November, whereas buds, twigs, and catkins were most important in December. The catkin forage class in December was composed of 41% birch and 59% hophornbeam.

The ME levels in crop contents from Maine increased from 53% and 2.40-2.43 kcal/g in October to 67% and 3.00 kcal/g in November and then decreased to 38% and 1.86-1.88 kcal/g in December (Figures 3.1 and 3.2). The ME estimates for Maine in November were the highest monthly estimates for all states and the result of the presence of large quantities of highly digestible apple fruit and acorns. Both total phenol and protein levels decreased from October to November as a result of the low levels of phenols and protein in apple fruit (Figures 3.3 and 3.4), but increased again in December when buds and twigs were common in crops. The greatest P/E ratios for all states were found for months when buds, twigs, and/or catkins were the primary forages (Table 3.5).

A regional comparison of diet quality was made for crops collected within the state of Maine. The food habits and diet quality of grouse that were known to have been collected in northern forested areas of Maine were compared with data for grouse known to have been collected from more disturbed habitats or agricultural areas of southern Maine. Crops from the southern region came from the coastal counties of Cumberland, Kennebec, Sagahahoc, and Waldo. Crops from the northern region were from forested areas of Aroostock and Somerset counties. Crops from the southern

region contained mostly fruits in October and November, whereas crops from the northern region had less fruit and more buds, twigs, and catkins in October (Table 3.6). The ME of the diet of grouse from northern forested habitats in October (47%) was 21 percentage units less than the ME in the southern region. Protein levels were high in October in the northern region (17.4%) and in December in the southern region (19.3%) when leaves, buds, twigs, and catkins made up the majority of the crop contents. Protein levels were lowest in crops collected in October (9.5%) and November (8.3%) in the southern region when fruits predominated. Most of the crops from unknown habitats probably came from areas similar to the southern region because of the similarity of food habits data for the southern region and the overall state-wide collection.

Soft fruits composed most the small number of crop contents collected in Washington (Table 3.4). As a result, total phenol levels were relatively low (2.5-6.4%, Figure 3.3), and ME values (39-55%, 1.70-2.32 kcal/g) for the crop contents were similar to ranges of values for other crop collections composed of soft fruits (Figures 3.1 and 3.3).

Ohio, West Virginia, Indiana-- In contrast to Georgia, North Carolina, and Virginia, evergreen leaves were found in few crops from these east-central states. Ferns were still

Table 3.6. Percent composition of foods in crops by forage class and the metabolizable energy and crude protein content of foods from crops of grouse collected in northern forested and southern agricultural areas of Maine during the 1982-83 and 1983-84 hunting seasons.

Month	No. of crops with food	Food habits[1]									ME[2] (%)			ME[2] (Kcal/g)			Crude[2] protein (%)		
		DWL	EWL	HL	FN	HF	SF	BT	CA	AM	$\bar{X}$	SE	N	$\bar{X}$	SE	N	$\bar{X}$	SE	N
Northern																			
October	63	12.3	0	23.5	0.1	20.7	4.4	13.6	19.4	t	46	2.0	53	2.20	0.08	43	17.4	1.3	44
Southern																			
October	18	34.5	0	2.0	t	44.5	17.6	0.5	0.2	0.3	67	3.3	17	3.17	0.05	12	9.5	1.5	13
November	12	0.9	0	10.6	0	12.4	70.1	3.7	0.1	0.1	63	2.4	12	2.66	0.16	12	8.3	3.3	12
December	7	14.4	0	43.4	10.4	0.6	18.4	12.6	0	0.3	53	3.7	6	2.30	0.14	5	19.3	0.8	6

[1]DWL=leaves of deciduous woody plants, EWL=leaves of evergreen woody plants, HL=leaves of herbaceous plants, FN=ferns, HF=hard fruit, SF=soft fruit, BT=buds and twigs, CA=catkins, AM=animal matter.
[2]Minimum and maximum estimates differed by less than 1%; therefore, only maximum estimates are reported.

found in substantial quantities (>10%) in some months. Buds and twigs were utilized heavily in West Virginia, but were found only in small quantities in Ohio.

In Ohio, soft fruits declined in importance during the fall and winter, but still were the forage class taken in the greatest amount in all months (Table 3.4). Grape, dogwood, and greenbrier were the most common fruits in November and December, while rose fruit and to a lesser extent honeysuckle and sumac fruit predominated in crops in January and February. Herbaceous leaves were more common in crops as fruits declined in January and February. Ferns made up 12.6% of the crop contents in Ohio in February, but evergreen leaves of woody plants were not found in crops. Most crops were collected in southeast Ohio, and the high use of fruits and leaves was consistent with a previous report on food habits of grouse in that region of the state (Stoll et al. 1980).

Dietary ME increased from November to February in Ohio as the influence of low digestible seeds of soft fruits decreased (Figures 3.1 and 3.2). However, monthly ME values for the nonseed crop contents remained stable (56-60%, 2.51-2.66 kcal/g) from November to February (Appendix Tables 3.4 and 3.5). Total phenol levels were low (<4%) as a result of the high use of soft fruits (Figure 3.3). Protein

levels increased substantially from November to February (Figure 3.4) as levels of high protein herbaceous leaves increased in the diet and to a lesser degree the late winter use of rose fruit, which has a higher protein content than grape and greenbrier fruit. The P/E ratio in Ohio in February also was greater than ratios in Georgia and North Carolina because of the low use of low protein evergreen leaves and the high use of high protein herbaceous leaves in Ohio (Table 3.5).

In West Virginia, buds and twigs occurred in the majority of crops and made up over 50% of the crop contents in December and January (Table 3.4). Cherry spp. made up 90% of the buds and twigs in December, while birch spp. were the most common buds (85%) in January. Greenbrier, grape, viburnum, and dogwood made up a total of 86% of the fruits in crops in February. The shift in the crop contents from buds and twigs of birch and cherry in December and January to soft fruits in February was likely due to differences in monthly collection locations. Most crops collected in December and January were from grouse taken in Preston and Randolph counties, which are located in a high elevation, northern hardwood forest type (Shrauder 1984). All crops from February were collected in Monongalia county, characterized by the more common mixed oak/hickory forest

type. Dietary ME in West Virginia was relatively low in December and January (34-39%, 1.56-1.91 kcal/g) as a result of the low ME of buds and twigs (Figures 3.1 and 3.2). The ME levels for February were similar to estimates for high fruit diets from more southern states. Protein estimates ranged from 11.2-14.1% in December and January and were lower in February (Figure 3.4).

Soft fruits (66-100% dogwood) made up nearly all of the crop contents collected from October to December in Indiana (Table 3.4). As in southeastern states, ME (27-39%, 1.40-1.86 kcal/g) and total phenols (0.6-3.0%) were low when soft fruit use was high (Figures 3.1, 3.2, 3.3), but the monthly ME values for the nonseed fraction of the crop contents was high and declined gradually from 56% and 3.13 kcal/g in October to 46% and 2.38 kcal/g in January (Appendix Tables 3.4 and 3.5).

Carcass Fat of Grouse from North Carolina

There was not a difference ($P=0.40$) nor a consistent trend in predicted carcass fat between adult and juvenile ruffed grouse ($N=118$) collected in North Carolina and no significant interactions ($P>0.10$) among age, sex, and month; therefore, carcass fat data of adults and juveniles were pooled within sex in Table 3.7 because of small sample sizes

Table 3.7. Predicted carcass fat (%) levels of 118 ruffed grouse collected in North Carolina from November 1981 to February 1984.

Month	Females			Males		
	$\bar{x}$	SE	N	$\bar{x}$	SE	N
November	9.3	1.0	25	8.5	0.7	18
December	13.2	1.7	22	9.8	1.2	20
January	9.7	2.2	8	9.1	1.5	12
February	9.8	1.7	9	5.0	1.3	4

in some months. However, conclusions concerning age effects must be made with caution because of the potential for errors in age determination. Female grouse had higher (P=0.04) predicted carcass fat levels than males. There was a marginally significant difference (P=0.058) among months. Mean values for both males and females tended to increase from November to December and decrease after December.

DISCUSSION

Forage Quality

Analyses of forages from crops was a satisfactory method of collecting information on forage quality. Total phenols and NDS in forages from crops were slightly less than those of hand-collected forages; however, because both NDS and total phenol levels in forages decrease in crops, i.e. phenols are components of NDS, the effects on ME estimates were minimal (see Chapter 1). Lower levels of NDS and total phenols in crop contents may have been the result of grouse selecting forages lower in phenols, the oxidation (loss) of phenols in the crops of the live grouse, or the oxidation of phenols as a result of freezing and thawing of crop samples during shipment (see Chapter 1). Some amount of phenol loss may be inevitable when crop samples are used.

Even though total phenol levels in samples from crops tended to be less than in hand-collected forages, relative

differences between forage types were consistent. For example, soft fruits had the lowest total phenols and laurel leaves and maple fruit had the highest total phenol levels in both crop and hand-collected samples. The only significant exception was Christmas fern. Two crop samples of Christmas fern had substantially lower NDS and total phenol levels than hand-collected samples. However, based on the overall consistency in total phenol levels of crop and hand-collected samples, the monthly trends in total phenols in crop contents are representative of trends in grouse diets except that absolute levels may be underestimated.

Only the ME of apple fruit was substantially lower (9 percentage units) in crop samples than in hand-collected samples; however, the apple fruit in crops typically contained large amounts of the fruit epidermis, which may have been the cause of the lower NDS levels in those samples.

Protein levels in hand-collected forage samples were not measured for comparison with crop samples; however, the protein levels of forages from crops agreed closely with previously reported data for the same or similar species. The medium protein levels for catkins (11.9-14.7%) found in the present study are similar to reported values for

hazelnut (15.0%, Triechler et al. 1946; 15.2%, Huff 1970), alder (16.6%, Triechler et al. 1946), and yellow birch (14.4%, Bump et al. 1947:846). The variability in the protein content of tree buds also is consistent with literature reports. Reported protein values range from lows of 7.8%, 8.0%, and 9.3% for serviceberry buds (Triechler et al. 1946), apple buds (Huff 1970), and yellow birch buds (Triechler et al. 1946), respectively, to highs of 10.1% for yellow birch buds (Bump et al. 1947:846), 11.4-12.9% for quaking aspen flower buds (Hill et al. 1968, Huff 1970, Doerr et al. 1974), 14.0% for willow buds (Doerr et al. 1974) and 18.4% for black cherry buds (Bump et al. 1947:846). Specific comparisons of these data with estimates for buds and twig samples from the present study were not possible because of the unknown ratios of buds to twigs in crops; however, protein levels in crop samples were generally in the above range.

Mountain laurel leaves, the only evergreen forage for which protein was measured in the present study, contained 9.2% protein. This low value is similar to the 9.9 and 8.2% mean values reported for mountain laurel leaves collected on burned and unburned forest stands, respectively, in Georgia (Thackston et al. 1982). Triechler et al. (1946) similarly found low protein levels in leaves or fronds of mountain

laurel (8.1%), wintergreen (6.1%), trailing arbutus (9.2%), Christmas fern (10.3%), partridgeberry (8.4%), and galax (9.2%), all evergreen species.

High protein levels have been reported for some herbaceous forages used by grouse. Bump et al. (1947:846-847) reported that protein levels of clover and dandelion leaves were 17-24% and 25%, respectively. Protein levels of mixed herbaceous leaf samples analyzed in the present study were within this range.

Concern about amylase contamination in crop contents and the potential effects on measured protein levels prompted some researchers in the past to correct crude protein values of forages from crops for nitrogen contamination (Moss 1972, Doerr et al. 1974). However, the close agreement between protein levels in crop samples in the present study and protein values found by other researchers for hand-collected forages indicates that nitrogen contamination generally was not a serious problem. Also, the wide range of protein levels found in forages from crops indicates that contamination was not sufficient to mask differences between forages. Doerr et al. (1974) corrected protein data a small amount by substracting a constant 0.1 percentage unit from crop content nitrogen values prior to calculating protein. A constant correction

does not seem justified because contamination in crops is likely influenced by the type of forage, the amount of forage in the crop, and the length of time the material is in the crop.

In conclusion, leaves of evergreen woody plants appear to be the poorest quality forages for ruffed grouse because of low ME and protein levels and high total and tannin phenol levels. Buds and catkins also have a low ME content, but in comparison to evergreen leaves they are higher in protein and lower in tannin phenols. Only herbaceous leaves contained high ME and protein and low levels of phenols. Soft fruit flesh was high in ME and low in protein and phenols. However, the ME of seeds of soft fruits was low.

This information is useful for defining forage classes in future grouse food habits and nutrition studies. Optimally, all species in a forage class should be similar in chemical composition and, therefore, in nutritional quality. In the past, researchers in the Southeast have classified forages in grouse crops as leaves of woody plants, herbaceous leaves, soft fruits, or hard fruits. Leaves of evergreen woody plants clearly should be partitioned into a separate forage class because of their high total and tannin phenol levels. Christmas fern, a common winter forage of grouse in the Southeast (Stafford

and Dimmick 1979, Seehorn et al. 1981) is usually classified as an herbaceous plant; however, Christmas fern is similar in quality to evergreen leaves of woody plants. Data on individual herbaceous species were not collected in the present study; however, separating the herbaceous leaf forage class into evergreen and nonevergreen forbs may be justified. For example, galax, by definition a herbaceous forage, is low in protein (Treichler et al. 1946) and high in tannin phenols (see Chapter 5). Galax was not identified in crops in the present study, but has been reported previously (Nelson et al. 1938).

Of the many forages used by ruffed grouse in winter, only aspen buds have received extensive study in the past (Hill et al. 1968, Huff 1970, Svoboda and Gullion 1972, Doerr et al. 1974). Quaking aspen flower buds are believed to be highly nutritious for ruffed grouse and greater in nutritional quality than other buds and catkins (Gullion 1966, Gullion 1970, Svoboda and Gullion 1972). Only one crop containing sufficient aspen flower buds (species unidentified) for separate analyses was obtained in the present study. Based on the data for this crop sample, the data on the hand-collected quaking aspen flower buds, and the reports in the literature, the nutritional quality of aspen buds does not appear to be substantially greater than

other buds and twigs or catkins. The ME and protein levels of aspen flower buds were within the range of values for other buds and catkins, and tannin levels in aspen buds were higher than in catkins and most other buds.

Other data corroborate the observation that aspen flower buds are low in ME. Huff (1970) found that aspen flower buds collected from trees that were known to be fed on by ruffed grouse had an acid detergent fiber (ADF) content of 51%, which is equivalent to 49% acid detergent solubles (100 - ADF). A forage with a NDS content of 49% and total phenols of 0% would have a predicted ME of 40%. However, NDS is always less than ADS in forages, and the total phenols in the buds collected by Huff (1970) were likely greater than 0%. Therefore, the predicted ME of the aspen flower buds collected by Huff (1970) would be less than 40% and in the range of ME values of other buds and twigs and catkins. Also, Svoboda and Gullion (1972) noted that ruffed grouse consume large amounts of aspen buds daily during the winter. A high intake also is indicative of a low energy food. Any nutritional advantage for grouse feeding on aspen flower buds may simply be the result of the large size and relatively high accessibility of this forage. (Svoboda and Gullion 1972).

Regional Food Habits
and Diet Quality

Food Habits--In general, food habits data were consistent with previous reports. Nearly all studies in the Southeast have noted a high use of fruits; however, the measured use has been variable (Stafford and Dimmick 1979, Seehorn et al. 1981, Norman and Kirkpatrick 1984). The low use of buds and twigs and the high use of evergreen leaves in winter in the Southeast also has been reported (Stafford and Dimmick 1979, Seehorn et al. 1981). However, these earlier reports did not partition evergreen species separately in food habits analyses. Smith (1977) found that laurel leaves made up 31.2% of the volume of foods from 83 crops collected in Georgia from November to February, and leaves or fronds of laurel, Christmas fern, trailing arbutus, and rhododendron (all evergreen species) made up a total of 48% of the volume of all crop contents. This level of evergreen leaf use was greater than levels of use found in Georgia and North Carolina crop collections in the present study.

Use of buds of black cherry, yellow birch, and hazelnut and catkins of yellow birch, hazelnut, and hophornbeam by grouse collected in the present study was generally consistent with previous reported usage; (Brown 1946, Bump et al. 1947, Vanderschaegan 1970, Woehr and Chambers 1975);

however, the low use of aspen buds in northern states was unexpected based on previous reports (Darrow 1939, Kittam 1943, Brown 1946, Bump et al. 1947, Vanderschagean 1970, Doerr et al. 1974). The highest recorded use for aspen buds in the present study was 14.2% for 19 crops collected in December in New York. Crop contents collected later in the winter in Maine and Wisconsin may have contained more aspen; however, the time of collection was not the sole reason for the absence of aspen buds in samples. High use of aspen buds in October has been previously reported (Brown 1946, Stollberg and Hine 1952). Svoboda and Gullion (1972) stated that male ruffed grouse in Minnesota were eating primarily male aspen flower buds by the end of October. Also, buds and catkins of other species were found in large quantities in crops of grouse in the fall and early winter in the present study and presumably aspens could have been fed upon as well if they were available.

Metabolizable Energy.--In the Southeast, grouse were consuming large amounts of poorly digested seeds of soft fruits during the fall. As a result, there was a pattern of increasing dietary ME during the fall as soft fruit use declined. However, despite their low ME content, soft fruit diets in the Southeast are apparently energetically adequate for ruffed grouse. Norman and Kirkpatrick (1984) found that

body fat levels of ruffed grouse in Virginia were high in early fall when hard and soft fruits made up the majority of the diet and fat levels increased further in the early winter when soft fruits comprised a majority of their diet. Predicted carcass fat levels of the ruffed grouse used for food habits analysis in North Carolina also tended to increase from November to December when soft fruits made up the majority of the crop contents and the ranges of estimated dietary ME were low. Maintenance or accumulation of body fat by grouse on diets of soft fruits in Virginia and North Carolina suggests that these diets are energetically adequate. Monthly ME values for the nonseed portion of the crop contents were relatively high and stable during November-January in Georgia (55-57%), North Carolina (49-53%), Virginia (49-57%), and Ohio (56-60%) when soft fruit use was high (Appendix Table 3.4). The ease of foraging on highly clustered fruits such as grape, greenbrier, and rose, and the high digestibility of fruit flesh probably offsets the concomitant ingestion of substantial quantities of poorly digested seeds.

Diets of buds, twigs, and catkins of grouse in northern states tended to have a lower ME content than diets of predominately evergreen leaves and ferns in southeastern states. For months in which buds, twigs, and catkins made

up >50% of the crop contents in New York (November and February) and Maine (December), ME estimates ranged from 35-38% and 1.62-1.95 kcal/g. The lowest ME estimate (35-36%, 1.62-1.67 kcal/g) for these samples was found in February in New York when the crop contents contained 62.2% buds and twigs and 28.2% catkins. Also, ME estimates for crop contents collected in West Virginia in December (66.4% buds, twigs, and catkins) and January (55.1% buds, twigs, and catkins) had a similar range (34-39%, 1.56-1.91 kcal/g). The predicted ME values for November in Wisconsin (42-44%, 1.96-2.04%), when use of buds and twigs was low (5.6%) and catkins made up 43.8% of the crop contents, was slightly greater than the above ranges. In contrast, dietary ME in February in North Carolina (44-45%, 2.03-2.10 kcal/g) and Georgia (48%, 2.26 kcal/g) tended to be higher than the estimates for diets of buds, twigs, and catkins in the North with the exception of Wisconsin.

The nutritional significance of this regional difference in dietary ME in winter is difficult to evaluate because little is known about ruffed grouse energetics and foraging ecology. Reports of ruffed grouse subsisting primarily on a diet of buds, twigs, and catkins in the winter in the northern region are numerous (Brown 1946, Bump et al. 1947:215, Vanderschaegan 1970, Woehr and Chambers

1975). The fact that grouse populations reach their highest densities in this part of their range suggests that grouse are well adapted to low energy winter diets.

Phenols.--Total phenols tended to be greater in evergreen leaf diets of the Southeast (February) than in bud, twig, and catkin diets of the North. More importantly it appears likely that tannin phenols may be substantially higher in diets of grouse in the Southeast because evergreen leaves were found to be consistently higher in tannin phenols than buds, twigs, and catkins. Tannins are toxic to a variety of animal species (McLeod 1974, Lindroth and Batzli 1984), and many effects of tannins occur at low dietary levels. Tannin levels of 1% reduce growth rates in chickens (Armstrong et al. 1974, Fuller et al. 1967). Lindroth and Batzli (1984) reported that quebracho, a condensed tannin, fed at 1% of the diet inhibited feeding and resulted in the death of prairie voles. These authors also found that quercetin (a flavonoid) and tannic acid (a hydrolyzable tannin) added to diets at 3% levels reduced growth rates of voles on low protein diets. Tannin phenol levels in evergreen leaf forages (6-8%), therefore, are high enough to potentially have an effect on grouse nutrition.

Leaves of mountain laurel and related species are known to be toxic to many species, including man, when eaten in

large quantities (Hardikar 1922, Waud 1940, Kingsbury 1964). The toxin, apparently present in the resin of leaves and twigs, is a diterpenoid grayanotoxin, also known as andromedotoxin and acetyandromedol (Sukata et al. 1977, Mancini and Edwards 1979, Sakakibara et al. 1979). Symptoms of poisoning include vomiting, slow pulse, convulsions, paralysis, and death in some instances (Hardiker 1922, Waud 1940).

The effects of this toxin on wild vertebrate herbivores has received little study. Forbes and Bechdel (1931) reported that a single force-feeding of dried, ground mountain laurel leaves to a white-tailed deer at a rate of 1.75% of body weight resulted in death (unspecified time). A second deer force-fed laurel at a rate of 1.29% of body weight was in critical condition within a few hours, but recovered a few hours later. Both deer exhibited symptoms of andromedotoxin poisoning. Deer provided with diets of either fresh laurel or rhododendron leaves for 45 days in February and March after being allowed to eat both species free-choice for 49 days while on a grain diet reportedly became thin and weak. The authors believed insufficient intake was the cause; however, intake was not recorded. Bump et al. (1947) attempted to maintain two captive ruffed grouse on a diet of mountain laurel leaves after allowing

them to freely supplement their normal daily ration with fresh laurel leaves for 4 weeks. Both birds died (unspecified time), apparently from malnutrition on the 100% laurel diet; however, the authors presented insufficent information to fully evaluate the experiment. During the present study, four captive ruffed grouse were maintained for 2 weeks on a mixed diet consisting of 30% dried, ground mountain laurel leaves and 70% commercial feed (maintenance diet described in Chapter 1) without ill-effects or significant body weight changes (unpublished data). Captive grouse also were fed a diet containing 50% dried, ground laurel leaves for 7 days in metabolism trials (see Chapter 1); however, birds reduced intake and did not maintain body weight (Appendix Table A.1). These toxins apparently can be tolerated at low to moderate levels of intake. Although the experimental evidence is weak, the fact that high intake of laurel can cause mortality in white-tailed deer poses questions as to the adequacy of laurel as a long-term winter food resource for grouse.

Protein.--Protein levels in bud, twig, and catkin diets in New York, Maine, and Wisconsin (range: 13.8-16.7%) tended to be greater than those in late winter diets of primarily evergreen leaves in Georgia (11.6%) and North Carolina (10.8-11.5%). This regional difference is consistent with

the high protein levels of buds and catkins and the low levels in evergreen leaves described earlier. Also, ratios of protein to energy generally were lowest in soft fruit diets and highest in bud, twig, and catkin diets. Monthly crop samples from northern states containing >50% buds, twigs, and catkins had P/E ratios 40-60% greater than February diets in Georgia and North Carolina, suggesting that protein intake in winter is substantially higher in northern areas. The higher P/E ratios in northern states are due to a combination of greater dietary protein and less dietary ME than found in diets in the Southeast.

High tannin levels in diets in the Southeast may further widen the differences in the protein available in typical winter diets in the North and Southeast. Protein digestibility is reduced by dietary tannin in the chicken (Nelson et al. 1975), prairie vole (Lindroth and Batzli 1984), and snowshoe hare (Sinclair et al. 1982). High tannin levels in late winter diets in the Southeast may reduce protein digestibility,

Lindroth and Batzli (1984) reported that quercetin and tannic acid reduced growth rates of voles only when they were fed in combination with low protein (8%) diets. If there is an interaction between dietary protein and tannins in grouse nutrition, the combination of low protein and high

tannin levels in evergreen leaves would have the most detrimental effects on grouse, whereas the effects of tannins in buds and catkins may be partially reduced by the higher protein levels of those forages.

Beckerton and Middleton (1983) suggested that a diet containing 3.45 kcal/g and 11.5% protein was probably adequate for maintenance of nonbreeding ruffed grouse. Such a diet has a calculated P/E ratio of 3.33g/100 kcal ME. Winter diets in the Southeast had greater P/E ratios than the above recommended maintenance level. However, direct comparisons of protein estimates for natural winter diets and the protein requirement estimates of Beckerton and Middleton (1983) may not be possible because tannin levels in natural diets likely reduce protein digestibility to an unknown degree.

While useful for comparing food habits and diet quality, monthly estimates of diet quality made from analyses of crop contents may not be indicative of the variability of diets of grouse populations. Hunters probably concentrate efforts in better grouse habitats because of the greater number of birds available. Therefore, mean nutritional values of crop contents may be most representative of diets in adequate habitat. Foods from marginal habitat may be under-represented. In

addition, statewide 'average' diet quality values are probably somewhat misleading. Even though many forage classes or species were often represented in late winter crop collections, individual grouse probably have diets that are less diverse. For example, evergreen leaves made up 44% of the crop contents in February in North Carolina, but it is likely that some proportion of the grouse population was utilizing greater quantities of these leaves.

To determine the potential regional variation in diet quality in winter, it is necessary to examine the diets of grouse shifting completely to late winter forages of buds and catkins or evergreen leaves. In general, the nutritional quality of buds, twigs, and catkin forages (Tables 3.1 and 3.3) are similar to monthly estimates of the quality of diets containing >50% buds, twigs, and catkins in Maine, New York, and Wisconsin. Therefore, a complete dietary shift to buds, twigs, and catkins would have little effect on late winter diet quality estimates in the North. In contrast, grouse subsisting on evergreen leaves in the Southeast would have diets lower in ME and protein content and greater in total phenols (and likely tannins) and grayanotoxin levels than 'average' February diets in Georgia and North Carolina. Therefore, evergreen leaf diets have ME levels similar to winter diets in the North, but exhibit

greater differences in phenols and protein levels with northern diets than did February diets in Georgia and North Carolina.

In conclusion, grouse in the Southeast, especially those utilizing evergreen leaves, appear to have poorer quality winter diets than northern grouse populations. Specifically, evergreen leaf diets are low in protein, and protein availability is likely further depressed by high levels of tannins. In addition, high tannin levels may have detrimental physiological effects, and mountain laurel, the most commonly utilized evergreen forage, contains a potential toxin. Regional differences in dietary metabolizable energy appeared insignificant.

While direct mortality of grouse in the Southeast because of poor nutrition or poisoning seems unlikely, much additional energy may be spent by grouse to buffer diets of evergreen leaves with less abundant herbaceous leaves and fruits during winter. The resulting increase in foraging activity also may increase susceptibility to predation. Alternatively, grouse may eat at submaintenance levels for short periods during the late winter in an effort to avoid continuous high intake of evergreen leaves.

Poor nutrition in late winter may have detrimental effects on reproduction the following spring as in ring-

necked pheasants (Phasianus colchicus) (Gates and Woehler 1968) and eastern wild turkeys (Meleagris gallopavo) (Porter et al. 1983). Reproductive organ recrudescence begins in the latter part of March (see Chapter 4) immediately after the period when diet quality is the poorest in the Southeast. Dietary protein has been shown to have an important influence on ruffed grouse reproduction (Beckerton and Middleton 1982), but whether low protein levels in late winter can affect reproduction in the spring is unknown.

Carcass Fat

Predicted fat levels of grouse collected in January and February in North Carolina were similar to the low levels of eight grouse collected in the same months in Ontario by Thomas et al. (1975). However, fat levels from November to February in North Carolina tended to be less than fall and winter mean values of grouse collected in Virginia between March 1979 and January 1980 (Norman and Kirkpatrick 1984). Mean carcass fat levels in winter for male (N=5) and female (N=5) grouse from Virginia were 13.6 and 19.0%, respectively. The food habits of grouse collected by Norman and Kirkpatrick (1984) contrasted sharply with the food habits of grouse collected in North Carolina in the present study and may explain the differences in fat levels. The crops of grouse from Virginia contained 50-65% hard fruits

(primarily acorns) in fall and 18% in early winter. Crops of grouse from North Carolina contained less than 9% hard fruits in all months. The availability of highly digestible acorns in the early fall may have been responsible for the higher fat levels found in Virginia.

Previous studies had not found differences in the fat content of male and female grouse at any time of the year (Thomas et al. 1975, Norman and Kirkpatrick 1984). Fat levels of females were slightly greater than males in North Carolina in the present study. In a study on fat levels of ruffed grouse during the breeding season in Virginia (see Chapter 4), it was found that male grouse had substantally lower fat levels than females. It was suggested that males may forage less during the breeding season because of an increase in time spent in territorial defense, or a strong attachment to a territory may limit food availability. Male grouse remain closely associated with drumming logs and activity centers most of the year, and drumming does occur during the fall (Gullion 1967). Factors responsible for the low fat levels of males in the spring breeding season in Virginia also may have been the cause of lower fat levels of males in North Carolina in the fall.

Food Availability
in the Southeast

Regional differences in forest composition largely account for the differences in food habits. Trees suitable for budding are relatively rare in the predominately oak forests of the southern Appalachians. When fruit supplies dwindle, grouse must switch to either evergreen leaves, herbaceous leaves, or persistent deciduous leaves.

Greenbrier is the most commonly utilized deciduous leaf in the winter in the Southeast (Stafford and Dimmick 1979, Seehorn et al. 1981). In the present study, greenbrier leaves made up 30% of the crop contents collected in February in Georgia. However, in Virginia, most greenbrier leaves have typically turned brown by late January indicating that greenbrier leaves are not an abundant and reliable winter food resource. Honeysuckle leaves, like greenbrier, are relatively high in ME and low in tannins and may be a high quality winter forage for ruffed grouse. Stafford and Dimmick (1979) reported high use of honeysuckle leaves by grouse in the Great Valley region of Tennessee. However, honeysuckle leaves apparently are not common in forested habitats occupied by grouse in the Southeast as evidenced by their reported low use in other southeastern states (Smith 1977, Seehorn et al. 1981) and in two regions

of Tennessee (Stafford and Dimmick 1979). Therefore, it is questionable whether there are sufficient quantities of greenbrier and honeysuckle leaves available to sustain large grouse populations during the winter period in the Southeast.

The energetic cost of foraging for small, widely dispersed herbaceous forbs in forest habitats may limit the contribution of this forage class to the diet of grouse. Harlow et al. (1975) estimated that available herbaceous forbs in the Broad Run Wildlife Research Area in southwestern Virginia in December ranged from 0.1 kg/hectare in mature oak-pine stands to 0.5 kg/hectare in 7-year old clearcuts. It seems unlikely that grouse could forage efficiently on foods that were so low in abundance, widely dispersed, and partially hidden by leaf litter. Mean time spent feeding on buds and twigs during a feeding period in northern habitats is low, ranging from 16-24 minutes (Svoboda and Gullion 1972, Doerr et al. 1974), and budding primarily occurs just prior to sunrise and just after sunset (Doerr et al. 1974). The ability to forage quickly may be important for winter survival.

With declining supplies of deciduous leaves and herbaceous forbs in forested habitats in winter, grouse in the Southeast probably have little alternative to utilizing

evergreen leaves. Evergreen leaves are apparently avoided in the fall and early winter because they are little utilized until late winter when supplies of other forages have diminished. The reason for the high use of mountain laurel and Christmas fern and the low use of abundant wintergreen and trailing arbutus leaves is unknown. All have similar ME, protein, and tannin levels. Galax, a common herbaceous evergreen species in the Southeast (Harlow et al. 1975, see Chapter 5), also is similar in the above nutritional characteristics (see Chapter 5), but is rarely found in crops. Tannins differ widely in their size, structure, toxic, and antinutritional qualities (McLeod 1974), and a variety of other types of plant toxins exist (Rhoades and Cates 1976), which may account for the above differences in forage preferences.

Gullion (1966) suggested that information on fall foods of ruffed grouse was meaningless because these forages were taken during a period of food abundance. However, fall foods, especially fruit supplies, may have an important role in the ecology of ruffed grouse in the Southeast. In the present study, fruits made up >45% of the diet of grouse collected in Georgia, North Carolina, and Virginia from November to January. Substantial new growth of herbaceous plants begins in mid to late March in Virginia, which means

that there is approximately a 6-week period (1 Feb to 15 Mar) when grouse are utilizing low quality evergreen leaves. However, fruit production can be highly variable among years. Poor fruit production that results in significant declines in fruit availability by the end of December would nearly double the length of time grouse would have to subsist on alternative forages (evergreen leaves) high in tannins and low in protein. Smith (1977) found high use of evergreen leaves in both late fall and early winter (Dec-Feb) in Georgia (no seasonal differences) when fruit use was low (1% of crop contents), which is consistent with the above hypothesis.

CONCLUSIONS

Whereas a lack of continuous snow cover in the Southeast would seem favorable to ruffed grouse from the standpoint of food availability, it is not necessarily true that grouse in the Southeast have ready access to adequate food supplies as has recently been suggested by Gullion (1984). Compared to the buds and catkins utilized by northern grouse populations in late winter, the evergreen leaf forages utilized in the Southeast are of questionable quality because of low protein levels, high tannin levels, and, in some instances, the presence of potentially toxic compounds. When catkins are abundant in winter, northern

grouse populations have available a medium to high protein, low tannin diet that is probably sufficient in metabolizable energy. In addition, buds and catkins remain available (unless eaten) the entire winter, and grouse probably have little competition from other wildlife for these forages. The likelihood of high food abundance and quality throughout the winter in southeastern states is low because fruit and herbaceous forb production from the previous summer and fall is probably insufficient to support large grouse populations for the entire winter, requiring a dietary shift to low quality evergreen leaves. In addition, grouse in the Southeast must compete with many frugivores for winter fruit supplies and with other herbivores (e.g. deer, turkeys) for leafy forages found primarily at ground level. The possibility that diet quality and food availability may vary among years in northern areas is not being discounted, but rather it is in northern habitats that there is the potential for an abundance of relatively high quality food in winter.

Therefore, the low population densities of grouse in the Southeast may be directly or indirectly related to late winter diet quality. The hypothesis described has many testable components that require study. Further investigation in this direction should elucidate the

importance of winter nutrition in the ecology of ruffed grouse in the Southeast.

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Appendix Table 3.1. List of common and scientific names of plants mentioned in text of Chapter 3.[1]

Common name	Scientific name
Alder	*Alnus* spp.
American beech	*Fagus grandifolia*
Apple	*Malus* spp.
Aspen	*Populus* spp.
Avens	*Geum* spp.
Bigtooth aspen	*Populus grandidentata*
Birch	*Betula* spp.
Black cherry	*Prunus serotina*
Black gum	*Nyssa sylvatica*
Blueberry	*Vaccinium* spp.
Bunchberry	*Cornus canadensis*
Cherry	*Prunus* spp.
Christmas fern	*Polystichum acrostichoides*
Clover	*Trifolium* spp.
Dandelion	*Taraxacum officinale*
Dogwood	*Cornus florida*
Dewberry	*Rubus* spp.
Flowering dogwood	*Cornus florida*
Foamflower	*Tiarella* spp.
Galax	*Galax aphylla*
Grape	*Vitis* spp.
Gray birch	*Betula populifolia*
Greenbrier	*Smilax* spp.
Hawthorn	*Crateagus* spp.
Hazelnut	*Corylus* spp.
Honeysuckle	*Loncera* spp.
Hophornbeam	*Ostrya virginiana*
Japanese honeysuckle	*Lonicera japonica*
Maple	*Acer* spp.
Mountain ash	*Sorbus* spp.
Mountain laurel	*Kalmia latifolia*
Multiflora rose	*Rosa multiflora*
Oak	*Quercus* spp.
Oxalis	*oxalis*
Partridgeberry	*Mitchella repens*
Privet	*Ligustrum* spp.
Quaking aspen	*Populus tremuloides*
Rhododendron	*Rhododendron* spp.
Rose	*Rosa* spp.
Serviceberry	*Amelanchier canadensis*
Sorrel	*Rumex* spp.
Staghorn sumac	*Rhus typhina*

Appendix Table 3.1. Continued.

Common name	Scientific name
Strawberry	Fragaria spp.
Sumac	Rhus spp.
Speckled alder	Alnus incana
Striped maple	Acer pensyvanicum
Sweet birch	Betula lenta
Trailing arbutus	Epigaea repens
Viburnum	Viburnum spp.
Willow	Salix spp.
Wintergreen	Gaultheria procumbens
Yellow birch	Betula alleghaniensis

[1]Scientific names follow Scott and Wasser (1980).

Appendix Table 3.2. Locations of crop collections by state and county. Number of crops is in parentheses.

Georgia:	Carter (2), Cohulta (3), Dawson (2), Fannin (22), Gilmer (12), Lumpkin (5), Macon (4) Murry (1), Rubun (1), Towns (6), Union (18)
North Carolina:	Ashe (4), Avery (6), Buncombe (3), Clay (3), Graham (15), Haywood (20), Henderson (1), Jackson (2), Macon (35), Madison (76), Transylvania (2)
Virginia:	Albermarle (1), Bath (6), Botetourt (10), Craig (4), Floyd (18), Giles (19), Mercer, WV (10), Monroe, WV (3), Montgomery (41), Grayson (2), Nelson (3), Pulaski, (2), Roanoke (17), Rockbridge (2), Wythe (1), Unknown (4)
West Virginia:	Monongalia (19), Randolph (5), Preston (3), Unknown (6)
Ohio:	Athens (43), Jackson (17), Meigs (7)
New York:	Chautaugue (4), Clinton (6), Franklin (79), Herkimer (1), Lewis (2), Madison (1), Oneida (8), Onondaga (4), Saint Lawerene (2), Steuben (3)
Wisconsin:	Juneau (2), Lincoln (1), Marathon (46), Portage (6), Taylor (1), Wood (43), Unknown (3)
Washington:	Lewis (1), Okanogan (34), Thurston (1)
Maine:	Aroostock (24), Cumberland (6), Franklin (22), Hancock (2), Kennebec (23), Oxford (1), Piscataquis (30), Penobscot (3), Sagadahoc (4), Somerset (60), Waldo (11), Washington (45)

Appendix Table 3.3. Foods from crops of ruffed grouse collected in ten states during fall and winter between November 1981 and February 1984. Values are percent dry weight and number of crops examined is in parentheses.

Species[1],[2]	Month					
	Sep	Oct	Nov	Dec	Jan	Feb
Georgia (N)			(6)	(16)	(36)	(19)
Greenbrier f.			76.8	2.4	5.2	0
Grape f.			13.1	38.3	6.4	0
Acorn			0.3	7.2	32.9	8.1
Mountain laurel l.			0	17.6	8.8	30.0
Greenbrier l.			0.7	2.0	10.8	29.7
Christmas fern			0.1	3.5	9.7	10.8
Honeysuckle l.			0	10.3	0	0
Foamflower l.			3.1	2.7	4.7	1.1
Cinquefoil l.			0	0.9	0.2	0.1
Trailing arbutus l.			0	0	0.6	0.5
% Identified (Total)			94.1	84.9	79.3	80.3
North Carolina (N)			(59)	(50)	(30)	(32)
Mountain laurel l.			2.0	6.6	13.2	38.2
Grape f.			28.8	13.5	22.0	1.0
Dogwood f.			0	23.1	16.8	0
Mountain ash f.			11.0	0	0	0
Greenbrier f.			10.3	8.4	8.1	2.6
Oxalis l.			0.3	0	0	0
Beechnut			1.1	0	0	0
Foamflower l.			0.6	t	0.3	0.3
Greenbrier l.			2.5	4.1	4.1	6.9
Dogwood bt.			0	0	8.6	0
Acorn			0	0	7.0	3.8
Maple f.			2.6	0.1	1.6	1.2
Christmas fern			1.0	3.6	4.2	8.6
Hawthorn f.			4.8	0	2.0	0
Strawberry l.			1.2	1.6	0.1	0.9
Rumex l.			0.3	0	0	0
Cinquefoil l.			0	0.1	0.4	0.3
Trailing arbutus l.			0	0	0	6.1
Rose f.			0	0	0.9	0
Prunus bt.			2.0	0	0	0
Blackgum f.			0	0	0	0.1
Sumac f.			6.0	0	0	0
Honeysuckle l.			0	0.3	0.7	0.4
% Identified (Total)			74.5	61.4	90.0	70.4

Appendix Table 3.3. Continued.

Species	Month					
	Sep	Oct	Nov	Dec	Jan	Feb
Virginia (N)			(59)	(50)	(30)	
Rose f.			0	13.3	22.2	
Grape f.			17.5	14.7	14.3	
Blackgum f.			15.3	0	0	
Acorn			14.9	0.5	0	
Greenbrier f.			8.9	12.9	8.3	
Dogwood f.			12.5	0.4	0.3	
Greenbrier l.			1.6	5.2	10.2	
Viburnum f.			8.9	1.3	2.0	
Christmas fern			0.4	0.4	2.2	
Cinquefoil l.			0.7	1.3	1.1	
Hawthorn f.			1.2	0.5	0	
Cherry bt.			1.0	0.6	6.4	
Birch ca.			0	0	0.1	
Rumex l.			0	0.1	0	
Wintergreen l.			0	0	0.6	
Trailing arbutus l.			1.0	0.2	t	
Sumac f.			5.8	3.5	2.3	
Honeysuckle f.			0	0.5	1.3	
Rose l.			0	t	t	
Mountain laurel l.			1.2	0.3	9.1	
Strawberry l.			0	0.3	0	
Dewberry l.			0	0	0.2	
Maple f.			0	0	t	
Clover l.			0	t	0	
% Identified (Total)			91.3	56.1	81.4	
West Virginia (N)			(10)	(8)	(11)	
Cherry bt.			59.5	0.8	0.5	
Greenbrier f.			18.6	0	48.5	
Birch bt.			6.3	47.1	0.7	
Grape f.			7.5	0	19.7	
Greenbrier l.			0	6.5	0.6	
Christmas fern			0	7.8	0.1	
Hophornbeam c.			1.3	0	0	
Maple f.			0.3	0.2	0	
Viburnum f.			3.2	0	8.9	
Mountain laurel l.			0	3.8	0.1	
Cinquefoil l.			0	1.1	0	
Honeysuckle l.			0	0	t	
Acorn			0	0	3.2	

Appendix Table 3.3. Continued.

Species	Month					
	Sep	Oct	Nov	Dec	Jan	Feb
Dogwood f.			0	0	8.5	
Sumac f.			0	6.4	0	
% Identified (Total)			96.7	73.7	90.8	
Ohio (N)			(4)	(14)	(28)	(21)
Grape f.			87.8	14.4	0	0
Rose f.			0	0	33.5	33.6
Dogwood f.			11.3	24.4	0	0
Japanese honeysuckle f.			0	7.4	21.9	0.1
Greenbrier f.			0	15.5	0.4	0
Sumac f.			0	1.7	11.0	0
Greenbrier l.			t	0.2	0.5	2.9
Cinquefoil l.			0	0	0	2.7
Viburnum f.			0	0	0.2	4.3
Avens l.			0.3	0	0.6	8.9
Christmas fern			0	0.9	0.7	1.4
Privet f.			0	0	1.9	t
% Identified (Total)			99.4	64.5	69.9	54.0
Indiana (N)		(5)	(11)	(3)	(3)	
Dogwood f.		99.6	91.8	56.8	0	
Hophornbeam c.		0	0	0	30.3	
Rose f.		0	0	29.5	0	
Greenbrier f.		0	0	0	15.1	
Japanese honeysuckle f.		0	5.4	0	0.3	
Honeysuckle l.		0	t	0	3.0	
Greenbrier l.		0	t	0	0	
Dogwood bt.		0	0.5	0	0	
% Identified (Total)		99.6	97.2	86.3	48.7	
New York (N)	(5)	(35)	(26)	(19)	(23)	(9)
Cherry bt.	0	16.2	0	0	17.8	55.3
Yellow birch c.	0	0.9	37.6	6.2	4.9	0
Viburnum f.	0	9.8	0.9	0	33.1	0
Maple f.	0	2.6	9.1	30.5	0	0
Hazelnut c.	0	2.5	10.9	2.4	0	28.2
Quaking aspen l.	12.7	9.4	0	0	0	0
Aspen bt.	0	2.5	2.5	14.2	0	1.1
Apple bt.	0	0	0	0	11.9	0
Corn	0	0	0	0	11.8	0

Appendix Table 3.3. Continued.

Species	Month					
	Sep	Oct	Nov	Dec	Jan	Feb
Hawthorn f.	0	5.2	0.1	0	0	0
Cinquefoil l.	0	0	0.2	1.5	0	2.3
Grape f.	0	2.4	0	8.7	7.7	6.3
Oxalis l.	0	1.1	0.6	2.9	0	0
Beechnut	0	0	0	0.3	0	0
Hazelnut bt.	0	5.7	6.8	5.7	2.9	0
Hophornbeam bt.	0	1.1	0	0	0	0
Apple f.	64.6	7.1	4.3	0	0	0
Birch bt.	0	0.3	6.7	1.0	0	0
Hophornbeam c.	0	0	0.2	0	0	0
Apple l.	0	6.7	0	0	0	0
Bigtooth aspen l.	0	1.9	0	0	0	0
Rumex l.	0	0.8	0	0	0	0
% Identified (Total)	77.3	75.1	81.0	73.4	90.1	93.2
Wisconsin (N)	(37)	(52)	(13)			
Acorn	65.7	9.2	0			
Hazelnut c.	0.8	21.4	38.2			
Hawthorn f.	0	16.8	8.3			
Hophornbeam c.	0	6.0	0			
Cherry f.	2.7	0	0			
Grape f.	0	2.2	0			
Birch bt.	0	0	2.8			
Aspen l.	0.2	2.3	0			
Maple f.	1.4	0	2.6			
Viburnum f.	0	5.4	0			
Clover l.	t	1.7	0			
Strawberry l.	0	0.2	0			
Cinquefoil l.	0	0.3	3.3			
Corn	0	1.9	2.1			
Birch ca.	0	0	5.4			
% Identified (Total)	71.0	67.3	62.8			
Washington (N)	(27)	(2)	(7)			
Rose f.	34.4	0	32.2			
Clover l.	9.7	0	0.4			
Aspen l.	1.2	0	0			
% Identified	45.3	0	32.6			

Appendix Table 3.3. Continued.

Species	Month				
	Sep	Oct	Nov	Dec	Jan	Feb
Maine (N)		(199)	(20)	(14)		
Apple f.		17.3	55.2	2.7		
Hophornbeam c.		0.2	0	23.1		
Acorn		6.3	22.6	0		
Apple l.		21.8	0.4	2.1		
Birch c.		2.6	0	15.9		
Maple f.		6.7	0	14.3		
Hazelnut c.		8.8	0	0		
Beech bt.		0.2	0	0		
Hazelnut bt.		0.3	0	0		
Rumex l.		t	1.2	0		
Aspen l.		1.9	0	0.8		
Blueberry f.		2.2	0	0		
Dandelion l.		t	0	0		
Cherry bt.		0.9	0	0		
Wintergreen l.		0	0.2	0		
Strawberry l.		0.2	0.3	3.9		
Cinquefoil l.		0	t	2.9		
Beechnut		1.3	0	0.6		
Birch bt.		5.6	0	5.2		
Oxalis l.		0.5	0	2.1		
Bunchberry l.		t	0	0		
Clover l.		7.0	1.9	0		
% Identified (Total)		83.8	81.8	70.7		

[1]Only the four most common forages in each month of each state-wide collection (except Washington) can be rank ordered as the most common forages in the monthly collections. Values for less common forages in each month may be exceeded by unknown values for unidentified species. Occurrence of species in the forage list of one state does not necessarily mean that those species were measured in other states.

[2]Plant part abbreviations: l.=leaves, f.=fruits, bt.=buds and twigs, c.=catkins.

Appendix Table 3.4. Maximum and minimum estimates of total phenols and metabolizable energy of all foods from crops and values for crop contents with seeds removed (nonseed crop contents) of ruffed grouse collected in ten states between November 1981 and February 1984.[1]

		Total phenolics (%)						Metabolizable energy (%)					
		Nonseed		Max.		Min.		Nonseed		Max.		Min.	
Month	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Georgia													
Nov	3	1.9	0.8	1.6	1.0	1.0	0.6	57	1.2	43	5.8	31	2.9
Dec	13	6.3	1.5	5.8	1.5	5.2	1.6	54	4.0	49	4.0	45	4.7
Jan	25	7.5	1.4	7.2	1.4	7.1	1.4	57	3.1	55	2.8	54	3.0
Feb	13	8.1	1.6	8.1	1.6	8.1	1.6	48	4.9	48	4.9	48	4.9
N. Carolina													
Nov	37	4.8	0.7	4.2	0.7	3.6	0.7	53	2.3	45	2.5	39	3.1
Dec	35	5.8	0.9	4.8	0.9	4.3	0.9	50	1.9	42	2.0	37	2.7
Jan	24	5.9	1.0	4.6	0.9	4.0	1.0	49	2.3	40	3.0	33	3.9
Feb	22	9.6	1.6	9.1	1.0	9.1	1.6	47	3.1	45	2.4	44	3.0
Virginia													
Nov	28	4.3	0.5	3.6	0.5	2.6	0.6	57	2.8	43	3.6	35	4.4
Dec	44	4.0	0.6	3.7	0.5	3.1	0.6	54	2.3	47	2.4	41	3.3
Jan	40	5.0	0.7	4.5	0.7	3.8	0.8	49	2.0	44	2.2	38	3.2
W. Virginia													
Dec	8	4.6	1.3	4.3	1.1	4.0	2.5	39	6.1	37	5.3	34	5.5
Jan	7	5.9	2.5	5.4	1.9	5.2	2.0	40	4.5	39	4.5	35	6.5
Feb	7	1.8	0.5	1.9	0.8	0.9	0.4	58	7.1	41	6.5	30	4.0
Ohio													
Nov	3	2.3	0.8	2.8	0.9	1.2	0.6	60	4.5	42	6.6	31	5.4
Dec	10	1.7	0.2	1.7	0.3	1.0	0.3	56	3.9	40	6.1	33	6.3
Jan	20	2.9	0.6	2.9	0.4	2.2	0.4	56	3.7	51	4.2	43	5.0
Feb	10	2.8	0.6	2.9	0.6	2.4	0.6	57	3.9	53	5.1	47	6.8
Indiana													
Oct	2	1.2	0.3	1.0	0.1	0.6	0.1	56	2.1	33	2.4	27	2.8
Nov	7	1.8	0.3	1.3	0.4	0.9	0.4	55	8.0	35	8.5	29	8.3
Dec	3	1.6	0.1	1.5	0.4	0.9	0.3	55	2.2	39	8.2	30	10.1
Jan	3	3.0	1.2	3.0	1.2	3.0	1.2	46	3.9	46	3.9	46	3.8

Appendix Table 3.4. Continued.

Month	N	Total phenolics (%)						Metabolizable energy (%)					
		Nonseed		Max.		Min.		Nonseed		Max.		Min.	
		$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
New York													
Sep	4	3.1	1.8	3.1	1.8	3.1	1.8	58	6.2	58	6.2	58	6.2
Oct	28	5.3	1.0	5.4	0.9	4.6	0.9	45	3.5	44	3.3	39	3.7
Nov	18	6.6	1.4	6.3	1.3	6.3	1.4	40	5.2	38	5.2	37	5.4
Dec	16	6.1	0.7	5.8	0.7	5.4	0.8	39	2.9	39	1.8	35	2.2
Jan	12	4.4	1.5	5.1	1.3	3.5	1.5	44	5.0	40	4.2	35	5.3
Feb	9	6.5	1.2	6.4	1.1	6.3	1.3	36	6.2	36	2.8	35	3.4
Wisconsin													
Sep	16	6.7	1.2	6.6	1.2	6.6	1.2	54	4.5	54	4.4	53	5.4
Oct	33	4.5	0.6	4.5	0.6	3.9	0.6	49	2.3	47	2.0	42	2.3
Nov	10	4.6	0.6	4.4	0.6	4.3	0.7	45	1.8	44	2.0	42	3.2
Washington													
Sep	17	6.4	1.2	5.3	0.8	4.4	0.8	56	1.1	52	1.6	39	3.3
Oct	2	2.5	0.1	2.5	0.1	2.5	0.1	47	0.8	47	0.8	45	0.5
Nov	3	4.5	1.5	3.8	1.2	3.1	1.3	56	5.5	55	6.7	39	14.9
Maine													
Oct	158	5.4	1.5	5.4	1.5	5.3	1.3	53	1.5	53	1.5	53	1.3
Nov	18	4.8	0.9	4.8	0.9	4.8	0.9	67	2.9	67	2.9	67	2.8
Dec	13	7.4	1.0	7.4	1.0	7.3	1.0	38	3.6	38	3.6	38	3.7

[1]Values are weighted means and standard errors of weighted means.

Appendix Table 3.5. Maximum and minimum estimates of metabolizable energy and crude protein of all foods from crops and values for crop contents with seeds removed (nonseed crop contents) of ruffed grouse collected in ten states between November 1981 and February 1984.[1]

		Metabolizable energy (Kcal/g)							Crude protein (%)					
		Nonseed		Max.		Min.			Nonseed		Max.		Min.	
Month	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
Georgia														
Nov	3	2.56	0.09	2.00	0.22	1.38	0.11	3	8.0	0.8	9.7	0.3	4.3	1.0
Dec	12	2.47	0.21	2.28	0.22	2.04	0.26	13	12.1	1.5	11.7	1.4	10.0	1.8
Jan	16	2.65	0.18	2.56	0.18	2.49	0.20	19	10.2	1.6	10.3	1.5	9.5	1.7
Feb	10	2.26	0.27	2.26	0.27	2.26	0.27	11	11.6	1.0	11.6	1.0	11.6	1.0
N. Carolina														
Nov	27	2.34	0.09	2.07	0.10	1.75	0.12	26	12.1	1.4	11.4	1.2	9.0	1.5
Dec	24	2.34	0.08	1.99	0.07	1.72	0.11	26	12.9	1.8	12.0	1.4	9.6	1.6
Jan	22	2.33	0.08	1.89	0.11	1.59	0.15	22	11.4	1.7	10.4	1.6	7.8	2.0
Feb	19	2.16	0.13	2.10	0.11	2.03	0.14	20	11.5	2.3	11.5	2.2	10.8	2.4
Virginia														
Nov	23	2.62	0.12	2.01	0.14	1.61	0.18	23	8.8	1.8	8.8	1.3	5.3	1.5
Dec	39	2.44	0.09	2.17	0.10	1.87	0.15	35	13.9	1.4	13.1	1.3	10.7	1.7
Jan	32	2.26	0.08	2.08	0.09	1.77	0.14	35	13.3	1.0	12.3	1.0	9.8	1.3
W. Virginia														
Dec	5	1.79	0.20	1.72	0.11	1.56	0.07	5	12.9	1.6	12.7	1.3	11.2	2.3
Jan	6	1.91	0.17	1.91	0.18	1.69	0.24	5	14.1	2.4	13.9	2.5	13.5	2.8
Feb	6	2.66	0.13	1.94	0.23	1.36	0.14	5	10.3	1.3	10.6	0.8	5.2	0.8
Ohio														
Nov	2	2.59	0.05	2.02	0.13	1.36	0.25	3	9.6	1.7	9.5	1.0	5.0	1.3
Dec	8	2.66	0.18	1.93	0.32	1.56	0.32	7	10.8	2.5	9.4	2.7	6.3	3.2
Jan	18	2.53	0.15	2.29	0.18	1.94	0.23	14	12.7	1.8	11.7	1.9	9.7	2.2
Feb	9	2.51	0.15	2.34	0.20	2.08	0.29	10	17.2	2.4	15.8	2.9	14.3	3.3
Indiana														
Oct	1	3.13		1.80		1.53								
Nov	6	3.03	0.47	1.86	0.38	1.60	0.35							
Dec	2	2.63	0.16	1.80	0.06	1.40	0.08							
Jan	2	2.38	0.38	2.38	0.38	2.38	0.38							

Appendix Table 3.5. Continued.

Month	Metabolizable energy (Kcal/g)						Crude protein (%)					
	Nonseed		Max.		Min.		Nonseed		Max.		Min.	
	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE
New York														
Sep	2	2.49	0.05	2.49	0.05	2.49	0.05	3	8.7	5.5	8.7	5.5	8.7	5.5
Oct	18	2.08	0.15	2.02	0.15	1.81	0.18	23	15.3	3.6	14.6	3.3	13.3	3.6
Nov	14	1.95	0.18	1.95	0.17	1.95	0.16	15	16.6	4.1	16.7	4.1	16.6	4.1
Dec	14	1.94	0.12	1.94	0.09	1.70	0.12	15	21.6	3.1	20.6	3.0	19.1	3.4
Jan	8	2.01	0.23	1.89	0.19	1.59	0.25	11	10.4	2.4	10.2	1.9	8.2	2.4
Feb	7	1.68	0.27	1.67	0.11	1.62	0.14	9	14.3	1.8	14.1	1.6	13.8	2.3
Wisconsin														
Sep	7	2.70	0.32	2.70	0.32	2.70	0.32	12	8.3	2.9	8.4	2.8	8.1	2.9
Oct	28	2.21	0.09	2.12	0.10	1.90	0.11	27	12.7	2.4	11.7	2.5	10.9	2.7
Nov	7	2.10	0.08	2.04	0.09	1.96	0.12	9	15.9	1.0	15.4	1.7	14.9	1.9
Washington														
Sep	13	2.43	0.05	2.32	0.08	1.70	0.15	16	13.9	2.7	13.4	2.8	9.7	2.8
Oct	2	2.20	0.06	2.20	0.06	2.13	0.12	2	16.9	7.4	16.7	7.4	16.3	7.7
Nov	2	2.49	0.13	2.30	0.27	2.03	0.39	2	18.3	1.4	16.5	3.1	14.9	3.7
Maine														
Oct	126	2.44	0.05	2.43	0.05	2.40	0.05	131	12.6	0.8	12.5	0.8	12.4	0.9
Nov	17	3.00	0.19	3.00	0.19	3.00	0.19	17	7.4	2.4	7.4	2.4	7.4	2.4
Dec	11	1.88	0.13	1.88	0.13	1.86	0.13	13	14.9	1.9	15.0	1.2	14.8	1.1

[1] Values are weighted means and standard errors of weighted means.

CHAPTER 4

SPRING FOOD HABITS, DIET QUALITY, CARCASS FAT, AND REPRODUCTIVE ORGAN MEASUREMENTS OF RUFFED GROUSE FROM SOUTHWESTERN VIRGINIA

Late winter and early spring nutrition may be an important aspect of the ecology of ruffed grouse in Virginia (Norman and Kirkpatrick 1984). Controlled studies have shown that nutrition prior to and during the breeding season can have a significant effect on reproduction in ruffed grouse (Beckerton and Middleton 1982) as has been demonstrated in other gallinaceous species (Breitenbach et al. 1963, Barret and Bailey 1971, Pattee and Beason 1979). However, the spring food habits of ruffed grouse in the southern Appalachians are not well documented, and little is known about the nutritional quality of the spring diet of the ruffed grouse in any part of its range. Norman and Kirkpatrick (1984) found low carcass fat levels for nine ruffed grouse collected in April in southwestern Virginia as part of a seasonal study. The present study was a more extensive examination of the nutrition of ruffed grouse in Virginia during the spring period. The objective was to determine the interrelationships among food habits, diet quality, and carcass fat levels of ruffed grouse during the early part of the breeding period.

STUDY AREA

Collections of ruffed grouse were made in the Jefferson National Forest in Giles and Craig counties of Virginia. This area lies within the Ridge and Valley Province of the Appalachian Hardwood subregion (Smith and Linnartz 1980). Elevations in the study area range from approximately 600 to 1200m. Mixed oak (Quercus spp.) hardwoods predominate, and even-age forest management is most common.

METHODS

A minimum of 20 ruffed grouse were collected in the late winter or early spring each year (10 during 15-31 March and 10 during 15-30 April) from 1982-1984. Grouse were collected by shooting from improved or unimproved roads. Crop contents were removed and frozen, and crop-free body weight was measured. Reproductive and digestive tracts were removed, and carcass fat was measured as described in Chapter 2. Fat levels were calculated as total fat weight, percent of fat in dry carcass weight, and as a lipid index ([g fat/g fat-free carcass weight]x100). Ovaries, oviducts, and paired testes of grouse were removed and weighed after lightly blotting moisture. In two instances, testes were damaged by shot and could not be weighed. Counts were made of the number of ovulated follicles, follicles larger than 4mm in diameter, and follicles 2-4mm in diameter. Age was

not determined because of a lack of a reliable aging technique for ruffed grouse in the spring.

Crop contents were oven-dried at 50 C for 24 hours and separated into eight forages classes: hard fruit, soft fruit, leaves and flowers of nonwoody herbaceous plants, ferns, leaves of deciduous woody plants, leaves of evergreen woody plants, buds and twigs, and animal matter. Grit was only found in small amounts and was not included in the food habits analysis or as part of the crop weight. The dry weight of each forage class in each crop was measured. To obtain an estimate of the major forage species in spring diets, the most common forage species in each year's sample were ocularly estimated as a percentage by volume of their respective forage classes in each crop. The percentages of other easily identified species also were ocularly estimated. The weight to volume ratios of forages in a forage class were assumed to be similar. Then, for each crop, the estimated percentage of each identified and measured species in its respective forage class was multiplied by the weight of the forage class to obtain an estimate of the dry weight of that species in the crop contents. Annual percentages of forage classes and species in the crops were calculated by the aggregate volume method (Martin et al. 1946), except dry weight was used.

Individual crop contents were recombined and ground to pass a 1mm screen. Crop contents were analyzed for percent neutral detergent solubles (NDS) (Goering and Van Soest 1970), total phenols (Singleton and Rossi 1965), gross energy, and crude protein as described in Chapter 3. When there was insufficient crop material for all analyses, priority was assigned in the following order: NDS, phenols, GE, crude protein. The percent metabolizable energy (ME) of each crop was calculated from the NDS, total phenols, and the percentage of acorns in the crop contents using the following equation (see Chapter 1):

$$ME = 0.87(NDS - phenols) + 0.18(\%\ acorn\ meat) - 5.76$$

The predicted ME per gram of forage dry matter was calculated from %ME and GE (kcal/g). Values for NDS and total phenols were likely reduced by freezing and oven-drying of crop contents; however, the effect (most likely an underestimation) on ME estimates was probably small because changes in NDS and total phenol values are largely offsetting in the ME prediction equation (see Chapter 1).

Monthly values of ME (% and kcal/g), total phenols, and crude protein were expressed as percentages or kcal/g of the aggregate total crop content weights (equivalent to a weighted mean with heavier crops having a greater influence

on results) for each month in order that food habits and nutritional quality data would be directly comparable. Standard errors of weighted means were calculated as in Chapter 1. A protein-energy ratio (g protein per 100 kcal ME) for the crop contents was calculated for each year using the aggregate protein and ME (kcal/g) values. Sex, month, and year differences in fat and reproductive measurements were tested by analysis of variance using SAS (Ray et al. 1982). Ovarian weight data were transformed to log values for ANOVA to equalize variances, but unweighted means are presented in tables. Specific differences among years were examined with Tukey's multiple range test with the Kramer modification for unequal sample sizes.

RESULTS

Food Habits and Diet Quality

Mean weight (SE) of the crop contents was 3.4g (0.8) in 1982, 2.4g (0.9) in 1983, and 2.2g (0.6) in 1984. In all years, crop contents were composed primarily of hard fruits, herbaceous leaves, or buds and twigs (Table 4.1). Other forage classes were of lesser importance (<7%). Hard fruits were found in 13 crops in 1982 and made up 63% of the diet of these grouse. Hard fruits were found in only three crops in both 1983 and 1984. Acorn meat made up nearly all (>94%) of the hard fruit found in all years (Table 4.2). Acorns

Table 4.1. Foods from crops of 63 ruffed grouse collected in March and April 1982-84 in Craig and Giles counties, Virginia. Values are frequency of occurrence (number of crops) and percent dry weight.[1]

Forage class	1982 (N=22)		1983 (N=21)		1984 (N=20)	
	Freq.	%	Freq.	%	Freq.	%
Hard fruit	13	63	3	30	3	4
Soft fruit	4	2	0	0	5	5
Herbaceous leaves and flowers	19	16	18	43	16	60
Ferns	9	4	4	2	4	2
Deciduous leaves	7	3	5	2	5	4
Evergreen leaves	4	2	3	2	2	7
Buds and twigs	10	6	8	22	9	19
Animal matter	3	2	1	t	0	0

[1] t=trace (<0.5%).

Table 4.2. Species composition of foods from crops of 63 ruffed grouse collected in March and April 1982-1984 in Craig and Giles counties, Virginia. Values are frequency of occurrence (number of crops) and percent dry weight.

Species[1]	1982 (n=22)		1983 (n=21)		1984 (n=20)	
	Freq.	%	Freq.	%	Freq.	%
Acorn (*Quercus* spp.)	10	60.0	3	29.7	2	3.5
Maple f. (*Acer* spp.)	4	3.8	0	0	1	0.2
Coltsfoot fl. (*Tussilago farfara*)	3	2.8	4	22.2	6	20.4
Dandelion l. (*Taraxacum officinale*)	4	2.3	7	3.7	1	4.8
Greenbrier l. (*Smilax* spp.)	2	0.5	2	2.0	5	3.5
Mountain laurel l. (*Kalmia latifolia*)	2	2.4	0	0	2	6.5
Christmas fern (*Polystichum acrostichoides*)	6	3.5	4	1.6	3	0.8
Cinquefoil l. (*Potentilla* spp.)	2	0	6	2.3	3	5.0
Trailing arbutus l. (*Epigaea repens*)	0	0	1	0.1	0	0
Wintergreen l. (*Gaultheria procumbens*)	0	0	2	2.0	0	0
Grape f. (*Vitis* spp.)	0	0	0	0	1	0.2
Greenbrier f.	0	0	0	0	2	5.1
Total identifed		74.9		63.6		50.0

[1]Plant part abbreviations: l.=leaves, f.=fruits, fl.=flowers.

were not identified to species in the present study because in nearly all cases only the acorn meat was found in the crops, and this made identification difficult. Herbaceous leaves and flowers were the most common forages in crops in all years (occurred in >75% of crops). Flowers of coltsfoot (Tussilago farfara) made up a large part of the herbaceous leaves forage class in 1982 (17%), 1983 (52%), and 1984 (37%). Buds and twigs were utilized the least when acorns were abundant. Buds found in crops were typically swelled or partially open with emerging leaves. Therefore, the buds and twigs measured in this study probably are greater in nutritional quality than the buds and twigs of winter diets.

Total phenols in crop contents tended to be highest in 1982 (8.3%) and lowest in 1984 (4.3%) (Table 4.3). Gross energy was lowest in 1982, the year that acorns were the most common in the crop contents. Metabolizable energy levels were greater than 60% and 2.6 kcal/g for both 1982 and 1983, but only 50% and 2.30 kcal/g in 1984. However, the food habits and diet quality data for 1983 were strongly influenced by one crop that contained 14g of acorns, well above the average crop weight of 2.4g for that year. This crop, which also was exceptionally high in GE (4.8 kcal/g), made up 29% of the combined weight of all crop contents for 1983 and, therefore, had a substantial influence on food

Table 4.3. Neutral detergent solubles (NDS), total phenols, gross energy (GE), metabolizable energy (ME), crude protein, and protein-energy ratios (P/E) of foods from crops of 63 ruffed grouse collected in March and April 1982-1984 in Craig and Giles counties, Virginia. Values are weighted means, standard errors of weighted means, and number of crops.

	1982			1983			1984		
	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N
NDS (%)	74.3	3.2	20	74.8	2.7	17	66.8	2.7	19
Total phenols (%)	6.7	1.1	20	5.4	1.0	17	3.5	1.1	19
ME (%)	64	4.4	20	60	3.2	17	50	2.9	19
GE (kcal/g)	4.21	0.88	18	4.57	0.15	11	4.49	0.10	17
ME (kcal/g)	2.68	0.16	18	2.78	0.22	11	2.30	0.15	17
Protein (%)	14.6	1.9	15	14.1	1.9	9	17.4	2.9	14
P/E (g protein/ 100 Kcal ME)[1]	5.45			5.07			7.57		

[1]Calculated from mean ME (kcal/g) and mean protein (%) values.

habits and diet quality results. Elimination of this crop from the 1983 data analysis produces food habits values (hard fruit=3%, herbaceous leaves=57%, buds and twigs=32%, all other forage classes<3%) and diet quality values (phenols=4.1%, ME=53% and 2.32 kcal/g, protein=17.4%, P/E ratio=7.50) that were similar to 1984 values. These latter values probably better reflect the actual food habits and diet quality of the grouse collected in 1983 and in years when acorns are not available in the spring.

Food habits and diet quality data also were analyzed by month. The crops collected in 1982 were excluded from this analysis as was the one crop from 1983 that contained 14g of acorns. High availability of acorns in the spring is probably unusual as will be discussed later. Eliminating grouse that had access to acorns in the spring allowed an examination of more typical spring diets, which contained few fruits.

More than 50% of the crop contents consisted of herbaceous leaves and flowers in both March and April (Table 4.4). Buds and twigs made up 32% of the crop contents in April compared to 9% in March. All other forage classes composed less than 10% of the crop contents in both months (Table 4.5). Total phenol and ME (% and kcal/g) values were similar in both months. The percent protein and P/E ratio of crop contents increased from March to April.

Table 4.4. Foods from crops of 40 ruffed grouse collected in March and April 1983-84 in Craig and Giles counties, Virginia. Values are frequency of occurrence (number of crops) and percent dry weight.[1]

Forage class	March (N=19)		April (N=21)	
	Freq.	%	Freq.	%
Hard fruit	1	1	3	5
Soft fruit	1	9	1	t
Herbaceous leaves and flowers	16	70	17	53
Ferns	5	4	2	1
Deciduous leaves	5	6	4	2
Evergreen leaves	1	t	4	8
Buds and twigs	6	9	11	32
Animal matter	0	0	1	t

[1] t=trace (<0.5%).

Table 4.5. Neutral detergent solubles (NDS), total phenols, gross energy (GE), metabolizable energy (ME), crude protein, and protein-energy ratios (P/E) of foods from crops of 40 ruffed grouse collected in March and April 1983-1984 in Craig and Giles counties, Virginia. Values are weighted means, standard errors of weighted means, and number of crops. Crops collected in 1982 and the one crop collected in 1983 that contained a large amount of acorns were excluded. See text for explanation.

	March			April		
	$\bar{x}$	SE	n	$\bar{x}$	SE	n
NDS (%)	68.1	2.1	16	69.3	2.6	19
Total phenols (%)	2.6	0.6	16	4.4	1.1	19
ME (%)	51	2.1	16	52	2.9	19
GE (kcal/g)	4.28	0.09	11	4.50	0.11	16
ME (kcal/g)	2.24	0.09	11	2.32	0.16	16
Protein (%)	15.0	0.9	10	18.8	3.0	12
P/E (g protein/ 100 Kcal ME)[1]	6.70			8.10		

[1]Calculated from mean ME (kcal/g) and mean protein (%) values.

Carcass Fat

Fat weight, percent carcass fat and lipid index were greater ($P=0.0001$) in females than males, greater ($P<0.011$) in March than April, but did differ ($P>0.20$) among years (Table 4.6). Absolute differences in fat data between sexes or months and among years are greater for lipid index than percent carcass fat because the divisor of the lipid index is not influenced by fat levels. However, conclusions derived from the two indexes were identical because variances also were proportionally larger for the lipid index and significance levels of statistical tests are similar.

Body weight was not different among years ($P=0.80$), between months ($P=0.15$) or between sexes ($P=0.54$) (Table 4.6). However, there was a month x sex interaction ($P=0.0005$). Females gained weight from March to April, whereas males tended to lose weight. In general, there was poor agreement between changes in body weight and changes in carcass fat.

Reproductive Organ Measurements

Oviduct ($P=0.0001$), paired ovarian ($P=0.0001$), and paired testes ($P=0.04$) weights were greater in April than in March (Table 4.7). Only oviduct weight was different

Table 4.6 Percent carcass fat (%), lipid index [(g fat/fat-free carcass weight) x 100], carcass fat weight (g), and whole body weight (g) of ruffed grouse collected in Giles and Craig counties, Virginia.

		Carcass fat (%)		Lipid index		Body weight (g)		Carcass fat (g)	
	N	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
March, 1982									
Females	10	22.4	1.3	29.2	2.2	627	12	37.5	3.2
Males	2	10.7	4.9	12.3	6.2	660	15	16.9	8.4
April, 1982									
Females	7	18.3	1.2	22.6	1.8	677	15	29.7	2.4
Males	3	5.6	1.5	6.0	1.7	597	25	7.5	2.2
March, 1983									
Females	3	16.0	7.0	20.8	10.7	616	43	27.9	15.8
Males	6	11.3	1.5	13.0	2.0	597	45	19.5	3.3
April, 1983									
Females	9	14.8	2.1	17.0	3.0	632	10	22.7	4.0
Males	2	2.4	0.5	2.5	0.6	615	49	3.0	0.4
March, 1984									
Females	3	20.0	4.4	25.9	7.0	618	36	34.1	9.2
Males	7	7.8	1.9	8.8	2.4	660	29	13.7	3.9
April, 1984									
Females	7	13.8	3.5	17.3	5.2	640	10	23.4	6.9
Males	3	2.6	0.5	2.7	0.5	617	6	3.8	0.9

Table 4.7. Ovarian, oviduct, and testes weights (g), number of large (>4mm), small (2-4mm), and ovulated follicles, and the number of females that had ovulated at least once of ruffed grouse that were collected in March and April, 1982-1984.

	Paired ovarian weight[1]			Oviduct weight[1,2]			Paired testes weight[1]			Number of ovarian follicles							Number of females with ovulated follicles
										>4mm			2-4mm		Ovulated		
	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	N	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	
1982																	
March	10	0.5	0.1	10	1.8	0.4	2	0.5	0.2	10	0.7	0.3	4.3	1.2	0.2	0.1	2
April	7	9.7	2.5	7	11.4	0.5	3	1.2	0.3	7	3.6	0.8	5.7	1.0	2.6	0.5	7
1983																	
March	3	0.3	0.1	3	0.9	0.6	7	0.7	0.1	3	0		3.3	0.7	0		0
April	9	6.6	1.6	9	9.8	0.3	2	1.3	0.1	9	2.6	0.6	5.8	0.7	2.7	0.5	8
1984																	
March	3	0.2	0.05	3	0.5	0.2	5	0.9	0.3	3	0		4.3	1.5	0		0
April	7	5.8	2.2	7	9.4	0.7	3	1.0	0.2	7	3.0	0.8	11.4	1.6	0.6	0.4	2

[1] Means are different between months ($P<0.05$).

[2] Means are different between months and among years ($P<0.05$). Mean in 1982 was greater than in 1983 and 1984.

(P=0.01) among years 1982 1983. Tukey's multiple range test indicated that oviduct weight only differed (P<0.05) between 1982 and 1983. As expected, follicle counts followed the same pattern as ovarian weights with increased numbers in April. With the exception of 1984, most females had ovulated at least once by late April. Two of ten females collected in March 1982 had ovulated indicating that some nesting may begin as early as late March.

DISCUSSION

Collecting grouse along forest roads was the only practical method of obtaining a sufficient number of samples for analysis; however, the influence that this collection method had on food habits results is unknown. Grouse may have been attracted to roads in the spring as it was easy to collect birds at that time. A 2-week effort to collect grouse in the early fall from the same areas and by the same personnel was unsuccessful. It did not appear that grouse frequented roadways for grit, as grit was found in only 5 of the 63 crops examined. New herbaceous and deciduous leaf growth may appear first in forest openings such as roadways and attract grouse during the early spring. A number of crops were packed to apparent capacity with coltsfoot flowers, a forage that has not been previously reported for ruffed grouse. Coltsfoot produces flowers in the early

spring (many crops collected in March contained these flowers) and is common along roadsides. Newly emerging deciduous leaves were used heavily in April.

Studies of ruffed grouse food habits in northern areas have found that catkins of quaking aspen were the primary spring forage (Vanderschaegan 1970, Woehr and Chambers 1975). Stoll et al. (1980) also found that aspen catkins were the most common spring food in Ohio even though aspen comprises little of the total forest acreage in that state. Aspen is relatively rare in the predominately oak forests of the southeastern U.S., and, therefore, not available as a food resource. Korschgen (1966) reported that hophornbeam (Ostrya virginiana) catkins and buds made up 25% of the volume of fecal droppings in Missouri in April. Arboreal feeding by grouse in the present study was primarily limited to use of emerging leaves (recorded as buds and twigs in the present study); however, these leaves may have been taken from the ground.

The fall of 1981 was an exceptional year for hard mast production. Acorn production in the Jefferson National Forest was the highest recorded in 32 years (Virginia Commission of Game and Inland Fisheries, 1982). The high occurrence of acorns in the crop contents in 1982 demonstrates that in years of high hard mast production,

acorns can constitute a substantial part of the spring diet of grouse.

When acorns were not available, the spring diet of ruffed grouse had approximately 2.2-2.3 kcal/g ME (%ME=50-53%) and 15-19% protein. Protein levels of diets in the spring were greater than in fall diets in Virginia (see Chapter 3). Higher protein in spring diets was probably the result of the high use of herbaceous plants and a higher protein content in new spring growth. Also, dietary protein may increase from March to April with the increased availability of new emerging leaves. A diet containing 2.3 kcal/g ME is in the upper part of the range of ME values of fall diets for Virginia and, therefore, is probably adequate for maintenance. Dietary ME (63%, 2.68 kcal/g) in 1982 was nearly 20% higher than in 1983-1984 crops without acorns. Therefore, ME was substantially increased when acorns were available. However, the higher ME in this case was due to the high digestibility of acorns and not to a higher GE content. The GE of the acorn meat in crops from 1982 was low (approximately 4.0 kcal/g) indicating they were low in fat.

The adequacy of a diet containing 2.3 kcal ME/g and 15-19% protein for grouse reproduction is unknown. However, 2.3 kcal ME and 18% protein is adequate for domestic turkey

reproduction (Menge et al. 1979) and 2.6 kcal ME and 15-16.5% protein meets requirements of laying white leghorn chickens (Scott et al. 1982:94). Beckerton and Middleton (1982) found that in diets containing 3.1-3.5 kcal ME/g and 21% protein resulted in the greatest reproduction in female ruffed grouse. Dietary protein in the present study was less than 21%; however, the lower ME in spring diets of wild grouse in Virginia probably would lower the level of dietary protein required to maintain protein intake. The P/E ratio of 7.5 found in the present study was 47% higher than the P/E ratio of the diet in the controlled study by Beckerton and Middleton (1982) that resulted in the greatest reproductive rate in female ruffed grouse. Therefore, given that wild grouse from Virginia could find sufficient amounts of food to meet their ME requirements, protein levels in 1983 and 1984 appeared to be satisfactory for reproduction. Tannin phenols in forages may reduce protein digestibility (McLeod 1974, Lindroth and Batzli 1984). However, tannin levels in crop contents were low in 1983 and 1984 probably because tannins are not common in herbaceous annuals or abundant in new growth (Rhoades and Cates 1976). Protein digestibility potentially could have been reduced in 1982 when acorns formed 60% of the diet. High levels of tannins have been found in acorns of some oak species (Ofcarcik and Burns 1971).

Mean percent carcass fat levels in females in all years and both months in the present study (11.3-22.4%) were greater than the mean of 4.8% for three spring-collected females collected by Norman and Kirkpatrick (1984). The reason for this difference in unknown, but may have been the result of variation among years or small sample size in the earlier study. Fat levels in females in March and April were nearly two times greater than the fat content of females collected in Ontario, Canada in March, April, and May (Thomas et al. 1974). It appears that there may be regional or annual variation in fat levels of prebreeding and breeding ruffed grouse. Although, no statistical difference in carcass fat was found among years in the present study, there was some evidence that differences may have existed. All 17 females collected in 1982 had carcass fat $\geq$ 13.8% (15 females had carcass fat $\geq$ 17%), whereas in 1983, 4 of 12 females had fat levels $\leq$ 7.6%, and in 1984, 4 of 10 females had fat levels $\leq$ 8.3%. Seven of the 8 females with low fat levels were collected in April. High fat levels in spring 1982 may have been the result of acorn abundance the previous winter. In typical years, the late winter diet of grouse in the Southeast contains large amounts of low quality evergreen leaves (see Chapter 3).

Large increases in fat reserves just prior to

egg-laying have been documented in wood ducks (Aix sponsa) and mallards (Anas platyrhynchos) (Krapu 1981, Drobney 1982). Mean carcass fat levels of females in spring 1983 (14.8-16.0%) and 1984 (13.8-20.0%) were as high or higher than fall and mid-winter levels reported in other studies of southeastern grouse populations (Norman and Kirkpatrick 1984, see Chapter 3), possibly indicating that female ruffed grouse are capable of increasing fat reserves prior to breeding if sufficient forage is available.

Male grouse consistently had lower carcass fat levels than females. Fat levels in the present study were similar to low levels previously reported for spring-collected males in Virginia (Norman and Kirkpatrick 1984) and Ontario, Canada (Thomas et al. 1975). Decreased body condition during the breeding season also has been reported for male spruce grouse (Canachites canadensis) and bobwhite quail (Colinus virginianus) (Ellison and Weeden 1979, McRae and Dimmick 1982). Male ruffed grouse may forage less during the breeding season because of an increase in time spent on territorial defense, or a strong attachment to a territory may limit food availability.

The decrease in fat from March to April for both sexes was probably directly related to breeding activities. Reproductive organs weights increased markedly from late

March to late April. All but one female had initiated egg laying by late April for 1982 and 1983. The reason for the lower proportion of females that had ovulated (2/7) by late April in 1984 is unknown. Development of reproductive organs and initial egg laying probably utilized some fat reserves in females; however, mean fat levels were still relatively high in April. Mallards (Krapu 1981) and wood ducks (Drobney 1982) expend a large proportion of their fat reserves during laying. Fat levels of female grouse in the present study likely would continue to decrease below April levels until clutches were complete. Fat levels of males may continue to decline through April as a result of continued territorial and breeding-behavior.

Body weight appears to have little usefulness as a body condition index in the spring (see also Chapter 2). While carcass fat levels decreased from March to April in every year, mean body weight values were not different between March and April. For females, increases in oviduct and ovarian weight accounted for much of the increase in body weight. In addition, some females had fully developed eggs in oviducts in April which added to the variability in body weight measurements.

MANAGEMENT IMPLICATIONS

The spring diet of ruffed grouse in the Southeast appears nutritionally adequate for reproduction. However, the ability of forest habitats in the Southeast to supply sufficient amounts of high quality food during the early breeding period may be important in determining grouse distribution and abundance. Because the primary spring forage of northern grouse populations (aspen catkins) is found on trees, adequate food supplies may be more evenly distributed in northern forested habitats than are the herbaceous forbs utilized by grouse in the present study. Abundant growth of high quality herbaceous forbs in Virginia forests may be limited to areas with maintained openings. An abundance of herbaceous forbs in March may be important for increasing fat reserves of female grouse prior to nesting, and management practices that promote herbaceous forb production in March may improve breeding habitat for ruffed grouse. Food availability during the breeding season of ruffed grouse needs investigation in southeastern forests.

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CHAPTER 5

HABITAT USE AND FORAGE AVAILABILITY FOR A RUFFED GROUSE POPULATION IN SOUTHWESTERN VIRGINIA

The diet of ruffed grouse in the southern Appalachians Mountains shifts to relatively low quality evergreen leaves in the late winter, suggesting that supplies of higher quality herbaceous and deciduous leaves are limited at that time (see Chapter 3). The relative abundance of such forages in grouse habitats may have a strong influence on diet quality in this region. However, measurements of foods available to grouse in southern habitats have not been made.

Habitat use by ruffed grouse in the fall and winter also has received little study in the southern Appalachians. White and Dimmick (1978) and Gudlin and Dimmick (1984) monitored fall and winter habitat use of grouse transplanted from Wisconsin to Tennessee and found that the most intensively used habitats were farkleberry (Vaccinium arboreum) and laurel (Kalmia latifolia) thickets and dense stands of hardwood saplings. Studies of resident populations have not been reported.

The objectives of the present study were (1) to measure forage availability and habitat use in fall and winter for a ruffed grouse population in southwestern Virginia, (2) to measure the nutritional quality of winter forages available

in the study area, (3) to estimate forage-based carrying capacity for the study area, (4) to measure cover variables in habitat types present, and (5) to determine relationships between habitat use by grouse and food and cover availability.

STUDY AREA

The study was conducted in a 1.8 x 1.3 km area known as Kelly Flats in the Jefferson National Forest in Giles County, Virginia (Figure 5.1). The study area is located between Fork and Big Mountains near Virginia State Route 635. The site was selected because it was known as an area of relatively high grouse abundance and it contained a variety of habitat types in close proximity. The study area lies within the Ridge and Valley Province of the Appalachian hardwood subregion (Smith and Linnartz 1980). The elevation on the area varied from 800 to 950m. The study area was partially bordered on the south by a maintained grass strip (20-40m wide) and further south by a two-lane road. On the east was a gated unimproved road for approximately one-half the border length. The northern and western boundaries and the remainder of the eastern boundary were arbitrarily situated to form a rectanglar area. The southern half of the area was on a relatively level valley floor. The northern half was situated on a south-facing slope. Forest

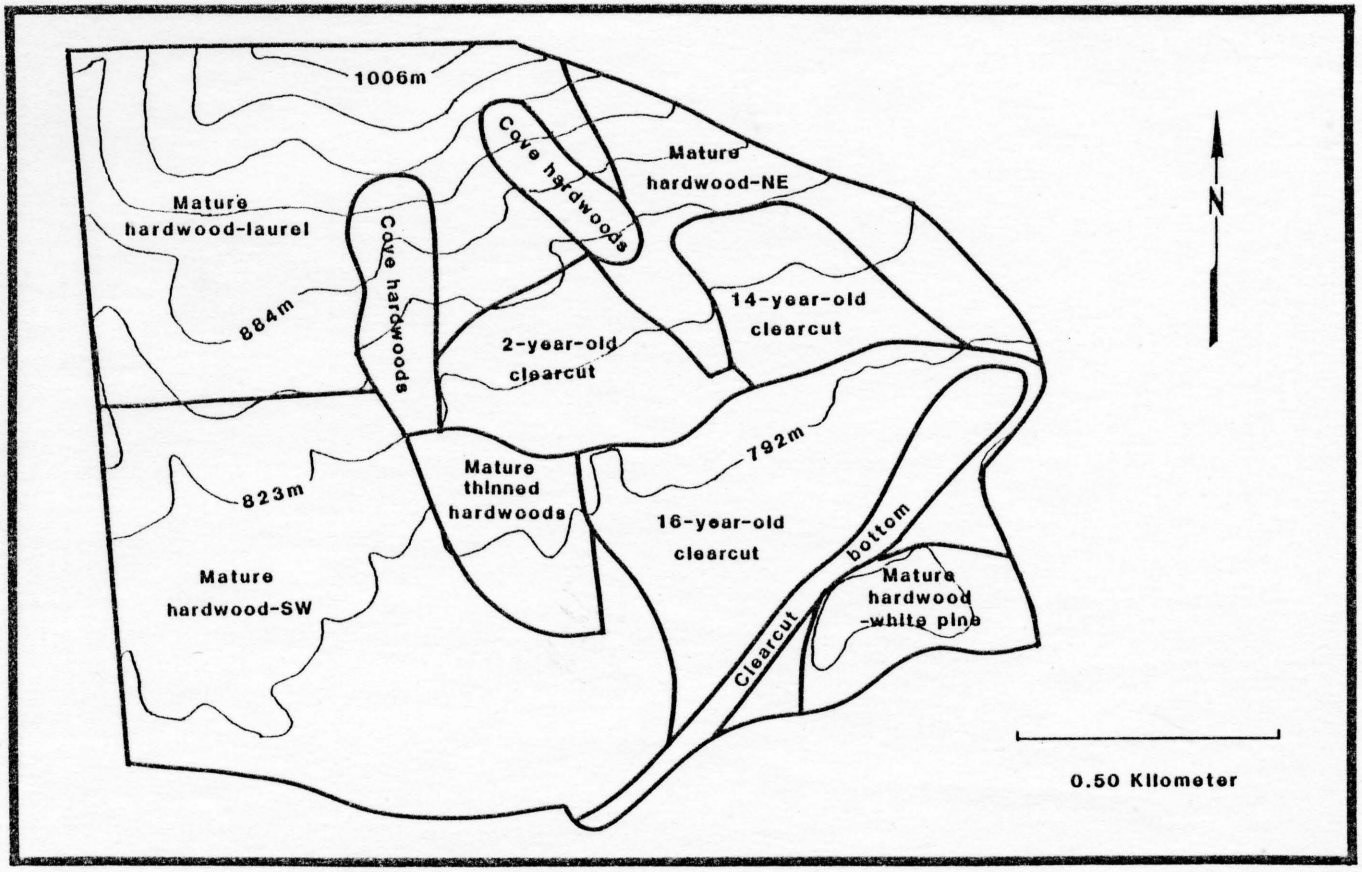

Fig. 5.1. Map of study area in Giles County, Virginia.

stands in the area were even-aged as a result of past management. Approximately 70% of the study area consisted of mixed-oak hardwood stands, 51-78 years old. Approximately 30% of the study area had been clearcut in the last 18 years. Overstory species primarily included white oak (Quercus alba), red oak (Quercus rubra), black oak (Quercus velutina), scarlet oak (Quercus coccinea), chestnut oak (Quercus prinus), hickory (Carya spp.), pitch pine (Pinus rigida), and Virginia pine (Pinus virginia). Understory vegetation was variable and primarily included saplings of overstory spp., blueberry and related species (Vaccinium spp.), huckleberry (Gaylussacia spp.), red maple (Acer rubrum), flowering dogwood (Cornus florida), and white pine (Pinus strobus). Mountain laurel was an important component of the understory only in the northwestern portion of the study area which had a southwest aspect. The distribution of laurel was patchy, ranging from sparse to dense thickets. Ground vegetation was dominated by aromatic wintergreen (Gaultheria procumbens), trialing arbutus (Epigaea repens), and galax (Galax aphylla). Oak regeneration characterized clearcuts except along a small stream that traversed one of the clearcuts. In the bottom bordering this drainage, white pine and hemlock (Tsuga canadensis) also were common in the overstory, and speckled

alder (Alnus incana), and sedges (Carex spp.) were common in the understory.

METHODS

For purposes of measuring forage availability, cover variables, and habitat use, ten forest stands were delinated in the study area based on age, overstory-understory composition, and location (Figure 5.1). Three clearcut stands, 4, 16, and 18 years old and approximately 11, 11, 45 ha in area, repectively, were sampled separately. The clearcut bottom in the 18-year-old clearcut also was sampled separately. Six mature (51-78 year old) stands were sampled. The mature hardwoods with the laurel understory found in the northwest corner of the study area were sampled as a single (mature hardwood-laurel) stand. Within this stand were two areas of mature hardwood coves (sampled as one stand) that were characterized by large overstory stem diameters and an absence of understory vegetation. Mature hardwood stands with relatively open understories occurred in the northeastern (mature hardwood-NE) and southwestern (mature hardwood-SE) portions of the study area. Approximately 8 ha in the mature hardwood-SE stand was thinned of stems <15cm and was sampled separately (thinned hardwoods). A mature hardwood stand on the southeastern corner of the study area had a white oak overstory with

white pine common in the understory (mature hardwood-white pine).

Measurements of forage availability, cover variables, and habitat use were made in the ten stands described above. Fall sampling was conducted from 1 October to 7 November, 1982; winter sampling was conducted from 1 February to 10 March, 1983. Nine permanent and parallel east-west transects were marked at approximately 150m intervals and numbered consecutively from north to south. The two transects adjacent and parallel to the gated road in the center of the area were separated an additional 100m. Relative use of stands by grouse was measured by recording locations of grouse flushed while traversing transects. All transects were walked at least once per week during the sampling periods when weather permitted. Transects were walked only when winds were less than 15 mph and there was no precipitation. Either odd- or even-numbered (randomly selected) transects were walked in random order the first sampling day of the week and the remaining set the second sampling day of the week. Half the transects walked each week were walked in the a.m. (randomly selected), starting approximately 1 hour after sunrise, and the other half were walked in the afternoon, finishing approximately 1 hour before sunset. An index of relative stand use was

calculated as the number of grouse flushed per kilometer of transect walked in each stand.

Cover and forage availability measurements were made at randomly selected points in each stand. At each sampling point, horizontal cover was measured from two randomly selected directions at 0.5, 1.0, and 2.0m heights using a 50cm x 20cm gridded density board. The percent area of the density board covered by vegetation was ocularly estimated to the nearest 5% from a distance of 6m. Total overhead canopy cover was measured with a spherical densiometer. Understory canopy cover between 1 and 3m in height was measured by the line intercept method using a 15.2m line centered on the sampling point in a randomly chosen direction.

Green leaves in a 1m x 1m quadrat and from 0 to 0.5m from the ground were collected at each sampling point and placed in a labeled bag. A 4m x 4m quadrat centered on each sampling point was searched for acorns and soft fruits on the ground. Soft fruits above the ground were counted by species in the same quadrat and a representative sample was collected to determine average dry weights of fruits by species. Total dry weights of fruits were calculated from counts and average dry weights. Availability of buds and twigs was not measured because these forages are not common

in the diet of grouse in the Southeast. Also, tree species in which buds and twigs are commonly fed upon by grouse, such as cherry (Prunus spp.) and birch (Betula spp.) were rare in the study area. Forages collected from plots were frozen until analyzed. An approximately equal number of plots were measured in each stand each week during the sampling period to minimize time effects. Stands were sampled until the variance of the total weight of fresh forages per plot stabilized.

Forages were freeze-dried and weighed by forage class and in some cases by species. Forage classes used included leaves of evergreen woody plants, leaves of deciduous woody plants, leaves of nonwoody herbaceous plants, ferns, hard fruits, and soft fruits. Definitions of forage classes are as in Chapter 3.

Samples of leaves and/or fruits of seven common species or commonly used forages of grouse found during the winter in the study area were collected in February 1985. The species collected included leaves of mountain laurel wintergreen, dewberry (Rubus spp.), partridgeberry (Mitchella repens), galax, and pyrola (Pyrola elliptica and/or Pyrola rotundifolia) and fruits of wintergreen and partridgeberry. Samples were immediately freeze-dried and analyzed for neutral detergent solubles (NDS), gross energy,

total phenols, and tannin phenols as described in Chapter 3. The percent ME for these forages was predicted with the following equation (see chapter 1):

$$ME = 0.87(NDS\text{-total phenols})-5.76$$

The predicted ME (kcal per gram of forage dry matter) was calculated from %ME and gross energy.

Season and stand differences in forage class weights were tested by the nonparametric Hettmansperger-McKean procedure (McKean and Hettmansperger 1976) because of nonnormal data and heterogeneous sample variances. This procedure requires equal sample sizes. Therefore, for testing purposes, the number of plot samples per stand were equalized by randomly eliminating a small number of plots from some stands. Season and stand differences in cover variables were tested by two-way analysis of variance.

RESULTS

All transects were walked seven times in the fall, and a total of 29 flushed grouse was observed for 113km of transects walked (Table 5.1). Seventy-six percent of the grouse flushed were observed in the clearcut areas. The number of grouse flushed per km of transect walked tended to be greater in the clearcut areas than the mature stands. The mature cove hardwoods and the thinned hardwoods were the only stands where no grouse were flushed in the fall.

Table 5.1. Total length (km) of transects in forest stands, total distance (km) walked on transects, and total number of grouse flushes observed on transects in fall and winter.[1]

Stand	Total length of transects in stands	Fall			Winter		
		Total dist. walked	No. flush.	No. flush. /km	Total dist. walked	No. flush.	No. flush. /km
4 year-old clearcut	1.33	9.3	9	0.97	6.7	0	0
16 year-old clearcut	0.71	5.0	1	0.20	3.6	1	0.28
18 year-old clearcut	2.11	14.8	9	0.61	10.6	1	0.09
Clearcut bottom	0.49	3.4	3	0.88	2.5	1	0.41
Mature hardwood-white pine	0.75	5.3	3	0.57	3.8	5	1.32
Mature hardwood-laurel	5.74	40.2	2	0.05	28.7	1	0.03
Mature hardwood-NE	1.13	7.9	1	0.13	5.7	0	0
Mature hardwood-SW	2.20	15.5	1	0.07	11.0	0	0
Mature thinned hardwood	0.63	4.4	0	0	3.2	0	0
Mature cove hardwood	0.83	5.8	0	0	4.2	0	0

[1]Transects walked seven times in fall and five times in winter.

Observations of grouse flushed while making cover and forage measurements also were recorded. All 24 flushes in the fall were observed in the clearcut stands.

Transects were walked five times in the winter. Only nine flushes were recorded for 79.5km of transects walked (Table 5.1). Three grouse were flushed in the clearcut areas and six in the mature stands. Five of the flushes in the mature stands were observed in the mature hardwood-white pine stand. Nine flushes were observed during plot sampling, three in the clearcuts and six in mature stands (four in the mature hardwood-white pine stand).

There were insufficient observations of flushed grouse to estimate grouse density on the study area. However, the greatest number seen in a single day's walk of the fall transects was eight; the maximum number observed in winter was four.

Horizontal cover at 1.0m and 2.0m, understory canopy cover, and total canopy cover were different among stands ($P=0.0001$), but not different ($P>0.05$) between fall and winter (Table 5.2). Seasonal differences in horizontal cover at 1.0m and 2.0m did not occur because most deciduous leaves had fallen during the fall sampling period. Horizontal cover at 0.5m was different among stands ($P=0.0001$) and greater ($P=0.0001$) in the fall than the

Table 5.2. Number of sample plots, horizontal cover (%) at heights of 0.5, 1.0, and 2.0m, understory canopy cover (%), and total canopy cover (%) in forest stands in fall and winter.

Stand (season)[1]		N	Horizontal cover 0.5m $\bar{x}$	SE	Horizontal cover 1.0m $\bar{x}$	SE	Horizontal cover 2.0m $\bar{x}$	SE	Understory canopy cover $\bar{x}$	SE	Total canopy cover $\bar{x}$	SE
4 yr old	(F)	18	75	5	32	6	29	6	64	4	64	8
clearcut	(W)	18	59	6	19	3	14	3	49	4	70	6
16 yr old	(F)	17	51	5	25	2	24	4	71	4	90	2
clearcut	(W)	18	52	5	25	2	24	3	70	4	82	5
18 yr old	(F)	17	56	7	29	3	33	6	77	5	83	5
clearcut	(W)	18	45	5	30	5	27	3	75	4	82	5
Clearcut	(F)	18	82	5	28	5	27	5	55	7	82	4
bottom	(W)	18	58	6	24	5	21	4	52	6	76	6
Mature hardwood-	(F)	15	28	5	14	3	15	2	64	6	98	1
white pine	(W)	15	26	4	18	3	23	4	60	6	99	1
Mature hardwood-	(F)	20	52	5	15	2	19	3	40	3	97	1
laurel	(W)	18	40	5	17	4	19	5	46	6	99	0.3
Mature	(F)	15	43	7	13	3	13	2	16	3	96	0.2
hardwood-NE	(W)	15	30	5	8	2	7	1	21	5	98	0.3
Mature	(F)	16	29	4	13	3	20	4	31	5	99	0.2
hardwood-SW	(W)	15	20	4	13	3	18	5	34	6	99	0.3
Mature thinned	(F)	15	44	5	10	2	11	2	14	3	94	1
hardwood	(W)	15	31	7	10	1	11	2	15	4	92	1
Mature cove	(F)	15	29	5	9	3	9	2	17	4	99	0.2
hardwood	(W)	15	19	4	8	2	7	1	15	4	99	0.2

[1]Season abbreviations: F=fall, W=winter.

winter. There were no interactions ($P<0.05$) between season and stand for any cover variable measured. In general, mean values for understory canopy cover and horizontal cover at 1.0m and 2.0m were greater in clearcut stands than in mature hardwoods as would be expected because of the well-developed shrub layer. Mean total canopy cover was greater in all mature stands than clearcut stands also as expected. The relatively high mean understory canopy cover in the mature hardwood-laurel stand and the mature hardwood-white pine stand was the result of their laurel and white pine understories, respectively.

Only weights of evergreen leaf and herbaceous leaf forage classes were tested for season and stand differences because other forage classes occurred only in small amounts (fruits) or in the case of deciduous leaves consisted of species not used by grouse for food (e.g. leaves of oaks, maples, dogwood). The availability (kg/ha) of evergreen leaves of woody plants was greater ($P<0.01$) in fall than winter and differed ($P<0.01$) among stands (Tables 5.3, 5.4, 5.5. 5.6). In general, clearcut stands contained greater quantities of evergreen leaves than mature stands. However, there was a season x stand interaction ($P=0.01$). The fall to winter decrease in evergreen leaves tended to be greater in clearcut stands than mature stands because clearcuts had

Table 5.3. Dry weight and frequency of occurrence (number of plots) of forages in five of ten forest stands sampled from October 1 to November 7, 1983.

Forage	4 year-old clearcut (N=18)			16 year-old clearcut (N=18)			18 year-old clearcut (N=18)			Clearcut bottom (N=18)			Mature thinned hardwoods (N=14)		
	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.
Leaves, evergreen woody plants															
Total	165.1	28.3	18	84.6	12.9	17	108.1	16.3	16	57.0	12.3	18	98.4	17.0	14
wintergreen	123.6	18.5	18	63.7	11.4	17	40.2	12.2	14	1.3	1.1	2	90.5	17.5	14
arbutus	33.2	15.1	10	15.7	6.0	9	24.1	7.3	10	0.6	0.6	1	2.0	1.9	2
dewberry	5.2	4.7	4	4.4	2.8	3	34.2	8.0	14	44.6	13.1	16	1.4	0.8	6
laurel	0		0	0.7	0.7	1	0		0	0.3	0.3	1	0		0
partridgeberry	3.1	3.1	1	0		0	9.1	3.5	7	10.2	4.7	6	4.3	2.6	5
Leaves, deciduous woody plants															
Total	2.4	1.2	9	19.6	8.5	11	6.2	3.2	14	0.9	0.4	8	2.9	0.9	14
greenbrier	0			0.6	0.4	3	1.7	1.0	10	0.1	0.04	2	0.4	0.2	6
Leaves, herbaceous plants															
Total	26.7	8.4	17	21.6	8.2	16	19.3	5.3	15	29.9	12.6	18	8.5	2.6	11
galax	18.4	9.0	10	16.6	8.6	8	6.2	3.8	3	0		0	0		0
pyrola	2.2	1.5	3	0		5	10.2	3.2	12	0.8	0.5	4	2.9	1.1	8
grass	1.9	0.9	11	1.5	0.9	7	0.2	0.1	5	23.2	9.8	11	0.4	0.4	1
other forbs	4.1	1.5	13	2.5	1.0	10	2.8	0.7	10	5.9	3.6	13	5.2	1.6	11
Soft fruits															
Total	0.01	0.001	4	0.06	0.06	1	0.04	0.02	5	3.3	2.5	8	0.3	0.3	7
greenbrier	0		0	0		0	0		0	3.2	2.5	6	0		0
dogwood	0		0	0.06	0.06	1	0		0	0		0	0.3	0.3	2
wintergreen	0.01	0.005	4	0		0	0.01	0.003	3	0		0	0		0
partridgeberry	0		0	0		0	0.04	0.03	4	0.02	0.01	2	0.02	0.03	2
Hard fruit															
Total	0		0	0		0	0.01	0.01	1	0		0	0		0

Difference between the total weight of a forage class and the sum of the individual forages equals the weight of the unidentified forage species.

Table 5.4. Dry weight and frequency of occurrence (number of plots) of forages in five of ten forest stands sampled from October 1 to November 7, 1983.

Forage[1]	Mature hardwood-NE (N=15)			Mature hardwood-SW (N=15)			Mature hardwood -white pine (N=15)			Mature hardwood -laurel (N=20)			Mature cove hardwoods (N=14)		
	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.
Leaves, evergreen woody plants															
Total	54.0	7.1	15	48.9	7.8	14	24.1	11.1	14	81.1	11.1	19	23.2	8.1	12
wintergreen	48.3	4.8	15	34.1	6.4	14	20.3	4.9	13	58.2	10.6	19	23.2	8.1	12
arbutus	5.7	3.3	4	7.2	2.6	9	0.8	0.8	1	2.8	2.0	3	0		0
dewberry	0	0	0	1.0	0.3	8	2.4	1.0	5	0		0	0		0
laurel	0		0	4.2	4.2	1	0		0	19.9	5.9	9	0		0
partridgeberry	0		0	0.3	0.2	3	0.6	0.5	2	0		0	0		0
Leaves, deciduous woody plants															
Total	4.5	1.4	10	3.1	1.0	14	1.6	1.1	8	10.2	3.6	16	4.9	1.4	12
greenbrier	0.4	0.3	3	1.5	1.1	8	0.1	0.1	3	1.36	0.4	10	0.6	0.3	6
Leaves, herbaceous plants															
Total	16.4	10.8	6	4.8	2.0	11	8.0	2.7	15	16.0	4.9	13	3.9	2.9	4
galax	16.2	10.8	4	2.4	1.7	2	0		0	15.8	4.9	10	3.7	2.9	4
pyrola	0		0	1.2	0.5	7	3.3	1.6	9	0.1	0.1	1	0		0
grass	0		0	0.2	0.2	3	2.1	1.4	9	0.03	0.03	1	0		0
other forbs	0.2	0.1	3	0.6	0.3	7	2.6	0.8	13	0.04	0.03	2	0.2	0.1	2
Soft fruits															
Total	t		1	0.086	0.045	6	0.001	0.001	2	0		0	0		1
greenbrier	0		0	0		0	0		0	0		0	0		0
dogwood	0		0	0.080	0.046	3	0		0	0		0	0		0
wintergreen	t		1	0.003	0.003	1	0.001	0.001	2	0		0	0.003	0.003	1
partridgeberry	0		0	0.021	0.013	0	0.001	0.001	2	0		0	0		0
Hard fruit															
Total	0.33	0.18	4	0.02	0.02	1	0		0	0.04	0.04	1	0.31	0.15	4

[1] Difference between the total weight of a forage class and the sum of the individual forages equals the weight of the unidentified forage species.

Table 5.5. Dry weight and frequency of occurrence (number of plots) of forages in five of ten forest stands sampled from February 1 to March 10, 1983.

Forage	4 year-old clearcut (N=18)			16 year-old clearcut (N=18)			18 year-old clearcut (N=18)			Clearcut bottom (N=18)			Mature thinned hardwoods (N=14)		
	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.
Leaves, evergreen woody plants															
Total	49.4	8.6	18	34.0	5.4	18	31.4	4.7	18	16.7	15.8	13	59.1	9.0	15
wintergreen	40.1	7.9	17	21.8	3.3	18	13.8	3.8	16	2.7	1.6	5	43.8	9.6	14
arbutus	8.6	3.2	8	12.2	4.1	8	4.6	1.8	9	0		0	1.6	1.1	4
dewberry	0.7	0.5	2	0.04	0.03	3	2.5	0.7	13	1.6	0.5	13	0.3	0.1	6
laurel	0		0	0		0	0		0	0		0	5.3	5.3	1
partridgeberry	0		0	0		0	10.4	4.3	7	12.4	5.7	8	8.0	3.6	8
Leaves, deciduous woody plants															
Total	0		0	0		0	0.02	0.02	1	0		0	0.01	0.01	1
greenbrier	0		0	0		0	0.02	0.02	1	0		0	0		0
Leaves, herbaceous plants															
Total	5.8	2.8	13	9.2	5.5	8	5.0	3.2	13	4.5	1.1	17	18.8	15.7	14
galax	5.0	2.8	6	8.8	5.4	5	3.2	3.2	1	0.5	0.5	1	16.0	15.2	4
pyrola	0.2	0.2	1	0.3	0.2	3	1.3	0.5	11	1.4	0.8	5	1.7	0.6	11
grass	0.1	0.05	3	0.02	0.02	1	0.2	0.1	5	0.2	0.1	13	0.02	0.02	1
other forbs	0.5	0.2	10	0.1	0.03	3	0.3	0.1	8	2.4	0.9	11	1.1	0.5	10
Soft fruits															
Total	0.002	0.001	0	0.01	0.005	3	0.02	0.02	1	0.02	0.02	1	0.0.6	0.03	7
greenbrier	0		0	0.01	0.005	1	0.02	0.02	0	0.02	0.02	1	0		0
dogwood	0		0	0		0	0		0	0		0	0		0
wintergreen	0.002	0.001		0		0	0.005	0.005		0		0	0.01	0.01	4
partridgeberry	0		0	0		0	0		0	0.005	0.005	2	0.01	0.03	3
Hard fruit															
Total	0		0	0		0	0		0	0		0	0.02	0.02	1

Difference between the total weight of a forage class and the sum of the individual forages equals the weight of the unidentified forage species.

Table 5.6. Dry weight and frequency of occurrence (number of plots) of forages in five of ten forest stands sampled from February 1 to March 10, 1983.

Forage[1]	Mature hardwood-NE (N=15)			Mature hardwood-SW (N=15)			Mature hardwood -white pine (N=15)			Mature hardwood -laurel (N=18)			Mature cove hardwoods (N=14)		
	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.	$\bar{X}$	SE	Freq.
Leaves, Evergreen woody plants															
Total	21.3	5.3	15	21.0	4.9	11	14.3	16.0	13	55.4	17.3	15	12.5	3.9	12
wintergreen	17.1	4.5	15	11.4	3.3	11	11.0	4.2	13	29.9	14.2	13	9.1	2.7	11
arbutus	4.0	2.2	6	5.7	2.6	4	2.4	2.4	1	3.7	1.6	6	0		0
dewberry	0.1	0.1	1	0.4	0.3	6	0.6	0.3	7	0		0	0		0
laurel	0		0	1.4	1.4	1	0		0	21.7	11.0	8	3.5	3.0	2
partridgeberry	0		0	0.3	0.2	3	0.6	0.5	2	0		0	0		0
Leaves, deciduous woody plants															
Total	0		0	0.03	0.03	2	0.03	0.03	1	0		0	0.03	0.03	1
greenbrier	0		0	0.03	0.03	2	0		0	0		0	0.03	0.03	1
Leaves, herbaceous plants															
Total	1.5	1.0	3	1.1	0.4	7	5.1	1.6	14	8.9	5.3	7	0		0
galax	1.5	1.0	2	0		0	0		0	8.8	5.3	7	0		0
pyrola	0		0	0.8	0.3	7	3.2	1.0	12	0		0	0		0
grass	0.05	0.05	1	0.1	0.1	2	0.4	0.2	7	0.08	0.07	2	0		0
other forbs	0		0	0.2	0.1	7	1.5	0.7	13	0		0	0		0
Ferns															
Christmas fern	0		0	1.0	1.0	1	0		0	0		0	0		o
Soft fruits															
Total	0.005	0.005	3	0.01	0.005	5	0		0	0.001	0.001	2	t		1
greenbrier	0		0	0		0	0		0	0		0	0		0
dogwood	0		0	0		0	0		0	0		0	0		0
wintergreen	0.005	0.005	3	0.01	0.005	5	0			0.001	0.005	2	0		0
partridgeberry	0		0	0		0	0		0	0		0	0		0
Hard fruit															
total	0		0	0.13	0.13	1	0		0	0		0	0		0

[1]Difference between the total weight of a forage class and the sum of the individual forages equals the weight of the unidentified forage species.

greater amounts of evergreen leaves. Leaves of evergreen woody plants were the most common forages in all stands in both fall and winter. Evergreen leaves accounted for 63-89% of the mean forage biomass in all stands in fall and 74-99% in winter. Wintergreen leaves were the most common evergreen forage available in all stands with the exception of the clearcut bottom in the fall when dewberry leaves predominated. The total amount of laurel leaves in the mature hardwood-laurel stand was not determined because leaves higher than 0.5m above the ground were not collected.

Herbaceous leaf biomass decreased ($P<0.01$) from fall to winter and was different ($P<0.05$) among stands (Tables 5.3, 5.4, 5.5, 5.6). In general, herbaceous leaf biomass was greater in clearcut than mature stands. However, there was a season x stand interaction ($P<0.05$). As was the case for evergreen leaves, the decrease in herbaceous leaf biomass tended to be greater in clearcut stands than mature stands. The majority of herbaceous leaves in stands consisted of either galax, pyrola, or grass. Christmas fern was not abundant in the study area and occurred in only a few plots.

Of the deciduous leaves collected (Tables 5.3, 5.4, 5.5, 5.6), only greenbrier is commonly eaten by grouse. Total biomass of greenbrier leaves was underestimated in the fall because leaves on vines greater than 0.5m above the

ground were not collected during the fall sampling period. However, by the winter sampling period, greenbrier leaves on elevated vines had fallen or turned brown and this measurement problem did not occur.

Acorn production was poor in the area during the year of the study (Tables 5.3, 5.4, 5.5, 5.6). Soft fruit availability was low during the fall, except in the clearcut bottom where greenbrier fruited heavily. Soft fruit availability was low in all stands during winter. Measurement results were consistent with field observations that fruit availability was low in all stands during the fall except for the clearcut bottom and nearly all of greenbrier fruit in the clearcut bottom had disappeared by 1 February.

Leaves of mountain laurel, trailing arbutus, wintergreen, and dewberry all had high levels of total and tannin phenols (Table 5.7). Predicted ME values of these forages were low, ranging from 1.93-2.10 kcal/g. Galax and pyrola, both evergreen herbaceous species, also were high in tannin phenols, but had slightly higher predicted ME values. In contrast, leaves of partridgeberry, which was classified as an evergreen woody forage, were low in tannin phenols and higher in ME (2.53 kcla/g) then other evergreen leaves. Wintergreen and partridgeberry fruits were low in tannins and had moderate levels of predicted ME.

Table 5.7. Neutral detergent solubles (NDS), total phenols, tannin phenols, gross energy, and predicted metabolizable energy (% and kcal/g) of hand-collected winter forages of ruffed grouse.

Forage [1]	NDS (%)	Total phenols (%)	Tannin phenols (%)	ME (%)	GE (kcal/g)	ME (kcal/g)
Laurel l.	70.0	17.5	7.0	40	5.25	2.10
Arbutus l.	65.7	13.0	7.1	40	4.81	1.93
Wintergreen l.	66.2	10.7	6.6	43	4.84	2.08
Dewberry l.	72.3	14.3	5.0	45	4.63	2.08
Partridgeberry l.	74.6	2.7	0.04	57	4.44	2.53
Galax l.	74.8	8.9	6.1	52	4.32	2.24
Pyrola l.	77.9	16.5	8.7	48	4.66	2.23
Wintergreen f.	67.5	5.3	2.4	48	4.61	2.21
Partridgeberry f.	64.2	1.2	0	49	4.71	2.19

[1]Plant part abbreviations: l.=leaves, f.=fruits.

DISCUSSION

The apparent preference by grouse for the clearcut stands in the fall was probably related to the cover provided by the relatively dense vegetation. Frequent use of habitats with a well-developed understory is well documented in other areas (Bump et al. 1947, Berner and Gysel 1969), and is consistent with findings for transplanted grouse in Tennessee (White and Dimmick 1978, Gudlin and Dimmick 1984). The highest relative use (grouse flushed/km) for the clearcut bottom may have been influenced by the high fruit production in that area, but there were too few observations to be conclusive. Observations of grouse in the mature hardwood-white pine stand in the fall and winter may have been due to the clumps of white pine present and to the close proximity to the clearcuts.

Evergreen leaves were available in large quantities in nearly all stands in the study area in late winter. These forages have low to moderate levels of ME, low levels of protein (see Chapter 3), and high levels of tannin phenols. Tannins are known to have a variety of detrimental physiological and nutritional effects on birds and mammals (McLeod 1974, see Chapter 3). Based on food habits studies, grouse apparently avoid use of evergreen leaves because they occur in the diet only during the late winter period (see

Chapter 3). Two of the most common evergreen species found in the present study, wintergreen and trailing arbutus, were similarly found in abundance in mature and clearcut stands in December in the Broad Run Wildlife Research Area in southwestern Virginia (Harlow et al. 1975). Wintergreen and trailing arbutus leaves have not been found in large quantities in food habits studies in the Southeast (see Chapter 3, Smith 1977, Stafford and Dimmick 1979, Seehorn et al. 1981). Specific types of tannins or other protective compounds in these forages may cause grouse to avoid feeding on them. Partridgeberry leaves were low in phenols and have been found in food habits studies for grouse (Nelson et al. 1938), but they are not a commonly used forage (Smith 1977, Stafford and Dimmick 1979, Seehorn et al. 1981). The high availability and low recorded use of these easily accessible evergreen species suggests that they are not a valuable food resource for grouse.

Herbaceous leaves in crop contents of grouse collected in the Southeast are high in ME and have low levels of total phenols (see Chapter 3). Of the herbaceous leaves available in this study area, galax and pyrola were high in tannins, and grasses are rarely eaten by grouse. Other unidentified herbaceous forbs found in the present study may constitute a high quality food resource; however, biomass of these

forages was low in winter, varying from 2.4 kg/ha in the clearcut bottom to 0.1-0.5 kg/ha in the three other clearcut stands and zero in many mature stands. Harlow et al. (1975) also found that herbaceous forb biomass was low, varying from 0.1 kg/ha in mature oak-pine stands to 0.5 kg/ha in 7 year-old clearcuts in December.

Grouse activity in the present study was centered around the clearcut stands. The potential of clearcut stands in this study area for meeting energy requirements of grouse in winter can be calculated from forage biomass measurements and estimates of energy requirements for ruffed grouse. Captive ruffed grouse on a diet of commercial Purina Gamebird Chow consume an average of 0.655 kcal/g of ME per gram of metabolic body weight in the fall and winter (Appendix Table A.1). The average of male and female body weights in fall and winter in southwestern Virginia is 630g (Norman and Kirkpatrick 1984). Based on these data, a 630g grouse would require 82 kcal/day. This estimate probably is an underestimate of the energetic cost of 'free-living' for grouse.

For the three upland clearcut stands (excludes the clearcut bottom), mean biomass of evergreen leaves of woody plants varied from 31.4 kg/ha in the 18-year-old clearcut to 49.4 kg/ha in the 4-year-old clearcut during the winter

sampling period. Using an approximation of 2.00 kcal of ME per gram of evergreen leaves and an energy requirement for grouse of 82 kcal/day, the calculated ME available in a 10 ha (25 acres) clearcut with the above range of evergreen leaf biomass could theoretically support 127 to 201 grouse for a 60-day period (late winter). However, as explained previously, the two most common evergreen leaves, wintergreen and trailing arbutus, are rarely found in large quantities in crops of grouse, indicating that these carrying capacities are substantial overestimates.

Mountain laurel is the only evergreen species frequently fed upon by grouse in the Southeast (Smith 1977, Stafford and Dimmick 1979, Seehorn et al. 1981, see Chapter 3). It is not unusual for mountain laurel to occur in regenerating clearcuts, but laurel was not found in large quantities in clearcuts in the present study. The biomass of laurel leaves in the mature hardwood-laurel stand was high (21 kg/ha) and could theoretically supply food for a large number of grouse. In addition, individual dense thickets of laurel would contain many times the average biomass recorded for this stand. Although eaten by ruffed grouse in substantial amounts in late winter, the low nutritional quality of laurel leaves may limit the value of this forage as a long-term winter food resource (see Chapter 3).

Unidentified forb biomass in the upland clearcuts varied from 0.1 to 0.5 kg/ha. These forbs may represent a high quality food resource for grouse. The ME of unidentified herbaceous forbs was not measured; however, the predicted ME of herbaceous leaf samples from crops of grouse from Virginia was 2.78 kcal/g (see Chapter 3). Using this ME value, 0.1 to 0.5 kg/ha of herbaceous forbs in a 10ha clearcut could theoretically support 0.5 to 2.8 grouse for 60 days. However, if the average ME value of crop contents is an overestimate of the ME of forbs found in the present study (grouse probably select forbs with higher than average ME), and if the estimate of winter energy requirements is greater than 82 kcal/day as suspected; then carrying capacity estimates based on these herbaceous forbs may actually be nearer to zero. The clearcut bottom contained greater amounts of herbaceous forbs than the upland clearcuts; however, it is unknown whether 2.5 kg/ha found in that area is sufficient for efficient foraging by grouse.

In Chapter 3, it was hypothesized that ruffed grouse in the Southeast utilize low quality evergreen leaves in the winter when supplies of higher quality fruits, herbaceous leaves, and deciduous leaves have decreased. In the three upland clearcuts, deciduous leaves (primarily greenbrier) and commonly used herbaceous forbs probably were not

abundant enough to support grouse in late winter, which would have necessitated use of evergreen forages by grouse occupying those habitats. The nutritional consequences of a dietary shift to low quality evergreen leaves in late winter is not known, but warrants further investigation.

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RESEARCH NEEDS IN RUFFED GROUSE NUTRITIONAL ECOLOGY

Results of the present study raised a number of questions for future research and delinated a number of areas where information on ruffed grouse nutritional ecology was lacking. Below is a list of research needs, some of which have been mentioned in individual chapters.

1. The effects of tannin phenols on the prediction (using equations described in Chapter 1) of metabolizable energy of forages of ruffed grouse needs further study (see Chapter 1 for further discussion). The ME of forages high in tannins may be overestimated by the prediction equation described in Chapter 1.

2. The lack of information on the extent to which ruffed grouse digest hard seeds of soft fruits complicates efforts to measure the metabolizable energy of natural diets. Controlled studies could easily provide this information as well as provide a better understanding of the value of soft fruits as a food resource.

3. Bone marrow fat has potential as a fat index for ruffed grouse. It may be possible to develop a method of distingishing grouse with depleted fat reserves by visual

inspection of bone marrow. The ulna bone may have the greatest potential for use because marrow fat is present in the ulna of waterfowl (Hutchinson and Owen 1984), and the ulna can be easily be collected from hunters.

4. The effects of high levels of dietary tannins on ruffed grouse nutrition and physiology need to be determined. Studies could be conducted with natural forages high in tannin content and with purified tannins added to commercial feeds. Dietary protein levels may strongly influence results in such studies (Lindroth and Batzli 1984) and, therefore, are an important consideration.

5. The adequacy of mountain laurel as a winter forage for ruffed grouse needs specific study because of the potentially toxic compounds it contains. Based on the limited data available, it appears that low (10-30%) levels of intake of laurel are tolerable for ruffed grouse. Future studies need to examine the effects of long-term use of laurel at moderate levels (50%) of intake and short- and long-term use at high levels (75-100%) of intake. Adequate acclimation of captive ruffed grouse to high fiber diets and laurel diets would be necessary.

6. The hypothesized importance of quaking aspen flower buds as a winter food resource of ruffed grouse in northern

ecosystems is well known to grouse biologists. The nutritional value of quaking aspen flower buds and winter catkins of other tree species (i.e. hazelnut, birches, and hophornbeam) needs to be determined experimentally. Earlier work on the metabolizability of aspen flower buds by ruffed grouse (Hill et al. 1968) was highly criticized by other reseachers. The problems encountered in that research probably were due to inadequate acclimation of captive grouse to aspen bud diets. However, captive grouse can be acclimated to low fiber diets and natural forages. Also, drying and grinding forages used in experiments may provide more reliable estimates of metabolizable energy than feeding whole forages if captive birds do not have well developed gizzards. Grinding forages to a large particle size probably would not influence results because the gizzard of wild grouse appears efficient at grinding these types of forages.

7. In southeastern states, soft fruits are the primary forages of ruffed grouse through January. High soft fruit production may be a characteristic of suitable grouse habitat in fall and winter. Relationships between soft fruit availability and habitat use by ruffed grouse needs investigation.

8. Food availability during the early breeding period of ruffed grouse needs investigation in the Southeast (see Chapter 4). Food availability may strongly influence the suitability of habitat for breeding. In addition, There is a need for information on the effects of poor quality diets (low protein, energy, and/or food intake) in late winter and early spring on subsequent reproductive performance by ruffed grouse.

9. Fat reserves of many male ruffed grouse collected in spring in Virginia were depleted. There is a need for similar condition studies of male grouse in northern ecosystems for comparison. Depleted fat reserves in the Southeast may be as much a result of inadequate food availability as breeding activity.

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Appendix A

ENERGETICS AND DIGESTIVE CAPABILITY OF CAPTIVE RUFFED GROUSE

Data on daily food consumption, metabolizable energy intake (kcal/g $BW^{0 \cdot 75}$) and body weight change of captive ruffed grouse fed diets in metabolism trials described in Chapter 1 are reported in Appendix Table A.1, along with the metabolizable energy (kcal/g) content of the diets. Initial body weights were recorded during the diet acclimation period, two days prior to the fecal collection period. Final weights were recorded at the end of the collection period. All metabolism trials were conducted in outdoors enclosures in the fall and winter under natural temperature conditions. The daily average of minimum and maximum temperatures during trial collection periods varied from 3 F to 10 C in the Experiment 1-Fall digestion trial, -7 to 4 C during the initial Experiment 1-Winter digestion trials, -9 to 5 C during the Experiment 2 trials, and -11 to -10 C during the Experiment 3 trials.

Relationships between metabolizable energy intake (MEI) and body weight change (BWC) for individual grouse were examined by regression analysis for each experiment:

Expt. 1, Fall	MEI=1.45(BWC)+609	r=0.47	P=0.007, N=32
Expt. 1, Winter	MEI=36.2(BWC)+559	r=0.69	P=0.001, N=25
Expt. 2	MEI=14.0(BWC)+603	r=0.56	P=0.001, N=30

Expt. 3 MEI=23.9(BWC)+715 r=0.70 P=0.001, N=29

where: MEI=metabolizable energy intake in kcal/day/$BW^{0 \cdot 75}$

BWC=percent change in body weight.

Predicted metabolizable energy intake at zero weight change in the above regressions (intercept values) for each experiment were variable, ranging from 559 kcal/day/$BW^{0 \cdot 75}$ in the Experiment 1 winter trials to 715 kcal/day/$BW^{0 \cdot 75}$ in Experiment 4. Metabolizable energy intake was likely influenced by temperature and diet palatability.

The apparent digestibilities of neutral detergent fiber (NDF) and acid detergent fiber (ADF) in diets fed to captive grouse in the three experiments described in Chapter 1 are presented in Appendix Table A.2. Both NDF and ADF digestibility tended to be low (<20%) except for the diets containing large amounts of acorns (Experiment 3). Apparent fiber digestibility estimates may be affected to an unknown degree by high levels of phenols in some diets. Tannin phenols can form complexes with dietary or endogenous protein which may elevate fecal fiber levels and, therefore, depress apparent fiber digestibilities.

Appendix Table A.1. Summary of energetic data for captive ruffed grouse fed diets of commercial feeds and/or natural forages in three experiments described in Chapter 1.

Diet[1,2]	N	Metabolizable energy of diet (kcal/g)		Dry matter intake (g/d)		Metabolizable energy intake (kcal/d/BW)		Body weight change (%)		Initial body weight (g)	
		$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Experiment 1, Fall											
Gamebird chow (G)	4	3.15	0.04	28.5	1.4	0.684	0.034	+1.6	1.7	674	47
Horse chow (H)	4	1.80	0.07	46.0	2.6	0.697	0.053	-0.2	1.5	591	35
H-aspen l.	4	1.64	0.08	34.4	4.9	0.465	0.091	-5.5	1.8	628	21
H-chokeberry f.	4	1.75	0.07	41.1	3.4	0.612	0.084	-6.6	3.1	587	37
H-grape f.	4	2.00	0.05	32.0	4.4	0.529	0.078	-5.1	3.0	601	23
G-autumn olive f.	4	2.94	0.04	23.4	1.9	0.506	0.033	-0.1	1.3	701	44
G-cinquefoil l.	4	2.57	0.09	29.9	3.5	0.574	0.074	-1.2	1.1	688	31
G-strawberry l.	4	2.57	0.09	27.7	2.1	0.543	0.048	-1.7	1.2	669	39
Experiment 1, Winter											
Gamebird chow	3	3.04	0.03	27.8	1.4	0.627	0.027	+1.3	0.2	689	26
Horse chow	3	1.47	0.05	36.2	10.1	0.407	0.119	-4.0	3.1	670	39
G-birch b.	3	1.99	0.07	33.9	2.0	0.501	0.003	-0.3	0.4	686	19
H-acorn	3	2.53	0.06	27.2	7.5	0.561	0.184	-1.7	1.4	662	67
H-fern	3	1.55	0.01	25.9	3.7	0.320	0.064	-5.0	1.1	656	67
G-laurel l.	3	2.17	0.24	25.4	2.1	0.420	0.069	-4.4	0.8	673	33
H-apple b.	3	1.49	0.03	37.8	4.7	0.454	0.081	-1.5	1.3	639	51
G-aspen b.	4	1.85	0.05	36.0	2.7	0.509	0.036	-2.4	1.5	666	22
Experiment 2											
1. Cherry f. (58), clover l. (40)	4	2.69	0.08	26.9	1.7	0.581	0.049	-2.0	0.7	632	53
2. Corn (73), dandelion l. (25)	4	3.33	0.07	27.6	1.5	0.840	0.041	+1.9	0.8	524	22
3. Hawthorn f. (38), strawberry l. (40), cinquefoil l. (20)	3	1.73	0.06	23.0	2.2	0.340	0.025	-10.6	2.6	572	36

Appendix Table A.1. Continued.

Diet[1,2]	N	Metabolizable energy of diet (kcal/g) $\bar{x}$	SE	Dry matter intake (g/d) $\bar{x}$	SE	Metabolizable energy intake (kcal/d/BW) $\bar{x}$	SE	Body weight change (%) $\bar{x}$	SE	Initial body weight (g) $\bar{x}$	SE
4. A. olive f. (28), clover l. (40), dandelion l. (30)	3	2.23	0.03	30.6	3.4	0.575	0.101	-3.1	1.3	606	81
5. A. olive f. (73), honeysuckle l. (25)	4	2.62	0.04	23.6	1.5	0.516	0.033	-3.2	0.9	591	7
6. Grape f. (58), laurel l. (25), Christmas fern (15)	3	1.94	0.14	28.4	1.0	0.499	0.029	-6.1	3.3	593	30
7. Grape l. (58), greenbrier l. (40)	3	2.02	0.05	21.4	4.4	0.442	0.097	-4.0	2.0	564	37
8. Sumac f. (50), a. olive f. (24), grape f. (24)	3	1.54	0.03	39.6	0.3	0.512	0.003	-13.3	7.9	562	20
Experiment 4											
Red oak f. (70)	3	3.63	0.08	16.5	2.2	0.508	0.037	-5.8	3.6	591	115
Red oak f. (50)	3	3.31	0.03	25.3	1.2	0.678	0.020	+0.5	1.2	615	13
Red oak f. (30)	3	2.99	0.05	27.6	4.2	0.690	0.086	-1.4	2.5	582	15
White oak f. (70)	3	3.39	0.03	27.8	0.9	0.783	0.045	+0.1	1.4	597	27
White oak f. (50)	3	3.23	0.03	28.6	2.1	0.756	0.018	+0.7	0.8	605	37
White oak f. (30)	3	2.91	0.02	34.9	2.8	0.828	0.039	+0.4	2.0	806	28
Chestnut oak f. (70)	3	3.07	0.09	23.4	2.6	0.582	0.032	+1.1	0.1	607	28
Chestnut oak f. (50)	3	2.98	0.06	29.3	1.4	0.735	0.018	+1.1	0.1	586	47
Chestnut oak f. (30)	3	2.54	0.03	38.4	2.4	0.838	0.050	+4.1	0.4	670	77

[1]Numbers in parentheses following forages listed in diets are percentages of forages in diet.

[2]Plant part abbreviations: l.=leaves, f.=fruits, b.=buds.

Appendix Table A.2. Apparent digestibilities (%) of neutral detergent fiber and acid detergent fiber by captive ruffed grouse fed diets of commercial feeds and/or natural forages in three experiments described in Chapter 1.

Diet[1],[2]	N	Neutral detergent fiber $\bar{x}$	Neutral detergent fiber SE	Acid detergent fiber $\bar{x}$	Acid detergent fiber SE
Experiment 1, Fall					
Gamebird chow (G)	4	27.3	3.6	10.5	4.3
Horse chow (H)	4	13.9	2.3	6.6	2.6
H-aspen l.	4	5.0	1.0	1.1	0.5
H-chokeberry f.	4	6.2	2.4	1.2	2.6
H-grape f.	4	14.1	3.4	2.5	2.2
G-autumn olive f.	4	16.2	1.7	8.3	3.1
G-cinquefoil l.	4	17.3	2.3	8.9	3.9
G-strawberry l.	4	23.3	4.8	13.7	5.1
Experiment 1, Winter					
Gamebird chow	3	21.7	1.5	2.0	2.5
Horse chow	3	5.6	1.0	2.4	0.8
G-birch b.	3	9.4	5.2	1.4	5.3
H-acorn	3	12.6	1.0	7.6	1.6
H-fern	3	2.9	2.1	-3.5	2.9
G-laurel l.	3	14.7	2.2	12.3	2.6
H-apple b.	3	12.3	1.9	8.1	1.7
G-aspen b.	4	8.9	0.8	-2.6	0.4
Experiment 2					
1. Cherry f. (58), clover l. (40)	4	12.9	1.2	7.5	1.3
2. Corn (73), dandelion l. (25)	4	17.9	1.6	3.8	2.5
3. Hawthorn f. (38), strawberry l. (40), cinquefoil l. (20)	3	14.1	2.8	10.4	3.1

Appendix Table A.2. Continued.

4. A. olive f. (28), clover l. (40), dandelion l. (30)	3	14.0	1.3	6.2	1.8
5. A. olive f. (73), honeysuckle l. (25)	4	10.0	1.6	11.1	1.6
6. Grape f. (58), laurel l. (25), Christmas fern (15)	3	11.7	0.6	6.3	1.4
7. Grape l. (58), greenbrier l. (40)	3	8.0	2.3	4.0	3.1
8. Sumac f. (50), a. olive f. (24), grape f. (24)	3	18.7	3.3	14.8	3.1
Experiment 4					
Red oak f. (70%)	3	26.6	2.4	14.2	4.2
Red oak f. (50%)	3	17.0	1.0	3.6	3.3
Red oak f. (30%)	3	11.7	2.6	5.3	2.5
White oak f. (70%)	3	53.8	0.5	10.1	1.9
White oak f. (50%)	3	40.8	1.0	11.8	3.7
White oak f. (30%)	3	23.9	1.5	9.6	2.4
Chestnut oak f. (70%)	3	50.6	1.3	13.3	3.0
Chestnut oak f. (50%)	3	30.8	0.6	6.6	1.6
Chestnut oak f. (30%)	3	18.3	1.0	4.5	0.8
Basal diet	3	11.6	0.8	5.8	1.5

[1]Numbers in parentheses following forages listed in diets are percentages of forages in diets.

[2]Plant part abbreviations: l.=leaves, f.=fruits, b.=buds.

Appendix B

MEAN SQUARE TABLES

Appendix Table B.1. Mean squares for predicted carcass fat of ruffed grouse collected in North Carolina from November-February between November 1981 and February 1984.

Source	DF	Mean square	P-value
Month	3	76.3	0.0576
Sex	1	134.1	0.0361
Age	1	20.8	0.4040
Month x Sex	3	8.1	0.8461
Month x Age	3	56.7	0.1317
Sex x Age	1	71.3	0.1246
Month x Sex x Age	3	30.2	0.3910
Error	102	29.8	

Appendix Table B.2. Mean squares for testes weights of ruffed grouse collected in Virginia in March and April between 1982 and 1984.

Source	DF	Mean square	P-value
Year	2	0.045	0.7785
Month	1	0.874	0.0427
Year x Month	2	0.131	0.4948
Error	15	0.178	

Appendix Table B.3. Mean squares for ovarian (log transformed values) and oviduct weights of ruffed grouse collected in Virginia in March and April between 1982 and 1984.

Source	DF	Mean square		P-value	
		Ovarian weight	Oviduct weight	Ovarian weight	Oviduct weight
Year	2	0.26	9.65	0.1455	0.0106
Month	1	11.89	644.72	0.0001	0.0001
Year x Month	2	0.02	0.56	0.9242	0.7419
Error	33	0.13	1.84		

Appendix Table B.4. Mean squares for percent carcass fat and lipid index of ruffed grouse collected in Virginia in March and April between 1982 and 1984.

Source	DF	Carcass fat		Lipid index	
		MS	P-value	MS	P-value
Year (Y)	2	50.6	0.2391	76.9	0.3686
Month (M)	1	299	0.0048	532	0.0106
Sex (S)	1	1339	0.0001	2502	0.0001
Y x M	2	1.33	0.9622	1.01	0.9867
Y x S	2	15.0	0.6492	27.6	0.6955
M x S	1	18.7	0.4642	7.2	0.7591
Y x M x S	2	19.7	0.5672	26.6	0.7053
Error	50	34.4		75.57	

Appendix Table B.5. Mean squares for whole body weight (g) and carcass fat weight (g) of ruffed grouse collected in Virginia in March and April between 1982 and 1984.

Source	DF	Fat weight		Body weight	
		MS	P-value	MS	P-value
Year (Y)	2	96.5	0.5286	442	0.8017
Month (M)	1	1127	0.0084	4229	0.1514
Sex (S)	1	3904	0.0001	808	0.5272
Y x M	2	5.32	0.9651	1410	0.4978
Y x S	2	56.5	0.6874	3670	0.1692
M x S	1	46.3	0.5803	27388	0.0005
Y x M x S	2	39.4	0.7695	789	0.6751
Error	50	149.6		1993	

Appendix Table B.6. Mean squares for horizontal cover at 0.5, 1.0, and 2.0m heights, understory canopy cover (UCC), and total canopy cover (TCC) in fall and winter in forest stands in a study area in southwestern Virginia.

		Horizontal cover				
Source	DF	0.5m	1.0m	2.0m	UCC	TCC
Season (SN)						
Mean square	1	9758	230	750	125	54
P-value		0.0001	0.2674	0.0821	0.5572	0.6256
Stand (SD)						
Mean square	9	9208	1998	1641	16958	4140
P-value		0.0001	0.0001	0.0001	0.0001	0.0001
SN x SD						
Mean square	9	438	189	312	300	149
P-value		0.4952	0.4278	0.2530	0.5890	0.7474
Error	312	468	186	246	361	226

Appendix Table B.7. ANOVA table for Hettmansperger-McKean procedure for two-way analysis of variance with interaction using the ranks of the residuals for the weights of herbaceouse leaf and evergreen leaf forage classes measured in fall and winter in ten forest stands in a study area in southwestern Virginia.

Source	Reduction	DF	Mean reduction	F ratio	P-value
Herbaceous 1.					
Season (SN)	4.8220	1	4.8220	12.55	<0.01
Error		269	0.3842		
Stand (SD)	7.2234	9	0.8026	2.09	<0.05
Error		269	0.3842		
SN x SD	8.1084	9	0.9009	2.33	<0.05
Error		260	0.3860		
Evergreen 1.					
Season (SN)	124.61	1	124.61	73.22	<0.01
Error		269	1.70		
Stand (SD)	201.50	9	22.39	13.16	<0.01
Error		269	1.70		
SN x SD	73.99	9	8.22	4.60	<0.01
Error		260	1.79		

Appendix C

SEXING RUFFED GROUSE IN THE SOUTHEAST

The length of mid-rectrix feathers is one of the most commonly used criteria for sex determination in ruffed grouse. Grouse with mid-rectrix lengths greater than 15cm are classified as males, and those with mid-rectrix lengths less than 15 cm as females (Larson and Taber 1980:183). However, geographic variation in rectrice lengths, which necessitated use of region-specific length criteria, has been reported within Ohio (Davis 1969) and north-central states (Larson and Taber 1980:183). The number of white dots on the terminal end of rump feathers (1 dot for females and 2 or 3 dots for males) was reported as an accurate (99%) criterion of sex in Quebec. Studies on the accuracy of sexing techniques for grouse in the southeastern U.S. have not been reported. In the present study, two techniques, mid-rectrix length and the number of rump feather dots (Roussel and Ouellet 1975) were tested with 62 ruffed grouse collected in southwestern Virginia in March and April during 1982-84.

Twenty-four male and 38 female ruffed grouse were collected in Virginia. Sex was determined by examination of reproductive organs. Mean $\pm$ SE mid-rectrix lengths for

females was 14.4 ± 0.1 cm, with a range of 12.6-16.6cm. The mean length for males was 17.8 ± 0.2, with a range of 16.1-19.4cm. Using a 15cm length as a classification criterion, all males were correctly classified, whereas, 4 (11%) of the females were misclassified as males. All 62 grouse were correctly classified using the rump feather method.

Distributions of length data for mid-rectrices of grouse collected in Maine (N=221), Wisconsin (N=86), New York (N=117), Ohio (N=64), Virginia (N=117), North Carolina (N=151), and Georgia (N=74) in fall and winter between 1981 and 1984 were examined for evidence of geographic variation. There was some evidence that mid-rectrix lengths in North Carolina and Georgia were greater than in northern states. Of the 424 rectrices collected in Maine, New York, and Wisconsin, only 2 (0.5%) were ≥19cm in length (Figure C.1). In contrast, 18 rectrices (24% of total) collected in Georgia and 16 rectrices (11% of total) collected in North Carolina were ≥19cm in length. Three (5%) and 4 (3%) of the rectrices collected in Ohio and Virginia, respectively, were ≥19cm. Comparisons of mean lengths between states are inappropriate because lengths vary with both age and sex (Davis 1969), both of which were unknown. However, adult males are known to have the greatest average mid-rectrix

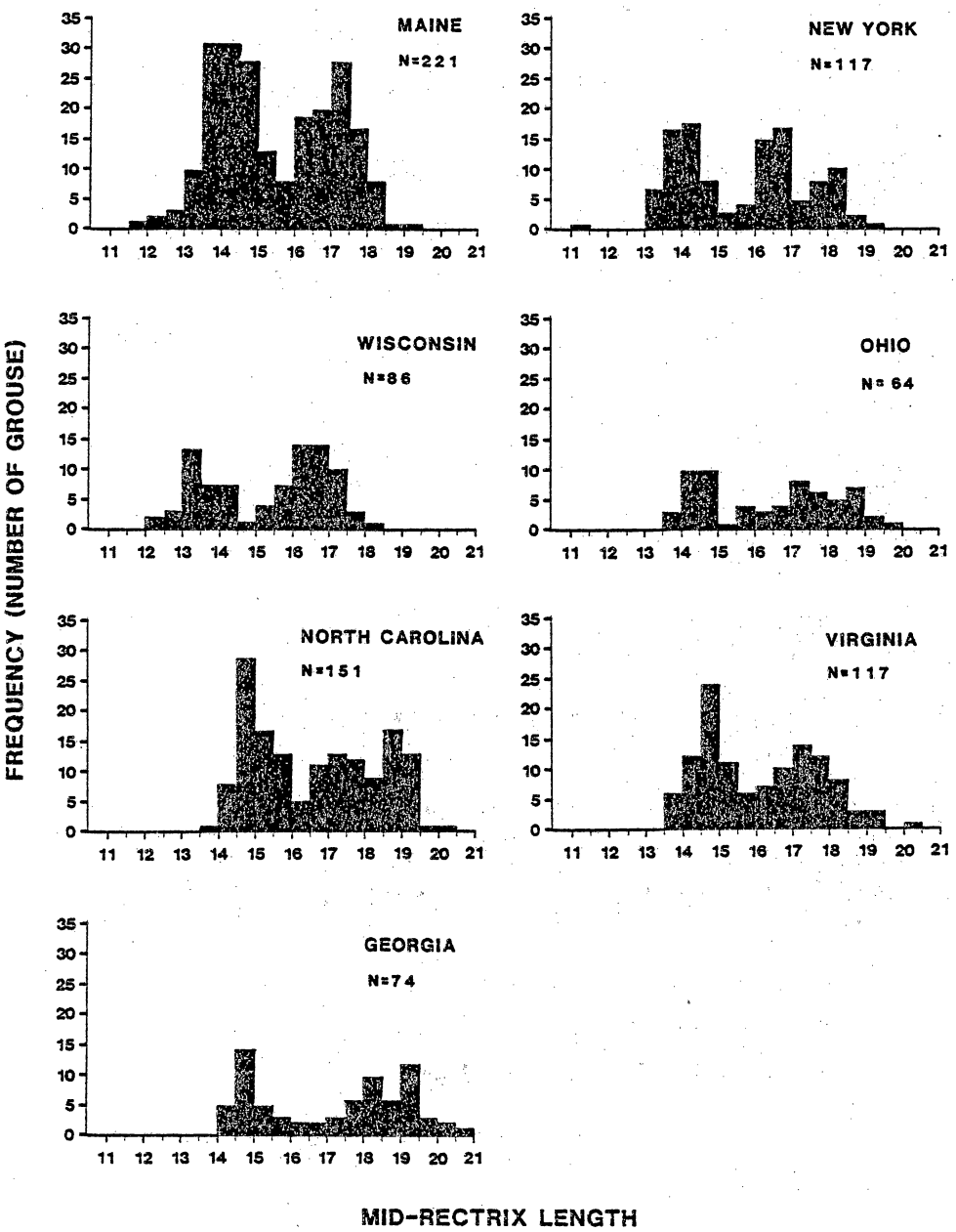

Fig. C.1. Frequency distributions of mid-rectrix lengths of ruffed grouse collected in seven states.

lengths (Davis 1969), and the greater number of rectrices ≥19cm observed in North Carolina and Georgia may be an indication that the average rectrice length of adult males in the Southeast is greater than in northern states. If the mean rectrix lengths for other age-sex classes also are greater in the Southeast than northern areas then critical measurements for sex classification by mid-rectrix lengths would be greater in the Southeast than in the North. This is supported by the results for the grouse from Virginia of known sex which indicated that rectrix lengths of females exceeded 15cm in 11% of the cases. Using 15cm as a classification point, sex ratios (females:males) for both North Carolina and Georgia were 25:75. This highly unbalanced ratio is probably due in part to the misclassification of some adult females.

Sexing criteria developed for Ohio grouse (Davis 1969) are probably the most appropriate available for use in the Southeast region because classification points are greater than 15cm (≤16.1cm and ≤15.3cm for adult and juvenile females, respectively). A disadvantage of this method is that accurate age classification is required. Using the criteria for Ohio may improve accuracy for sexing grouse in the Southeast; however, there is sufficient evidence for geographical variation in rectrix lengths to warrant study

of specific criteria for southeastern states. A better alternative may be the use of rump feathers for sex determination. This method was highly accurate in Virginia and Quebec (Roussel and Ouellet 1975), appears to be independent of age, and does not depend upon the measurement of a continuous variable.

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