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To the Graduate Council:

I am submitting herewith a thesis written by Robert Gordon Nichols entitled "Tissue Fat of the Jawbone Cavity as an Indicator of Condition of the White-tailed Deer (Odocoileus virginianus) in Tennessee." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife Management.

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TISSUE FAT OF THE JAWBONE CAVITY AS AN INDICATOR OF CONDITION
OF THE WHITE-TAILED DEER (ODOCOILEUS VIRGINANUS)
IN TENNESSEE

A Thesis
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Master of Science

by
Robert Gordon Nichols

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ABSTRACT

This study was based on data collected from six wildlife management areas (WMA's) in Tennessee. Information on fat from the white-tailed deer (Odocoileus virginianus) was obtained through the analysis of jawbones and femurs collected during the period of December, 1969 to December, 1971.

Fat from the tissue of the femur (FMT) was found to be a poor standard with which to verify that the fat in the tissue of the jawbone (JCT) was an indicator of condition. Fat from the tissue of the jawbone cavity was found to separate into more distinguishable condition classes than was FMT fat. Data indicated that JCT fat was utilized prior to the utilization of FMT fat.

Percent JCT fat was found to vary between the right and left jawbones of the same animal. Animals 2 1/2 years or older had much less variation between the JCT fat levels of the right and left jawbone than did animals 1 1/2 years or less.

Age, sex, and date of collection were found to affect JCT fat levels. Percent JCT fat increased from the fawn age class up to and including the 3 1/2 age class. Percent JCT fat remained relatively stable in all age classes above 3 1/2 years. Females were found to have a percent JCT fat that was higher than the percent JCT fat of males. Fat in the tissue of the jawbone cavity increased during the months of October, November, and early December, and decreased in late December and early January.

Mean JCT fat levels of the deer on four of the WMA's were found to be closely grouped and high. The deer herd on the Natchez Trace WMA had a JCT fat level that was lower than the JCT fat levels of the other areas. The JCT fat level of the deer herd on the Tellico WMA could not be determined due to inadequate sampling.

Fat from the tissue of the jawbone cavity was shown to be a fat reserve, and therefore, could be used as an indicator of condition, provided JCT fat's position in the fat utilization and replacement order is known, and provided that JCT fat is not completely utilized or replaced.

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CHAPTER I

INTRODUCTION

Many of the decisions for habitat manipulation and population controls are based on the condition or "state of well being" of the animal population in question. The condition of a population of animals may be deducted indirectly from the effects of a population on its habitat. However, much research has been attempted to develop a measurement of physical criteria of individual animals of a population to determine the population's condition.

Gross weight, hind foot length, heart girth, antler growth, and gross internal and external visual estimates have been used singularly or in combination to determine condition in large animals (Harris, 1945; Riney, 1955; McIlwain, 1965). These indices of condition are qualitative rather than quantitative measurements. Attempts to develop quantitative measurements of condition usually involved the measurement of the fat reserves in the animal's body. The measurement of the fat reserves as a criteria of condition has long been used as an index of condition in domestic animals (Riney, 1955). Bear (1971) used subcutaneous fat reserves to measure changes in condition in the pronghorn (Antilocapra americana). Cheatum (1949) first described the use of bone marrow as an index of condition in the white-tailed deer (Odocoileus virginianus). Riney (1955), studying the red deer (Cervus elaphus) of New Zealand, advocated the use of kidney fat as a measure of condition, rather than bone marrow. Ransom

(1965) compared kidney and bone marrow fat in the white-tailed deer, and found both to be useful criteria in determining the condition of an animal. Other authors, Bischoff (1954) and Greer (1968), have recommended variations of the bone marrow technique to determine condition in deer and elk (Wapiti). Baker and Leuth (1966) conducted a cursory study on the tissue of the jawbone cavity of the white-tailed deer, and found that the fat in the tissue of the jawbone cavity might be a useful indicator of deer condition.

This study deals with the fat in the jawbone of the white-tailed deer in Tennessee. Collections of jawbones were made on six wildlife management areas across the state. Each WMA was located in a different physiographic region (Dickson, 1960; Rand, 1970). The areas where collections were made included the Tellico, Chuck Swan, Catoosa, Cheatham, Natchez Trace, and Shelby WMA's (Figure 1). The collections were carried out during the 1969-1970 and 1970-1971 hunting seasons on the Chuck Swan WMA, and on all WMA's during the 1970-1971 hunting season. The major objectives of this study were:

1. To verify the use of fat from the tissue of the jawbone cavity as an indicator of condition in white-tailed deer.

2. To determine the effects of various parameters such as sex, age, weight, and date of collection on fat levels of the tissue of the jawbone cavity in the white-tailed deer.

3. To establish the levels of fat in the tissue of the jawbone cavity for various deer herds in Tennessee.

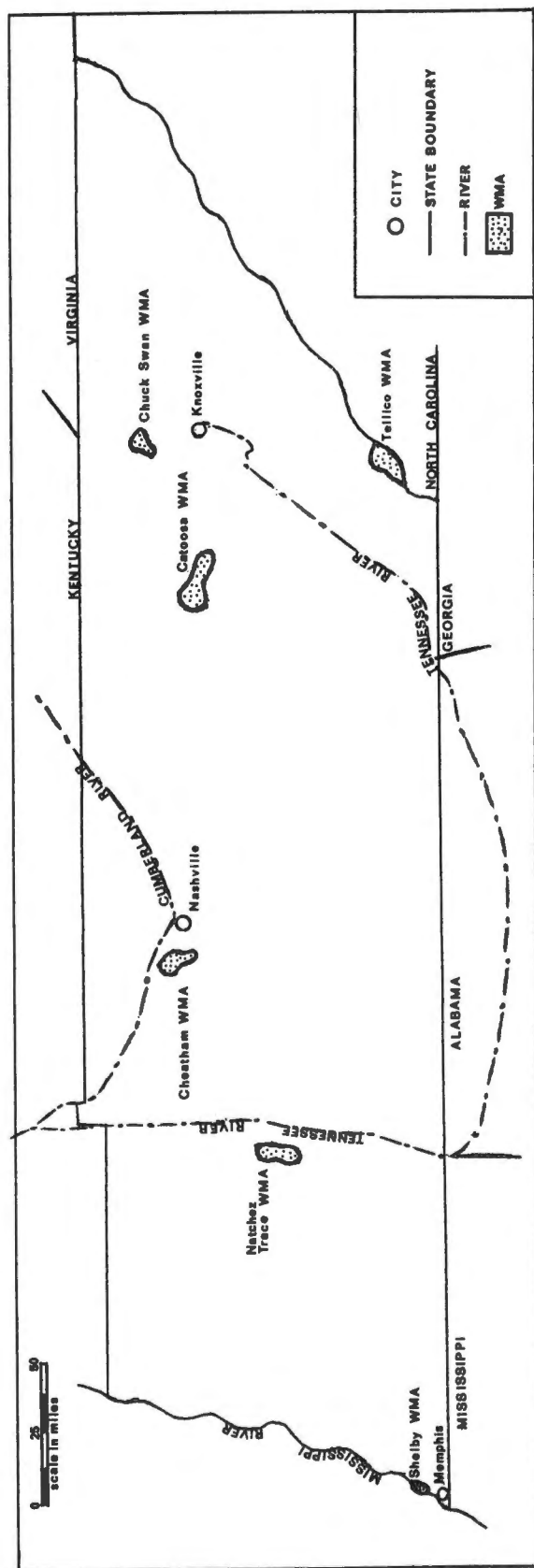


Figure 1. Map of the state of Tennessee, showing location of study areas and major drainages.

CHAPTER II

DESCRIPTION OF STUDY AREA

Tennessee is a state of varied topography, ranging from high mountains on the eastern border to the Mississippi River bottoms on the western border. Seven physiographic regions are recognizable in the state. The Great Smoky Mountains on the eastern border are the most elevated and rugged portion of Tennessee's topography. Elevations range from 888 feet to 6642 feet above sea level. Paralleling the mountains on the west is the Great Valley of East Tennessee. This valley is funnel-shaped, varying in width from 30 miles in the south to 90 miles in the north. Topography varies from 700 feet in the south to 1500 feet above sea level in the north. Bounding the Great Valley on the west is the Cumberland Plateau. This plateau averages 2000 feet above sea level in elevation, and extends northeast-southwest across the state in a belt 30 to 50 miles wide. The Highland Rim, which bounds the Cumberland Plateau on the west, extends in a wide circle touching the Tennessee River Valley on the west. Elevation for the Highland Rim ranges from 600 feet above sea level along the Tennessee River, to 1000 feet above sea level in the east. Between the wide circle of the Highland Rim and the Cumberland Plateau is the Central Basin. The basin which has an average elevation of 600 feet above sea level, contains some hills having elevations above 1000 feet (Dickson, 1960).

The western portion of the state is divided into two other physiographic regions; the Eastern Gulf Coastal Plain, and the Mississippi Alluvial Plain (Dickson, 1960). The Mississippi Alluvial Plain, averaging 200 feet above sea level, is a narrow strip approximately 20 miles wide, extending along the Mississippi River. The Eastern Gulf Coastal Plain, extending from the Mississippi Alluvial Plain eastward to the Highland Rim, has elevations ranging from 200 feet above sea level in the west to 600 feet above sea level in the east (Dickson, 1960).

With the exception of a few small rivers which drain directly into the Mississippi River, drainage is primarily into the Tennessee or Cumberland Rivers. Both rivers flow northward and eventually empty into the Ohio River near the Kentucky-Illinois border. Important tributaries of these rivers include the Clinch, Little Tennessee, Hiwassee, Elk, and Duck Rivers (Dickson, 1960).

The average annual temperature varies considerably from east to west in the state. The highest peaks of the mountains average 45°F, while the extreme southwest corner of the state averages 62°F. On the average, Tennessee is characterized as having warm, humid summers, and mild winters. Increased elevation is the primary cause of cooler summer and winter temperatures in many localities. These temperature variations cause the length of the growing season (freeze-free period) to vary from 130 days in the high mountains of the east to 237 days in the western bottomlands (Dickson, 1960).

The mountains of the east have an average annual precipitation of about 80 inches, making this area the wettest region of the state.

The average annual precipitation in the Great Valley of East Tennessee ranges from 40 inches in the northern portion of the valley, to 50 inches in the southern portion of the valley. The Cumberland Plateau and Highland Rim have an average annual precipitation of 50 to 55 inches, while the Central Basin averages 45 inches annually. The Mississippi Alluvial and Gulf Coastal Plains average 46 to 54 inches of precipitation per year, with rainfall increasing from the Mississippi River eastward. Although precipitation usually is heaviest in the winter and early spring, rainfall does occur throughout the year (Dickson, 1960).

Tennessee is located in two major forest regions, the Appalachian Highland Region and the Southern Bottomland Hardwood Region (Barrett, 1960). The Appalachian Highland Region extends from the Great Smoky Mountains in the east through the Highland Rim in the middle portion of the state. This region has seven forest types; yellow pine, eastern white pine, pine-hardwoods, bottomland types, northern hardwoods, spruce-fir, and oak-hickory. The oak-hickory type is the most frequent type, with the spruce-fir type occurring only on the higher mountains of the east portion of the state (Barrett, 1960).

The Southern Bottomland Hardwood region extends from the western edge of the Highland Rim to the Mississippi River. The major forest species found in this area are oaks, hickory, sweetgum, and cypress (Barrett, 1960).

Six wildlife management areas across the state were chosen as study areas (Figure 1, page 3). Six of Tennessee's seven physiographic regions were represented by these WMA's. The areas were Tellico,

Chuck Swan, Catoosa, Cheatham, Natchez Trace, and Shelby WMA's. Data on physiographic region, soils, average annual temperature, rainfall and snowfall by WMA are presented in Table 1.

Tellico Wildlife Management Area

The Tellico Wildlife Management Area is located in the western portion of Monroe County, Tennessee, forming a part of the eastern border of Tennessee and North Carolina. The area is in the southern portion of the Cherokee National Forest, approximately ten miles southwest of the Great Smoky Mountains National Park (Rand, 1970). This area consists of 78,000 acres, most of which are rugged mountains (Whitehead, 1971). Two major drainages are found on the area, the Citico Creek drainage, and the North River-Tellico River drainage. The area is extremely rugged with elevations ranging from 1000 feet to 4500 feet above sea level (Hubbard, et al., 1945).

Pine, yellow poplar (Liriodendron tulipifera L.), white oak (Quercus alba L.), red oak, hickory (Carya Nutt.), and cove hardwoods are the major species (Hubbard, et al., 1945). Only 180 acres of the total 78,000 acres are maintained as some type of permanent opening (Whitehead, 1971).

Chuck Swan Wildlife Management Area

The Chuck Swan Wildlife Management Area, formerly known as the Central Peninsula WMA, is located in the western portion of Union County and eastern portion of Campbell County, Tennessee. The area encompasses a total of 25,000 acres (Whitehead, 1971). This WMA is located 25 miles north of Knoxville, Tennessee (Rand, 1970). The WMA

TABLE 1

PHYSIOGRAPHIC REGION, SOILS, AVERAGE ANNUAL TEMPERATURE, RAINFALL AND SNOWFALL
BY WILDLIFE MANAGEMENT AREA

Wildlife Management Area	Physiographic Region	Soils	Avg. An. Temp. (°F)	Avg. An. Rainfall (Inches)	Avg. An. Snowfall (Inches)
Tellico WMA ^a (Hubbard, et al., 1945)	Great Smoky Mountains	Ramsey Soil Series	57.2	54.3	8.0
Chuck Swan WMA (Rudolph, et al., 1939)	Great Valley of East Tennessee	Clarksville-Fullerton-Claiborne Soil Assoc.	54.7	50.2	13.4
Catoosa WMA (Hubbard, et al., 1930)	Cumberland Plateau	Hartsells-Crossville, Muckingham-Hartsells-Crossville, Muskingham-Hartsells Soil Assoc.	55.6	54.0	12.1
Cheatham WMA (Kerr, et al., 1928)	Highland Rim	Clarksville and Baxter Soil Series	58.2	48.3	10.0
Natchez Trace WMA (Flowers, et al., 1954)	Eastern Gulf Coastal Plain	Ruston-Lexington, Shubuta-Cuthbert Soil Assoc.	59.5	50.7	8.7
Shelby WMA (Sease, et al., 1970)	Eastern Gulf Coastal Plain, Mississippi Alluvial Plain	Robinsonville-Crevasse-Commerce, Tunica-Sharkey-Bowdre, and Mississippi Soil Assoc.	62.0	50.3	3.9

^aWildlife management area.

is somewhat unique in that it is a peninsula with its northern and southern boundaries being the Powell and Clinch Rivers (Rand, 1970). Only the eastern boundary is not surrounded by these rivers which merge at this point to form Norris Lake.

The topography of the area consists of dolomitic hills, which are smooth and well rounded, and narrow V-shaped valleys. Elevations range from 1000 feet to 2500 feet above sea level. Forest species are mainly oak and pine, with 60 percent of the area comprised of hardwoods. The oaks consist of white oak, northern red oak (Quercus rubra L.), and southern red oak (Quercus falcata Michx.). The pines found on the area are shortleaf pine (Pinus echinata Mill.), Virginia pine (Pinus virginiana Mill.), and white pine (Pinus strobus L.). Other associated species include hickory, yellow poplar, and eastern redcedar (Juniperus virginiana L.) (Rudolph, et al., 1939). Approximately 2000 acres of the area are maintained as permanent openings, many of which are food plots (Whitehead, 1971).

Catoosa Wildlife Management Area

The Catoosa Wildlife Management Area is located in Cumberland and Morgan Counties, Tennessee. The area is 60 miles west of Knoxville, Tennessee (Rand, 1970). The topography of the area averages 1800 to 2000 feet above sea level, and is generally level to gently rolling. The area is dissected by two major streams, the Obed River and Daddy's Creek.

This 80,000 acre area is located in the Appalachian Highland Forest Region. The predominate forest species are red oak, black oak

(Quercus velutina Lam.), Virginia pine, and sourwood (Oxydendron aboreum L.) on the uplands. Oaks, white pine and hemlock (Tsuga canadensis (L.) Carr.) occur on the stream banks. Other common species are hickory, maple (Acer sp.) and beech (Fagus grandifolia Ehrh.) (Hubbard, et al., 1930). Approximately 1900 acres of the area are kept at early successional stages by wildlife management practices including the planting of food plots (Whitehead, 1971).

Cheatham Wildlife Management Area

The Cheatham Wildlife Management Area is located in the central portion of Cheatham County, Tennessee. The area is 20 miles west of Nashville, Tennessee (Rand, 1970). This region is a plateau which is predominately hills, having smooth ridgetops and steep-sided valleys. Elevations range from 800 feet to 900 feet above sea level (Kerr, et al., 1928).

The soils on this area support a variety of hardwoods, with 50 percent or more of the stand white oak, red oak, or hickory. Other associated species include red cedar, gum, elm (Ulmus L.), maple and yellow poplar (Kerr, et al., 1928). Of the 20,723 acres which comprise the area, 363 acres are maintained as permanent openings. In addition, power line right-of-ways greatly increase the amount of open space on this area (Whitehead, 1971).

Natchez Trace Wildlife Management Area

The Natchez Trace Wildlife Management Area is located at the junction of Henderson, Carroll and Benton Counties, Tennessee. This area is approximately halfway between Nashville and Memphis, Tennessee

(Rand, 1970). The area is located on a plain which is highly dissected and prevailingly hilly. Elevations range from 380 feet to 640 feet above sea level (Flowers, et al., 1954).

More than 50 percent of the forest stand on these soils are upland hardwoods. Red oak, white oak, hickory, and maple are the major hardwood species (Flowers, et al., 1954). Much of the area has been planted to pine, most of which is shortleaf or Virginia pine (Whitehead, 1971). Other associated species include yellow poplar and gum (Flowers, et al., 1954). The 43,000 acre area has 100 acres maintained as permanent openings (Whitehead, 1971).

Shelby Wildlife Management Area

The Shelby Wildlife Management Area is located in the northwest corner of Shelby County, Tennessee, about 15 miles north of Memphis, Tennessee (Rand, 1970). The eastern one-third of the area consists of gently rolling to undulating hills averaging 200 to 300 feet above sea level, while the western two-thirds of the area is generally smooth and level, averaging 100 to 200 feet above sea level (Sease, et al., 1970).

The forest species on these soils include oaks, cypress (Taxodium distichum (L.) Rich.), and gum. These species comprise more than 50 percent of the forested areas. Other forest species found on the area include cottonwood (Populus deltoides Bartr.), ash (Fraxinus L.), maple and willow (Sease, et al., 1970). The 10,000 acre area has 84 acres which are maintained as permanent openings (Whitehead, 1971).

CHAPTER III

PROCEDURES

Deer Femur/Jawbone^{*} Combinations

Collection of deer femur/jawbone combinations was initiated during the 1969-1970 hunting season on the Chuck Swan Wildlife Management Area. These collections were continued during the 1970-1971 and 1971-1972 hunting seasons for this area. Femur/jawbones, taken on WMA's, were removed from only those animals that were killed illegally, or those animals shot, but not found by the hunter. This was a necessary procedure due to the problem of hunter disapproval of removal of femur/jawbones from hunter killed deer. Since the procedure involved considerable effort, manpower was available to collect only on the Chuck Swan WMA.

Other femur/jawbone combinations were collected, on a year-round basis, from deer accidentally killed throughout the state. These collections began in December, 1969, and continued until December, 1971. All femur/jawbone combinations were tagged, placed in double plastic bags, and frozen until time for analysis.

Deer Jawbone Collections

Collections of jawbones from the Chuck Swan WMA were begun during the 1969-1970 hunting season. During the 1970-1971 hunting

*In the present study, "jaw" refers to both the left and right mandible of the same animal, while "jawbone" refers to only the left or the right mandible of an animal.

season, jawbones were collected from all six management areas. Jawbones from all areas but the Chuck Swan WMA were collected by Tennessee Game and Fish Commission personnel. Jawbones were collected throughout the hunting season on each area by the collection of jawbones from each hunt on the areas. At Shelby and Tellico WMA's, where the deer-kill was not expected to be large (75 deer or less), jawbones were collected from all animals killed. At Catoosa, Cheatham and Natchez Trace WMA's, the number of jawbones to be collected was set at 50 jawbones per area. Special collections of jawbones and lower jaws were made at the Chuck Swan WMA, with no maximum number being established.

All jawbones collected were removed from the deer using the method described by Marshall, et al. (1964). As this technique of collection is used by the Tennessee Game and Fish Commission personnel for removing the jawbone for age determination, hunter acceptance to the collection technique was good.

Upon removal from the animal, the jawbones were tagged with a number which corresponded to the number of the metal kill-tag placed on each animal by the Tennessee Game and Fish Commission. This was to enable later correlation of each jawbone with the parameters of sex, age, weight, date and area. The jawbones were then placed in a double plastic bag, and frozen no later than the end of the day on which they were collected.

Femur and Jawbone Analysis

The femurs and jawbones were stored at a temperature of 0°C or less until time for analysis. Upon removal from the freezer, all excess tissue was removed from the femurs and corresponding jawbones.

The sample of the femur tissue (FMT) consisted of all FMT from the middle one-third of the femur (Figure 2). The bone was easily cracked and the FMT removed with forceps. Any bone chips were removed, and a small portion of each end of the sample was also removed to insure that no bone dust got into the sample. The sample was sectioned and placed in a pre-weighed aluminum pan. All weighings were to the nearest 0.1 milligrams on a Mettler type H6T balance. Moisture was removed by placing the sample in a vacuum oven at 27 inches of Hg. for a minimum of 36 hours at 50°C.

Upon removal from the vacuum oven, the samples were cooled and reweighed. The dry weight of the FMT was determined by subtracting the pan weight from this latter weighing. The FMT was removed from the pan and placed in a Soxhlet ether extraction apparatus (Horwitz, 1960). The material was extracted for a period of four and one-half hours in a petroleum ether-chloroform solution in the proportions 5:1. At the end of the extraction period, the ether solution was removed by boiling. The flask, now containing fat and other ether soluble substances, and the thimble, containing FMT residues, were placed in an oven for 24 hours at 65°C to remove any ether solution left after boiling. After the 24 hour period, the flasks and thimbles were cooled and reweighed. The percent FMT fat was determined on both a dry and wet weight basis, by dividing the weight of the material extracted from the FMT by the dry and wet weight of the FMT prior to extraction.

A standardized sample from each jawbone was produced by placing the jawbone in a vise and removing that portion of the jawbone posterior to the third molar and anterior to the second premolar (Figure 3).

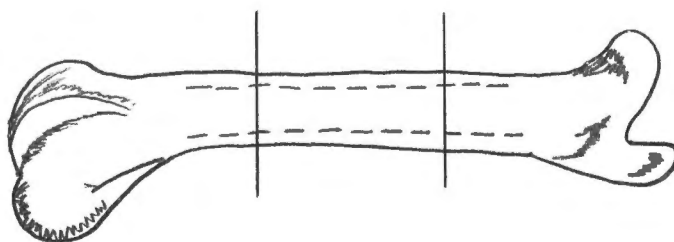


Figure 2. The standardized section of a femur. Dotted lines (---) indicate approximate position of the femur marrow tissue. Sample consisted of area between the solid vertical lines (—).

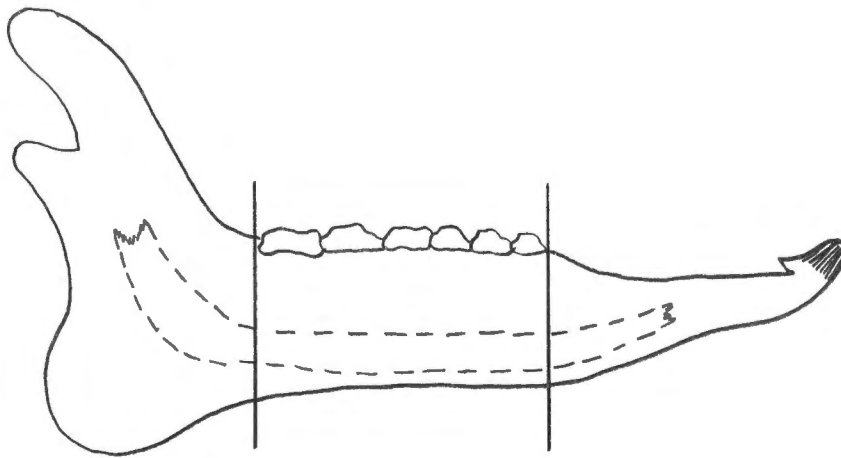


Figure 3. The standardized section of a jawbone. Dotted lines (---) indicate approximate position of the tissue of the jawbone cavity. The sample consisted of area between the solid vertical lines (—).

Samples from fawn jawbones were obtained by the same method, but the cut was made into the ramus of the jawbone to insure being posterior to the third molar. The tissue of the jawbone cavity (JCT) was exposed by placing the jawbone section on a flat hard surface and striking the jawbone with a hammer. With practice, it was very easy to crack the bone in such a manner that the JCT could be removed in one piece.

Upon removal from the jawbone, the JCT was inspected for bone chips. These chips were removed with forceps. The marrow was sectioned and placed into pre-weighed aluminum pans. The procedure for weighing, dehydrating and extracting the JCT was the same as for the FMT procedure.

Data concerning the femur and jawbone comparisons were analyzed on a Wang Advanced Programming Calculator. The statistical procedure included the determination of means and linear regressions of percent FMT fat, JCT fat, age, weight, date of collection and general condition.

Data for the jawbones collected on the six wildlife management areas were analyzed on an IBM 360, type 65 computer, using the statistical procedure developed by Barr and Goodnight (1971). The statistical procedures used included determination of the means, standard deviations, linear regressions and analysis of variances of percent JCT fat by area, sex, age and date of collection.

Special Jawbone Analysis

In addition to analyzing femur/jawbone combinations and single jawbones, where possible, fat levels of the left and right jawbones of the same animal were compared. Also, seven jawbones were sectioned into five pieces to determine if there were any variations in fat levels

within separate sections of the JCT cavity of one jawbone. Method of fat analysis of left and right paired jawbones and sections of individual jawbones was the same as for the jawbone analysis previously mentioned.

Standardized sections for the seven jawbones were produced in the following manner (Figure 4):

Section 1: All marrow posterior to molar #3.

Section 2: All marrow between the anterior and posterior ends of molar #3.

Section 3: All marrow between the anterior end of molar #3 and posterior end of premolar #3.

Section 4: All marrow between the posterior end of premolar #3 and anterior end of premolar #2.

Section 5: All marrow anterior to premolar #2.

The statistical procedure for analysis of left/right jawbone comparisons and sectioned jawbones involved the determining of means and paired t-tests.

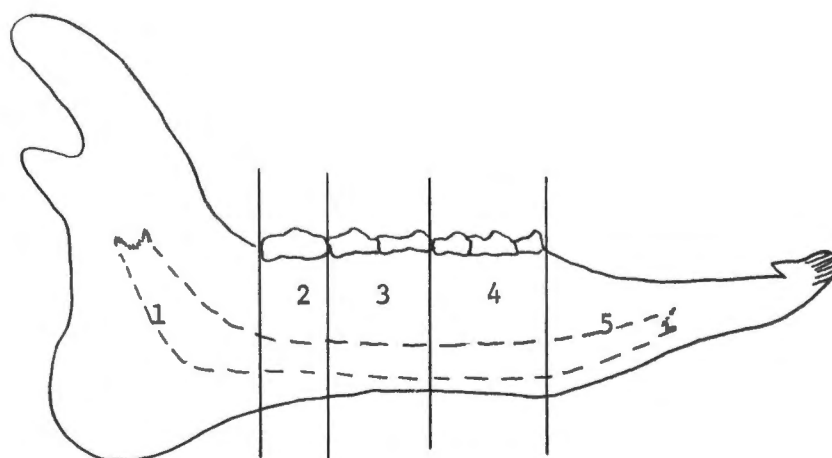


Figure 4. Standardized sections of jawbone for comparing fat levels throughout the JCT cavity. Dotted lines (---) indicate approximate position of the jawbone cavity tissue. Samples consist of the JCT between the solid vertical lines (—). Numbers indicate the section number.

CHAPTER IV

RESULTS AND DISCUSSION

I. ANALYSIS OF FEMUR/JAWBONE COMBINATIONS

A total of 68 femurs and jawbones from 59 animals was analyzed. If both femurs and the lower jaw were collected from an animal, these were considered as two separate samples for femur fat and jawbone fat comparisons. An average of the FMT fat and JCT fat levels for each individual was used for comparison with age, weight, sex, date of collection and general condition.

A summary of the regression coefficients (r) for all femur/jawbone combinations collected and subsequently analyzed is presented in Table 2. The highest correlation coefficient was $r = 0.693$ (significant at $P \leq 0.05$), the correlation coefficient for the femur marrow tissue, jawbone cavity tissue relationship. Other significant correlations ($P \leq 0.05$) included age/weight ($r = 0.557$), general condition/weight ($r = 0.494$), general condition/date collected ($r = 0.468$), JCT/weight ($r = 0.498$) and JCT/age ($r = 0.288$).

On 20 animals, from which femurs and jawbones were collected, the general condition of the animals was determined visually by estimation of the amount of body fat present. In this sample, the FMT/JCT relationship had a correlation of $r = 0.862$. In addition, JCT was significantly correlated to age ($r = 0.462$) and weight ($r = 0.501$). Other correlation coefficients for animals of known condition

TABLE 2
CORRELATION COEFFICIENTS OF EACH OF SIX VARIABLES WITH
EACH OF THE OTHER VARIABLES FOR FEMUR/JAWBONE
COMBINATIONS OF WHITE-TAILED DEER

	Femur Marrow Tissue Fat	Age	Weight	General Condition	Date
Age	0.063 (51) ^a				
Weight	0.217 (44)	0.557 ^b (44)			
General Condition	0.346 (22)	0.306 (20)	0.494 ^b (18)		
Date	0.049 (51)		0.166 (44)	0.468 ^b (20)	
JCT Fat ^c	0.693 (68)	0.288 (51)	0.498 (44)	0.413 (20)	0.065 (51)

^aNumber in parentheses represents the sample size for the correlation.

^bCorrelation coefficient significant at $P \leq 0.05$.

^cTissue fat of the jawbone cavity.

are shown in Table 3. The mean percent FMT fat for those animals of known condition was 77.0 percent for those animals placed in the poor condition class (Class 1), 90.5 percent for those animals in fair to good condition (Class 2-3), and 97.7 percent for those animals in excellent condition (Class 4). The corresponding means for JCT fat were 63.4, 78.6, and 92.4 percent, respectively (Table 4).

In their work on the fat from the tissue of the jawbone cavity, Baker and Leuth (1966) noted that JCT fat was related to physical condition in deer. They concluded that this relationship was valid due to the fact that age, weight and date of collection were more highly correlated with JCT fat than with FMT fat. In the present work, significant correlations were found between JCT/weight and JCT/age. The correlations of FMT and these latter variables were not significant. The fat from the tissue of the jawbone cavity was significantly correlated ($P \leq 0.10$) with general condition ($r = 0.413$), whereas the correlation coefficient for FMT and general condition ($r = 0.346$) was not significant at this probability level. Since each of the factors (age, weight, general condition) are closely related to or affect condition in deer (Baker and Leuth, 1966), there seems to be a close relationship of JCT fat and condition. The correlation coefficients for those animals of known condition further emphasize this relationship.

The means of the FMT and JCT for each of the three condition classes show that JCT separates into better condition classes than does FMT fat (Table 4). The above results are similar to those obtained by Baker and Leuth (1966). The decrease of JCT fat from

TABLE 3
CORRELATION COEFFICIENTS OF EACH OF FOUR VARIABLES WITH
EACH OF THE OTHER VARIABLES FOR FEMUR/JAWBONE
COMBINATIONS OF WHITE-TAILED DEER OF
KNOWN CONDITION

	Femur Marrow Tissue Fat	Age	Weight
Age	0.230 (20) ^a		
Weight	0.328 (18)	0.882 ^b (18)	
JCT Fat ^c	0.862 ^b (20)	0.462 ^b (20)	0.501 ^b (18)

^aNumber in parentheses represents the sample size for the correlation.

^bCorrelation coefficient significant at $P \leq 0.05$.

^cTissue fat of the jawbone cavity.

TABLE 4

MEAN OF PERCENT OF TISSUE OF THE FEMUR MARROW AND OF
TISSUE FAT OF THE JAWBONE CAVITY OF WHITE-TAILED
DEER BY VISUALLY ESTIMATED CONDITION CLASSES

Condition Class	N	Mean % FMT Fat	Mean % JCT Fat
1 (Poor)	7	77.0	63.4
2 and 3 (Fair to Good)	10 ^a	90.5	78.6
4 (Excellent)	3	97.7	92.4

^aClasses were averaged due to the means for percent of tissue of the femur marrow and of tissue fat of the jawbone cavity of each class being nearly equal (difference of class 2 and 3 for FMT = 0.03 percent, JCT = 2.60 percent).

condition class 4 to condition class 2-3, was 13.8 percent, while the decrease of FMT fat was only 7.2 percent between the same condition classes. The difference in the decrease of JCT fat and FMT fat was narrower, 12.5 percent to 15.2 percent, respectively, for the next two condition classes (Classes 2-3 and 1). These data indicate the possibility that JCT fat was utilized prior to the utilization of FMT fat.

II. ANALYSIS OF RIGHT/LEFT JAWBONE COMPARISONS

An analysis was conducted on the percent JCT fat of the left and right jawbones of the same individual in order to determine if variation occurred between the fat levels of each side. A total of 53 lower jaws (106 jawbones) was extracted, and the percent JCT fat determined.

The results of these extractions are presented in Table 5. The mean difference of JCT fat levels in the left versus the right jawbone of the same animal was 4.6 percent. In 24 animals, the left side of the jawbone had a higher percent fat than the right side ($\bar{D} = 4.3$ percent). In the other 29 animals, the percent fat of the left side was lower than the right side ($\bar{D} = 4.8$ percent). Twenty-four individuals of the total sample could be placed into an age group consisting of animals 2 1/2 years or older. The other 29 animals were 1 1/2 years or less. The 2 1/2 years or older age group had a mean difference between fat levels of the left and right jawbone of 2.9 percent, while the 1 1/2 years or less age group had a mean difference of 6.3 percent. Also presented in Table 5 are the confidence limits, calculated t-values, and tabular t-values for these data.

TABLE 5
 MEAN DIFFERENCES, CONFIDENCE LIMITS, CALCULATED AND
 TABULAR t-TEST VALUES FOR THE RIGHT/LEFT
 JAWBONE COMPARISONS OF INDIVIDUAL
 WHITE-TAILED DEER

Group	Sample Size	Mean Difference	C.L. P ≤ 0.05	t 05(N-1) Cal. (tabular)
Total Samples	53	4.6% ^a	±1.3%*	7.179 (2.021)
Left side higher than right side	24	4.3	±1.8	4.330 (2.069)
Left side lower than right side	29	4.8	±1.8	5.424 (2.042)
2 1/2 years or older	24	2.9	±1.8	4.686 (2.069)
1 1/2 years or less	29	6.3	±1.9	6.680 (2.042)

^aFigures have been rounded to the nearest 0.1.

These analyses show that there is a difference in the JCT fat of the left and right jawbones of the same animal ($\bar{D} = 4.6$ percent). However, the fat concentration on neither side of the jawbone was consistently higher than the other side. The mean difference when the left jawbone was higher than the right, or conversely, was essentially the same.

The 2 1/2 years or older age group exhibited the lower mean difference between the JCT fat levels of the right and left jawbones, while the 1 1/2 years or less age group exhibited the higher mean difference between these levels. Severinghaus (1949) noted that tooth eruption, hence jawbone growth, was not completed in the white-tailed deer until the animal was over 18 months of age. Therefore, there is a possibility that the difference of $\bar{D}$ between the two age groups (3.4 percent) is due to growth of the jawbone and tooth eruption in the younger age group. Since those animals 2 1/2 years or older have ceased to have tooth eruptions, and for all practical purposes jawbone growth, the figure of 4.7 percent (2.9 percent $\pm$ 1.8 percent) difference between the left and right jawbones can be taken as the maximum difference that would normally be expected between left and right jawbones. In the sample of 24 animals 2 1/2 years or older, only four individuals had greater than a 4.7 percent difference in the left and right jawbone, while 14 of 29 individuals 1 1/2 years or less had greater than a 4.7 percent difference. The likelihood of this variability of the younger age classes occurring should be taken into account when comparing the JCT fat of samples of different age classes.

In addition, the 4.7 percent difference in the JCT of the right and left jawbones could be biologically significant if the difference were large enough to cause an animal to be incorrectly classified into a higher or lower condition class. It can be postulated that the 4.7 percent difference in the left and right jawbone is biologically nonsignificant, since the present study and the study by Baker and Leuth (1966) found a 15 percent and 14 percent difference among the JCT fat levels of animals in the excellent, fair and poor condition classes.

III. ANALYSIS OF SECTIONED JAWBONES

Seven jawbones were cut into five sections each to determine if it was necessary to utilize the whole JCT or only a portion of this cavity. The ages of the animals from which jawbones were obtained to be utilized in this study were two animals 1 1/2 years old, two animals 2 1/2 years old, two animals 3 1/2 years old, and one 4 1/2 year old animal. The results of these extractions are presented in Table 6.

Considerable variation was exhibited among the sections of each jawbone. Age appeared to have little effect on this variation, since all age groups exhibited deviations between sections. Due to these deviations, the sections were combined to form blocks of three sections each to determine if this procedure would obtain a sample of sufficient size, and approximate the percent JCT fat of the whole jawbone cavity tissue (Table 7). Block 1 exhibited the least mean difference (2.4 percent), block 3 the middle mean difference (2.6

TABLE 6

PERCENT OF TISSUE FAT OF THE JAWBONE CAVITY OF THE SECTIONS
OF SEVEN JAWBONES OF WHITE-TAILED DEER

Section	Jawbone Tag Number						
	360	374	377	2905	2917	2918	2920
1	74.5%	70.2%	92.5%	82.3%	69.6%	56.1%	81.6%
2	72.0	88.9	93.0	80.1	83.1	65.9	84.0
3	57.6	88.7	91.7	69.1	88.4	60.1	88.2
4	74.8	81.1	91.1	66.8	86.8	49.2	81.5
5	63.0	87.1	84.4	74.2	70.2	34.5	84.8
Jawbone Mean	66.6	83.2	90.5	74.5	79.6	53.0	84.0

TABLE 7
PERCENT OF TISSUE FAT OF THE JAWBONE CAVITY OF THE
SECTIONS OF SEVEN JAWBONES OF WHITE-TAILED
DEER BY BLOCKED SECTIONS

Sample No.	Block Number			Total JCT ^a 1/2/3/4/5
	1	2	3	
	Sections in Block			
	1/2/3	2/3/4	3/4/5	
360	68.0%	68.1%	65.1%	66.6%
374	82.6	85.9	85.6	83.2
377	92.4	91.9	89.1	90.5
2905	77.2	72.0	70.0	74.5
2917	76.7	86.1	81.8	79.6
2918	60.7	58.4	47.9	53.0
2920	84.6	84.6	84.8	84.0
$\bar{D}^b$	2.4%	2.7%	2.6%	
Cal. t-test	.737	.810	.844	

^aTotal tissue fat of the jawbone cavity.

^b $\bar{D}$ is the mean difference of percent fat of each block and total tissue fat of the jawbone cavity.

percent), and block 2 the highest mean difference (2.7 percent). The lowest t-test value between block percent JCT fat and the whole jawbone percent JCT fat was for block 1, while the highest t-test value was for block 3.

Statistically, the best sample that could be used to approximate the percent fat for the whole JCT was the first block (Sections 1/2/3). However, when jawbones are collected by the method used in this study (Marshall, et al., 1964), there is a hazard that portions of blocks 1 and 3 will be lost (see Figure 5). Thus, block 2 (Sections 2/3/4) was chosen as the representative sample, since this block remains intact when the jawbone is removed from an animal.

IV. ANALYSIS OF JAWBONES COLLECTED ON SIX WILDLIFE MANAGEMENT AREAS IN TENNESSEE

A total of 488 jawbones was collected from six wildlife management areas across the state. Of this total, 187 jawbones were collected from the Chuck Swan WMA during the 1969-1970 hunting season. There was a variation of PCFT among the six wildlife management areas from which jawbones were collected (Table 8).

Females had a higher PCFT than did males for all areas, with a mean PCFT for females of 85.1 percent and a mean PCFT for males of 81.3 percent (Table 9). Age classes on all areas exhibited a general trend of increasing PCFT from the fawn age class up to and including the 3 1/2 age class (Table 10). From the 4 1/2 age class to the 5 1/2+ age class, PCFT began to level off or slightly decrease depending on the management area in question. The overall means by age classes

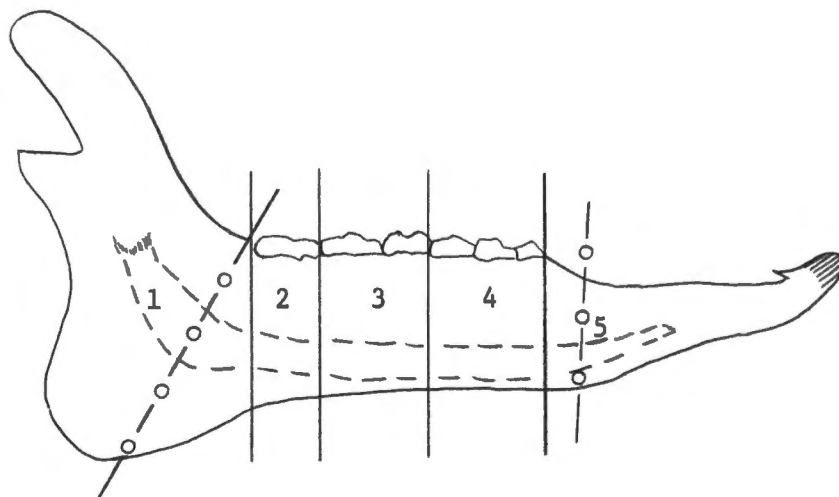


Figure 5. Diagram of sectioned jawbone showing possible abnormal cuts and breakages using the standard method of deer jawbone removal. Solid vertical lines (—) divide sections. Dotted lines (---) indicate area of JCT. Numbers indicate the section number. Broken lines (—○—) indicate where breakage or cut could occur.

TABLE 8

MEANS AND STANDARD DEVIATIONS OF PERCENT OF TISSUE FAT OF THE
JAWBONE CAVITY FROM WHITE-TAILED DEER ON A DRY WEIGHT
(PCRT) AND WET WEIGHT (PCFTW) BASIS^a
BY MANAGEMENT AREA

Area	N	Mean ^b PCFT	N	Mean PCFTW	S.D. PCFT	S.D. PCFTW
Tellico	41	83.4%	36	59.2%	9.22	12.01
Chuck Swan	59 ^c	80.3	59	54.8		
Catoosa	50	87.4	50	63.7	7.65	9.90
Cheatham	34	88.2	24	61.7	6.23	16.14
Natchez Trace	50	80.2	49	51.7	10.66	13.14
Shelby	67	82.0	67	51.1	8.93	11.19

^aRefer to Femur and Jawbone Analysis, page 13, for method of calculation.

^bAnalysis of variance of tissue fat of the jawbone cavity by areas revealed a significant difference in tissue fat between areas ($P \leq 0.05$).

^cTotal sample for Chuck Swan Wildlife Management Area was 246 jawbones. For all comparisons involving area, only those jawbones collected during the 1970-1971 hunting season were used.

TABLE 9
MEANS AND STANDARD DEVIATIONS OF PERCENT OF TISSUE
FAT OF THE JAWBONE CAVITY OF WHITE-TAILED DEER
BY MANAGEMENT AREA AND SEX

Area	PCFT ^a Males	S.D. Males	PCFT ^a Females	S.D. Females
Tellico	83.4%	9.22	NC ^b	-
Chuck Swan	79.7	11.27	81.2%	14.36
Catoosa	85.3	7.74	88.6	7.45
Cheatham	85.7	7.40	89.3	5.50
Natchez Trace	76.8	12.81	81.9	9.11
Shelby	78.8	9.53	84.5	7.64

^aPercent fat content.

^bBuck only.

TABLE 10
MEANS OF PERCENT OF TISSUE FAT OF THE JAWBONE CAVITY
OF WHITE-TAILED DEER BY MANAGEMENT
AREA AND AGE CLASS

Area	Age Classes					
	Fawn	1 1/2	2 1/2	3 1/2	4 1/2	5 1/2+
Tellico	NC ^a	81.6%	83.0%	86.0%	86.0%	84.6%
Chuck Swan	66.5%	74.4	81.0	84.7	88.1	89.2
Catoosa	82.0	85.7	87.4	90.0	92.7	93.8
Cheatham	84.7	85.3	90.2	91.0	NC ^a	92.8
Natchez Trace	70.5	81.5	81.9	90.5	81.3	89.8
Shelby	72.1	83.1	88.9	87.0	89.8	87.3

^aNC indicates no collections made.

were as follows: fawns, 75.1 percent; 1 1/2 age class, 82.1 percent; 2 1/2 age class, 85.3 percent; 3 1/2 age class, 87.9 percent; 4 1/2 age class, 87.4 percent; and 5 1/2+ age class, 88.4 percent. PCFT increased by month of collection for most WMA's in the study (Table 11). The exception was the Tellico WMA where there was a 3.3 percent decrease in PCFT from October to November.

Additional monthly comparisons were obtained from the 1969-1970 Chuck Swan collections (see Table 12). There was a 6.4 percent decrease from December, 1969 to January, 1970. In addition, the PCFT of jawbones in the 1969-1970 Chuck Swan collections exhibited varying increases and decreases corresponding to date of collection and age class (Table 13). The PCFT of all age classes of this collection exhibited an increase from December 11, 1969 to December 23, 1969. The PCFT of the 1 1/2 and 2 1/2 age classes began to decrease at this point, with the decrease continuing throughout the collections. The 3 1/2 age class continued to increase until December 29, 1969, at which time the PCFT of this age class began to decrease. The total decrease in PCFT (13.9 percent for the 1 1/2 age class, 6.6 percent for the 2 1/2 age class, and 8.4 percent for the 3 1/2 age class) occurred in a period of two weeks for the 1 1/2 and 2 1/2 age classes and one week for the 3 1/2 age class.

Even though collections on the Chuck Swan WMA occurred in different months for the two collection-years, some comparisons could be made (Table 12). The mean PCFT for the first year was 80.1 percent, while the mean PCFT for the second year was 80.3 percent. Due to the fact that the first year was a buck-only hunt, no comparisons of the

TABLE 11

MEANS OF TISSUE FAT OF THE JAWBONE CAVITY OF WHITE-TAILED
DEER BY MANAGEMENT AREA AND MONTH OF COLLECTION

Area	October	November	December
Tellico	85.7%	82.4%	NC ^a
Chuck Swan	66.0	81.4	NC
Catoosa	NC ^a	87.4	NC
Cheatham	NC	88.2	NC
Natchez Trace	79.5	79.7	82.6%
Shelby	81.6	82.3	NC

^aNC indicates no collections made.

TABLE 12

MEAN PERCENT OF TISSUE FAT OF THE JAWBONE CAVITY OF WHITE-TAILED DEER ON THE CHUCK
SWAN WILDLIFE MANAGEMENT AREA FOR COLLECTION YEARS 1969-1970 AND 1970-1971
BY YEAR, SEX, AGE CLASS, AND MONTH OF COLLECTION

Year	Mean PCFT	Mean PCFTW	Sex		Fawn	Age Class								Month					
			Males	Fe- males		1	1 1/2	2	1 1/2	3	1 1/2	4	1 1/2	5	1/2+	Oct.	Nov.	Dec.	Jan.
First (1969- 1970)	80.1%	56.8%	80.1%	NC ^a	NC	75.7%	80.5%	82.7%	86.3%	79.1%	NC	NC	80.8%	74.4%					
Second (1970- 1971)	80.3	54.8	79.7	81.2	66.5	74.4	81.0	84.7	88.1	89.2	66.0	81.4	NC	NC					

^aNC indicates no collections made.

TABLE 13

MEAN PERCENT OF TISSUE FAT OF THE JAWBONE CAVITY OF WHITE-TAILED
DEER BY AGE CLASS AND DATE OF COLLECTION FOR JAWBONES
COLLECTED ON THE CHUCK SWAN WILDLIFE MANAGEMENT
AREA DURING THE PERIOD OF DECEMBER, 1969
TO JANURAY, 1970

Collection Dates	Age Classes				
	1 1/2	2 1/2	3 1/2	4 1/2	5 1/2+
Dec. 11-17	75.9%	79.7%	83.1%	-	-
Dec. 17-23	76.9	83.0	83.2	-	-
Dec. 23-29	75.5	78.7	83.8	-	-
Dec. 29-Jan. 3	69.3	76.5	78.9	86.2 ^a	81.8 ^a

^aDue to the small sample size, all jawbones in the 4 1/2 and 5 1/2 age classes were averaged.

PCFT for females could be made. The mean PCFT for males in the first year was 80.1 percent and the second year 79.7 percent. Both years' collections exhibited an increase in PCFT in age classes, with the PCFT of the first year generally being 1 to 2 percent lower than the second year. No comparison of the mean monthly PCFT could be made due to the fact that there was no overlapping of collections.

The previous literature which presented data concerning percent fat, expressed the percent fat on a wet weight basis (Riney, 1955; Baker and Leuth, 1966; Ransom, 1965). In the present study, percent fat was determined on both a dry (PCFT) and wet (PCFTW) weight basis. However, only dry weight values were used to interpret data.

Since the PCFTW was based on weights of material that contained moisture, much variability due to water loss could occur. This moisture loss could occur when the jawbone was severed to be removed from the animal, or during storage. In addition, water was often lost from the JCT when the JCT was removed from the jawbone for extraction. This moisture loss would cause two jawbones to have the same PCFT but different PCFTW. In many cases, this difference amounted to over 5 percent.

In addition to moisture loss, the possible range of percent fat was a factor in determining the use of PCFT over PCFTW. The minimum and maximum PCFT values found in this study were 2.0 percent and 95.2 percent, respectively. The same values for PCFTW were 0.3 percent and 81.0 percent. The range for PCFT was 93.2 percent, while the range for PCFTW was 80.7 percent. Hence, PCFT had a range which was 12.5 percent greater than was the range of PCFTW. Riney (1955)

concluded that, with greater range, a measure of condition would better be able to reflect slight changes in condition. Thus, PCFT was a better basis of comparison than PCFTW.

When analyzing the data from the jawbones collected on the six wildlife management areas, an attempt was made to standardize procedures to reduce the possible introduction of variation that otherwise could have been avoided. This procedure was accomplished by: (1) attempting to collect the same approximate sample size from each area; (2) collection of jawbones randomly as animals were killed; (3) collection of only the left jawbone; (4) use of a standardized section of JCT for processing; (5) utilization of PCFT in analysis of data.

An analysis of percent JCT fat between the six WMA's showed considerable variation between the mean PCFT's of the deer on the six areas. When a SNK range test was conducted on those means, the mean PCFT of the Cheatham and Catoosa WMA's were significantly higher ($P \leq 0.05$) than the mean PCFT's of the Chuck Swan, Natchez Trace, and Shelby WMA's.

The differences that occurred between these areas could be due to many reasons (such as sex, age and month of collection). The possibility also exists that the deer populations on the two areas were in better physical condition than were the deer on the other areas.

With the exception of the Tellico WMA, where a buck-only hunt was held, jawbones from both males and females were collected. The data revealed that females had a mean PCFT that was 1.2 percent to 5.7 percent higher than the PCFT of males. A possible explanation for the difference was that collections occurred either near or during

the rutting season. During the rut, bucks lose weight rapidly due to little food intake and high energy expenditure (Taylor, 1961). Since the decrease of body weight was due to the utilization of fat for energy, there will be a decrease in PCFT during the rut period.

The sex ratios (females/males) determined for each area were: Chuck Swan 1:0.903, Catoosa 1:0.562, Cheatham 1:0.417, Natchez Trace 1:0.515, Shelby 1:0.810. These ratios could be significant due to females having a higher mean PCFT than males. If a sample of jawbones contained a higher proportion of jawbones from females than a sample of jawbones from another area, the mean PCFT of the first sample would be biased higher. It can be concluded that any comparison of mean PCFT between areas should utilize the PCFT of either males or females, not a combination of both.

To further complicate the comparison of mean PCFT between areas, the number of individuals collected in the various age classes could cause an increase or decrease of mean PCFT for each area. It was shown earlier that there was a considerable difference of PCFT between age classes. The average difference between age classes for all areas being 7.0 percent between fawns and the 1 1/2 age class, 3.2 percent between the 1 1/2 and 2 1/2 age classes, 2.6 percent between the 2 1/2 and 3 1/2 age classes, -0.5 percent between the 3 1/2 and 4 1/2 age classes, and 1.0 percent between the 4 1/2 and 5 1/2+ age classes. There is a possibility that the PCFT of the fawn and 1 1/2 age classes can be higher or lower than the values shown here due to the variability of the JCT previously encountered in these age classes. It is felt that this variation is the cause of the differences of the PCFT levels

in the fawn age class and the 2 1/2 age class for the WMA's. The differences ranged from 5.4 percent for the Catoosa WMA to 16.8 percent for the Shelby WMA. The above indicates that a comparison of PCFT between areas should use only the upper age classes, since this group has the least variability between age classes and individual jawbones.

Besides the parameters of sex and age affecting the mean PCFT of deer for a given area, date of collection might also influence the mean PCFT of the deer on the areas in question. The mean PCFT showed an increase in the months of October, November and December. These increases of PCFT by month were from 1.0 percent to 2.9 percent, and depended on the area and month in question. It was interesting to note that on the Chuck Swan WMA there was a 15.4 percent increase from October to November. However, this increase was due to the October sample consisting entirely of animals in the fawn age class. A comparison of the December and January collections from the Chuck Swan WMA revealed a decrease in PCFT of 6.4 percent between the jawbones collected during these two months. Thus, date of collection can have a significant effect on mean PCFT levels.

Additional analysis of the jawbones collected from the Chuck Swan WMA during the period of December, 1969 and January, 1970 revealed that PCFT by age classes exhibited a differential decrease, with the younger age classes first showing a decrease in PCFT (Table 13, page 39). This type of decrease in a fat reserve should be expected as it is the younger animals who suffer from food shortages first, due to their greater need of food for both maintenance and growth. Thus,

analysis of data on condition of deer should include data on fawns and yearlings, but due to the variabilities of PCFT in these age classes, this data should be analyzed on the basis of trends rather than absolute values.

In the previous discussions, it was concluded that both age and sex ratios explained part of the variation of PCFT between the six wildlife management areas in this study. The date of collection was found to have little effect on the variation of PCFT between areas in the 1970-1971 collections. It was shown that collections made while the mean PCFT was increasing (October, November, December) should not be compared to collections made while the mean PCFT was decreasing (late December and January). Because of the complexity of the interrelationship of sex and age on the mean PCFT for the six wildlife management areas, an analysis of the PCFT of females 2 1/2 years or older was conducted. By using this sample, the influence of sex and age was removed. A small sample size prevented analyzing the same data for males. Since a buck-only hunt was conducted on the Tellico WMA, a comparison of the mean PCFT of this area with the mean PCFT of the other areas could not be made.

The results of the comparison of the mean PCFT of females 2 1/2 years or older are shown in Table 14. The mean PCFT of females 2 1/2 years or older was from 2.9 percent to 7.1 percent higher, by area, than the mean PCFT calculated by using the PCFT from all jawbones collected on each area. The difference of these means was likely due to the influence of the younger age groups. The Chuck Swan WMA had an adequate sample of jawbones of males 2 1/2+ years from which the

TABLE 14

MEAN PERCENT OF TISSUE FAT OF THE JAWBONE CAVITY BY AREA
AND SEX FOR WHITE-TAILED DEER 2 1/2 YEARS OR
OLDER FOR THE 1970-1971 COLLECTION

Area	Males		Females	
	N	PCFT	N	PCFT
Tellico	26	84.2%	- ^a	-
Chuck Swan	18	83.3	16	87.4%
Catoosa	4	90.1	23	90.8
Cheatham	2	91.0	16	91.0
Natchez Trace	2	92.7	20	83.6
Shelby	4	86.2	15	88.9

^aBuck-only hunt.

PCFT of males and females could be compared. The difference of the mean PCFT of females and males increased from 1.5 percent for all age groups to 4.1 percent for animals 2 1/2+ years. This comparison again shows the difference of PCFT of males and females. The mean PCFT of females 2 1/2+ years was compared by area using a SNK multiple range test at a probability level of 0.05 or less. The test showed that there was no statistical difference between the mean PCFT of the five WMA's. However, the mean PCFT of the deer herd on the Natchez Trace WMA was somewhat lower (3.8 to 7.4 percent) than the mean PCFT's of the deer herds on the other WMA's. A comparison of data on browse, mast and population indexes (Tennessee Game and Fish Commission, 1970) for the WMA's did not reveal possible causes for the variation.

V. TISSUE FAT OF THE JAWBONE CAVITY, ITS USE AS AN INDICATOR OF CONDITION IN DEER

Tissue of the jawbone cavity was analyzed to determine if this fat deposit could be a reliable measure of condition in deer. The method of verifying this hypothesis was to compare the JCT fat to fat of the femur marrow. However, the problem encountered when FMT was used as a basis of comparison was that FMT fat only indicated a narrow range of condition. That is, FMT fat only indicates when an animal is in poor condition (Riney, 1955). Both the previous study by Baker and Leuth (1966) and the present study arrived at the same conclusion, that JCT fat, based on FMT fat comparisons, may be a useful indicator of condition, but cannot be definitely called an indicator of condition.

In the present study, JCT fat was more thoroughly analyzed than was JCT fat in the study by Baker and Leuth (1966). In the present study, it was found that JCT had a wide range of percent fat, 2.0 to 95.2 percent. Percent JCT fat varied according to age (with the lower age classes having the lower PCFT) and sex (with females having a higher PCFT). It was also found that JCT fat varied by date of collection. These changes in JCT fat and age, sex and date of collection follow very closely the changes of other known fat reserves and the same variables (Harris, 1945; Riney, 1955). The above factors, therefore, indicate that JCT is a fat reserve, and thus could be used as an index of fat utilization and replacement.

A review of available literature indicates that the fat reserves in an animal's body are utilized and replaced in a certain order. When attempting to use JCT fat to determine condition, it is essential to know at what stage of this utilization and replacement order that JCT fat is used. Since the animals in the FMT/JCT portion of the study were in varying degrees of condition, it is possible to look at fat utilization and offer conjecture as to the time of utilization of JCT fat as compared to FMT fat. As previously mentioned, the JCT fat was found to decrease prior to FMT fat (see Table 5, page 26). The additional facts that JCT fat was more highly correlated to age, weight and general condition than was FMT fat, would seem to indicate that JCT fat was utilized prior to FMT fat.

Data collected by Bischoff (1954) indicates that a fat reserve is useful as an indicator of condition only between the points of total fat utilization or replacement. The knowledge that femur fat is high, or subcutaneous fat is fully utilized, would only show that the

animal is not in excellent or poor condition. The entire gradient of condition between excellent and poor would not be measured. With the knowledge of where each fat reserve fits into the utilization and replacement order, and the knowledge that a number of fat reserves are at a certain stage of utilization, the condition of the animal or population could be determined.

CHAPTER V

SUMMARY

A study of the tissue of the jawbone cavity of the white-tailed deer (Odocoileus virginianus) in Tennessee was conducted from December, 1969 to December, 1971. The major objectives of the study were: to verify the use of the tissue fat of the jawbone cavity as an indicator of condition in white-tailed deer; to determine the effects of various parameters such as sex, age, weight, and date of collection on fat levels of tissue fat of the jawbone cavity in deer; to establish jawbone cavity tissue fat levels for various deer herds in Tennessee.

Six wildlife management areas across the state were selected as study areas. Those WMA's chosen for the study were Tellico, Chuck Swan, Catoosa, Cheatham, Natchez Trace, and Shelby WMA's. Topography for the areas ranged from rugged mountains with peaks 5000 feet above sea level, to the Mississippi River Bottoms averaging 100 feet above sea level. Forest cover varied from upland hardwoods to bottomland hardwoods.

Femur/jawbone combinations were collected on a statewide basis during the period of the study. Jawbones were collected from the six wildlife management areas, during scheduled deer hunts, by the method described by Marshall, et al. (1964). Sixty-eight femur/jawbone combinations were collected across the state. A total of 187 jawbones were collected on the Chuck Swan WMA during the 1969-1970 hunting

season. An additional 301 jawbones were collected on the six wild-life management areas during the 1970-1971 hunting season.

The femurs and jawbones were analyzed by ether extraction for fat in the tissue of the femur marrow (FMT) and jawbone cavity (JCT). The results expressed FMT and JCT fat as a percentage of the dry weight of the FMT and JCT.

The investigation of the femurs and matching jawbones revealed that FMT and JCT had a strong relationship ($r = 0.693$). In addition, JCT was more highly correlated to age, weight, and general condition than was FMT. Tissue fat from the jawbone cavity, from animals of known condition, was found to separate into more distinguishable condition classes than was FMT fat. Also, JCT fat decreased prior to FMT fat in those animals of known condition. Therefore, the data indicates that JCT fat is more closely related to variables that affect condition than is FMT fat. There is also an indication that JCT fat is utilized prior to FMT fat.

The comparison of right and left jawbones of the same animal revealed a mean difference of 4.6 percent JCT fat between the opposite jawbones. Neither side of the lower jaw had a consistently higher JCT fat. Older animals (2 1/2 years) had a lower mean deviation (2.9 percent) than did the animals 1 1/2 years or less (6.3 percent). It was thought that tooth eruption and jawbone growth in the younger age group caused the variation. The conclusion was reached that the difference between the right and left jawbone would not be a factor which could deter the usefulness of JCT as an index of condition, provided that samples that consisted of only young animals or older animals were not compared.

An analysis of seven jawbones sectioned into five parts indicated that a sample consisting of the posterior one-half of the JCT would be the sample which would most consistently approximate the fat of the whole JCT. However, the technique used in this study for removing the jawbones from the deer caused the section of JCT under the molar and premolar teeth to be chosen as the standardized sample.

Differences, a maximum of 8.2 percent, occurred between the mean percent JCT fat (PCFT) of the six wildlife management areas on which the study was conducted. Catoosa WMA and Cheatham WMA had mean PCFT that were statistically significantly higher ($P \leq 0.05$) than the mean PCFT of the other WMA's. Females, for all areas collected, were found to have an average PCFT that was 3.8 percent higher than the PCFT of the males. There was an increasing PCFT from the fawn age class up to and including the 3 1/2 age class, after which PCFT for the remaining age classes remained relatively stable. It was also found that the mean PCFT increased with date of collection on most WMA's. The Chuck Swan WMA collections revealed an increase of PCFT during the months of October and November, and a decrease in PCFT during the months of December and January. A differential decrease of PCFT by age class was found in the collections made on the Chuck Swan WMA during December and January, where the younger age classes showed a decrease in PCFT before the older animals. It was concluded that the effects of age and sex caused much of the variability of mean PCFT between the study areas. Due to these effects, an analysis of the PCFT of females 2 1/2+ years was conducted. The mean PCFT by area for females 2 1/2+ years was from 3.0 to 7.0 percent higher than the

PCFT of the same areas when both sexes and all age classes were analyzed. The removal of the influence of age and sex on PCFT was believed to be the cause of the increase of mean PCFT. The mean PCFT of females 2 1/2+ years old was compared by area and found to be nonsignificant. The mean PCFT of the deer herd on the Natchez Trace WMA was somewhat lower than the mean PCFT's of the deer herds on the other WMA's. A comparison of browse, mast and population indexes did not reveal possible causes for the variation.

It was concluded that FMT fat was as inadequate fat reserve with which to compare JCT fat. The data in the study did indicate that JCT fat was indeed a fat reserve and could serve as an indicator of condition. Comparison of JCT fat to FMT fat did indicate that JCT fat was utilized prior to the utilization of FMT fat. It was shown that in order for a fat reserve to be a reliable indicator of condition, the position of the fat reserve in the utilization and replacement order would have to be known. Also, it was shown that when a fat reserve was totally utilized or replaced, that the fat reserve would have only limited use as an indicator of condition.

CHAPTER VI

RECOMMENDATIONS

A reliable measure of condition was not available for verification of the use of JCT fat as an indicator of condition. The use of JCT fat as a technique to determine condition would be improved if researchers were to inquire into the following:

1. Further verify the use of JCT fat as an indicator of condition in deer by obtaining a large sample of animals in which all fat reserves can be measured and compared to JCT fat.

2. Determine the type of fat reserve that JCT fat is, and the composition of the tissue of the jawbone cavity.

3. Determine the position of JCT fat in the fat utilization and replacement order.

4. Develop a technique for the determination of JCT fat that is less expensive, but still accurate.

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