JOURNAL OF THE TENNESSEE ACADEMY OF SCIENCE
VOLUME 51, NUMBER 1, JANUARY, 1976

RELATIONSHIPS BETWEEN BODY MEASUREMENTS AND WEIGHT OF THE BLACK BEAR

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ABSTRACT

Ten body measurements were recorded on 77 black bears, 47 males and 30 females in the Great Smoky Mountains National Park in Tennessee. Regression equations were derived; four body measurements exhibited strong correlations with body weight. The chest girth measurement appears to be the best predictor of weight for black bears, particularly in the lower weight range (<50 kg). The present data were judged insufficient to warrant the use of the equations to accurately predict weight of heavier bears (>70 kg), because of the wide range of weights at the 95 percent level of confidence.

INTRODUCTION

Direct weight measurement of large wild animals in the field is a time consuming and awkward process and various researchers have attempted to find methods of circumventing this inconvenience. Smart *et al.* (1973) derived two regression equations relating weight to heart girth in white-tailed deer *(Odocoileus virginianus)*. One equation was for use with fawns and one for adults. Predictive equations expressing weight as a function of heart girth have also been derived for barren-ground caribou *(Rangifer arcticus)* (McEwan and Wood, 1966) and several African ungulates (Talbot and McCullough, 1965).

This study was undertaken to see what relationships, if any, existed between body weight and various body measurements in the black bear *(Ursus americanus)*. It was hoped that regression equations could be derived which would prove to be accurate predictors of weight. The use envisioned for such equations is the development of an accurate weight tape for use in a population study of the black bear in the Great Smoky Mountains National Park.

METHODS

Ten body measurements were recorded on 77 bears, 47 males and 30 females captured in the Great Smoky Mountains National Park 1970-1974. Body measurements were:

Total Length—tip of tail to nose along backbone
Skull Length—peak of sagittal crest to tip of nose
Skull Width—between the inner bases of the ears
Forearm Circumference—widest part of the forearm
Hindfoot Length—maximum pad length excluding claws
Hindfoot Width—maximum pad width
Forefoot Length—maximum pad length excluding claws
Forefoot Width—maximum pad width
Neck Circumference—self-explanatory
Chest Girth—around chest directly behind the front legs

Regression analysis was carried out on three groupings by sex: males, females, and males and females combined.

The body measurements (independent variables) were plotted versus weight (dependent variable). The graphical relationship which manifested itself when the body measurements were plotted versus weight was a power curve. To perform a linear regression on data related in this way it is necessary to tranform both the independent and dependent variables into their respective natural logarithms (Sokal and Rohlf, 1969). Beauchamp and Olson (1973) pointed out that when the transformed variables are converted back into original units the resulting equations are biased. These authors have developed a technique for deriving unbiased allometric regression equations. However, in order to arrive at unbiased equations in this study it was decided to use a least squares estimations of non-linear parameters technique.

RESULTS AND DISCUSSION

Of the ten body measurements only chest girth, total length, forearm circumference, and forefoot width exhibited strong correlations with body weight. Six regression equations showing the strongest correlations were derived, the two best for each sex grouping (Table 1). The best overall measurement appeared to be chest girth. Combinations of two or more measurements did not significantly increase the accuracy of the technique. Table 2 presents the predicted weights and the 95 percent upper and lower confidence limits for males, females, and both sexes combined derived from the chest girth measurement. The weights were converted to kilograms from pounds.

The chest girth measurement appears to be a good predictor of weight at the lower weight range of the black bear (<50 kg). However, at the 95% level of confidence the wide range at the heavier weight categories (>70 kg) make the use of the technique questionable at the present time for larger bears. An experienced researcher can guess weights of heavier bears as accurately as the equations in Table 1 can predict them; additional samples will likely increase the accuracy of this technique.

The data presented in Table 2 also show that the weight of females and males of the same chest girth is different. If regression equations with more acceptable confidence limits are eventually derived it appears that different equations will be required for males and females.

ACKNOWLEDGEMENTS

This study was supported from funds made available by the Great Smoky Mountains Natural History Association and McIntire-Stennis Project No. 12 of the Department of Forestry and Agricultural Experiment Station, The University of Tennessee, Knoxville, 37916. Thanks are expressed to various personnel of the National Park Service, Great Smoky Mountains National Park, and to graduate students Larry E. Beeman, Larry C. Marcum, Dan Eagar, and Louis Eubanks for collections of field data.

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TABLE 1: *Predictive equations for weights of black bears. The equations were derived using inches and pounds as the units of measurement.*

Sex	Regression Equations	R-Square Values	Body Measurements
Females	$\hat{Y} = (0.394)x_1^{1.646}$	0.88	x_1: Chest Girth
	$\hat{Y} = (0.220)x_1^{1.02}x_2^{1.15}$	0.92	x_2: Forearm Circumference
Males	$\hat{Y} = (0.049)x_1^{2.27}$	0.92	x_1: Chest Girth
	$\hat{Y} = (0.003)x_1^{1.39}x_2^{1.46}$	0.95	x_2: Total Length
Males and Females	$\hat{Y} = (0.052)x_1^{2.24}$	0.91	x_1: Chest Girth
	$\hat{Y} = (0.076)x_1^{1.83}x_2^{0.782}$	0.93	x_2: Forefoot Width