G.J.B.A.H.S.,Vol.5(4):16-23 (October-December, 2016) ISSN: 2319 – 5584

GLOBAL JOURNAL OF BIOLOGY, AGRICULTURE & HEALTH SCIENCES
(**Published By**: *Global Institute for Research & Education)*

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Does Kidney Fat Index Determine Body Condition of the Common Hippopotamus (*Hippopotamus amphibius*) in Luangwa River, Zambia?

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Abstract

The body condition of common hippopotamus (*Hippopotamus amphibius*) in Luangwa River, eastern Zambia was assessed using Kidney Fat Index. Thirty-two (32) hippopotamus carcasses from culled specimens were picked at random to assess body condition. Using a sharp knife, kidneys were extracted from the lumen of each of the 32 hippopotamus carcasses. The whole kidney with surrounding fat was weighed in grammes using a solar powered digital weighing scale. The fat deposited immediately around the kidney (ignoring the fat extending anteriorly and posteriorly in the kidney mesentery), was removed and re-weighed. Kidney Fat Index index of 40 percent was obtained suggesting poor body condition rating of 40.91 percent Left kidneys had 40.20 percent and the right kidneys 41.63 percent Kidney Fat Index varied significantly between seasons (χ^2 = 55.99, DF= 8, α= 0.05, P < 0.001), being higher during the first half of the year January - June when pasture was in good condition and lower in the last half of the year July - December, when grass was of poor quality. Quality of pasture per season determined body condition of hippopotamus. More research is required to establish hippopotamus body condition classes during years of good rains and drought.

Keywords: *Kidney-fat, mobilisation, physiological condition, mesentery, season, grass quality*

Introduction

Physiological and demographic vigour have been used as indicators of population condition (Sinclair and Grimsdell 1982). Body condition for instance, is closely linked to the individual animal's chances of living or dying and as such is an important factor influencing mortality (Klein and Olsen 1960, Hirst 1969, Sinclair 1970, Klein 1970, Sinclair and Duncan 1972, Hanks et al. 1976). It is indexed by a variety of parameters, including, deposited fat reserves, adrenal cortical hypertrophy, blood chemistry and haematology, urinary excretion of hydroxyproline, and aspects of body growth. Such indices are considered as a measure of the 'physiological condition' of a population and are linked to the individual animal's survival (Sinclair and Grimsdell, 1982).

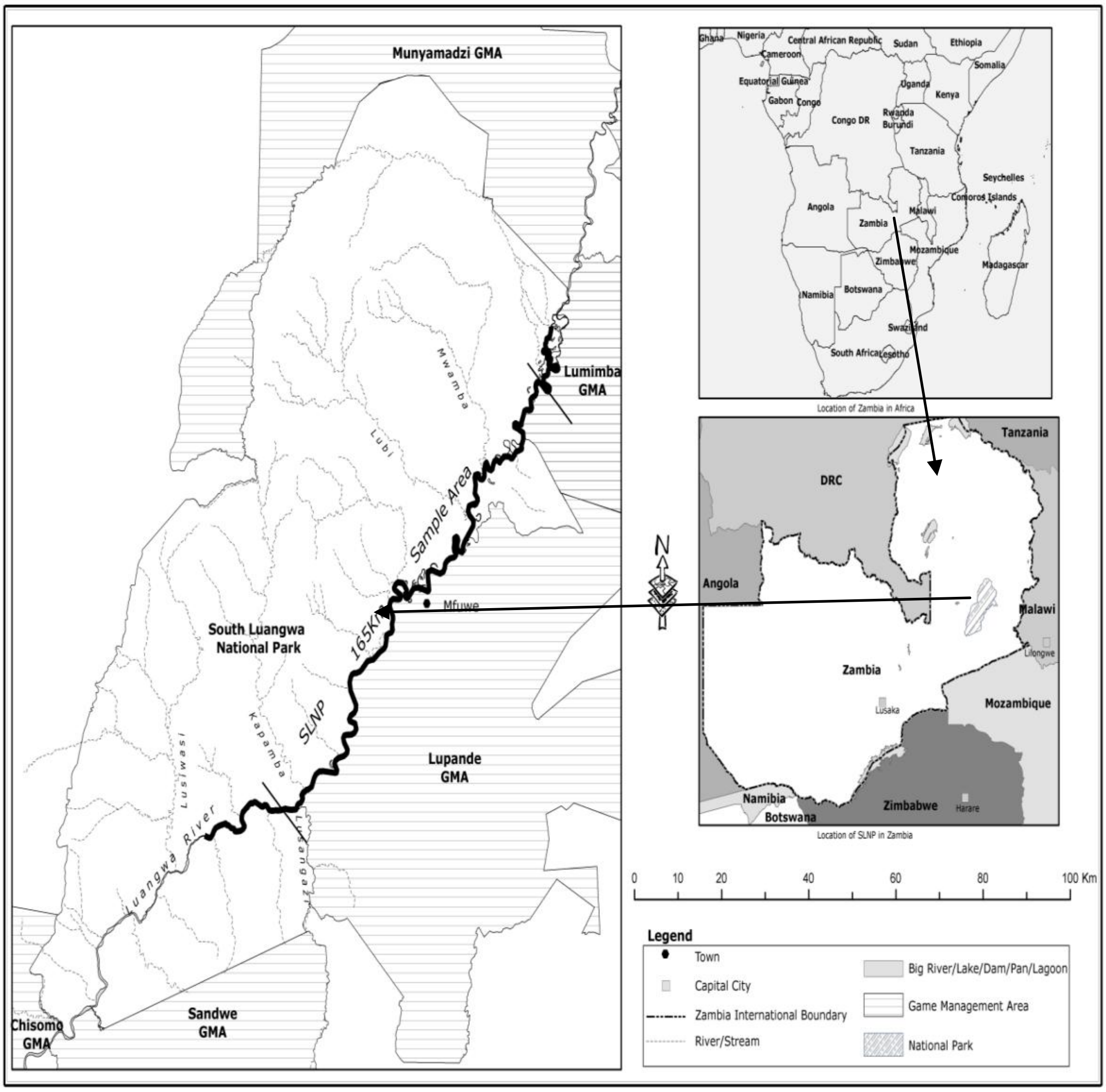
Physiological condition of individuals in a population is also related to the population's potential rate of increase, and Kidney Fat Index is an important indicator of body condition and general health of a population. It is used in detecting changes in fat mobilization which in turn reflects physiological condition of the animal. Smith (1970) found that in seven species of East African wild ungulates, KFI and the total body fat exhibited a significant correlation at 0.01 level. Smith (1970) also examined subcutaneous fat deposition and visceral fat, and concluded that of various methods used for assessing condition, KFI was the most useful and best fulfilled the needs of a workable technique. Riney (1955) also postulated that fat could be taken as a direct measure of the animal's condition, reflecting the metabolic level of goodness of physiological adjustment of an animal with its environment. He acknowledged that KFI was the most robust method of determining body condition.

Kidney Fat Indes as a measure of the population's condition was used in the present study because it is more robust in detecting changes in fat mobilization as emphasized by Smith (1970). In arriving at this conclusion, Smith (1970) examined subcutaneous fat deposition and visceral fat, and recommended that of various methods used for assessing body condition, KFI was the most useful and best fulfilled the needs of a workable technique. Riney's (1955) KFI method has subsequently been used extensively in an identical or slightly modified form by Hughes and Mall (1958), Taber et al. (1959), Ransom (1965), Allen (1968), Trout and Thiessen (1968), Caughley (1970), Laws et al. (1970), Smith (1970), Albl (1971), Bear (1971), Caughley (1971), Huntley (1971), Anderson et al. (1972), Sinclair and Duncan (1972), Dauphine (1975), Laws et al. (1975), Williamson (1975), Hanks et al.(1976), McNab (1976), Brooks et al. (1977), Malpas (1977). This is the most robust method and was used in this study to determine common hippopotamus body condition.

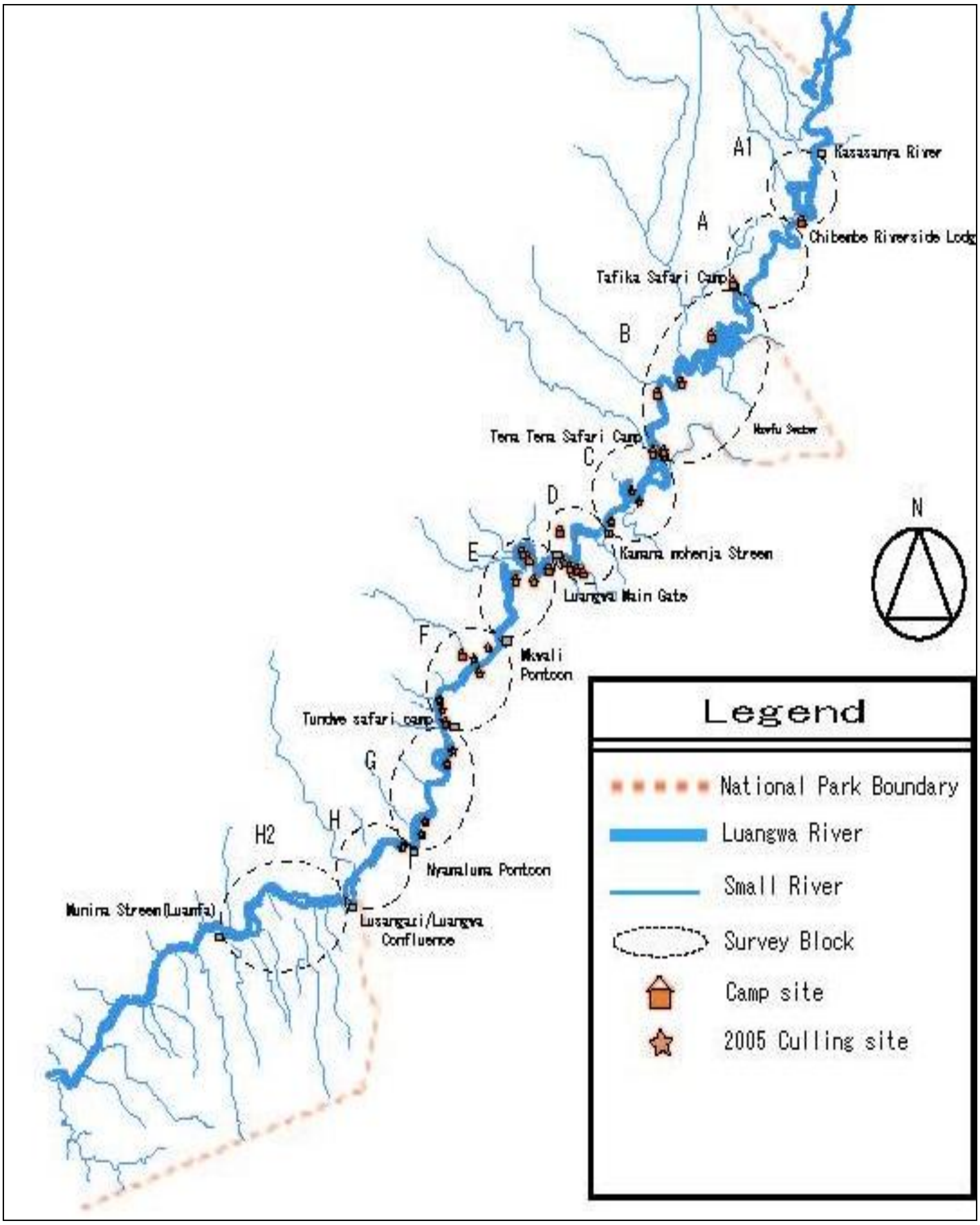
2. Materials and Methods

2.1 Study area Location and description

This study was conducted in the Luangwa River and valley in eastern Zambia. It covered the river segment of 165 km, starting from the Chibembe pontoon (12^o 48'S, 32^o 03'E) to the Lusangazi-Luangwa confluence (13^o 24' S, 31^o 33' E) (Figure 1a, b).



(a)



(b)

Figure 1: Location of study area and study blocks Luangwa Valley, Zambia

2.2 Kidney Fat Index

Kidney Fat Index (KFI) was used to detect changes in fat mobilization of the common hippopotamus as an indication of the animal's physiological condition. Kidneys were extracted from 32 culled hippopotamus specimens which were 20 percent of the specimens culled during the year, 2008. The year was divided into four quarters, first quarter being January - March, second quarter April - June, third quarter July - September and fourth quarter October - December. Specimens from which the kidneys were extracted were picked at random per quarter except for the first quarter (January - March) where the first and only specimen hunted in March was examined.

Using a sharp knife, kidneys were removed together with the surrounding fat from the abdominal cavity and weighed in grammes using a solar powered digital weighing scale adjusted to the nearest 0.5 grammes. The fat deposited immediately around the kidney (Fig. 2) was removed and weighed. All the data on weights for left and right kidneys were entered in separate columns on a data sheet. KFI was determined using the formula provided by Chapman and Reiss (2000), as follows;

$$\text{Kidney Fat Index} = \frac{\text{Perinephric fat weight}}{\text{Kidney weight}} \times 100$$

Chi-square Test was used to compare differences in KFI between seasons as described by Fowler, et al. (1998); Dytham 2002 and Brower and Zar (1977) as;

$$\chi^2 = \frac{\sum (0 - E)^2}{E}$$

Where *0*, represented frequency of kidney fat measurements taken in the population, and *E* was the expected frequency of measurements.

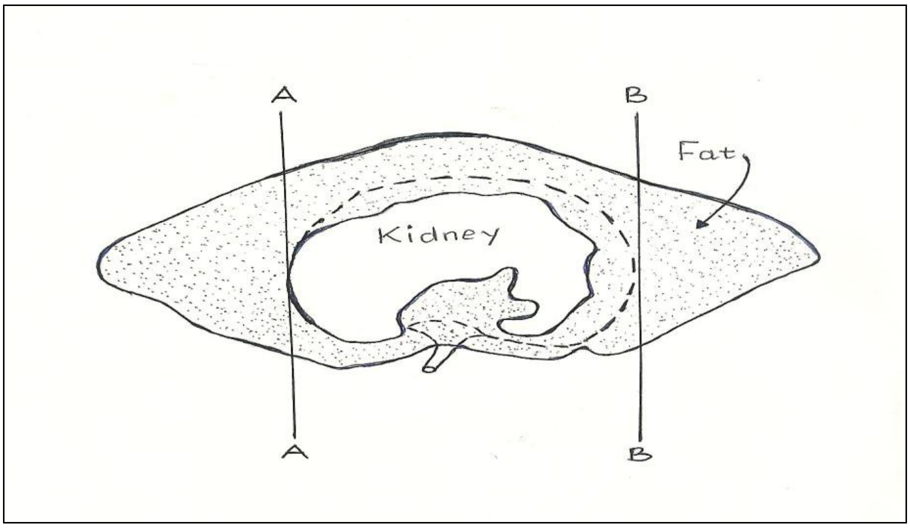


Figure 2: The standard cuts, AA and BB used to remove the left kidney and a uniform amount of fat surrounding the kidney from an animal.

3. Results

Body condition rating for the common hippopotamus was 40 percent and rated poor (Sensu Sinclair and Grimsdell, 1982). Left Kidneys had 40.20 percent and right Kidney had 41.63 percent (Table 1). There was a significant difference in the KFI between seasons ($\chi^2 = 55.99$, DF= 8, $\alpha = 0.05$, $P < 0.001$). KFI was highest in first and second quarters of the year January - June) which dropped significantly from the third quarter. In July which is the fourth month after the start of the dry season, KFI dropped below 80 percent (Figure 3). By fourth quarter (October – December), body condition rating dropped to below 40 percent which is poor body condition rating and susceptible to various forms of mortality including disease.

Table 1: Kidney Fat Index rating of 32 individuals randomly sampled from culled specimens

Specimen Random Number	**Sex**	**Location**	**Age group**	**Month**	**Percent (%) KFI Rating**		
					Left Kidney	Right Kidney	Mean
113	Female	Manzi Confluence	S/Adult	May	97	94	95.5
111	Female	Manzi	Adult	April	98	90	94
93	Male	Confluence	Adult	September	50	58	54
86	Female	Chawo cha ngombe	S/Adult	September	40	62	51
249	Female	Chawocha ngombe	S/Adult	September	50	50	50
57	Male	Manzi confluence	Adult	August	73	74	73.5
58	Female	Chawo changombe	S/Adult	July	62	87	74.5
61	Female	Nkoma wafwa	Adult	July	71	71	71
265	Male	Changozi Chipela lagoon	S/Adult	May	92	89	90.5

24	Male	Vicks Drowning camp	Adult	April	91	91	91
95	Male	Vicks drowning camp	Adult	May	90	92	91
45	Male	Chamadaka area	Adult	June	80	83	81.5
60	Male	Chamadaka area	S/Adult	July	68	60	64.
64	Male	Manzi confluence	Adult	July	70	70	70
66	Female	Manzi confluence	Adult	July	64	72	68
71	Male	Manzi confluence	S/Adult	March	94	97	95.5
83	Male	Manzi confluence	S/Adult	April	94	95	94.5
74	Female	Manzi confluence	S/Adult	April	90	92	91
67	Male	Manzi confluence	S/Adult	April	92	96	94
101	Female	Kamana Culling camp	S/Adult	October	39	43	41
165	Male	Kamana Culling camp	Adult	October	40	40	40
117	Female	Kamana Culling camp	Adult	September	50	52	51
203	Male	Manzi confluence	S/Adult	October	36	40	38
**07	Male	Manzi confluence	Adult	November	5	9	7
21	Female	Manzi confluence	Adult	June	74	89	82
250	Male	Kamana Culling camp	S/Adult	October	42	38	40
178	Female	Kamana Culling camp	Adult	Aug.	65	58	61.5
189	Male	Manzi confluence	Adult	October	40	36	38
181	Male	Manzi confluence	Adult	October	30	32	31
179	Male	Manzi confluence	Adult	November	51	48	49.5
2	Male	Manzi confluence	Adult	October	32	32	32
Mean					**40.20**	**41.63**	**40.91**

Notes: ** Specimen had deep scars on the skin probably sustained from fighting. The specimen was also found with plastics, pieces of cloth, empty mineral water bottles and old mopane leaves in its stomach compartments.

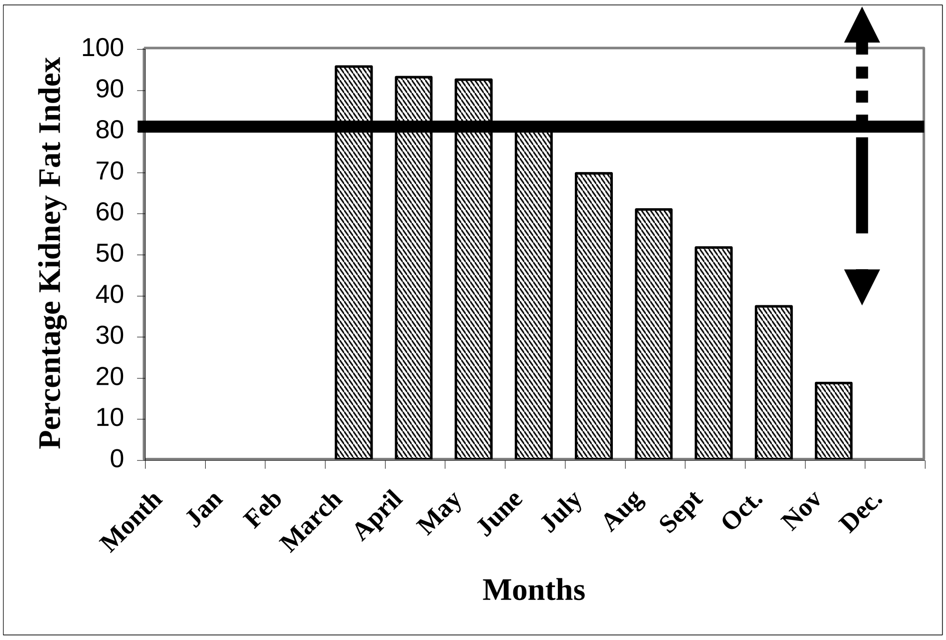


Figure 3: Hippopotamus Kidney Fat Index between seasons, Luangwa River

Key: ——— Considered to be the cutoff point (Sensu Sinclair and Grimsdell, 1982), above which the animal is considered to be in good body condition and below as poor body condition. ▪▪▪▪▪▪▶ Good condition, 80 percent and above; ▬ ▬▶ Poor condition below 80 percent.

4. Discussion

Hippopotamus body condition was rated poor in the dry season. Poor condition rating in the dry season was largely related to availability of forage and nutritious status of grass in the fourth quarter. During the rainy season when the grass is green animals were in good condition. As grass started to dry by May - June the hippopotamus' body condition dropped because grass quality and quantity dropped and unable to sustain nutritional needs of the hippopotamus (see Figure 3). Fluctuations in KFI between seasons also reflected physiological and behavioural events associated with reproduction which is negatively affected as has been demonstrated in several species, including Himalayan thar *(Hemitragus jemlahicus)* by Caughley (1970), pronghorns (*Antilocarpa americana*) by Bear (1971), mule deer *(Odocoileus hemionus hemionus)* by Anderson et al.(1972), and impala *(Aepyceros melampus)* by Hanks et al. (1976). Hanks (1980) demonstrated that KFI value of 80 percent and above indicated that an individual was in good condition and was resilient to deprivations including disease. Additionally, an animal under constant stress is likely to exploit its fat reserves in order to overcome the physical and emotional stress. Under such circumstances the kidney fat reserves are likely to be lower as was the case with Luangwa hippopotamus during the last quarter.

In defining adrenal cortical hypertrophy and hyperplasia as reactions of body to stress and that an increase in adrenal cortical tissue has a direct relation to adrenal weight, Christian (1975) showed that with an increase in population density, there was a concurrent intensification in social aggressive interactions due to crowding. In such cases, a stressful stimulus resulted in endocrine responses in the form of increased pituitary adrenocortical activity which consequently depletes fat reserves to over come stress. In Luangwa valley hippopotamus population, increase in population size might have contributed to rapid depletion of fat reserves particularly in the dry season when food was in short supply.

In this study, population size of 6,318 and density of 38/km were assumed to be high and exacerbated aggressive behaviour, which allegedly caused depletion of fat reserves (sensu Christian, 1975). Hippos could only maintain good body condition up to June when KFI was 80 percent and above. By end of September and towards the beginning of October, the animals were already in poor body condition with KFI below 40 percent caused mainly by decline in quantity and quality of food implying that the animals had to mobilise bone marrow fat (Fig. 3) to meet energy requirements and their resistance to environmental stress was reduced. It is at this time that hippopotamus become very susceptible to disease such as anthrax. Christian (1975) noted that animals in such a condition may not be in a position to breed, and this might be contributing to low recruitment rate in the hippopotamus population in the Luangwa valley. Information on the taste of meat obtained from culled hippopotamus specimens after September was reported not have good quality by L and L Safaris a company contracted by Zambia Wildlife Authority (ZAWA) now Department of National Parks and Wildlife (DNPW) to conduct culling (V. Vahuen, Lusaka pers. comm.). At this time of the year, the animals were showing inanition, thus the tendency to become thin as condition dropped. The loss of kidney fat recorded in this study was characteristic of a population at ecological carrying capacity *K* where food resources were in short supply such that animals' survival depended on mobilising fat reserves in the body.

It is here concluded that hippopotamus in 'good' condition should be not only far removed from death, but should be sufficiently resilient to absorb either progressive decline in food resources or sudden environmental stress and similarly hippopotamus in 'poor' condition should not only be close to death, but in addition it should be so low in resilience that it is unable to tolerate any further deprivations and unlikely to breed. While KFI is widely used to determine body condition, no detailed work has been done to determine poor condition to the animals' chances of living or dying. With the exception of the work by Decalesta et al. (1975) relating body weight loss to starvation and eventual death, no attempt has been made in any of the previous work to equate a particular physiological parameter to the animal's chances of living or dying, although in many cases including this study it was defined by 'good' and 'poor' condition.

It has been assumed in previous studies that an animal experiencing adrenal cortical hypertrophy is in 'poor' condition, yet in the majority of cases no evidence was shown to support such assertion. A population biologist or wildlife manager should be able to evaluate the significance of a 'poor' condition index associated with adrenal cortical hypertrophy, and unless such index can be related to the capacity for the animal to absorb further environmental stress, a measure of hypertrophy *per se* may pose a challenge. The characterization of population condition, based on an assessment of physiological condition, therefore requires a great deal of further study to elucidate the details of the complex relationships between the various physiological parameters concerned, coupled with a study of the significance of these parameters in terms of an individual animal living or dying. Furthermore, each parameter within the physiological system needs to be much more carefully examined in relation to the systems' response to all the relevant environmental variables. It is also suggested that each factor be assessed in terms of its resilience as supported by Caughley and Gunn (1996).

Despite the challenges of using body condition rating, Klein (1968) however, contested that while it is necessary to examine all environmental parameters within the physiological system so as to determine the ones that are responsible for the animal's possibility to die or to absorb further environmental stress, he emphasized the importance of food as key. Animals on a good diet are likely to withstand environmental stress.

Characterization of population condition therefore remains an important aspect of large mammal population dynamics that deserves further study and it should be integrated within a multidisciplinary approach that includes behavioural characteristics and an assessment of habitat condition and trend.

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