Brief communication

Evaluation of ultrasound scanning as a method for measuring subcutaneous fat in Svalbard reindeer

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Background

The fitness of an animal is generally strongly dependent on its body condition. A reliable measure of body condition is therefore valuable in ecological studies. However, body condition is difficult to measure directly in live animals, and most studies are based on measures of body mass (Green, 2001) or subjective condition indices (Gerhart *et al.*, 1996). There are a number of problems with using body mass as a measure of body condition. First, it depends on the overall size of the animal causing confounding between big skeleton size and good condition. When only crude estimators of sceletal size are available (*e.g.* leg length), statistical techniques used to control for the effect of structural size on body mass show poor performance (Green, 2001). Secondly, total body mass can be strongly affected by degree of gut fill in ruminants (Adamczewski *et al.*, 1987). The alternative approach of using subjective body condition indices have the problem that observers may judge animals differently, and their scale are typically restricted to as few as 3 to 5 levels.

Back fat thickness is a useful measure of body condition and accurate predictor of total fat in many cervids (Langvatn, 1977; Reimers & Ringberg, 1983; Stephenson *et al.*, 1998; Cook *et al.*, 2001). Standard back fat measurements are usually obtained after culling and skinning, however in live animals it can be measured using ultrasound scanning (Starck *et al.*, 2001). We evaluated two potential sources of error when using this method on Svalbard reindeer (*Rangifer tarandus platyrhynchus*). First, the bias and accuracy of the ultrasonic measurements by comparing them with carcass measurements at the same measurement point. Second, the errors caused by variability in the location of the measurement point were evaluated by comparing the measurements at the point of ultrasound scanning with the measurements done by an independent observer.

Material and methods

Female reindeer, 2 yrs or older, were culled on Nordenskiöldland, Spitsbergen (77°50’-78°20’N, 15°00’-

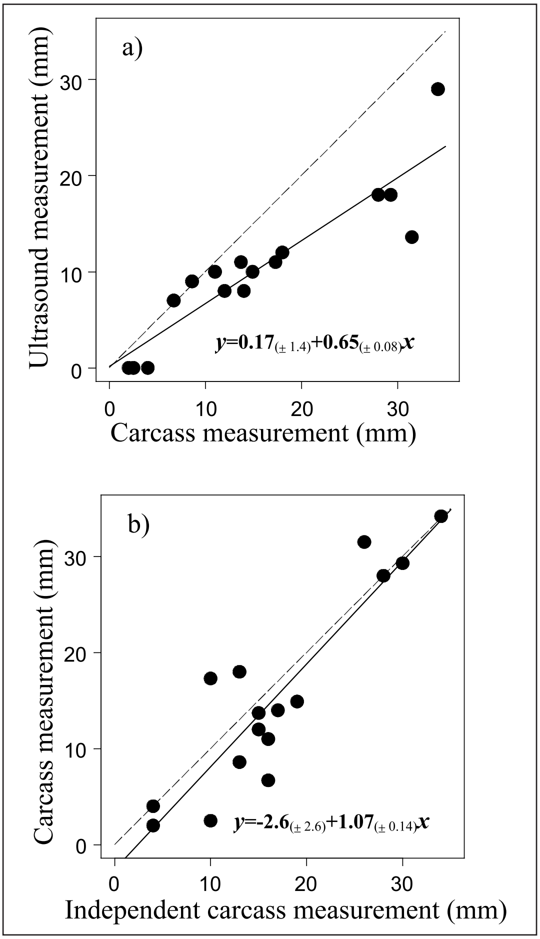

Fig. 1. a) Ultrasound measurements of Svalbard reindeer back fat depth plotted against carcass measurements at the same point (n=16 taken in April-May), and
b) the carcass measurements at the point of scanning plotted against carcass measurements done by an independent observer. The optimal 1:1 relationship (dashed lines) between the variables and fitted regression lines (full lines) are shown together with the regression equations (with ±1 standard error in brackets).

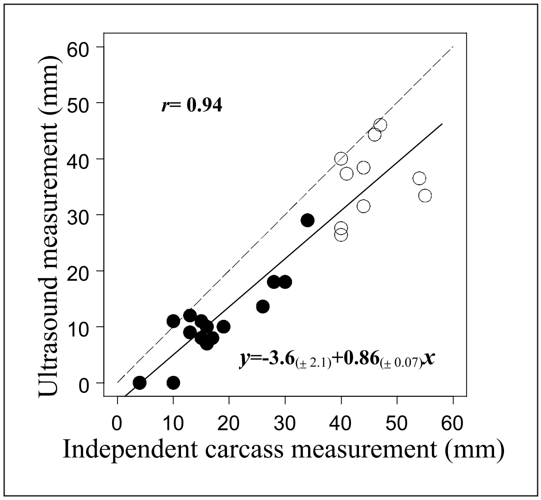

Fig. 2. Ultrasound measurements of the back fat thickness of Svalbard reindeer plotted against independent carcass measurements. Animals sampled in April-May (closed circles, n=16) and October (open circles, n=10). The optimal 1:1 relationship (dashed line) between the variables and fitted regression line (full line) are shown together with the regression equation (with ±1 standard error in brackets) and correlation coefficient (r).

17°30'E). Group 1 (n=16) were culled in late winter (30 April and 2 May 2001 in Sassendalen and Colesdalen) and group 2 (n=10) in early winter (24 October 2001 in Colesdalen). For group 1, ultrasound measurements were taken immediately after culling. Group 2 were brought to laboratory and scanned 2-8 hrs after culling. The echogeneity of the subcutaneous back fat tissue changed little over this period of time. The ultrasound measurements were taken with animals kept in lateral recumbency. A small patch of hair was removed at the measurement point 12 cm along a line going at a 45° angle cranial from the base of tail. This point was used because other anatomical structures were difficult to use on animals with great fat thickness. The anatomical location of this point was determined by dissection to be slightly medial of the sacrotuberosal ligament and the third corner in an equilateral triangle with the other corners being *Tuber ischiadicum* and *Trochanter major* of the femur. We used a real-time portable ultrasound scanner (Scanner 100, Pie Medical) with a linear 5 MHz transducer and a water based coupling gel. For group 1, the point of ultrasound measurement was marked with a cut through the skin and subcutaneous fat layer. Carcass measurements of the back fat thickness was measured using a calliper after skinning at the same point as the ultrasound measurement, and in addition, a carcass measurement was taken by an independent observer according to standard methodology, where the fat layer was at its thickest along the line going at a 45° angle cranial from the base of tail (Langvatn, 1977). Only the ultrasound and independent carcass measurements were taken on group 2. We expected the measurement error in the ultrasound measurements to be greater than in the carcass measurements and least in the independent carcass measurements. To reduce bias in estimates, we fitted the measure with least expected measurement error as the predictor in linear regressions (McArdle, 1988). In addition we calculated Pearson's correlation coefficient (*r*).

Results and discussion

Ultrasound and carcass measurements taken at the same point showed a high correlation ($r=0.91$). However, the relationship had two prominent features (Fig. 1a). First, the scanning equipment had a detection limit at a fat thickness between 4 and 7 mm, below which the fat layer was too thin to be detected by the ultrasound equipment. Second, the ultrasound measurements generally underestimated the back fat thickness by 5 to 10 mm. This bias is likely to be caused by the observer compressing the fat layer with the ultrasound probe when taking the measurement (Starck *et al.*, 2001). The independent carcass measurements and carcass measurements at the point of scanning were also highly correlated ($r=0.90$), but did not deviate significantly from the optimal 1:1 relationship ($P=0.44$). This result suggests that little bias was introduced by errors in the determination of the point of scanning. However, variation between the two measurements was caused by variation in the point of measurement (Fig. 1b). Taken altogether, the patterns in Fig. 1a-b resulted in ultrasound measurements that consistently underestimated the fat thickness as measured by the independent observer (Fig. 2).

Reimers & Ringberg (1983) developed a statistical model for the relationship between carcass measurements of back fat thickness and the total chemically determined fat content of Svalbard reindeer. Ultrasound measurements should be corrected for bias before that model can be applied. However, in many ecological applications where the measurements are used to monitor temporal changes in the condition of individuals or average levels in herds, the rescaling of the measurements to total body fat will be less important and the bias unproblematic as long as it is constant between measurements. The sensitivity of the ultrasound measurements justifies its suitability in studies of large vertebrates, where variation in fat thickness is at the scale of centimetres rather than millimetres. Our successful use of ultrasound back fat measurements to detect the negative impact of parasites on the body condition of Svalbard reindeer support this presumption (Stien *et al.*, 2002). The method is likely to be more sensitive and less dependent on the observer than subjective condition indices, and allows direct measurements of one aspect of the animals body condition independent of body mass.

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