AN ABSTRACT OF THE THESIS OF

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in Biology presented on 1 May 1978

Title: FOOD AND TOOTH CALCIUM LEVELS OF WHITE-TAILED DEER

Abstract approved: [signature]

The primary objective of this study was to determine the relationship, if any, between calcium content in principal foods and calcium content in teeth of white-tailed deer from seven deer management units in Kansas. Varying degrees of hardness and tooth wear of yearling deer have been noted and speculation on possible correlation between tooth calcium content and dietary calcium content led to this study. Brown (1972) found no significant correlation between calcium content levels of water from major Kansas streams and calcium content of incisor teeth in deer. A review of literature failed to yield references pertaining to calcium levels of incisor teeth in deer, although studies relating dental annuli to age were found.

The research was divided into five phases and seven deer management units of Kansas were studied. Plant samples were collected in the eastern one-third of Kansas. Plant samples from spring, summer and fall seasons were collected, and food items were distinguished and analyzed. Teeth from yearling white-tailed deer taken during the 1973

hunting season were studied and plant samples were taken from counties from which tooth samples of deer were obtained.

No significant differences in content of calcium in plant samples between the seven management units were found. Three significant differences in levels of tooth calcium between management units were noted. Dietary calcium was considered adequate for normal development of the deer population. No correlation between tooth calcium levels and plant calcium levels was noted.

FOOD AND TOOTH CALCIUM LEVELS OF WHITE-TAILED DEER

A Thesis

Submitted to

the Division of Biological Sciences

Emporia State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

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May, 1978

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ACKNOWLEDGMENTS

The author is indebted to Dr. Dwight Spencer, who served as major advisor for this study. His continuous encouragement, constructive criticism, and advice were appreciated. Also, I am indebted to Dr. Robert Boles and Dr. Tom Eddy for serving as graduate committee members. Dr. John Ransom provided invaluable aid in statistical analyses.

William C. Peabody of the Kansas Fish and Game Commission provided all teeth used in this study and supplied considerable information regarding past, present, and future populations. During the field portion of this study several district game biologists assisted in sampling spring plants, and their assistance was greatly appreciated.

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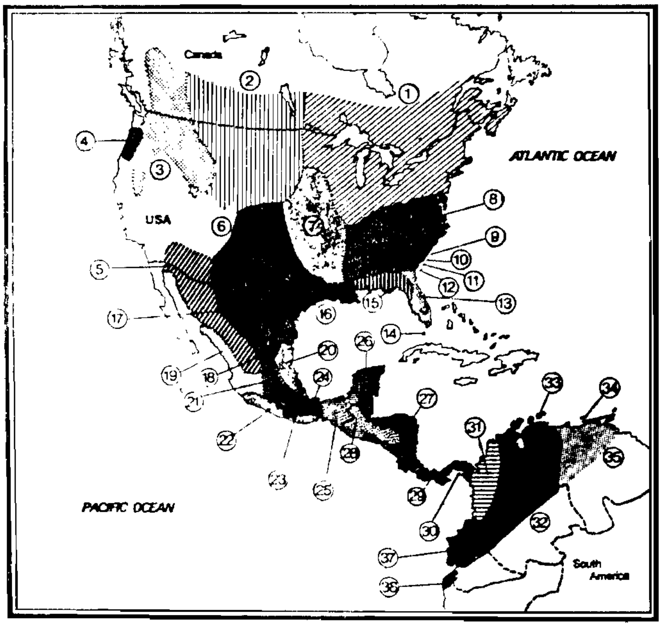
INTRODUCTION

The White-Tailed Deer, *Odocoileus virginianus* (Boddaert), is widely distributed in North America and is a resident in every state of the United States except Alaska, Hawaii, and possibly Utah. Northwards the range of the white-tailed deer extends into the southern part of all provinces of Canada adjacent to the United States, and Nova Scotia. It is absent from Labrador, North-West Territories, Yukon and Newfoundland. To the South, the range extends through Mexico and Central America into the northern half of South America. Throughout its entire range 38 subspecies are recognized (Figure 1), (Whitehead, 1972).

The white-tailed deer is the primary big game animal in Kansas as well as the United States, and can now be found in almost every county in Kansas (Peabody, personal communication).

Because of near extirpation of the species in Kansas by the late 1800's, the legal deer season was closed in Kansas from the early 1900's through 1964. The Fish and Game Commission as well as a few private individuals stocked deer in various parts of the state in the late 30's and early 40's. By the 1950's evidence of deer was frequently noted throughout the state and it was apparent that the species was making a comeback in Kansas (Pittman-Robertson, 1976). In 1965 the Kansas Fish and Game Commission reestablished a hunting season and followed the management unit approach with limited permits and flexible hunting regulations.

Table I shows the results of each yearly Kansas harvest of white-tailed deer from 1972 to 1976 for the seven management units in eastern



Map 5. The range of White-tailed deer *Odocoileus virginianus* in North and Central América -

1.	*Odocoileus virginianus borealis*	South-east Canada and north-east U S A
2.	*O.v.dacotensis*	Alberta to north Dakota
3.	*O.v.ochrourus*	North-west U S A and Canada
4.	*O.v.leucurus*	Oregon and west coast
5.	*O.v.couesi*	Arizona
6.	*O.v.texanus*	Texas and adjoining States
7.	*O.v.macrourus*	Kansas and adjoining States
8.	*O.v.virginianus*	Virginia and adjoining States
9.	*O.v.taurinsulae*	Bulls Island
10.	*O.v.venatorius*	Hunting Island
11.	*O.v.hiltonensis*	Hilton Head Island
12.	*O.v.nigribarbis*	Blackbeard Island
13.	*O.v.seminolus*	Florida
14.	*O.v.clavium*	Florida Keys
15.	*O.v.osceola*	North-west Florida
16.	*O.v.mcilhennyi*	Louisiana
17.	*O.v.carminis*	North Mexico
18.	*O.v.miquihuanensis*	Central Mexico
19.	*O.v.sinaloae*	Mid-west Mexico
20.	*O.v.veraecrucis*	East Mexico
21.	*O.v.mexicanus*	Central Mexico
22.	*O.v.acapulcensis*	South-east Mexico
23.	*O.v.oaxacensis*	South Mexico
24.	*O.v.toltecus*	South Mexico
25.	*O.v.thomasi*	South-east Mexico
26.	*O.v.yucatanensis*	Honduras
27.	*O.v.truei*	Nicaragua and adjacent States
28.	*O.v.nelsoni*	South Mexico and Guatemala
29.	*O.v.chiriquensis*	Panama
30.	*O.v.rothschildi*	Coiba Island
31.	*O.v.tropicalis*	West Colombia
32.	*O.v.goudotii*	Colombia and western Venezuela
33.	*O.v.curassavicus*	Curaçao Island
34.	*O.v.margaritae*	Margarita Island
35.	*O.v.gymnotis*	Venezuela and the Guianas
36.	*O.v.cariacou*	French Guiana and northern Brazil
37.	*O.v.ustus*	Ecuador (Andes)
38.	*O.v.peruvianus*	Peru and marginally

Figure 1. Distribution of white-tailed deer (Whitehead, 1972).

TABLE I. Total number of deer harvested per year from 1972 through 1976 for each of the seven management units included in this study (Pittman-Robertson, 1976).

UNIT	1972	1973	1974	1975	1976
Osage Prairie	326	423	485	619	676
Republican	150	287	226	315	286
Lower Arkansas	51	64	51	37	53
Tuttle Creek	220	158	384	283	246
Flint Hills	173	220	382	424	341
Chautauqua Hills	172	212	315	295	284
Missouri River	22	28	28	23	26
Year Total	1114	1392	1871	1996	1912
Percent of Annual Statewide Harvest	37.35%	33.85%	34.16%	36.37%	37.31%

Kansas included in this study. Annual deer harvest in the Osage Prairie and Flint Hills units increased over 100 % between 1972 and 1976 and the Republican Unit harvest increased over 90 % during the same period; the Chautauqua Hills unit increased 64 % and Tuttle Creek increased 12 %. For most units, increase in deer harvest has been directly proportional to unit size. The Lower Arkansas and Missouri River units have remained relatively stable in number of deer harvested even though they are at opposite ends of the state. Both are small units and have little room for large herd growth.

The pre-hunting-season deer population for the entire state was estimated to be 30,000 in 1972 and by 1976 the pre-hunting-season population was estimated to be 40,000, an increase of 10,000 animals during the four-year period. In 1976 the seven eastern Kansas units yielded approximately 37 % of the state-wide harvest. This represents an 80 % increase over the 1972 harvest in the seven units.

Management goals of the Fish and Game Commission are designed to increase and maintain the total deer population at 45,000 to 50,000 animals (Pittman-Robertson, 1976). Figure 2 shows estimated pre-hunting-season populations from 1972 to 1976.

Age structure of the population has been monitored at regular intervals by the Kansas Fish and Game Commission. The primary method used for aging the herd has been the cementum annulus count (after Matson, 1977).

A significant portion of the annual harvest each year has been composed of yearlings. In the 1975-76 season, 68 % of the animals taken were yearlings and their mean age was 17 months.

Varying degrees of hardness and wear of teeth in yearling deer

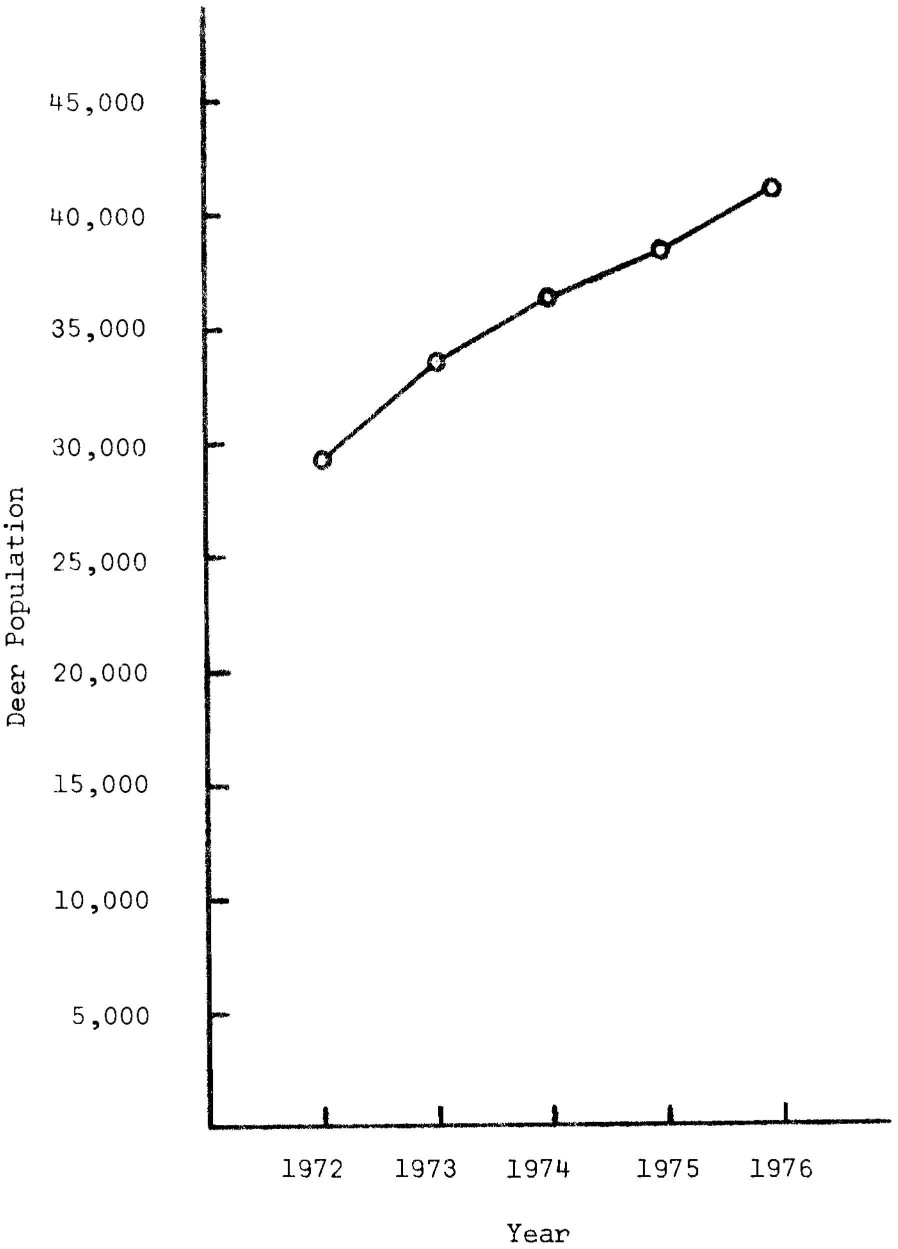


Figure 2. Estimated pre-hunting-season populations of white-tailed deer in Kansas from 1972 to 1976 (Pittman-Robertson, 1976).

have been noted, and speculation as to a positive correlation between tooth calcium (Ca) and dietary Ca content (Brown, and Peabody, personal communication) led to this study. Brown, (unpublished research paper, 1972), did not find a positive correlation between Ca levels in water from major Kansas waterways and Ca levels in deer teeth from various management units. He also considered the possibility that high or low Ca content in vegetation might reflect corresponding levels of Ca in teeth of resident deer populations.

Objectives of the present study were to: (1) determine the Ca content of principal deer foods in each of the seven management units; (2) determine the Ca content of permanent incisor teeth from yearling deer in each of the seven management units; (3) compare tooth Ca content data of deer within these units; (4) compare plant Ca content data of the management units; (5) correlate Ca levels between teeth and plants in each unit; and (6) determine the biological significance of the findings.

At the onset of this study it was postulated that a direct relationship existed between Ca content in principal foods and Ca content in teeth. The research was divided into the following phases:

1. Samples of indicator plant species were collected from each of the seven eastern Kansas deer management units during the summer and fall of 1973 and the spring of 1974.
2. Incisor teeth of white-tailed deer were obtained and prepared for Ca analysis.
3. Ca contents in plant material and in incisor teeth were analyzed.
4. Statistical analyses of Ca levels of plants and teeth from

each management unit were made.

5. Comparisons of tooth and plant Ca levels were made of samples from each management unit.

Literature Review

Various studies have been conducted on nutritional content of diet and effects of diet on Odocoileus virginianus. Ullrey et al. (1975) reported on effects of feeding diets supplemented with a minimum of 0.2 % and maximum of 1.25 % Ca by weight to pen-raised deer. They concluded that a Ca level of 0.22 % was inadequate for normal development, but that 0.40 % dietary Ca favored weight gain, rib strength and antler development, and was a desirable dietary level during the post-weaning year.

Schultz (1966) reported Ca levels ranging from 34.6 % to 36.3 % by weight in mandibles of cattle and found no significant differences among age and sex classes in calves, yearlings, and two-and three-year-old mature animals.

French et al. (1956) reported deer on a low Ca diet did not completely shed their winter hair until July as contrasted with the normal molting time of June. Slow body growth was also attributed to low Ca.

Torgerson and Pflander (1971), after analyzing the foods of Missouri white-tailed deer reported an average content of 1.95 % Ca by weight.

Swift (1948) reported that white-tailed deer preferred green winter wheat from one section of a field over green winter wheat from another section of the same field. The preferred wheat had 0.43 % Ca by weight, while wheat that was not preferred contained 0.29 % Ca.

The preferred wheat also contained greater amounts of phosphorous and ether extract than the wheat that was not preferred. The overall diet of the deer using the preferred wheat contained 12 % more ether extract, 38 % more Ca and 34 % more phosphorous than deer diets that included the other wheat.

Short et al. (1966) reported that Ca, to a large degree, was located in plant leaves and in greater quantity in older than in young leaves.

Gastler et al. (1951) sampled 11 browse plants from the Black Hills of South Dakota and reported variation of Ca composition from 0.07 % to 0.89 % of total sample weight.

Ullrey et al. (1975) noted that when the diet contained 0.46 to 0.51 % Ca by weight, weaned white-tailed deer fawns did not require more than 0.26 % phosphorous for optimum development.

Dietz et al. (1962) and Dietz (1965) stated that phosphorous metabolism in deer is inhibited when Ca to phosphorous ratios are higher than five to one.

Ullrey et al. (1973) determined that antler weight was not significantly affected by diet, but antler specific gravity was lower on a 0.18 % Ca diet than on a 0.29 % or 0.40 % by weight Ca diet. Increased dietary Ca resulted in increased Ca in the bloodstream and increased antler specific gravity. Poor antler growth was reported as a result of a sustained low Ca diet (French et al. 1956).

Smith et al. (1956) and French et al. (1956) found identical requirements for Ca and phosphorous for white-tailed deer. They also reported that a decrease in the capacity for bearing normal young resulted from an inadequate intake of energy, protein, phosphorous, cobalt, vitamin A and Ca.

Magruder et al. (1957) noted that a 16.9 % protein diet containing 0.59 % Ca and 0.54 % phosphorous by weight resulted in best antler development when compared with other higher and lower levels of Ca and phosphorous.

Morrison (1945) found the ideal Ca to phosphorous ratio in livestock food was from 1:1 to 2:1.

The literature search failed to yield references pertaining to Ca levels of incisor teeth, although studies relating dental annuli to age were found. A partial listing of dental annuli to age references follows: Gilbert (1966), Ransom (1966), Gilbert and Stolt (1970), Lockard (1972), and Low and Cowan (1973).

Description of Study Area

The Fish and Game Commission has divided Kansas into 18 deer management units, seven of which are the Lower Arkansas, Tuttle Creek, Missouri River, Osage Prairie, Chautauqua Hills, Flint Hills and Republican. Considerable variation in vegetative cover exists among the seven units and Kuchler (1974) identified two primary vegetation types in Kansas: prairie and forest. The seven management units selected for this study (Figure 3) exhibit various combinations of these two vegetation types and all of the following management unit descriptions are after Kuchler (1974).

Three units, the Lower Arkansas, Flint Hills, and Tuttle Creek are bluestem prairie. These management units consist of dense stands of tall and medium graminoids. Forbs vary in height from tall to very tall and are numerous. They may strongly affect the physiognomy of the prairie and vary greatly from season to season. Dominant species

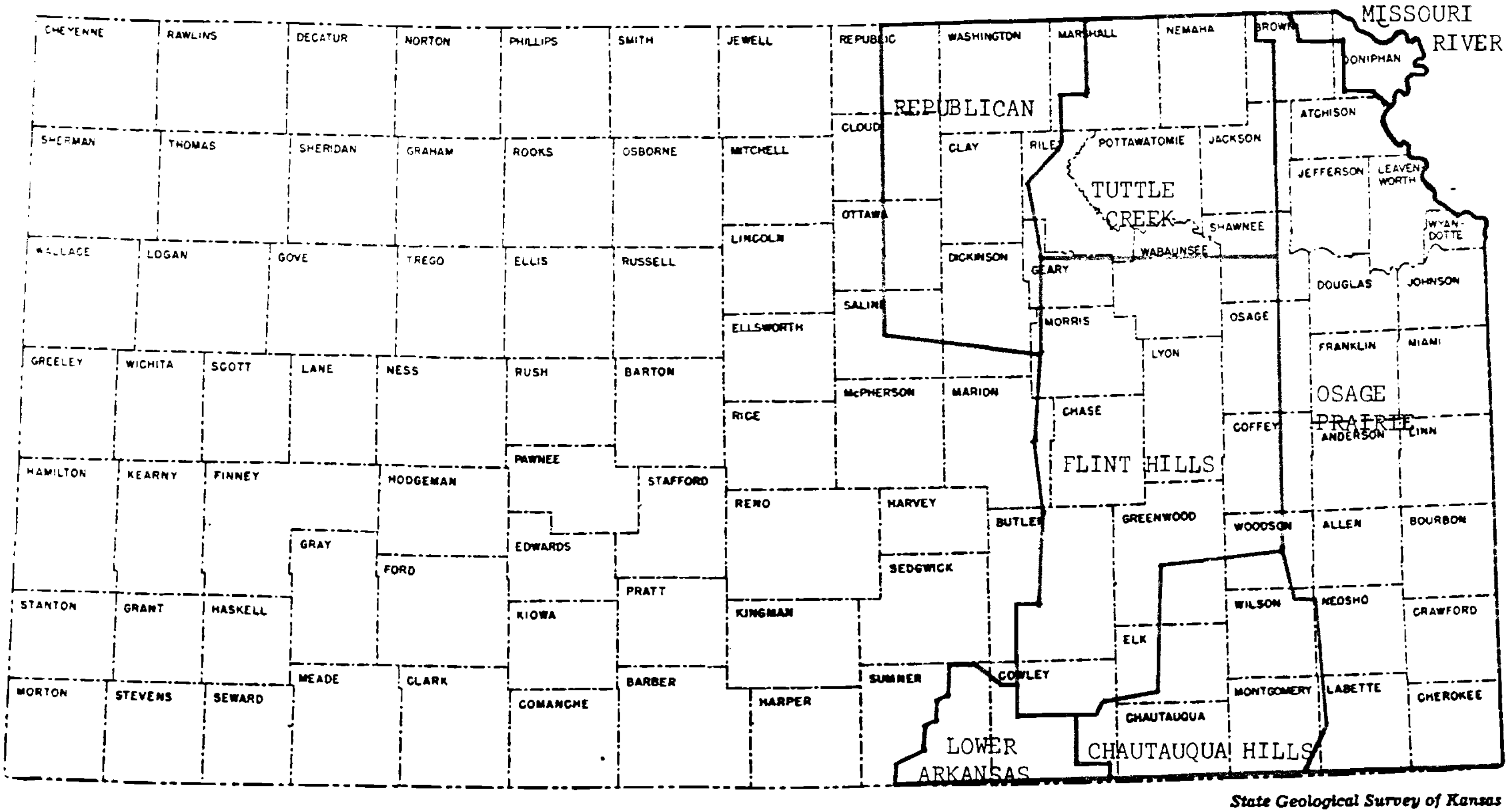


Figure 3. Seven Kansas Fish and Game deer management units.

of the three units are big bluestem (Andropogon gerardi), little bluestem (A. scoparius), switchgrass (Panicum virgatum) and indian grass (Sorghastrum nutans). This vegetation occurs primarily on upland throughout eastern Kansas, and may extend far westward on the floodplains of rivers and streams.

The Republican is the westernmost management unit included in the study and consists of three vegetation types: bluestem prairie, bluestem-gramma prairie, and a transition area between the two. The bluestem-gramma prairie has two dense communities of graminoids and forbs, often with two distinct layers, one of short grasses and one of medium tall grasses and forbs. Taller grasses are more sparse than short grasses. Dominant species in this management unit are big bluestem, little bluestem, sideoats gramma (Bouteloua curtipendula), and blue gramma (B. gracilis). The transition area between the bluestem-gramma prairie and bluestem prairie occurs on a substrate Dakota sandstone. Though the growth forms and taxa of both prairie types are well represented here, the dominant species are much the same as in the bluestem prairie. This transition area usually occurs on uplands, but extends westward on breaks in the dissected parts of the High Plains.

Vegetation of the Chautauqua Hills unit consists primarily of flora identified as cross timbers. It has medium tall, rather dense stands of graminoids with low broadleaf deciduous trees growing singly or in groves. Trees within the groves are often rather sparse permitting a grass cover on the forest floor. This cross timbers vegetation is mixed with bluestem prairie. Dominant species occur mainly on sandstone and sandstone-derived upland soils and are big bluestem, little bluestem, blackjack oak, (Quercus marilandica), and post oak (Q. stellata). Blackjack oak occurs in shallower soil than post oak.

The Missouri River unit is the smallest of those studied. It possesses an oak-hickory forest component, a bluestem prairie area, and a mosaic of both. The oak-hickory forest is a medium tall multi-layered broadleaf deciduous forest on uplands and steep valley sides of eastern Kansas. White oak (Quercus alba), shagbark hickory (Carya ovata) and blackjack oak are the dominant species. The bluestem prairie adjoins the oak-hickory forest in this management unit resulting in a mosaic and the boundaries of the bluestem prairie and oak-hickory forest are not sharply defined. In a mosaic, the species of one type are not mixed with those of the other and a sharp irregular line of distinction exists between the two vegetation types. In the Missouri River unit forest with islands of prairie gradually change westward into a forest-prairie mosaic and finally to bluestem prairie with forest islands.

The Osage Prairie management unit was subdivided into two separate study areas due to its large size and varied habitat. The management unit subdivisions were designated A (north), and B (south). The line dividing the two subunits was the northern boundaries of Linn, Anderson and Coffey counties.

The Osage Prairie unit consists of bluestem prairie, a mosaic of the bluestem prairie and of the oak-hickory forest, a few small areas of cross timbers, and a small portion of the ozark forest. The ozark forest is a small area in extreme southeast Kansas. It is a medium tall broadleaf deciduous forest with islands of bluestem prairie. The dominant species are bitternut hickory (Carya cordiformis), shagbark hickory, white oak and Shumard's oak (Quercus shumardii).

Farming has considerably altered most of the areas previously mentioned. While some grassland areas have remained relatively unchanged due to their unsuitability for farming, most other areas have succumbed to modern farming practices. In most instances the variety of crops produced, when combined with adequate cover, have provided increased food and carrying capacity for deer.

METHODS AND MATERIALS

Plant Material

Watt et al. (1967) examined stomach contents of 88 white-tailed deer and found that 21 principal food items constituted the majority of food eaten during the course of a year. These 21 items made up a yearly total of 93.6 % of the yearly diet, and each of the 21 items made up one percent or more of the diet.

Of the 21 items listed by Watt et al. (1967), 14 comprised a total of 86.6 % of the yearly diet. Table II shows food items selected for sampling for this study and percent of yearly usage as determined by Watt et al. (1967). The 14 sampled food items were analyzed for Ca content and compared with Ca levels of incisor teeth of white-tailed deer from the same management unit.

While the study by Watt et al. (1967) was principally confined to the Missouri River, Tuttle Creek and northern areas of the Flint Hills and Osage Prairie management units, an assumption was made that dietary preferences and usage of food items would be applicable for all Kansas deer where specific food items were available.

Plant samples were collected from the seven deer management units studied (Figure 3). These units included all or parts of 47 counties in eastern Kansas and encompassed approximately the eastern one-third of the state. Five samples were collected in each of the seven management units during spring, summer, and fall seasons of 1973-74. The Osage Prairie unit was treated as two units as previously stated. Counties in which plant collections were made were noted. Plant Ca levels

TABLE II. Food items sampled and percent of total yearly diet, after Watt et al. (1967).

Food Items Sampled	Percentage of Yearly Diet
Corn (*Zea mays*) grain cob	28.6
Tree and shrub browse	11.6
Sorghum (*Sorghum ssp.*) grain	8.4
Coralberry (*Symphoricarpos orbiculatus*) leaves fruit stem	7.8
Unclassified forbs	7.4
Winter wheat (*Triticum aestivum*)	6.8
Oaks (*Quercus ssp.*) leaves	6.4
Alfalfa (*Medicago sativa*)	2.8
Wild lettuce (*Lactuca canadensis*) leaves	2.8
Soybeans (*Glycine max*) pods, beans, and stems	1.9
Smooth sumac (*Rhus glabra*), Aromatic sumac (*Rhus aromatica*), leaves fruit stems	1.1
Grasses	.9
American elm (*Ulmus americana*) leaves	.7
Total Percent of Yearly Diet	86.6

from each unit were then compared with tooth Ca levels from the same geographical area.

Summer and fall plant samples were collected by the author and placed in 45mm x 55mm glass snap-cap vials. Spring samples were collected by district game division biologists and sent by mail to the author. All plant samples were dried at 50 Ca for 24 hours before analysis.

All food items were not available in every unit. This was considered when statistical analyses were completed.

The procedure for analysis of plant Ca content follows:

1. A dried sample of 50 to 100 mg was weighed on a Voland Analytical Balance and placed in a test tube.
2. A 10 ml 1:1 mixture of nitric acid and perchloric acid was added to the sample in the test tube.
3. This mixture (#1) was heated in a boiling water bath until plant material dissolved, then it was cooled to room temperature.
4. A 0.2 ml portion of mixture #1 was combined with 10 ml of 0.1 % lanthonum oxide in 0.5 % hydrochloric acid.
5. This solution was analyzed with a Perkin-Elmer atomic absorption spectrophotometer, Model 303, and Ca level was determined and recorded.
6. Blanks of deionized water and a calcium certified atomic absorption standard were also analyzed as controls.
7. A student t-test for an unequal number of observations at $p=0.05$ level of significance was conducted on mean percentages of Ca content of sampled food items.

Food Items

Corn (Zea mays) grain and cob were sampled and analyzed to determine if large variations in Ca content were evident, while grain was the only part of the sorghum plant (Sorghum, ssp.) sampled.

Multiple parts of coralberry (Symphoricarpos orbiculatus), soybeans (Glycine max), smooth sumac (Rhus glabra), and aromatic sumac (Rhus aromatica) were sampled and analyzed. Pods, beans, and stems of soybeans from all units were sampled and analyzed while coralberry and smooth and aromatic sumac stems, fruit, and leaves were sampled and analyzed.

Green leaves were collected and analyzed from grasses, oaks (Quercus, ssp.), winter wheat (Triticum aestiuum), wild lettuce (Lactuca canadensis), and American elm (Ulmus americana). Alfalfa (Medicago sativa) stems and leaves were both sampled and analyzed.

Tree and shrub browse collected and analyzed consisted of stems from trees or shrubs in the area sampled and were not further identified, although there were no duplications of other individual sample categories. Watt et al. (1967) stated that individual species in this category were not of major importance, although collectively they accounted for a large portion of the yearly diet.

The food class unclassified forbs was used for herbaceous plants other than grasses. These plants were mostly perennials, with roots often going deeper than those of grasses (Stephens, 1961). Individual forb species may not be important, but as a group they rank high in usage (Watt et al. 1967). Giant ragweed (Ambrosia trifida) was sampled exclusively for this category.

Teeth

Incisor teeth from yearling white-tailed deer taken during the 1973 hunting season were provided by William C. Peabody, big game project leader for the Kansas Fish and Game Commission. Teeth were sorted according to the county in which the deer were taken. Plant samples were collected in counties from which tooth samples were obtained.

The procedure for analysis of calcium content of teeth follows:

1. All flesh was removed from each tooth by the use of a wire buffing wheel.
2. A piece of the tooth root was clipped off using wire cutters.
3. A 30 to 50 mg sample of the root was weighed using a Voland Analytical Balance and placed in a test tube.
4. A 10 ml portion of mixture #1, which was a 1:1 mixture of nitric acid and perchloric acid, was added to the test tube containing the tooth sample, forming mixture #2.
5. Mixture #2 was heated in a boiling water bath until the contents were dissolved and it was then cooled to room temperature.
6. A 0.2 ml portion of mixture #2 was then mixed with 10 ml of a 0.1 % lanthonum oxide in 0.5 % hydrochloric acid forming mixture #3.
7. One part of mixture #3 was diluted with 10 parts of lanthonum oxide forming mixture #4.
8. Mixture #4 was analyzed for calcium content with a Perkin-Elmer atomic absorption spectrophotometer, Model 303.
9. Blanks of deionized water and a Ca certified atomic absorption standard were also analyzed as controls.

10. A student t-test for an unequal number of observations at $p=0.05$ level of significance was conducted on mean percentages of Ca content of teeth for each management unit.

RESULTS AND DISCUSSION

Calcium Content of Plants

Table III shows Ca content of food items from seven management units studied.

Corn, where available, made up the largest single part of the diet (28.6 %) (Watt et al. 1967), yet consistently ranked near the lowest in Ca level of any of the food items analyzed. Neither cob or grain contained over 0.236 % Ca. Tree and shrub browse constituted 11.6 % of the yearly diet (Watt et al. 1967). Tree and shrub browse contained one of the largest percentages of Ca of the sampled food items with samples from the Chautauqua Hills unit containing the highest amount, 2.383 %, and the Osage Prairie-B unit samples had the lowest amount, 1.644 %. Samples of tree and shrub browse from all other management units ranged from 2.126 % to 2.246 %. Sorghum ranked third in percentage of yearly diet, but was the lowest in Ca content of any of the items sampled. Maximum Ca content in sorghum grain was 0.263 % but most samples were under 0.10 %. Coralberry ranked forth in percent of yearly diet and contained amounts of Ca ranging from 0.890 % to 1.304 % in leaves, 0.144 % in fruit and 0.254 % to 0.243 % in stems. Fruits, stems and leaves were analyzed because of the possibility that the deer may have ingested all three parts in the process of acquiring one part that was higher in Ca content than the other two. Watt et al. (1967) found coralberry most important in winter as browse, consequently Ca in coralberry leaves most probably goes unused. The Ca content of unclassified forbs was among the highest of the sampled food items,

TABLE III. Calcium content of principal food items eaten by white-tailed deer in seven management units studied. All values are expressed as percent of dry weight. Zeros indicate either no sample available (*) or no significant amount of calcium (**).
The units are Osage Prairie-A (OP-A), Osage Prairie-B (OP-B), Republican (R), Lower Arkansas (LA), Tuttle Creek (TC), Flint Hills (FH), Chautauqua Hills (CH), and Missouri River (MR).

Food Items and Parts	OP-A	OP-B	R	LA	TC	FH	CH	MR
Corn								
grain	.005	.080	.031	0.0*	.069	0.0**	.206	.003
cob	.069	.032	.110	0.0*	.129	.256	.286	.152
Tree and Shrub Browse	2.199	1.644	2.246	2.216	2.154	2.145	2.283	2.206
Sorghum								
grain	.030	.080	.150	.263	.078	.080	.041	.004
Coralberry								
leaves	1.222	1.181	.890	1.253	1.304	1.144	1.03	1.100
fruit	.144	.188	.207	.195	.221	.177	.162	.243
stem	.320	.895	.498	.493	.369	.254	.722	.509
Unclassified Forbs	2.371	1.536	2.560	1.679	1.849	1.856	3.069	2.544
Winter Wheat								
leaves	.304	.743	.555	.978	.391	.605	.398	.435
Oaks								
leaves	.743	.657	1.13	.538	1.045	.502	.486	.534

Table III. (cont.)

Food Items and Parts	OP-A	OP-B	R	LA	TC	FH	CH	MR
Alfalfa	1.637	1.569	1.060	1.404	1.592	1.436	1.716	1.712
Wild Lettuce								
leaves	.644	.914	.660	.978	.933	.800	1.028	.734
Soybeans								
pods	.420	.405	0.0*	.593	0.0*	.595	.691	.296
beans	.111	.097	0.0*	.133	.343	.133	.136	.196
stem	.420	.432	.883	.806	1.270	.740	.345	.308
Smooth Sumac								
leaves	.498	.376	.401	.700	.654	.340	.323	.394
fruit	.163	.198	.153	.228	.216	.166	.246	.263
stem	.678	.791	.485	.885	1.081	.810	.844	.569
Aromatic Sumac								
leaves	0.0*	.700	.383	.648	0.0*	.386	.568	0.0*
fruit	0.0*	.050	.223	.950	0.0*	0.0**	.143	0.0*
stem	0.0*	.626	.566	.793	0.0*	0.0**	.488	0.0*
Grasses	.461	.494	.368	.399	.608	.385	.484	.461
American Elm								
leaves	1.042	.706	1.175	1.078	1.244	.891	3.727	1.240
Total of Ca Percentages for each unit.	13.481	14.553	14.765	16.918	15.541	13.701	19.322	15.903

ranging from a low of 1.536 % Ca to a high of 3.069 %. Ca content of wheat ranged from 0.304 % to 0.978 %.

Oak leaves were sampled in all areas of each management unit where they were available. Ca content was moderate with a range of 0.468 % to 1.130 %.

Alfalfa and wild lettuce each constituted 2.8 % of the yearly diet of the white-tailed deer as determined by Watt et al. (1967), but alfalfa Ca level was approximately twice the amount contained in wild lettuce. Wild lettuce Ca ranged from 0.644 % to 1.208 %, while alfalfa ranged from 1.060 to 1.716 %. The Ca level in alfalfa was relatively consistent throughout all management units studied.

Fruits, stems, and pods of soybeans were analyzed, and of the three parts, fruits contained the least Ca. Ca content of soybean fruits varied from 0.097 % to 0.43 %; pods ranged from 0.296 % to 0.691 %; stems contained the highest level, with a range of 0.245 % to 1.270 % and stem utilization was probably greatest during winter months (Watt et al. 1967). Except for one sample that contained 1.081 % Ca, sumac stem values were less than 1.000 %.

Grasses and American elm leaves comprised 0.900 % and 0.700 % respectively of the yearly diet (Watt et al. 1967). In this study grasses ranged from 0.368 % to 0.608 % Ca and American elm leaves ranged from 0.706 % to 3.727 % Ca and all but two samples exceeded one percent.

Farm crops comprised 47.5 % of deer food items (Watt et al. 1967). Crops of major importance were corn, sorghum, and winter wheat. All three contained low amounts of Ca when compared with Ca content of other food items sampled (Table III).

A student t-test for an unequal number of observations at $p=0.05$ level of significance was conducted on mean percentages of Ca content of sampled food items. The results of the test showed no significant difference in plant Ca levels between any of the management units.

Calcium Content of Teeth

Figure 4 shows mean Ca percentages for teeth analyzed from each management unit. They were: Osage Prairie-A 42.545 %; Osage Prairie-B, 37.616 %, Chautauqua Hills, 45.661 %, Missouri River, 34.059 %, Republican, 42.711 %, Lower Arkansas, 49.736 %, Tuttle Creek, 46.675 % and Flint Hills, 45.989 %. Figure 5 shows average tooth Ca values from counties sampled.

A student t-test for an unequal number of observations at $p=0.05$ level of significance was conducted on mean percentages of Ca content of teeth for each management unit to determine if a significant difference in tooth Ca content existed between units.

These significant differences in tooth Ca levels were limited to the Missouri River, Osage Prairie, and Chautauqua Hills management units.

The sum of all Ca percentages was calculated for all food items in each management unit (Table III). Figure 4 shows average Ca contents of teeth by management units and compares the sums of plant Ca contents among management units. Tooth Ca values were constant except for the afore mentioned exceptions and no relationship was noted between plant Ca values and tooth Ca values.

A Spearman correlation coefficient test was performed on mean Ca percentages of teeth for each management unit and sums of plant Ca contents for each management unit. No significant difference was found

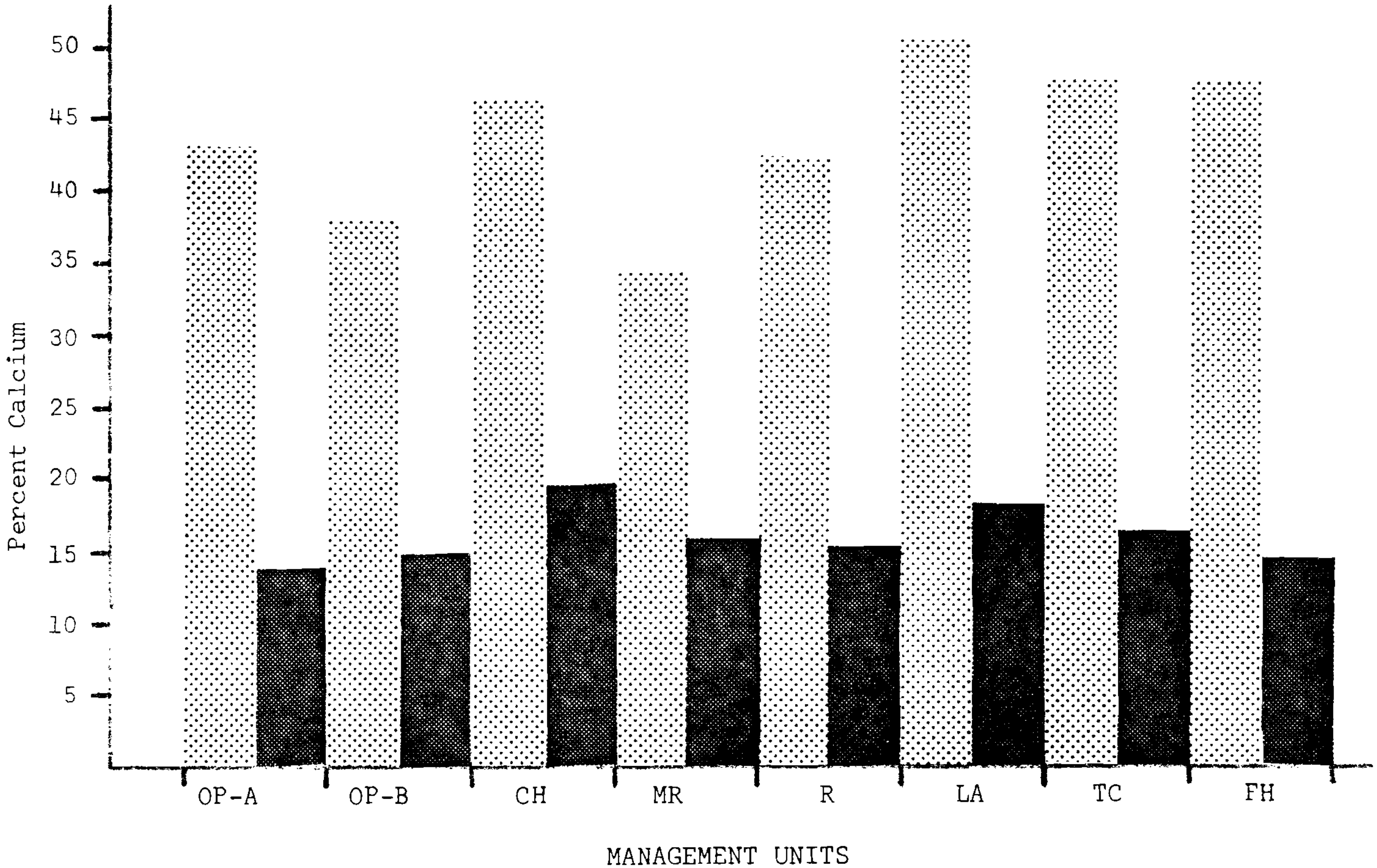


Figure 4. Average calcium content of teeth (light bar) and available plant calcium in management units (dark bar). The units are Osage Prairie-A (OP-A), Osage Prairie-B (OP-B), Chautauqua Hills (CH), Missouri River (MR), Republican (R), Lower Arkansas (LA), Tuttle Creek (TC), and Flint Hills (FH).

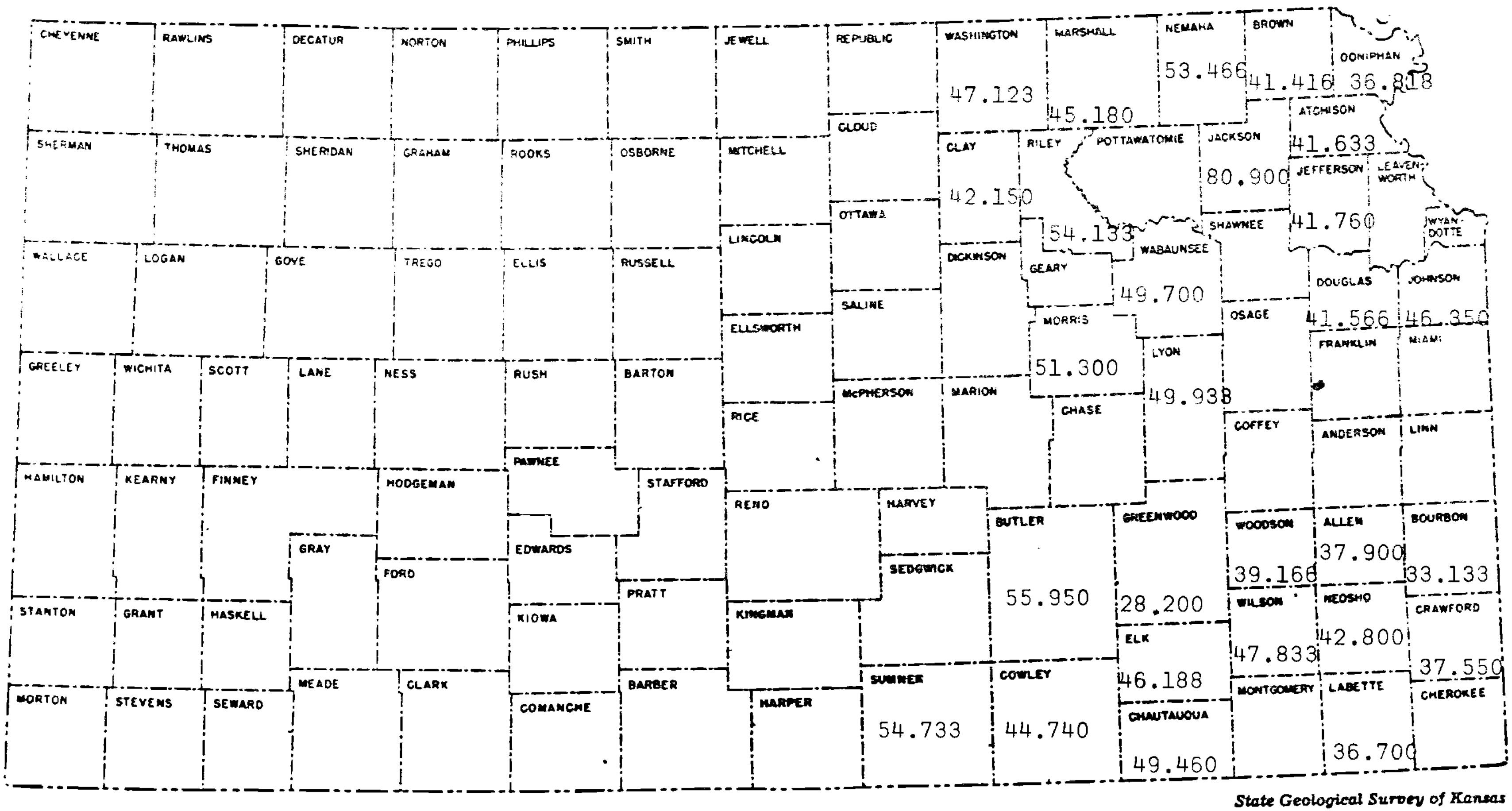


Figure 5. Percent calcium of white-tailed deer incisor teeth. Values shown represent a mean of sampled teeth for each county.

as a result of the Spearman test.

The management unit that ranked number one in tooth Ca was the Lower Arkansas with 49.736 % Ca; it also had a plant Ca level that ranked number two with 16.918 %. Number two in tooth Ca level, the Tuttle Creek unit, with 46.675 % Ca had a plant Ca level that was number four at 15.541 %. The Flint Hills unit at 45.989 % tooth Ca ranked third while the plant Ca level for the unit ranked seventh at 13.701 %. Chautauqua Hills ranked fourth in tooth Ca with 45.661 % and number one in plant Ca at 19.332. The Republican unit ranked fifth in tooth Ca with 42.711 % and ranked fifth in plant Ca at 14.765 %. The Osage Prairie-A unit ranked sixth in tooth Ca with 42.545 % and eighth in plant Ca with 13.481 %. The Osage Prairie-B and Missouri River units ranked seventh and eighth in tooth Ca, with 37.616 % and 34.059 % respectively, and sixth and third in plant Ca, with 14.553 % and 15.903 % respectively.

It has been established that dietary Ca has many and varied effects upon the growth and development of white-tailed deer, some of which are antler growth and development, weight gain, rib strength, and antler specific gravity. A decrease in the capacity for bearing normal young due in part to a lack of Ca has been reported, as has abnormal molting of winter hair.

Brown (1972) indicated major Kansas waterways in the seven management units involved in this study had a Ca content that ranged from .006 % to .008 %. While this amount can be considered in the complete intake of Ca in the diet it is so small that its effect must be considered negligible. More importantly, variance of Ca content between these major waterways is only .002 % and should not significantly affect individual highs and lows of plant and tooth Ca levels in different management units. Southeastern Kansas has soil and underlying strata that contain high amounts of Ca carbonate (Peabody, personal communication) and Ca carbonate contains approximately 40 % calcium. Deer eat plants that have dust on them, and thus high amounts of Ca carbonate. This causes accelerated tooth wear in deer from southeastern Kansas (Peabody, personal communication) yet no unusually high level of Ca in plants or Ca in teeth from management units in this area of the state was noted. This could indicate that plants have a maximum level of Ca which they are able to isolate in their systems and deer have a maximum amount of Ca which they are able to metabolize and isolate in their systems. While adequate Ca intake is important, Dietz (1965) and Dietz et al. (1967) indicate excessive Ca in the diet could inhibit phosphorous metabolism.

Some food items contained no detectable amounts of Ca but most fell in a range of 0.003 % to 3.727 % Ca. This compared favorably with 0.06 % to 0.86 % Ca reported by Gastler et al. (1951) in browse plants from the black hills of South Dakota.

While no attempt was made to estimate average yearly intake of Ca, it would appear that adequate Ca is available for normal development of deer in Kansas. Ullery et al. (1973) reported 0.29 % Ca was adequate but 0.18 % was inadequate for antler development, and 0.22 % was inadequate for normal body development, but that 0.40 % was adequate. A desirable minimum level of Ca in the diet is probably somewhere between these two values.

While Ca content of individual plant species may not be of significance, they combine to provide a major portion of the dietary intake and the major portion of the Ca necessary for normal development of incisor teeth in deer and normal body and antler development. The Ca levels found in incisor teeth during the course of this study may be constant in all deer where adequate dietary Ca is available for absorption into the bloodstream. Kansas deer have been a healthy and growing resource and adequate nutritional level of the diet has no doubt been an important part of this growth.

SUMMARY

1. A study of food and tooth Ca levels of yearling white-tailed deer was conducted in seven eastern Kansas deer management units from July 1973 to May 1974. Because of the possibility of deer reflecting high or low Ca levels from their immediate environment through food eaten, and the absence of information in the literature, this study was undertaken.

2. Plant materials representing 14 food items that comprise 86.6 % of the annual diet were selected for sampling. These materials were sampled one time during each of the spring, summer and fall seasons from five locations within six management units and 10 locations in one management unit due to its size.

3. A total of 216 teeth representing samples from the six management units was obtained from the Kansas Fish and Game Commission. The teeth were sorted and cleaned for calcium analysis.

4. A portion of each plant sample and the tip of each tooth were selected for Ca analysis. Each individual plant sample and tooth root were analyzed for Ca content by atomic absorption.

5. It was found that most plant Ca levels range from .003 % to 3.727 % Ca and teeth Ca ranged from 28.200 % to 54.733 % Ca.

6. Statistical analyses yielded no significant difference between and among plant Ca values from all management units, and three significant differences for tooth Ca values from all management units at $p=0.05$ level of significance.

7. It was postulated that all tooth Ca levels would fall into

a given range of values if the dietary Ca level remains adequate.

8. It was concluded that available plant Ca is adequate for a normal diet and adequate bloodstream Ca is available for normal body growth and development.

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