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Morphometric Characterization of Donkeys (*Equus asinus*) in D/Kudu Kano State For Selective Breeding and Genetic Conservation

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ABSTRACT

Donkeys (*Equus asinus*) is a domestic livestock animal and popular in helping farming activities and providing food for some societies. Population of donkeys were drastically decreasing due to the overexploitation for its hides and industrialization. Little is known regarding the morphometric measurements of this species which provide a useful information for selective breeding and genetic conservation. One hundred and forty-four male donkeys from D/Kudu Kano state where enrolled in this study for morphometric characterisation. Seven morphological parameters were analysed in association with age and coat colour of donkeys observed. Descriptive statistical analysis, analysis of variance (ANOVA) as well as correlation coefficient among parameters were evaluated. Result revealed that donkeys in the studied area were categorised into 7 different coat colour with light grey (30.6%) being the dominant colour. High frequency distribution of donkeys between the ages of 5-7 years (41%) were recorded. Also, both age and coat colour showed a significant (P <0.01) difference on face length, ear length, chest circumference and body length. Significant and positive correlation (r = 0.43–0.91) is observed in all morphological traits except relationship for tail length which is negatively correlated. In conclusion, the morphological features analysed in this study can be regarded as a preliminary for further studies on the Kano donkey breed.

Keywords: Body morphometric, breeding, donkeys, genetic conservation, Kano

INTRODUCTION

About 6000-7000 ago, donkeys *Equus asinus* were domesticated in Northeastern part of Africa and played a vital role in the growth and development of human being populations as well as in trade practices in the ancient world (Camillo et al., 2018). It is believed that donkey can thrive better under difficult environmental conditions

such as high temperature, low rainfall and low quality feeds as a result of certain genetic and morphological changes occurred during its domestication (Pearson & Ouassat, 2000; Rossel et al., 2008). According to FAOSTAT (2014), the world population of donkeys was around 43 million, with 1.6%, 42.6%, 38.7% and 17% in Europe, Asia, Africa and America, respectively. In Nigeria, donkeys are widely distributed in Northern part of the country, possibly introduced by caravan trading across the Sahara (Starkey & Fielding, 2004). Donkeys are mainly used for traction and farming activities due to the religious beliefs in Northern Nigeria, however, traders purchased donkeys (16,000 annually) and transported to the Southern part of Nigeria where both meat and milk are consumed (Blench, 1995; Starkey & Fielding, 2004; John et al., 2017).

Populations of many donkey breeds are globally decreasing and vulnerable to extinction as agricultural mechanization decreasing their economic value (Quaresma et al., 2013). Recently, increasing demand for donkey hides from China for the production of medicine (*ejiao*) has also triggers global donkey population decline (FAO, 2016; DoF, 2017; Matlhola & Chen, 2020). In Nigeria, the donkey-hide trading was seen as a profitable industry with the ability to make fast cash, with 3,000 donkeys being sold by dealers every week (DoF, 2018). It is being observed that most of these donkey-hides trading are taken place in Kano State of Northern Nigeria and causes the sighted population of these species very rare nowadays. These trading activities causes loss and wipe-out many qualitative desired breeds with highly valuable traits. The loss will be disastrous in the genetic resources available to animals for the future and should be avoided because of their significance in habitat conservation and economic development in remote areas (Quaresma et al., 2013).

Genetic resource conservation is one of the key issues aimed at conserving biodiversity, especially when indigenous breeds are declining at an incredible rate (Ljubodrag et al., 2015; Ahmad-Syazni et al., 2017). Significant decline in population size might generate high inbreeding rates, inbreeding depression with the high risk of breed extinction (Ljubodrag et al., 2015; Khaleel et al., 2019). The loss of genetic diversity in domestic populations is particularly significant in potentially unsustainable species such as donkeys, causing the simultaneous loss of essential functional traits (Navas et al., 2017). Genetic diversity study is an excellent field that ensures the genetic variation is maintained in any given species (Ha et al., 2017; Ahmad-Syazni et al., 2017). Variations in phenotype and morphological features are the basic parameters in the genetic diversity study of a species (Rosa et al., 2007). The parameters creates basics for comparison that is cheaper and yields positive results especially among different breeds (Lanari et al., 2003; Tolenkhomba et al., 2012).

Other studies also highlighted the benefits of comparative body morphological traits amongst different breeds as an essential and prerequisite for genetic modification as well as selective breeding database (Papa & Kume, 2012; Ljubodrag et al., 2015; Turke et al., 2016; John et al., 2017; Behl et al., 2017). Also, understanding morphological and phenotypic characteristics of animal helps in determining the history, origin and geographical distribution of a breed (Turke et al., 2016). Although, much researches have been conducted to characterize and classify the animal genetic resources in most of the livestock species, still there is limited documentation on the donkey population. Our research aimed to determine the morphological and phenotypic characteristics of donkey population as affected by age in order to provide useful data for easy identification, selection, breeding and conservation purposes.

MATERIALS AND METHODS

Study area

The study was conducted at D/Kudu Local Government area of Kano State in Northwestern part of Nigeria (11°50'22.4"N 8°35'36.1"E) as shown in Fig. 1. Based on KNARDA (2007) report, the area was characterized with wet and dry seasons (May to September and October to April, respectively). The annual rainfall ranges from 787-960 mm, the mean annual temperature range from 21-39^{O}C, with low humidity and high evapotranspiration rate (Olofin et al., 2008). This location is suitably selected for this study because it possesses high population of donkeys in the state (no data available for donkey population in Kano).

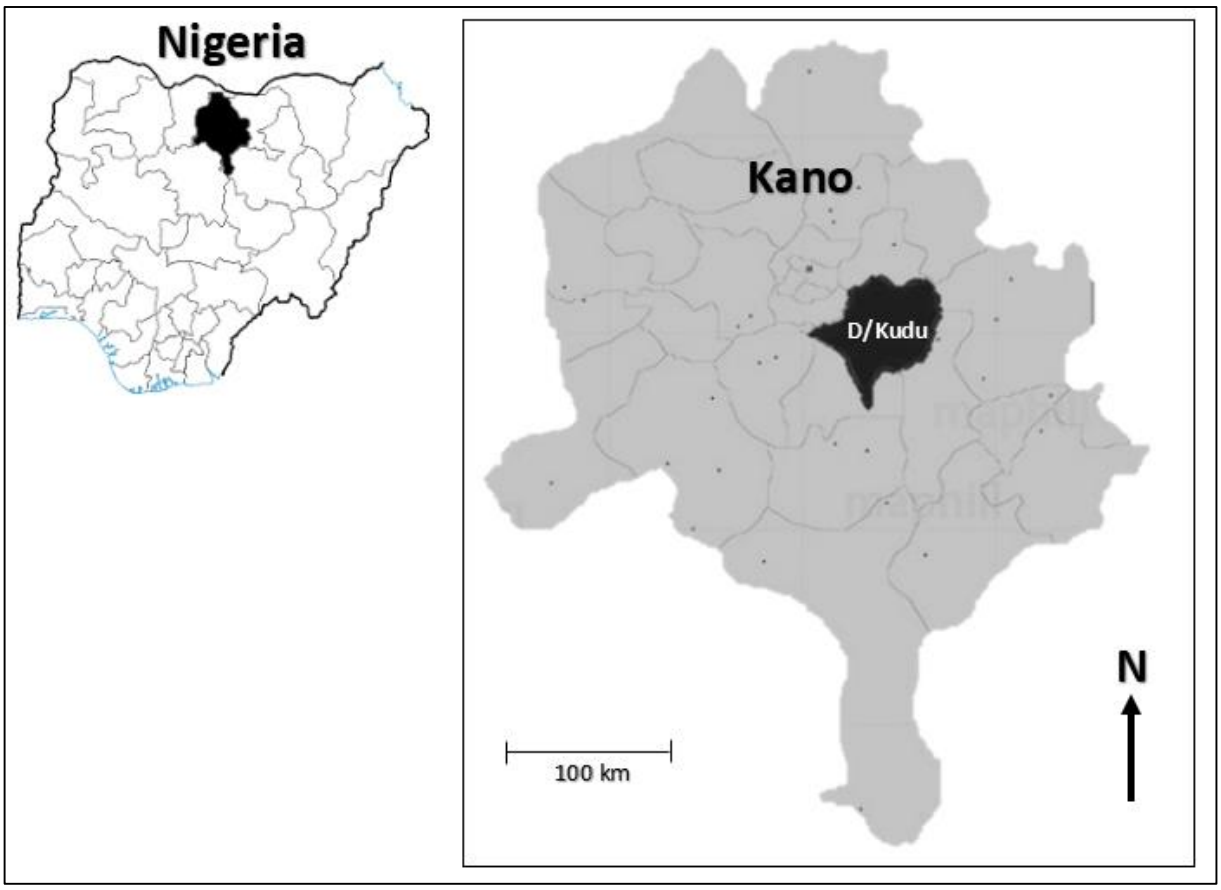

Fig. 1. A map showing the donkeys sampling/study area in D/Kudu Local Government area of Kano State.

Age determination, phenotypic and morphometric measurements

A total of 144 male donkeys (two years and above) were randomly selected and used for this study. All donkeys in the study area were naturally feeding on natural pasture and grain stalks left after harvesting with no feed supplementation. Therefore, age criteria was used to select the animal. The number differences in sample number collected per age group were resulted from sample availability. Ages of donkeys were determined by comparing the appearance of unique dental features as described by Muylle et al. (1999). Coat colour was selected to determine the phenotypic characteristics of donkeys as described in Table 1. Morphometric parameters measured includes neck length (NL), ear length (EL), face length (FL), tail length (TL), height at wither (HW), chest circumference (CC) and body length (BL) as shown in Fig. 2. The measurements were carefully taken by following the previous research guides and protocols (Papa & Kume, 2012; Ljubodrag et al., 2015; Turke et al., 2016). Example, the height at wither was measured from vertical floor to between the shoulder, and tail length was measured from base tail to the end of caudal vertebrae. Also, chest circumference was measured as the circumference of thoracic cavity taken just behind the fore limbs, and the body length was measured as the distance between the points of rump to a point of shoulder.

Table 1. Names and colours of donkey breeds in Nigeria.

Names	Colour
Auraki	Rust or Red
Duni	Dark brown to black
Fari	Pale cream to white
Idabari	Grey to light-medium brown. Village donkeys

Source: Blench et al. (1990)

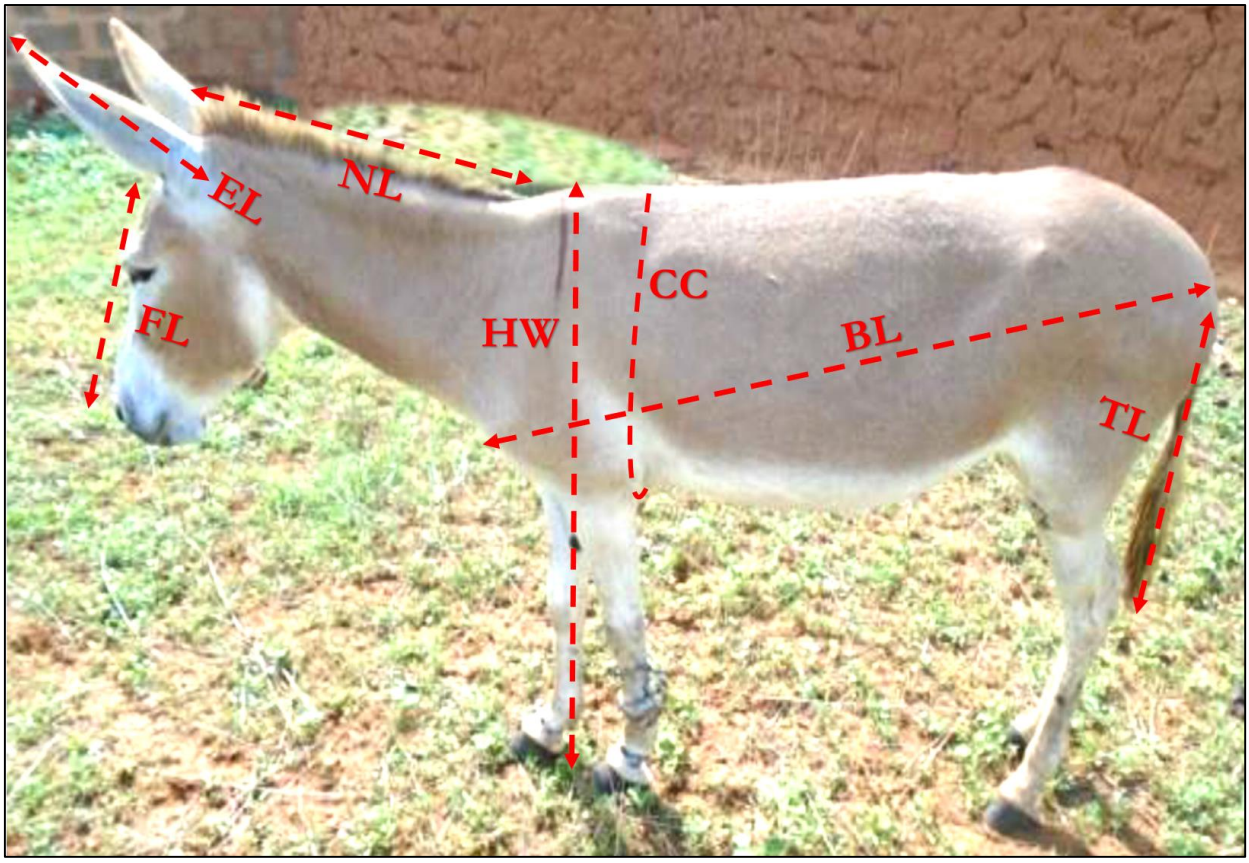

Fig. 2. Donkey morphometric parameters measured in D/Kudu includes neck length (NL), ear length (EL), face length (FL), tail length (TL), height at wither (HW), chest circumference (CC) and body length (BL). The coat colour of donkey is light grey (*Photo modified from* John, 2010).

All morphometric measurements were taking using measuring tape and recorded in centimetres (cm). During measurement, donkeys were standing upright on a flat surface to avoid any error in taking the measurement. Descriptive statistics was used to obtained frequencies and percentages of the coat colours and ages of the donkeys. The data was also subjected to analysis of variance (ANOVA) for age and coat colour versus body morphometric traits. Significantly different means were separated using Duncan multiple range test (DMRT). Correlation coefficient (r) was analysed between the morphometric traits. All statistical analysis were computed in SPSS software v.19.

RESULTS AND DISCUSSION

In Northwestern part of Nigeria, donkeys play a significant role in rural and urban societies like other livestock animals. Although, donkeys do not provide food for humans due to the religious and cultural beliefs, yet they make a major economic contribution to the region for transporting of goods, agricultural activities and income generation. Industrial revolution and donkey hide trading are major factors forcing the population of donkey to decline and probably lead to the species extinction. It has been proposed that providing information on morphometric and phenotypic characteristics of animal is essential for selective breeding database (Turke et al., 2016). Therefore, the main aim of current research was to determine the morphometric and phenotypic variation at different ages as well as estimating the correlation coefficient among measured traits of donkeys in D/Kudu Kano.

Donkeys distributions based on age and coat colour

Among 144 Kano male donkeys studied, donkeys with the age between 2-4 and 5-7 years were majority and highly observed with percentage distribution of 30.6% and 41.7%, respectively (Table 2). While donkeys above the age of 11 years were less observed with less than 10% distribution rate. Seven coat colours were identified, where light grey (30.6%) and light brown (16.7%) were the dominant colours, followed by dark grey and dark brown with other colours sharing the remaining percentage (Table 3).

Table 2. Frequency distribution and percentages age of donkeys in D/Kudu Kano State.

Age (years)	**Frequency** (n=144)	**Percentage** (%)
2-4	44	30.6
5-7	60	41.7
8-10	28	19.4
11-above	12	08.3

Table 3. Frequency distribution and percentages coat colour of donkeys in D/Kudu Kano State.

Coat colour *(Phenotype)*	**Frequency** (n=144)	**Percentage** (%)
Black	16	11.1
Dark grey	20	13.9
Light grey	44	30.6
Dark brown	20	13.9
Light brown	24	16.7
White with brown	12	08.3
White	08	05.5

Survey findings showed that the coat colour was diverse with a predominance of light grey followed by dark grey and light brown each. Four strains of donkeys (rust or red "*Auraki*", dark brown to black "*Duni*", pale cream to white "*Fari*" and grey to light medium brown "*Idabari*") were previously characterized based on their coat colour in Northwest Nigeria (Starkey & Fielding, 2004). Highest coat colours observed in this study resembled *Idabari* strain. *Idabari* were reported to be a popular among donkeys' strain in Northern Nigeria. People preference to raise them might be due their high market price value compared to other strains (Blench et al., 1995; Starkey & Fielding, 2004). Blench et al. (1995) added that *Idabari* has a stronger body that can carry heavier loads than other strains. Similarly, high percentage of *Idabari* (86%) with lower observation on remaining strains in the past researches across all North-western Nigeria States were also reported (Starkey & Fielding, 2004; John et al., 2017). Brown + white strain observed could be resulted from crosses between *Duni* and *Fari* strains. In addition, brown coat colour was predominant (46%) followed by grey (19%) in Algerian donkeys' research conducted in Kabylie area (Ayad et al., 2019). This study suggested that abundance of brown coat colour donkeys in Kabylie area might be due to their good performance and ability to walk across the mountain which is a typical nature of the study area.

Donkey morphometric

Table 4 provides detailed statistics of the morphological parameters including mean, standard error of means (SEM), coefficient of variation and minimum-maximum. The coefficient of variation for most morphometric traits measured were within the range of 3-7%. Relatively larger coefficient of variation (10%) was measured for average ear length (EL) which indicates a greater variability in terms of ear length. John et al. (2017) reported different values with the exception of tail length with a closer value of 57.8cm. Weaned donkeys used in the previous study was a major factor that create such differences as animal features are not fully matured. The tail of donkeys normally ceased to develop and reach its full maturity at early life stage of donkey which could be the reason for the similarities. Current results is in disagreement with the findings of Labbaci et al. (2018) as different breeds of donkey (dwarfs) were used in their study.

Table 4. Morphometric characteristics of donkey in D/Kudu Kano State.

Trait (*cm*)	**n**=144	**Means ± SEM**	**CV** (%)	**Min value**	**Max value**
Face length	144	44.0 ± 0.15	6.2	38.1	48.2
Neck length	144	31.1 ± 0.13	7.8	25.4	33.0
Ear length	144	26.7 ± 0.15	10.0	22.4	24.4
Tail length	144	60.7 ± 0.09	2.8	58.4	66.0
Height at Withers	144	102.4 ± 0.21	3.6	96.5	106.7
Chest Circumference	144	113.2 ± 0.41	6.3	99.0	121.9
Body Length	144	64.0 ± 0.16	4.5	55.9	71.1

Where, CV= Coefficient of variation, n = total number of samples

Effect of age and coat colour on measured quantitative traits of donkey

The result indicated that age has a significant effect ($P < 0.01$) on face length (FL), ear length (EL), chest circumference (CC) and body length (BL) as shown in Table 5 below. However, no significant ($P < 0.01$) effect observed on neck length (NL), tail length (TL) and height at withers (HW). Similarly, coat colour also showed a significant effect ($P < 0.01$) on face length (FL), ear length (EL), chest circumference (CC) and body length (BL) with other traits remained non-significant (Table 6).

Table 5. Effect of age on measured morphometric traits of donkey

Parameters	**FL**	**NL**	**EL**	**TL**	**HW**	**CC**	**BL**	**n** = (144)
***Age* (Years)**								
2-4	43.65	31.01	26.40	61.16	102.46	112.75	63.75	44
5-7	43.90	31.01	26.62	60.60	102.48	112.87	63.93	60
8-10	43.91	31.23	26.62	60.60	102.61	112.90	64.08	28
11-above	45.94	31.55	28.33	60.82	102.97	118.21	65.60	12
Test of significance	**	NS	**	NS	NS	**	**	
SEM	0.060	0.070	0.073	0.029	0.030	0.061	0.044	

** Significance ($P < 0.01$); NS = Non –significance; SEM = Standard error of means

Table 6. Effect of coat colour on measured morphometric traits of donkey

Parameters	**FL**	**NL**	**EL**	**TL**	**HW**	**CC**	**BL**	**n** = (144)
Coat colour								
Black	44.70	31.90	27.15	60.50	103.12	115.73	64.36	16
Dark grey	44.01	31.82	26.61	60.80	102.38	113.53	63.85	20
Light grey	43.71	31.41	26.36	60.60	101.93	112.21	63.88	44
Dark brown	43.35	31.11	26.31	60.78	101.93	111.78	63.37	20
Light brown	44.52	31.21	27.10	60.60	102.46	114.78	64.97	24
White + Brown	44.52	30.78	27.33	61.34	102.56	114.68	64.66	12
White	45.72	30.48	28.52	60.55	112.94	114.04	66.21	8
Test of significance	**	NS	**	NS	NS	**	**	
SEM	0.060	0.070	0.073	0.029	0.030	0.061	0.044	

** Significance ($P < 0.01$); NS = Non –significance; SEM = Standard error of means

Our findings revealed both age and coat colour have a significant difference on the same body parameters i.e. FL, EL, CC and BL. This might be due to the fact that physiological development continues as the animal age is progressing, hence resulted in phenotypic changes and morphological development (Ayad et al., 2019). No significant different on NL, TL and HW was also observed, it is assumed that some morphological traits reach their peak developmental stage at certain age and stop developing. Our findings were similarly obtained from previous results of various researches on donkey strains from different parts of Africa (Kaboré, 2014; Roamba,

2014; Nininahazwe et al., 2017; John et al., 2017; Labbaci et al., 2018; Ayad et al., 2019). Wilson (1981) reported that there are little physical differences in donkeys found across Africa.

Correlation between morphometric traits of donkeys

The result of the current study showed the measured traits were significant ($P < 0.01$) and positively correlated ($r = 0.43–0.91$) except for most tail length (TL) relationship that showed significant ($P < 0.01$) and negatively correlated (Table 7). In addition, tail length (TL) and ear length (EL) are negatively correlated, thus, it is non-significant (- 0.07).

Table 7: Morphometric correlation coefficient (r) between measured traits of donkey

Traits	FL	NL	EL	TL	HW	CC	BL
Face length (FL)		0.60*	0.91*	-0.25*	0.60*	0.91*	0.88*
Neck Length (NL)			0.43*	-0.77*	0.66*	0.46*	0.65*
Ear Length (EL)				-0.07	0.43*	0.85*	0.85*
Tail Length (TL)					-0.50*	-0.13*	-0.33*
Height at wither (HW)						0.64*	0.54*
Chest circumference (CC)							0.77*
Body length (BL)							

* Significance ($P < 0.01$)

Results obtained from the correlation analysis between measured traits of donkeys were strong and positively correlated ($P < 0.01$), similar to many studies (Sobotková & Jiskrová, 2015; Daloum et al., 2015; John et al., 2017; Ayad et al., 2019). High correlations observed between FL versus EL, CC & BL were similarly reported in Hassawi Donkey of Eastern Province in Saudi Arabia (Turke et al., 2016). Chest circumference (CC) was found to be more reliable and easier to measure compared to umbilical circumference that might be influenced by several factors such as moment of consumption, quantity of food and physiological state of animal (De Aluja et al., 2005). Furthermore, negative correlation seen between tail length (TL) and other parameters is a clear indication that tail reach its maximum development stage at early age in donkeys (probably < 2 years).

CONCLUSION

This is a first study focused on corporal observations of the phenotypic and morphometric characterization of donkeys in D/Kudu region of Kano state. Our findings suggested that donkeys in this region are of different coat colour. Age and coat colour were found to be suitable and useful parameters to detect changes in certain morphological characteristics of donkeys. These findings are preliminary data for a better understanding of the genetic variability of equines which would be useful for genetic enhancement. Meanwhile, further studies on the molecular genetic characterisation would help in better understanding and identification of donkey breeds in Kano.

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