# MORPHOLOGICAL, PHYSIOLOGICAL AND NUTRITIONAL STATUS OF THE FORT RILEY, KANSAS, DEER HERD

by

SCOTT ROBERT KLINGER

B.S., The Pennsylvania State University, 1977

A MASTER'S THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

Division of Biology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1983

APPROVED: R. J. Robel

Robert J. Robel
Major Professor

THIS BOOK
CONTAINS
NUMEROUS PAGES
WITH THE ORIGINAL
PRINTING BEING
SKEWED
DIFFERENTLY FROM
THE TOP OF THE
PAGE TO THE
BOTTOM.

THIS IS AS RECEIVED
FROM THE
CUSTOMER.

# TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

LIST OF APPENDIX TABLES

Table | Page

## ACKNOWLEDGMENTS

Financial support for this study was provided by the Division of Biology, the Department of Animal Science and Industry, and the Kansas Agricultural Experiment Station, Kansas State University; the Department of the Army, Fort Riley, Kansas; and the Kansas Fish and Game Commission.

I am particularly indebted to B. A. Brown for the guidance, knowledge, assistance, and support he provided throughout the various phases of this project. Special thanks are also due to B. E. Brent for making the facilities in the Department of Animal Science available for this cooperative project and for providing valuable recommendations on various aspects of the study.

Thanks are due to committee members L. Hulbert and C. Owensby for their seemingly endless patience as I struggled to complete this work while performing the duties of Wildlife Administrator at Fort Riley.

I am especially thankful to my committee chairman, R. J. Robel, who encouraged me to complete this work and carefully reviewed this manuscript.

Special thanks are due L. Lorence for his dedication and assistance throughout the seasonal collection phase of this project and M. Reid, Fort Riley, for procuring the necessary equipment and funding for project initiation and completion. S. Cirone provided equipment and facilities for blood collection and necropsy work. R. Adams, assisted in analyzing blood and L. Nuzback assisted and coordinated the running of the volatile fatty acids and crude proteins.

Gratitude and sincere appreciation is reserved for the many undergraduate assistants at Kansas State University who aided in the collection of data.

I would also like to thank R. L. Kirkpatrick, Virginia Polytechnic Institute and State University, and R. L. Warren, Texas Tech University, for their valuable insights into various aspects of this study.

Sincere appreciation is due B. Wagner and L. Jensen for the editing and typing of this manuscript.

Special appreciation and love are reserved for my parents, June and James R. Klinger and my grandmother, Bernice Heimbach. I will be forever thankful for the love, encouragement, and confidence they provided me throughout my undergraduate and graduate education.

Perhaps most importantly, special thanks are reserved for the person closest to me, Sheliah. Her encouragement and understanding have made all these months of hard work worthwhile.

This thesis is dedicated to the memory of the late Charles F. Heimbach, my grandfather. His love for the land and life has been an inspiration to me.

# INTRODUCTION

The importance of habitat quality to maintain healthy white-tailed deer (Odocoileus virginianus) populations is well documented. Reliable estimates of carrying capacity must consider the interrelationships between nutrient and energy requirements of deer and the ability of the range to supply those needs.

Considerable research has been expended by deer biologists to evaluate range carrying capacity through food habit studies, estimations of quantity and quality of preferred forages and establishing the energy and protein requirements of deer. Such evaluations are time consuming, labor intensive and often cost prohibitive for fish and game agencies.

An alternative to direct habitat evaluation is to monitor the deer themselves. Morphological and physiological measurements reflect the condition of free-ranging deer and, by inference, the quality of habitat. Some variables which have been related to the condition of deer include: body weight and various external measurements, antler development, skeletal ratios, reproductive activity, blood chemistries, parasite loads, rumen content and fluid analyses, and fat reserves.

The purpose of this study was to collect baseline information on the morphological, physiological and nutritional status of a free-ranging white-tailed deer herd on the Fort Riley Military Reservation, Kansas.

## STUDY AREA

Animals were collected from the Fort Riley Military Reservation, approximately 20 km west of Manhattan, Kansas. The reservation encompasses 40,874 hectares in Geary and Riley counties on the western edge of the Flint Hills. The terrain is mostly upland prairie or old farm land which has reverted to various stages of plant succession (Robel 1969).

Old fields comprise 35% of the land area while grasslands, shrublands and woodlands make up 30, 15, and 18%, respectively. Croplands make up <2%.

Old fields are characterized by an abundance of forbs such as western ragweed (Ambrosia psilostachya),[1] common sunflower (Helianthus annuus), roundhead lespedeza (Lespedeza capitata), showy partridge pea (Cassia fasciculata), Korean lespedeza (Lespedeza stipulacea), and goldenrod (Solidago spp.). Typical grasses include sideoats grama (Bouteloua curtipendula), buffalograss (Buchloe dactyloides) and tall dropseed (Sporobolus asper). Heavily disturbed sites are typically invaded with three awn (Aristida spp.) and brome (Bromus spp.)

Grasslands are characterized by big bluestem (Andropogon gerardi), little bluestem (Andropogon scoparius), indiangrass (Sorghastrum nutans), switchgrass (Panicum virgatum) and sideoats grama. Common forbs and legumes include prairieclover (Petalostemum spp.), leadplant (Amorpha canescens), Illinois tickclover (Desmodium illinoense), roundhead lespedeza, plains wildindigo (Baptisia leucophaea), prickly

[1] Common and scientific names follow Anderson and Owensby (1969).

lettuce (Lactuca serriola), sunflowers, western ragweed and giant ragweed (Ambrosia trifida). Woody species when present include rough leaf dogwood (Cornus drummondi), smooth sumac (Rhus glabra) and american plum (Prunus americana). Heavily disturbed or improperly managed grasslands show invasion of eastern redcedar (Juniperus virginiana), buckbrush (Symphoricarpus orbiculatus), honeylocust (Gleditsia triacantos) and osageorange (Maclura pomifera).

Woodlands comprise approximately 4,100 hectares and vary from bottom land hardwoods to upland timber. Common trees include bur oak (Quercus macrocarpa), chinquapin oak (Quercus muehlenbergii), black walnut (Juglans nigra), common hackberry (Celtis occidentalis) and elm (Ulmus spp.). Understory species include greenbriar (Smilax spp.), wild grape (Vitis spp.), and giant ragweed. Bottomland hardwoods include locust, boxelder (Acer negundo), ash (Fraxinus spp.), eastern cottonwood (Populus deltoides) and willow (Salix spp.).

Shrublands contain a mixture of american plum, dogwood, sumac and buckbrush.

Land use includes outleasing of land for haying and planting of crops such as soybeans, milo and winter wheat. Grain crops make up <2% of the reservation.

The estimated deer population was 1000 (1 per 40 hectares) in 1978 (B. A. Brown, pers. commun.). The herd has been hunted since 1971.

# MORPHOLOGICAL CHARACTERISTICS OF THE FORT RILEY DEER HERD

## Introduction

Various skeletal measurements, body weights and their associated ratios have been used as indices of growth, condition and nutritional status of wild ungulates (Riney 1955, Bandy et al. 1956, Klein 1964, McEwan and Wood 1966). Body weights and measurements have been used as standard criteria to evaluate the growth of domestic livestock and laboratory animals (Brody 1945).

A simplified method for determining the condition of white-tailed deer (Odocoileus virginianus) using antler and body measurements was proposed by Park and Day (1942). Dressed weight, reproductive rate, eye lens weight, and antler size in association with age composition proved the best indices for measuring physical condition in New York white-tails (Hesselton and Sauer 1973). Morphological characteristics of the Crab Orchard deer herd were reported by Roseberry and Klimstra (1975). Body weight and antler size were good indicators of physical condition.

For morphological measurements to be useful in monitoring the condition of deer populations, baseline information is required to provide reference values for comparing animals between regions or years. Morphological characteristics of Kansas white-tailed deer have not been reported. The objectives of this study were to (1) collect baseline measurements on selected morphological characteristics of free-ranging Fort Riley deer (2) develop predictive equations to estimate whole body weight from field dressed weights and (3) develop predictive equations of whole weight from various linear measurements.

I am indebted to many undergraduate wildlife biology students, Kansas State University for assistance in collection of data. Special thanks are due M. Reid and L. Lorence, for making facilities available at the Fort Riley deer check station. K. Sexson, Kansas Fish and Game Commission coordinated the aging of deer and R. J. Robel critically reviewed the manuscript. This study was supported by the Division of Biology, Kansas Agricultural Experiment Station, Kansas State University; the Kansas Fish and Game Commission; and the Department of the Army.

## Methods

Bodyweight and various skeletal measurements were taken on 346 white-tailed deer processed at the Fort Riley deer check station in December 1978-1981. In addition, 50 animals were collected seasonally as part of a concurrent study of the nutritional and physiological status of the Fort Riley deer herd.

External measurements were made before weighing the animal. Total body length was measured along the dorsal surface from the tip of the nose to the end of the tail vertebrae following the curvature of the neck and body. Hind foot length was measured with the tape drawn tight from the tip of the heel (tuber calcis) to tip of extended hoof, and girth (chest circumference) was measured immediately behind the scapulae. All measurements were made with a flexible cloth tape to the nearest centimeter (Park and Day 1942, Roseberry and Klimstra 1975).

Number of antler points (> 2.5 cm long) on both antlers was recorded for yearling and adult males. Beam circumference 2.5 cm above the base on the right antler was measured to the nearest centimeter.

Whenever possible, deer were weighed whole, to the nearest pound (±0.45 kg), eviscerated, then reweighed (field dressed weight) on a spring scale.

Animals collected in December were placed in appropriate age classes based on incisor size and structure and counts of cementum annuli (Sexson 1982). Fawns were classified as < or > 6 months of age based on incisor size. Greater than 6-month-old fawns were separated from yearlings (18 months) based on incisor structure. Yearlings were separated from adult deer based on amount of wear on the incisers.

Thirty month and older deer were assigned age classes based on counts of cementum annuli.

Animals collected seasonally were aged using tooth eruption and wear (Severinghaus 1949). Deer were classified as fawns (4-12 months) and adults ($\geq$ 13 months).

All data were analyzed using the general linear model procedure of SAS (Barr et al. 1979). Analysis of variance was used to test for differences in age, sex and year of collection. The student t-test was employed to determine significant ($p < 0.05$) differences between sample means. When sample variances were unequal, an approximate number of degrees of freedom was assigned for t-test comparisons by an extension of Satterthwaite's rule (Snedecor and Cochran 1980). Linear and multiple regressions were used to compare external body measurements to whole body weight. The MAX $R^2$ improvement technique was used to select the best models for predicting body weight from morphological measurements (Barr et al. 1979).

## Results and Discussion

Linear measurements were obtained from 197 male and 149 female white-tailed deer of different age classes (Table 1). Body weights were obtained from 146 males and 114 females collected in December 1978-1981 (Table 2).

Age and sex were significant ($p < 0.01$) sources of variation for all measurements while age by sex by year of collection was not. Because no yearly differences were found for any of the morphological characteristics measured, data from all deer were pooled and examined for differences due to age and sex.

### Total Body Length, Hind Foot Length, Chest Girth Measurements

Yearling and adult males were larger ($p < 0.01$) than females of the same age class with respect to all measurements (Table 1). However, male fawns (< 6 months) were not different from female fawns (< 6 months) in relation to total body length ($p = 0.16$), hind foot ($p = 0.07$) or chest girth ($p = 0.19$). Male fawns (> 6 months) had larger hind foot lengths ($p = 0.03$) but not girth ($p = 0.33$) or total body length ($p = 0.75$) compared to female fawns (> 6 months). Roseberry and Klimstra (1975) found male fawns were larger than females in chest girth and hind foot length in the Crab Orchard herd. In their study, fawns were not separated into two age-classes. Similar to their study, I found the least variable skeletal measurement within an age class was hind foot length. In general, variability of fawn morphological measurements was higher in the Crab Orchard herd than in Fort Riley fawns.

Table 1. Morphological characteristics of 346 white-tailed deer by sex and age, Fort Riley Military Reservation, Kansas, December 1978-1981

| | Age of Males (months) | | | | | | Age of Females (months) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fawns | | Yearlings | Adults | | | Fawns | | Yearlings | Adults | | |
| | <6 (26)[a] | >6 (39) | 18 (76) | 30 (25) | 42 (16) | 54+ (15) | <6 (24) | >6 (35) | 18 (47) | 30 (13) | 42 (8) | 54+ (22) |
| **Total Body Length (cm)** | | | | | | | | | | | | |
| Mean | 149.4 | 154.6 | 181.9 | 191.3 | 192.9 | 198.3 | 145.5 | 153.9 | 172.1 | 172.5 | 172.1 | 178.7 |
| SD | 9.7 | 8.7 | 13.5 | 7.3 | 9.0 | 7.9 | 11.1 | 7.8 | 7.8 | 7.2 | 7.8 | 6.4 |
| Min | 132.0 | 132.0 | 117.0 | 180.0 | 180.0 | 193.0 | 114.0 | 139.0 | 155.0 | 160.0 | 161.0 | 170.0 |
| Max | 167.0 | 172.0 | 210.0 | 210.0 | 290.0 | 220.0 | 167.0 | 170.0 | 192.0 | 182.0 | 183.0 | 185.0 |
| t[b] | * | | ** | ** | NS | NS | ** | | ** | NS | NS | * |
| CV[c] | 6.5 | 5.6 | 7.4 | 3.8 | 4.7 | 3.9 | 7.6 | 5.0 | 4.5 | 4.2 | 4.5 | 3.6 |
| **Hind Foot Length (cm)** | | | | | | | | | | | | |
| Mean | 43.7 | 45.3 | 50.3 | 51.3 | 50.7 | 50.8 | 42.8 | 44.3 | 47.5 | 47.3 | 47.3 | 47.8 |
| SD | 2.4 | 1.6 | 2.0 | 1.9 | 2.1 | 1.8 | 1.7 | 1.7 | 1.7 | 1.8 | 1.5 | 2.1 |
| Min | 40.0 | 42.0 | 44.0 | 48.0 | 48.0 | 48.0 | 39.0 | 41.0 | 44.0 | 44.0 | 45.0 | 43.0 |
| Max | 48.0 | 48.0 | 51.0 | 55.0 | 54.0 | 53.0 | 45.7 | 48.0 | 52.0 | 50.0 | 49.0 | 50.0 |
| t | ** | | ** | * | NS | NS | ** | | ** | NS | NS | NS |
| CV | 5.5 | 3.5 | 3.9 | 3.7 | 4.1 | 3.5 | 3.9 | 3.8 | 3.6 | 3.8 | 3.2 | 4.4 |
| **Chest Girth (cm)** | | | | | | | | | | | | |
| Mean | 82.2 | 84.3 | 95.6 | 104.4 | 109.0 | 107.4 | 79.8 | 82.8 | 93.1 | 95.9 | 94.9 | 97.9 |
| SD | 4.7 | 4.8 | 6.9 | 6.0 | 12.9 | 5.7 | 5.4 | 7.2 | 4.9 | 5.8 | 4.2 | 5.7 |
| Min | 76.0 | 76.0 | 80.0 | 93.0 | 100.0 | 90.0 | 69.0 | 69.9 | 84.0 | 87.0 | 91.0 | 87.0 |
| Max | 93.0 | 93.0 | 131.0 | 116.0 | 155.0 | 115.0 | 88.0 | 96.0 | 103.0 | 103.0 | 102.0 | 108.0 |
| t | NS | | ** | ** | * | NS | NS | | ** | NS | NS | NS |
| CV | 5.7 | 5.7 | 7.2 | 5.7 | 11.8 | 5.3 | 6.8 | 8.7 | 5.3 | 6.0 | 4.4 | 5.8 |

[a] Sample size

[b] t-test between means of adjacent age classes: *($p < 0.05$) **($p < 0.01$) NS ($p > 0.05$)

[c] Coefficient of variation

Table 2. Whole body weights, field dressed weights and whole body weight/hind foot ratio of white-tailed deer by sex and age, Fort Riley Military Reservation, Kansas, December 1978-1981.

| | Age of Males (months) | | | | | | Age of Females (months) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fawns | | Yearlings | Adults | | | Fawns | | Yearlings | Adults | | |
| | <6 | >6 | 18 | 30 | 42 | 54+ | <6 | >6 | 18 | 30 | 42 | 54+ |
| **Whole Body Weight (kg)** | | | | | | | | | | | | |
| Sample Size | 22 | 27 | 54 | 19 | 14 | 10 | 19 | 27 | 36 | 11 | 5 | 16 |
| Mean | 40.7 | 47.9 | 73.3 | 89.9 | 99.8 | 100.0 | 38.1 | 43.3 | 60.6 | 63.6 | 64.8 | 70.2 |
| SD | 5.4 | 4.2 | 8.0 | 6.9 | 9.6 | 5.2 | 5.2 | 3.8 | 6.5 | 4.7 | 4.5 | 6.9 |
| Min | 27.2 | 37.4 | 54.9 | 73.0 | 86.2 | 91.2 | 24.9 | 37.1 | 47.2 | 53.1 | 61.2 | 59.9 |
| Max | 49.4 | 54.9 | 89.8 | 100.6 | 117.0 | 111.1 | 45.4 | 51.4 | 78.0 | 68.9 | 71.7 | 83.0 |
| t [a] | ** | ** | ** | ** | NS | | ** | ** | NS | NS | NS | |
| CV [b] | 13.3 | 8.8 | 10.9 | 7.7 | 9.6 | 5.2 | 13.6 | 8.8 | 10.7 | 7.4 | 6.9 | 9.8 |
| **Field Dressed Weight (kg)** | | | | | | | | | | | | |
| Sample Size | 13 | 16 | 51 | 16 | 7 | 9 | 13 | 18 | 24 | 7 | 4 | 9 |
| Mean | 32.9 | 36.4 | 56.1 | 70.3 | 82.8 | 78.1 | 27.9 | 33.3 | 46.4 | 51.6 | 53.5 | 53.1 |
| SD | 5.0 | 4.5 | 6.7 | 9.4 | 9.5 | 8.0 | 5.8 | 3.3 | 4.5 | 1.2 | 4.9 | 5.8 |
| Min | 22.6 | 27.0 | 42.6 | 54.9 | 67.5 | 59.6 | 18.1 | 27.2 | 39.4 | 50.0 | 48.0 | 45.8 |
| Max | 42.9 | 42.9 | 71.2 | 92.1 | 97.1 | 86.1 | 40.8 | 40.1 | 57.4 | 53.5 | 59.0 | 64.0 |
| t | NS | ** | ** | ** | NS | | ** | ** | NS | NS | NS | |
| CV | 15.2 | 12.3 | 11.9 | 13.4 | 11.5 | 10.2 | 20.8 | 9.9 | 9.7 | 2.3 | 9.2 | 10.9 |
| **Whole Body Weight/Hind Foot Ratio (kg/cm)** | | | | | | | | | | | | |
| Sample Size | 22 | 27 | 54 | 19 | 14 | 10 | 19 | 27 | 36 | 11 | 5 | 15 |
| Mean | 0.94 | 1.05 | 1.46 | 1.78 | 1.97 | 2.00 | .89 | .98 | 1.27 | 1.35 | 1.37 | 1.46 |
| SD | .12 | .08 | .13 | .13 | .16 | .09 | .11 | .07 | .12 | .11 | .06 | .12 |
| Min | 0.59 | .89 | 1.14 | 1.40 | 1.65 | 1.91 | .62 | .86 | 1.04 | 1.09 | 1.30 | 1.30 |
| Max | 1.10 | 1.23 | 1.76 | 1.91 | 2.29 | 2.18 | 1.08 | 1.14 | 1.59 | 1.53 | 1.46 | 1.67 |
| t | ** | ** | ** | ** | NS | | ** | ** | NS | NS | NS | |
| CV | 12.8 | 7.6 | 8.9 | 7.3 | 8.1 | 4.5 | 12.3 | 7.1 | 9.4 | 8.1 | 4.4 | 8.2 |

[a] t-test between means of adjacent age classes: *($p < 0.05$) **($p < 0.01$) NS ($p > 0.05$)
[b] Coefficient of variation

Males reached mature total body length at 30 months, while female yearlings were as large as older females. Similarly, adult hind foot length was achieved at 30 months in males and 18 months in females. Forty-two month old males had greater chest girths than 30-month-old males ($p < 0.05$). Chest girth of adult females was not larger than yearling females.

Whole Body Weight, Field Dressed Weight, Body Weight/Hind Foot Ratio

Yearling and adult males were heavier ($p < 0.01$) (whole and field dressed weight) than females of the same age class (Table 2). Whole weights of male fawns < 6 months old were not different from female fawns ($p = 0.19$), however, older male fawns were heavier ($p < 0.05$) than older female fawns. Field dressed weights of male fawns > 6 months old were not different than > 6-month-old female fawns ($p = 0.15$). Smaller sample sizes and greater variability in field dressed weight may have contributed to lack of significant differences between sexes of older fawns.

Whole body weight and field dressed weight increased through 54 months in males. Yearling females did not differ from adult females in body weight. Older fawns (> 6 months old) were heavier (whole weight) than younger fawns ($p < 0.01$). However, field dressed weight of older male fawns did not differ from younger male fawns ($p < 0.10$) while females did ($p < 0.01$). Body weight as an index of range condition has been well documented (Severinghaus 1954, Gill 1956). Fall field dressed weights of Fort Riley yearling bucks were 2 kg heavier than New York white-tails from excellent habitat (Severinghaus 1954) and 9 kg heavier than Michigan yearlings considered in prime condition (McCullough 1982).

The ratio of whole body weight/hind foot length showed similar patterns to whole body weight. Yearling and adult males had higher ratios than females of the same age class. Male and female fawns (< 6 months old) had similar ratios, while older male fawns had higher ratios than older females ($p = 0.02$). McEwan and Wood (1966) after examining the relationship of heart girth, hind foot length, and body weight in barren ground caribou (Rangifer tarandus groendandicus) concluded bodyweight per unit of hind foot length might provide a useful index for estimating the developmental restriction of wild ungulates. Results reported here show such ratios are highly age x sex dependent in Kansas white-tailed deer.

The use of bodyweight to compare the condition of deer populations from different regions or states is not valid because of the inherent differences in body size between subspecies. Hind foot length should provide an adjustment for variations in skeletal size for a wide range of white-tailed deer subspecies. Unfortunately, bodyweight/hind foot ratios have not been reported for white-tailed deer over a wide range of habitat types. Fort Riley deer bodyweight/hind foot ratios averaged 15% higher than calculated ratios for the Crab Orchard herd over all age classes (Roseberry and Klimstra 1975).

## Antler Characteristics

Although number of antler points and beam circumference increased with age, the only significant difference was between 18- and 30-month-old deer (Table 3). The mean number of antler points increased from 6 for yearlings to 11 for 78 month and older deer. There was considerable variation in the number of antler points within and between age classes.

Table 3. Antler characteristics of white-tailed bucks, Fort Riley Military Reservation, Kansas, December 1978-1981.

| | Age (months) | | | | | |
|---|---|---|---|---|---|---|
| | 18 | 30 | 42 | 54 | 66 | 78+ |
| | Number of Points | | | | | |
| Sample Size | 76 | 25 | 16 | 7 | 5 | 4 |
| Mean | 6.5 | 8.9 | 9.5 | 10.4 | 10.8 | 11.0 |
| SD | 2.1 | 1.3 | 1.4 | 2.8 | 3.6 | 1.4 |
| Min | 2.0 | 7.0 | 8.0 | 7.0 | 8.0 | 10.0 |
| Max | 10.0 | 11.0 | 13.0 | 14.0 | 17.0 | 13.0 |
| t [a] | ** | NS | NS | NS | NS | |
| | Beam Circumference (cm) | | | | | |
| Sample Size | 61 | 20 | 12 | 5 | 4 | 4 |
| Mean | 8.5 | 11.4 | 12.4 | 13.2 | 12.4 | 14.8 |
| SD | 1.3 | 3.2 | 1.8 | 0.8 | 0.9 | 1.7 |
| Min | 6.0 | 8.0 | 10.0 | 12.0 | 11.0 | 13.0 |
| Max | 12.0 | 24.0 | 16.5 | 14.0 | 13.0 | 17.0 |
| t | ** | NS | NS | NS | NS | |

[a] t-test between means of adjacent age classes: ** ($p < 0.01$) NS ($p > 0.05$)

Of 133 bucks examined only one was a spike (2 pointer). A small percentage of spike bucks is considered a good indication of animals on a high plane of nutrition (Severinghaus et al. 1950, French et al. 1955, Dahlberg and Guettinger 1956). Beam circumference increased from 8.5 cm ± 1.3 for yearlings to 14.8 ± 1.7 cm for 78 month and older deer. Number of antler points was significantly correlated to whole body weight ($r = 0.44$, $p < 0.001$) while beam circumference was not ($r = 0.30$, $p < 0.07$). Roseberry and Klimstra (1975) found antler beam length ($R^2 = 0.778$) and diameter ($R^2 = 0.77$) were more closely associated with body weight than number of points ($R^2 = 0.450$). Taber (1958) suggested Montana mule deer (O. hemionus) yearling antler development may reflect winter nutritional levels during the previous winter and thus aid in assessment of winter range. This hypothesis was not supported by Anderson and Medin (1969) who found no relationship between antler morphometry and environmental variables for mule deer in Colorado. Antler morphometry and size of Fort Riley bucks were indicative of animals on a very high plane of nutrition.

## Whole-Dressed Weight Relationships

Least squares linear regression equations of whole body weight on dressed weight were estimated for different sex-age classes (Table 4). Slope of the lines were very similar for all sex-age classes. The high $R^2$ values and low SE $\hat{y}$ suggest all equations can accurately estimate whole body weight from field dressed weight. The lower SE of estimated bodyweights for fawns is due to lower variability of actual fawn whole weights between individuals. For practical use, the line representing all deer should be adequate for predicting whole weight from dressed

Table 4. Predictive equations of whole body weight from field dressed weight for Fort Riley white-tailed deer, December 1978-1981.

| Age class | N | Equations | $R^2$ | $SE(\hat{Y})$ |
|---|---|---|---|---|
| Adult males | 49 | BW = 9.62 + 1.11 FD[a] | 0.94 | 3.82 |
| Adult females | 29 | BW = 3.85 + 1.19 FD | 0.95 | 1.69 |
| Adults | 78 | BW = 6.96 + 1.14 FD | 0.96 | 3.22 |
| Male fawns | 13 | BW = 7.34 + 1.07 FD | 0.92 | 1.53 |
| Female fawns | 19 | BW = 4.90 + 1.13 FD | 0.96 | 1.04 |
| Fawns | 32 | BW = 5.30 + 1.12 FD | 0.95 | 1.25 |
| All deer | 110 | BW = 4.11 + 1.18 FD | 0.98 | 2.86 |

[a] BW = whole body weight in kg, FD = field dressed weight in kg.

weight in kilograms (BW = 4.11 + 1.18 FD, SE Y = 2.86). Ninety-five percent of my animals fell within 5.7 kg of the actual weight using this equation. The equation developed by Roseberry and Klimstra (1975) for predicting whole weight from dressed weight of Crab Orchard deer was very similar (BW = 2.2 + 1.17 FD) to mine. Because the slopes of these lines are nearly identical, the lower y-intercept of their equation would result in whole weight estimates about 2 kg lower for a given field dressed weight. The equations developed for Fort Riley deer should be applicable to other regions where adult deer average 70 kg and fawns 40 kg whole weight in December. These equations may not be useful during different seasons. Seasonal variation between whole and field dresssed weight of deer has been documented (Hamerstrom and Camburn 1950, Severinghaus and Cheatum 1956, Moen and Severinghaus 1981).

Whole Weight - Skeletal Measurement Relationships

Preliminary analysis of data suggested other than linear functions might be necessary to predict whole body weight from skeletal measurements. No quadratic equations examined produced significantly higher $R^2$ values than linear equations, therefore, linear predictive equations for whole body weight based on chest girth, total body length and hind foot were developed for different sex-age classes (Table 5). Chest girth was the best 1-variable model for bucks ($R^2$ = 0.58), does ($R^2$ = 0.51) and male fawns ($R^2$ = 0.39) (Table 5). Hind foot length was the best model for female fawns ($R^2$ = 0.43). Chest girth and total body length was the best 2-variable model for bucks ($R^2$ = 0.64) does ($R^2$ = 0.68) and male fawns ($R^2$ = 0.58). The model developed for adult deer BW = -56.8 + 1.33 G [BW = whole body weight (kg) and G = chest

Table 5. Linear prediction equations for whole body weight of Fort Riley white-tailed deer based on chest girth, total body length and hind foot length. All deer collected December 1978-1981.

| Age Class | N | Best single variable model | $R^2$ | Best two variable model | $R^2$ |
|---|---|---|---|---|---|
| Adult males | 102 | BW = -34.5 + 1.15 G[a] | 0.58 | BW = -78.9 + 0.91 G + 0.36 TBL | 0.67 |
| Adult females | 74 | BW = -14.9 + 0.86 G | 0.51 | BW = -82.6 + 0.80 G + 0.42 TBL | 0.68 |
| All adults | 177 | BW = -56.8 + 1.33 G | 0.60 | BW = -111.7 + 0.94 G + 0.51 TBL | 0.72 |
| Male fawns | 46 | BW = -16.6 + 0.73 G | 0.39 | BW = -53.2 + 0.65 G + 0.28 TBL | 0.58 |
| Female fawns | 45 | BW = -35.2 + 1.75 HF | 0.43 | BW = -42.2 + 0.19 G + 1.75 HF | 0.50 |
| Fawns | 91 | BW = -32.4 + 1.71 HF | 0.39 | BW = -33.6 + 0.41 G + 0.278 TBL | 0.50 |
| All deer | 271 | BW = -80.1 + 1.54 G | 0.75 | BW = -109.3 + 0.89 G + 0.52 TBL | 0.87 |

[a]BW = whole body weight in kg, G = chest girth in cm, TBL = total body length in cm, HF = hind foot length in cm.

girth (cm)] was similar to the equation for adult South Carolina deer reported by Urbston et al. (1976) (BW = -44.10 + 1.18 G). The addition of total body length produced slight increases in $R^2$ values for all models tested. Contrary to the work of Smart et al. (1973) and Urbston et al. (1976) chest girth was not highly correlated to body weight in Fort Riley fawns. In the Urbston et al. (1976) study, animals were collected from September through December so fawns could have been quite variable in age. All Fort Riley fawns were collected in December and therefore less variable in age and bodyweight. Using equations from this study, estimates of adult body weights from chest girth should produce results useful for determining the mean weights of a particular deer population. Using the equation for all adults, the 95% confidence limit for the mean predicted weight of 74.5 kg is 72.5-76.5 kg, however, the standard error of individual predicted values is 9.4 kg. In my sample, 95% of the predicted values from chest girth were within 18 kg of the observed value.

Predictive equations based on 50 deer collected from February-October, 1979, were determined to evaluate the use of chest girth for predicting body weight on a seasonal basis. The slopes of the regression lines were nearly identical for all seasons (Table 6) and similar to the model for all deer collected at hunter check stations 1978-1981 (Table 5). Apparently, the relationship between chest girth and body weight is similar regardless of seasonal changes in body weight.

Table 6. Seasonal predictive equations for whole weight of white-tailed deer based on chest girth, Fort Riley, Kansas, 1979.

| Season[a] | N | | | Equations | $R^2$ | $SDb_0$ | $SDb_1$ |
|---|---|---|---|---|---|---|---|
| | M | F | Juv | | | | |
| Winter | 3 | 9 | 1 | BW = -95.6 + 1.7 G[b] | 0.87 | 17.9 | 0.20 |
| Spring | 2 | 8 | 2 | BW = -86.4 + 1.7 G | 0.71 | 30.0 | 0.34 |
| Summer | 1 | 12 | 2 | BW = -94.6 + 1.8 G | 0.82 | 20.3 | 0.23 |
| Fall | 2 | 5 | 3 | BW = -83.8 + 1.7 G | 0.99 | 4.9 | 0.05 |

[a]Winter (1 Feb-23 Mar), Spring (24 Mar-23 Jun), Summer (24 Jun-16 Sep) Fall (17 Sep-20 Oct).

[b]BW = whole body weight in kg, G = chest girth in cm.

## Conclusions and Management Implications

Morphological characteristics of Kansas deer have not previously been reported. This study provided reference values for total body length, hind foot length, chest girth and body weights and antler size of northeast Kansas deer. Body size and weights of Fort Riley deer were comparable to a larger subspecies from New York on excellent range.

Morphological measurements of Fort Riley deer were strongly influenced by age and sex. Yearling and adult males were significantly larger than females of the same age class with respect to all measurements. In general, male and female fawns < 6 months of age were similar in skeletal and body size; however, male fawns > 6 months old were larger than female fawns > 6 months of age.

It is unlikely that skeletal measurements can accurately represent between year differences in habitat quality for white-tailed deer. Total body length and hind foot length comparisons of growing fawns may be useful for monitoring the nutritional restrictions affecting bone growth, although reductions in growth would not occur unless there were severe changes in habitat quality. Body weight/hind foot ratio may be useful for comparing the physical condition of deer from different regions and subspecies. The higher the ratio the better the condition of the animal.

Equations presented in this paper for predicting whole weight from field dressed weight will produce estimates within 6 kg of actual values. These equations should be applicable throughout the mid-west where adult deer average 70 kg whole weight.

Prediction equations developed for estimating whole weight from chest girth in adult deer are adequate for estimating mean whole weights of a particular deer population, regardless of season. However, the relationship is not strong enough to predict accurate weights for research purposes or specific weights of individual animals. The relationship of whole weight to skeletal measurements in fawns was not strong and whole weights were poorly predicted from linear measurements. The use of chest girth to estimate whole body weight allows the deer manager to estimate seasonal weights for the deer population from road-kill deer, and is less laborious and more rapid than actually weighing deer.

# REPRODUCTIVE CHARACTERISTICS OF THE FORT RILEY DEER HERD

## Introduction

The reproductive biology of white-tailed deer (Odocoileus virginianus) has been studied extensively. Reproductive data of midwestern white-tailed deer females have been reported for Illinois (Roseberry and Klimstra 1970), Ohio (Nixon 1971), Iowa (Haugen 1975), and Indiana (Kirkpatrick et al. 1976).

Knowledge of male and female reproductive characteristics is essential for intensive deer management. Such information allows estimation of fawn production, conception dates, onset of the rut and provides an index to range quality (Cheatum and Severinghaus 1950, Longhurst 1951, Severinghaus and Tack 1954). Published information on reproduction in Kansas white-tailed deer is lacking. The purpose of this study was to collect baseline data on ovulation rates, fetal rates, persistence of lactation and testes weights of the Fort Riley deer herd.

I thank personnel of the Fish and Wildlife Conservation Office, Fort Riley, for making facilities available at the deer check station and the wildlife biology students from Kansas State University for assistance in data collection. K. Sexson, Kansas Fish and Game Commission, coordinated aging of all deer. B. A. Brown provided suggestions and assistance on various aspects of the study. R. J. Robel carefully reviewed the manuscript. This study was supported by the Division of Biology, Kansas Agricultural Experiment Station, Kansas State University; the Kansas Fish and Game Commisssion; and the Department of the Army.

## Methods

White-tailed deer were collected the first 3 weekends in December 1978-1981 at a mandatory hunter check station on the Fort Riley Military Reservation. In addition, animals were collected seasonally in 1979 as part of a concurrent study of the nutritional status of the Fort Riley deer herd.

Animals were weighed whole, then, before field dressing, the mammary gland was removed from each female deer, sliced in half and examined for presence of milk. Animals with milk were termed lactating females.

The entire reproductive tract was removed from each female deer and placed in a liter jar containing 10% formalin. Within 2 months after collection, reproductive tracts were removed from containers, the ovaries were removed from the right and left horn and both horns were examined for visible embryos ($\geq$ 2 mm). Ovaries were sliced with a razor blade into 1 mm thick sections and examined for corpora lutea of pregnancy (Cheatum 1949; Trauger and Haugen 1965).

Fresh forehead-rump lengths (cm) were taken on all fetuses collected from February through June 1979, and the fetuses were sexed and aged according to the equation of Short (1970). Conception dates were determined by back dating embryo ages from date of collection.

Testes, without attached epididymides, were removed from male deer and weighed to the nearest 0.1 g. A testicular index (TI) was calculated for each male deer by dividing the mean testis weight (g) by whole body weight (kg).

Animals collected in December were placed in 1 of 4 age classes: < 6-month-old fawns, > 6-month-old fawns, yearlings (1-1/2 years) and adults ($\geq$ 2-1/2 years). Fawns were classified as < or > 6 months of age based on incisor size. Greater than 6-month-old fawns were separated from yearlings based on incisor structure. Yearlings were separated from adult deer based on amount of wear on the incisors (Sexson 1982).

Deer collected between February and June were aged using tooth eruption and wear (Severinghaus 1949) and classified as fawns (4-13 months), yearlings (14-25 months) and adults ($\geq$ 26 months).

Analysis of variance was used to test for differences ($p < 0.05$) due to age and year of collection. Chi-square analysis was used to determine significant ($p < 0.05$) differences between frequency data.

## Results and Discussion

### Pregnancy Rates, Fetal Sex Ratio, Conception Dates

Eleven adults, 12 yearlings and 6 female fawns were collected between February and June 1979. Pregnancy rates were 100%, 92% and 50% for adults, yearlings and fawns, respectively (Table 7). Adults averaged 2.0 fetuses per doe, yearlings 1.7, and 3 pregnant fawns carried 1 fetus each. Ovulation rates were higher than fetal rates for all age classes. Corpora lutea per pregnant doe were 2.2, 2.0 and 1.3 for adults, yearlings and fawns, respectively. Of 25 pregnant females, 15% of the ova shed did not produce a fetus. Roseberry and Klimstra (1970) estimated 21.4% ova loss in Crab Orchard fawns, 7.8% for yearlings and 13.7% for adults. Haugen (1975) found 9.4% loss in Iowa fawns, 15.2% in yearlings and 0% in adults. Earlier studies by Ransom (1967) indicated a high rate of ova loss for adult and yearling white-tailed deer from quality habitat in Manitoba. He attributed high ovulation rates to increased consumption of high quality forage during and prior to the rut.

The fetal sex ratio of all Fort Riley does favored males (57%) to females (43%). The ratio was more skewed toward males in adult does (1.8:1.0) than yearlings (1.1:1.0). Variations in fetal sex ratios have been related to the nutritional status of the female (Trivers and Willard 1973). Verme (1969) reported penned deer on a high plane of nutrition produced 35.6% males, while those on restricted diets 68.4% males. Haugen (1975) found a fetal sex ratio of 55% males to 45% females for free-ranging Iowa white-tailed deer considered to be in excellent physical condition. On the other hand, Woolf and Harder

Table 7. Ovulation and fetal rates of pregnant Fort Riley white-tailed deer collected February-June 1979

| Age Class | Number of Does Collected | | Number Fetuses | | Fetuses Per Pregnant Doe | | Number Corpora Lutea/Doe[a] | | Percent Ova Fertilized |
|---|---|---|---|---|---|---|---|---|---|
| | Total | Pregnant | M | F | $\bar{x}$ | SD | $\bar{x}$ | SD | |
| Adults | 11 | 11 | 14 | 8 | 2.0 | 0.8 | 2.1 | 0.8 | 95 |
| Yearlings | 12 | 11 | 10 | 9 | 1.7 | 0.6 | 2.0 | 0.5 | 85 |
| Fawns | 6 | 3 | 1 | 2 | 1.0 | 0.0 | 1.3 | 0.5 | 77 |
| All deer | 29 | 25 | 25 | 19 | 1.8 | 0.7 | 2.0 | 0.7 | 85 |

[a] Based on animals which had ovulated

(1979), in a high density, nutritionally stressed, Pennsylvania deer herd found 60% female fetuses.

Based on estimated conception dates of 11 adults and 11 yearling female deer, 36% of adults and yearlings bred during the 1-14 November period and 59% bred during the 15-30 November period (Table 8). Mean conception date was 16 November for adults and 19 November for yearlings. Of 3 pregnant fawns, conception dates were 2 and 4 December and 2 February. Earlier breeding by adults and yearlings compared to fawns have been reported by Cheatum and Morton (1946), Roseberry and Klimstra (1970), and Jackson and Hesselton (1973). Breeding dates of Fort Riley deer were similar to those for Iowa white-tailed deer (Haugen 1975).

Between Year Comparisons of Female Reproductive Activity

Collection of 52 adults, 43 yearlings and 52 female fawns at a mandatory hunter check station on Fort Riley during the first 3 weekends in December 1978-1981 provided an opportunity to compare reproductive success between years.

Percent yearlings and adults ovulating ranged from 91 to 100% (Table 9). Yearling ovulation rates were lower ($p < 0.05$) in December 1979 than other years. Number of corpora lutea of pregnancy per adult doe was higher ($p < 0.05$) in 1978 ($2.9 \pm 1.0$) than in other years. Ovulation rates were similar between adults and yearlings except yearling rates were lower ($p < 0.05$) than adults in 1979.

Fetal rates are difficult to interpret from hunter check station animals because uteri of many pregnant females do not show visible embryos (> 2 mm) in December. For all years, 38% of yearlings with

Table 8. Estimated conception dates of 25 Fort Riley female white-tailed deer based on fetuses collected February-June 1979

| Period of Conception | Fawns | Yearlings | Adults | All Deer |
|---|---|---|---|---|
| 1-14 Nov | 0 | 2 | 6 | 8 |
| 15-30 Nov | 0 | 9 | 4 | 13 |
| 1-30 Dec | 2 | 0 | 1 | 3 |
| 1-31 Jan | 0 | 0 | 0 | 0 |
| 1-28 Feb | 1 | 0 | 0 | 1 |

Table 9. Ovulation and fetal rates of 92 Fort Riley yearling and adult deer collected the first three weekends in December 1978-1981

| Year of Collection | Yearlings | | | | | | Adults | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | Number Ovulated | Corpora Lutea/Doe | | Fetuses Doe[a] | | N | Number Ovulated | Corpora Lutea/Doe | | Fetuses Doe[a] | |
| | | | $\bar{x}$ | SD | $\bar{x}$ | SD | | | $\bar{x}$ | SD | $\bar{x}$ | SD |
| 1978 | 6 | 6 | 2.2 | 0.8 | 2.0 | 0.0 | 10 | 10 | 2.9 | 1.0 | 2.0 | 0.0 |
| 1979 | 9 | 9 | 1.4 | 0.5 | 2.0 | 0.0 | 15 | 14 | 1.9 | 0.7 | 2.0 | 0.0 |
| 1980 | 17 | 17 | 1.9 | 0.5 | 1.7 | 0.5 | 15 | 15 | 2.1 | 0.6 | 1.9 | 0.4 |
| 1981 | 11 | 10 | 2.1 | 0.9 | 1.8 | 0.5 | 12 | 11 | 2.0 | 0.9 | 2.0 | 0.0 |
| All Years | 43 | 42 | 1.9 | 0.6 | 1.8 | .50 | 52 | 50 | 2.2 | 0.8 | 2.0 | 0.1 |

[a] Based only on animals which had visible fetuses

corpora lutea and 38% of adults had visible embryos. Haugen (1975) found 36% of Iowa yearlings and 45% adult females carried fetuses in December. Assuming that embryos are not visible until 3 to 4 weeks of age (Roseberry and Klimstra 1970) and a mean collection date of 14 December, the majority of Fort Riley deer would have conceived on or before 24 November. Of deer with fetuses, embryo counts were not different between years or between yearlings and adults. Yearlings averaged 1.8 fetuses/doe and adults 2.0 fetuses/doe (Table 9).

The percentage of fawns ovulating was influenced by age and year of collection (Table 10). For all years, a higher ($p < 0.05$) percentage of > 6-month-old fawns had ovulated than younger fawns. Percentage of fawns reaching puberty has been related to nutrition and physical development (Harder 1980). Whole bodyweights of Fort Riley fawns were higher in 1978 and 1979 compared to 1980 and 1981 (Table 11). Concurrent studies of the morphological characteristics of the Fort Riley deer herd showed > 6-month-old female fawns were heavier ($p < 0.05$) than younger fawns collected in December (43.3 kg vs 38.1 kg). Hesselton and Sauer (1973) thought the threshold weight for white-tailed deer fawn breeding was 38 to 40 kg. The proportion of < 6-month-old Fort Riley fawns to > 6-month-old fawns in the harvest was higher ($p < 0.05$) in 1981 with fewer ($p < 0.05$) fawns ovulating compared to 1978-1980.

Number of corpora lutea per doe fawn was similar between years (Table 10). Of fawns which had ovulated, both age classes averaged 1.0 corpora lutea/doe. No fawns collected in December had visible embryos. This was not unexpected considering most fawns bred in December. It is possible that some fawns examined the first 3 weekends

Table 10. Ovulation rates of 52 Fort Riley fawns collected the first three weekends in December 1978-1981

| Year of Collection | Fawns < 6 Months Old | | | | Fawns > 6 Months Old | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Number Ovulated | Corpora Lutea/Doe[a] $\bar{x}$ | SD | N | Number Ovulated | Corpora Lutea/Doe $\bar{x}$ | SD |
| 1978 | 6 | 2 | 1.0 | 0.0 | 6 | 3 | 1.0 | 0.0 |
| 1979 | 3 | 2 | 1.0 | 0.0 | 9 | 7 | 1.3 | 0.5 |
| 1980 | 4 | 0 | 0.0 | | 13 | 6 | 1.3 | 0.5 |
| 1981 | 7 | 0 | 0.0 | | 4 | 1 | 1.0 | |
| All Years | 20 | 4 | 1.0 | 0.0 | 32 | 17 | 1.2 | 0.4 |

[a] Based only on fawns which had ovulated

Table 11. Relationship between whole bodyweights, age ratios and number of fawns ovulating in December 1978-1981, Fort Riley, Kansas

| Year of Collection | N | Whole Bodyweight (kg) $\bar{x}$ | SD | Number Ovulating | Ratio[a] >6m:<6m |
|---|---|---|---|---|---|
| 1978 | 12 | 41.6 | 2.5 | 5 | 1.0:1.0 |
| 1979 | 12 | 42.9 | 4.9 | 7 | 3.0:1.0 |
| 1980 | 17 | 39.4 | 6.7 | 6 | 3.0:1.0 |
| 1981 | 11 | 39.3 | 4.5 | 1 | 0.6:1.0 |

[a] > 6-month-old fawns : < 6-month-old fawns

in December without evidence of ovulation may breed later. However, Haugen (1975) found 77% of all fawn breeding in Iowa occurred 1-15 December. Of 17 > 6-month-old Fort Riley fawns harvested between 7-13 December, 75% had ovulated. Seventy percent of fawns harvested between 14-21 December had ovulated. Of course, some of the fawns examined after 14 December could have ovulated earlier. These data suggest counts of corpora lutea in December should produce accurate estimates of fawn breeding activity.

## Persistence of Lactation

Persistence of lactation was not uncommon into December in Fort Riley deer and varied between years (Figure 1). Percent yearlings lactating in any year was related to the number of fawns ovulating the preceding December. Thirty-seven percent of yearlings were lactating in December 1980 (75% fawns ovulated in 1979). In contrast, no yearlings were lactating in 1981 (9% of fawns had ovulated in 1980). Percentage of adults lactating tended to be lower in years of high fawn breeding and higher when fewer fawns bred. It is likely that breeding fawns would have been weaned prior to ovulation. All lactating females collected in December had ovulated. Apparently, the persistence of lactation does not prevent ovulation in white-tailed does. Similar findings have been reported by Scanlon et al. (1976) and Scanlon and Urbston (1978) for white-tailed deer in Virginia and South Carolina.

## Testicular Weight of Males

Testicular weights were obtained from 115 male deer during December 1978-1981 at the Fort Riley hunter check station (Table 12). Mean

**THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.**

**THIS IS AS RECEIVED FROM CUSTOMER.**

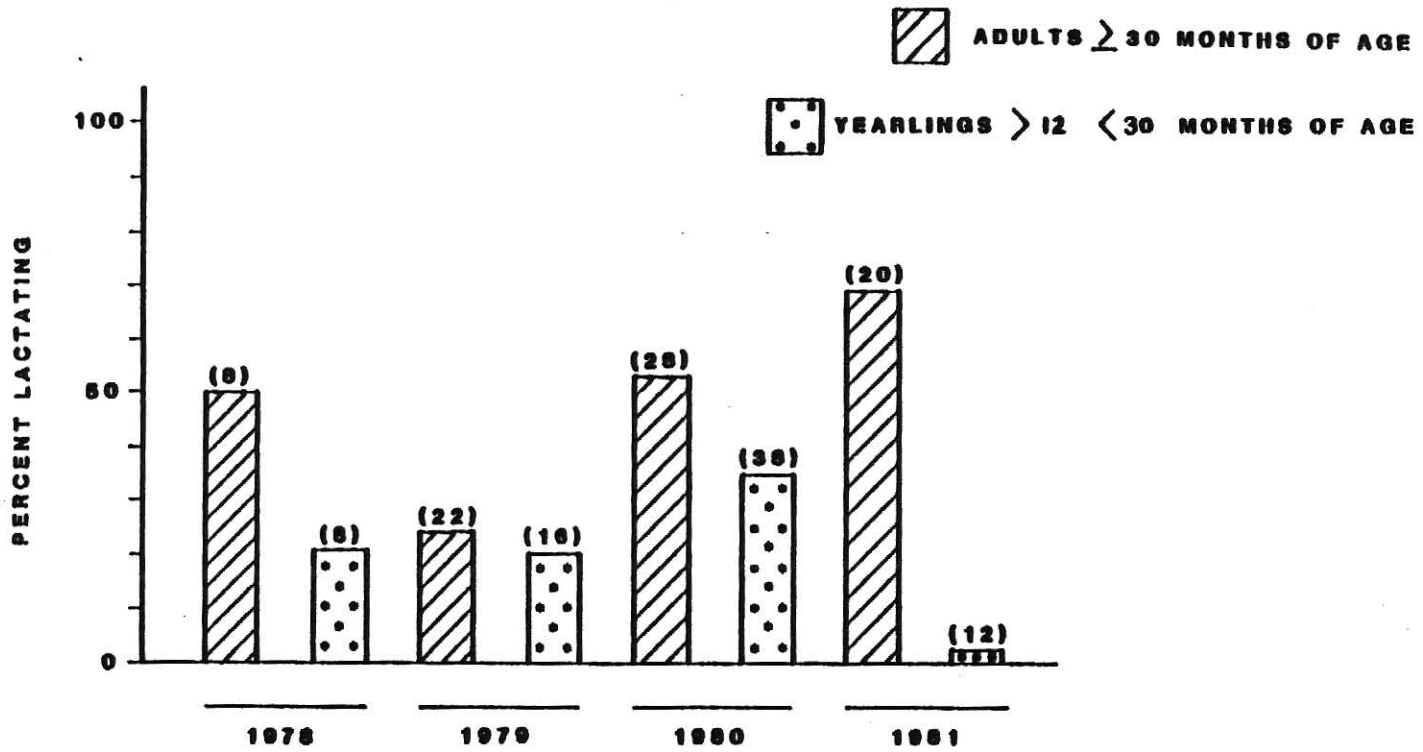


Fig. 1. Persistence of lactation in adult and yearling white-tailed deer collected in December 1978-1981 on the Fort Riley Military Reservation, Kansas. Numbers in parenthesis indicate sample size.

Table 12. Mean testis weight and testicular index (TI) of 115 male white-tailed deer, Fort Riley, Kansas, December 1978-1981

| | | Age of Deer (Months) | | |
|---|---|---|---|---|
| | Fawns | 18 | 30 | ≥ 42 |
| | | Testis Weight (g) | | |
| Sample Size | 36 | 53 | 14 | 12 |
| Mean | 19.9a[a] | 53.4b | 63.5c | 59.9c,b |
| SD | 6.8 | 11.4 | 12.8 | 11.2 |
| Min | 8.2 | 31.3 | 40.3 | 43.9 |
| Max | 39.1 | 77.2 | 83.1 | 80.5 |
| | | Testicular Index (TI)[b] | | |
| Sample Size | 29 | 43 | 13 | 10 |
| Mean | 0.43a | 0.76b | 0.75b | 0.60c |
| SD | 0.14 | 0.13 | 0.14 | 0.11 |
| Min | 0.13 | 0.48 | 0.50 | 0.43 |
| Max | 0.82 | 0.93 | 0.95 | 0.77 |

[a]Means within a row having identical letters do not differ ($p > 0.05$)

[b]$TI = \frac{\text{Testes Weight (right \& left) (g)}}{\text{Whole body weight (kg)}}$

testis weight was higher ($p < 0.05$) in yearlings than fawns. Thirty-month-old males had heavier ($p < 0.05$) testes than yearlings but not heavier than 42-month and older deer. Testis weight was highly correlated to body weight ($r = 0.84$, $p < 0.01$).

In order to standardize testis weight for body weight, a testicular index (TI) was calculated for each deer. The testicular index was higher ($p < 0.05$) for yearlings and adults than fawns. Forty-two month and older males had lower ($p < 0.05$) TI's than 18- and 30-month-old deer. Apparently, few, if any, male fawns reach sexual maturity at 5-6 months of age. Lenker and Scanlon (1973) found 35% of male fawns collected in November and December from South Carolina had reached puberty (spermatozoa in testes). Paired testes weights were significantly heavier in post puberal fawns than those without evidence of spermatogenesis. Cheatum and Morton (1946) concluded that New York white-tail males do not participate in the rut until 18 months of age. During concurrent studies of the nutritional characteristics of the Fort Riley deer herd, 8 adult males and 3 juvenile males were collected from February through November 1979. Adult and yearling males had lower testicular weights in the winter ($N = 4$, 19.3 g) and summer ($N = 1$, 31.9 g) compared to animals collected in October and November ($N = 3$, 58.1 g). Similarly, TI's were elevated in the fall (0.71) compared to winter (0.35) and spring through summer (0.37). The TI of 3 adult males collected in November was very similar to the 0.76 TI of adults at hunter check stations in December. Fawns had similar TI's to adults in winter ($N = 1$, 0.37) but much lower in the fall ($N = 30$, 0.40). These results indicate adult and yearling males are sexually active from late October through December. While some male fawns may reach puberty in

December, it is unlikely that any participate in the rut. Similar seasonal variations in testicular weights of white-tailed deer have been reported by Lambiase et al. (1972) in Pennsylvania, and Russel et al. (1975) and Mirarchi et al. (1976) in Virginia.

Productivity of the Fort Riley Deer Herd

Assuming the female age-structure of the Fort Riley deer herd is similar to that of the harvest, one can estimate the relative annual production of fawns by different age classes (Table 13). I assumed fertilization rates would remain constant between years. Embryos per conception and ovulation rates were obtained from deer collected at hunter check stations. In this study, ovulation rates were relatively stable between years in adults and yearlings but were highly variable in fawns. Three to 15% of the estimated annual increment was produced by Fort Riley fawns in 1978-1981. Fawns made up 33% of the female population in 1979 and produced 15% of the offspring. In 1978 fawns made up 43% of the female population and produced 13% of the increment. Obviously, age structure and ovulation rates are important factors in determining fawn production between years. Haugen (1975) concluded fawns contribute an estimated 30% of the annual increment in Iowa.

Variability in Fort Riley fawn breeding activity was related to the proportion of < 6-month-old fawns to > 6-month-old fawns in the December population. Persistence of lactation in adult and yearling deer generally support the fact that the age ratio (< 6 months: > 6 months) of Fort Riley fawns in the December harvest varied between years. In 1979 a large percentage of fawns ovulated and were > 6 months of age. Fewer adults were observed lactating (27%) in 1979 than other years

Table 13. Estimated relative contribution of various age groups to annual production of fawns, Fort Riley, Kansas, 1978-1981

| | AGE | Females Harvested | | Percent Ovulating | Percent Fertilization | Embryos per Conception | Total Fawns | Percent |
|---|---|---|---|---|---|---|---|---|
| | | Total | Percent | | | | | |
| 1978 | Fawns | 12 | 43 | 42 | 77 | 1.0 | 4 | 13 |
| | Yearlings | 6 | 21 | 100 | 85 | 2.0 | 10 | 31 |
| | Adults | 10 | 36 | 100 | 91 | 2.0 | 18 | 56 |
| 1979 | Fawns | 12 | 33 | 75 | 77 | 1.0 | 7 | 15 |
| | Yearlings | 9 | 25 | 100 | 85 | 2.0 | 15 | 32 |
| | Adults | 15 | 42 | 93 | 91 | 2.0 | 25 | 53 |
| 1980 | Fawns | 17 | 35 | 35 | 77 | 1.0 | 5 | 9 |
| | Yearling | 17 | 35 | 100 | 85 | 1.7 | 25 | 45 |
| | Adults | 15 | 30 | 100 | 91 | 1.9 | 26 | 46 |
| 1981 | Fawns | 11 | 32 | 9 | 77 | 1.0 | 1 | 3 |
| | Yearlings | 11 | 32 | 91 | 85 | 1.8 | 16 | 43 |
| | Adults | 12 | 36 | 92 | 91 | 2.0 | 20 | 54 |

indicating a larger percentage of fawns had been weaned by December. On the other hand, 70% of adult females harvested in 1981 were lactating, while few fawns had ovulated and a large percentage were < 6 months of age. Further, the highest percentage of yearlings lactating (37%) was in 1980 following the highest year of estimated fawn breeding.

If population densities are high and habitat quality low, virtually no fawns will breed (Woolf and Harder 1979). Data collected in my study suggest extent of fawn breeding in low density (1 per 40 hectares), high quality habitat may also vary between years because of alternating age ratios of fawns in the December population and not nutritional deficiencies of the fawns. Variations in the number of < 6-month-old fawns to > 6-month-old fawns in the fall population are related to the breeding dates of does the previous year. Fawns conceived in mid November will be > 6 months old by the following December. Those conceived in mid December will be < 6 months of age. McGinnes and Downing (1977) found early mean birth weights of Virginia white-tailed deer were significantly correlated with high rainfall the previous May and with low fawn survival the previous summer. Verme (1965) suggested that undernourished does cannot recover from the stress of lactation in time to be in prime condition for ovulation during the first estrus and, thus, breed about 1 month later than well nourished does.

Variations in female fawn breeding activity related to differences in bodyweight may be more appropriately related to the age of fawns at the onset of the rut. I know of no other studies which have reported the breeding activity of fawns based on separating younger fawns (< 6 months) from older fawns (> 6 months).

The productivity of the Fort Riley deer herd is indicative of animals on a high plane of nutrition (Moustgaard 1959). Midwestern white-tailed deer are typically more productive than northern deer from forest habitats. This high production has been linked to the large consumption of agricultural crops (Harder 1980). In addition to high productivity of adult deer, a high percentage of female fawns breed in such habitats. Haugen (1975) found 82% of fawns bred in Iowa. Fifty percent of Fort Riley fawns collected in 1979 were pregnant. Concurrent studies of the food habits of the Fort Riley deer herd showed little use of crops on a year-round basis. Apparently, despite little use of agricultural crops, productivity of prairie white-tailed deer is comparable to deer in Iowa where > 60% of the diet consists of agricultural crops.

## Conclusions and Management Implications

This study provided baseline data on ovulation rates, fetal rates, persistence of lactation and testes weights of the Fort Riley deer herd. Ovulation and fetal rates were comparable to productivity in other areas of the midwest where agricultural crops comprise a much larger percentage of the year-round diet of deer. Fetal sex ratios and mean conception dates were similar to those reported for Iowa white-tailed deer.

Percentage of female fawns breeding varied considerably between years. The annual population increment attributed to fawns was estimated to range between 3 and 15%. Variability in female fawn breeding activity was attributed to the age of fawns at the onset of the rut.

Persistence of lactation was not uncommon into December in Fort Riley deer. Variations in lactating yearling females between years was related to percent fawns breeding the previous year.

A testicular index (TI) was useful for monitoring the seasonal and yearly sexual activity of males. Yearlings and adults had elevated TI's in the fall. There was no evidence male fawns participated in the rut.

Less than 6-month-old female fawns were less productive and smaller than > 6-month-old fawns. In high quality habitat, one may be able to estimate the percent of female fawns breeding in a given year simply from the age of fawns at the onset of the rut.

# BLOOD CHARACTERISTICS OF THE FORT RILEY DEER HERD

## Introduction

Research on the use of blood tests for assessment of the condition of wild deer populations and, by inference, condition of their habitat has increased recently. LeResche et al. (1974) and Seal (1977) reviewed the use of blood parameters in evaluating the condition of various ungulates and concluded that the full potential of blood analyses has not been fully reached. Seal et al. (1981) stressed the importance of collecting "reference" values of blood parameters, rather than impossible to define "normal values" for specific deer populations.

Blood characteristics of white-tailed deer (Odocoileus virginianus) have been reported for free-ranging herds in Maryland (Wilber and Robinson 1958), Texas (White and Cook 1974, Blankenship and Varner 1977), Michigan (Coblentz 1975) and Minnesota (Seal and Erikson 1969, Seal et al. 1978). Most of these studies had small sample sizes (<10), data on only a few parameters, or samples from a single month or season.

While Tumbleson et al. (1968) examined blood parameters in penned Missouri deer, no studies have reported the blood characteristics of free-ranging, mid-western, white-tailed deer. The purpose of this study was to establish reference values for selected hematological and blood chemistry parameters of a free-ranging white-tailed deer herd on the Fort Riley Military Reservation, Kansas.

I thank personnel of the Veterinary Activity, Fort Riley, especially S. Cirone and R. Hunt for providing supplies and coordinating blood sample analyses. R. Adams, Department of Pathology, Irwin Army

Hosiptal, for assistance in interpreting results. B. A. Brown and L. A. Lorence assisted in collecting deer. K. Sexson, Kansas Fish and Game Commission, coordinated aging of all deer. R. L. Kirkpatrick and R. J. Warren provided valuable insights and encouragement, and R. J. Robel carefully reviewed the manuscript. This study was supported by the Division of Biology, Kansas Agricultural Experiment Station, Kansas State University; the Kansas Fish and Game Commission; and the Department of the Army.

## Methods

Between February 1979 and October 1979, 54 white-tailed deer were collected from the Fort Riley Military Reservation, Kansas. Deer were killed between 2100 and 0300 by shooting in the head or neck. Within 10-30 minutes after shooting the animal, whole blood samples were collected from the jugular vein of each deer; two 20 ml plain vacutainers full and 10 ml in heparinized collection tubes. Blood samples were placed on ice in an insulated cooler and transported to a field laboratory. The 20 ml blood samples were allowed to clot at room temperature for 2-3 hours. Samples were then centifuged at 7,000 rpm for 15 minutes; the sera extracted and placed in 10 ml glass vials and frozen. Only samples which showed no hemolysis or lipemia were used in blood chemistry studies (Blankenship and Varner 1977).

Within 4 weeks after sample collection, serum was allowed to thaw at room temperature and blood chemistries for glucose, lactic dehydrogenase (LDH), serum glutamic oxalacetic transaminase (SGOT), alkaline phosphatase, uric acid, serum urea nitrogen (BUN), total protein, albumin, cholesterol and calcium were determined on an SMA-12 Technicon Analyzer in the Department of Pathology, Irwin Army Hospital. Duplicate 2 ml sub-samples were analyzed in all cases.

Heparinized blood samples were transferred to micro-hematocrit capillary tubes. Samples were centrifuged at 7,000 rpm for 15 minutes and hematocrit (packed cell volume, PCV) recorded from a micro-hematocrit card reader.

Deer were aged using tooth eruption and wear (Severinghaus 1949) and classified as fawns ($\leq$ 12 months of age) or adults (> 12 months of

age). Based on date of collection, animals were placed in 1 of 4 seasons: winter (2 Feb - 23 Mar), spring (1 Apr - 17 May), summer (24 Jun - 15 Aug) or fall (17 Sep - 22 Oct).

In addition, blood samples were collected from hunter killed, white-tailed deer at the Fort Riley hunter check station in December 1979-1981. Hunters were required to bring animals in whole and record the time of death before tagging the deer. As soon as the animal arrived at the check station, the chest was opened and a blood sample drawn from the superior vena cava into a 20 ml syringe. The sample was transferred to a 20 ml vacutainer and allowed to clot at room temperature for 2-3 hours. Additionally, 2 heparinized micro-hematocrit tubes were filled with blood and centifuged at 7,000 rpm for 15 minutes. PCV was determined on a micro-hematocrit card reader. Whole blood samples were centrifuged at 7,000 rpm for 15 minutes; sera extracted and placed in 10 ml glass vials and frozen. Within 4 weeks after collection, serum was analyzed for the blood chemistry parameters already mentioned on an SMA-12 Technicon Analyzer.

Animals were aged based on incisor structure, size and counts of cementum annuli (Sexson 1982). Deer 1.5 years and older were classified as adults. Animals 5-7 months of age were classified as fawns.

Data collected on a seasonal basis were treated separately from hunter check station collections. All data were examined using SAS (Barr et al. 1979). Analysis of variance for unequal sample sizes was used to test for differences due to age, sex, season and year of collection. When significant ($p < 0.05$) differences were found, the LSMEANS procedure or student t-test was used to compare sample means.

Product moment correlation coefficients were used to test the relationship between time of harvest and time of sample collection after death on blood parameters of hunter check station deer. In addition, correlation coefficients were used to test the interrelationships between selected parameters.

## Results and Discussion

Fifty-four white-tailed deer were collected between February and October 1979. Useable blood samples were obtained from 30 adult does and 13 fawns. No useable samples were obtained from adult males.

Because I found no age or season differences ($p > 0.05$) for PCV, glucose, LDH, SGOT, albumin, total protein or uric acid, I pooled all deer to calculate means for these parameters (Table 14). Mean PCV was 45.9% for 30 does and 9 fawns. Seal et al. (1978) found PCV of 43.5% for 40 white-tailed deer collected in Minnesota. PCV for Texas white-tailed deer averaged 49.5% with a range of 39.4-66.1%. No differences in PCV were related to age or season of collection (White and Cook 1974). PCV for Fort Riley deer ranged from 37-56%. Franzmann and LeResche (1978) concluded PCV reflected changes in habitat quality and was the best single parameter for predicting condition of Moose (Alces alces).

Glucose, SGOT, LDH and uric acid values were highly variable among animals. Coefficients of variation (CV) ranged from 59.5% for glucose to 130.3% for SGOT. CV for albumin, total proteins and calcium was much lower averaging 12%. Increased levels of excitability, stress and trauma have been associated with elevated levels of serum glucose and serum emzymes (Franzmann 1972, Seal et al. 1981). Elevated levels of LDH and SGOT are indicative of general trauma and tissue damage (Coles 1967). The high degree of variability for glucose, LDH, SGOT and uric acid in Fort Riley deer suggests that despite attempts to instantly kill deer, considerable differences between deer existed in the amount of stress while dying. Several animals had much higher levels for glucose, LDH and SGOT than the reference values report by Seal et al. (1981).

Table 14. Packed cell volume (PCV) and blood chemistries of free-ranging Fort Riley deer collected February through October 1979.

| Characteristic | Sample Size | $\bar{x}$ | SD | Range | | CV[a] |
|---|---|---|---|---|---|---|
| | | | | Min | Max | |
| Packed cell volume % | 39 | 45.9 | 5.2 | 37.0 | 66.0 | 11.3 |
| Glucose (mg/dl) | 43 | 200 | 119 | 59 | 660 | 59.5 |
| SGOT (U/L) | 43 | 254 | 331 | 83 | 1730 | 130.3 |
| LDH (U/L) | 43 | 742 | 548 | 296 | 3010 | 73.9 |
| Uric Acid (mg/dl) | 43 | 0.6 | 0.4 | 0.1 | 1.6 | 66.7 |
| Albumin (g/dl) | 43 | 3.0 | 0.4 | 2.3 | 4.0 | 13.3 |
| Total Protein (g/dl) | 43 | 6.2 | 0.7 | 4.9 | 8.0 | 11.3 |
| Calcium (mg/dl) | 43 | 10.0 | 1.3 | 6.6 | 12.8 | 13.0 |

[a] Coefficient of variation

Mean total serum protein and albumin levels of Fort Riley deer were 6.2 g/dl and 3.0 g/dl, respectively. Anderson et al. (1972) found seasonal variation in total serum protein in adult male deer, but not females. Age was also a source of variation for serum protein levels. Seal et al. (1978) found no age, sex or season effects for serum protein or albumin in free-ranging Minnesota white-tailed deer. Warren et al. (1981) found no difference in albumin levels between ablibitum and restricted diets in adult male white-tailed deer.

Calcium levels of Fort Riley deer ranged from 6.6 mg/dl to 12.8 mg/dl and were within the range of those reported for white-tailed deer (Seal et al. 1981) and other ungulates (LeResche et al. 1974). Tumbleson et al. (1968) found serum calcium increased from birth to 6 months of age. The majority of fawns collected in this study were > 6 months old. Lack of differences in calcium levels related to age of Fort Riley fawns may be due to the older age of the animals sampled or the small sample size.

BUN was unaffected by age ($p < 0.35$) but varied seasonally ($p < 0.01$) (Figure 2). Mean values ranged from 13 mg/dl in winter to 38 mg/dl in spring. Concurrent studies of the nutritional status of the Fort Riley deer herd showed that crude protein levels of the rumen contents increased from late winter through spring and then declined. BUN was highly correlated to protein levels of the rumen contents ($r = 0.62$, $p < 0.01$). Other investigators have reported a high correlation between protein intake and BUN levels in livestock (Preston et al. 1961, 1965, Torell et al. 1974), moose (LeResche et al. 1974, Franzmann and LeResche 1978), bighorn sheep (Ovis canadensis) (Franzmann 1972), bison (Bison bison) (Hawley and Peden 1982) and white-tailed deer

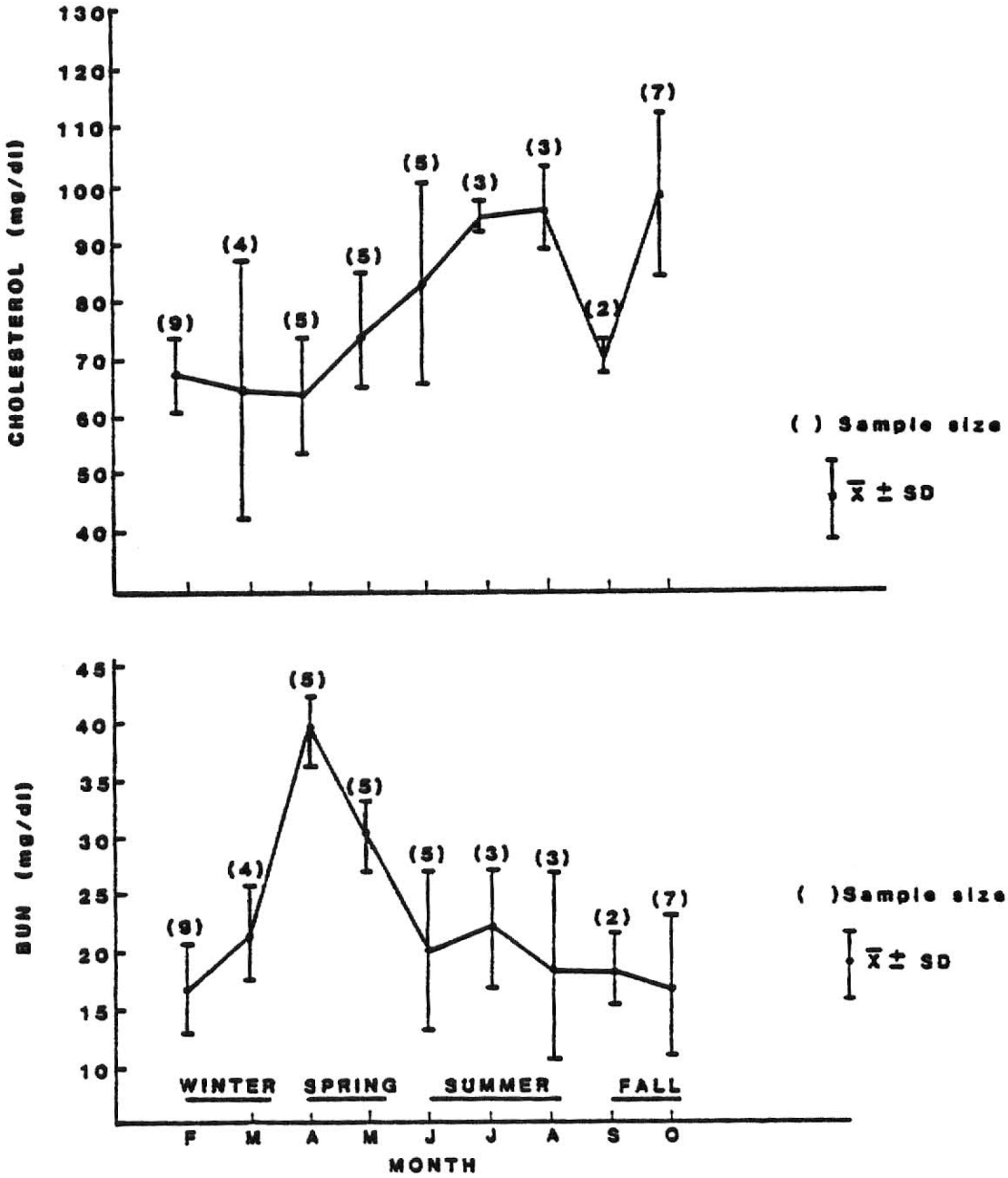


Fig. 2. Seasonal variation in cholesterol and serum urea nitrogen (BUN) of Fort Riley white-tailed deer, February 1979- October 1979.

(Skeen 1974). Kirkpatrick et al. (1975) emphasized the importance of both protein intake and energy intake on BUN levels. Urea nitrogen may be elevated in the blood with increased protein intake or protein catabolism.

Serum cholesterol was unaffected by age ($p < 0.35$) but varied seasonally ($p < 0.03$) (Figure 2). Levels were lowest in winter (68 mg/dl) and highest in fall (96 mg/dl). Cholesterol levels were positively correlated to the molar percent of butyric acid in the rumen fluid ($r = +0.40$, $p < 0.01$) and negatively correlated to the molar percent of acetic acid ($r = -0.43$, $p < 0.01$). Increased levels of propionic and butyric acid and reduced levels of acetic acid are typical of ruminants consuming highly digestible foods (Church 1975). Coblentz (1975) found decreasing cholesterol in Michigan white-tailed deer from October through January. Serum cholesterol was believed to reflect the quantity and quality of forage consumed. Seal el al. (1978) found no seasonal differences in cholesterol levels of Minnesota white-tails; however, they collected animals only from November through March.

Alkaline phosphatase levels of Fort Riley fawns were higher ($p < 0.01$) than adult does and varied ($p < 0.03$) seasonally (Table 15). Fawns had significantly higher circulating levels than adults in all seasons. Mean level for fawns was lower ($p < 0.05$) in winter compared to spring, summer and fall. Considering bone growth is associated with an increase in osteoblast activity and, therefore, an increase in serum alkaline phosphatase levels (Coles 1967), these results indicate a decrease in skeletal growth over winter in growing fawns and an increase in growth the following spring through fall. Adult females tended to have higher alkaline phosphatase levels in late spring compared to other

Table 15. Alkaline phosphatase activity (U/L) of 30 doe and 13 fawn white-tailed deer collected February through October 1979, Fort Riley.[a]

| Age Class | Season | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Winter | | Spring | | Summer | | Fall | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| Adult Does | 111 | 33d (11) | 222 | 62a (7) | 140 | 61ad (6) | 151 | 84ad (6) |
| Fawns | 206 | 33c (2) | 643 | 55b (3) | 616 | 59b (5) | 736 | 200b (3) |

[a] Means within a row or column having a common letter are not different ($p > 0.05$). Sample size in paranthesis.

seasons. Elevated alkaline phosphatase activity during the last trimester of pregnancy has been reported for domestic livestock (Duke 1955).

Hunter Check Station Collections

Blood samples were collected from 149 white-tailed deer at a mandatory hunter check station on Fort Riley in December 1979, 1980 and 1981. Useable samples were obtained from 75 deer (31 bucks, 28 does, 16 fawns).

The time of day killed and time lapse between death and blood sample collection were not correlated to any of the blood parameters sampled (Table 16). The low correlation coefficients suggest that sampling time and time lapse between death and sampling account for little of the variation in blood values among animals. The majority of the animals were killed between 0800 and 1200 hours. Blood was taken from most animals between 0.5 and 2 hours after death. No hemolytic or lipemic samples were included in these analyses.

For most parameters measured, the coefficients of variation were similar between hunter check station deer and those collected seasonally. Mean values for PCV, glucose, SGOT, LDH, and uric acid were not different between hunter check station collections and animals collected systematically (Table 17).

There were between year differences ($p < 0.05$) in total protein, albumin, cholesterol and calcium (Table 18). None of these parameters was affected by age or sex. Total proteins, albumin, cholesterol and calcium were lower in 1980 compared to 1979 and 1981.

Table 16. Correlation of time killed and time lapse between sample collection and death to selected blood parameters of white-tailed deer collected December 1979-1981, Fort Riley.

| Parameter | N | Time of Day Killed[a] | | Time Lapse[b] Between Sample Collection and Death | |
|---|---|---|---|---|---|
| | | r | Significance | r | Significance |
| Packed cell volume | 73 | 0.08 | $p > 0.5$ | 0.08 | $p > 0.5$ |
| Glucose | 72 | 0.07 | $p > 0.5$ | -0.13 | $p > 0.3$ |
| SGOT | 71 | 0.02 | $p > 0.9$ | -0.11 | $p > 0.4$ |
| LDH | 71 | -0.01 | $p > 0.9$ | -0.04 | $p > 0.8$ |
| Alkaline phosphatase | 72 | -0.14 | $p > 0.2$ | 0.20 | $p > 0.05$ |
| Uric acid | 72 | 0.09 | $p > 0.4$ | -0.14 | $p > 0.3$ |
| Total Protein | 72 | -0.04 | $p > 0.7$ | -0.16 | $p > 0.2$ |
| Albumin | 72 | -0.11 | $p > 0.3$ | -0.18 | $p > 0.1$ |
| Cholesterol | 72 | 0.19 | $p > 0.1$ | -0.11 | $p > 0.4$ |
| Calcium | 70 | -0.09 | $p > 0.5$ | -0.11 | $p > 0.4$ |

[a] Times ranged from 0800 - 1700 hours

[b] Times ranged from 0.5 - 3.5 hours

Table 17. Packed cell volume (PCV) and blood chemistries of free-ranging Fort Riley deer obtained at a hunter check station, December 1979-1981.

| Parameter | N | Mean | SD | Range | CV[a] |
|---|---|---|---|---|---|
| PCV % | 61 | 42.5 | 7.5 | 26.5-58.0 | 17.6 |
| Glucose (mg/dl) | 75 | 213 | 200 | 20-670 | 93.9 |
| SGOT (U/L) | 74 | 237 | 211 | 51-2950 | 89.0 |
| LDH (U/L) | 74 | 674 | 221 | 237-1010 | 32.8 |
| Uric Acid (mg/dl) | 75 | 0.7 | 0.4 | 0.1-1.9 | 57.0 |

[a] Coefficient of variation

Table 18. Between year variability in total proteins, albumin, cholesterol and serum calcium levels of Fort Riley deer collected in December, 1979-1981.

| Year | N | Total Proteins (g/dl) | | Albumin (g/dl) | | Cholesterol (mg/dl) | | Calcium (mg/dl) | |
|---|---|---|---|---|---|---|---|---|---|
| | | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| 1979 | 14 | 5.9 | 0.7a[a] | 3.0 | 0.4a | 54 | 14a | 10.8 | 1.0a |
| 1980 | 25 | 4.4 | 1.3b | 2.1 | 0.6b | 32 | 10b | 8.1 | 2.5b |
| 1981 | 36 | 5.8 | 1.0a | 3.0 | 0.3a | 40 | 11c | 10.0 | 1.3a |

[a] Means within a column having a common letter do not differ. ($p > 0.05$)

Alkaline phosphatase activity was not different between year of collection for any age-sex class. Fawns had higher ($p < 0.05$) levels than bucks or does, except fawns collected in 1979 were not significantly ($p < 0.10$) different than does (Table 19).

BUN levels were affected by age ($p < 0.02$) but not year of collection ($p < 0.10$). Within an age X sex class, BUN levels did not differ between years (Table 19). However, serum urea values of bucks tended to be higher than does or fawns and were significantly ($p < 0.05$) so in 1981. Elevated levels of BUN in adult males may be related to protein catabolism rather than differences in protein intake. Concurrent studies of the nutritional status of the herd showed adult males have very low fat reserves in December compared to does and fawns. Adult males are in a negative energy balance in December because of reduced food intake and the high energy demands of the rut (Long et al. 1965, Mautz 1978). In order to meet their energy needs, adult males may have to mobilize body proteins resulting in elevated BUN levels. Adult females and fawns deposit considerably more fat by December, do not reduce food intake appreciably, and are in a positive energy balance. BUN values for does and fawns collected in December probably reflect dietary protein levels.

"Normal" values for blood parameters of free-ranging white-tailed deer are impossible to define because of variations in blood chemistry produced from method of handling and sampling, stress, season of collection, and nutritional effects in apparently healthy animals (LeResche et al. 1974, Wesson 1979 a,b). The establishment of "reference" values are more appropriate (Seal et al. 1981).

Table 19. Variation in alkaline phosphatase and serum urea nitrogen (BUN) levels of Fort Riley deer collected in December of 1979-1981.[a]

| Year | PARAMETER | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Alkaline phosphatase (U/L) | | | | | | BUN (mg/dl) | | | | | |
| | Bucks | | Does | | Fawns | | Bucks | | Does | | Fawns | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| 1979 | 167 | 103a (4) | 260 | 203ab (6) | 399 | 227b (4) | 21 | 11a (4) | 18 | 7ab (6) | 15 | 2ab (4) |
| 1980 | 259 | 193a (9) | 206 | 180a (11) | 410 | 191b (10) | 23 | 6a (9) | 18 | 5a,b (11) | 16 | 8b (10) |
| 1981 | 232 | 175a (18) | 215 | 136a (11) | 431 | 220b (7) | 28 | 9a (18) | 21 | 7b (11) | 19 | 7b (7) |

[a] Means within a row or column having a common letter are not different ($p > 0.05$). Sample size in paranthesis. Parameters treated separately.

Blankenship and Varner (1977) concluded that the best deer blood samples comes from an animal that drops immediately from a shot in the neck without any subsequent struggle. They felt extreme caution should be used in interpreting any blood data acquired from drugged animals.

Animals collected at the Fort Riley hunter check station varied considerably in the amount of stress while dying. Evidence for this is the large CV for glucose, SGOT and LDH. Abnormally high levels of these blood parameters have been related to stress (Seal and Erikson 1969, LeResche et al. 1974, Franzmann 1972). However, the low CV for other parameters, particularly BUN and cholesterol, suggests degree of stress and trauma have little influence on these parameters. Hunter check station animals provide a means of collecting a large sample and establishing reference values for selected parameters. Abnormally high levels of glucose, LDH and SGOT indicate an animal severely stressed while dying and, thus, provide a means of screening blood samples before developing a set of blood profiles for a specific deer herd.

## Conclusions and Management Implications

This study provided reference values for selected hematology and blood chemistries of free-ranging white-tailed deer on the Fort Riley Military Reservation, Kansas. Glucose, LDH, SGOT and uric acid values were highly variable among animals and probably related to stress while dying. Abnormally high levels for glucose and serum enzymes may be used to "screen" blood samples when developing a blood profile of a deer herd. Total protein, albumin and calcium were unaffected by age or season of collection. Cholesterol and BUN were unaffected by age but varied seasonally. Increased cholesterol levels were related to increased rumen butyric acid levels, and BUN was highly correlated to crude protein levels of rumen contents. Alkaline phosphatase activity reflected bone growth in growing fawns.

Reference values for packed cell volume and blood chemistries reported in this study were within the established range for undrugged white-tailed deer (Seal et al. 1981). Of all parameters examined, only BUN and cholesterol show potential for monitoring the short-term nutritional history of free-ranging white-tailed deer. Care should be exercised when attempting to evaluate nutritional status based solely on blood parameters.

# NUTRITIONAL CHARACTERISTICS OF THE FORT RILEY DEER HERD

## Introduction

The importance of nutrition to maintaining optimum wildlife populations is well documented. In general, animals with adequate food of acceptable quality grow larger, produce more young and are more vigorous and healthy and more resistent to disease than undernourished animals (Nagy and Haufler 1980).

Various methods have been developed to evaluate the nutritional status of free-ranging animals (Kirkpatrick 1980). Chemical composition of rumen solids has been used to evaluate habitat conditions of free-ranging ungulates (Klein 1962, Kirkpatrick et al. 1969 and Skeen 1974). Rumen fluid volatile fatty acid concentration and composition have been related to food intake and quality of foods consumed (Bath and Rook 1963, Hodgson et al. 1976). Rumen volatile fatty acids have been reported for free-ranging moose (Alces alces) (Gasaway and Coady 1974), mule deer (Odocoileus hemionus) (Short et al. 1966) and white-tailed deer (Odocoileus virginianus) (Short 1963, Short et al. 1969a and Skeen 1974).

Because of changes due to differential digestion (Bruggeman et al. 1968, Lascano et al. 1970), contamination of sample with recycled nitrogen (Robbins et al. 1974) and saliva (Cook 1964) and effects of variable feeding times (Church 1975), exact amounts of chemical components of ingested forages cannot be determined from rumen content analyses; however, such analyses can reflect relative differences in forage quality and nutritional status of wild ruminants (Kirkpatrick et al. 1969, Klein and Schonheyder 1970).

Fat reserves provide a means of evaluating the energetics of free-ranging deer and, by inference, the quality of their diet on a short term basis (Kirkpatrick 1980). The kidney fat index developed by Riney (1955) and the modified total kidney fat index developed by Monson et al. (1974) have been used to evaluate the fat reserves of white-tailed deer (Hesselton and Sauer 1973, Finger et al. 1981, Kie et al. 1983).

The purpose of this study was to describe and relate seasonal variations in food habits, chemical composition of rumen contents, and fat reserves to the nutritional status of free-ranging white-tailed deer on the Fort Riley Military Reservation, Kansas.

I thank personnel of the Fish and Wildlife Office, Fort Riley, for making facilities available at their field laboratory and for assistance in collecting animals. B. A. Brown assisted in collecting animals and provided valuable advice on data analysis. T. Barkley and H. Townsend assisted in food habits evaluations and L. Nusback coordinated running of volatile fatty acids and crude proteins. B. E. Brent provided expertise on various aspects of sample collection procedures, analysis and data interpretation. K. Sexson aged all deer and R. J. Robel carefully reviewed the manuscript. This study was supported by the division of Biology, Kansas Agricultural Experiment Station, Kansas State University; the Kansas Fish and Game Commission; and the Department of the Army.

## Methods

White-tailed deer were collected between 2100 and 0300 by shooting in the head or neck. Within 4 hours after death, the rumen was removed intact; separated from the abomasum, omasum and reticulum, then the rumen contents were emptied into a plastic pail and thoroughly mixed. A liter sample of rumen contents was squeezed through cheese cloth and the solids placed in 10% formalin. A 20 ml sample of the cheese cloth filtrate was collected in a glass vial and the pH determined using an electronic pH meter. The sample was acidified with 4 ml of 6N sulfuric acid to prevent further fermentation, then frozen. Another 1 liter sample of rumen contents was squeezed as dry as possible, and the solid portion placed in freezer bags and frozen. When 2 liters of rumen contents were not available, the contents were divided into 2 equal samples.

Kidneys with attached perirenal fat were removed from each animal. Kidneys and fat were weighed to the nearest 0.1 g; the fat removed and the kidneys reweighed. Amount of fat was determined by substraction. The total kidney fat index (TKFI) (Monson et al. 1974) was calculated:

$$\text{TKFI} = \frac{\text{wt. right kidney fat + wt. left kidney fat}}{\text{wt. right kidney + wt. left kidney}} \times 100$$

In cases where 1 kidney was damaged, a single kidney was used to calculate the TKFI.

Identical procedures were used to collect samples from deer brought in whole to a hunter check station in December 1978. The time the deer was killed was obtained from the hunter, and the time of rumen sample collection was recorded for each deer. Rumen samples were collected

only from deer with undamaged stomachs. Additionally, TKFIs were determined for road kill deer collected between February and October 1979, and hunter check animals in December 1979-81.

## Laboratory Analysis

### Food Habits

Rumen samples collected for food habits analyses were washed with tap water through 4 and 10 mesh screen sieves to remove small fragments. Samples were analyzed by the point-frame method of Chamrad and Box (1964). Dietary items were identified to species whenever possible. All fragments were placed in 1 of 7 forage classes for seasonal comparisons: browse (woody stems and leaves), grasses (stems and leaves), fruits and seeds, forbs (stems and leaves), agricultural crops, acorns, and unidentified fragments. Common and scientific names of plants follow Anderson and Owensby (1969).

### Rumen Solid Analysis

Within 1 month of collection rumen solid samples were thawed, weighed and oven dried for 48 hours at 65°C. Percent partial dry matter was calculated as percent weight remaining (Harris 1970). The sample was then ground in a Wiley cutting mill, placed in a glass vial, sealed and frozen. A 3 g sample of the partial dry sample was oven dried for 24 hours at 105°C. Percent dry matter was calculated as percent weight remaining. Duplicate samples were run on all samples.

Percent nitrogen was determined using Macro-Kjedahl digestion (Boric Acid Procedure). Percent crude protein was estimated by

multiplying the percent nitrogen by 6.25 (Harris 1970). Neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin were determined using the procedures of Goering and Van Soest (1970). The permanganate-lignin procedure was used in this study (Harris 1970). Standard AOAC (1975) methods were used to determine total ash. Gross energy was determined using a Parr adiabatic oxygen bomb calorimeter at 20 atmospheres of oxygen. Percent NDF, ADF, lignin, ash, crude protein and gross energy of rumen solid samples are reported on a dry weight basis.

Rumen Fluid Analysis

Acidified rumen fluid samples were analyzed for volatile fatty acid concentrations. Samples were thawed and centrifuged at 25,000 rpm for 20 minutes. Rumen liquor was separated from solid material using a bacterological pipette and placed in a glass vial, tightly sealed and stored frozen. Within 2 months, samples were thawed, then analyzed for concentrations of the individual volatile fatty acids: acetic, propionic, butyric, valeric, isovaleric and isobutyric on a gas liquid chromatograph using a 6 ft. x 1/8 in. chromosorb 10 glass column and a hydrogen flame ionization detector. Because individual concentrations were minimal, valeric, isovaleric, and isobutyric were combined into higher acids. Total acid concentrations (VFAs) were determined by adding the individual acids together. Molar percents of the individual acids were calculated as percent of the total acids.

Deer collected between February and October 1979 were aged by tooth eruption and wear (Severinghaus 1949) and classified as fawns ($\leq$ 13 months old), or adults (> 13 months). Animals were placed in 1 of

4 seasons based on date of collection: winter (2 Feb - 23 Mar), spring (1 Apr - 17 May), summer (24 Jun - 15 Aug), or fall (17 Sep - 23 Oct). Animals collected in December were aged based on incisor size, structure and wear. Incisor size and structure were used to separate fawns from yearlings. Adults were separated from yearlings based on amount of wear on the incisors (Sexson 1982).

Data were analyzed using SAS (Barr et al. 1979). Least squares analysis of variance for unequal sample size was used to partition variation due to age, sex, season or year of collection. When no significant differences were detected, the data were collapsed. When appropriate, the student t-test and LSMEANS procedure were used to compare sample means. Product moment correlation coefficients were used to test the correlation between selected variables. Statistical tests attaining an alpha level of $p < 0.05$ were considered significantly different.

Data from animals collected in December were analyzed separately from those collected seasonally. Rumen samples of deer collected in December 1978 were used to test the effects of time of day killed, time lapse between sample collection and death and age x sex on selected rumen solid and rumen fluid parameters.

## Results and Discussion

### Effects of Time of Day Killed and Time Lapse Between Sample Collection and Death on Rumen Content Parameters

#### Rumen Solids

Rumen solid samples were obtained from 59 white-tailed deer in December 1978 at a hunter check station on Fort Riley. Animals were killed between 0800 and 1750. Thirty-eight animals were harvested between 0800-1100, 9 between 1101-1359, and 12 between 1400-1700. Time of day Fort Riley deer were killed was not correlated to any of the rumen solid parameters (Table 20). Kirkpatrick et al. (1969) concluded time of kill was not a significant source of variation for rumen chemical components of deer killed throughout the southeast.

Time lapse between sample collection and death varied from 0.5 to 4 hours (Table 20). Rumen solids sampled > 2 hours after death had lower ($p < 0.05$) ash content than those collected $\leq$ 1 hour after death. Percent rumen NDF was higher ($p < 0.05$) in animals dead > 2 hours than those dead > 1 $\leq$ 2 hours. Lignin levels were higher ($p < 0.05$) for animals dead > 1 hour compared to $\leq$ 1 hour. Percent ADF and gross energy (Kcal/g) were higher ($p < 0.05$) for deer dead > 2 hours compared to those dead $\leq$ 1 hour. Crude protein levels were higher ($p < 0.05$) from deer dead > 1 $\leq$ 2 hours, than those dead $\leq$ 1 hour or > 2 hours. In general, percent NDF, ADF and lignin increased the longer the animal was dead, while percent ash declined. These results are consistent with continued microbial digestion of soluble carbohydrates after the death of the animal. Under such conditions, the fiber portion

Table 20. Effect of time killed and time of sample collection after death on rumen content parameters of white-tailed deer collected December 1978, Fort Riley, Kansas.

| Parameter | Time Lapse Between Sample Collection And Death[a] | | | | | | r | |
|---|---|---|---|---|---|---|---|---|
| | ≤1 hour | | >1≤2 hours | | >2 hours | | TimeK[c] | TSCAD[d] |
| N | 12 | | 17 | | 12 | | 41 | 41 |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | | |
| (Dry Matter Basis) | | | | | | | | |
| ASH % | 11.4 | 4.2a | 8.8 | 3.6ab | 7.5 | 2.0b | 0.19 | 0.24 |
| NDF % | 62.8 | 9.3ab | 60.8 | 4.9a | 66.1 | 5.4b | 0.08 | -0.14 |
| ADF % | 41.5 | 4.5a | 44.0 | 4.9ab | 46.5 | 5.5b | 0.14 | -0.05 |
| Lignin % | 10.1 | 1.7a | 12.5 | 2.7b | 13.4 | 3.5b | 0.08 | 0.04 |
| Crude Protein % | 12.1 | 2.6a | 14.0 | 2.1b | 12.0 | 2.7a | 0.17 | 0.17 |
| Gross Energy (Kcal/g) | 4.5 | 0.2a | 4.7 | 0.2ab | 4.7 | 0.1b | -0.19 | 0.07 |

[a,b]Means with a common letter within a row are not different ($p > 0.05$)

[c]Time of day killed

[d]Time lapse between sample collection and death

of the forages consumed would increase in proportion to the soluble carbohydrates in the rumen.

Rumen Fluid

Rumen fluid samples were collected from 41 deer. Time of day killed was not significantly correlated to rumen fluid values, except that propionic acid concentration was negatively related to time killed ($r = -0.33$) (Table 21). The low correlation coefficient indicates < 11% of the variation in propionic concentration was attributed to time of day killed. Level of food intake and time since last feeding can affect VFA concentrations in the rumen (Annison and Lewis 1959, Church 1975)

Time lapse between sample collection and death was significantly correlated to nearly all rumen fluid parameters (Table 21). Acetic, propionic, butyric, higher acid and total volatile fatty acid concentrations were higher ($p < 0.05$) in samples collected > 2 hours after death compared to those collected $\leq$ 2 hours after death. Molar percent of acetic acid was lower ($p < 0.05$) while butyric and higher acids were elevated ($p < 0.05$) in samples collected > 2 hours after death, compared to samples collected < 2 hours after death. Molar percent of propionic acid and the acetic : propionic ratio were not related to sampling time after death.

Increased rumen VFA concentrations for deer dead > 2 hours suggests microbial fermentation continued after death of the animal, but absorption of VFAs across the rumen wall into the blood stream did not. Rumen VFA concentrations and molar percents were not different for animals dead $\leq$ 1 hour and animals dead > 1 $\leq$ 2 hours. Short et al. (1969a) concluded variations in rumen VFAs collected from white-tailed

Table 21. Effect of time killed and time of sample collection after death on rumen fluid parameters of white-tailed deer collected December 1978, Fort Riley, Kansas.

| Parameter | Time Lapse Between Sample Collection and Death | | | | | | r | |
|---|---|---|---|---|---|---|---|---|
| | ≤1 | | >1≤2 hours | | >2 hours | | TimeK[c] | TSCAD[d] |
| N | 12 | | 17 | | 12 | | 41 | 41 |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | | |
| Acetic Acid mM/L | 47.8 | 11.9a | 44.4 | 11.0a | 57.1 | 9.2b | -0.13 | 0.50**[e] |
| Propeonic mM/L | 23.9 | 7.9ab | 20.3 | 6.7a | 29.6 | 7.0b | -0.33* | 0.24 |
| Butyric mM/L | 11.9 | 5.7a | 9.6 | 4.7a | 18.1 | 6.1b | -0.13 | 0.56** |
| Higher mM/L | 1.3 | 1.0ab | 1.2 | 0.8a | 2.0 | 1.0b | -0.14 | 0.49** |
| Total VFA mM/L | 85.2 | 23.9a | 75.5 | 21.3a | 106.9 | 15.8b | -0.22 | 0.50** |
| Molar % | | | | | | | | |
| Acetic Acid | 57.3 | 5.2ab | 58.6 | 4.6a | 53.5 | 4.5b | 0.21 | -0.09 |
| Propionic | 28.0 | 4.0a | 27.4 | 2.9a | 27.5 | 3.7a | -0.24 | -0.30* |
| Butyric | 13.4 | 4.5ab | 12.4 | 3.6a | 16.7 | 6.8b | -0.05 | -0.45** |
| Higher | 1.8 | 0.9ab | 1.6 | 0.9a | 2.4 | 1.0b | 0.11 | 0.21 |
| Acetic: Propionic | 2.1 | 0.4a | 2.2 | 0.3.a | 2.0 | 0.4a | 0.11 | 0.04 |

[a,b]Means with a common letter within a row are not different ($p > 0.05$)

[c]Time killed

[d]Time lapse between sample collection and death: [e] *$p < 0.05$ **$p < 0.01$.

deer in Texas were due to time of day examined. However, in their study samples were taken from deer dead up to 4 hours, therefore, some of the differences they attributed to time killed might have been differences due to sampling time after death. To further complicate interpretation of their data, they studied variations due to time of day when the rumen sample was examined and not the time of day the deer was killed. Earlier work reporting seasonal variations in VFAs from the rumen of mule deer were obtained from animals collected 2 to 8 hours after death (Short et al. 1966). VFA concentrations from animals dead > 2 hours are difficult to interpret because of the effects of time lapse between sampling and death. In this study, rumen samples from deer dead > 2 hours were not included in seasonal comparisons.

Age-Sex Effects on Rumen Content Parameters

Age and sex of deer were not significant sources of variation for any of the rumen solid parameters (Table 22). Of all the rumen fluid characteristics examined, only the concentration of higher acids was affected by age x sex interaction ($p < 0.02$) (Table 23). Short et al. (1966) found no consistent differences in VFA composition, pH or rumen dry matter related to age or sex for 30 Colorado mule deer.

Seasonal Variations in Food Habits and Rumen Content Characteristics

Fifty-four white-tailed deer were collected between February and October 1979. Useable rumen samples were obtained from 31 adult does, 13 fawns, and 6 adult bucks. Because previous work indicated no age or sex effects on rumen parameters, all deer were grouped together for seasonal comparisons.

Table 22. Rumen solid characteristics of Fort Riley white-tailed deer, by age-sex group, December 1978.

| Character | Males | | Females | | Males | Females | Source of Variation | | |
|---|---|---|---|---|---|---|---|---|---|
| | Adults $\bar{x}$ SD | Fawns $\bar{x}$ SD | Adults $\bar{x}$ SD | Fawns $\bar{x}$ SD | $\bar{x}$ SD | $\bar{x}$ SD | Age | Sex | Age by Sex |
| (Dry Matter Basis) | | | | | | | | | |
| ASH % | 7.4 3.6 (18) | 10.3 3.9 (9) | 8.5 3.6 (13) | 7.7 4.2 (8) | 8.4 3.7 (27) | 8.2 3.8 (21) | p<0.39 | p<0.51 | p<0.10 |
| NDF % | 62.0 5.1 (18) | 64.2 6.5 (10) | 62.7 8.4 (14) | 61.1 8.3 (8) | 62.8 5.6 (28) | 62.1 8.4 (22) | p<0.39 | p<0.86 | p<0.19 |
| ADF % | 41.4 5.7 (18) | 45.3 4.2 (10) | 44.1 5.9 (14) | 43.3 8.1 (8) | 42.8 5.1 (28) | 43.8 6.7 (22) | p<0.91 | p<0.56 | p<0.36 |
| Lignin % | 9.8 2.7 (18) | 12.3 2.9 (10) | 11.4 2.7 (14) | 11.9 3.1 (8) | 10.7 2.8 (28) | 11.6 2.8 (22) | p<0.08 | p<0.44 | p<0.24 |
| Gross Energy (Kcal/g) | 4.7 0.2 (18) | 4.6 0.2 (10) | 4.7 0.2 (14) | 4.7 0.1 (8) | 4.7 0.2 (28) | 4.7 0.2 (22) | p<0.40 | p<0.46 | p<0.69 |
| Crude Protein % | 10.9 3.0 (17) | 12.2 1.9 (10) | 13.9 2.3 (13) | 12.0 2.8 (7) | 11.4 2.6 (27) | 13.2 2.5 (20) | p<0.68 | p<0.08 | p<0.06 |

[a]Sample size

Table 23. Rumen fluid characteristics of Fort Riley white-tailed deer, by age-sex group, December 1978.

| Character | Males | | | | Females | | | | Males | | Females | | Source of Variation | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Adults | | Fawns | | Adults | | Fawns | | | | | | | | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | Age | Sex | Age by Sex |
| N | 7 | | 11 | | 11 | | 4 | | 18 | | 15 | | | | |
| Acetic Acid mM/L | 43.7 | 4.3 | 51.7 | 10.8 | 44.3 | 12.5 | 37.5 | 7.8 | 47.7 | 8.3 | 40.9 | 11.2 | p<0.11 | p<0.11 | p<0.36 |
| Propionic Acid mM/L | 23.2 | 4.9 | 24.6 | 7.5 | 20.6 | 8.4 | 16.9 | 3.7 | 23.9 | 6.5 | 18.8 | 7.1 | p<0.67 | p<0.07 | p<0.34 |
| Butyric Acid mM/L | 10.8 | 5.1 | 12.7 | 4.8 | 9.7 | 5.2 | 9.6 | 5.7 | 11.7 | 4.9 | 9.6 | 5.3 | p<0.64 | p<0.29 | p<0.58 |
| Higher Acids mM/L | 0.8 | 0.5 | 1.5 | 1.1 | 1.4 | 0.7 | 0.5 | 0.4 | 1.2 | 0.9 | 0.9 | 0.6 | p<0.73 | p<0.44 | p<0.02 |
| Total VFA mM/L | 78.6 | 8.9 | 90.5 | 21.2 | 76.1 | 25.5 | 64.7 | 16.6 | 84.6 | 16.4 | 70.3 | 23.1 | p<0.97 | p<0.08 | p<0.14 |
| Molar % | | | | | | | | | | | | | | | |
| Acetic Acid | 55.7 | 4.9 | 56.8 | 4.2 | 59.6 | 5.1 | 58.8 | 6.1 | 56.2 | 4.5 | 59.2 | 5.4 | p<0.96 | p<0.12 | p<0.68 |
| Propionic | 29.5 | 5.0 | 28.1 | 3.3 | 26.7 | 2.6 | 26.5 | 2.4 | 28.8 | 3.9 | 26.6 | 2.6 | p<0.51 | p<0.10 | p<0.64 |
| Butyric | 13.3 | 5.0 | 13.9 | 3.3 | 12.1 | 3.5 | 13.6 | 5.8 | 13.6 | 3.9 | 12.8 | 4.1 | p<0.49 | p<0.62 | p<0.76 |
| Higher | 1.4 | 0.5 | 1.8 | 1.2 | 1.9 | 0.9 | 1.1 | 0.6 | 1.6 | 0.9 | 1.5 | 0.8 | p<0.51 | p<0.93 | p<0.08 |
| Rumen pH | 6.1 | 0.1 | 5.9 | 0.2 | 6.4 | 0.2 | NA[a] | | 6.0 | 0.1 | 6.4 | 0.2 | p<0.06 | p<0.28 | NA |
| Acetic: Propionic | 1.9 | 0.4 | 2.0 | 0.3 | 2.3 | 0.4 | 2.2 | 0.3 | 2.0 | 0.3 | 2.2 | 0.4 | p<0.76 | p<0.07 | p<0.64 |

[a]Data not available

Food Habits

Fruits were most abundant in the rumens of deer collected in winter and fall (Figure 3). Acorns were absent from deer rumens in summer, but comprised 15% of the diet in fall. Browse was used relatively equally between winter, summer and fall but was less used in the spring. Grasses comprised only 4% of the year round diet of Fort Riley deer, while forbs were most used in the spring and summer, accounting for 67% of the diet in spring and 56% in summer. Agricultural crops were consumed in winter and fall, with winter wheat (Triticum sp.) and milo (Sorghum sp.) being the most common crops indentified in deer rumens. Agricultural crops comprised a smaller percent of the year round diet of Fort Riley deer than northeast Kansas deer (Watt et al. 1967) or Missouri deer (Korshgen 1962). The high consumption of acorns in the fall by Fort Riley deer was not surprising because agricultural crops were not available in large quantities. The importance of mast to deer has been well documented (Duvendeck 1962, Lay 1965, Harlow et al. 1975).

Rumen Solid Analysis

Percent ash was lower ($p < 0.05$) in the rumen solids of Fort Riley deer in the fall compared to spring or summer, but not winter. Gross energy of rumen solids averaged 4.7 Kcal/g, regardless of season collected.

Rumen solid crude protein levels were higher ($p < 0.05$) in spring than other seasons (Table 24). Summer levels were higher ($p < 0.05$) than fall and winter. The high rumen crude protein levels in spring and summer were related to the consumption of forbs ($r = 0.73$, $p < 0.01$). Low levels of crude protein in fall rumen samples were negatively

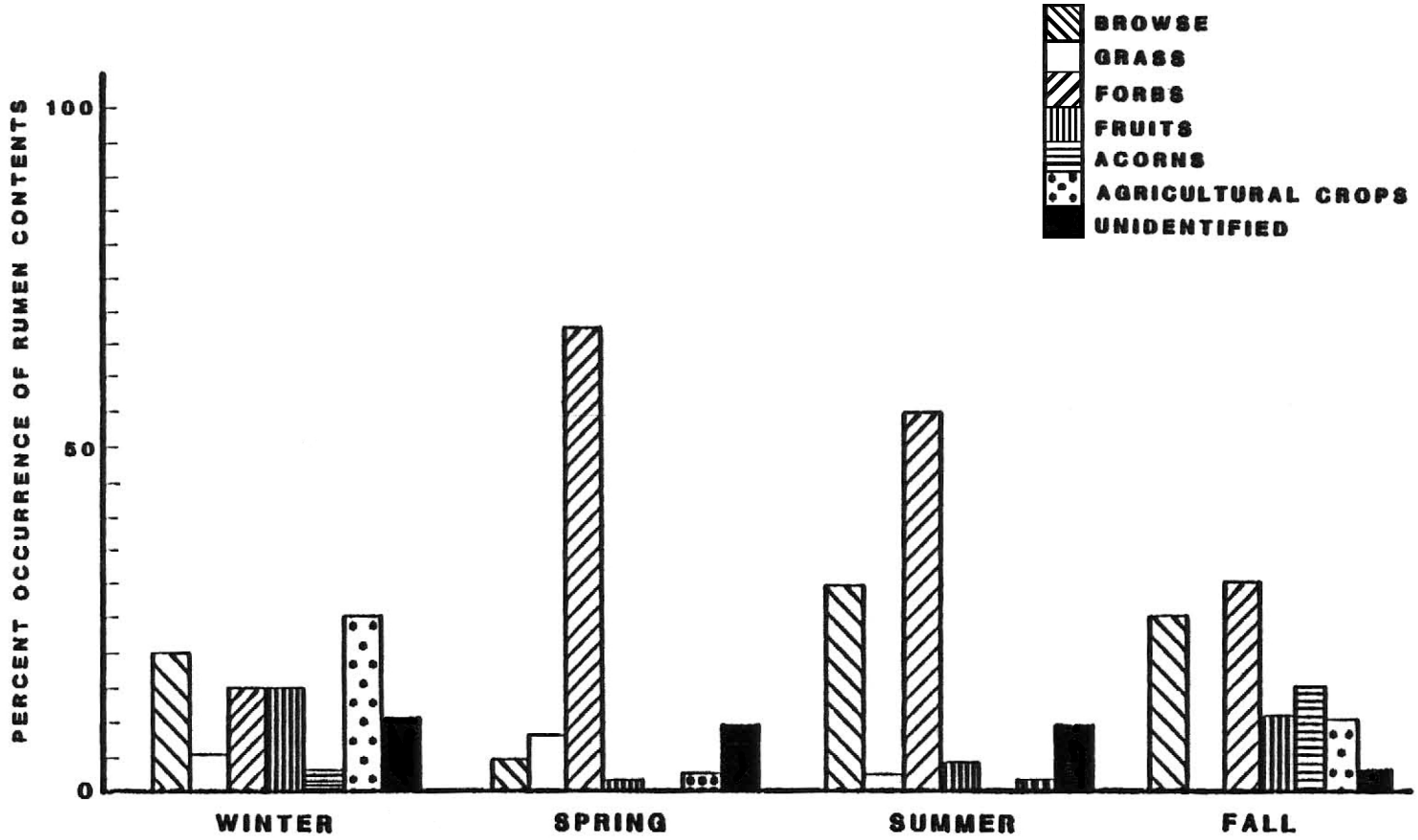


Fig. 3. Relative volume of 7 forage classes determined from rumens of white-tailed deer on Fort Riley, Kansas, February 1978–October 1978.

Table 24. Rumen solid characteristics of white-tailed deer collected February-October, 1979, Fort Riley, Kansas

| Characteristic | Season | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Winter | | Spring | | Summer | | Fall | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| N | 13 | | 12 | | 15 | | 10 | |
| (Dry Matter Basis) | | | | | | | | |
| NDF % | 62.6 | 7.1a | 54.0 | 8.8b | 48.5 | 3.7c | 60.0 | 11.4ab |
| ADF % | 47.5 | 7.4a | 43.8 | 3.6a | 40.2 | 4.2b | 35.6 | 10.2b |
| Lignin % | 14.5 | 8.0a | 15.2 | 2.3a | 13.0 | 2.2a | 8.6 | 2.5b |
| Crude Protein % | 13.7 | 5.3a | 25.8 | 3.3b | 20.9 | 3.8c | 13.2 | 3.6a |
| Gross Energy (Kcal/g) | 4.7 | 0.1a | 4.7 | 0.3a | 4.7 | 0.2a | 4.6 | 0.2a |
| ASH % | 10.9 | 4.5ab | 12.6 | 1.9b | 12.4 | 1.5b | 8.6 | 2.9a |

$^{a,b,c}$ Means within a row having a common letter are not different ($p > 0.05$)

correlated to the consumptions of acorns ($r = -0.50$, $p < 0.01$) and other woody fruits ($r = -0.41$, $p < 0.01$). Duvendeck (1962) found acorns were high in energy but low in crude protein. Seasonal changes in rumen crude protein for southeastern white-tailed dear were similar to Fort Riley deer (Kirkpatrick et al. 1969). Skeen (1974) found gross rumen crude protein levels were not different between summer and fall for deer in Virginia. Klein (1962) attributed differences in crude protein of gross rumen contents of mule deer to differences in range quality. Because of contamination with microbial protein and differential digestion, crude protein of gross rumen solids is not a precise estimate of forage crude protein, but does provide an index to crude protein intake (Kirkpatrick et al. 1969, Klein and Schonheyder 1970). Crude protein levels of gross rumen contents for Fort Riley deer should be adequate for maintenance and growth during all seasons (Murphy and Coates 1966).

Percent NDF, ADF, and lignin differed ($p < 0.01$) between seasons (Table 24). Summer rumen solid NDF was lower ($p < 0.05$) than other seasons. ADF was lower ($p < 0.05$) in summer and fall rumen samples than winter or spring. Percent lignin was lower ($p < 0.05$) in the fall compared to other seasons. NDF is a measure of the cell wall fraction of the plant and provides a more biologically meaningful measurement of digestible components of ruminant diets than crude fiber (Van Soest 1964). Reduced rumen levels of NDF and ADF in spring and summer are indicative of animals consuming high quality, low fiber diets (Short et al. 1974, Whittemore and Moen 1980).

Rumen Fluid Analysis

Rumen fluid pH did not differ significantly ($p < 0.08$) between seasons, although the highest level was in winter (6.0 ± 0.2) and lowest in summer (5.6 ± 0.2) (Table 25). Total VFAs were lower ($p < 0.05$) in winter and higher in spring, summer and fall rumen fluid samples. More VFAs are produced in the rumen from forages containing high levels of soluble carbohydrates and protein than foods high in fiber (Hogan et al. 1969, Hogan and Weston 1969). Level of feeding may also influence VFA production rates (Hodgson et al. 1976). VFAs provide 50-90% of the metabolizable energy derived from the ruminants diet (Blaxter 1962). Total VFA concentrations from the rumens of Fort Riley deer were correlated ($r = 0.43$, $p < 0.01$) to consumption of forbs in the spring and summer.

Acetic acid concentration was higher ($p < 0.05$) in the rumen of deer collected in the summer compared to fall and winter (Table 25); however, the acetic : propionic ratio was higher ($p < 0.05$) during winter than other seasons. Propionic and butyric acid concentrations were lower ($p < 0.05$) in winter compared to other seasons. Highest levels of rumen propionic and butyric acids were found in fall samples. Higher acids (valeric, isovaleric and isobutyric) comprised < 4% of the total rumen VFAs, regardless of season. Molar percent of acetic acid was higher ($p < 0.05$) in the winter than other seasons, while molar percent of butyric acid was highest in fall (15.6 ± 6.0%) and lowest in winter (11.3 ± 3.2%). Variations in molar percents of individual acids have been related to gross chemical nature of the diet. Generally, easily fermented materials produce higher levels of propionate relative to acetate while forages higher in fiber (NDF) produce greater

Table 25. Rumen fluid characteristics of white-tailed deer collected February-October, 1979, Fort Riley, KS

| Characteristic | Season | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Winter | | Spring | | Summer | | Fall | |
| | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD | $\bar{x}$ | SD |
| N | 13 | | 12 | | 15 | | 10 | |
| Acetic Acid (mM/L) | 49.3 | 13.3a | 59.2 | 10.5ab | 64.3 | 17.4b | 52.1 | 7.5a |
| Propionic Acid (mM/L) | 16.7 | 8.4a | 30.5 | 6.3b | 27.6 | 9.3b | 31.0 | 6.4b |
| Butyric Acid (mM/L) | 9.4 | 5.4a | 16.0 | 5.2b | 15.5 | 4.6b | 16.8 | 8.5b |
| Higher Acid (mM/L) | 1.6 | 1.3a | 3.4 | 0.9b | 2.8 | 0.7bc | 2.3 | 1.4ac |
| Total VFAs (mM/L) | 78.8 | 25.0a | 109.1 | 21.0b | 110.2 | 29.8b | 102.2 | 18.9b |
| Acetic % | 64.0 | 6.4a | 54.4 | 3.4bc | 58.5 | 3.4b | 51.0 | 8.0c |
| Propionic % | 22.6 | 3.5a | 27.9 | 2.0b | 24.6 | 2.5a | 30.3 | 3.4c |
| Butyric % | 11.3 | 3.2a | 14.4 | 2.8b | 14.1 | 2.1ab | 15.6 | 6.0b |
| Higher % | 2.1 | 1.0a | 3.4 | 0.8b | 2.7 | 0.8a | 2.0 | 1.2a |
| pH | 6.0 | 0.2a | 5.7 | 0.3a | 5.6 | 0.2a | 5.9 | 0.1a |
| Acetic: Propionic | 2.9 | 0.7a | 1.9 | 0.2b | 2.4 | 0.3c | 1.7 | 0.3b |

[a,b,c] Means within a row having a common letter are not different ($p > 0.05$)

proportions of acetate (Hungate 1966). Nearly all deer rumens examined in this study in October contained acorns or milo. Percent occurrence of acorns in the rumen of deer was negatively correlated to the molar percent of acetate ($r = -0.35$, $p < 0.01$), and positively correlated to the molar percent of propionate ($r = 0.36$, $p < 0.01$) and butyrate ($r = 0.36$, $p < 0.01$). Short et al. (1969b) found higher rates of fermentation, VFA production and butyric acid levels for deer consuming a high percentage of acorns.

Fat Reserves of Deer

Thirty-one adult does, 14 adult bucks and 13 fawns were collected between February and October 1979 to evaluate seasonal variations in fat reserves of the Fort Riley deer herd (Table 26). Adult does had higher ($p < 0.05$) TKFIs than bucks or fawns in winter and spring, while adult bucks had higher ($p < 0.05$) TKFIs in fall than does or fawns. For all age classes, TKFIs declined between fall and winter. Fawns had higher ($p < 0.05$) TKFIs in summer compared to spring. TKFIs of Fort Riley fawns in the fall were from animals 4-5 months of age. TKFIs of adult does and fawns increased between fall (October) and December, while TKFIs for adult bucks decreased by nearly 85% (Table 26). Apparently, the energetic costs of breeding and voluntary reduction in food intake (Long et al. 1965, Short 1975) place adult males in a very negative energy balance during this period (Mautz 1978).

Finger et al. (1981) reported seasonal variations in TKFIs for 52 white-tailed deer collected in South Carolina without regard for age or sex. Maximum levels were observed in fall and lowest in winter and spring. TKFIs were much lower than those reported for Fort Riley deer.

Table 26. Kidney fat indices (TKFIs) of white-tailed deer collected February-October, 1979, Fort Riley, Kansas.

| Age by Sex Class | Season | | | | Hunter Check Station |
|---|---|---|---|---|---|
| | Winter $\bar{x}$ SD | Spring $\bar{x}$ SD | Summer $\bar{x}$ SD | Fall $\bar{x}$ SD | December 1979 $\bar{x}$ SD |
| Adult Does | 107 54Aad (7) | 58 29Ba (8) | 56 50Ba (10) | 214 80Ca (6) | 396 195Ca (24) |
| Adult Bucks | 38 27Ab (4) | 24 20Ab (2) | 53 24Aa (4) | 366 70Bb (4) | 55 35Ab (28) |
| Fawns | 24 15ABb (2) | 9 3Ab (3) | 39 16Ba (5) | 34 34Bc (3) | 275 85Ca (21) |

[a]Means within a row having a common upper case letter and means within a column having a common lower case letter are not different ($p > 0.05$). Sample size in parenthesis.

Age, sex and year harvested were significant ($p < 0.05$) sources of variation for TKFIs of 254 white-tailed deer collected in December 1979-81 (Table 27). Adult and yearling females and male and female fawns had higher ($p < 0.05$) TKFIs in 1979 than in 1980 and 1981. Regardless of year harvested, adult and yearling males had similar TKFIs. Adult and yearling females had higher ($p < 0.05$) TKFIs than similar aged males. Male and female fawns had similar TKFIs regardless of year harvested.

Finger et al. (1981) found a high correlation between total body fat of white-tailed deer and the TKFI. Fat deposition of deer is related to energetic costs and energy intake (Moen 1973). Despite large variations between animals, the TKFI is useful for estimating relative fat stores and, by inference, energy balance of free-ranging deer (Monson et al. 1974, Johns et al. 1980).

## Nutritional Status of the Fort Riley Deer Herd

Lower TKFIs from deer collected in winter compared to fall suggests deer were in a negative energy balance over winter. Higher percent NDF, ADF, molar percent of acetic acid, and low levels of crude protein and total VFAs in the rumens of white-tailed collected in winter indicate Fort Riley deer were consuming high fiber, low quality foods during this period. Dietary intake during winter is apparently inadequate to meet the maintenance energy requirements of free-ranging Fort Riley deer. Ammann et al. (1973) concluded deer were able to adjust food intake levels to meet maintenance energy requirements when feeding on forage > 50% digestible dry matter. Below this level, rumen fill and increased retention times reduced food intake. Short (1963) concluded deer have

Table 27. Kidney fat indices (TKFIs) of white-tailed deer collected during December, 1979-1981, Fort Riley, Kansas.

| Year | Males | | | Females | | |
|---|---|---|---|---|---|---|
| | Fawns x SD | Yearlings x SD | Adults x SD | Fawns x SD | Yearlings x SD | Adults x SD |
| 1979 | 245 88Aa (9) | 66 35Ba (15) | 45 35Ba (13) | 301 80ACa (12) | 369 185CDa (9) | 424 206Da (15) |
| 1980 | 104 55Ab (19) | 86 63Aa (18) | 42 30Aa (15) | 171 112Bb (22) | 223 84BCb (20) | 273 109Cb (17) |
| 1981 | 120 87Ab (8) | 45 34Ba (23) | 34 32Ba (14) | 199 110ACb (14) | 263 142Cb (7) | 227 110Cb (15) |

[d] Means within a row having a common upper case letter and means within a column having a common lower case letter are not different ($p > 0.05$). Sample size in parenthesis.

smaller rumens in relation to body size than cattle, and therefore must have higher turnover rates of rumen digestion to gain similar amounts of energy from the diet. Based on the equation developed by Short et al. (1974) for predicting dry matter digestibility from NDF, winter foods consumed by Fort Riley deer were approximately 40% digestible. Apparently, winter foods of Fort Riley deer are to low in quality to meet the maintenance energy requirements of deer (Ullrey et al. 1970).

Fort Riley deer were on a much better nutritional plane in spring and summer (lower NDF, higher crude protein and VFAs in rumen samples) than winter. While dietary quality was higher in spring and summer compared to winter, adult female deer were less fat in summer than winter. The energetic costs of pregnancy, particularly the last trimester (April-June), are very high for pregnant female deer with most of the increased dietary metabolizable energy (VFAs) going to fetal development (Moen 1973).

The rumen fluid of deer collected in the fall contained higher molar percent of propionic and butyric acid and low levels of acetic acid compared to winter, spring and summer samples. Total rumen VFAs from fall samples were equal to spring and summer levels. Most of the deer collected in October had acorns in the rumen. Higher rates of fermentation, VFA production and butyric acid levels are typical of deer consuming highly soluble carbohydrates, such as acorns, fruits and agricultural grains. Propionate and butyrate are higher in energy than acetate, and thus provide increased metabolizable energy to the ruminant for productive processes (Annison and Armstrong 1970). This high level of dietary quality in the fall is significant because it places Fort Riley deer in a very positive energy balance allowing the accumulation

of large amounts of body fat. Early work emphasized the importance of adequate winter browse for deer (Petrides 1941, Hamerstorm and Blake 1956). This study indicates the importance of food quality to deer during other seasons, particularly fall, when deer are depositing sustaining fat reserves.

## Conclusions and Management Implications

Time killed was not a source of variation for any of the rumen solid or rumen fluid parameters examined in this study. However, time lapse between sample collection and death affected nearly all rumen fluid characteristics. Animals dead > 2 hours had higher VFAs than deer dead < 2 hours. Age and sex were not significant sources of variation for rumen solid or rumen fluid chemical analyses.

Forbs comprised the bulk of deer diets in spring and summer, and browse was used equally in winter and fall. Grasses comprised < 4% of the year round diet, and agricultural crops were less abundant in the rumens of Fort Riley deer than northeast Kansas deer. Acorns were most abundant in deer rumens in the fall.

Spring and summer rumen content samples were lower in NDF and ADF with higher levels of ash, crude protein, and VFAs compared to winter samples. Fall rumen samples had similar VFAs to spring and summer but lower crude protein levels. These results are interpreted as reflecting increased rumen fermentation during spring and summer when highly digestible forages are consumed and reduced fermentation in the winter when deer consumed high fiber (NDF) low quality foods. Increased VFA concentrations in the fall were related to consumption of acorns, and agricultural crops.

Total kidney fat indices (TKFIs) were influenced by age, sex, season and year of collection. TKFIs of adult males peaked in October and declined rapidly during the rut. Regardless of age class, TKFIs were highest in the fall and lowest in winter. The use of large amounts of body fat over winter suggests Fort Riley deer were in a negative

energy balance during this period. Habitat programs for midwestern white-tailed deer should be directed to meeting the energy requirements of deer, particularly in the fall, when deer are depositing sustaining fat reserves.

# MANAGEMENT IMPLICATIONS

Animal scientists recognized long ago the need for basic physiological and nutritional research on domestic livestock. Wildlife managers have been slow to recognize the importance of basic research on the physiology and nutrition of wild animals. Indices of morphology, physiology and nutrition which reflect changes in habitat quality or animal condition on a seasonal basis may be useful in reflecting habitat changes over longer periods of time or between management areas. Baseline data collected during this study on 37 variables related to the morphology, physiology and nutrition of the Fort Riley deer herd indicate some parameters may be more useful in habitat evaluation programs than others.

All of the morphological measurements were strongly influenced by age and sex, but not year of collection. It is unlikely that skeletal measurements can be used to evaluate between year differences in nutritional status of the fawns. Total body length and hind foot length of growing fawns may be useful for monitoring nutritional restrictions affecting bone growth, although reductions in growth would not occur unless there were severe changes in nutritional status of the fawns. If consideration is given to age effects and normal seasonal fluctuations in body weight, long-term habitat changes may be monitored using antler points, beam circumference and body weight. The advantage of morphological measurements is the ease of data collection at hunter check stations.

Testis weight and testicular index were useful tools for monitoring the reproductive activity of male deer. Data are easily collected at

hunter check stations and the results may indicate changes in the onset of the breeding season in free-ranging white-tailed deer. Ovulation rates and fetal counts were excellent methods to evaluate the reproductive condition of female deer and estimate the contribution of breeding fawns to the following year's population. Increased ovulation rates and fetal rates, should be a good indicator of high habitat quality on a short-term basis; lowered levels may signal a decrease in habitat quality. Persistence of lactation into December appears common in midwestern white-tails although highly variable between years. Whether there are nutritional influences involved in these differences is not known.

Most blood chemistry parameters are of little use in monitoring the recent nutritional history of deer, particularly from deer collected at hunter check stations. Many of the parameters appear highly influenced by stress of the animal while dying (glucose, LDH, SGOT, uric acid); however, blood urea nitrogen was highly correlated to crude protein intake and if account is taken of the energy stores and protein catabolism, BUN should be useful in monitoring the crude protein intake of free-ranging white-tailed deer. Cholesterol was correlated to rumen volatile fatty acids and may reflect increased rumen fermentation rates indicating higher food intake and quality of foods consumed. Alkaline phosphatase was excellent for monitoring active bone growth in white-tailed deer.

Most of the rumen content and rumen fluid parameters were influenced by season of collection. However, neutral detergent fiber (NDF) and crude protein appear the most useful for monitoring dietary quality of free-ranging Fort Riley deer. In addition, of the rumen

fluid parameters, the molar percent of the individual acids were the most useful for monitoring changes in dietary quality. Concentration of individual acids may be affected by time lapse between sample collection and death, time since feeding, level of feeding and other variables. However, the molar percent of the individual acids appears less affected by these variables. Animals dead > 2 hours should not be used when taking rumen content or rumen fluid samples. In general, low NDF, elevated crude protein, low molar percent of acetic acid and high levels of propionic and butyric acid would be indicative of deer on a high quality diet. By developing a nutritional profile for each deer one may be able to compare the profile means between years and monitor the immediate nutritional history of a selected deer population.

Fat reserves may be the most useful parameter available to the deer manager for evaluating the condition of the deer herd, particularly at hunter check stations. Fat reserves, estimated from the Total Kidney Fat Index (TKFI), were related to age, sex, season and year of collection. TKFIs provide a clue to the short-term but not immediate nutritional history of the animal. Fat reserves of deer examined in December were probably laid down several weeks or months prior, thus, fat indices may be useful in monitoring the energy balance of free-ranging white-tailed deer.

Physiological and nutritional indices provide the deer manager with additional tools to monitor the condition of a specific deer population. Coupled with changes in age structure and/or population censuses, metabolic indices may allow the deer manager to make more sophisticated decisions in manipulating deer populations and habitats and provide a means of monitoring the success of those programs at a relatively low cost.

**THIS BOOK CONTAINS NUMEROUS PAGES WITH ILLEGIBLE PAGE NUMBERS THAT ARE CUT OFF, MISSING OR OF POOR QUALITY TEXT.**

**THIS IS AS RECEIVED FROM THE CUSTOMER.**

## SUMMARY

Between December 1978 and 1981, baseline data on morphology, physiology and nutrition were collected from 407 free-ranging white-tailed deer on the Fort Riley Military Reservation.

Morphological measurements were strongly influenced by age and sex. There were no between year differences in body, antler or skeletal measurements within each age by sex class. Total body length and hind foot length of growing fawns may be useful for monitoring severe nutritional restrictions affecting bone growth. Regression equations were successfully developed to predict whole weight from field dressed weight and chest girth. The equations should be applicable throughout the midwest where adult deer average 70 kg whole weight. The use of chest girth to estimate whole body weight is less laborious and more rapid than actually weighing deer.

Pregnancy rates and fetal rates were higher on Fort Riley than in other Kansas white-tailed deer populations and were comparable to productivity in other areas of the midwest where agricultural crops comprise a much larger percentage of the year round diet. Percentage of fawns breeding varied considerably between years and was attributed to alterations in the age of fawns at the onset of the rut. Fawns < 6 months old were less productive and smaller than > 6-month-old fawns. Providing from 3-15% of the annual increment, percentage fawns breeding had a dramatic impact on herd dynamics. Persistence of lactation was not uncommon into December and, in yearling does, was related to percent of fawns breeding the previous year.

A testicular index was useful for monitoring seasonal and yearly sexual activity of males. There was no evidence fawns participated in the rut.

Blood values reported in this study were within the range for white-tailed deer reported by other investigators. Serum glucose, LDH, SGOT, and uric acid measurements were highly variable between animals and probably related to stress while dying. BUN and cholesterol were significantly correlated to crude protein and rumen VFAs, respectively. Many, if not all, blood components are homeostatically controlled by a very complex neuro-endocrine network. Care should be exercised when attempting to draw conclusions of nutritional status based solely on blood parameters.

Time killed and age and sex of deer were not sources of variation for any rumen solid or rumen fluid parameters. However, time lapse between rumen sample collection and death affected nearly all rumen fluid characteristics. Animals dead > 2 hours had higher VFAs than deer dead $\leq$ 2 hours.

Forbs comprised the bulk of deer diets in spring and summer, and grasses comprised <4% of the year-round diet. Agricultural crops were less abundant in the rumens of Fort Riley deer than northeast Kansas deer. Acorns were most abundant in deer rumens in the fall.

Spring and summer rumen solid samples were generally lower in NDF, ADF and lignin with elevated levels of ash and crude protein compared to fall and winter samples. VFA analysis detected increased rumen fermentation in spring and summer indicating higher dietary quality. Molar percent of VFAs in rumen samples was less variable between animals than VFA concentrations. Acetate was more abundant in the rumen of deer

in winter, while propionate and butyrate were higher in spring, summer and fall. Rumen NDF, crude protein and molar percent of VFAs appear useful for monitoring dietary quality of free-ranging deer.

The Total Kidney Fat Index was useful for monitoring fat reserves of deer. Adult females and fawns had higher levels of fat in December than late February-March. Fat reserves of adult males reached a peak in October and declined rapidly during the rut. Fat reserves provided information on the nutritional and energetic balance of the deer herd during the previous several weeks or months. Fort Riley deer were in a negative energy balance during winter requiring the use of large amounts of body fat to meet energy requirements.

Characteristics of morphology, physiology and nutrition which reflect changes in habitat quality on a seasonal basis may be useful in determining habitat differences between years or between management areas. Baseline data collected on 37 characteristics related to the morphology, physiology and nutrition of the Fort Riley deer herd indicate some parameters may be more useful than others in evaluating quality of deer habitat.

# LITERATURE CITED


Ammann, A. P., R. L. Cowan, C. L. Mothershead, and B. R. Baumgardt. 1973. Dry matter and energy intake in relation to digestibility in white-tailed deer. J. Wildl. Manage. 37:195-201.

Anderson, A. E., and D. E. Medin. 1969. Antler morphometry in a Colorado mule deer population. J. Wildl. Manage. 33:520-533.

Anderson, A. E., D. E. Medin, and D. C. Bowden. 1972. Total serum protein in a population of mule deer. J. Mammal. 53:384-387.

Anderson, K. L. and C. E. Owensby. 1969. Common names of a selected list of plants. Kans. Agric. Exp. Stn. Tech. Bull. 117-R. 62 pp.

Annison, E. F. and D. G. Armstrong. 1970. Volatile fatty acid metabolism, and energy supply. Pages 422-437 in A. T. Philipson, ed., Physiology of digestion and metabolism in the ruminant. Oriel Press Limited, Newcastle upon Tyne, England. 636 pp.

Annison, E. F. and D. Lewis. 1959. Metabolism in the rumen. London: Metheun and New York, Wiley. 184 pp.

A.O.A.C. 1975. Official methods of analysis. 12 ed. Assoc. Off. Anal. Chem., Washington, D.C. 1094 pp.

Bandy, P. J., I. McT. Cowan, W. D. Kitts, and A. J. Wood. 1956. A method for the assessment of the nutritional status of wild ungulates. Can. J. Zool. 34:48-52.

Barr, A. J., J. H. Goodnight, J. P. Sall, W. H. Blair, and Daniel M. Chilko. 1979. SAS user's guide. SAS Inst. Inc. Raleigh, N.C. 494 pp.

Bath, I. H. and J. A. Rook. 1963. The evaluation of cattle foods and diets in terms of the rumenal concentration of volatile fatty acids. 1. The effects of level of intake, frequency of feeding, the ratio of hay to concentrates in the diet, and of supplementary foods. J. Agri. Sci. (Camb.). 61:341-348.

Blankenship, L. H. and L. W. Varner. 1977. Factors affecting hematological values of white-tailed deer in south Texas. Proc. Southeast. Assoc. Fish and Wildl. Agencies Conf. 31:107-115.

Blaxter, K. L. 1962. The energy metabolism of ruminants. Hutchinson Press, London. 332 pp.

Brody, S. 1945. Bioenergetics and growth, with special reference to the efficiency complex in domestic animals. Reinhold Publ. Corp., New York. 1023 pp.

Bruggeman, J., D. Lsieseche, and K. Walsea-Karst. 1968. Methods for studying microbial digestion in ruminants post-mortem, with special reference to wild species. J. Wildl. Manage. 31:198-207.

Chamrad, A. D. and T. W. Box. 1964. A point frame method for sampling rumen contents. J. Wildl. Manage. 28:473-477.

Cheatum, E. L. 1949. The use of corpora lutea for determining ovulation incidence and variations in the fertility of white-tailed deer. Cornell Vet. 39:282-291.

Cheatum, E. L. and G. H. Morton. 1946. Breeding season of white-tailed deer in New York. J. Wildl. Manage. 10:249-263.

Cheatum, E. L. and C. W. Severinghaus. 1950. Variations in the fertility of white-tailed deer related to range conditions. Trans. North Am. Wildl. Conf. 15:170-190.

Church, D. C. 1975. Digestive physiology and nutrition of ruminants. Vol. I. Digestive physiology. D. C. Church, Oregon State Univ. Corvallis. 350 pp.

Coblentz, B. E. 1975. Cholesterol level changes in George Reserve deer. J. Wildl. Manage. 39:343-346.

Coles, E. H. 1967. Veterinary clinical pathology. W. B. Saunders Co., London. 455 pp.

Cook, C. W. 1964. Collecting forage samples representative of ingested material of grazing animals for nutritional studies. J. Anim. Sci. 23:265.

Dahlberg, B. L. and R. C. Guettinger. 1956. The white-tailed deer in Wisconsin. Wis. Conserv. Dep. Tech. Wildl. Bull. 14. 282 pp.

Duke, H. H. 1955. The physiology of domestic animals. Comstock Publishing Assoc. Ithaca, N.Y. 1020 pp.

Duvendeck, J. P. 1962. The value of acorns in the diet of Michigan deer. J. Wildl. Manage. 26:371-379.

Finger, S. E., I. L. Brisbin, Jr., and M. H. Smith. 1981. Kidney fat as a predictor of body condition in white-tailed deer. J. Wildl. Manage. 45:964-968.

Franzmann, A. W. 1972. Environmental sources of variation of bighorn sheep physiological values. J. Wildl. Manage. 35:924-932.

Franzmann, A. W. and R. E. LeResche. 1978. Alaskan moose blood studies with emphasis on condition evaluation. J. Wildl. Manage. 42:334-352.

French, C. W., L. C. McEwen, N. D. Magruder, R. H. Ingram, and R. W. Swift. 1955. Nutritional requirements of white-tailed deer for growth and antler development. Pa. Agric. Exp. Stn. Bull. 600. 50 pp.

Gasaway, W. A. and J. W. Coady. 1974. Review of the energy requirements and rumen fermentation in moose and other ruminants. Nat. Can. (Que.). 101:227-262.

Gill, J. 1956. Regional differences in size and productivity of deer in West Virginia. J. Wildl. Manage. 20:286-292.

Goering, H. K. and P. J. Van Soest. 1970. Forage fiber analysis, U.S. Dep. Agric., Agric. Res. Serv. Handb. 379. 20 pp.

Hamerstrom, F. N. and J. Blake. 1956. Winter movements and winter foods of white-tailed deer in central Wisconsin. J. Mammal. 20:206-215.

Hamerstrom, F. N., Jr. and F. L. Camburn. 1950. Weight relationships in the George Reserve deer herd. J. Mammal. 31:5-17.

Harder, J. D. 1980. Reproduction of white-tailed deer in the north central United States. Pages 23-35 in R. L. Hine and S. Nehls, eds., White-tailed population management in the Northcentral States - proc. of a symposium. 41st Midwest Fish and Wildl. Conf. Urbana, Ill.

Harlow, R. F., J. B. Whelan, H. S. Crawford, and J. E. Skeen. 1975. Deer foods during years of oak mast abundance and scarcity. J. Wildl. Manage. 39:330-336.

Harris, L. E. 1970. Nutrition research techniques for domestic and wild animals. Lorin E. Harris, Logan, Utah. pp. 101-5501-7.

Haugen, A. O. 1975. Reproductive performance of white-tailed deer in Iowa. J. Mammal. 56:151-159.

Hawley, A. W. and D. G. Peden. 1982. Effects of ration, season, and animal handling on composition of bison and cattle blood. J. Wildl. Dis. 18:321-328.

Hesselton, W. T. and P. R. Sauer. 1973. Comparative physical condition of four deer herds in New York according to several indices. N.Y. Fish and Game J. 20:77-107.

Hodgson, J. C., P. C. Thomas, and G. Wilson. 1976. The influence of the level of feeding and fermentation in the rumen of sheep receiving a diet of ground barley, ground hay, and flaked maize. J. Agri. Sci. 87:297.

Hogan, J. P. and R. H. Weston. 1969. The digestion of pasture plants by sheep. III. The digestion of forage oats varying in maturity and in the content of protein and soluble carbohydrate. Aus. J. Agric. Res. 20:347-363.

Hogan, J. P., R. H. Weston and J. R. Lindsay. 1969. The digestion of pasture plants by sheep. IV. The digestion of Phalaris tuberosa at different stages of maturity. Aust. J. Agric. Res. 20:925-940.

Hungate, R. E. 1966. The rumen and its microbes. Academic Press, New York and London. 533 pp.

Jackson, L. W. and W. T. Hesselton. 1973. Breeding and parturition dates of white-tailed deer in New York. N.Y. Fish and Game J. 20:40-47.

Johns, P. E., M. H. Smith, and R. K. Chesser. 1980. Effects of sex, age, habitat, and body weight on kidney weight in white-tailed deer. Growth. 22:46-53.

Kie, J. G., M. White, and D. L. Drawe. 1983. Condition parameters of white-tailed deer in Texas. J. Wildl. Manage. 47:583-594.

Kirkpatrick, C. M., C. M. White, T. W. Hoehstra, F. A. Stormer, and H. P. Weeks. 1976. White-tailed deer of U.S. Naval Ammunition Depot Crane. Purdue Univ. Agric. Exp. Stn. Res. Bull. No. 932. 42 pp.

Kirkpatrick, R. L. 1980. Physiological indices in wildlife management. Pages 99-113 in S. D. Schemnitz, ed., Wildlife Management Techniques Manual. The Wildlife Society, Washington, D. C.

Kirkpatrick, R. L., D. F. Buckland, W. A. Abler, P. F. Scanlon, J. B. Whelan, and H. E. Burkhart. 1975. Energy and protein influences on blood urea nitrogen of white-tailed deer fawns. J. Wildl. Manage. 39:692-698.

Kirkpatrick, R. L., J. P. Fontenot, and R. F. Harlow. 1969. Seasonal changes in the rumen chemical components are related to forages consumed by white-tailed deer of the Southeast. Trans. North Am. Wildl. Conf. 34:299-238.

Klein, D. R. 1962. Rumen content analysis as an index to range quality. Trans. North Am. Wildl. Conf. 27:150-162.

Klein, D. R. 1964. Range related differences in growth of deer reflected in skeletal ratios. J. Mammal. 45:226-235.

Klein, D. R. and F. Schonheyder. 1970. Variations in ruminal nitrogen levels among some cervidae. Can. J. Zool. 48:1437-1442.

Korschgen, L. J. 1962. Foods of Missouri deer with some management implications. J. Wildl. Manage. 26:164-172.

Lambiase, J. T. Jr., R. P. Amann, and J. S. Lindzey. 1972. Aspects of the reproductive physiology of male white-tailed deer. J. Wildl. Manage. 36:868-875.

Lascano, C. E., B. Theurer, H. A. Pearson, and W. H. Halek. 1970. Factors influencing fiber and lignin content of rumen fistual forage. Proc. West. Sect. Am. Anim. Sci. 21:87-92.

Lay, D. W. 1965. Fruit utilization by deer in southern forests. J. Wildl. Manage. 29:370-375.

Lenker, D. K. and P. F. Scanlon. 1973. Gonad activity of male and female fawns of the white-tailed deer. Proc. Southeast Assoc. Fish and Wildl. Agencies Conf. 27:295. (Abstr.).

LeResche, R. E., U. S. Seal., P. D. Karns, and A. W. Franzmann. 1974. A review of blood chemistry of moose and other cervidae with emphasis on nutritional assessment. Nat. Can. (Que.). 101:263-290.

Long, T. A., R. L. Cowan, G. D. Strawn, R. S. Wetzel, and R. C. Miller. 1965. Seasonal fluctuations in feed consumption of the white-tailed deer. Pa. Agric. Exp. Stn. Prog. Rep. 262. 5 pp.

Longhurst, W. M. 1951. Range conditions as an influence on big game productivity. Western 31:190-194.

Mautz, W. W. 1978. Sledding on a bushy hill side: the fat cycle in deer. Wildl. Soc. Bull. 6:88-90.

McCullough, D. R. 1982. Antler characteristics of George Reserve white-tailed deer. J. Wildl. Manage. 46:821-826.

McEwan, E. H. and A. J. Wood. 1966. Growth and development of the barren-ground caribou. I. Heart girth, hind foot length, and body weight relationships. Can. J. Zool. 44:401-411.

McGinnes, B. S. and R. L. Downing. 1977. Factors affecting the peak of white-tailed deer fawning in Virginia. J. Wildl. Manage. 41:715-720.

Mirarchi, R. E., P. F. Scanlon, and R. L. Kirkpatrick. 1976. Seasonal variation in gonadal characteristics of male white-tailed deer. J. Anim. Sci. 42:271-272.

Moen, A. N. 1973. Wildlife ecology. W. H. Freeman and Company, San Francisco. 458 pp.

Moen, A. N. and C. W. Severinghaus. 1981. The annual weight cycle and survival of white-tailed deer in New York. N.Y. Fish and Game J. 29:162-177.

Monson, R. A., W. B. Stone, B. L. Weber and F. J. Spadaro. 1974. Comparison of Riney and total kidney fat technique for evaluating the physical condition of white-tailed deer. N.Y. Fish and Game J. 21:67-72.

Moustgaard, J. 1959. Nutrition and reproduction in domestic animals. Pages 169-223 in H. H. Cole and P. T. Cupps, eds., Reproduction in domestic animals. Vol. 2. Academic Press, New York and London. 451 pp.

Murphy, D. A. and J. A. Coates. 1966. Effects of dietary protein on deer. Trans. North Am. Wildl. Conf. 31:120-126.

Nagy, J. G. and J. B. Haufler. 1980. Wildlife Nutrition. Pages 129-143 in S. D. Schmenitz, ed., Wildlife Management Techniques Manual, 4th Ed. The Wildlife Society, Washington, D.C.

Nixon, C. M. 1971. Productivity of white-tailed deer in Ohio. Ohio J. Sci. 71:217-225.

Park, B. C. and B. B. Day. 1942. A simplified method for determining the condition of white-tailed deer herds in relation to available forage. U. S. Dep. Agric. Tech. Bull. 840. 60 pp.

Petrides, G. A. 1941. Observations on the relative importance of winter deer browse species in central New York. J. Wildl. Manage. 5:416-422.

Preston, R. L., L. H. Brewer, and G. B. Thompson. 1961. Blood urea in cattle as affected by energy, protein, and stibesterol. J. Anim. Sci. 20:977. (Abstr.)

Preston, R. L., D. D. Schnakenberg, and W. H. Pfander. 1965. Protein utilization in ruminants. I. Blood urea nitrogen as affected by protein intake. J. Nutri. 86:281-288.

Ransom, A. B. 1967. Reproductive biology of white-tailed deer in Manitoba. J. Wildl. Manage. 31:114-123.

Riney, T. 1955. Evaluating condition of free-ranging red deer (Cervus elophus), with special reference to New Zealand. N. Z. J. Sci. Tech. 36:429-463.

Robbins, C. T., R. L. Prior, A. N. Moen, and W. J. Visek. 1974. Nitrogen metabolism of white-tailed deer. J. Anim. Sci. 38:186-191.

Robel, R. J. 1969. Food habits, weight dynamics, and fat content of bobwhites in relation to food plantings in Kansas. J. Wildl. Manage. 33:237-249.

Roseberry, J. L. and W. D. Klimstra. 1970. Productivity of white-tailed deer on Crab Orchard National Wildlife Refuge. J. Wildl. Manage. 34:23-28.

Roseberry, J. L. and W. D. Klimstra. 1975. Some morphological characteristics of the Crab Orchard deer herd. J. Wildl. Manage. 39:48-59.

Russel, M. D., J. A. Wessen III, R. L. Kirkpatrick, and P. F. Scanlon. 1975. Seasonal and age differences in male reproductive organ weight of white-tailed deer. Va. J. Sci. 26:60 (abstr.).

Scanlon, P. F., W. F. Murphy, Jr., and D. F. Urbston. 1976. Initiation of pregnancy in lactating white-tailed deer. J. Wildl. Manage. 40:373-374.

Scanlon, P. F. and D. F. Urbston. 1978. Persistence of lactation in white-tailed deer. J. Wildl. Manage. 42:196-197.

Seal, U. S. 1977. Assessment of habitat condition by measurement of biochemical and endocrine indicators of the nutritional, reproductive, and disease status of free-ranging animal populations. Pages 305-329 in Proceeding national symposium on classification, inventory and analysis of fish and wildlife habitat. U. S. Fish and Wildl. Serv. Off. Biol. Serv. Publ. 78/76. 604 pp.

Seal, U. S. and A. W. Erikson. 1969. Hematology, blood chemistry and protein polymorphisms in the white-tailed deer. (Odocoileus virginianus). Comp. Biochem. Physiol. 30:695-713.

Seal, U. S., M. E. Nelson, L. D. Mech, and R. L. Hoskinson. 1978. Metabolic indicators of habitat differences in four Minnesota deer populations. J. Wildl. Manage. 42:755-764.

Seal, U. S., L. J. Verme, and J. J. Ozoga. 1981. Physiological values. Pages 17-24 in W. R. Davidson, ed., Diseases and parasites of white-tailed deer. Misc. Publ. No. 7. Tall Timbers Res. Stn., Tallahassee, Fla.

Severinghaus, C. W. 1949. Tooth development and wear as a criteria of age in white-tailed deer. J. Wildl. Manage. 13:195-216.

Severinghaus, C. W. 1954. Deer weights as an index of range conditions on two wilderness areas in the Adirondack region. N. Y. Fish and Game J. 2:154-160.

Severinghaus, C. W. and E. L. Cheatum. 1956. Life and times of the white-tailed deer. Pages 57-186 in W. P. Taylor, ed., The deer of North America. Stackpole Co., Harrisburg, Pa., and Wildl. Manage. Inst., Washington, D. C.

Severinghaus, C. W., H. F. Maguire, K. A. Cookingham, J. E. Tanck. 1950. Variations in age class in antler beam diameters of white-tailed deer related to range conditions. Trans. North Am. Wildl. Conf. 15:551-570.

Severinghaus, C. W. and J. E. Tanck. 1954. Productivity and growth of white-tailed deer from the Adirondack region of New York. N. Y. Fish and Game J. 11:13-27.

Sexson, K. A. 1982. Deer population dynamics and harvest trends. Kans. Fish and Game Comm. Annu. Rep. Pittman-Robertson Proj. w-23-R-19. 58 pp.

Short, C. L. 1970. Morphological development and aging of mule and white-tailed deer fetuses. J. Wildl. Manage. 34:383-388.

Short, H. L. 1963. Rumen fermentations and energy relationships in white-tailed deer. J. Wildl. Manage. 27:184-195.

Short, H. L. 1975. Nutrition of southern deer in different seasons. J. Wildl. Manage. 39:321-329.

Short, H. L., R. M. Blair, and C. A. Segelquist. 1974. Fiber composition and forage digestibility by small ruminants. J. Wildl. Manage. 38:197:209.

Short, H. L., D. E. Medin, and A. E. Anderson. 1966. Seasonal variations in the volatile fatty acids in the rumen of mule deer. J. Wildl. Manage. 30:466-470.

Short, H. L., E. E. Remmenga and C. E. Boyd. 1969a. Variations in rumino-reticular contents of white-tailed deer. J. Wildl. Manage. 33:187-191.

Short, H. L., C. A. Segelquist, P. D. Goodrum, and C. E. Boyd. 1969b. Rumino-reticular characteristics of deer on food of two types. J. Wildl. Manage. 33:380-383.

Skeen, J. E. 1974. The relationship of certain rumino-reticular and blood variables to the nutritional status of white-tailed deer. Ph.D. Diss., Virginia Polytechnical Institute and State Univ., Blacksburg, Va. 110 pp.

Smart, C. W., R. H. Giles, Jr., and D. C. Gwynn, Jr. 1973. Weight tape for white-tailed deer in Virginia. J. Wildl. Manage. 37:553-555.

Snedecor, G. W. and W. G. Cochran. 1980. Statistical methods. 7th ed. Iowa State Univ. Press, Ames, Iowa. 507 pp.

Taber, R. D. 1958. Development of the cervid antler as an index to late winter physical condition. Proc. Montana Acad. Sci. 18:27-28.

Torell, D. T., I. D. Hume, and W. C. Weir. 1974. Factors affecting blood urea nitrogen and its use as an index of the nutritional status of sheep. J. Anim. Sci. 39:435-440.

Trauger, D. L. and A. O. Haugen. 1965. Corpora lutea variation of white-tailed deer. J. Wildl. Manage. 29:487-492.

Trivers, R. L. and D. E. Willard. 1973. Natural selection of parental ability to vary the sex ratio of offspring. Science 179 (4068):90-92.

Tumbleson, M. E., M. G. Wood, A. R. Dommert, D. A. Murphy, and L. J. Korschgen. 1968. Biochemic studies on serum from white-tailed deer in Missouri. Am. J. Vet Clin. Pathol. 2:127-131.

Ullrey, D. E., W. G. Youatt, H. E. Johnson, L. D. Fay, B. L. Schoepke and W. T. Magee. 1970. Digestible and metabolizable energy requirements for winter maintenance of Michigan white-tailed does. J. Wildl. Manage. 34:863-869.

Urbston, D. F., C. W. Smart, and P. F. Scanlon. 1976. Relationship between heart girth and body weight in white-tailed deer from South Carolina. Proc. Southeast. Assoc. Fish and Wildl. Agencies Conf. 30:471-473.

Van Soest, P. J. 1964. Symposium on nutrition of forage and pastures. New chemical procedures for evaluating forages. J. Anim. Sci. 23:838-845.

Verme, L. J. 1965. Reproduction studies on penned white-tailed deer. J. Wildl. Manage. 29:74-78

Verme, L. J. 1969. Reproductive patterns of white-tailed deer related to nutritional plane. J. Wildl. Manage. 33:881-887.

Warren, R. J., R. L. Kirkpatrick, A. Oelshlager, P. F. Scanlon, and F. C. Guazdaushaus. 1981. Dietary and seasonal influences on nutritional indices of adult male white-tailed deer. J. Wildl. Manage. 45:926-935.

Watt, P. G., G. L. Miller, and R. J. Robel. 1967. Food habits of white-tailed deer in Northeastern Kansas. Trans. Kans. Acad. Sci. 70:223-240.

Wesson, J. A. III, P. F. Scanlon, R. L. Kirkpatrick and H. S. Mosby. 1979a. Influence of the time of sampling after death on blood measurements of the white-tailed deer. Can. J. Zool. 57:777-780.

Wesson, J. A. III, P. F. Scanlon, R. L. Kirkpatrick, and H. S. Mosby. 1979b. Influence of chemical immobilization and physical restraint on PCV, total protein, glucose, and BUN in blood of white-tailed deer. Can. J. Zool. 57:756-767.

White, M. and R. S. Cook. 1974. Blood characteristics of free-ranging white-tailed deer in southern Texas. J. Wildl. Dis. 10:18-23.

Whittemore, S. and A. N. Moen. 1980. Composition and in vitro digestibilities of various summer foods of white-tailed deer. Can. J. Anim. Sci. 60:189-192.

Wilber, C. G. and P. F. Robinson. 1958. Aspects of blood chemistry in white-tailed deer. J. Mammal. 39:309-310.

Woolf, A. and J. D. Harder. 1979. Population dynamics of a captive white-tailed deer herd with emphasis on reproduction and mortality. Wildl. Monogr. No. 67. 53 pp.

# APPENDIX

## Statistical Analysis

The Statistical Analysis System (SAS) (Barr et al. 1979) was employed for analysis of all data. Statistical tests attaining an alpha level of ($p < 0.05$) were considered statistically significant. Analysis of variance was conducted using a least squares regression procedure (PROC GLM). The GLM procedure is ideally suited for analysis in which unbalanced data sets occur. Type IV ss were employed for the F-Test comparisons. Sources of variation were partitioned as needed to test for the main fixed effects (age, sex, season, year of collection) and the interaction of these effects in relation to selected dependent variables. After determination of no significance or interaction, the fixed effects were collapsed and PROC GLM was performed on specific main effects. The PROC plot procedure was used to plot scattergrams to compare the interrelationships of selected dependent variables. Data were statistically analyzed using predetermined correlation comparisons (r). PROC CORR comparisons were considered significant at ($p < 0.01$). Product moment correlation coefficients were determined for all comparisons. Different age and sex classes were considered separately before being combined in any analysis.

Multiple and linear regression procedures were used for specific comparisons and in developing models to predict the relationships between condition indices. PROC Mean Procedure was utilized to obtain arithmetic means, minimum and maximum values, standard deviations and standard error for selected dependent variables. The LSMEANS procedure was utilized to compare specific means where the F-Test was significant at ($p < 0.05$). Chi-square analysis were used to determine significant ($p < 0.05$) differences in frequency data.

Table 1. Analysis of variance of age, sex, and year harvested for total body length length of white-tailed deer collected in December 1978-81, Fort Riley, Kansas.

| Source | DF | MS | F-Value | Significance |
|---|---|---|---|---|
| Overall Model | 23 | 3962.99 | 24.68 | $p < 0.001$ |
| ERROR | 365 | 160.59 | | |
| TOTAL | 388 | | | |
| Age[a] | 2 | | 205.42 | $p < 0.001$ |
| Sex | 1 | | 38.98 | $p < 0.001$ |
| Age by Sex | 2 | | 13.84 | $p < 0.001$ |
| Year | 3 | | 1.94 | $p < 0.129$ |
| Age by Year | 6 | | 1.20 | $p < 0.303$ |
| Sex by Year | 3 | | 0.48 | $p < 0.701$ |
| Age by Sex by Year | 6 | | 0.54 | $p < 0.780$ |

[a]Ages compared were fawns (5-7 months), yearlings (18 months) and adults ($\geq$ 30 months).

Table 2. Analysis of variance of age, sex, and year harvested for chest girth of white-tailed deer collected in December 1978-81, Fort Riley, Kansas.

| Source | DF | MS | F-Value | Significance |
|---|---|---|---|---|
| Overall Model | 23 | 1374.94 | 20.24 | $p < 0.001$ |
| ERROR | 360 | 67.94 | | |
| TOTAL | 383 | | | |
| Age[a] | 2 | | 174.86 | $p < 0.001$ |
| Sex | 1 | | 27.96 | $p < 0.001$ |
| Age by Sex | 2 | | 9.77 | $p < 0.001$ |
| Year | 3 | | 9.20 | $p < 0.001$ |
| Age by Year | 6 | | 0.25 | $p < 0.959$ |
| Sex by Year | 3 | | 1.35 | $p < 0.258$ |
| Age by Sex by Year | 6 | | 1.33 | $p < 0.241$ |

[a]Ages compared were fawns (5-7 months), yearlings (18 months) and adults ($\geq$ 30 months).

Table 3. Analysis of variance of age, sex, and year harvested for hind foot length of white-tailed deer collected in December 1978-81, Fort Riley, Kansas.

| Source | DF | MS | F-Value | Significance |
|---|---|---|---|---|
| Overall Model | 23 | 130.63 | 30.71 | $p < 0.001$ |
| ERROR | 365 | 4.25 | | |
| TOTAL | 388 | | | |
| Age[a] | 2 | | 216.90 | $p < 0.001$ |
| Sex | 1 | | 117.83 | $p < 0.001$ |
| Age by Sex | 2 | | 17.56 | $p < 0.001$ |
| Year | 3 | | 0.92 | $p < 0.430$ |
| Age by Year | 6 | | 0.78 | $p < 0.585$ |
| Sex by Year | 3 | | 0.77 | $p < 0.517$ |
| Age by Sex by Year | 6 | | 1.73 | $p < 0.112$ |

[a]Ages compared were fawns (5-7 months), yearlings (18 months) and adults ($\geq$ 30 months).

Table 4. Analysis of variance of age, sex, and year harvested for whole body weight of white-tailed deer collected in December 1978-81, Fort Riley, Kansas.

| Source | DF | MS | F-Value | Significance |
|---|---|---|---|---|
| Overall Model | 23 | 4406.43 | 68.91 | $p < 0.001$ |
| ERROR | 236 | 63.94 | | |
| TOTAL | 259 | | | |
| Age[a] | 2 | | 534.23 | $p < 0.001$ |
| Sex | 1 | | 200.60 | $p < 0.001$ |
| Age by Sex | 2 | | 55.93 | $p < 0.001$ |
| Year | 3 | | 0.96 | $p < 0.414$ |
| Age by Year | 6 | | 0.84 | $p < 0.539$ |
| Sex by Year | 3 | | 2.14 | $p < 0.935$ |
| Age by Sex by Year | 6 | | 0.32 | $p < 0.924$ |

[a]Ages compared were fawns (5-7 months), yearlings (18 months) and adults ($\geq$ 30 months).

Table 5. Analysis of variance of age, sex, and year harvested for field dressed weight of white-tailed deer collected in December 1979-81, Fort Riley, Kansas.

| Source | DF | MS | F-Value | Significance |
|---|---|---|---|---|
| Overall Model | 13 | 3049.91 | 32.2 | $p < 0.001$ |
| ERROR | 173 | 94.78 | | |
| TOTAL | 186 | | | |
| Age[a] | 2 | | 133.00 | $p < 0.001$ |
| Sex | 1 | | 63.34 | $p < 0.001$ |
| Age by Sex | 2 | | 11.49 | $p < 0.001$ |
| Year | 2 | | 2.43 | $p < 0.908$ |
| Age by Year | 3 | | 0.88 | $p < 0.454$ |
| Sex by Year | 1 | | 0.72 | $p < 0.398$ |
| Age by Sex by Year | 2 | | 0.06 | $p < 0.938$ |

[a]Ages compared were fawns (5-7 months), yearlings (18 months) and adults ($\geq$ 30 months).

Table 6. Analysis of variance of age, sex, and year harvested for body weight/hind foot ratio of white-tailed deer collected in December 1978-1981, Fort Riley, Kansas.

| Source | DF | MS | F-Value | Significance |
|---|---|---|---|---|
| Overall Model | 23 | 1.28 | 54.98 | $p < 0.001$ |
| ERROR | 235 | 0.023 | | |
| TOTAL | 258 | | | |
| Age[a] | 2 | | 445.55 | $p < 0.001$ |
| Sex | 1 | | 129.87 | $p < 0.001$ |
| Age by Sex | 2 | | 39.74 | $p < 0.001$ |
| Year | 3 | | 1.18 | $p < 0.319$ |
| Age by Year | 6 | | 0.52 | $p < 0.796$ |
| Sex by Year | 3 | | 2.25 | $p < 0.081$ |
| Age by Sex by Year | 6 | | 0.25 | $p < 0.959$ |

[a]Ages compared were fawns (5-7 months), yearlings (18 months) and adults ($\geq$ 30 months).

Table 7. Analysis of variance of age and year harvested for antler points of adult male white-tailed deer collected in December 1978-81, Fort Riley, Kansas.

| Source of Variation | DF | F-Value | Significance |
|---|---|---|---|
| | | Antler Points | |
| Age[a] | 1 | 90.89 | $p < 0.001$ |
| Year | 3 | .53 | $p < 0.669$ |
| Age by Year | 3 | .97 | $p < 0.408$ |
| | | Beam Circumference | |
| Age | 1 | 42.63 | $p < 0.001$ |
| Year | 3 | 8.58 | $p < 0.004$ |
| Age by Year | 3 | 1.80 | $p < 0.171$ |

[a]76 yearlings, 47 adults.

Table 8. Analysis of variance of age and year harvested for number of corpora lutea of pregnancy and number of embryos of white-tailed deer collected in December 1978-1981, Fort Riley, Kansas.

| Source of Variation | DF | F-Value | Significance |
|---|---|---|---|
| | Number of Corpora Lutea of Pregnancy | | |
| Age[a] | 2 | 83.84 | $p < 0.001$ |
| Year harvested | 3 | 1.49 | $p < 0.219$ |
| Age by Year | 6 | 3.57 | $p < 0.003$ |
| | Number of Visible Embryos | | |
| Age | 2 | 13.11 | $p < 0.001$ |
| Year harvested | 3 | 1.31 | $p < 0.272$ |
| Age by Year | 6 | .37 | $p < 0.896$ |

[a]52 adults, 43 yearlings, 52 fawns.

Table 9. Analysis of variance of age and season for various hematology and blood chemistry parameters of 30 doe and 13 fawn white-tailed deer, Fort Riley, Kansas.

| Source of Variation | DF | F-Value | Significance |
|---|---|---|---|
| | | Packed Cell Volume | |
| Age | 1 | 1.57 | $p < 0.215$ |
| Season[a] | 3 | 1.59 | $p < 0.783$ |
| Age by Season | 3 | 1.77 | $p < 0.322$ |
| | | Glucose (MG/DL) | |
| Age | 1 | 0.07 | $p < 0.785$ |
| Season | 3 | 0.50 | $p < 0.690$ |
| Age by Season | 3 | 0.20 | $p < 0.897$ |
| | | Lactic Dehydrogenase (U/L) | |
| Age | 1 | 0.48 | $p < 0.490$ |
| Season | 3 | 0.63 | $p < 0.603$ |
| Age by Season | 3 | 2.60 | $p < 0.060$ |
| | | Serum glutamic Oxalacetic Transaminase (U/L) | |
| Age | 1 | 0.43 | $p < 0.514$ |
| Season | 3 | 0.44 | $p < 0.726$ |
| Age by Season | 3 | 0.33 | $p < 0.807$ |
| | | Total Protein (G/DL) | |
| Age | 1 | 0.12 | $p < 0.746$ |
| Season | 3 | 1.14 | $p < 0.474$ |
| Age by Season | 3 | 2.08 | $p < 0.498$ |
| | | Uric Acid (MG/DL) | |
| Age | 1 | 0.03 | $p < 0.854$ |
| Season | 3 | 1.47 | $p < 0.669$ |
| Age by Season | 3 | 2.39 | $p < 0.470$ |
| | | Alkaline Phosphatase (U/L) | |
| Age | 1 | 43.21 | $p < 0.001$ |
| Season | 3 | 3.08 | $p < 0.034$ |
| Age by Season | 3 | 2.80 | $p < 0.101$ |

Table 9. (continued)

| Source | DF | F-Value | Significance |
|---|---|---|---|
| | | Albumin (G/DL) | |
| Age | 1 | 0.01 | p < 0.970 |
| Season | 3 | 0.77 | p < 0.519 |
| Age by Season | 3 | 0.80 | p < 0.501 |
| | | Cholesterol (MG/DL) | |
| Age | 1 | 1.47 | p < 0.231 |
| Season | 3 | 3.14 | p < 0.032 |
| Age by Season | 3 | 0.80 | p < 0.501 |
| | | Serum Urea Nitrogen (MG/DL) | |
| Age | 1 | 0.14 | p < 0.709 |
| Season | 3 | 16.00 | p < 0.001 |
| Age by Season | 3 | 1.13 | p < 0.340 |

[a]Winter (2 Feb - 23 Mar), Spring (1 Apr - 17 May), Summer (24 Jun - 15 Aug), Fall (17 Sep - 22 Oct).

Table 10. Analysis of variance of age, sex and year harvested on selected hematology and blood chemistry parameters of white-tailed deer collected in December 1979-81, Fort Riley, Kansas.

| Source of Variation[a] | DF | F-Value | Significance |
|---|---|---|---|
| | | Packed Cell Volume | |
| Age | 1 | 0.96 | p < 0.331 |
| Sex | 1 | 0.06 | p < 0.813 |
| Year | 3 | 0.45 | p < 0.724 |
| Age by Sex by Year | 3 | 1.53 | p < 0.214 |
| | | Glucose (MG/DL) | |
| Age | 1 | 0.77 | p < 0.384 |
| Sex | 1 | 0.99 | p < 0.325 |
| Year | 3 | 1.06 | p < 0.375 |
| Age by Sex by Year | 3 | 0.27 | p < 0.762 |
| | | SGOT[b] (U/L) | |
| Age | 1 | 0.89 | p < 0.348 |
| Sex | 1 | 0.16 | p < 0.686 |
| Year | 3 | 1.06 | p < 0.375 |
| Age by Sex by Year | 3 | 0.51 | p < 0.605 |
| | | Uric Acid (MG/DL) | |
| Age | 1 | 0.48 | p < 0.491 |
| Sex | 1 | 0.72 | p < 0.399 |
| Year | 3 | 1.57 | p < 0.204 |
| Age by Sex by Year | 3 | 0.09 | p < 0.913 |
| | | LDH[c] (U/L) | |
| Age | 1 | 1.04 | p < 0.310 |
| Sex | 1 | 1.76 | p < 0.386 |
| Year | 3 | 2.36 | p < 0.078 |
| Age by Sex by Year | 3 | 0.12 | p < 0.887 |
| | | ALP[d] (U/L) | |
| Age | 1 | 4.76 | p < 0.033 |
| Sex | 1 | 0.00 | p < 0.972 |
| Year | 3 | 0.88 | p < 0.476 |
| Age by Sex by Year | 3 | 2.49 | p < 0.091 |

Table 10. (continued)

| Source of Variation[a] | DF | F-Value | Significance |
|---|---|---|---|
| | | Albumin (G/DL) | |
| Age | 1 | 0.26 | p < 0.609 |
| Sex | 1 | 3.17 | p < 0.079 |
| Year | 3 | 20.86 | p < 0.001 |
| Age by Sex by Year | 3 | 0.55 | p < 0.579 |
| | | Total Protein (G/DL) | |
| Age | 1 | 0.45 | p < 0.503 |
| Sex | 1 | 6.16 | p < 0.016 |
| Year | 3 | 8.41 | p < 0.001 |
| Age by Sex by Year | 3 | 0.36 | p < 0.698 |
| | | Cholesterol (MG/DL) | |
| Age | 1 | 2.36 | p < 0.129 |
| Sex | 1 | 1.37 | p < 0.246 |
| Year | 3 | 10.81 | p < 0.001 |
| Age by Sex by Year | 3 | 0.36 | p < 0.698 |
| | | Calcium (ca) (MG/DL) | |
| Age | 1 | 0.00 | p < 0.966 |
| Sex | 1 | 1.36 | p < 0.249 |
| Year | 3 | 8.52 | p < 0.001 |
| Age by Sex by Year | 3 | 0.37 | p < 0.691 |
| | | BUN[e] (MG/DL) | |
| Age | 1 | 5.62 | p < 0.207 |
| Sex | 1 | 1.45 | p < 0.340 |
| Year | 3 | 1.77 | p < 0.160 |
| Age by Sex by Year | 3 | 1.06 | p < 0.249 |

[a]Age by sex classes included: 31 bucks, 28 does and 21 fawns. (12 males, 9 females)

[b]SGOT - Serum glutamic oxalacetic transaminase

[c]LDH - Lactic dehydrogenase

[d]ALP - Alkaline phosphatase

[e]BUN - Blood urea nitrogen

Table 11. Analysis of variance of season for various rumen solid parameters of white-tailed deer collected February-October, 1979, Fort Riley, Kansas.

| | Source of Variation - Season[a,b] | | |
|---|---|---|---|
| Parameter | DF | F-Value | Significance |
| Percent Neutral Detergent Fiber | 3 | 8.75 | $p < 0.001$ |
| Percent Acid Detergent Fiber | 3 | 6.80 | $p < 0.001$ |
| Percent Lignin | 3 | 4.37 | $p < 0.008$ |
| Percent Ash | 3 | 4.22 | $p < 0.010$ |
| Percent Crude Protein | 3 | 25.44 | $p < 0.001$ |
| Gross Energy (Kcal/g) | 3 | .65 | $p < 0.588$ |

[a]Season of Collection: Winter (2 Feb - 23 Mar), Spring (1 Apr - 17 May), Summer (24 Jun - 15 Aug), Fall (17 Sep - 22 Oct).

[b]Sample Size (winter-13), (spring-12), (summer-15), (fall-10).

Table 12. Analysis of variance of season for selected rumen fluid parameters of white-tailed deer collected February-October 1979, Fort Riley, Kansas.

| Parameter | Source of Variation - Season[a] DF | F-Value | Significance |
|---|---|---|---|
| Rumen Fluid pH | 3 | 2.30 | $p < 0.080$ |
| Acetic Acid Conc (mM/L) | 3 | 3.66 | $p < 0.019$ |
| Propionic Acid Conc (mM/L) | 3 | 2.19 | $p < 0.102$ |
| Butyric Acid Conc (mM/L) | 3 | 4.05 | $p < 0.012$ |
| Higher Acid Conc (mM/L) | 3 | 5.74 | $p < 0.002$ |
| TVFAC[b] (mM/L) | 3 | 4.55 | $p < 0.007$ |
| Acetic Acid Molar % | 3 | 12.89 | $p < 0.001$ |
| Propionic Acid Molar % | 3 | 16.62 | $p < 0.001$ |
| Butyric Acid Molar % | 3 | 2.73 | $p < 0.054$ |
| Higher Acid Molar % | 3 | 1.67 | $p < 0.187$ |

[a]Winter (N=13), Spring (N=12), Summer (N=15), Fall (N=10).

[b]TVFAC = Total Volatile Fatty Acid Concentration.

Table 13. Analysis of variance of age, sex, and year harvested for TKFI of white-tailed deer collected December 1978-81, Fort Riley, Kansas.

| Source of Variation | DF | F-Value | Significance |
|---|---|---|---|
| Age | 2 | 0.44 | $p < 0.6465$ |
| Sex | 1 | 194.31 | $p < 0.0001$ |
| Age by Sex[a] | 2 | 19.70 | $p < 0.0001$ |
| Year | 3 | 29.18 | $p < 0.0001$ |
| Age by Sex by Year | 6 | 2.11 | $p < 0.0807$ |

[a](42 adult males, 47 adult females, 56 yearling males, 36 yearling females, 36 male fawns, 48 female fawns)

Table 14. Comparison of year-round diets of white-tailed deer from two areas in Kansas.

| Study Location | Food Item (%) | | | | | |
|---|---|---|---|---|---|---|
| | Browse[a] | Fruits and Seeds[b] | Forbs | Grass | Agric. Crops | Other[c] |
| Northeast Kansas[d] | 24.0 | 8.5 | 12.2 | 1.0 | 49.9 | 4.4 |
| Fort Riley | 18.0 | 18.2 | 40.9 | 4.5 | 10.1 | 8.2 |

[a]Woody stems and leaves

[b]Both woody and herbaceous

[c]Includes unidentifiable items, hair, and fungus

[d]From Watt et al. (1967)

Table 15. Foods identified in rumen samples from white-tailed deer on Fort Riley, Kansas. S = stems, L = leaves, F = flowers, fruits or seeds.

| Parts Identified | Food Item[a] | | Month of Occurrence in Rumens |
|---|---|---|---|
| F | Ambrosia sp. | ragweed | Dec, Oct |
| S,L | Baptisia sp. | wildindigo | Apr |
| S,L,F | Ceanothus americanus | Jerseytea ceanothus | May, Jun, Oct |
| F | Celastrus scandens | American bittersweet | Feb, Mar |
| S | Celtis occidentalis | common hackberry | Feb |
| L | Cercis canadensis | eastern redbud | Jun |
| F | Chenopodium sp. | goosefoot | Sept |
| L | Convolvulus arvensis | field bindweed | May |
| S,L,F | Cornus drummondii | roughleaf dogwood | Aug, Oct |
| F,L | Cyperaceae | sedge | Feb, Apr |
| S | Euonymus atropurpureus | eastern wahoo | Aug |
| S,L | Euphorbia maculata | spotted euphorbia | Sept |
| F | Euphorbia sp. | euphorbia | Oct |
| F | Gleditsia triacanthos | common honeyhocust | Dec, Feb, Mar |
| S,L,F | Hibiscus trionum | flowerofanhour | Oct |
| L | Juniperus virginiana | eastern redcedar | Feb |
| S,L | Lactuca serriola | prickly lettuce | May, Jun, Jul, Aug |
| F | Maclura pomifera | osageorange | Dec, Feb |
| F | Medicago sp. | alfalfa | Sept, Oct |
| S,L,F | Morus rubra | red mulberry | Jun |
| L | Parthenocissus quinquefolia | Virginia creeper | Feb |
| F | Physalis sp. | groundcherry | Feb, Oct |
| F | Phytolacca americana | common pokeberry | Sept, Oct |
| F | Quercus macrocarpa | bur oak | Dec, Mar, Apr, Oct |
| L,F | Quercus muehlenbergii | chinquapin oak | Dec, Mar |
| F | Rhus aromatica | aromatic sumac | Feb |

Table 15. (Continued)

| Parts Identified | Food Item[a] | | Month of Occurrence in Rumens |
|---|---|---|---|
| S,F | Rhus glabra | smooth sumac | Dec, Feb, Mar, Apr |
| S,L | Rosa sp. | rose | Sept, Oct |
| F | Sambucus canadensis | American elderberry | Oct |
| F | Solanum carolinense | horsenettle | Oct |
| L,F | Sorghum sp. | sorghum | Dec, Apr, Aug, Oct |
| | Symphoricarpos orbiculatus | buckbrush | Dec, Feb, Mar, Oct |
| L,F | Taraxacum sp. | dandelion | Apr |
| L | Triticum sp. | wheat | Feb, Mar, Apr |
| S,L | Ulmus americana | American elm | Dec, Feb, Jun Jul, Aug |
| F | Zea mays | corn | Dec, Mar |

[a]Scientific and common names follow Anderson and Owensby (1969)

# MORPHOLOGICAL, PHYSIOLOGICAL AND NUTRITIONAL STATUS OF THE FORT RILEY, KANSAS, DEER HERD

by

SCOTT ROBERT KLINGER

B.S., The Pennsylvania State University, 1977

---

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the
requirements for the degree

MASTER OF SCIENCE

Division of Biology

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1983

Aspects of the morphology, physiology, and nutrition of white-tailed deer (Odocoileus virginianus) were documented for a free-ranging herd on the Fort Riley Military Reservation, Kansas, between December 1978 and 1981. Morphological measurements were influenced by age and sex ($p < 0.01$) but not year of collection. Body size and weights were comparable to a larger sub-species from New York on excellent range. Equations for predicting whole weight of deer from field dressed weight were accurate within ±6 kg. Prediction equations for estimating whole weight from chest girth in adult deer were adequate for estimating mean weight of a deer population, but not individual weights of deer. Body weight/hind foot ratio may be useful in comparing the condition of deer from different regions and subspecies. The higher the ratio the better the condition.

Ovulation and fetal rates of Fort Riley white-tailed deer were comparable to other areas of the midwest where agricultural crops comprise a much larger percentage of the diet. Fetal sex ratios favored males (57%) to females (43%). Mean conception date was 16 November for adults and 19 November for yearlings. Fawns bred several weeks later. Greater than 6-month-old female fawns were more ($p < 0.05$) productive and heavier ($P < 0.05$) then < 6-month-old female fawns. Percentage of female fawns breeding varied between years and was attributed to alterations in age of fawns at the onset of the rut. Between year variations in number of lactating yearling females were related to percent fawns breeding the previous year. Yearling and adult males had elevated testis weights in the fall. There was no evidence male fawns participated in the rut.

Packed cell volume and blood chemistries were within the range for white-tailed deer reported in other studies. Samples with very high

glucose, lactic dehydrogenase, and serum glutamic oxaloacetic transaminase may indicate abnormal stress while dying. Serum urea nitrogen and cholesterol were the only parameters which showed potential for monitoring immediate nutritional history of free-ranging Fort Riley deer.

Forbs comprised the bulk of deer diets in spring and summer. Browse was used equally in winter and fall. Grasses comprised < 4% of the year-round diet, and forbs were used more in early spring and summer than fall and winter. Agricultural crops were used less by Fort Riley deer than northeast Kansas deer. Acorns constituted more than 15% of deer diets in the fall.

Some of the rumen content parameters and nearly all of the rumen fluid parameters were affected by time lapse between sample collection and death of the deer. Time killed, age, and sex were not sources of variation for rumen parameter values. Spring and summer rumen samples were lower ($p < 0.05$) in neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, and percent acetate with higher ash, crude protein, volatile fatty acids (VFAs), percent propionate and percent butyrate than winter samples. High rumen VFAs in the fall were related to consumption of highly digestible crops (milo) and acorns. Fat reserves (total kidney fat index - TKFIs) of adult females and fawns were highest in mid-December and lowest in summer. Fat reserves of adult males reached a peak in October but declined rapidly during the November-December rut. Rumen solid, NDF, and crude protein were useful for monitoring dietary quality of free-ranging deer. VFAs provided a gross index to dietary metabolizable energy content. TKFIs provided data on stored fat and the energy balance of the deer population during the previous several weeks or months.