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INFLUENCE OF AGE AND SEX ON DRESSED-WHOLE BODY WEIGHT RELATIONSHIPS IN BLACK-TAILED DEER

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Relationships of dressed and whole body weights were evaluated among age-sex categories in 54 female and 46 male black-tailed deer, *Odocoileus hemionus columbianus*. Using model selection techniques we found that regressions between dressed and whole body weight differed between the sexes and among age categories. Dressed-whole body weight relationships varied among female and male age categories and between the sexes. Dressed-whole body weight relationships should be site- and season-specific to obtain unbiased estimates of whole body weight because of season, geographic variation in morphology, and nutritional state.

INTRODUCTION

Hamerstrom and Camburn (1950) found a strong relationship between dressed (carcass minus blood loss and all organs in the thoracic, abdominal, and pelvic cavities) and whole body (carcass minus blood loss) weights among 131 white-tailed deer, *Odocoileus virginianus*, which did not vary appreciably between sex, age, or weight classes. However, it is unclear how this conclusion was reached. Differences in dressed to whole body weight relationships due to age and sex could be expected because metabolism varies with age, and body tissue composition differs between the sexes (Ralls 1977; Clutton-Brock 1987; Barboza and Bowyer 2000). The purpose of this study is to test whether dressed and whole weight relationships differ among age-sex categories of black-tailed deer. This information may be useful for obtaining unbiased estimates of whole body weight from dressed body weight of harvested deer.

METHODS

Adult males (*n*=46) shot during public hunts at Hopland Research and Extension Center; Mendocino County, California, were brought to a check station where they were processed. Whole body weight minus blood loss was taken to the nearest kilogram and animals were field dressed and again weighed to the nearest kilogram by FWW or DRM. Field dressed body weight (hereafter dressed weight) was determined following the removal of all organs in the thoracic, abdominal, and pelvic cavities after a midventral incision was made from the anus to the sternum. Data from harvested males was obtained in August 1989 – 1990. Females (*n*=54) were collected in February 1990-1991 under a scientific collecting permit and processed in a manner identical to males. From each animal, the lower jaw was removed to determine age by tooth replacement for yearling (1.0 – 1.5 years) animals and the cementum annuli technique for older animals (McCullough and Beier 1986).

We built four models to assess whether the relationship between dressed and whole body weight varied among age categories in intercept, slopes, or both coefficients. The fit of the models to the data was assessed using Akaike Information Criterion corrected for small sample size (AIC_c) and Akaike weights (Burnham and Anderson 2002). A model that fits the data, compared to other models, has a small AIC_c and an Akaike weight closer to one. Age categories were created such that samples sizes ($n \geq 9$) were suitable for estimating regressions (female: 1.0-2.5, 3.0-4.0, ≥ 5.0 years old, male: 1.0-2.5, ≥ 3.5 years old). Sex and age categories were coded with dummy variables. We also conducted an extra sum of squares test to determine if separate linear regression equations were needed for males and females in the 1.0-2.5 years age category.

RESULTS

Model D (Table 1) was selected to summarize the dressed-whole weight relationships for females and males. Model D, which included dressed weight, age, and dressed weight:age interaction, suggested that regressions for each age category differed in intercepts and slopes. The coefficients of determination (r^2) were somewhat higher for the regressions of males (0.96) than females (0.84). The residual standard deviations of the chosen models indicated that, on average, predicted whole weights for females deviated 1.63 kg from observed whole weight and 1.71 kg for males. The extra sums of squares test performed on the 1.0-2.5 year old females and males showed that separate linear regression equations were needed for females and males ($F_{2,58} = 8.08$; $P = 0.0008$). Thus, a total of five regression equations (Table 2) were developed to predict whole body weight from dressed body weight.

DISCUSSION

Our results differ from those of a previous study (Hamerstrom and Camburn 1950) that estimated whole body weight from dressed weight using one regression for all age-sex categories. However, Hamerstrom and Camburn (1950) did not have access to the sophisticated statistical tools to rigorously examine the effect of age and sex on dressed-whole body weight relationships. The high coefficients of determination of regressions estimated in this study suggest that there is an agreeable fit over the range of the data for both female and male age categories. Among females, the dressed-whole body weight relationship changed in ways unexpected by metabolic changes with age. For example, females ≥ 5.0 years old were estimated to have a greater dispar-

Table 1: Summary of Akaike Information Criterion model selection for female (n=54) and male (n=46) whole-weight linear regressions for a black-tailed deer population in California, 1989-1991.

		Females				Males			
Models	Coefficients[a]	K[b]	SSE[c]	AIC_c[d]	Akaike weight	K	SSE	AIC_c	Akaike weight
A	Intercept only	2	908.48	156.67	<0.01	2	3518.70	203.79	0.01
B	DW	3	214.68	81.01	<0.01	3	125.10	52.59	0.03
C	DW + Age	5	168.02	72.55	0.01	4	124.10	54.63	0.08
D	DW + Age + DW:Age	7	128.17	63.11	0.99	6	122.80	59.32	0.88

[a] DW=Dressed weight in kilograms, Age=Age categories, DW:Age=Interaction between dressed weight and Age.
[b] Number of parameters estimated in each regression model.
[c] SSE=Sums of Square Error.
[d] AIC_c=Akaike Information Criterion corrected for small sample size.

Table 2. Linear Regression equations between dressed and whole weight by age category and sex for a black-tailed deer population in California, 1989-1991.

Age Category		n[a]		Regression Equations[b]		Dressed Weight Range[c]	
F[d]	M[d]	F	M	F	M	F	M
1.0-2.5	1.0-2.5	30	31	$\hat{Y}= 0.73+1.32X$	$\hat{Y}= 6.84+1.17X$	20.87 - 31.75	27.22 - 58.06
3.0-4.0	≥ 3.5	9	15	$\hat{Y}= 11.40+0.98X$	$\hat{Y}= 4.61+1.23X$	28.12 - 30.84	34.47 - 54.43
≥ 5.0	—	15	—	$\hat{Y}= 20.49+0.69X$	—	24.49 - 31.75	—

[a] Sample size
[b] $\hat{Y}$=Whole body weight, X=Dressed body weight
[c] Weights in kilograms
[d] F-female, M-male

ity between dressed and whole body weight than females 1.0 – 2.5 years old in the dressed body weight ranges common to both age categories (24 – 30 kg). A female ≥ 5.0 years old had a whole:dressed body weight ratio (predicted whole body weight divided by dressed body weight) of 1.54 and 1.37 at 24 and 30 kg, respectively. A female 1.0 – 2.5 years old had a whole:dressed body weight ratio of 1.35 and 1.34 at the same respective dressed weights. Further, males were expected to have greater disparity between whole and dressed weight, which was found. For 1.0 – 2.5 year old animals with a dressed weight of 28 kg, the respective whole:dressed body weight ratios were 1.41 and 1.35 for males and females.

To obtain unbiased whole body weights from dressed body weights, regressions for the different age categories are useful, particularly for females. For example, when a female had a dressed body weight of 24 kg the estimated whole body weight was 32.4 kg for a 1.0 – 2.5 year old female and 37 kg for a female ≥ 5.0 years old. Although managers at check stations may not have the opportunity to determine ages of animals with the cementum annuli technique, distinguishing 1.0 – 2.5 year old animals from ≥ 5.0 year old animals can be accomplished from tooth replacement and wear (Severinghaus 1949).

Our findings indicate that dressed-whole body weight relationships in black-tailed deer can vary among age categories and between sexes. However, other populations of black-tailed deer may not follow the same relationships that we estimated. Dressed-whole weight relationships may vary between black-tailed deer populations because of season, geographic variation in morphology, or nutritional state (Gould and Johnston 1972; Illius and Gordon 1992). It is likely, therefore, that dressed-whole body weight relationships should be site- and season-specific to obtain unbiased estimates of whole body weight.

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LITERATURE CITED

Barboza, P.S., and R.T. Bowyer. 2000. Sexual segregation in dimorphic deer: A new gastrocentric hypothesis. Journal of Mammalogy 81:473-489.

Burnham, K.P., and D.R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Second Edition. Springer-Verlag, New York, New York, USA.

Clutton-Brock, T.H. 1987. Sexual selection in the Cervidae. Pp. 110-122 in Biology and management of the Cervidae (C.M. Wemmer, ed.). Smithsonian Institution Press, Washington, D.C.

Gould, S.L., and R.F. Johnston. 1972. Geographic Variation. Annual Review of Ecology and Systematics 3:457-498.

Hamerstrom, F.N., and F.L. Camburn. 1950. Weight relationships in the George Reserve deer herd. Journal of Mammalogy 5-17.

Illius, A.W., and I. J. Gordon. 1992. Modeling the nutritional ecology of ungulate herbivores: evolution of body size and competitive interactions. Oecologia. 89:428–434.

McCullough, D.R., and P. Beier. 1986. Upper vs. lower molars from cementum annuli age determination. Journal of Wildlife Management 50:705-706.

Ralls, K. 1977. Sexual dimorphism in mammals: avian models and unanswered questions. The American Naturalist 122:917-938.

Severinghaus, C. W. 1949. Tooth development and wear as criteria of age in white-tailed deer. Journal of Wildlife Management 13:195-216.

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