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Morphometrics of Hares from Three Ecological Regions in Sudan

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Abstract

A study was conducted to determine morphological discrimination in body measurements of *Lepus capensis* collected from different geographic regions of Sudan and to test if the morphological results are consistent in the different regions. Ninety six hares (44 males and 52 females) were examined for body weight, total length, ear length, tail length, hind foot length, length of front leg, length of back leg, distance between ears, distance between eyes, neck length, height and back length. Body measurements were taken by a tape, live weight by digital balance with 0.05 mm precision. The results revealed that tail length, distance between eyes and height varied in hares among the geographical regions; females were heavier, with shorter necks compared with males. The conclusion of the study the hares from Western region had longer tails than those between the White and Blue Niles, and those from the Eastern region. Also females were heavier than males, this is indicating to sexual dimorphism,

Key words: Morphometric, hares, geographical regions, sexual dimorphism

Introduction

Hares belong to the order Lagomorpha. This order was recognized in 1912, when a review by Gridley (1912) separated lagomorphs from rodents (order Rodentia), to which they were previously allocated. The distinction was based on some morphological characters, as the presence of a second set of incisors (named peg) behind the upper front incisors in lagomorphs. An elongated rostrum of the skull (Flux and Angermann, 1990) and the presence of a leporine lip were other characteristic anatomical traits of Lagomorpha in comparison with Rodentia. Within Lagomorpha, two families are currently recognized, Ochotonidae and Leporidea. While the former is a monotypic family harbouring the genus *Ochotona* (pikas), the latter contains eleven genera divided in true rabbits (ten of the eleven genera) and true hares (genus *Lepus).*

Mammals' body size is most frequently described by means of body weight and

certain linear measurements - usually the body length; other measurements, like sternum length or chest circumference, are less often used (Szuba *et al.*, 1988; Schmidt-Nielsen, 1994).

In small mammals, apart from body weight and body length, ear length and hind foot length measurements are also used (Yom-Tov and Geffen, 2011). The mentioned parameters are used in systematic, morphological, ontogenetic, and ecological studies; sometimes also in establishing appropriate relations of allometric characters (Gould, 1966; Szuba *et al.,* 1988; Reiss, 1991). Krunoslav *et al.,* (2014) found that the family of hares (Leporidae) expressed significant variation of morphological features under the influence of environment and diet. Temporal and geographical variation in body size of animals is a common phenomenon, and has been related to many factors (Yom-Tov and Geffen, 2011).

Among these factors is predation, ambient temperature, fluctuations in various climatic phenomena including climate changes, interspecific competition and food availability (Gosler *et al.,* 1995; Grant and Grant, 1995; Yom-Tov, 2003; Yom-Tov *et al.,* 2003; Ozgul *et al.,* 2009). Reduction in body size of many species was generally attributed to global climate change (Gardner *et al.,* 2011; Sheridan and Bickford, 2011). On the other hand, an increase in body size was attributed to increased food availability, either by human activity or higher primary productivity in northern latitudes (Yom-Tov and Geffen, 2011).

Recently, McNab (2010) argued that the tendency of mammals to vary in size depends on the abundance, availability and size of resources, and termed this pattern the "resource rule". Among mammals, food availability, especially during the growth period, is a key predictor in determining final body size. Quantity and quality of nutrition during this period affects growth rates and final body size, and these have effects on skeletal size and carry over into adulthood (Searcy *et al.,* 2004; Ho *et al.,* 2010).

In mammals, body size is influenced by food availability during the short period of juvenile growth (Henry and Ulijaszek 1996; Lindstrom 1999). Food availability is influenced by biotic factors and fluctuates accordingly in time and space, in turn affecting body size. Demirbas, *et al.,* (2013) suggested that environmental conditions and nutrients do not have much effect on the body and cranial measurements of hares from Turkey; because there were significant differences only in body weight and hind foot length.

The aim of this study was to determine the morphological discrimination in body measurements of hares from different regions of Sudan. Also to test and determine if the morphological results are consistent in the different regions.

Materials and Methods

Hares used in this study were collected from three geographic regions in Sudan

under the control and permission of the Wildlife Conservation General Administration (WCGA) during the period 2012 to 2015; the regions were the West river Nile, East river Nile and between the Blue Nile and the White Nile (Figure 1). In total 96 specimens were collected and examined from the three regions as 19 specimens from the West, 59 from the East and 20 between the Blue Nile and White Nile (Table 1).

Table 1: Sample sizes and Regions of Hares collection

Region	States	Females	Males	Total
East of the Nile	Sinner	5	6	11
	Gedarif	4	7	11
	Northern State	4	4	8
	River Nile	13	11	24
	Khartoum	2	1	3
	Gazira	1	1	2
West of the Nile	North Kurdofan	4	4	8
	River Nile	5	4	9
Between Blue and White Niles.	Gazira	14	6	20
	Total	52	44	96

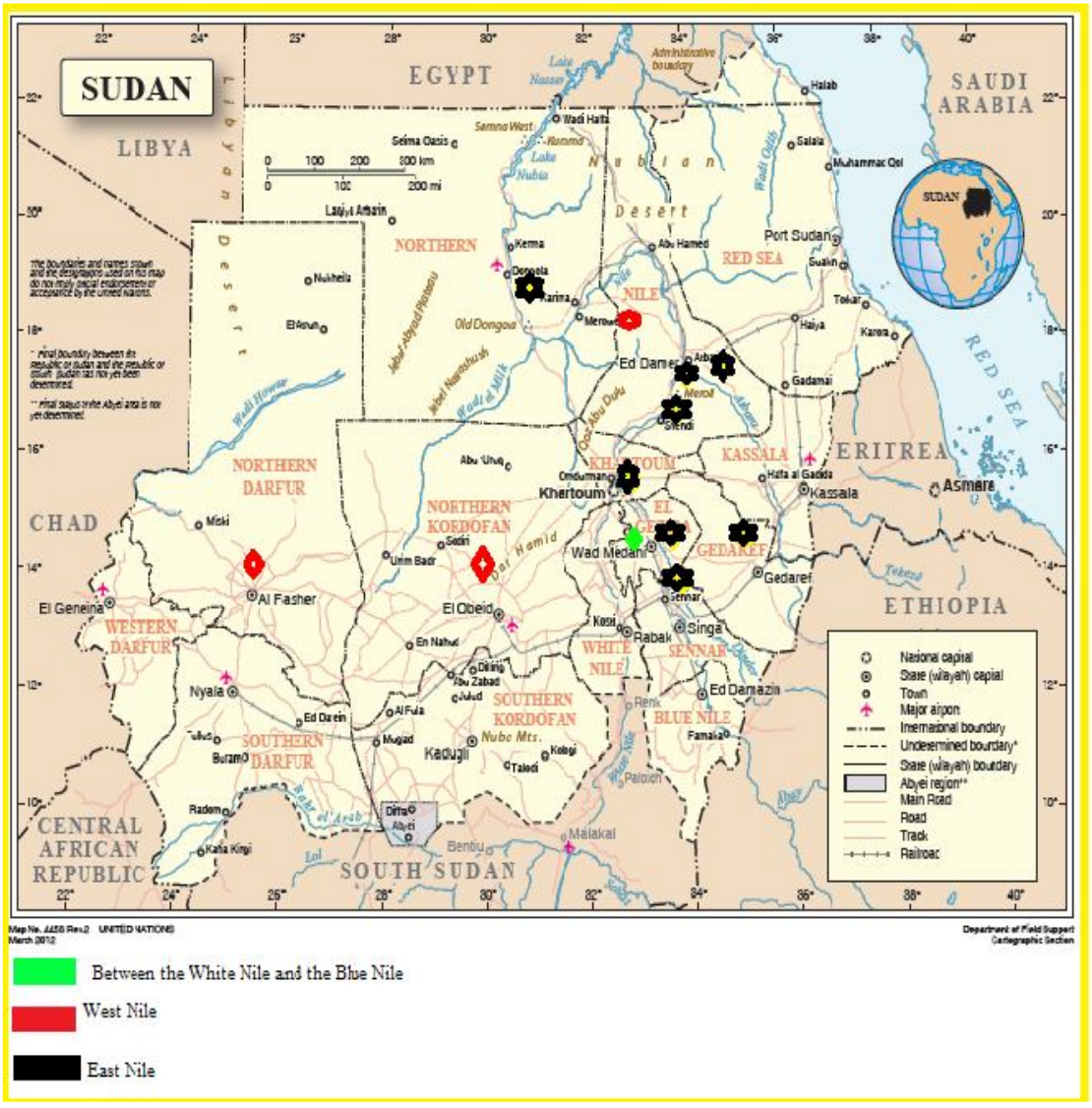

Figure 1: Map showing regions of samples collection in Sudan

Source : https://en.wikipedia.org/wiki/Sudan.

Morphometric:

Immediately after the collection of the samples from the field live weight was recorded from fresh animals, using a digital balance with an accuracy of 0.05 mm (Nagorsen, 1985; Harrison and Bates, 1991). The samples were then transported to the laboratory where body measurements were taken, with the help of a tape: body length was measured from tip of nose to tip of fleshy part of the tail vertebrae, the tail length was measured as the distance between the base of the tail close to the body to the tip of the tail. Ear length is the distance between the tip of the ear and the white base according to Anthony and Robert (1979).

Statistical analysis:

Analysis of Variance, LSD for means separation, T-test and SPSS version 22 were used.

Results

Morphometrics parameters of hares are presented in Table (2). Three parameters differed considerably among the three geographic regions; these were the tail length ($P < 0.0001$), the distance between eyes ($P < 0.0001$) and the height ($P < 0.004$). Hares from the Western region had longer tails (9.12± 0.90 cm) compared with those between the Blue and White Niles (8.18± 0.80 cm) and from the Eastern region (7.37 ± 1.5 cm). Contrary, the distance between eyes was wider (4.25± 0.70) for hares between the two Niles compared with those from the Western region (3.33 ± 0.80) and the Eastern region (2.87 ± 0.50). Hares from the Eastern region were taller (16.91 ± 3.2) than the hares between the two Niles (15.53 ± 2.40 cm) and hares from the Western region (14.18 ± 2.90 cm).

Table 2: The body measurements of hares collected from three geographical regions*

Parameters	Geographical region				
	East (n = 59)	West (n = 19)	Between Blue and White Niles (n = 18)	95% confidence	P-values
Body weight (Kg)	1.42±0.3	1.57±0.4	1.34±0.3	1.36-1.5	0.129
Total length (cm)	43.13±6.4	42.71±4.4	41.81±4.1	41.46-43.61	0.884
Ear length (cm)	10.75±1.4	10.59± 1.0	10.00± 0.7	10.41-10.92	0.724
Tail length (cm)	7.37± 1.5^{c}	9.12±0. 9^{a}	8.18±0.8^{b}	9.84-10.25	0.000
Hind Foot (cm)	10.02±1.2	9.85± 0.5	10.28 ± 0.6	9.84-10.25	0.432
Length of font leg (cm)	22.55±3.4	21.53±2.2	22.95±1.9	21.85-23.05	0.324
Length of back leg (cm)	27.63±3.8	26.94±2.0	28.60±2.5	27.03-28.39	0.313

Length between ears (cm	3.25±0.9	3.00±0.7	3.58±0.6	3.11-3.43	0.084
Distance between eyes (cm)	2.87±0.5[c]	3.33±0.8[b]	4.25±0.7[a]	3.11-3.43	0.000
Neck length (cm)	4.15±1.3	3.91±0.6	4.63±0.8	3.98-4.44	0.293
Height (cm	16.91±3.2[a]	14.18±2.9[b]	15.53±2.4 [ab]	15.5-16.77	0.004
Back length (cm)	26.84±3.8	28.29±1.9	27.65±2.7	26.59-27.94	0.242

*The geographic regions were: West of the Nile, East of the Nile and between the White Nile and the Blue Nile.

Sexual Dimorphism:

Morphometrics parameters of sexes were presented in Table (3). Among the 12 measurements, only live weight and neck length varied between males and females. Females were heavier than males ($P < 0.003$). The mean body weight of females was 1.49 ± 0.4 kg (n = 51) compared to that of males (1.36 ± 0.3 kg, n = 43). Contrarily, males had longer necks ($P < 0.034$) compared to females, the respective neck lengths being 4.46 ± 1.30 cm and 4.00 ± 0.90 cm.

Table 3: Sex morphometric of hares collected from three geographical regions*

Parameters	**Sex**		**P -value**
	Male (n=43)	Female (n=51)	
Body weight (Kg)	1.36±0.3	1.49±0.4	0.003
Total length (cm)	42.22±5.1	42.81±5.4	0.637
Ear length (cm)	10.57±1.8	10.75± 1.3	0.290
Tail length (cm)	7.81± 1.6	7.89±1.3	0.256
Hind Foot (cm)	10.08±1.1	10.01 ± 0.9	0.269
Length of front leg (cm)	22.68±2.8	22.26±3.1	0.373
Length of back leg (cm)	27.78±3.6	27.64±3.1	0.695
Distance between ears (cm	3.25±0.7	3.29±0.9	0.356
Distance between eyes (cm)	3.18±0.7	3.45±0.8	0.171
Neck length (cm)	4.46±1.3	4.00±0.9	0.034
Height (cm	16.11±3.4	16.15±3.0	0.414
Back length (cm)	27.11±3.4	27.39±3.3	0.995

*The geographic regions were: West of the Nile, East of the Nile and between the White Nile and the Blue Nile.

Discussion

Variations in Hares morphometric parameters in different geographic regions are attributed by many researchers to environmental factors. Variations in body sizes of both homeotherms and ectotherms is a common phenomena that are related to intraspecific compotation, food availability reaction to ambient temperature in accordance to Bergmann's rule (Ashton *et al.*, 2000; and Freckelton *et al.*, 2003; Meiri and Dayan 2003). A study conducted by Yom-Tov and Nix (1986) in a largely dry region in Australia has shown that body size variations in five species of mammals was better correlated with moisture index and precipitation than with temperature, leading to the conclusion that food supply was the main factor determining body size. These findings support the hypothesis that body size of mammals inhabiting relatively dry areas is often influenced by primary production (and its correlate, food availability) and not by ambient temperature alone (Kolb 1978; Geist 1987). Mace *et al.*, (1981) compared body weights of brown hares living in Poland to representatives of this species from Western Europe and found that fully grown-up individuals from Poland were about twice as heavy as those from Western Europe. Studies on the geographical variation of *Lepus capensis* (Yom-Tov 1967), *Acomys cahirinus* (Nevo 1989) and *Spalax ehrenbergi (*Nevo *et al.*, 1986) in Israel and Sinai reveal that in these species, northern animals were larger than southern ones, and that body size was negatively correlated with temperature variables and positively with plant cover (reflecting productivity or food resources) and water-related parameters such as the number of rainy days, annual rainfall and relative humidity.

These results support James (1970) who claims that body size variation is related to a combination of climatic factors. Referring to available literature, the findings that the tail length, the distance between eyes and the height are different among hares in the three geographic regions has not been reported before.

Although the three regions have different environmental factors, live weights of hares collected from these regions were equal which is not in line with the findings of previous investigators (Yom-Tov 1967, James, 1970, Mace *et al.*, 1981, Kolb 1978; Nevo *et al.*, 1986,Yom-Tov and Nix 1986, Geist 1987Ashton *et al.*, 2000; Freckelton *et al.*, 2003; Meiri and Dayan 2003).

This implies that hares in the three geographic regions are not conspecific (the same species), supporting the hypothesis that 'hares populations separated by geographical barriers, hinder gene-flow and leading to genetically differentiated populations'. Further research is needed to verify this hypothesis. It is worth mentioning that the distance between eyes and height are not standard measurements in mammology.

These comparisons which were carried out by Riga *et al.*, (2001) and Cervantes and Lorenzo, (1997) revealed that morphometric parameters of males and females are similar for the genus *Lepus* which, contradicts Demirbaş *et al,* (2013) and Yom-Tov (1967) respective findings that Turkish hares vary in body weight and hind-foot length with variations in geographic areas, and Israeli hare decreases in body size from north to south. It remains whether neck length and body weight is accepted as a standard measurement

In conclusion the hares from Western region had longer tails than those between the White and Blue Niles, and those from the Eastern region. Generally, females were heavier than males, indicating sexual dimorphism.

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