A SURVEY OF THE FOOD HABITS OF THE GRAY SQUIRREL (*SCIURUS CAROLINENSIS*) IN MONTGOMERY COUNTY, VIRGINIA

by

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Few works represent the efforts of one man. This study, in turn, is the result of the support, cooperation, and assistance of several organizations and individuals, and it is a pleasure to recognize their contributions.

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INTRODUCTION

The gray squirrel has long been one of Virginia's most popular game animals in terms of numbers havested, and is probably more familiar to most people than any other game animal because of its customary residence in parks, woodlots, and wooded residential districts. With the increasing leisure, wages, and mobility of Virginia's population, the demand for good squirrel hunting will no doubt increase. At the same time the forest habitat on which the squirrel depends will greatly change.

Approximately 63% of the land area in Virginia is forested (Amer. For. Prod. Ind. Inc., 1961). Of this area, 46% is occupied by the upland hardwoods type. Much of this type is immature, low-grade oak-hickory that has regenerated from the destructive logging at the beginning of the century (Craig, 1949). Currently these second-growth forests support far fewer squirrels than the original forests, and it is not known whether this decrease in numbers is caused by a deficiency in food quantity, food quality, den sites, or a combination of these factors. But as these forests mature, squirrel populations will probably increase since mature forests traditionally support large numbers of the animals. When mature, however, these forests will again be marketable, but due to the general low grade, the method of harvesting will tend to be the most profitable rather than

one that will protect the forest as a natural resource, particularly on private land. Even on public lands, the management trend is toward pure, even-aged stands, a practice that will no doubt improve the forest as a source of wood, but whose value to wildlife is questionable, especially to squirrels. Squirrel populations may again suffer unless our knowledge of the animal and its requirements are exact enough to recommend procedures that will prevent or at least minimize the reduction of squirrel populations.

Squirrel studies increasingly indicate that food supply is one of the chief factors limiting population levels (Barber, 1954). Even as recent as 1959, Uhlig stated that squirrel food habits still require additional research. Therefore, it is essential that we determine what the gray squirrel eats, the importance of each food, and how this diet is affected by availability. Furthermore, in the near future a more extensive knowledge of what role the gray squirrel plays in forest ecology will be required, especially as forest land comes under more intensive management.

LITERATURE REVIEW

Results of Past Studies

Many researchers have studied the food habits of the gray squirrel, and the results of these studies have varied with the geographic region of the investigation and the method of research employed. In eastern Texas, Goodrum (1940) analyzed 87 stomachs throughout the year and identified 25 food items. Fifty-nine per cent of all food eaten consisted of acorns, the remaining amount being largely composed of pecan nuts, fungi, various fruits, flowers, and other vegetation. Based on observations of the gray squirrel in southwestern Virginia, Cross (1942) listed 20 species of plants utilized for food, but did not designate the relative importance of these foods. The results of the examination of 98 squirrel stomachs in Illinois by Brown and Yeager, as cited in Martin, Zim, and Nelson (1951), are summarized in Table 1.

The results obtained by Barber (1954) in observing the food habits of the gray squirrel over a two-year period are shown in Table 2.

In West Virginia, Uhlig (1956) compiled a list of gray squirrel foods comparable to the results of previous works, but with additional items such as butternut, greenbrier, grape, and buckeye. Nichols (1958) obtained similar results in a study of New York City squirrels.

Table 1. Plant foods consumed by the gray squirrel in Illinois as determined by stomach analysis plus observation, 1945 (Brown and Yeager, 1945; from Martin, et al., 1951)

Food	Season when consumed (in order of importance)	Per cent of diet
Oak, acorns, and flowers	Su F W Sp	25-50
Hickory	F W Sp Su	10-25
Beech	F W	5-10
Maple	Su F W	5-10
Black Walnut	F W	1-5
Hornbeam	F	1-5
Pine	F W	1-5
Blackgum	F	1-5
Flowering dogwood	F	1-5
Mulberry	Su	1-5
Sweetgum	F	1-5
Fungus	Su F W Sp	1-5
Spruce	W	1-5

Table 2. Per cent by observation of total fox and gray squirrel diet computed for each plant species based on observations in Kentucky, 1954 (Barber, 1954)

Plant species	Per cent of total diet			
	July 1, 1952 to May 20, 1953	May 21, 1953 to May 31, 1954	June 1, 1954 to Sept. 30, 1954	Average for all years
American beech	30	7	5	14
Black oak	3	19	1	10
Shagbark hickory	14	9	7	10
Black walnut	7	8	12	9
Pignut hickory	5	6	9	6
Yellow poplar	0	13	1	6
White oak	2	4	11	5
Mockernut hickory	5	1	8	4
Mulberry	0	3	12	4
Black gum	0	2	11	3
Unidentified oak	4	3	0	3
Red hickory	5	2	0	2
Silver maple	4	2	0	2
Bitternut hickory	0	2	4	2
Flowering dogwood	3	1	0	2
Red maple	2	2	0	2
Scarlet oak	2	2	0	2
Unidentified hickory	1	2	3	2
Shellbark hickory	1	0	8	2
Northern red oak	1	1	3	1
Chestnut oak	0	1	3	1
Corn	2	1	0	1

Table 2. Per cent by observation of total fox and gray squirrel diet computed for each plant species based on observations in Kentucky, 1954 (Barber, 1954) (Continued)

Plant species	Per cent of total diet July 1, 1952 to May 20, 1953	May 21, 1953 to May 31, 1954	June 1, 1954 to Sept. 30, 1954	Average for all years
Blackberry	0	2	0	1
Pin oak	1	1	0	1
Chinquapin	2	0	0	1
Mushroom	2	0	0	1
Other (21 species)	6	7	4	6
Total per cent	102	101	102	103

Analysis of Foods Eaten

Determination of the food habits of the gray squirrel may be accomplished by stomach content analysis or by observation. Observation generally requires a longer period of time and is more difficult to do accurately than stomach content analysis (Goodrum, 1940). Stomach content analysis has the disadvantage of food volume being altered by digestion. Furthermore, the data gathered from stomach content analysis alone does not clearly indicate preference or availability, but an unknown degree of compromise between the two (Davidson, 1963). A combination of the two methods tends to reduce the disadvantages of both methods.

When employing stomach content analysis in a food habits investigation, it is not necessary to analyze the material the day it is collected because it can be preserved in a utilizable condition indefinitely by the technique described by Martin (1949).

Stomach content analysis must be based upon a reference collection of identifiable parts of foods consumed. A histological procedure for the preparation of microscope slides of identifiable plant tissues was developed by Dusi (1949) for a cottontail rabbit food habits study. This procedure was revised and simplified by Dusi in 1952. Dusi (1949) also developed a technique for the preparation of fecal material for analysis of foods eaten. An analytical

procedure that applies strictly to the preparation and examination of squirrel stomach contents was developed by Baumgartner and Martin (1939) and appears to be simpler and more applicable than Dusi's method.

A quick method for determining the volume of general food classes eaten by muskrats was developed by Arata (1959) and is applicable to squirrel stomach contents.

Analysis of Data

Two methods of data analysis were devised by Martin, Gensch, and Brown (1946) for food habits studies. The formulas for the two methods, aggregate percentage and aggregate volume, are as follows:

$$\text{Aggregate percentage} = \frac{\text{Sum of the percentages of the food item in all samples}}{\text{Total number of samples}}$$

$$\text{Aggregate volume} = \frac{\text{Total volume of the food items}}{\text{Total volume of all foods}}$$

Martin et al. stated that because, regardless of volume, each crop is accorded equality (100 per cent volume) in the aggregate percentage method, a condition which usually does not exist, the aggregate volume method more clearly reflects the true food habits. They further stated, however, that average difference between the two methods for a given food is approximately $\pm$ 2% when each food item is considered as part of the whole. The difference may be as great as $\pm$ 300% when the food item is considered alone.

Beck (1952), on the other hand, stated that neither occurrence nor volume adequately evaluate the importance of a food, but that both are of equal importance. Consequently he derived the following formula, where R is the index of importance:

% Vol (dec.) x % Occurrence x Specific gravity = R.

The adequacy of the sample size may be tested by applying the following formula derived by Hanson and Graybill (1956):

$$N = \frac{m + 2\sqrt{m(1-p)}}{p}$$

The notation is as follows:

N = Sample size

p = Proportion of animals with a given food in stomach, expressed as a decimal

$m = \frac{t\sigma^2}{e^2}$

σ = Standard deviation of mean volume of the food in the sample

e = Allowable volume by which food item eaten by the sample animals may vary with the population

t = Student's t-function

PROCEDURES AND TECHNIQUES

Preparation of Reference Material

Because a food habits study can be only as precise as the reference material upon which identifications are based, a large amount of time was spent assembling a workable reference collection. Microscope slides of the diagnostic parts of foods were prepared by the method outlined by Dusi (1952). Examples of such parts are nut and seed testae, fruit pericarps, bud scales, bark, and epidermal tissues. Other foods, such as small flowers, small plants, and insect larvae were preserved whole in small vials containing 10% formalin because these items were not so finely masticated by the squirrels as to be unrecognizable by gross examination. Each reference specimen was then carefully examined for recognizable characteristics, some of which were suggested by Baumgartner and Martin (1939) and are as follows: size and pattern of conductive elements, general cell shapes and patterns, size and number of stomata, pubescence, reproductive elements, color, and texture.

Plants or plant parts included in the reference collection were selected from lists of food items reported in previous squirrel food habits studies and upon the basis of observations of squirrels feeding in the local area.

Collection and Preservation of Squirrel Stomachs

Gray squirrels were collected throughout the entire year and the stomachs from these squirrels were preserved in labeled jars containing 10% formalin. Formalin was also injected into the stomachs to preserve the contents. Squirrels were collected by shooting because the bait corn used in trapping distorted the food habits of captured animals and confounded the stomach-content examination.

Field observations of feeding habits were made when the squirrels were collected to provide a check for the stomach-content examination.

Examination of Stomach Contents

Stomach contents were washed several times through a combination of forty- and sixty-gauge sieves. All wash water was saved and allowed to set so that suspended food particles would settle out. This sediment was then mixed with the material in the sixty-gauge sieve and centrifuged in a graduated centrifuge tube. The food material from the forty-gauge sieve was then poured into a large water-filled funnel with a wide tube on which was attached polyethylene tubing (Fig. 1). A pinch clamp on the tubing allowed the contents of the funnel to be drained at will from the bottom. Once in the funnel, the food materials settled out differentially (Fig. 2), and each strata could be drawn out individually. This procedure was suggested by the work

Fig. 1. Funnel apparatus used to obtain separation of food materials.

Fig. 2. Example of separation of food contents from one stomach.

done by Arata (1959) on muskrat food habits. Because this method was not always successful, several modifications were developed. Careful agitation and decanting were also successful in separating the food. Another separatory method was to direct a strong stream of water from a wash bottle into a beaker containing the food and water. This procedure often caused one food to float to the top while it did not affect the others. When all else failed, foods were separated under a dissecting microscope by hand, if possible.

Once separated, each food was placed in a graduated centrifuge tube and centrifuged for ten minutes. The volume of each tube containing material from the forty-gauge sieve was recorded, and the material then examined under a dissecting microscope. All identifiable tissues were removed, identified immediately if possible, or soaked in Bismarck BY stain (Blaydes, 1939) for ten minutes, and treated according to the procedure outlined by Baumgartner and Martin (1939). The prepared slides were then compared with reference slides and the tissues identified.

If the extremely fine, unidentifiable sediment previously centrifuged had separated into layers, the volume of each layer was added to the volume of the appropriate food. If this procedure was impossible, the sediment was divided in proportion to the volumes of the coarser material

since it was assumed that all foods were masticated equally well by the squirrels.

Rating of the Availability of Foods

The availability of foods was rated by the author throughout the entire year. Because of the difficulty of measuring the availability of foods such as buds or seeds, all foods in edible condition were rated according to the following categories:

copious--covering the branches or carpeting the ground
e.g.--mast so heavy a dozen edible nuts could be collected in one spot

moderate--scattered throughout the branches or lightly over the ground
e.g.--mast widely scattered so that collection of a dozen nuts required movement about the tree

scarce--a few per tree, in the branches or on the ground
e.g.--collection of three nuts required considerable searching

absent--none in the branches, none on the ground
e.g.--extensive searching produced no edible nuts

Analysis of Data

The proportion of the diet that consisted of a given food was calculated by seasons using the methods described by Martin, Gensch, and Brown (1940). Foods were then

ranked in importance upon the basis of the rating index, obtained by multiplying the aggregate volume by the aggregate percentage. This method is a modification of the procedure recommended by Beck (1952). Adequacy of the sample size was calculated by the formula derived by Hanson and Graybill (1956).

The calculated proportions of the diet were graphically compared to the availability rating to indicate whether food items were preferred, staple, or emergency foods.

RESULTS

Reference Collection

Microphotographs of recognizable plant tissues taken to facilitate identification of stomach contents are presented and described in Fig. 3-18.

Analysis of Stomach Contents

A total of 143 squirrels was collected throughout the year. Of these squirrels, 30 had stomachs that contained less than five cubic centimeters and were thus considered empty and not examined. The number and volume of stomachs examined are shown in Table 3.

Tables 4-7 summarize the results of the stomach content examinations. The foods are listed according to rating index rather than aggregate volume or aggregate percentage. Red oak and white oak refer not to specific species, but to respective subgeneric groups as defined by Harlow and Harrar (1959:333-352). The major species composing the red oak group (Erythrobalanus) are Quercus rubra and Quercus velutina, while the white oak group (Leucobalanus) consists largely of Quercus alba and Quercus prinus. Hickory refers to the Carya genus and is composed largely of Carya ovalis, Carya glabra, Carya tomentosa, and Carya ovata. The specific names of the remaining foods are as follows: black walnut (Juglans nigra), maple (Acer rubrum, Acer saccharum), elm (Ulmus americana, Ulmus rubrum),

Fig. 3. Distinct, dendritic venation of hickory testa (Carya sp., 40x).

Fig. 4. Stout, abrupt venation of black walnut testa (Juglans nigra, 40x).

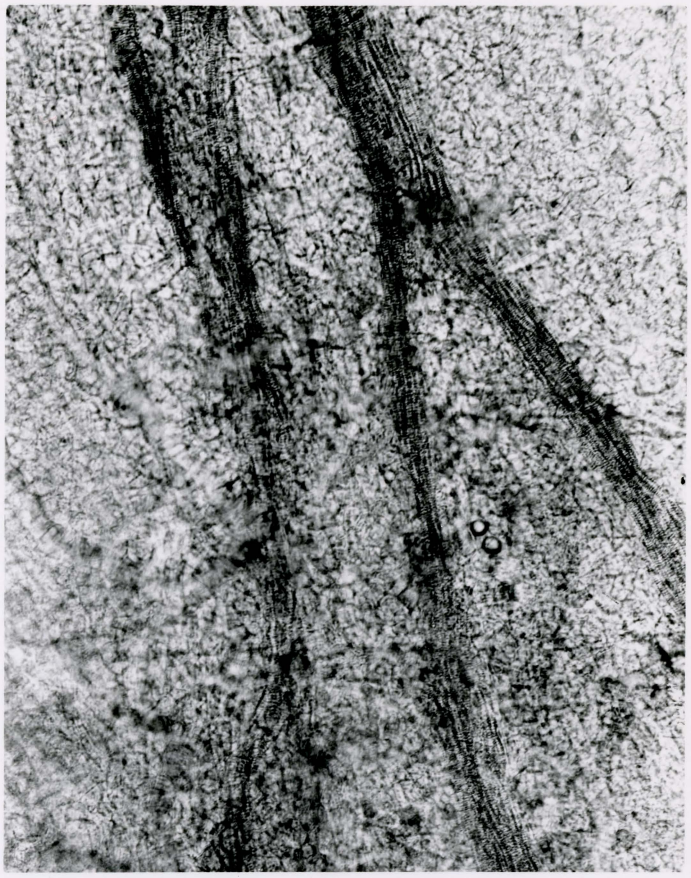

Fig. 5. Indistinct, discontinuous venation of oak testa (*Quercus* sp., 40x).

Fig. 6. Thick, bunched pubescence of red oak testa (Quercus rubra, 100x).

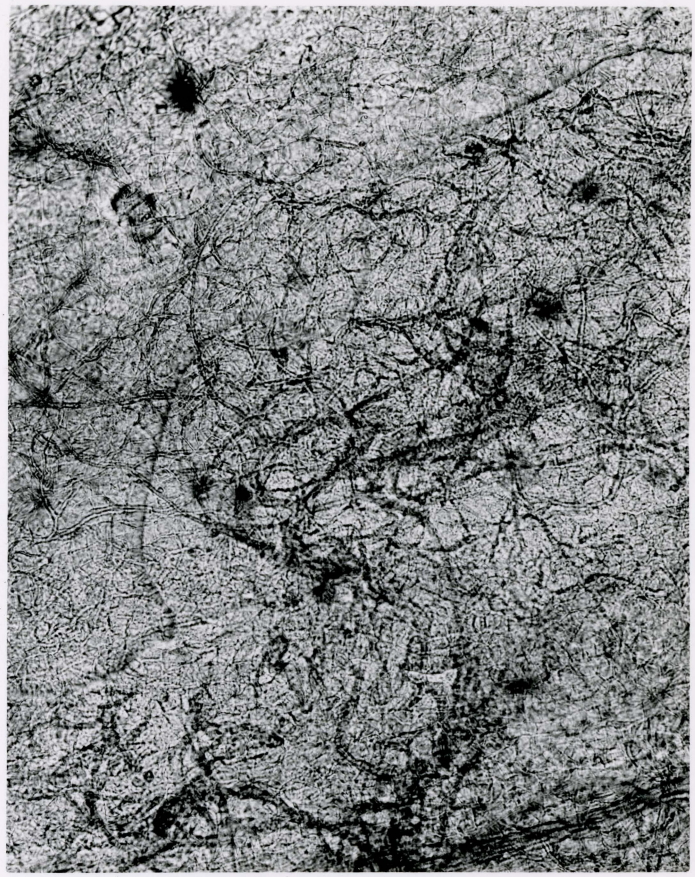

Fig. 7. Fine, scattered pubescence of white oak testa (Quercus alba, 100x).

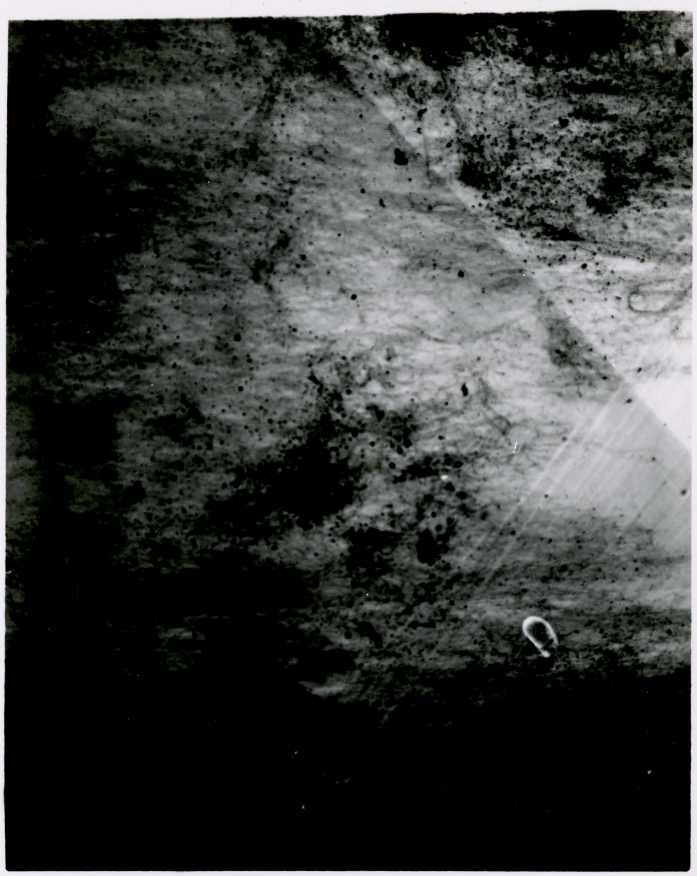

Fig. 8. Mycelial fibers of fungus (40x).

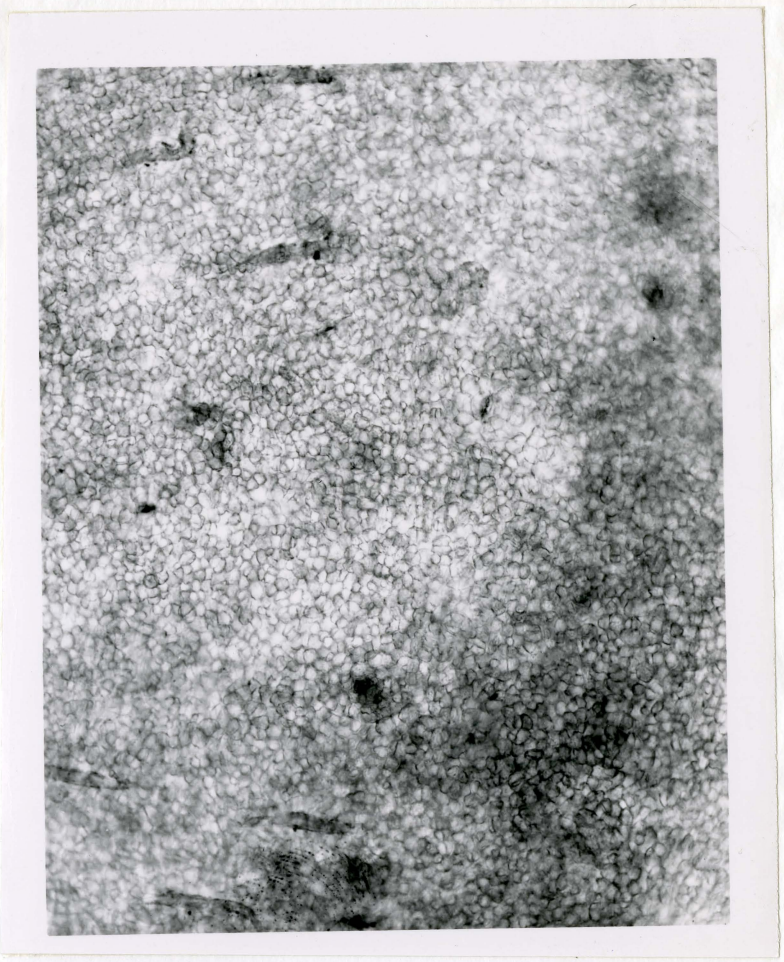

Fig. 9. T-shaped pubescence of dogwood pericarp (Cornus florida, 100x).

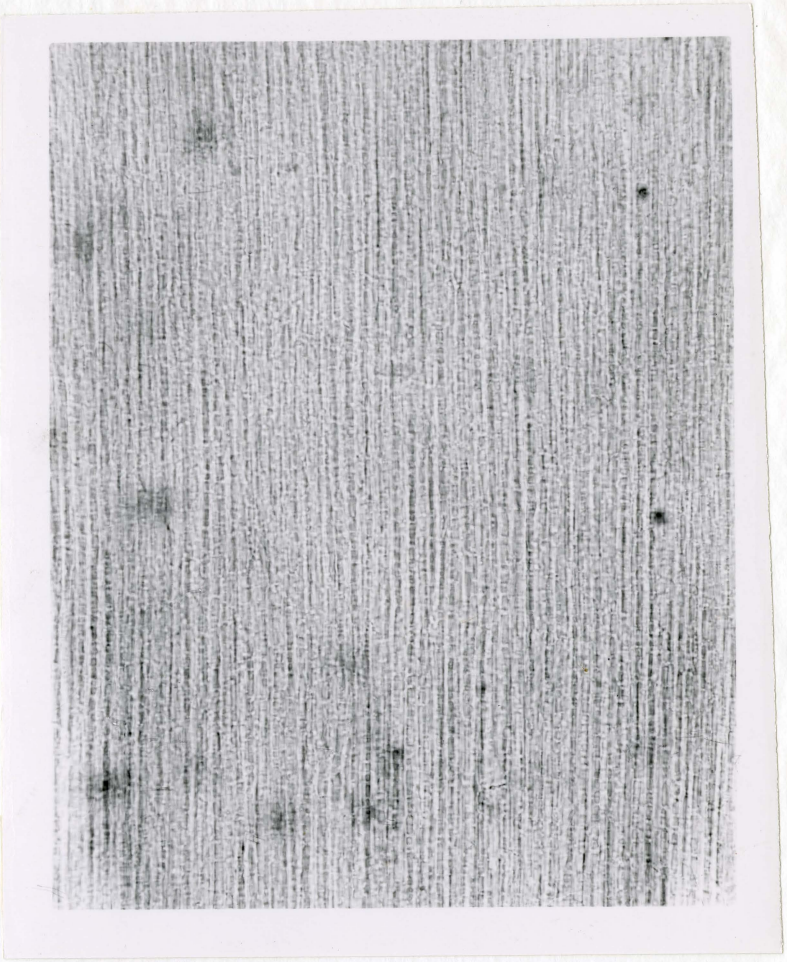

Fig. 10. Columnar arrangement of the seed coat of a corn kernel (Zea sp., 100x).

Fig. 11. Coarse, matted, surface pubescence and fine, apical, fringe pubescence of oak bud scale (Quercus sp., 40x).

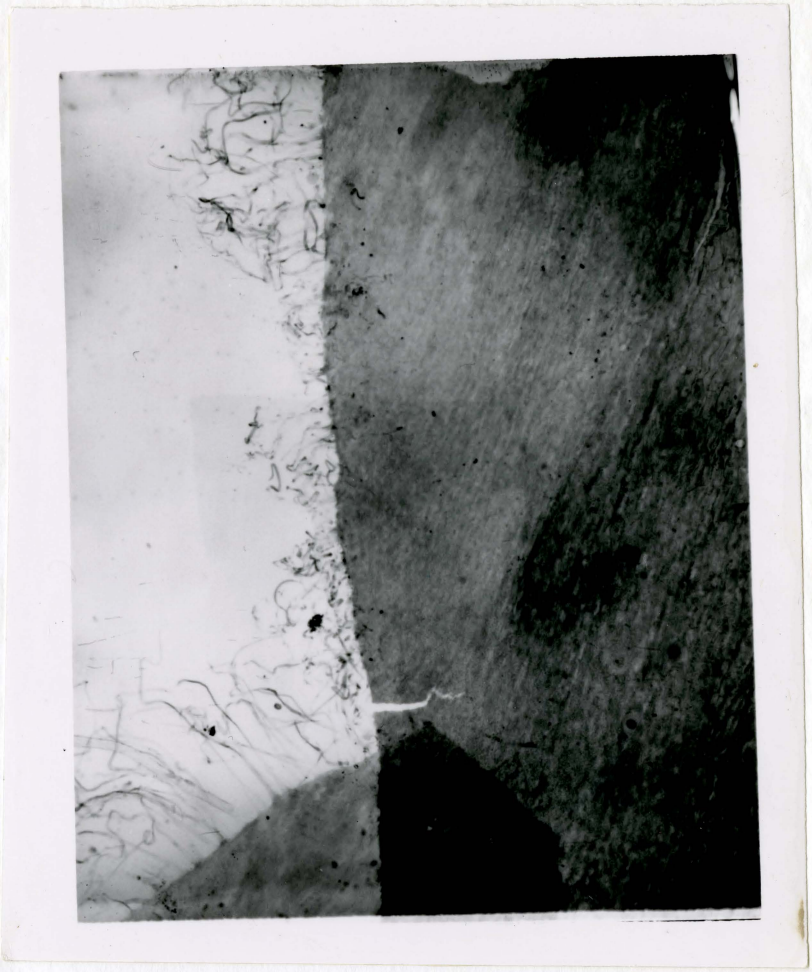

Fig. 12. Smooth surface and fine, curly, marginal, fringe pubescence of elm bud scale (*Ulmus* sp., 40x).

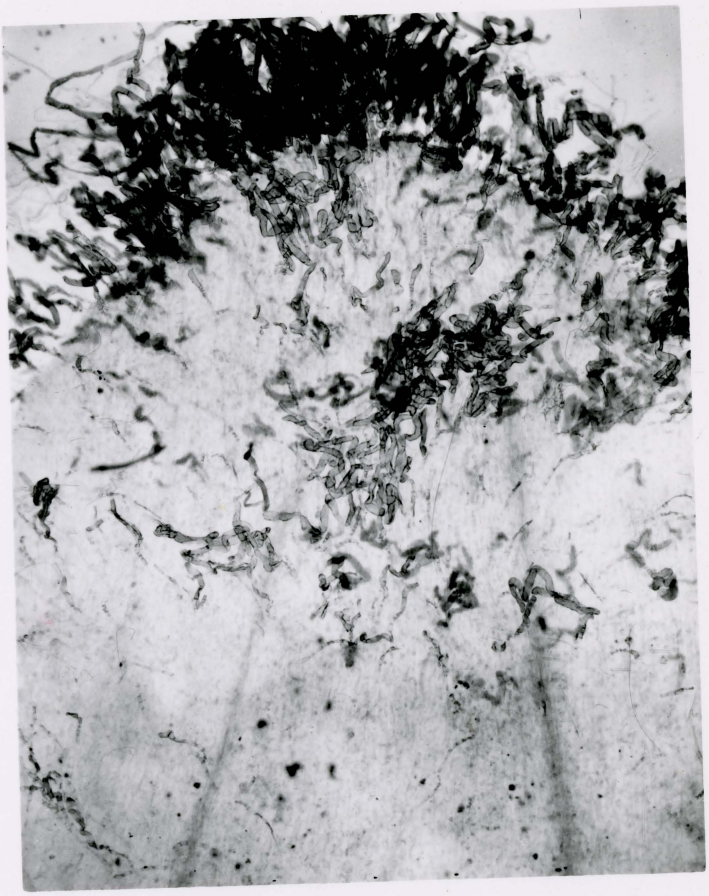

Fig. 13. Dense, kinky, apical, fringe pubescence of maple (Acer sp., 100x).

Fig. 14. Diamond-shaped lenticels of red maple bark (Acer rubrum, 40x).

Fig. 15. Wavy cell pattern of maple seed testa (Acer sp., 100x).

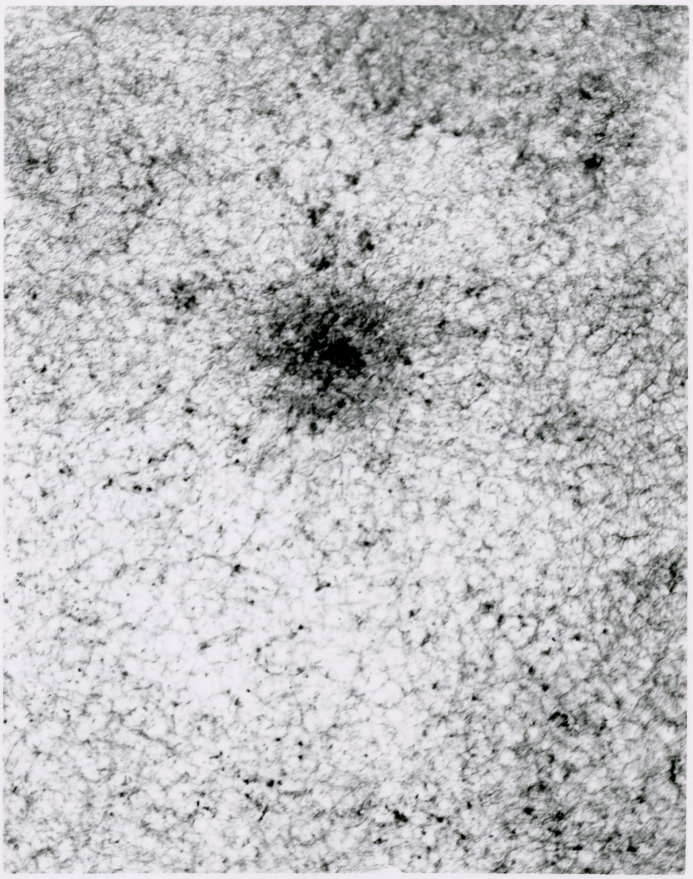

Fig. 16. Cell clusters of pericarp of crab apple (*Malus* sp., 45x).

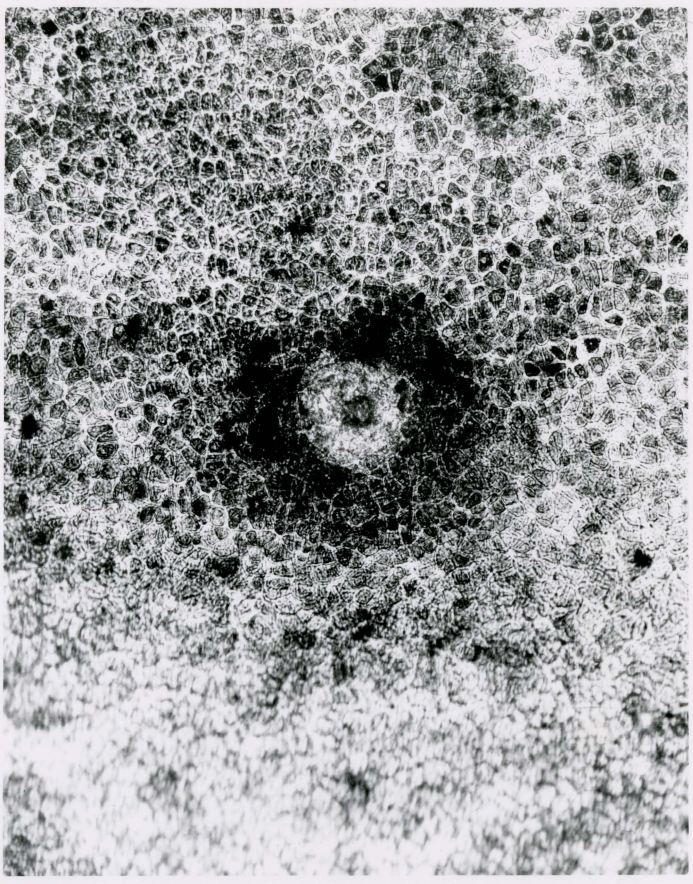

Fig. 17. "Bulls-eye" cell pattern of pericarp of grape (Vitus sp., 100x).

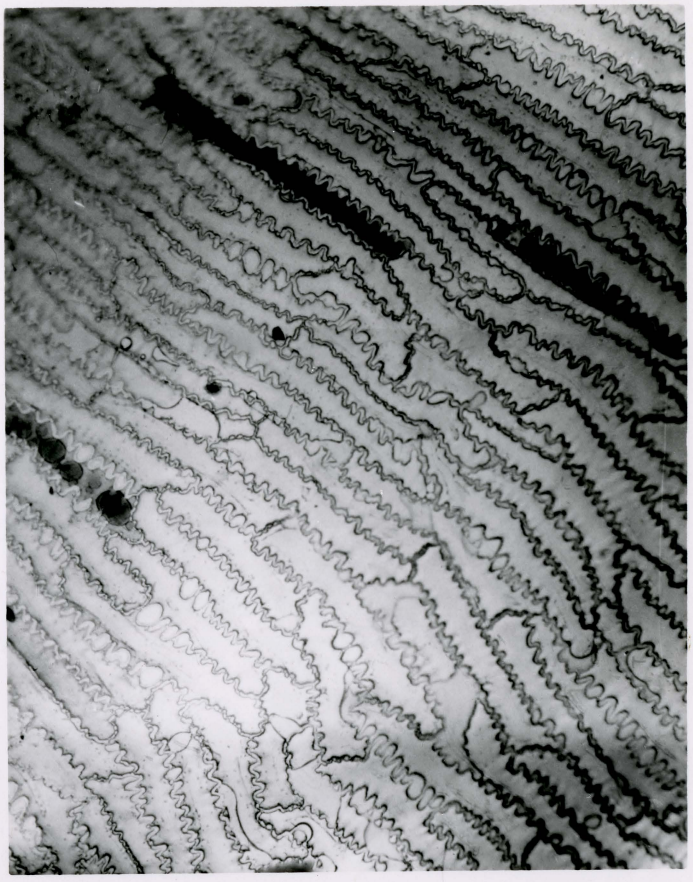

Fig. 18. Long, wavy-walled cells of pine seed coat (Pinus sp., 100x).

Table 3. The number and volume of gray squirrel stomachs from Montgomery County, Virginia, examined during 1966-67

Month	Number of stomachs analyzed	Total volume (cc)
June	5	112.4
July	5	60.2
August	5	57.7
Summer total	15	230.3
September	32	430.2
October	7	98.2
November	6	93.5
Fall total	45	621.9
December	15	297.0
January	6	70.0
February	7	125.6
Winter total	28	492.6
March	15	275.2
April	7	207.3
May	3	42.4
Spring total	25	524.9

Table 4. The fall food habits of the gray squirrel in Montgomery County, Virginia, for September, October, and November, 1966

Food	Aggregate volume (per cent)		Aggregate per cent		Rating index
Hickory nuts		31		36	11.16
Fungi		27		26	7.02
White oak acorns		14		12	1.68
Black walnuts		15		10	1.50
Red oak acorns		3		3	.09
Red oak, white oak, and hickory	2		1		
Red oak and black walnut	1	3	1	3	.09
Red oak and hickory	--		1		
Insects*		2		3	.06
Dogwood fruits		1		2	.02
Pine seeds		1		1	.01
Miscellaneous**		3		4	.12

* Composed largely of Coleoptera larvae, Lepidoptera larvae, and Orthoptera adults.

** Composed of black cherry bark, grass, nut shell, moss, roots, corn, soil, stones, and unidentified vegetation.

Table 5. The winter food habits of the gray squirrel in Montgomery County, Virginia, for December, January, and February, 1966-67

Food	Aggregate volume (per cent)		Aggregate per cent		Rating index
Red oak acorns		31		36	11.16
Red oak and black walnuts	23		12		
Red oak, white oak, and hickory nuts	8		4		
White oak and black walnuts	6	38	3	22	8.36
Red oak and white oak acorns	1		3		
Fungi		13		16	2.08
Black walnuts		8		10	.80
Hickory		3		6	.18
Corn		3		3	.09
Maple bark		1		4	.04
Serviceberry buds		2		1	.02
Grass		1		1	.01
Miscellaneous*		--		1	--

* Composed of clover, insects, maple buds, oak buds, and teaberry leaves.

Table 6. The spring food habits of the gray squirrel in Montgomery County, Virginia, for March, April, and May, 1967

Food	Aggregate volume (per cent)	Aggregate per cent	Rating index
Red oak acorns	19	26	4.94
Red oak and black walnuts	19	17	3.23
Elm buds and flowers	13	10	1.30
Corn	9	9	.81
Oak staminate flowers	11	6	.66
Hickory staminate flowers	7	8	.35
Red maple samaras	4	4	.16
Herbaceous sprouts and stems	4	4	.16
Black walnuts	3	4	.12
Fungi	3	3	.09
Hickory nuts	2	4	.08
Rosaceae flowers	3	2	.06
Sugar maple buds and flowers	2	1	.02
Yellow poplar flowers	1	1	.01
Miscellaneous*	--	1	--

* Composed of chickory seeds, grass, nut shell, insects, red maple buds, serviceberry buds, unidentified bark, and vine tendrils.

Table 7. The summer food habits of the gray squirrel in Montgomery County, Virginia, for June, July, and August, 1966

Food	Aggregate volume (per cent)	Aggregate per cent	Rating index
Herbaceous stems and leaves*	48	24	11.52
Woody buds**	15	10	1.50
Hickory nuts	7	13	.91
Herbaceous buds	5	13	.65
Crab apples	9	7	.63
Black walnut	3	7	.21
Eggs	2	7	.14
Bark, unidentified	3	4	.12
Unidentified vegetative matter	2	3	.06
Bulbs	1	5	.05
White ash seeds	1	3	.03
Unidentified flowers	1	2	.02
Red and white acorns	1	1	.01
Miscellaneous***	2	1	.02

* Composed largely of mayapple fruits and seeds.
** Composed largely of apple buds.
*** Composed of fern gametophytes, grass, insects, and moss.

Table 8. The availability rating of major foods of the gray squirrel in Montgomery County, Virginia, 1966-67

Food	Months											
	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Hickory nut	A	A	C	C	C	M	M	S	S	S	A	A
Red oak acorns	A	A	M	C	C	C	M	M	M	S	S	S
White oak acorns	A	A	S	M	S	S	S	A	A	A	A	A
Black walnuts	A	A	M	C	C	C	M	M	S	S	A	A
Fungi	M	M	C	C	C	M	M	S	S	S	S	M
Buds	S	S	C	C	C	C	C	C	C	M	S	A
Fruits and seeds (other than nuts)	M	C	C	C	C	M	S	S	S	S	M	M
Herbaceous plants (other than grass)	C	C	C	C	M	S	A	A	A	S	M	C
Flowers	S	S	S	S	A	A	A	A	A	M	C	C

C--copious
M--moderate
S--scarce
A--absent

serviceberry (Amelanchier sp.), dogwood (Cornus florida), apple (Malus sp.), yellow poplar (Liriodendron tulipifera), and pine (Pinus strobus, Pinus virginiana, Pinus rigida). Some of the fungi was identified as Dibotryon sp., Daedalea sp., Polyporous sp., and Russula sp.

The results of this study revealed that although a wide variety of foods were consumed, only four foods constituted more than half of the entire diet for any season. In the fall, hickory nuts (36%), fungi (26%), white oak acorns (12%), and black walnuts (10%) were the major foods (Table 4). During the winter, the relative importance of hickory (6%) and red oak was completely reversed from the order of importance in the fall (Table 5). Combinations of oak, hickory, and walnuts (22%), fungi (16%), and black walnuts (10%) constituted the majority of the remainder of the winter diet (Table 5). Red oak acorns (26%) again headed the list for spring food, followed by a red oak-black walnut mixture (17%), elm buds and flowers (10%), and corn (9%). As a group, however, flowers accounted for 28% of the spring diet (Table 6). Summer foods consisted mainly of herbaceous plants (24%), herbaceous buds (13%), hickory nuts (13%), and woody buds (10%) (Table 7). However, the extensive consumption of maturing acorns in the summer, as reported by Goodrum (1940), was not detected during this investigation.

In previous studies (Barber, 1954; and Martin, Zim, and Nelson, 1951), fungi composed less than 5% of the total diet. As shown in Tables 4 and 5, however, fungi constituted 26% of the fall diet and 16% of the winter diet. Corn is another food rated below 5% or not at all in previous studies (Goodrum, 1940; Uhlig, 1956; and Nichols, 1958). In this study, however, corn was consumed in increasing volumes through fall (1%), winter (3%), and spring (9%) (Tables 4, 5, and 6).

Availability of Major Squirrel Foods

The availability ratings of major squirrel foods are presented by month in Table 8 and expressed graphically in Fig. 19-27.

Mast availability was copious to moderate throughout all of the fall and most of the winter, with the exception of white oak acorns, which were scarce or absent in every month but August, when they were moderately available. Red oak acorns and black walnuts were present from August to April and May, the longest period of availability for all foods except fungi, and fruits and seeds, which occurred throughout the year. As these masts became scarce, the supply of flowers, fruits and seeds, and herbaceous vegetation increased and remained copious throughout most of the summer and into the fall.

Relationship Between Availability and Utilization of Major Squirrel Foods

The relationship between availability and utilization of nine major food classes is expressed graphically in Fig. 19-27. The peaks of utilization and availability correlate in both hickory and white oak, thus indicating that these masts were preferred foods, especially since there was a large variety of other foods from which to select (Fig. 19 and 21). The two curves for red oak do not correspond, however, thus indicating that the acorn was not a preferred mast (Fig. 20). Due to the importance it played in the diet, however, it must be considered a staple food. Black walnut does not appear to be a preferred food, but was utilized as long as it was available and was therefore most likely a staple food (Fig. 22). As with white oak, black walnut was utilized after it was rated absent. This disparity was probably due to hidden caches.

Fungus must be classed as a preferred food because of the correlation of the utilization and availability curves and because it was selected along with the preferred masts (Fig. 23). Although the two curves for flowers correlate, the food is difficult to describe because there were few other foods for the squirrels to choose from (Fig. 27). Fruits, seeds, and herbaceous plants (Fig. 25 and 26) were likewise difficult to judge except that they

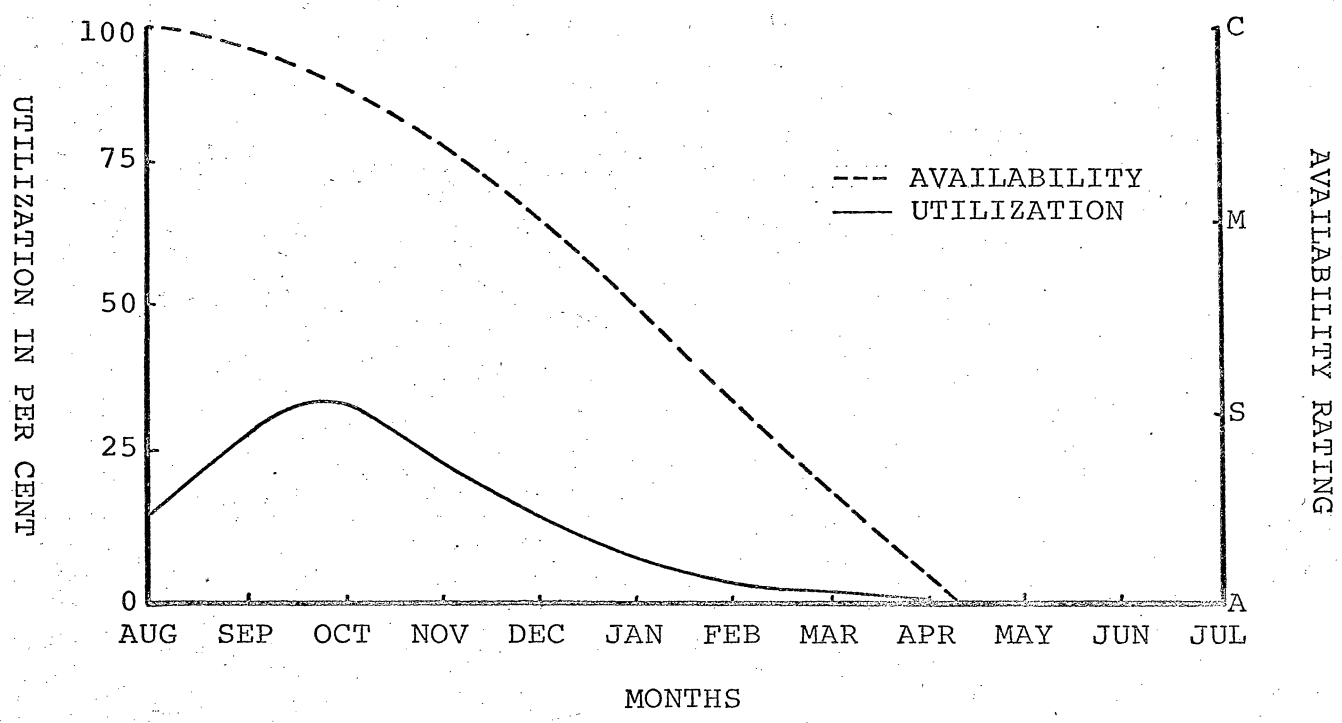

Fig. 19. Utilization of hickory nuts by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

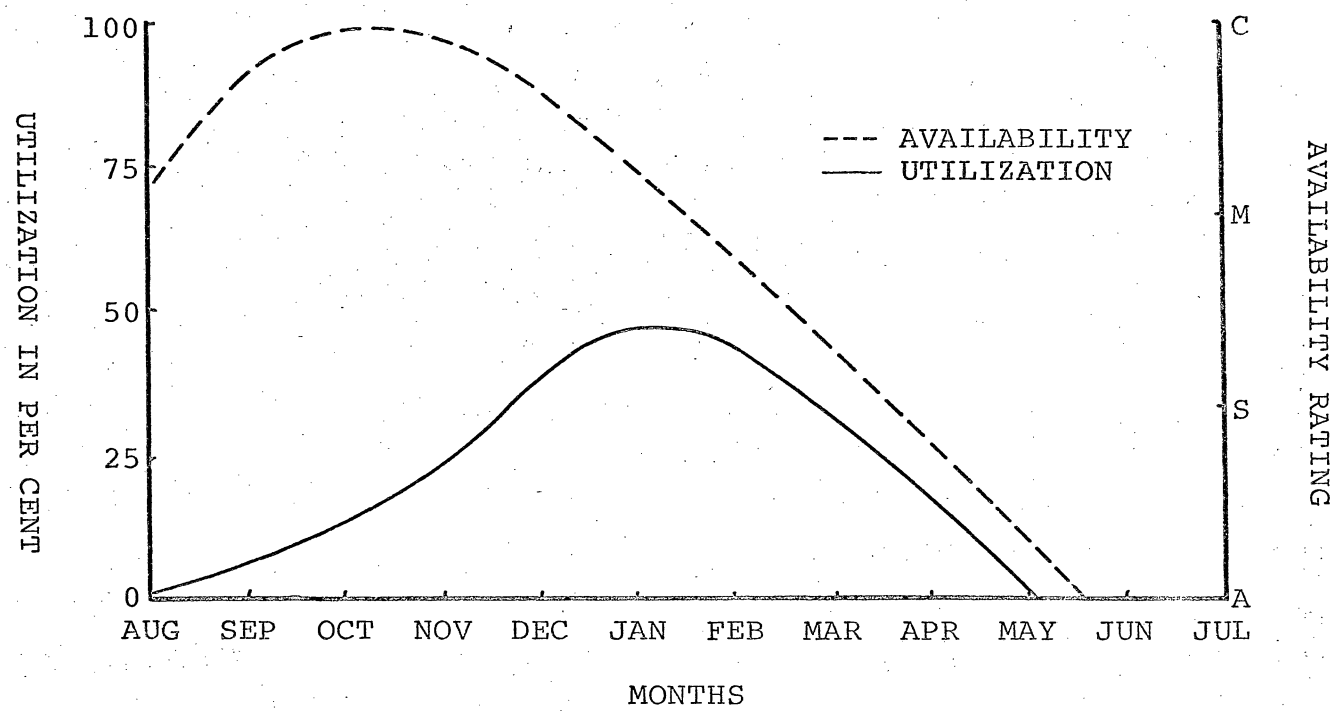

Fig. 20. Utilization of red oak acorns by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

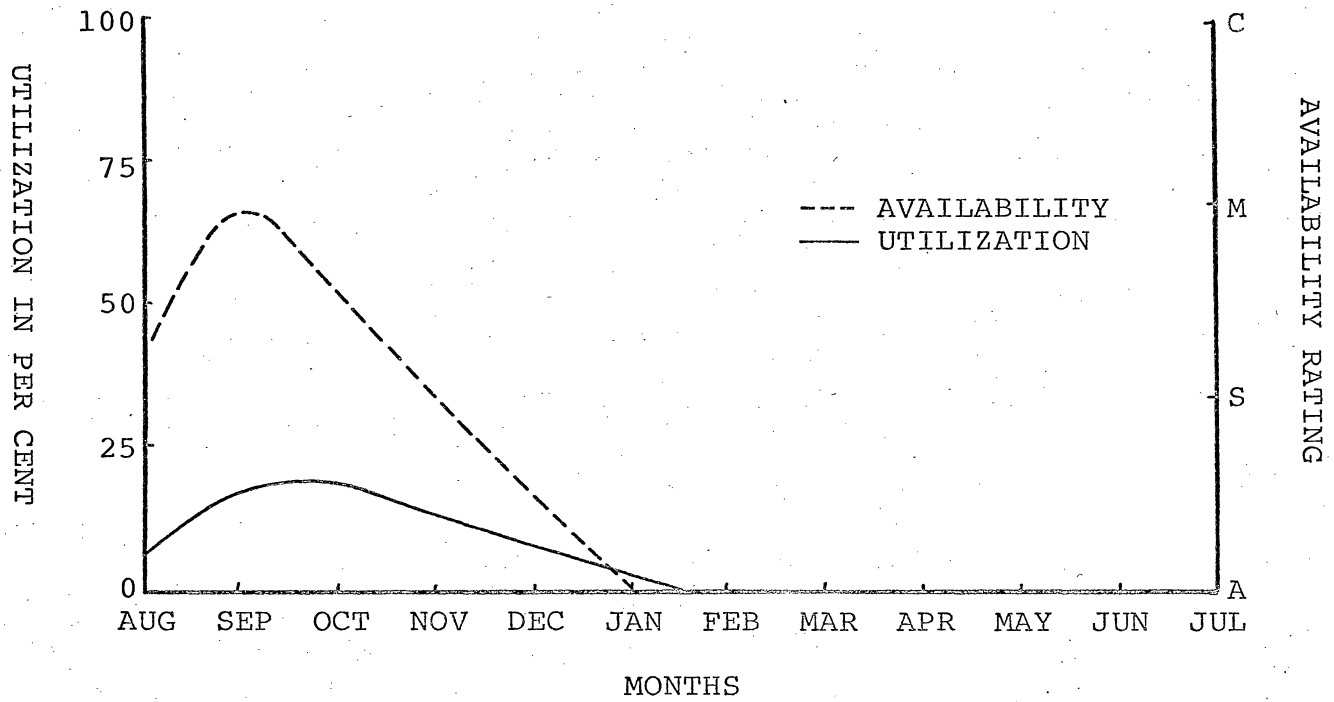

Fig. 21. Utilization of white oak acorns by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

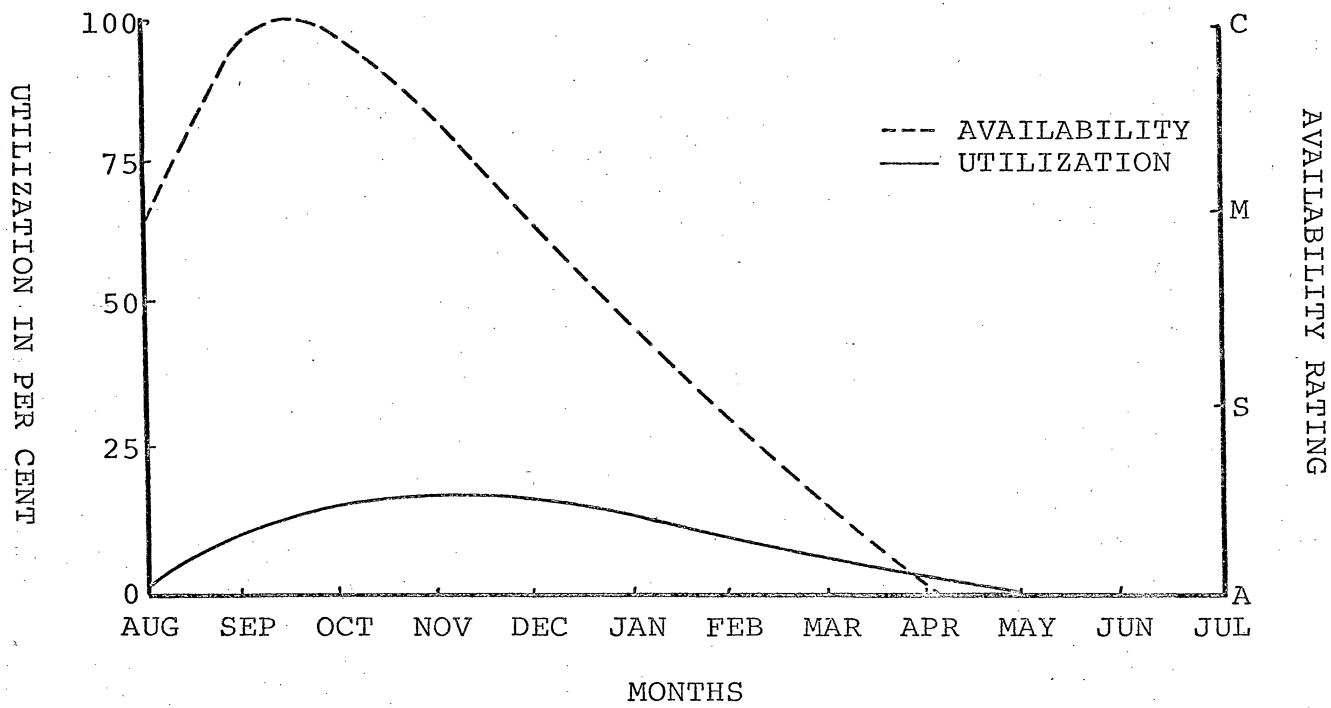

Fig. 22. Utilization of black walnuts by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

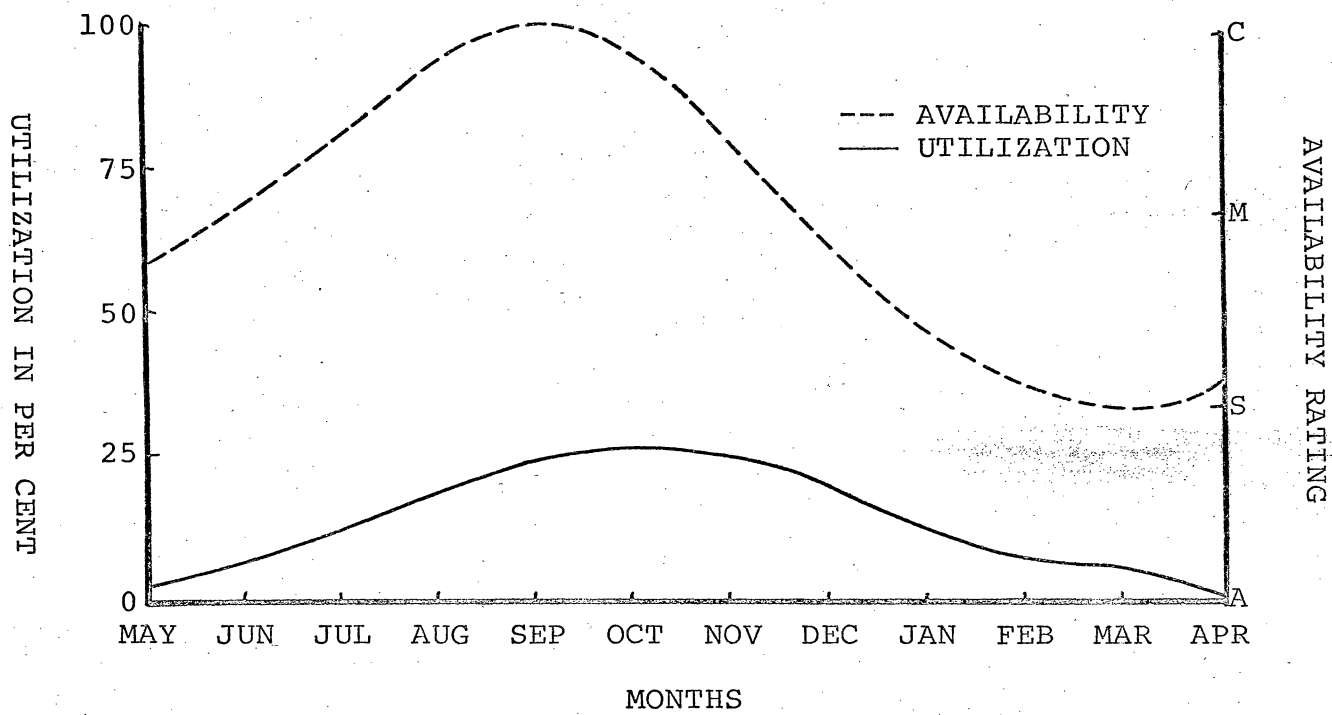

Fig. 23. Utilization of fungi by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

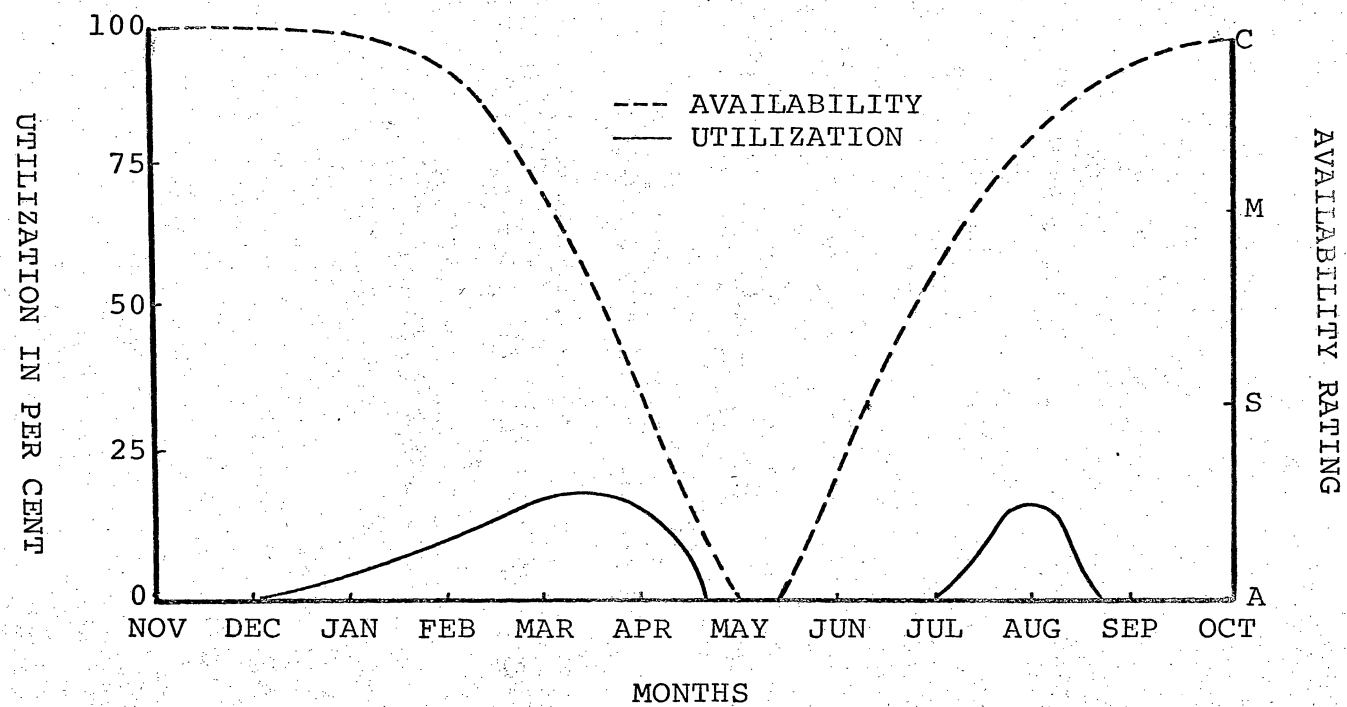

Fig. 24. Utilization of buds by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

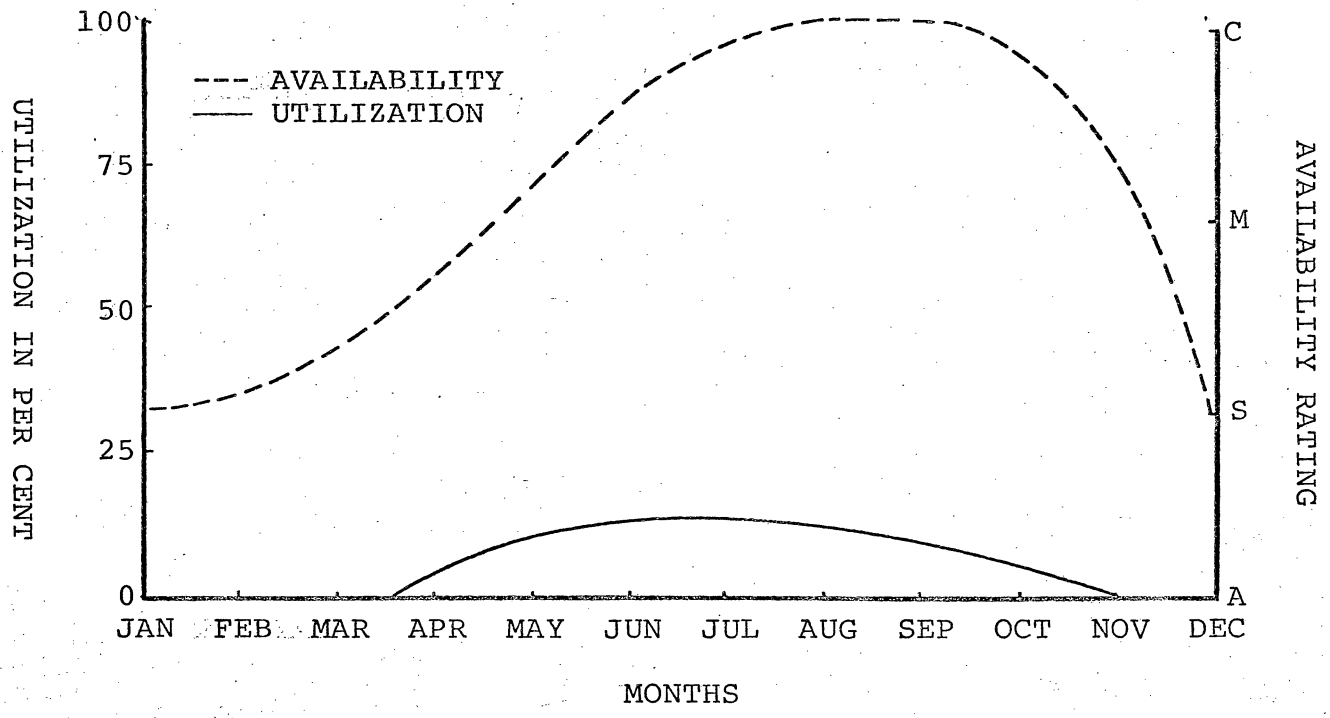

Fig. 25. Utilization of fruits and seeds by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

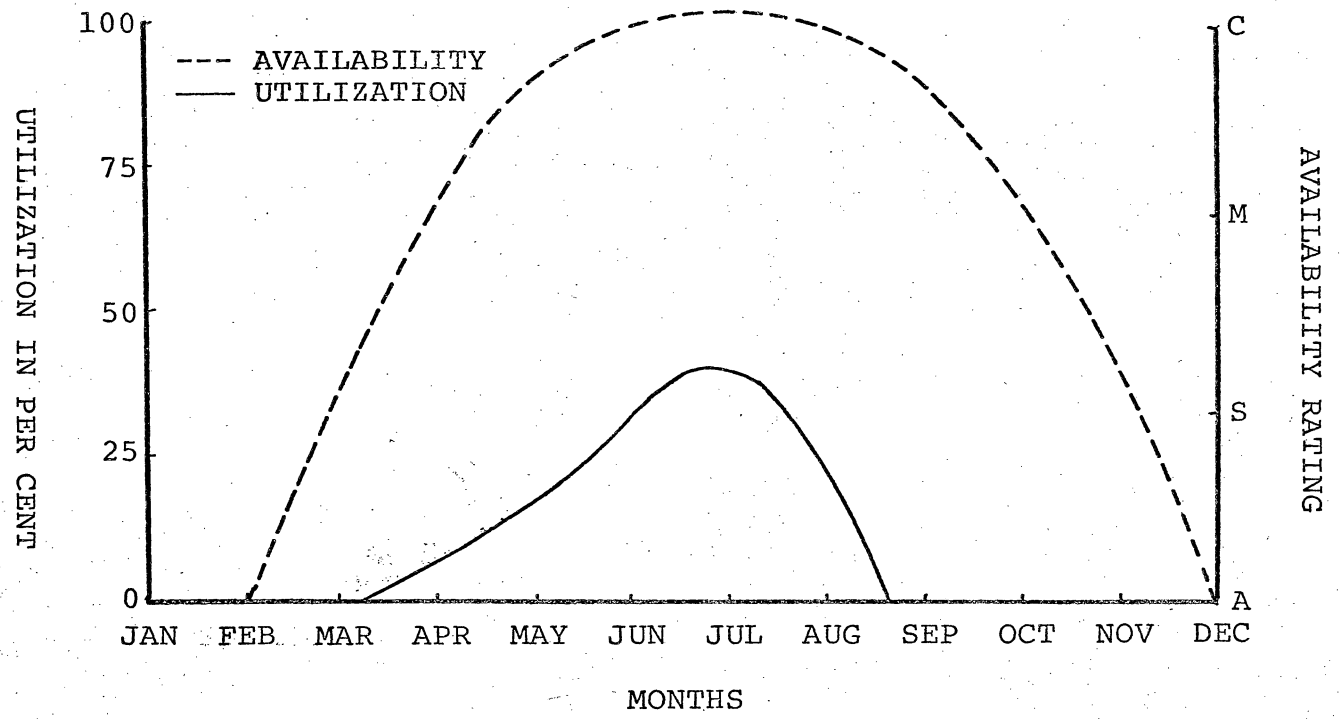

Fig. 26. Utilization of herbaceous plants by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

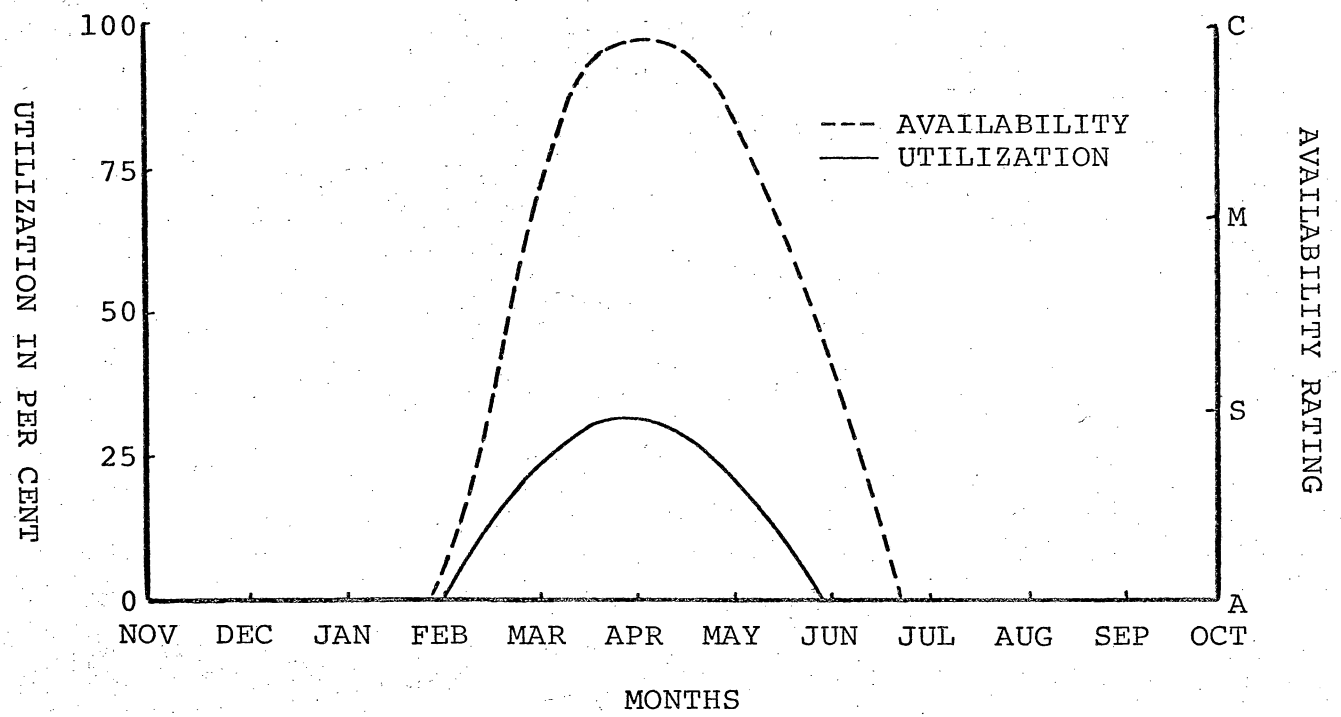

Fig. 27. Utilization of flowers by gray squirrels in Montgomery County, Virginia, as compared to availability for 1966-67.

were quickly abandoned as foods once mast became available. This situation would indicate that these items were at least emergency foods and possibly staple foods. Buds, obviously, were emergency food, since there is little correlation of the two curves and little utilization at any time of the year (Fig. 24).

Adequacy of Sample

The required sample size for a ten per cent standard error at a ninety per cent confidence level was calculated using the formula derived by Hanson and Graybill (1956).

The following are the required sample sizes calculated for each season: fall--107, winter--512, spring--287, and summer--2,964. Obviously, these sample sizes were not, and could not, be obtained.

DISCUSSION

Mast is by far the most important food group in the diet of the gray squirrel. Mast is consumed from August to April and constitutes the majority of the diet in every season but summer. Besides being a major source of food, mast, especially red oak acorns and black walnuts, is almost the sole source of sustenance throughout the winter. Though the diet of the gray squirrel is highly variable, it is doubtful that other natural foods could replace mast.

Other foods, such as fruits, flowers, buds, seeds, and vegetative matter appear to be only an alternate source of food supply when mast is unavailable.

Several discrepancies occur between the results of this study and the results of similar investigations. The importance of fungi in the diet of the gray squirrel is one such disagreement. The author can offer no explanation, other than geographic difference, for disagreement between his results and other studies based on stomach-content analysis. It is not surprising however, that observational studies rate fungi low, because, throughout the entire time the author observed squirrels as a check on his work, he recorded only one instance of fungi ingestion. Perhaps this discrepancy is caused by the fact that fungi can be ingested quicker and easier than mast or flowers. Another disagreement between this and previous food habits

is the degree of utilization of acorns during the summer. Perhaps acorns mature earlier in Illinois (Martin, Zim, and Nelson, 1951) and eastern Texas (Goodrum, 1940) and are consequently ingested earlier than in the mountainous areas of Virginia. If such is not the case, then this utilization was not detected because of the relative smallness of the sample.

When classifying food according to the degree of utilization, it was surprising to note that black walnut could not be judged a preferred food. Upon reflection, however, the writer recalled observing gray squirrels choosing red hickory and white oak over black walnut. Apparently, squirrels do not judge food by taste, as humans do, for most people judge black walnut far more tasty than red hickory and oak. It may be, however, that squirrels are not willing to spend the extra effort cracking a walnut when other easier opened nuts are available. This same relationship appears to hold true with red hickory and mockernut hickory, as red hickory was often selected over the sweeter but harder mockernut. Buds are another food whose classification may not reveal taste preference. Although obviously an emergency food most of the year, buds may be a preferred food item just before opening or just after forming, because sugar concentrations are highest at these times.

As indicated by the test for adequacy, this study was not designed to obtain a given statistical confidence level because there was no basis upon which to estimate a required sample size. This study provides that basis. Furthermore, any food habits study of an animal that selects as great a variety of foods as the gray squirrel would require an unfeasible number of samples to establish reasonable statistical confidence in the absolute values of the results. Attainment of such absolute values will become feasible only as gray squirrel management becomes more and more intensive.

SUMMARY AND CONCLUSIONS

A good reference collection is essential in any gray squirrel food habits investigation. Microphotographs of such a collection greatly facilitate its use. With increasing practice, however, an investigator will have to rely less and less upon the collection and even upon microscopic examination. Contrary to popular opinion, gray squirrels do not masticate food entirely beyond recognition. Often whole seeds and flowers, large pieces of nut meat, and even nutshell were found in the stomachs.

Examination of stomach contents revealed a large variety of foods eaten. However, only four foods constituted more than half of the entire diet for any season. In the fall, hickory nuts (36%), fungi (26%), white oak acorns (12%), and black walnuts (10%) were the major foods (Table 4). During the winter, red oak acorns (36%), combinations of oak, hickory, and walnuts (22%), fungi (16%), and black walnuts (10%) constituted most of the diet (Table 5). Red oak acorns (26%) again head the list for spring food, followed by a red oak-black walnut mixture (17%), elm buds and flowers (10%), and corn (9%). As a group, however, flowers accounted for 28% of the spring diet (Table 6). Summer foods consisted mainly of herbaceous plants (24%), herbaceous buds (13%), hickory nuts (13%), and woody buds (10%) (Table 7).

Of the aforementioned food, hickory, white oak, and fungi were classified as preferred foods; red oak and black walnut were classified as staple foods; fruits and seeds and herbaceous plants were classified as emergency or staple foods; buds were classified as emergency food. Flowers were unclassifiable from the information at hand.

Calculations of sample size revealed that a sample of well over 2,000 animals would be required to secure data at a ninety per cent confidence level with a ten per cent standard error.

LITERATURE CITED

American Forest Products Industries, Inc. 1961. Virginia Forest Facts. Va. Comm. of Amer. For. Prod. Ind., Inc., Washington, D. C. 15 p.

Arata, A. A. 1959. A quick method for gross analysis of muskrat stomach contents. J. Wildl. Mgmt. 23:116-117.

Barber, H. L. 1954. Gray and fox squirrel food habits investigation. Proc. Ann. S.E. Ass. of Game and Fish Comm., New Orleans, La. 8:92-94.

Baumgartner, L. L., and A. C. Martin. 1939. Plant histology as an aid in squirrel food habit studies. J. Wildl. Mgmt. 3:266-268.

Beck, J. R. 1952. A suggested food rank index. J. Wildl. Mgmt. 16(3):398-399.

Blaydes, G. W. 1939. The use of Bismarck brown Y in some new stain schedules. Stain Tech. 14:105-110.

Craig, R. B. 1949. Virginia--forest resources and industries. U. S. D. A. Misc. Pub. No. 681. 64 p.

Cross, R. H., Jr. 1942. A study of the habits and management of the gray squirrel in Virginia. Unpub. Master's Thesis, V. P. I., Blacksburg. 40 p.

Davison, V. E., and E. G. Sullivan. 1963. Mourning doves' selection of foods. J. Wildl. Mgmt. 27(3):373-383.

Dusi, J. L. 1949. A method of determining food habits by plant microtechnique and histology and their application to cottontail food habits. J. Wildl. Mgmt. 13(3):295-298.

_____. 1952. Food habits of several populations of cottontail rabbits in Ohio. J. Wildl. Mgmt. 16(2): 180-186.

Goodrum, P. D. 1940. A population study of the gray squirrel in eastern Texas. A. and M. Coll. of Texas Bull. No. 591. Texas Agric. Expt. Sta. 34 p.

Hanson, W. R., and F. Graybill. 1956. Sample size in food habits analysis. J. Wildl. Mgmt. 20:64-68.

Harlow, W. M., and E. S. Harrar. 1958. Textbook of Dendrology. McGraw-Hill, New York. 561 p.

Martin, A. C., R. H. Gensch, and C. P. Brown. 1946. Alternate methods in upland gamebird food analysis. J. Wildl. Mgmt. 10(1):8-12.

_____. 1949. Procedures in wildlife food studies. U. S. D. I. Wildl. Leafl. No. 325. 9 p.

_____, H. S. Zim, and A. L. Nelson. 1951. American Wildlife and Plants--A Guide to Wildlife Food Habits. Dover Pub., New York. 500 p.

Nichols, J. T. 1958. Food habits and behavior of the gray squirrel. J. Mammal. 39:376-380.

Uhlig, H. G. 1956. The gray squirrel in West Virginia. Conserv. Comm. W. Va. 83 p.

_____. 1959. Squirrel management and research. Proc. Ann. Conf. S. E. Ass. Fish and Game Comm., Baltimore, Md. 13:387-389.

LITERATURE REVIEWED BUT NOT CITED

Baker, R. H. 1944. Ecology of tree squirrels in eastern Texas. J. Mammal. 25(1):8-24.

Bakken, A. 1959. Behavior of gray squirrels. p. 393-407. In Symposium on the gray squirrel. Flyger, V. [ed.] Md. Dept. Res. and Ed., Baltimore.

Brown, L. C., and L. E. Yeager. 1945. Fox and gray squirrels in Illinois. Ill. Nat. Hist. Surv. Bull. 87 p.

Chamberlain, C. J. 1932. Methods in Plant Histology. Univ. of Chicago Press, Chicago. 405 p.

Davison, V. E. 1964. Selection of foods by gray squirrels. J. Wildl. Mgmt. 28(2):346-352.

Esau, K. 1962. Anatomy of Seed Plants. John Wiley and Sons, Inc., New York. 376 p.

Madson, J. 1964. Gray and fox squirrels. Cons. Dept., Olin Mathieson Chem. Corp. 112 p.

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A SURVEY OF THE FOOD HABITS OF THE GRAY SQUIRREL (*SCIURUS CAROLINENSIS*) IN MONTGOMERY COUNTY, VIRGINIA

by

Glenn Raymond Dudderar

ABSTRACT

The examination of one hundred-thirteen gray squirrel stomachs collected throughout the year revealed a total of seventy-eight food items eaten. Only four, however, contributed more than half of the entire diet for any season. In the fall, hickory nuts (36%), fungi (26%), white oak acorns (12%), and black walnuts (10%) were the major foods. Red oak acorns (36%) and combinations of acorns, hickory nuts, and walnuts (22%) constituted most of the winter diet, followed by fungi (16%) and black walnuts (10%). Red oak acorns (26%) again headed the list for spring foods, along with a red oak-black walnut mixture (17%), elm buds and flowers (10%), and corn (9%). As a group, however, flowers composed 28% of the spring diet. Summer foods consisted primarily of herbaceous plants (24%), herbaceous buds (13%), hickory nuts (13%), and woody buds (10%).

Of the aforementioned foods, hickory nuts, white oak acorns, and fungi were classified as preferred foods; red oak acorns and black walnuts were classified as staple

foods; fruits, seeds, and herbaceous plants were classified as emergency or staple foods; buds were classified as emergency foods. Flowers were unclassifiable from the information at hand.