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A NOTE ON CONDITION INDICES FOR ADULT MALE IMPALA, *AEPYCEROS MELAMPUS*

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OPSOMMING: 'N WAARDEBEPALING VAN KONDISIE INDEKSE VIR VOLWASSE ROOIBOKRAMME, *AEPYCEROS MELAMPUS*

Maatstawwe van kondisie word bespreek en gedefineer. Agt-en-dertig kondisie indekse, geneem vanaf nege volwasse rooibokramme was getoets vir liniêre korrelasie met kondisie en totale liggaamsvet. Indekse afgelei van die volledige disseksie van 'n boud was die betroubaarste, maar aangesien die niervetindeks ook betroubaar was, en heelwat makliker is om te bepaal, word dit aanbeveel as 'n geskikte veldtegniek mits niervet teenwoordig is. Nóg beenmurgvet nóg enige ander indeks wat vanaf lewendige diere verkry kan word het goeie korrelasie getoon met kondisie.

SUMMARY:

Citeria of condition are discussed and defined. Thirty-eight condition indices taken from nine adult male impala were tested for linear correlation with condition and total body fat. Indices derived from the complete dissection of a buttock proved to be the most reliable, but as the kidney fat index was also reliable, and considerably easier to obtain, this was recommended as a more suitable field technique as long as perinephric fat was present. Neither bone marrow fat nor any of the indices which could be obtained from live animals proved to be well correlated with condition.

Introduction

Assessing body condition of wild African ungulates has become increasingly important in recent years with a view to their management, as this reflects not only their ability to survive under different conditions but also their potential as producers of meat. Most studies have assumed that condition can best be assessed by some objective measurement of the fat content of the body as is common practice with domestic livestock, despite the fact that in their best condition carcass fat percentages rarely exceed 5 per cent compared to 7 per cent for emaciated *Bos indicus* steers, or 30 per cent for those in good condition (Talbot, Payne, Ledger, Verdcourt & Talbot, 1965). Because wild ungulates can decline very markedly in body condition this leads to the speculation that body protein may be utilised to a much greater extent as a reserve source of energy, yet few studies have included assessments of body protein. Smith (1970) however, did suggest that this may be an important source of energy under stress.

In domestic ungulates a good assessment of body composition can be made by determining the amount of dissectable fat in the buttock, which is highly correlated with the total fat content of the carcass (Orme, Cole, Kincaid & Cooper, 1960; Butterfield, 1962), and this has also been used in some wild ungulate studies (Huntley 1971, Von La Chevallerie & Van Zyl, 1971), although it has never been shown whether the same correlation exists.

However, in most studies of wild ungulates the indices used have been bone marrow fat (Chaetum, 1949; Sinclair & Duncan, 1972; Brooks, Hanks & Ludbrook, 1977), or the kidney fat index (Riney, 1955; Caughley, 1970), although some authors consider the latter to be inadequate as a single index for animals in poor condition (e.g. Ransom, 1965). The same inadequacy would apply to animals in which perinephric fat was completely absent for part of the year due to its relatively early mobilisation under conditions of nutritional stress. On the other hand, Smith (1970) has been the only one to correlate a number of condition indices with whole body constituents and he concluded that the kidney fat index represented the most workable technique, but leg fat, viceral fat and "live weight ratio" $\frac{\text{(corrected live weight)}}{\text{hind foot length}}$ also showed positive correlations with whole body fat. Franzmann, Le Resche, Arneson and Davis (1976), studying moose in Alaska, found that a combination of packed red cell volume, total plasma proteins, haemoglobin, calcium, and phosphorus levels gave a reasonable indication of body condition.

The purpose of the present study was to investigate a number of condition indices for adult male impala and to correlate these with body constituents to establish which gave the best estimate of body condition.

Procedure

Nine adult male impala from the northern Transvaal were used in this investigation. Immediately after they had been shot through the neck a venous blood sample of about 100 ml was collected from each animal in a heparinised plastic bottle. After returning to the laboratory this blood was centrifuged for one hour at 3 000 r.p.m. to separate off the plasma and to find the haematocrit value (packed cell volume) using graduated small calibre centrifuge tubes. After separation the plasma was kept frozen until it was required for analysis.

After shooting the animals were encased in plastic sheeting to prevent excessive loss of blood and body fluids whilst in transit to the dissecting laboratory. Here, having estimated age from horn shape and made a visual assessment of condition from body conformation following Riney (1960), the animals were weighed, routine body measurements were taken, and they were then butchered. One buttock, which made up a mean of 14,4 ± 1,0 per cent of the carcass weight of each animal, was dissected into muscle, bone and tendon, and fat, the femures being kept frozen for later marrow fat analyses. Riney's (1955) kidney fat index (KFI $= \frac{\text{weight of perinephric fat}}{\text{weight of kidney}} \times 100$ was calculated for each animal.

All the pieces of the carcass were put into one plastic bag, and the rest of the individual, except the horns, but including the emptied intestine, was put into another. These were then left in a deep freezer overnight before being separately minced in a "Wolfking" mincing machine capable of reducing all body components to small fragments. Samples of the well mixed mince from each bag were taken and dried to constant weight to find their water content. These dried samples were then finely ground in preparation for chemical analyses of protein, fat, and ash content using the methods of the Association of Official Agricultural Chemists (Horwitz, 1965).

Femur marrow water and fat contents were found by removing about 5 cm of marrow from the centre of each femoral shaft, weighing this, and drying it to constant weight before extracting the fat with ether in a soxhlet apparatus.

The samples of blood plasma were analysed in two batches: the first, from animals one to five, was analysed using the methods of Wooton (1974) for total plasma proteins, Kingsley (1940) for serum albumin, Coulombe and Fourean (1963) for urea nitrogen, Falholt, Lund and Falholt (1973) for free fatty acids, Watson (1960) for cholesterol, and a "Merk" commercial kit (E. Merk, Darmstadt, Germany) for total lipids.

The second batch, from animals six to nine, was analysed using a refractometer (American Optical Company, Keene, N.H., U.S.A.) for total plasma proteins, an "Albustrate" reagent system (Warner-Lambert Co., Morris Plains, N.J., U.S.A.) for serum albumin, a "Roche" test kit (Roche products, Berne, Switzerland) for urea nitrogen, a "Dr Heinz Haury" test kit (Dr Heinz Haury, München, Germany) for free fatty acids, and "Dr Lange-Küvetten-Test" kits (Dr Bruno Lange, Berlin, Germany) for cholesterol and total lipids.

Indices of body condition

Most indices have been used without defining what condition is in terms of body composition. Because other sources of energy may be important in wild ungulates some influence was given to these by considering body condition as $\frac{\text{Body fat}}{\text{Ash}} \times 100$, where fat and ash were both expressed as percentages of dry weight. Fat was therefore still the most important element, but the total amount of organic matter also played a role in determining condition.

Apart from considering straightforward measurements of blood constituents and fat as indicators of condition, any measurement which might increase or decrease with changing condition could also be used if it were divided by any measurement which remained reasonably constant. Thus in the live individual body mass and heart girth are changing parameters which could be divided by head length, metacarpal length, hind foot length, body length or shoulder height, while in the slaughtered animal carcass weight, buttock weight or buttock circumference could be divided by carcass length, metacarpal length, hind foot length or buttock length to give an index of condition. In this study a total of 38 possible condition indices were evaluated by correlation with the above criterion for condition and with total body fat (per cent dry weight of organic matter).

Results

The actual condition ratings of the nine animals according to three different criteria are given in Table 1.

Table 1

Three assessments of the physical condition of nine male impala shot in the northern Transvaal between June 1976 and September 1977

F/A $= \frac{\text{body fat}}{\text{ash}} \times 100$ (fat and ash as per cent of dry weight)
BF = Total body fat (per cent dry weight of organic matter)
Vis = Visual estimate (made just before dissection of animal)

Animal number	F/A	BF	Vis
1	135,1	24,0	Good
2	32,5	6,5	Good
3	82,2	15,3	Good
4	80,7	16,1	Fair
5	27,1	6,0	Fair
6	36,3	7,9	Good
7	19,5	4,9	Poor
8	42,2	8,8	Good
9	22,8	5,1	Fair

It is apparent from this table that visual estimation of condition from body conformation was neither defintive nor particularly accurate in terms of actual body composition, but that percentage body fat (BF) and $\frac{\text{Body fat}}{\text{Ash}}$ x 100 (F/A) were in fairly good agreement in the assessment of condition.

The basic data collected from the nine impala, including KFI and the results of bone marrow and blood analyses are given in Table 2 with the coefficients of correlation for the linear regression of all the condition indices evaluated against F/A and BF. Table 3 shows the chemical body condition of the impala.

A good negative correlation was found between the percentage of water (W) and the percentage of fat (F) in the wet femur marrow, supporting the findings of Neiland (1970) and others. The regression equation generated by the present results was

$$F = 89{,}43 - 0{,}93W \ (r = 0{,}99).$$

It is clear that the only three indices which could be used as indicators of condition as here defined are, buttock fat per cent wet weight, KFI and buttock bone and tendon per cent wet weight, as these were the only ones that were significantly correlated with F/A and BF.

Table 2

The body measurements, blood constituents and correlation coefficients for condition indices with $F/A = \frac{body\ fat}{ash} \times 100$ (fat and ash as per cent dry weight) and BF = body fat (per cent dry weight of organic matter) for nine adult male impala shot in the northern Transvaal between June 1976 and September 1977

N = 9	Mean ± S D	Range	±	F/A	BF
Body mass kg	57,2 ± 8,5	39,0 – 64,0	+	0,53	0,50
Body length cm	137,3 ± 7,2	130,0 – 149,0		–	–
Carcass weight kg	34,9 ± 5,9	22,9 – 41,0	+	0,45	0,44
Carcass length cm	74,9 ± 3,7	71,5 – 81,0		–	–
Buttock weight kg	4,9 ± 0,7	3,8 – 5,7	+	0,66	0,65
Kidney fat index	22,2	3,1 – 102,7	+	0,95	0,93**
Buttock fat per cent wet weight	0,98 ± 0,58	0,56 – 2,32	+	0,96	0,95**
Buttock bone and tendon per cent wet weight	14,7 ± 1,7	12,3 – 17,4	–	0,84	0,84*
Femur marrow per cent H_2O	42,5 ± 24,4	8,1 – 85,6	–	0,63	0,63
Femur marrow fat per cent dry weight	81,6 ± 21,3	27,4 – 97,6	+	0,33	0,31
Hematocrit per cent	48,3 ± 5,3	41,1 – 56,5	–	0,22	0,17
Total plasma proteins g/100 ml	6,7 ± 1,2	5,3 – 8,7	+	0,65	0,66
Albumin g/100 ml	2,9 ± 0,8	1,8 – 4,2	+	0,21	0,20
Albumin : Globulin ratio	0,92 ± 0,52	0,38 – 1,94	–	0,31	0,33
Blood urea nitrogen mg/100 ml	18,5 ± 4,6	12,5 – 26,7	+	0,70	0,68
Total lipids mg/100 ml	269,8 ± 186,0	65,0 – 580,0	–	0,51	0,49
Free fatty acids mg/1	0,13 ± 0,07	0,02 – 0,24	+	0,28	0,30
Cholesterol mg/100 ml	82,3 ± 27,1	35,0 – 118,0	+	0,05	0,04

* $P < 0{,}01$
**$P < 0{,}001$
Remainder non-significant

Table 3

The chemical body composition of nine dehorned male impala shot in the northern Transvaal between June 1976 and September 1977. H_2O = per cent wet weight : all other figures refer to dry weight. Mean ± S D and Range

N	H_2O	Weight (kg)	Protein (%)	Fat (%)	Ash (%)
9	71,3 ± 1,7 (67,9–74,1)	13,6 ± 1,7 (12,6–15,6)	66,1 ± 4,3 (57,8–72,3)	8,8 ± 5,6 (3,9–20,4)	17,3 ± 1,5 (15,1–20,0)

As both buttock fat and buttock bone and tendon determinations required complete buttock dissection, and as the former was positively and the latter negatively correlated with condition, it seemed sensible to combine these two indices as $\frac{\text{Buttock fat}}{\text{Buttock bone and tendon}}$ to give an even more reliable index – the buttock dissection index (BDI). Correlation coefficients for this index were 0,97 and for all indices correlation with F/A was rather better than with BF.

Discussion

The present results showed that a far more reliable index of condition was obtainable from individual dead animals than from live animals, and it was only within the scope of this investigation to recommend those methods of appraisal even though a live animal index might be preferable as a management tool. Such an index could possibly be obtained from the tritiated water (TOH) techniques of estimating body composition used by Meissner and Bieler (1975) and others, although these would be difficult to apply to large numbers of wild animals.

As for domestic animals the best individual indicator of condition found in the present study was the percentage of dissectable fat in the buttock. When combined with the proportion of bone and tendon in the buttock as BDI this became even more reliable. For general use this index could be said to have a linear relationship with condition (F/A) roughly expressed by the equation F/A = 8 x BDI. Its relationship to total body fat (BF) can be given by the equation BF = 1,4 x BDI + 1,25.

The disadvantage of the indices requiring buttock dissection lay in the time and effort required to obtain them. One of the essential attributes of a good workable condition index is that it should be relatively easy to obtain in the field, and for this reason the slightly less reliable kidney fat index (KFI) seemed preferable to the buttock indices, as long as kidney fat were present throughout the year. It was much quicker to obtain and was still highly significantly correlated with physical condition. Its approximate relationship to F/A and BF respectively are given by the following equations: F/A = 1,5 x KFI + 24; BF = 2,26 x KFI + 5,5.

The decision as to what levels of F/A or BF represent good or poor condition is of course completely arbitrary. The following values could be used as a guide for adult male impala:

F/A $<$ 30	BF $<$ 6,6	Poor	BDI $<$ 3,75	KFI $<$ 4,1
F/A 30–50	BF 6,6–10,0	Fair	BDI 3,75–4,25	KFI 4–17
F/A $>$ 50	BF $>$ 10,0	Good	BDI $>$ 6,25	KFI $>$ 17,3

Conclusions

Although a large number of measurable condition indices were tested in this study very few of them proved to be significantly and consistently correlated to actual body condition as here defined. Similarly, visual assessment made on criteria of body conformation did not appear to accurately reflect body composition. The "buttock dissection index" was found to show the closest correlation with condition, but due to the greater ease with which it could be obtained the "kidney fat index" was recommended as the most suitable field technique. Bone marrow fat was not significantly ($P < 0{,}1$) correlated with body condition and unfortunately no reliable index of condition was obtained from live animals.

The low levels of fat found in impala suggest that adipose tissue may not be used as a major source of energy storage in this species. The fat-related definitions of condition used in this study may therefore not reflect the true physiological state of the animals. Future research in this field would benefit from a better understanding of the metabolic reactions of tropical ungulates to nutritional stress, allowing "condition" to be more realistically defined.

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