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Estimation of Body Composition in Moose

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SUMMARY

We investigated techniques for estimation of body composition in moose (*Alces alces*). Three nondestructive methods (urea dilution, bioelectrical impedance analysis [BIA], and real-time ultrasonography) were assessed for use on live animals. Composition of the peroneus muscle group also was evaluated as a predictor of body composition of dead animals. Some estimators of body condition require an estimate of body mass, but moose often are too large to weigh in the field. Body length and girth measurements often are used as estimators of body mass in moose and other species, but these measurements are not sensitive to seasonal mass fluctuations attributable to fat deposition and mobilization. We investigated the potential of adding a condition evaluation score to traditional length-mass equations to improve precision and also assessed the ability of fat measurements obtained with ultrasonography to estimate mass. Three manuscripts that summarize our research results were prepared for submission to technical journals. These manuscripts are submitted as the final report for this study. They include Evaluation of Three Methods for Estimating Body Condition of Moose, Predicting Body Mass in Alaskan Moose (*Alces alces*) Using Body Measurements and Condition Assessment, and Prediction of Body Fat and Body Mass in Moose Using Ultrasonography.

Key words: *Alces alces*, BIA, bioelectrical impedance analysis, body composition, body fat, body mass, body water, girth, length, moose, morphometrics, real-time ultrasound, urea dilution.

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BACKGROUND

Body condition was identified as a critical variable within the moose carrying capacity model (Hubbert 1987, Schwartz et al. 1988*a*, 1988*b*), and body fat is a major driver of the moose submodel. Body fat must be accurately measured in moose. A proposal was prepared to test methods for estimating body composition of moose (Schwartz et al. 1988*c*), focusing primarily on measurement of urea space (Preston and Kock 1973), as an *in vivo* technique, and measurement of composition of the peroneus muscle group (peroneus tertius, extensor digitorum longus, and extensor digiti III proprius, Huot and Goodreault 1985), as a technique for use on dead animals.

Over the last decade a body composition estimation technique known as bioelectrical impedance analysis (BIA) has been demonstrated to be a precise and unbiased predictor of human body composition (Lukaski 1987) and was investigated for potential use in animal applications (Hall et al. 1989, Jenkins et al. 1988, Swantek et al. 1991, Farley and Robbins 1994). This technique was tested as a potential indicator of moose body composition.

Implicit in the estimation of body composition by the aforementioned techniques is an accurate measurement of body mass. Obtaining mass estimates of free-ranging moose is difficult because they are often too heavy to be lifted and weighed by a helicopter. Franzmann et al. (1978) and Haigh et al. (1980) reported high correlations between certain body measurements and body mass of moose; however, body measurements are insensitive to changes in the fat depots of moose. Franzmann et al. (1976) developed a subjective 11-point scale for assessing condition class (CC) of moose based on physical appearance that may, when combined with body length, more precisely predict body mass. We developed models combining body length and condition class estimates to predict body mass and compared them to traditional models.

OBJECTIVES

- 1 To determine the relationship between urea space measurements, impedance measurements, chemically determined composition of the peroneus muscle group, and chemically determined body composition in moose.
- 2 To determine if moose body weight can be predicted accurately from measurement of body length and heart girth, and appraisal of physical appearance.
- 3 To determine if these techniques have potential to estimate moose body composition in field applications.

RESULTS

A manuscript was prepared that describes efforts to address objectives 1 and 3 (Part 1). A manuscript was prepared that describes efforts to address objective 2 (Part 2).

During the course of this study a new technique, real-time ultrasonography, was brought to our attention by Thomas Stephenson, then a graduate student at the University of

Idaho. Although ultrasonography had not been used previously to determine body condition in cervids, Tom proposed that the thickness of the fat deposit on the rump might be a good indicator of condition. We tested the technique at the Moose Research Center and prepared a manuscript describing our results (Part 3).

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PART 1

EVALUATION OF THREE METHODS FOR ESTIMATING BODY COMPOSITION OF MOOSE.

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Abstract: Estimation of body composition of cervids is important when examining nutritional ecology assessing habitat capability. We evaluated 3 methods for determining body composition in moose (*Alces alces*). Bioelectrical impedance analysis (BIA) and urea dilution were tested as nondestructive estimators of composition for use in the field. Composition of the peroneus muscle group was examined as an index available from dead animals. The best models included BIA and body mass as predictors of body fat and water, but if an estimate of body mass is not available BIA and sex were included in stepwise regression models. Estimates of percentage fat and water in the body derived from BIA were less precise than were estimates of fat and water mass. Impedance estimates decreased as the subject's hindleg was straightened, indicating that animal positioning must be standardized to minimize bias. Urea dilution yielded highly variable estimates of body water mass, with individual equilibration times ranging from 10-30 minutes after urea infusion. Predictive equations using estimates of urea space derived from blood samples taken 10 and 30 minutes post-infusion were similar. We attribute the failure to generate a consistent equilibration time or identify a best model to a lack of precision in serum urea nitrogen (SUN) estimates. Nonetheless, we rejected urea dilution as a viable field technique because of the time involved in completing the procedure. Composition of the peroneus muscle group was not a good predictor of body composition. Of these techniques, only BIA has value to studies of body composition of moose and other cervids, but its limitations make it more suitable for the laboratory than the field.

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Key words: *Alces alces*, BIA, bioelectrical impedance analysis, body composition, body fat, body water, moose, urea dilution.

INTRODUCTION

Body composition of cervids, particularly percent body fat, is an important indicator of habitat quality and environmental stress. Northern cervids rely on accumulated body fat to provide energy throughout the winter, and depletion of these reserves before spring forage is available leads to death (Mautz 1978). Precise estimation of body condition is necessary for validating models of nutritional dynamics of populations and estimation of carrying capacity (Hubbert 1987, Hobbs 1989).

Nondestructive methods for estimating body composition under field conditions have been proposed, but no method has been universally accepted. Isotope (tritium or deuterium) dilution procedures, albeit precise, require extended periods while waiting for equilibration (>1 hr when sampling blood [Holleman et al. 1982] and >15 hr when sampling urine [Torbit et al. 1985]). Assessment of nutritional status by assigning condition indices or classes (Franzmann et al. 1976, Gerhart et al. 1995) is subjective and can vary among observers. Although useful in many circumstances, these techniques are not always suitable for precise determination of body composition in the field.

Over the last decade a body composition estimation technique known as bioelectrical impedance analysis (BIA) has been demonstrated to be a precise and unbiased predictor of human body composition (Lukaski 1987a) and has been investigated for potential use in animal applications (Hall et al. 1989, Jenkins et al. 1988, Swantek et al. 1991, Farley and Robbins 1994). This technique works on the principle of measuring the impedance (resistance to alternating current) of hydrated body tissues to an alternating current of known frequency. Nyboer et al. (1943) demonstrated that

$$V = rL^2/Z$$

where V = body water volume, r = volume resistivity and is constant for a given conductor, L = conductor length, and Z = impedance. Impedance is computed by $(R_s^2 + Xc^2)^{0.5}$ where R_s = resistance and Xc = reactance. This technique was tested as a potential estimator of moose body composition.

Preston and Kock (1973) proposed a dilution technique using urea that reportedly equilibrated with body water in cattle in 12.5 min. This technique produced reliable estimates of body water and fat. Furthermore, it uses a nontoxic substance as the marker, which is highly desirable for wildlife management. This technique estimates the ingesta-free body water (the volume of water in the body not including ingesta) by calculating the urea space (US, the pool of body water into which urea infuses). Urea space is estimated as

$$US = [D/(S_e - S_b)] - V_d$$

where D = dose of urea nitrogen (UN) administered (= mass urea * 0.467); S_e = equilibrium-specific concentration of SUN, S_b = background SUN naturally occurring in the animal (from the blood sample taken at $t = 0$); and V_d = the volume of urea solution infused. As V_d is negligible in comparison to US the equation can be reduced to

$$US = D(S_e - S_b)^{-1}$$

We estimated S_e by a least squares model

$$S_0 = S_t(e^{-kt})^{-1} = S_t e^{kt}$$

where S_0 = the extrapolated specific concentration of SUN, which approximates S_e , S_t = SUN at time t , provided t occurs after equilibration, and k = a constant (Holleman et al. 1982). As urea does not infuse significantly into the rumen space over the duration of our sampling (Bartle and

Preston 1986), we confined ourselves to analysis of the relationship between ingesta-free body water (which we define as the chemically determined water content) and US. Theoretically, a regression model of ingesta-free body water and urea space should have a slope not different than 1.0 and an intercept not different than 0.0 (Rule et al. 1986). Using these criteria, we evaluated models using different time estimates of SUN.

Estimating partial or total body composition of ungulates by analyzing composition of indicator muscles has proven successful (Price and Berg 1976, Ringberg et al. 1981). Huot and Goodreault (1985) evaluated a number of indices to estimate body condition of caribou (*Rangifer tarandus*), and reported the percentage fat in the peroneus muscle group (peroneus tertius, extensor digitorum longus, and extensor digiti III proprius) correlated significantly with total body fat. This muscle group lies along the humerus and is dissected easily from dead animals. It remains a potential indicator of body condition for wild cervids.

METHODS

Experimental animals were kept in captivity at the Kenai Moose Research Center (MRC) and were fed a formulated ration (Schwartz et al. 1985). All research activities followed an animal welfare protocol approved by the Alaska Department of Fish and Game.

For urea dilution, animals were weighed before immobilization whenever possible and were immobilized with either xylazine hydrochloride and/or carfentanil citrate by means of hand-injection or darting. A polyethylene catheter was inserted into the jugular vein from which blood samples were drawn into a nonheparinized evacuated tube. A solution containing 20% urea in physiological saline was administered through the catheter at a rate of 66 ml/100 kg body mass (130 mg urea/kg). Blood samples were drawn at 10, 15, 20, 30, 40, 50, 60, 75, and 90 min post-infusion (time 0 was defined as the midpoint of the duration of the infusion, which took approximately 2 min to complete). The blood samples were centrifuged at the MRC immediately after collection, and serum was stored frozen until analyzed by an independent veterinary pathology lab for serum urea nitrogen (SUN), which was expressed to the nearest mg/dl.

For BIA, a plethysmograph (Model BIA-101, RJL Systems, Inc. Detroit, MI) was used to estimate electrical impedance of moose. The animals were allowed to assume a sternally recumbent position after immobilization. Any variation in positioning of animals was corrected so that all animals were tested in similar positions. Electrodes were constructed from trocars removed from 18ga spinal needles and were bent to an angle of 90° 13mm from the tip. A "source" electrode was inserted subdermally at the carpal joint on the foreleg and at the joint between the metatarsus and the hoof on the hind leg on the side of the body most exposed while the moose was sternally recumbent. A "detector" electrode was placed 7.5 cm proximal to each source electrode. A second set of positions was tested on some animals wherein the electrodes were placed on the peak of the spinal column between the shoulders (hump) and at the base of the tail (rump), thereby removing the legs from the analysis. The tips of the electrodes always were oriented distally under the skin. Electrodes were connected to the plethysmograph via alligator clips on the end of 10-ft cables. A current of 800 mA alternating current at 50 kHz was introduced through the distal electrodes and R_s and X_c were recorded as well as total body length (TL). Electrodes were removed and re-inserted, and resistance and reactance measured, a

minimum of 3 times per animal to ascertain variation associated with electrode placement. Mean values of R_S and X_c for each animal were used in predictive equations. Variation associated with animal position also was estimated by taking readings with the hind leg in various positions. The straight-line distance between the knee and the tarsal joint was measured to the nearest cm. This distance increased as the leg was straightened, and changes in BIA were noted at various distances.

Animals were killed within 24 h after US and BIA measurements were completed. Animals were eviscerated and skinned (with as much fat as possible being left on the carcass). Empty carcasses were bisected along the spinal column, with one half of the carcass frozen for analysis. The peroneus muscle group was dissected from the carcass half that was not used in the analysis and was frozen. The digestive tract was emptied and the viscera was weighed. Viscera and samples of shaved hide were frozen. The frozen side of the carcass and the visceral mass were cut into 51- and 25-mm slices, respectively, on a commercial band saw. Sawdust that accumulated at the base of the blade was collected for each component and was thoroughly mixed and refrozen before analysis (Huot and Picard 1988). We determined crude fat by ether extraction, crude protein content by the Kjeldahl procedure (AOAC 1975), ash content by burning in a muffle furnace at 550 °C for 2 h, and percent organic dry matter (1.00 - moisture content) by drying samples in a 100 °C oven for 12-16 h and subtracting ash content. Three replicates of each sample were analyzed. Peroneus and hide samples were freeze-dried and ground in a Wiley mill before being subject to chemical analysis.

Peroneus composition, US, and BIA values (TL^2/Z) were compared to chemically determined body composition estimates by simple linear regression. In this report references to "body" composition refer to the ingesta-free body, which we define as the entire body less hair and the contents of the gastrointestinal tract. The adjusted coefficient of multiple determination (R_a^2) was reported for regressions with more than one independent variable because it is a more conservative estimate of explained variance than is R^2 (Neter and Wasserman 1974, Wilkinson et al. 1996). Proportions and percentages were subjected to arcsine transformation on the original data prior to statistical analysis (Freeman and Tukey 1954).

RESULTS

Percentage ingesta-free body fat of moose in this study ranged from 0.3 - 19.4% (Table 1), which we believe includes the extremes of body condition found in the wild. Body mass ranged from 180 - 535 kg, which also represents the expected range of wild moose. Estimation of water and fat (mass and percentage) in the ingesta-free body was best accomplished using linear regression with body mass and sex as predictors (Table 2). Females had a higher percentage of ingesta-free body fat than did males ($t = 2.22$, $P = 0.039$). Percent body fat was related significantly to ingesta-free mass for females ($r = 0.93$, $P = 0.0001$) but not for males ($r = 0.52$, $P = 0.08$). The relationship between percentages of fat and water in the body of both sexes combined was analyzed using a Model II major axis regression. This model took the form of Y (% fat) = 80.02 - 1.09 X (% water). Solving this equation for the X -intercept yields an estimate of 73.4% water in the fat-free body, which corresponds with the interspecies mean of 73.2% reported by Pace and Rathbun (1945).

UREA DILUTION

Estimated equilibration times of urea in body water varied from 10-30 minutes, based on regression results. This amount of variation was not expected and probably due either to differences in dilution kinetics among animals or more likely to the precision of urea measurements (nearest mg/dl) and the duration of the trials (maximum of 90 min). For the urea concentrations observed, a more precise estimate of SUN (nearest 0.1 mg/dl) would have been desirable but was not possible with the techniques available to us.

Using estimates of US derived from SUN concentrations at 15 and 30 min post-infusion yielded the best predictive equations for ingesta-free body water mass (Fig 1). The regression using the 15-min value as the independent variable ($Y = 49.4 + 1.05X$, $R^2 = 0.60$, $SEE = 26.9$) predicted body water with a slope not different than 1.0 (95% CI = 0.46-1.64) and an intercept not different than 0.0 ($t = 0.12$, $P = 0.26$), which follows the theoretical kinetics model at equilibrium. The regression using the 30-min value ($Y = 70.4 + 0.67X$) had a lower slope, although not different than 1.0 (95% CI = 0.30-1.04), but had slightly better predictive power ($R^2 = 0.65$, $SEE = 24.9$).

BIA

Impedance values from foreleg-hind leg electrode positions were used to predict body composition. Electrode placement on the rump and hump yielded mean R_S and X_C values that were 8.6% and 10.8%, respectively, of the mean values using the legs. The limited sensitivity of rump-hump measurements resulted in their rejection as a potential indicator of composition of the entire body.

The relationship between TL^2/Z and body composition differed between the sexes (Fig 2), a characteristic noted in humans (Lukaski 1987b) but lacking in bears (*Ursus* spp., Farley and Robbins 1994). Linear models of the relationships shared common slopes (Table 2) and were subjected to pooled regressions using sex as a dummy variable (male = 0, female = 1). The pooled regression models indicated that TL^2/Z and sex were significant predictors of body water and fat (mass and percentage) (Table 3), although they were not superior to models using only body mass and sex as predictors (Table 4). When TL^2/Z , sex, and body mass were included in stepwise regressions, TL^2/Z and body mass were the best predictors of fat and water mass in the ingesta-free body (Table 5) although models estimating percentage fat and water were not improved.

As the distance between the knee and tarsal joint of a moose increased, BIA values decreased. To determine the significance of this effect, BIA values were standardized among animals by dividing the observations for each animal by the adjusted mean value for that animal. Homogeneity of slopes among animals was confirmed by a nonsignificant interaction between distance and animal in ANCOVA ($F = 0.19$, $P = 0.97$). A regression analysis of adjusted BIA values (independent variable) and distance (dependent variable) indicated that distance had a highly significant effect on BIA ($t = -12.4$, $P < 0.0001$, Fig. 3).

PERONEUS MUSCLE GROUP

Percentage fat in the peroneus muscle group was related to percentage IFB fat ($R^2 = 0.29$, $P = 0.01$; Fig. 4), but the amount of variation explained by the regression model was slight. A great amount of variance was noted in animals with more than 5% body fat. We could derive no

explanation for this variance; consequently, this relationship is of little value in predicting body fat.

DISCUSSION

Techniques useful for estimation of body composition in field situations must be quick and easy to perform and, with large animals such as moose, must work without an estimate of body mass. We considered urea dilution as a potentially viable technique because of reported equilibration times of 12.5 min in domestic cattle (Preston and Kock 1973). Our observations, however, indicate that equilibration times in moose varied among animals and that the pooled estimate of equilibration time (15 min) did not provide consistent results. Precise estimates require blood samples collected at timed intervals for at least 60 min post-infusion, which negates any time advantages associated with this technique. Also, precision was unacceptable. Considering the difference between background and equilibration levels of urea in the blood, SUN estimates either must be expressed at least to the nearest 0.1 mg/dl or sampling must be extended for 1 or more hours beyond infusion to yield a precise estimate of SUN at equilibration. Finally, the volume of urea solution infused is relatively large, which adds to the time necessary for this technique and requires an intravenous administration set and catheterization of the animal. Our dissatisfaction with the amount of time necessary to prepare the urea solution and the extra equipment necessary for an intravenous administration caused us to cease investigation of this technique before the termination of the study.

Bioelectrical impedance produced acceptable estimates of body water and fat mass (Fig. 2*c,d*). Converting these estimates to percentage body water and fat, however, requires an estimate of ingesta-free body mass; direct estimates of percent body composition (Fig. 2*a,b*) were less precise. Estimates of body composition using BIA were no better than those derived from body mass. The difficulty in estimating mass of adult moose in the field, however, must be considered. Furthermore, when mass estimates are available, their inclusion in a model with BIA produces the best model for predicting fat and water mass.

Consistent positioning of the body among subjects is essential for generating reliable and repeatable results with BIA; however, this is difficult to achieve under field conditions. Moose can assume various positions when immobilized, particularly in deep snow. Inconsistent positioning among animals changes signal path geometry and introduces bias to the composition estimate (Hall et al. 1986). Our data indicate an increase in knee-tarsal joint distance of 10 cm causes a decrease of approximately 3.9% in TL^2/Z . The change in the estimate of body water mass associated with this change in leg position would range from 2.5-3.5%, depending on sex of the animal and the value of TL^2/Z . Although such a bias alone may not cause biologically meaningful changes in composition estimates, potential bias introduced by other positional inconsistencies, which we did not measure, must be considered. Positioning the electrodes along the torso would eliminate concerns about leg positioning, but R_s and X_c values are much lower and vary less with changes in body composition. This makes the technique less sensitive. Moreover, BIA requires the impedance of the subject be measured on a nonconductive surface; this is difficult to achieve under field conditions. Measuring animals in dry snow does not present a problem, but measurements on conductive surfaces, such as wet snow, or with wet animals are problematic (Farley and Robbins 1994, Robert et al. 1994).

The peroneus muscle group was a poor predictor of body fatness because of the increasing variance observed as fat levels increased. We cannot explain the existence of 2 distinct relationships within one muscle group from one species. The potential for sampling the wrong muscle group in moose always exists, but the peroneus group is easily identifiable in a skinned carcass. No differences attributable to sex or season have been reported (Huot and Goodreault 1985) and we failed to note any trends. Huot and Goodreault (1985) did report the existence of outliers in their study of this muscle group in reindeer. We conclude this indicator muscle group is unsuitable for fat estimation in moose.

None of the techniques we investigated can be considered well suited for application in the field with moose. Urea dilution may be more precise if SUN estimates are measured to the nearest 0.1 mg/dl, allowing the potential derivation of a common equilibration time. Under the best circumstances, however, this technique will still require at least 20 min to complete in the field. Alternatively, BIA can be measured quickly (less than 5 min) but the problems of consistent animal positioning and short-circuiting are hard to overcome in the field. This technique may be suitable for estimation of body composition of cervids under controlled conditions.

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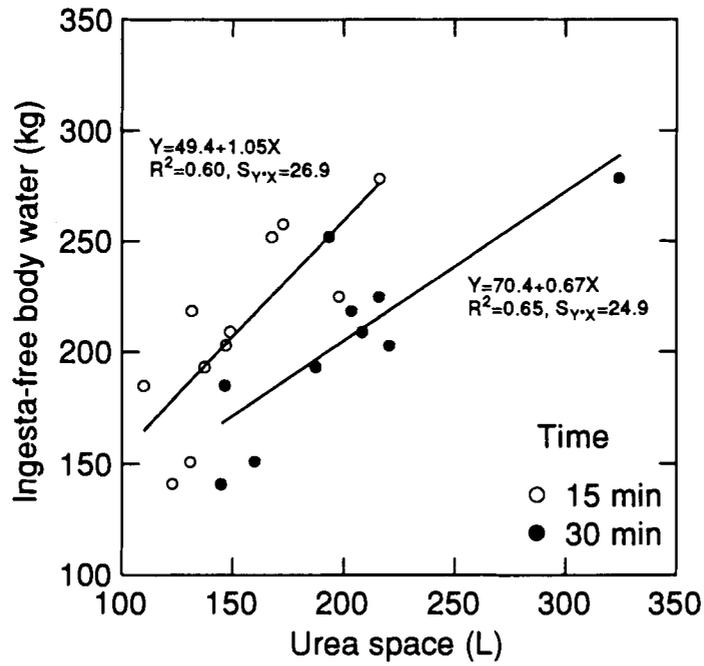


Fig. 1. The relationship between urea space and ingest-free body water in moose. Urea space was estimated at 15 and 30 min after urea infusion.

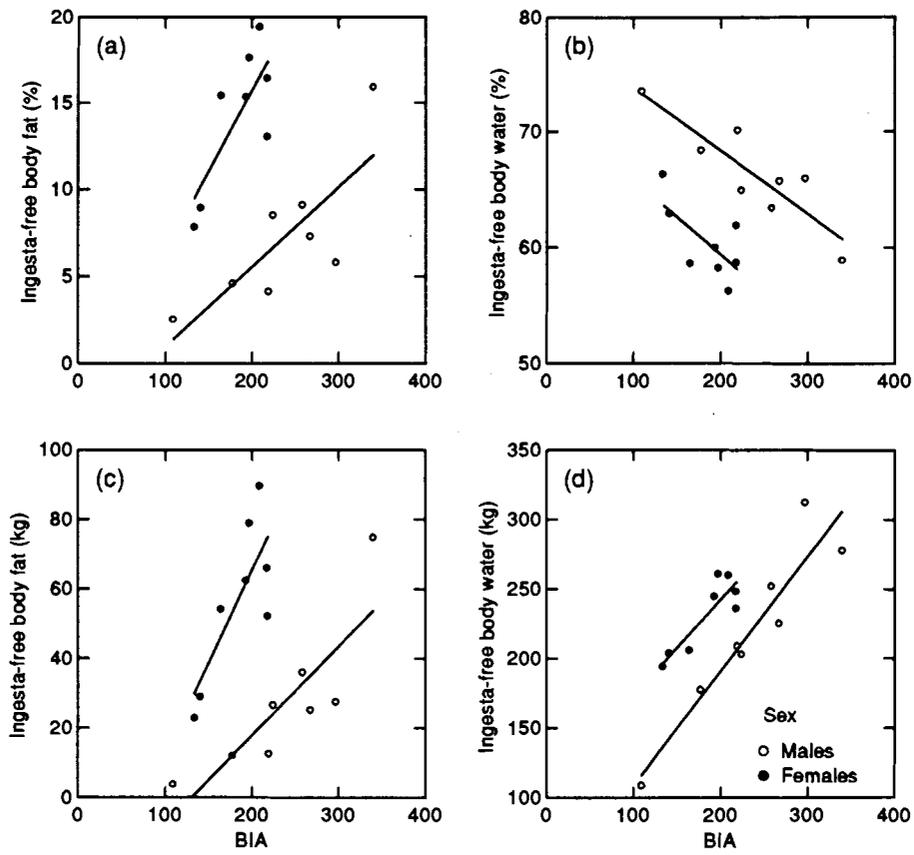


Fig. 2. Relationships between the BIA value (TL^2/Z) and body composition estimates in moose. Sex-related differences are apparent and sex-specific responses share common slopes.

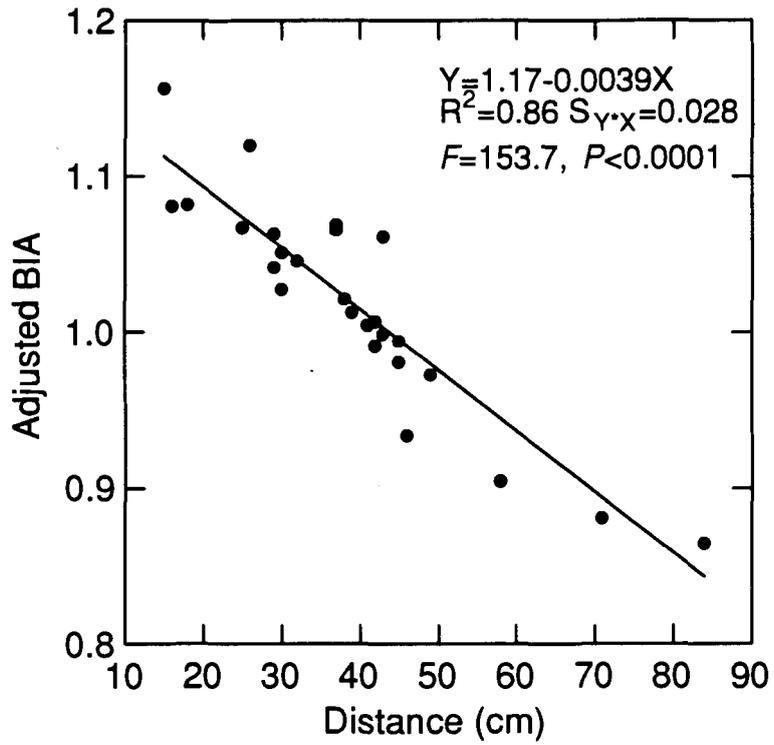


Fig. 3. The relationship of the distance between the knee and tarsal joint of moose and the concomitant BIA value (TL^2/Z).

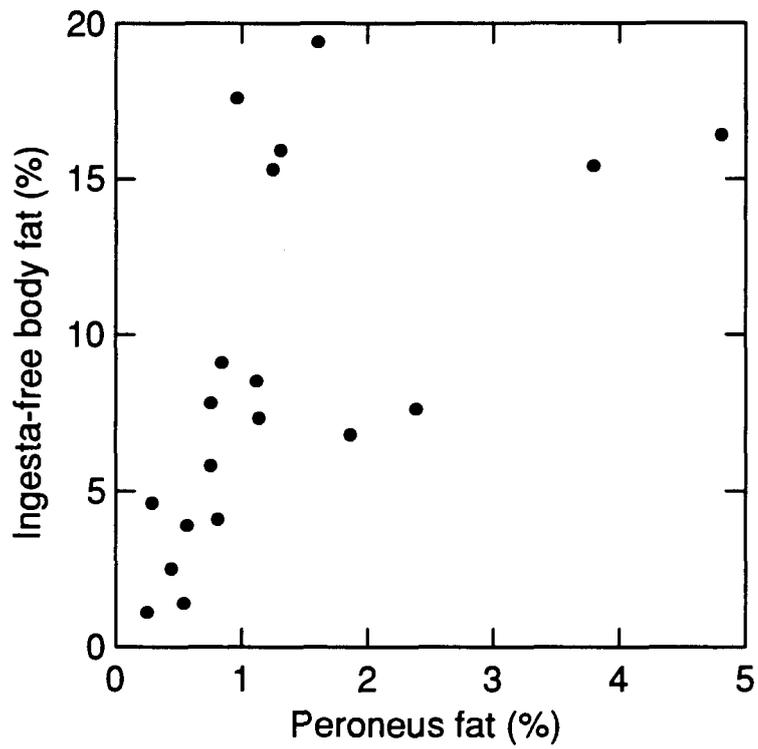


Fig. 4. The relationship between percentage fat in the peroneus muscle group and the ingesta-free body of moose.

Table 1. Chemically-determined body composition of moose, Kenai Moose Research Center. Values listed are means (range).

Component	Males (<i>N</i> = 12)	Females (<i>N</i> = 10)	Total (<i>N</i> = 22)
Whole body mass (kg)	360.2 (180-535)	409.5 (290-525)	382.6 (180-535)
IFB ¹ mass (kg)	316.8 (147.8-473.9)	361.4 (252.0-461.9)	337.1 (147.8-473.9)
IFB water (kg)	210.9 (108.6-312.2)	222.9 (184.5-260.5)	216.4 (108.6-312.2)
IFB fat (kg)	22.3 (3.7-74.8)	45.8 (0.7-89.5)	40.0 (0.7-89.5)
IFB protein (kg)	67.0 (32.1-108.9)	74.3 (53.6-93.4)	70.3 (32.1-108.9)
IFB ash (kg)	16.6 (3.4-25.4)	18.4 (13.2-21.3)	17.4 (3.4-25.4)
Water (% IFB mass)	67.4 (58.9-73.6)	62.6 (56.2-73.2)	65.2 (56.2-73.6)
Fat (% IFB mass)	6.5 (1.4-15.9)	11.5 (0.3-19.4)	8.8 (0.3-19.4)
Protein (% IFB mass)	21.0 (18.8-23.0)	20.7 (19.6-22.7)	20.9 (18.8-23.0)
Ash (% IFB mass)	5.1 (2.3-6.1)	5.2 (4.2-7.0)	5.1 (2.3-7.0)

¹ Ingesta-free body

Table 2. Sex-specific slope coefficients of body composition parameters versus bioelectrical impedance values (TL^2/Z). Non-significant t values indicate a common slope between the sexes for a given parameter.

Parameter	Slope		t	P
	Females	Males		
Water (kg)	0.82	0.69	-0.545	0.60
Fat (kg)	0.26	0.54	1.63	0.16
Water (%)	-0.00057	-0.00067	-0.30	0.76
Fat (%)	0.00085	0.0014	1.04	0.32

Table 3. Simple linear regression coefficients for predicting fat and water (percentage and mass) in the ingesta-free body of moose using bioelectrical impedance analysis on live animals. Dependent variables expressed as percentages are arcsine-transformed proportions. Unadjusted (R^2) and adjusted (R_a^2) coefficients of multiple determination are reported, as well as the standard error of the estimate (SEE).

Dependent variable	Predictor	Coefficient	<i>P</i>	R^2	R_a^2	SEE
kg Fat	Constant	-45.717	0.0216			
	TL ² /Z	0.308	0.0008			
	Sex ¹	45.714	0.0001	0.730	0.688	14.780
kg Water	Constant	31.390	0.1800			
	TL ² /Z	0.798	<0.0001			
	Sex ¹	52.655	0.0002	0.863	0.841	18.669
% Fat	Constant	0.040	0.4541			
	TL ² /Z	0.001	0.0005			
	Sex ¹	0.168	<0.0001	0.794	0.762	0.044
% Water	Constant	1.092	<0.0001			
	TL ² /Z	-0.0006	0.0002			
	Sex ¹	-0.093	<0.0001	0.810	0.781	0.024

¹ Male = 0, female = 1

Table 4. Simple linear regression coefficients for predicting fat and water (percentage and mass) in the ingesta-free body of moose using whole body mass and sex as predictors ($n = 20$). Dependent variables expressed as percentages are arcsine-transformed proportions. Unadjusted (R^2) and adjusted (R_a^2) coefficients of multiple determination are reported, as well as the standard error of the estimate (SEE).

Dependent						
Variable	Predictor	Coefficient	<i>P</i>	R^2	R_a^2	SEE
kg Fat	Constant	-37.515	0.0087			
	Body mass	0.166	0.0001			
	Sex ¹	22.469	0.0036	0.766	0.739	13.577
kg Water	Constant	32.922	0.0294			
	Body mass	0.494	<0.0001			
	Sex ¹	-15.520	0.0478	0.919	0.909	14.837
% Fat	Constant	0.099	0.0870			
	Body mass	0.0004	0.0091			
	Sex ¹	0.103	0.0021	0.668	0.629	0.058
% Water	Constant	1.071	<0.0001			
	Body mass	-0.0003	0.0005			
	Sex ¹	-0.0517	0.0018	0.746	0.716	0.029

¹ Male = 0, female = 1

Table 5. Simple linear regression coefficients for predicting fat and water mass in the ingesta-free body of moose using bioelectrical impedance analysis on live animals and body mass. Unadjusted (R^2) and adjusted (R_a^2) coefficients of multiple determination are reported, as well as the standard error of the estimate (SEE).

Dependent						
Variable	Predictor	Coefficient	<i>P</i>	R^2	R_a^2	SEE
kg Fat	Constant	-38.032	0.0371			
	Body mass	0.299	0.0001			
	TL ² /Z	-0.201	0.0355	0.739	0.699	14.525
kg Water	Constant	32.683	0.0354			
	Body mass	0.388	<0.0001			
	TL ² /Z	0.073	0.0419	0.940	0.931	12.351

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