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Dustin Schaible
*Utah Division of Wildlife Resources*, dustinschaible@utah.gov

Charles D. Dieter
*South Dakota State University, Brookings, SD*, charles.dieter@sdstate.edu

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# HEALTH AND FERTILITY IMPLICATIONS RELATED TO SEASONAL CHANGES IN KIDNEY FAT INDEX OF WHITE-TAILED JACKRABBITS IN SOUTH DAKOTA

**Dustin Schaible**

*Utah Division of Wildlife Resources*
*P.O. Box 606*
*Cedar City, UT 84721-0606*
*DustinSchaible@utah.gov*

and

**Charles Dieter**

*Department of Biology and Microbiology*
*South Dakota State University*
*Brookings, SD 57007*
*Charles.Dieter@sdstate.edu*

**ABSTRACT**—White-tailed jackrabbit (*Lepus townsendii*) populations in the Northern Plains have been in a general decline for the past decade or longer. A suggested reason for this population decline was reduced body condition of individual jackrabbits due to habitat changes. In order to evaluate body condition, we determined the kidney fat index of 314 white-tailed jackrabbits harvested in 44 counties throughout South Dakota. We removed and weighed kidneys and all perirenal fat associated with the kidneys from collected jackrabbits. We measured kidney weight to determine times of high metabolic activity as indicated by an increase in mass. Body condition was assessed by measuring the amount of kidney fat within each collected jackrabbit. Seasonal fluctuations were evident in average kidney weight and kidney fat for both sexes of white-tailed jackrabbits. The kidney fat index in both male and female peaked in winter and was near 0% in summer. We believe that changes in body condition as indicated by the kidney fat index were related to the onset of breeding season rather than availability of food resources.

**Key Words:** kidney fat index, kidney weight, South Dakota, white-tailed jackrabbit

## INTRODUCTION

Estimating the nutritional status of a wildlife population by using condition indices is an important step in wildlife management. Kidney weight and related fat have frequently been used as an index of physical condition in mammals (Caughley and Sinclair 1994; Garant and Crête 1999) as fat reserves influence the probability of survival (DeCalesta et al. 1975; Garant and Crête 1999). Perirenal fat is easily accessible and measurable while producing a wide scale of values under regular environmental circumstances, and is considered to be a reliable indicator of body condition (Caughley 1970; Flux 1971). Riney (1955) proposed using a kidney fat index (KFI) as a measure of physical condition for mammals. The KFI is based on the assumption that the amount of perirenal fat is a reliable indicator of total body fat (Van Vuren and Coblentz 1985). The KFI has been accepted as a satisfactory means of rating body condition (Caughley 1970; Monson et al. 1974), although decreased predictability of very low KFI values is recognized (Ransom 1965; Finger et al. 1981). The kidney fat index can be used as a measure of seasonal trends in condition for a variety of ungulates (Ransom 1965; Blood and Lovaas 1966; Batcheler and Clark 1970; Caughley 1970; Bear 1971; Monson et al. 1974; Dauphine 1975; Van Vuren and Coblentz 1985; Takatsuki 2000; Oosthuizen 2004; Spinage 2008), for opossums (*Didelphis virginiana*) (Bamford 1970), and for several leporids (Flux 1970, 1971; Martin 1977; Pepin 1987; Parkes 1989).

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Flux (1971) found the kidney fat index to be useable in examining hares (*Lepus capensis* and *L. europaeus*), in which kidney fat deposits are the largest in the body. Henke and Demarais (1990) found that the kidney fat index was a good indicator of short-term nutritional stress in black-tailed jackrabbits (*L. californicus*). However, no data have been published regarding the kidney fat index in white-tailed jackrabbits (*L. townsendii*). While conducting an ecological study of white-tailed jackrabbits in South Dakota, we had the opportunity to examine a large number of individuals. We examined distribution, home range, reproductive information, and nutritional status. An objective of this research was to determine seasonal kidney weight and body condition of white-tailed jackrabbits using the kidney fat index, which we report on here.

## MATERIAL AND METHODS

We collected white-tailed jackrabbits in 44 counties throughout South Dakota from August 2004 to September 2005 (Fig. 1). We attempted to collect 15–20 jackrabbits each month using a .22 caliber rifle in isolated areas of each county between 1600 and 2200 hours. All specimens were fitted with an individual ear tag, placed in a plastic bag, and frozen for later examination. All research conducted on jackrabbits was approved by the South Dakota State University Institution's Animal Care and Use Committee.

We estimated the ages of collected jackrabbits using the epiphyseal closure method (Hale 1949; Lechleitner 1959; James and Seabloom 1969). We used X-ray analysis (0.15 second exposure time) to determine epiphyseal closure in the left or right humerus. Jackrabbits were classified into two age classes based on the amount of closure observed on the proximal epiphysis of the humerus. In juveniles (2–12 months) the epiphyseal area had a definite groove or was at least visible. In adults (over 1 year old), there was no evidence of an epiphyseal line (Lechleitner 1959).

We removed and weighed kidneys and all perirenal fat associated with the kidneys from collected jackrabbits. We measured kidney weight to determine the average increase in mass throughout the year. If kidneys were damaged in the collection process, those jackrabbits were omitted from examination. We assessed body condition by measuring the amount of kidney fat within each collected jackrabbit. The KFI was calculated as (total kidney fat weight) / (kidney weight) × 100, and expressed as a percentage (Riney 1955) for each specimen. We calculated the overall average KFI for both sexes for each season.

Figure 1. White-tailed jackrabbit in northeast South Dakota. Photograph courtesy of Bob Losco, Conservation Officer, Webster, SD.

We used two sample t-tests to detect any differences in kidney weight between age groups and sexes ($\alpha = 0.05$). We pooled 3 months of data for seasonal calculations and comparisons as follows: summer (June–August), fall (September–November), winter (December–February), and spring (March–May). Since the kidney fat data were not normally distributed, we transformed the data using the square root of the original data for analyses.

## RESULTS

We collected 314 white-tailed jackrabbits and were able to estimate age for 264 individuals. There were 171 jackrabbits classified as adults and 93 classified as juveniles. We could not use 21 of the specimens because the kidneys were damaged during collection. We examined 243 (126 male, 117 female) white-tailed jackrabbits with undamaged kidneys to determine monthly and seasonal fluctuations in kidney weights and for calculation of the kidney fat index (Table 1).

The average female kidney weight (9.32 g; SE = 0.17) was not different from average male kidney weight (7.92 g; SE = 0.15) ($t_{241}$ = 1.31, p = 0.19). There was no difference in average kidney weight between adult (8.04 g; SE = 0.22) and juvenile males (7.58 g; SE = 0.31) ($t_{124}$ = 0.35, p = 0.55) or adult (9.77 g; SE = 0.28) and juvenile females (9.23 g; SE = 0.35) ($t_{115}$ = 0.71, p = 0.48), so we pooled adult and juveniles for other data analyses.

There were seasonal differences in average kidney weight for females ($F_3$ = 2.83, P = 0.042). The average kidney weight was higher in spring (9.99 g; SE = 0.32) than in summer (8.76 g; SE = 0.33), but there were no differences for fall (9.58 g; SE = 0.31) or winter (9.57 g; SE = 0.27) (Table 2). There were also differences in seasonal average kidney weight in males ($F_3$ = 3.58, P = 0.016). Average

TABLE 1
MEAN KIDNEY WEIGHTS (g) OF WHITE-TAILED JACKRABBITS FROM SOUTH DAKOTA, 2004–2005

| | Male | | | Female | | |
|---|---|---|---|---|---|---|
| **Month** | **Adult** | **Juvenile** | **Kidney wt. (SE)** | **Adult** | **Juvenile** | **Kidney wt. (SE)** |
| 2004 | | | | | | |
| Aug. | 10 | 7 | 7.63 (0.29) | 14 | 11 | 9.04 (0.5) |
| Sept. | 2 | 5 | 8.02 (0.18) | 1 | 4 | 9.28 (0.85) |
| Oct. | 1 | 2 | 9.18 (0.6) | 2 | 2 | 9.72 (0.99) |
| Nov. | 2 | 4 | 9.06 (0.98) | 2 | 2 | 10.48 (0.05) |
| Dec. | 4 | 3 | 9.43 (0.29) | 3 | 4 | 10.02 (0.39) |
| 2005 | | | | | | |
| Jan. | 6 | 3 | 7.14 (0.24) | 6 | 1 | 8.76 (0.51) |
| Feb. | 9 | 0 | 8.56 (0.41) | 10 | 0 | 9.83 (0.42) |
| Mar. | 12 | 0 | 7.23 (0.1) | 11 | 0 | 9.89 (0.41) |
| Apr. | 22 | 0 | 8.61 (0.16) | 10 | 0 | 10.31 (0.51) |
| May | 3 | 0 | 9.62 (0.26) | 1 | 0 | 8.03 |
| June | 4 | 2 | 7.21 (0.57) | 3 | 3 | 8.91 (0.89) |
| July | 5 | 5 | 6.12 (0.31) | 2 | 4 | 7.28 (0.62) |
| Aug. | 4 | 2 | 7.81 (0.42) | 4 | 6 | 8.85 (0.63) |
| Sept. | 4 | 5 | 7.71 (0.54) | 4 | 7 | 9.29 (0.44) |

TABLE 2
SEASONAL MEANS FOR KIDNEY WEIGHT (g) AND ASSOCIATED KIDNEY FAT (g)
IN WHITE-TAILED JACKRABBITS IN SOUTH DAKOTA, 2004–2005

| | Male | | Female | |
|---|---|---|---|---|
| | **Kidney wt. (SE)** | **Kidney fat (SE)** | **Kidney wt. (SE)** | **Kidney fat (SE)** |
| Summer | 7.20$^a$ (0.21) | 3.45$^a$ (0.88) | 8.76$^a$ (0.33) | 1.72$^a$ (0.42) |
| Fall | 8.30$^b$ (0.32) | 10.00$^b$ (1.12) | 9.58 (0.31) | 9.81$^b$ (1.22) |
| Winter | 8.29$^b$ (0.26) | 27.67$^c$ (2.87) | 9.57 (0.27) | 39.50$^c$ (3.55) |
| Spring | 8.20$^b$ (0.37) | 15.04$^b$ (2.86) | 9.99$^b$ (0.32) | 16.02$^b$ (2.40) |

Note: Within columns, *a* is significantly different than *b* or *c*; *b* is significantly different than *c*.

kidney weight was lower in summer (7.20 g; SE = 0.21) than in fall (8.30 g; SE = 0.32), winter (8.29 g; SE = 0.26), and spring (8.20 g; SE = 0.37) (Table 2).

Perirenal fat reserves fluctuated monthly and seasonally in both sexes (Table 2). Female kidney fat was seasonally different ($F_3$ = 61.37, $P < 0.001$). Winter fat deposits (39.5 g; SE = 3.55) were higher than during any other season, and summer fat deposits (1.72 g; SE = 0.42) were lower than the other seasons. There was no difference between fat deposits in fall (9.81 g; SE = 1.22) and in spring (16.02 g; SE = 2.40). Male kidney fat was seasonally different ($F_3$ = 19.10, $P < 0.001$). Winter fat deposits (27.67 g; SE = 2.87) were higher than any other season. Summer fat deposits (3.45 g; SE = 0.88) were lower than the other seasons. There was no difference between fall fat deposits (10.00 g; SE = 1.12) and spring fat deposits (15.04 g; SE = 2.86). KFI for both sexes gradually rose from summer to fall. There was a peak in winter for both sexes. Female KFI peaked in January and male KFI peaked in February. The kidney fat index for both sexes regressed in spring and was low again in summer (Fig. 2).

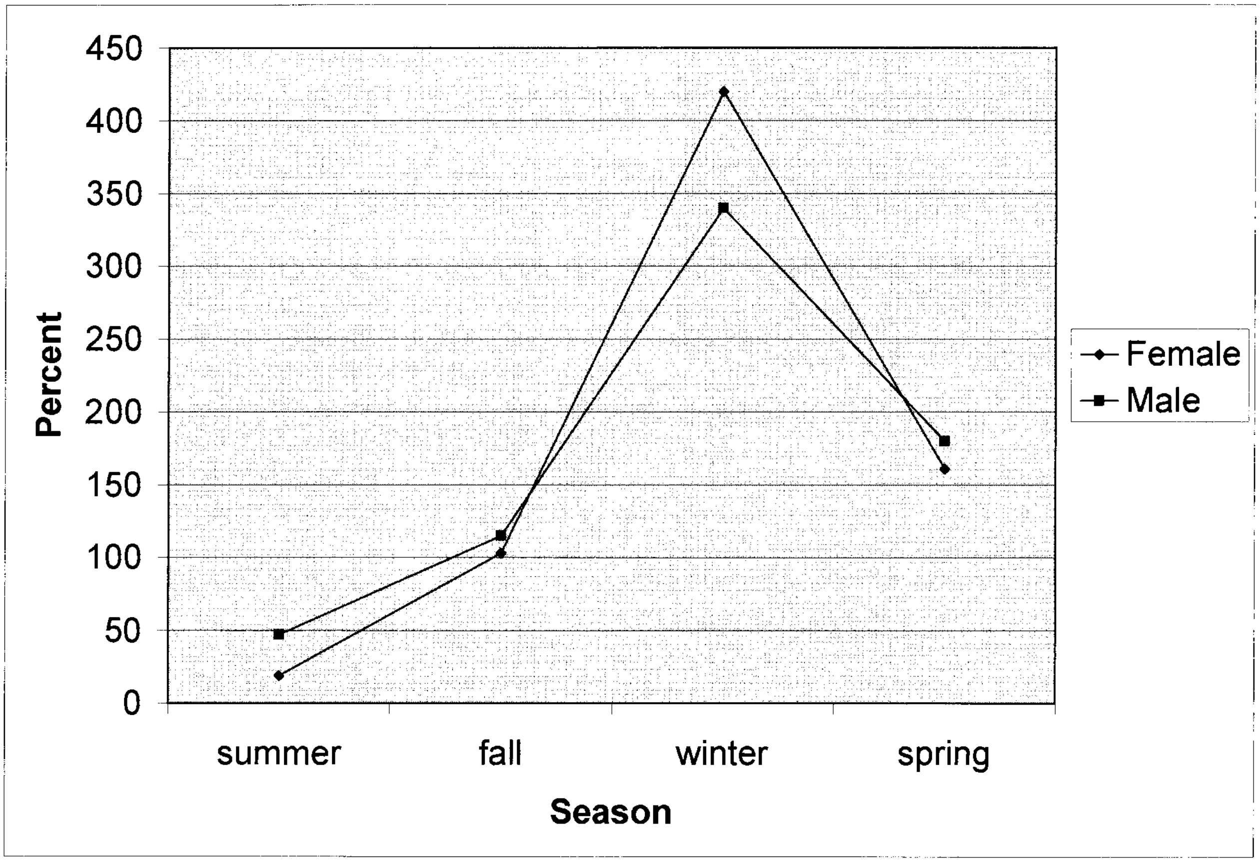


Figure 2. Seasonol differences in kidney fat index for white-tailed jackrabbits collected in South Dakota in 2004–2005.

## DISCUSSION

Although sexual dimorphism occurs in white-tailed jackrabbits (Lim 1987), we found that mean kidney weight for females did not differ from mean kidney weight of males. We also found no difference in kidney weights between juveniles and adults. There was little seasonal variation of average kidney weights except during summer, when kidney weight was lowest in both sexes. Flux (1971) found a similar seasonal variation of about 10% in the kidney weight of hares in New Zealand. The extreme heat as well as the stress of reproduction occurring during summer may have inhibited normal activity, resulting in lower average kidney weights.

Jackrabbits are unlikely to carry excess fat at any time since they are subject to predation (Lim 1987). However, both sexes of white-tailed jackrabbits in South Dakota retained more perirenal fat during winter months. The KFI for both sexes steadily increased from fall to winter. The male KFI peaked in February while females peaked in January. Individual jackrabbits had high fluctuations in seasonal fat deposition, with a KFI of 100%–270% during winters and a low of 0% during summer. Similar to our findings, the KFI of both males and female European rabbits (*Oryctolagus cuniculus*) was maximal in winter and minimal in summer (Boyd and Myhill 1987). In Scotland, the KFI of the mountain hare (*L. timidus*) peaked late in winter in both males and females (Flux 1970). In contrast, Flux (1971) found that hares in New Zealand showed little seasonal variation in fat depositions.

In South Dakota, fat in white-tailed jackrabbits started to accumulate in late autumn or early winter rather than in summer when food is plentiful, indicating that jackrabbits had sufficient nutrition. White-tailed jackrabbits in South Dakota were found to be highly productive, with 3–4 litters per year (Schaible 2007). With inadequate nutrition, white-tailed jackrabbits have decreased reproductive output (Rogowitz 1992).

It is likely that the buildup of kidney fat was related to the onset of the breeding season rather than the availability of food resources. After peak months, regression in perirenal fat was observed for both sexes, likely due to increased activity during breeding season. As the breeding season progressed, the kidney fat index for both sexes gradually decreased and reached 0% during June, at which point it began to increase again. Throughout the year males gained and lost fat reserves about a month after females. The different patterns in male and female jackrabbits tie in closely with the breeding season, as females are reproductively active a month before males (Schaible 2007). It is clear that fat storage was important for energy during reproduction, especially where early breeding is advantageous. Body fat reserves declined throughout the reproductive season in both sexes, and the steepest decline in the KFI of females occurred during the most productive phase of the season (Schaible 2007). Reproduction in both sexes places demands on stored fat reserves. The decline of fat in late summer may be associated with a reduced capacity to meet the energy demands of reproduction, and in contrast, the onset of reproduction in late winter is associated with attaining maximal body condition.

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