A reliable body condition scoring technique for estimating condition in African buffalo

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Abstract

Evaluating animal body condition is a necessary component of many ecological studies. Although many methods for assessing animal body condition have been developed, relatively few can be used for estimating condition on live animals. Noninvasive body condition scoring techniques have been developed for assessing condition in livestock and more recently such techniques have been applied to wild ungulates. In this study, we examined the reliability of a body condition scoring technique for assessing condition in African buffalo (*Syncerus caffer caffer*). We compared a body condition score (BCS) based on visual assessment and manual palpation of an animal's body to two standard metrics of condition widely used in mammals: kidney fat index (KFI) and haematocrit (HCT). Across all buffalo, BCS was significantly and positively correlated with both KFI and HCT. For HCT, this pattern was observed among adults, juveniles, males and females; and in the wet season but not in the dry season. For KFI, BCS was significantly and positively correlated with KFI among adults, juveniles and males, but not in females. Overall, our results suggest that the BCS technique can serve as a useful method for estimating body condition in buffalo.

Key words: African buffalo, body condition, haematocrit, kidney fat index, nutritional condition, *Syncerus caffer*

Résumé

L'évaluation de la condition corporelle d'un animal est une composante nécessaire de nombreuses études écologiques. Bien que l'on ait mis au point de nombreuses méthodes pour réaliser cette évaluation, relativement peu peuvent servir à estimer la condition d'animaux vivants. Des techniques noninvasives ont été développées pour évaluer la condition physique chez le bétail et, plus récemment, de telles techniques ont aussi été appliquées aux animaux sauvages. Dans cette étude, nous avons examiné la fiabilité d'une technique d'évaluation de la condition physique conçue pour étudier celle du buffle africain (*Syncerus caffer caffer*). Nous avons comparé un indice de condition corporelle (Body condition score – BCS) basé sur une évaluation visuelle et la palpation manuelle du corps d'un animal à deux indicateurs standards de condition largement utilisés chez les mammifères: l'indice graisseux des reins (Kidney fat index – KFI) et l'hématocrite (HTC). Chez tous les buffles, le BCS était significativement et positivement lié avec le KFI et le HTC. Pour le HTC, ce schéma tenait pour les adultes et les juvéniles, mâles et femelles; et en saison des pluies mais pas en saison sèche. En ce qui concerne le KFI, le BCS lui était significativement et positivement lié chez les adultes, les juvéniles et les mâles, mais pas les femelles. En général, nos résultats suggèrent que la technique de BCS peut être une méthode utile pour évaluer la condition corporelle des buffles.

Introduction

Body condition is often strongly correlated with individual fitness including survival and reproductive potential. Thus, measuring animal condition is of considerable importance in many ecological studies, and as a wildlife management tool. For example, in disease ecological research, information on changes in body condition can reveal negative effects of parasites on hosts or indicate the relative susceptibility of hosts to infection (Wilson *et al.*, 2002). Although many methods for estimating body condition in vertebrates have been developed (reviewed in Brown, 1996; Stevenson & Woods, 2006), few of these are broadly applicable to ecological studies of large mammals because they are often highly invasive, totally destructive, or too

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expensive. To solve the problem of assessing condition in large numbers of live animals, noninvasive body condition scoring techniques have been developed for livestock (e.g. Wildman *et al.*, 1982; Edmonson *et al.*, 1989). More recently, similar methods have been applied to several wild ungulate species including impala (Gallivan, Culverwell & Girdwood, 1995), caribou (Gerhart *et al.*, 1996), elk (Cook *et al.*, 2001) and mule deer (Cook *et al.*, 2007). However, in some ecological studies, where these techniques have been used, it is unknown how well BCSs reflect actual differences in stored energy reserves or nutritional status of study subjects (e.g. Bro-Jorgensen & Durant, 2003; Caron, Cross & Du Toit, 2003; Jolles *et al.*, in press). Thus, our goal in this study was to validate a noninvasive body condition scoring technique for estimating condition in African buffalo.

To investigate whether body condition scoring is a reliable alternative to more invasive procedures for estimating body condition in buffalo, we compared a visual/manual body condition scoring (BCS) technique to two standard methods for assessing condition in mammals, the kidney fat index (KFI) and haematocrit (HCT). KFI is an indicator of an animal's total fat reserves (Riney, 1955; Finger, Brisbin & Smith, 1981) and is one of the most widely used metrics for assessing condition in African ungulates (Gallivan *et al.*, 1995; Oosthuizen, 2004). However, despite its broad utility, KFI is totally destructive and not amenable for use in studies where individuals and their response to environmental conditions need to be tracked over time. HCT is often used as a tool for assessing nutritional status in vertebrates and can be a reliable indicator of anabolism and mineral deficiencies (Brown, 1996; Rincker *et al.*, 2004). Although less destructive than KFI, requiring only a blood sample, HCT analysis can be expensive and/or time consuming for large studies. Furthermore, as HCT is sensitive to short-term fluctuations in diet and water availability, it may be less predictive of an animal's long-term energetic status (DelGiudice *et al.*, 1992; Gallivan *et al.*, 1995).

Materials and methods

Study animals

African buffalo were captured over a 2-week period in October 2005 and May 2006 as part of the Bovine Tuberculosis (TB) Control Program at Hluhluwe-iMfolozi Park, South Africa (28°10′–28°14′S; 31°54′–32°03′N). All capture operations were conducted by KwaZulu-Natal Wildlife, the park management organization, using a helicopter and funnel system to drive buffalo herds into a corral. Once corralled, buffalo were anaesthetized for bovine TB testing. Age and sex were determined for all captured animals. Age class was assessed using a combination of body size, degree of horn development, tooth eruption patterns and tooth wear (Sinclair, 1977; Jolles, Cooper & Levin, 2005). All buffalo under the age of 5.5 years were classified as juveniles and those >5.5 years were classified as adults. TB status was determined using a tuberculin skin test similar to tests used to diagnose human TB (Jolles *et al.*, 2005). We collected data on morphological condition and haematology of all captured individuals ≥1 year old during both the October 2005 (dry season) and May 2006 (wet season) capture periods (n = 495). We also collected kidneys from slaughtered TB positive buffalo in May 2006 to measure KFI (n = 23).

Condition indices

Buffalo condition was evaluated using three different indices: (i) a BCS, which is a categorical index of subcutaneous fat and provides an assessment of an animal's physical condition; (ii) HCT, which is a measure of red blood cell volume and is sensitive to nutritional variation thus reflecting changes in an animal's nutritional status; and (iii) KFI, which is a measure of stored fat and is a widely used technique for assessing animal's energy reserves.

Following similar methods developed for cattle (Wildman *et al.*, 1982) and African buffalo (Prins, 1996), we estimated BCS by visual inspection of the animal's coat and manual palpation of four areas of the body where buffalo store fat: ribs, spine, hips and base of the tail (hereafter referred to as 'tail') (Fig. 1). Each body part, including the coat, was given a score between 1 and 5, with a higher score reflecting a thicker, shinier coat or greater fatness (Table 1). The sum of all five scores (maximum = 25) was then used as a composite measure of overall body condition. To determine HCT, blood samples were collected from the jugular vein into 10 ml EDTA vacutainer tubes. Samples were immediately placed on ice and shipped to the laboratory of Dr Bouwer & Partners Inc (Durban, South Africa) for haematological analysis on an ADVIA 120 automated analyzer (Bayer Diagnostics, Tarrytown, NY, USA). To measure KFI, we extracted the kidneys along with the peri-renal fat from the body cavity of slaughtered

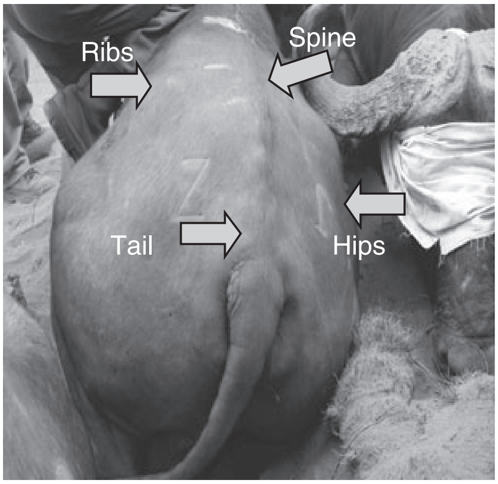

Fig 1 Components of the body condition score (BCS). Arrows indicate locations for manual palpation of the ribs, spine, hips and base of tail (tail). Overall coat condition was assessed, but not included in the final BCS composite

TB positive animals. The fat surrounding the kidneys was trimmed and both the fat and kidneys were weighed separately to the nearest 0.1 g. We calculated KFI as (kidney fat/kidney mass) × 100 following Riney (1955).

Statistical analyses

To examine whether our BCS technique was a predictor of either physical condition or nutritional status of buffalo, we tested for associations between BCS, HCT and KFI using Pearson correlation tests. First, we looked at relationships between the separate components of BCS (ribs, spine, hips, tail and coat) and both HCT and KFI to examine the predictive value of each component of the BCS. Next, we recalculated a composite BCS using only those components that were significant in individual tests. We then examined associations between composite BCS and HCT and KFI across all buffalo and split by sex, age, TB status and season. For KFI analyses, TB status and season tests were not performed because these data were collected only on TB positive animals during the wet season. All statistical analyses were two-tailed and the significance level was set at $P \leq 0.05$. For testing associations between the composite BCS and standard condition indices, we adjusted the significance level for multiple comparisons using the sequential Bonferroni method (Rice, 1989). Adjusted P-values were computed for HCT and KFI analyses using $k = 9$ and $k = 5$ respectively, with k equal to the number of tests run.

Table 1 Description of assessment criteria for individual components of the BCS (ribs, spine, hips, tail and coat)

	Region of body				
Score	Ribs	Spine	Hips	Tail	Coat
5 (Obese)	Not visible; fatty layer on and between ribs	Spine bones not visible. Spine sits in slight depression between fatty bulges left and right of spine	Convex, smooth rear, hip bones not visually apparent	Tail base sits in depression surrounded by soft fatty tissue	Glossy coat covering entire body
4	Few ribs visible towards abdomen; ribs can be felt	Spine bones not visible. Spine feels flat; bone and surrounding tissue are on level	Hip bones can be seen, round smooth appearance and feel	Tail base on level with surrounding fatty tissue	Thin coat covering entire body; or glossy coat with few small bald patches
3	Some ribs visible in centre of ribcage; abdominal ribs feel ridged	Spine palpable as a slightly elevated bony centre-line	Points of hips distinctly visible; bone easy to feel but not protruding	Tail base protrudes slightly; obvious by touch, but not by sight	Some bald patches behind the shoulders or along the flanks
2	Ribs visible throughout; all have ridged feel	Individual spinal vertebrae clearly palpable	Points of hips protrude; flanks are concave	Tail base visibly sticks up from surrounding tissue	Large bald patches throughout torso
1 (Emaciated)	Ribs clearly visible with deep depressions between them; very ridged feel	Vertebrae distinguishable by sight and touch	Hip bones protrude beyond the hip point; emaciated rear	Tissue surrounding tail base forms round hollow defined by pelvis	Majority of body area bald or very sparsely coated

Results

Four out of five BCS components were correlated with HCT and KFI. The ribs, hips, spine and tail scores were significantly and positively correlated with HCT or KFI, whereas the coat score was not correlated with either measure of condition (Table 2). Given these results, we combined the ribs, hips, spine and tail scores into a composite BCS and then looked at correlations between this composite measure and HCT and KFI.

Body condition score was significantly and positively correlated with HCT across all buffalo; the same pattern being observed among males, females, juveniles, adults, TB negative animals and TB positive animals (Table 3). Furthermore, BCS was significantly and positively correlated with HCT in the wet season, but not in the dry season (Table 3). In the KFI analyses, BCS was significantly and positively correlated with KFI across all buffalo; as well as among males, adults and juveniles (Table 3). There was no significant correlation between BCS and KFI in females ($r = 0.349$, $P = 0.2486$; Table 3), however, when we further subdivided females by reproductive status (lactating, n = 9 or pregnant, n = 5), BCS was marginally and positively correlated with KFI among lactating females ($r = 0.645$, $P = 0.0603$).

Discussion

Our results suggest that body condition scoring can provide an estimate of relative body condition in African buffalo. Our final BCS index included assessment of four areas of the body: ribs, hips, spine and base of the tail, while a fifth component, coat condition, was dropped as it proved to be a poor indicator of overall body condition. The use of multiple components to estimate BCS is likely to minimize any effect of variability in fat deposition and/or loss across different age and sex classes (Gerhart *et al.*, 1996) leading to the fairly consistent associations between BCS and condition we observed in this study. With regard to coat condition, buffalo coats deteriorate progressively with age at the study site (A. E. Jolles, personal observations) and this effect may be independent of body condition explaining the lack of association between coat condition and either HCT or KFI. Other factors such as ectoparasite

Table 2 Correlations between haematocrit (HCT), kidney fat index (KFI) and individual components of the BCS (ribs, spine, hips, tail and coat)

	N	Ribs	Spine	Hips	Tail	Coat
HCT	495	**$r = 0.323$ $P < 0.0001$***	**$r = 0.311$ $P < 0.0001$***	**$r = 0.276$ $P < 0.0001$***	**$r = 0.362$ $P < 0.0001$***	$r = 0.021$ $P = 0.6376$
KFI	23	**$r = 0.630$ $P = 0.0009$***	**$r = 0.439$ $P = 0.0353$***	$r = 0.335$ $P = 0.1190$	**$r = 0.421$ $P = 0.0447$***	$r = 0.257$ $P = 0.2389$

Components that were significantly correlated with either HCT or KFI are shown in bold.
*Significance at $P \leq 0.05$.

Table 3 Correlations between haematocrit (HCT), kidney fat index (KFI) and composite BCS for different classes of buffalo

HCT versus BCS	N	Correlation coefficient	KFI versus BCS	N	Correlation coefficient
All	495	$r = 0.366$ $P < 0.0001$*	All	23	$r = 0.518$ $P = 0.0103$*
Female	294	$r = 0.416$ $P < 0.0001$*	Female	13	$r = 0.349$ $P = 0.2486$
Male	201	$r = 0.338$ $P < 0.0001$*	Male	10	$r = 0.802$ $P = 0.0035$*
Adult	137	$r = 0.472$ $P < 0.0001$*	Adult	8	$r = 0.762$ $P = 0.0251$*
Juvenile	358	$r = 0.370$ $P < 0.0001$*	Juvenile	15	$r = 0.684$ $P = 0.0037$*
Dry season	307	$r = 0.125$ $P < 0.0870$			
Wet season	188	$r = 0.340$ $P < 0.0001$*			
TB negative	423	$r = 0.380$ $P < 0.0001$*			
TB positive	67	$r = 0.295$ $P = 0.0151$*			

Composite BCS was calculated as ribs + hips + spine + tail.
*Significance after adjustment for multiple comparisons.

burden may also influence variation in coat condition in buffalo.

Overall, BCS was a better predictor of fat reserves than nutritional status as revealed by correlation coefficients for KFI which ranged from 0.5 to 0.8, compared to those for HCT which ranged from 0.3 to 0.4. Nevertheless, consistent significant correlations between HCT and BCS across multiple classes of buffalo, suggest that BCS can provide an important relative indicator of variation in buffalo nutritional status, particularly in adults and females. However, BCS failed to reflect variation in HCT during the dry season, perhaps because BCS is more sensitive to losses in body fat than to factors such as dehydration and mineral deficiencies which are likely to influence variability in HCT during dry periods.

The strong associations we found between BCS and KFI across all buffalo, as well as in adults, juveniles and males, indicate that BCS can be used as a reliable index of relative body condition across these groups. The lack of a correlation between BCS and KFI in females, but marginally significant relationship among lactating females, suggests that for females, reproductive status can be an important confounding factor in evaluating condition using body condition indices. This may be because of asymmetrical losses of stored fat in females in different reproductive states. Finally, our KFI–BCS comparison used only TB positive animals and it is possible that TB status may have influenced these results. However, the lack of an effect of TB status in the HCT analyses (Table 3), suggests that TB infection is unlikely to have significantly biased the KFI results.

In conclusion, our study describes a method for body condition scoring in African buffalo and tests the validity of this method by comparing BCS with two standard metrics of condition, KFI and HCT. The results indicate that BCS can be used as an indicator of both nutritional status and stored fat reserves in buffalo, with high reliability for comparing condition across certain age and sex classes. While validations of body condition scoring techniques have been carried out for a number of North American ungulate species (Gerhart *et al.*, 1996; Cook *et al.*, 2001, 2007); few such validations exist for African ungulates (see Gallivan *et al.*, 1995 for a notable exception). Here, we outline a relatively simple and practical method for non-invasively assessing body condition in captured, live African buffalo. This method could be broadly applicable for ecological and management studies needing to track individuals over time.

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