Fat Levels in Male White-Tailed Deer during the Breeding Season

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Abstract: Percent body fat was estimated from the Kidney Fat Index for 1,726 male, white-tailed deer from the Savannah River Plant in South Carolina for the years 1974 through 1978. There was a significant decrease in percent body fat from September through December in all animals ≥ 2.5 years. Percent fat in fawns increased significantly from September through December. Fat levels in 1.5-year-old animals did not show a general trend for either an increase or decrease from September through December. However, the lowest percent fats were consistently observed in November for all but the 0.5-year-old males. Percent body fat was significantly related to body weight, month of collection, and age of the male, but the multiple coefficient of determination was small for this relationship ($R^2 = 0.09$). The rapid change in fat levels in males during the breeding season indicates that caution must be exercised when using the kidney fat index as a management tool. Management decisions derived from the use of KFI should be based upon animals collected at the same time of the year and of the same sex and age class. Low fat levels in older males during the breeding season are primarily a result of breeding activity.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 36:454–462

A number of indices of body condition have been developed for white-tailed deer (Stockle et al. 1978), but in most cases their relationships to actual levels of total body fat are not known. Percent body fat and kidney fat index (KFI) were highly correlated in a South Carolina white-tailed deer herd (Finger et al. 1981). Fat levels in this herd showed large seasonal changes (Johns et al. 1980, Finger et al. 1981, Smith et al. 1982) as has also been demonstrated for other more northerly herds (Hesselton and Sauer 1973, Anderson et al. 1972). Sex and age affect the pattern and magnitude of the seasonal changes in fat levels (Johns et al. 1980). During certain seasons monthly variations in body condition are probably substantial.

Most of the information on body condition is available for white-tailed deer taken during the hunting season. This season is one of high energy expenditure for older males because of rutting activities. Detailed monthly analyses of fat reserves during this season could help in understanding the degree to which males of different ages participate and lose stored energy during the breeding period. Annual changes in fat levels during the rut are also possible but have not been rigorously examined because of a lack of long term studies (Caughley 1970, Hesselton and Sauer 1973). Large temporal variations in body condition complicate the use of indices such as the KFI in a management context.

Our primary objective was to determine changes in the KFI among 4 age classes of male, white-tailed deer sampled over a 5-year period. Secondarily, we wished to determine the effects of habitat type on fat levels among the males. We also wished to evaluate the usefulness of estimates of fat levels for management purposes.

This research was supported by a contract (DE-AC09-76-SR00819) between the University of Georgia and the U.S. Department of Energy. Other groups cooperated in conducting this research including the employees of the E. I. DuPont de Nemours and Co. and the U.S. Forest Service at the Savannah River Plant (SRP). The South Carolina Department of Wildlife and Marine Resources granted permission to conduct the research. Special thanks are extended to S. F. Finger, M. N. Manlove, and our colleagues at the Savannah River Ecology Laboratory who contributed their labor and ideas to our work.

Methods

Male white-tailed deer ($N = 1726$) were collected from 1974 through 1978 during public hunts from September through December on the SRP near Aiken, South Carolina. Deer were classified as coming from upland or swamp habitats (Johns et al. 1980). Ages were estimated by degree of tooth wear and pattern of eruption (Severinghaus 1949). Deer were weighed to the nearest pound on a spring scale and weights were converted to kilograms for analyses. Kidneys and perirenal fat deposits were removed according to the method of Riney (1955). Occasionally only 1 kidney was available, and the data from it were used instead of the mean of 2 kidneys. The weight of the peri-

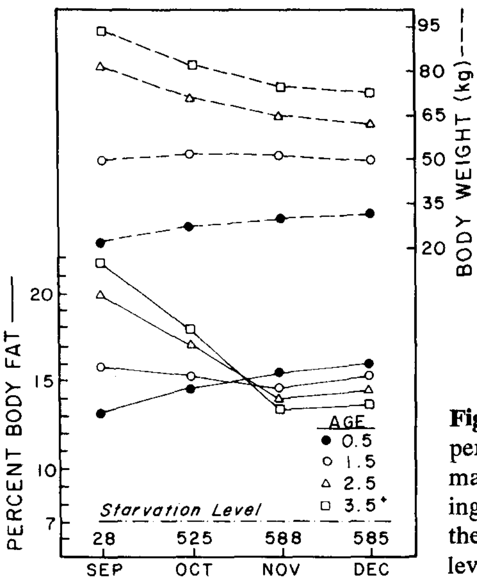

Figure 1. Changes in body weight and percent total body fat for 4 age classes of male white-tailed deer through the breeding season. Sample sizes are given above the monthly designations. The starvation level, as given by Pond (1978), is denoted.

renal fat (g) was divided by the fresh weight of the kidneys (g) and multiplied by 100 to obtain the KFI. The KFI was transformed by the use of natural logarithms (ln KFI) before statistical analyses. Percent total body fat (% Fat) on a dry weight basis was calculated from the KFI: $\% \text{ Fat} = 3.05 + 3.13 \ln(\text{KFI} + 1)$ ($R^2 = 0.87$, Finger et al. 1981). Statistical analyses were performed using the Statistical Analysis System (Barr et al. 1979).

Results

Male white-tailed deer from the SRP showed significant monthly variation in fat levels (Fig. 1, Table 1). There was a significant ($P \leq 0.0001$) decrease in percent fat from September through December in all animals $\geq$2.5 years of age ($r = 0.303$ and 0.524 for 2.5 and 3.5^+ age classes respectively). Animals $\geq$3.5 years of age exhibited the greatest loss in percent body fat. Only the fawn age class showed a marked increase in fat levels throughout the study period. Fat levels in 1.5-year-old animals did not show a general trend for either an increase or decrease in percent total body fat from September through December, but the lowest fat levels were generally observed in November (Fig. 2). A general increase in percent body fat was observed across the 5-year study period with the exception of 1976 (Fig. 3). During 1976 a decrease in body fat was observed in all age classes.

The relative associations of age, habitat, month and year, as well as the interactions of these variables with variation in body weight and ln KFI are

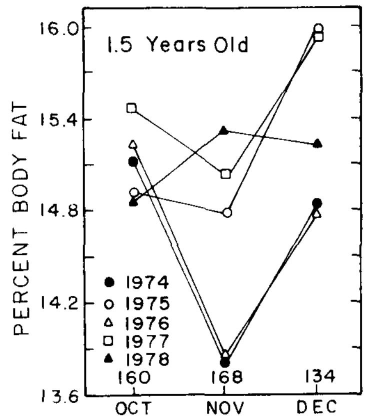

Figure 2. Percent body fat changes for 1.5-year-old male deer during the months of October, November and December for 5 consecutive years. Sample sizes are given above the monthly designations.

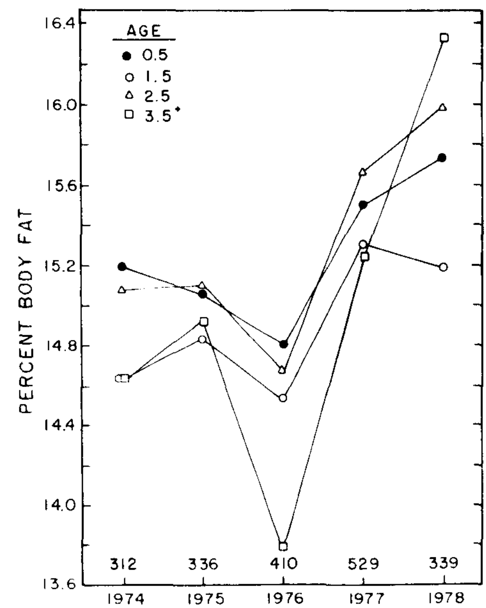

Figure 3. Percent body fat for males of 4 age classes across 5 consecutive years. Sample sizes are given above the year designations.

summarized in Table 1. Age differences accounted for most of the variation in body weight while month, the second most important factor, accounted for less than 1% of the variation in body weight. There was also a relatively strong month-age interaction indicating that variation in body weight due to age was not the same in different months. Although habitat and year were statistically associated with significant amounts of variation in body weight in the overall analysis, the amount of the variation attributable to either year or

Table 1. Results of Multiple Regression for the Effects of the Independent Variables and Their Interactions on the Dependent Variables Body Weight and the Natural Logarithm of the Kidney Fat Index (ln KFI). R^2 is equal to the Proportion of the Overall Sums of Squares Attributable to a Particular Source in the Analyses and F is from a Type I Sums of Squares Analyses of Variance (Barr et al. 1979)

Source	Degrees of Freedom	Body Weight[a] R^2	Body Weight[a] F	ln KFI[b] R^2	ln KFI[b] F
Age	1	0.772	6,346.8***	0.005	10.9**
Habitat (Hab)	1	0.002	16.5***	0.006	12.9**
Month (Mo)	1	0.007	57.1***	0.018	37.9***
Year (Yr)	1	0.001	8.2*	0.017	36.7***
Mo x Yr	1	0.00004	0.3[NS]	0.000	0.2[NS]
Mo x Age	1	0.012	100.3***	0.161	341.8***
Mo x Hab	1	0.00006	0.5[NS]	0.001	1.3[NS]
Age x Yr	1	0.0004	3.5[NS]	0.003	6.4*
Hab x Yr	1	0.00003	0.2[NS]	0.002	5.3*
Hab x Age	1	0.0005	4.3*	0.003	7.1*
Total	1,726				

* $P \leq 0.05$ ** $P \leq 0.001$ *** $P \leq 0.0001$ NS $P > 0.05$
[a] $R^2_{\text{Body Weight}} = 0.80$.
[b] $R^2_{\ln \text{KFI}} = 0.22$.

habitat was very small (<1%). The differences in the means for body weight and percent fat in the swamp (50.35 kg, 15.43%) and upland areas (50.55 kg, 15.05%) were negligible.

Month was the single most important variable associated with ln KFI, although the amount of variation accounted for by differences among years was nearly as great (Table 1). The interaction between month and age accounted for more of the variation in ln KFI than any single factor. This high degree of interaction is due to the differences in the loss rates for body fat in the older animals compared to those for the 0.5 and 1.5-year-old animals. The lack of a significant interaction between month and year indicates that the pattern of change for ln KFI across months was essentially the same every year. Age and habitat significantly influenced the variation in ln KFI but accounted for little of the total variation (<1% each; Table 1).

Percent body fat was statistically related to body weight (BWT) month of collection (MO) and age of the male (AGE) as follows: % FAT = 7.105 − 1.056 AGE + 0.058 BWT − 0.236 MO. The independent variables in the model are given in the order of their importance to the prediction of % fat. The standard errors for the intercept and slopes were 0.704 – intercept, 0.095 – AGE, 0.005 – BWT and 0.061 – MO. The variables each added a significant amount to the overall predictability of the multiple regression model ($P < 0.0001$ in every case), but the multiple coefficient of determination was small ($R^2 = 0.09$). Even when the interaction terms were added to the predictive model, less than 25% of the variation in fat levels was accounted for (Table 1).

The annual and fall season temperatures and rainfall for the 5 year study period were analysed for comparisons with the KFI levels. The annual temperatures for the years 1974 through 1978 were respectively 19 C, 19 C, 17 C, 18 C and 18 C. The annual rainfalls for these years were respectively 16.57 cm; 22.63 cm, 21.40 cm, 17.85 cm, and 15.47 cm. No significant correlations were found between the KFI levels and either the fall season or annual temperatures and rainfalls.

Discussion

Growth and breeding behavior are 2 major processes occurring in males during the fall breeding season. Both are energy demanding but to differing magnitudes in males of various ages. Copulations take place throughout the 4 months of our study but are most prevalent around the first of November (Payne et al. 1966, Johns et al. 1977, Cothran et al. 1983). Fat levels in older males decrease rapidly just prior to this peak in the copulatory behavior most likely because of the large amount of energy expended in chasing and accompanying females and or preventing those females from mating with other males. The change in fat levels is most extreme in the oldest age class (Fig. 1), and it is likely that they are the males that impregnate most of the females (Hirth 1977). The 2.5-year-old males lost almost as much fat as males $\geq$3.5 years old and, thus, apparently used this energy in their attempts to participate in the breeding activity. The adult males even decrease their dietary intake during the rut period (Long et al. 1965), and this is probably adaptive in that it increases the chances of breeding receptive females by males that stay alert to breeding possibilities.

The 1.5-year-old males lose only slight amounts of fat and 0.5-year-old males even gain fat during the rut. Growth processes are emphasized to a greater degree in the youngest males, but the 1.5-year-old males have not completed their growth either (Smith et al. 1982). Nevertheless, the 1.5-year-old males can lose a considerable amount of fat in certain years (Fig. 2). These males may be involved to varying degrees in the breeding activities from year to year and/or their fat levels may be sensitive indicators to annual changes in the local environments. Even if the 1.5-year-old males do not breed with many females, they may be heavily harassed by the older males who consider them as potential competitors for the available females. The 1.5-year-old males are capable of fertilizing females on the SRP (Urbston 1976).

The male fawns steadily gained fat during the study period but had less fat in September and October than males of any other age class (Fig. 1). By December, their fat level had reached the level of the next older age class at the beginning of the rut. However, the monthly fat levels in fawn males changed consistently across years, and most of the variation in fat levels due to the interaction of age and year (Table 1) was due to the data from the 1.5-year-old males (Fig. 2). We interpret the consistency of the fawn male pattern in monthly fat levels as due to the predominant effects of growth and its energy demands in this age class of males.

Male deer had average fat levels well above the starvation level at all times during the breeding season (Fig. 1). However, some of the individual males especially in the older age classes exhibited very low percent body fat at or below the level indicative of starvation (Unpubl. data). Some individual males probably come close to total exhaustion of their energy reserves, and in southerly climates they may not be at a big disadvantage because of generally higher forage availability in the winter (Harlow et al. 1979). However, fat levels are associated with body weight and age and to a lesser extent to antler size characteristics (Smith et al. 1982), and these characteristics may be affected in males that totally exhaust their fat reserves.

Significant annual variation in percent body fat was observed but the magnitude of the maximum fluctuation for any age class was approximately 2.5 percent body fat (Table 1, Fig. 3). The lowest annual average was about 13.5% body fat for males ≥3.5 years old in 1976, a value well above the starvation level of 7% (Pond 1978). The SRP herd does not appear to be under severe environmental stress, although 1976 may have been a difficult year for some unknown reason. The decline in fat levels for each age class during that year was not correlated with any known climatic condition or local management decision. The general upward trend in fat levels across years may be indicative of better habitat conditions for the deer due to density fluctuation or land management decisions, such as clear cutting of large tracts of land. Annual fluctuations in mast production may also be responsible for variation in KFI (Goodrum et al. 1971, Graybill et al. 1975).

The highly variable fat levels in the older males during the breeding season make it difficult to use KFI as a precise management tool. The low predictability of KFI from the other variables should also indicate the need for caution in using KFI values in making management decisions. Unless KFI values are calculated for deer collected using almost exactly the same sampling scheme, they could vary tremendously just due to a sampling bias such as including more animals for a particular age class or month in 1 sample than in another. Management decisions should be based upon overall trends and not information from individual deer.

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