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VARIATIONS IN FAT LEVELS OF MANDIBULAR CAVITY TISSUE IN WHITE-TAIL DEER *(Odocoileus virginianus)* IN TENNESSEE[1]

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ABSTRACT

Age, sex, and date of collection were found to affect fat levels of mandibular cavity tissue (MCT). Percent MCT fat increased from the fawn age class up to and including the 3½ age class. Percent MCT fat remained relatively stable in all age classes above 3½ years. Females were found to have a percent MCT fat that was higher than the percent MCT fat of males. Fat in the tissue of the mandibular cavity increased during the months of October, November, and early December, and decreased in late December and early January.

Mean MCT fat levels of whitetail deer on four wildlife management areas (WMA) were found to be closely grouped and high. The deer herd on the Natchez Trace WMA had a MCT fat level that was lower than the MCT fat levels of the other areas.

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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 mandibular cavity of whitetailed deer, and found that the fat in the tissue of the mandibular cavity might be a useful indicator of deer condition.

This study deals with the fat in the mandible of the white-tailed deer in Tennessee. Collections of mandibles were made on six wildlife management areas across the state. Each WMA was located in a different physiographic region (Table 1) (Dickson, 1960; Rand, 1970). The areas where collections were made included the Tellico, Chuck Swan, Catoosa, Cheathum, 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 1970-71 hunting season.

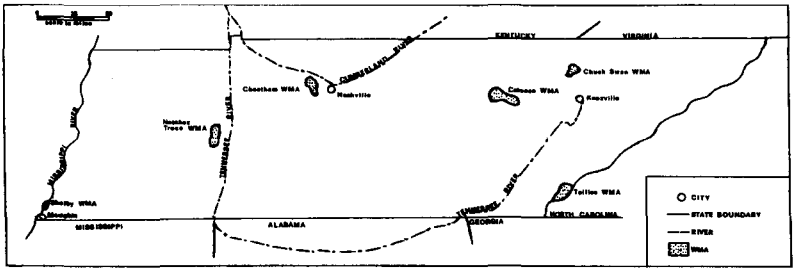

Figure 1. Map of the state of Tennessee, showing location of study areas and major drainages.

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 WMAa (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.

PROCEDURES

Collections of mandibles from the Chuck Swan WMA were begun during the 1969-1970 hunting season. During the 1970-1971 hunting season, mandibles were collected from all six management areas. At Shelby and Tellico WMA's, where the deer-kill was not expected to be large (75 deer and less), mandibles were collected from all animals killed. At Catoosa, Cheathum and Natchez Trace WMA's, the number of mandibles to be collected was set at 50 per area. Special collections of mandibles were made at the Chuck Swan WMA, with no maximum number being established.

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

Upon removal from the animal, the mandibles 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 mandible with the parameters of sex, age, weight, date and area. The mandibles were then placed in a double plastic bag, and frozen no later than the end of the day on which they were collected.

A standardized sample from each mandible was produced by placing the mandible in a vise and removing that portion of the mandible posterior to the third molar and anterior to the second premolar. Samples from fawn mandibles were obtained by the same method, but the cut was made into the ramus of the mandible to insure being posterior to the third molar. The tissue of the mandibular cavity (MCT) was exposed by placing the mandible section on a flat hard surface and striking the mandible with a hammer. With practice, it was very easy to crack the bone in such a manner that the MCT could be removed in one piece.

Upon removal from the mandible, the MCT was inspected for bone chips. These chips were removed with forceps. The marrow was sectioned and placed into pre-weighed aluminum pans. 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 MCT was determined by subtracting the pan weight from the latter weighing. The MCT 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 MCT 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 MCT fat was determined on both a dry (PCFT) and wet (PCFTW) weight basis, by dividing the weight of the material extracted from the MCT by the dry and wet weight of the MCT prior to extraction.

Fat data for the mandibles 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 MCT fat by area, sex, age and date of collection.

RESULTS AND DISCUSSION

A total of 488 mandibles was collected from six wildlife management areas across the state. There was a variation of the percent fat (PCFT) among the six wildlife management areas from which mandibles were collected (Table 2). 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 3). Age classes on all areas exhibited a general trend of increasing PCFT from the fawn age class up to and including the 3½ age class (Table 4). From the 4½ age class to the 5½+ age class, PCFT began to level off or slightly decrease depending on the management area in question. The overall means by age classes were as follows: fawns, 75.1 percent; 1½ age class, 82.1 percent; 2½ age class, 85.3 percent; 3½ age class, 87.9 percent; 4½ age class, 87.4 percent; and 5½+ age class, 88.4 percent. Cursory data indicated that PCFT increased by month of collection (Table 5). The one exception was the Tellico WMA where there was a 3.3 percent decrease in PCFT from October to November.

Monthly comparisons were obtained from the 1969-1970 Chuck Swan collections (Table 6). There was a 6.4 percent decrease from December, 1969 to January, 1970. In addition, the PCFT of mandibles in the 1969-1970 Chuck Swan collections exhibited varying increases and decreases corresponding to date of collection and age class (Table 7). The PCFT of all age classes of this collection exhibited an increase from December 11, 1969 to December with the decrease continuing throughout the collections. The 3½ 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 (7.6 percent for 1½ age class, 6.5 percent for the 2½ age class, and 4.9 percent for the 3½ age class) occurred in a period of two weeks for the 1½ and 2½ age classes and one week for the 3½ age class.

TABLE 2
MEANS AND STANDARD DEVIATIONS OF PERCENT OF TISSUE FAT OF THE MANDIBULAR CAVITY FROM WHITE-TAILED DEER ON A DRY WEIGHT (PCFT) AND WET WEIGHT (PCFT) BASIS BY MANAGEMENT AREA

Area	N	Mean PCFT	N	Mean PCFTW	S.D. PCFT	S.D. PCFTW
Tellico	41	83.4%	36	59.2%	9.22	12.01
Chuck Swan	59b	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

aAnalysis of variance of tissue fat of the mandibular cavity by areas revealed a significant difference in tissue fat between areas (P 0.05).

bTotal sample for Chuck Swan Wildlife Management Area was 246 mandibles. For all comparisons involving area, only those mandibles collected during the 1970-71 hunting season were used.

TABLE 3
MEANS AND STANDARD DEVIATIONS OF PERCENT OF TISSUE FAT OF THE MANDIBULAR CAVITY OF WHITE-TAILED DEER BY MANAGEMENT AREA AND SEX

Area	PCFTa Males	S.D. Males	PCFTa Females	S.D. Females
Tellico	83.4%	9.22	NCb	-
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 4
MEANS OF PERCENT OF TISSUE FAT OF THE MANDIBULAR CAVITY OF WHITE-TAILED DEER BY MANAGEMENT AREA AND AGE CLASS

Area	Age Classes					
	Fawn	1½	2½	3½	4½	5½+
Tellico	NCa	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	NCa	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.

TABLE 5
MEANS OF TISSUE FAT OF THE MANDIBULAR CAVITY OF WHITE-TAILED DEER BY MANAGEMENT AREA AND MONTH OF COLLECTION

Area	October	November	December
Tellico	85.7%	82.4%	NCa
Chuck Swan	66.0	81.4	NC
Catoosa	NCa	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 7
MEAN PERCENT OF TISSUE FAT OF THE MANDIBULAR CAVITY OF WHITE-TAILED DEER BY AGE CLASS AND DATE OF COLLECTION FOR MANDIBLES COLLECTED ON THE CHUCK SWAN WILDLIFE MANAGEMENT AREA DURING THE PERIOD OF DECEMBER, 1969 TO JANUARY, 1970

Collection Dates	Age Classes 1½	2½	3½	4½	5½+
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	86.2a	81.8a

aDue to the small sample size, all mandibles in the 4½ and 5½ age classes were averaged.

TABLE 6
MEAN PERCENT OF TISSUE FAT OF THE MANDIBULAR 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	Males	Fe-males	Fawn	1½	2½	3½	4½	5½+	Oct.	Nov.	Dec.	Jan.
First (1969-1970)	80.1%	56.8%	80.1%	NCa	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.

Even though collections on the Chuck Swan WMA occurred in different months for the two collection-years, some comparisons could be made (Table 6). 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 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.

An analysis of percent MCT 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 Cheathum and Catoosa WMA's were significantly higher (P 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 have been due to many reasons (such as sex, age and month of collection). The possibility also existed 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, mandibles 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 would be a decrease in PCFT during the rut period.

Sample sex ratios (females/males) determined for each area were: Chuck Swan 1:0.903, Catoosa 1:0.562, Cheathum 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 mandibles contained a higher proportion of mandibles from females than a sample of mandibles 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 was 7.0 percent between fawns and the 1½ age class, 3.2 percent between the 1½ and 2½ age classes, 2.6 percent between the 2½ and 3½ age classes, -0.5 percent between the 3½ and 4½ age classes, and 1.0 percent between the 4½ and 5½+ age classes. There is a possibility that the PCFT of the fawn and 1½ age classes can be higher or lower than the values shown here due to the variability of the MCT that was encountered in these age classes (Nichols, 1972). It is felt that this variation is the cause of the differences of the PCFT levels between the fawn and the 2½ age classes for each of 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 mandibles.

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 exhibited 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 ques-

tion. 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 mandibles collected during these two months. Thus, date of collection can have a significant affect on mean PCFT levels.

Additional analysis of the mandibles 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 the younger age classes first showing a decrease in PCFT (Table 7). 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 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 discussion, 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 2½ 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 2½ years or older are shown in Table 8. The mean PCFT of females 2½ 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 mandibles 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 mandibles of males 2½+ years from which the 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 2½+ years. This comparison again shows the difference of PCFT of males and females. The mean PCFT of females 2½+ 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.

TABLE 8
MEAN PERCENT OF TISSUE FAT OF THE MANDIBULAR CAVITY BY AREA AND SEX FOR WHITE-TAILED DEER 2½ YEARS OR OLDER FOR THE 1970-1971 COLLECTION

Area	Males N	PCFT	Females 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.

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