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INFLUENCE OF QUALITATIVE TRAITS ON ZOOMETRIC CHARACTERISTICS OF DONKEYS IN NORTH WEST NIGERIA

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ABSTRACT
Qualitative and zoometrical traits were used to determine the relationship among Red (Auraki), Black (Duni), White (Fari), Brown (Idabari) and Brown-white (Idabari-fari) donkeys at different ages. A total of 700 donkeys were used for the study. Zoometric measures taken were body weight, head length, head width, ear length, neck length, neck circumference, shoulder width, height at withers, heart girth, body length and tail length. The qualitative data were collected on hair type, skin colour, skin type, coat colour pattern, tail shape, eye colour and head profile. Data obtained were subjected to statistical analysis system (SAS) to determine the distribution of phenotypic traits. Analysis of variance were used to determine the effect of various qualitative factors on zoometric indices. Significant variations were observed between qualitative ($P<0.01$) and zoometric ($P<0.01$) traits of donkeys. The results of the study showed that the short-smooth hair type, brown coat colour, thick skin type, solid coat colour pattern, high-set tail shape, brown eye colour and straight head profile were preponderant in the studied population. The adult body size measures of donkeys in Northwestern Nigeria were body weight (149.3kg), Body length (108.6cm), Heart girth (118.0cm), Height at withers (111.6cm), Shoulder width (24.0cm), Neck circumference (63.0cm), Neck length (52.0cm), Head length (47.4cm), Head width (16.0cm), Ear length (26.0cm) and Tail length (60.0cm). The qualitative and zoometric differences existed among the observed strains of donkeys in the Northwestern Nigeria. Further studies should be carried out for determination of diversity that exists among strains of donkeys in Nigeria.

Keywords: Qualitative traits, Zoometric characteristics, Donkeys, Nigeria.

INTRODUCTION

Characterization of animal genetic resource (AnGR) encompasses all activities associated with the identification, quantitative and qualitative description of breed populations and the natural habitat and production systems to which they are or not adapted. The domestic donkey, *Equus asinus*, belongs to the horse family, *Equidae* and descended from the wild African ass (*Equus africanus*) in north-eastern Africa. The population of donkeys is on the increase in Africa, and the animals are increasingly becoming important in transportation of farm produce (Blench, 2004a). The use of donkeys as draught animals in rural areas has improved considerably the involvement of small-scale farmers in the market economy (Fernando and Starkey, 2004; Starkey and Starkey, 2004). In Nigeria about 16,000 donkeys are transported yearly from the Northern states to the Southern part of the country for meat (Blench, 2004b). They also provide greater mobility with which to face erratic rainfalls and are used for carrying firewood, loads, including water, house-hold structures, goods and children (Marshall and Weissbrod, 2011). Presently, donkeys are used in the production of milk for children, who are allergic to bovine milk (Caldin *et al*., 2005). Even in urban areas, donkeys are used by people for small scale transport services such as transportation of building materials and food items (grains) in particular in the Northern part of the country. Most of the literature from Nigeria focused on the use of donkey as draught animals (Mohammed, 2000).

Body size and shape measured objectively could improve selection for growth by enabling the breeder to recognize early maturing and late maturing animals of different sizes. Measurement of various body conformations are of value in judging quantitative characteristics of meat animals and are also helpful in developing suitable selection criteria. Body measurements have been used to evaluate breed performance and to characterize animals. In addition, they have been used as a means of selecting replacement animals (Sowande and Sobola 2008). There are four major strains of donkeys in North West Nigeria which are clearly identified by coat colours, that is, Auraki (Rust or red), Duni (Dark brown to black), Fari (Pale cream to white), and Idabari (Grey to light medium brown) (Blench *et al*., 1990; Starkey and Fielding, 2004). The coat colour is sometimes used as a determining factor for the price of a donkey in most parts of North West Nigeria (Blench *et al*., 1990). Idabari strain is the most popular donkey variety among the smallholder farmers and was reported to cost higher than the other types (Blench *et al*., 1990). Generally, coat colour was the

bases for classifying donkeys into strains in Northwest Nigeria. The knowledge of qualitative and zoometric body measurements of donkeys could be exploited to aid adequate management and production of donkeys. Qualitative and zoometric phenotypic differentiations exist among the observed strains of donkeys in the Northwestern Nigeria. This study is purposed to establish the linkages between qualitative and zoometric characteristics of donkeys in Northwest Nigeria.

MATERIALS AND METHODS

Experimental location

The field research was conducted in the semi-arid zone of Nigeria in Sokoto, Jigawa, Kano, Katsina, Kaduna, Zamfara and Kebbi States respectively. These States in North West Nigeria were selected because of existence of high population of donkeys. All the three senatorial zones in each of the seven States were covered in this study. The semi-arid zone of Nigeria starts from about 11ºN latitude and ends at the Nigeria-Niger frontier. It encompasses the Sudan Savanna, Sahel Savanna and part of the Northern Guinea Savanna. The mean annual temperature runs between 26 and 28ºC. There is a single rainy season from May to October, with mean annual rainfall ranging from 1016mm in the wettest parts to less than 508mm in the driest parts. The length of growing period is about 100-150 days which makes it possible to cultivate a wide variety of crops (Ogungbile *et al*., 1998). The semi-arid zone has a land mass of 113,530km^2 and a population of over 35 million people (NPC, 2006). This part of Nigeria has very low level of infrastructure i.e. roads which render it difficult for the people to have access to both rural and urban markets. The major inhabitants of this area are Hausa and Fulani who are predominantly mixed crop-livestock farmers and livestock herders respectively.

Sampling size and sampling structure

A random sampling method was used to choose the experimental animals. A total of seven hundred (700) donkeys were used for this study. Thirty-three (33) donkeys were randomly selected from two senatorial zones and thirty-four (34) were also selected randomly in the third zone in all the states making a total of one hundred (100) donkeys comprising of weaners, young and adults males and females in almost equal number.

Ages of donkeys were determined by using teeth count in combination with the information provided by the donkey owners.

Phenotypic characterization

Body measurements of seven hundred (700) donkeys of various strains were taken for phenotypic characterization. The qualitative traits were determined using visual observation while the zoometric traits were measured using a flexible measuring tape.

Qualitative (morphological) measurement

The qualitative characters that were observed on each animal include: hair type (HT), skin type (ST), coat colour (CC), coat colour pattern (CCP), tail shape (TS), eye colour (EC) and head profile (HP). Reference marks for qualitative traits observation according to the method of John *et al*. (2017) was adopted.

Hair Type: This was observed and categorized into Short-Smooth, Short-Rough and Long-Curly (woolly) hair types

Coat Colour Pattern: This was observed and categorized as solid and patched.

Skin Type: This was observed and categorized as thick and thin.

Coat colour: This was observed and categorized as rust or red, dark brown to black, pale cream to white and grey to light medium brown

Tail shape: This was observed and categorized as pendent and high-set.

Eye colour: This was observed and categorized as black, brown and white.

Head profile: This was observed and categorized as sub-concave and straight.

Zoometric (morphometric) measurements

Flexible measuring tape was used to take the body measurement. During body measurement, animals were made to stand upright and restrained by assistants in such a way that their necks, heads and ears were stretched almost in a straight line. Each measurement was taken for at least two times and recorded to the nearest centimeter. Reference marks for body measurement according to the method of Searle *et al*., (1989a and b), and Salako (2006a) was adopted.

Body Weight (BWT): This was determined using prediction equation (kg)

Head Length (HL): Measured as the distance from between the ears to the upper lip (cm).

Head Width (HDW): Measured as the distance between the outer ends of both eyes (cm).

Ear length (EL): Measured as the distance from the base to the zygomatic arch of the ear (cm).

Neck length (NL): Measured as the distance from the base of the cervical vertebra to the base of the top shoulder (cm).

Neck circumference (NC): Taken as the circumference of the neck at the midpoint (cm).

Shoulder width (SW): Measured as the horizontal distance between the two shoulders or distance between the lateral tuberisities of the humeri which is also described as the widest point over the intraspinus muscle (cm).

Height at Wither (HW): Vertical distance from ground to the point of withers (measured vertically from the ridge between the shoulder bones to the fore hoof in cm).

Heart girth (HG): Measured as the circumference of the body at the narrowest point just behind the shoulder perpendicular to the circumference of the body, just in front of the hind leg perpendicular to the body axis (cm).

Body length (BL): Distance between points of shoulder to point of hip i.e. the distance from the first thoracic vertebrae to base of tail. This is also described as the distance between the most cranial palpable spinosus process of thoracic vertebrae and either sciatic tubers or distance between the tops of the pelvic bone (cm).

Tail length (TL): Measured from the base of the tail to the tip (cm).

Weights of the donkeys were measured using prediction equation that were generated elsewhere (John and Iyiola-Tunji, 2019).

Statistical analysis

General Linear Model procedure of SAS (2004) statistical package was used to analyze the effect of qualitative and age categories as shown in the model below:

$Y_{ijk} = \mu + A_i + Q_j + \varepsilon_{ijk}$

Where Y_{ijk}=observation of each trait of the ijth Animal.

μ= population mean

A_i= effect of the ith age groups (weaner, young and adult)

Q_j= effect of jth qualitative traits of donkeys (hair type, skin type, coat colour pattern, tail shape, eye colour and head profile)

ε_{ijk}= residual error associated with each record ($\varepsilon \sim N(0, \sigma^2)$).

Cluster analysis

Cluster analysis of qualitative traits of donkeys using UPGMA was used for clustering of the strains using dendrogram in order to determine the relatedness among donkey strains for coat colour, hair type, skin type, coat colour pattern, tail shape, eye colour and head profile.

Distances were used to construct a dendrogram using the unweighted pairs group method analysis implemented in R 2.13.0 (R Development Core Team, 2015) package TREE procedure that prints the Dendrogram based on the distances between the clusters introduced in PROC CLUSTER procedure. Scatter diagram for visual interpretation of different groups of qualitative traits were also generated during the cluster analysis.

RESULTS AND DISCUSSION

Hair type significantly ($P<0.01$) affected the morphometric traits of weaner, young and adult donkeys (Table 1). All the traits (body weight and linear body measurements) of weaner donkeys were significantly ($P<0.001$) affected by hair type. Generally, donkeys with short-smooth hair type were superior for all the biometric traits measured than short-rough and long-curly types. The BWT (117.62±4.58kg), HL (40.69±0.45cm), NL (39.19±0.42cm), NC (50.71±0.53cm) and TL (46.75±0.99cm) for short-smooth hair type were similar to that of short-rough. Weaner donkeys with short-smooth hair type had the widest HWD (12.67±0.16cm) while the smallest HWD (11.89±0.19cm) was recorded in weaner donkeys with long-curly hair type. Longest EL (23.18±0.12cm) was observed in weaner donkeys with short-curly hair type. The broadest SW (18.25) was obtained in donkeys with short-smooth whereas the smallest SW (16.22±0.34cm) was obtained in long-curly hair type donkeys. The highest HW (94.59±0.54cm) was obtained in short-smooth hair type. However, the shortest HW (89.95±0.64cm) was obtained from long-curly hair type. Largest HG (97.11±0.77cm) was recorded in short-smooth hair type donkeys while the smallest HG (89.97±0.93cm) was recorded in long-curly hair type. Longest BL (94.51±0.77cm) was recorded in short-smooth hair type. However, shortest BL (87.95±0.93cm) was recorded in weaner donkeys with long-curly hair type.

Young donkeys were significantly ($P<0.01$) affected by hair type. All the traits (body weight and linear body measurements) of young donkeys were also affected by hair type except HWD. The young donkeys with long-curly hair type had high value for HL (47.50±1.90cm), HWD (14.00±0.90cm), NL (46.00±2.10cm), NC (58.50±3.11cm), SW (22.00±1.92cm), BL (103.00±2.89cm), and TL (57.00±5.50cm) compared to short-smooth and long-curly hair type. The NC (58.50±3.11cm) was similar to that of short and smooth hair type. Heaviest BWT (115.23±0.79kg) was recorded in short-smooth hair type while the small BWT was recorded in short-rough (113.15±2.57kg) and long-curly (112.14±7.69kg) hair type. Longest HL (47.50±1.90cm) was observed in young donkeys with long-curly hair type. However, short HL was observed in short-rough (45.28±0.63cm) and short-smooth hair type. Young donkeys with the longest EL (24.18±0.08cm) was observed in short-smooth hair type. Shortest EL (22.50±0.79cm) was observed in young donkeys with long-curly hair type. Longest NL (47.00±2.10cm) was obtained in long-curly hair type while the shortest NL (43.50±0.70cm) was obtained in short-rough hair type. Broader SW (22.00±1.92cm) was recorded in long-curly hair type whereas the narrowest SW (20.22±0.64cm) was recorded in short-rough hair type. The highest HW (100.23±0.21cm) was observed in young donkeys with short-smooth hair type while least HW (97.00±2.00cm) was observed in long-curly hair type. Largest HG (105.18±0.29cm) was obtained in young donkeys with short-smooth hair type whereas the smallest HG (102.00±2.92cm) was obtained in donkeys with long-curly hair type. Longest BL (103.00±2.89cm) was obtained in long-curly hair type. Shortest BL (100.17±0.96cm) was obtained in short-rough hair type. The longest TL (57.00±5.50cm) was recorded in young donkeys with long-curly hair type. However, the shortest TL (49.67±1.83cm) was recorded in short-rough hair type donkeys.

Adult donkeys with long-curly hair type recorded high values for HL (47.57±0.49), NC (63.79±1.19), SW (24.00±0.67), HG (112.71±1.15), BL (107.29±1.03), TL (59.29±1.82) compared to short-rough and short-smooth hair type. The HL (47.50±1.90cm) and SW (24.00±0.67), were similar to those of short-rough hair type. Widest HWD (15.29±0.27cm) was obtained in short-rough hair type whereas the smallest HWD (14.79±0.27cm) was obtained in long-curly hair type. Adult donkeys with short-rough hair type recorded the longest EL (25.21±0.24cm) while shortest EL (24.86±0.24cm) was recorded in long-curly hair type. Donkeys with short-rough hair type recorded the longest NL (47.79±0.64cm). The short NL were observed in long-curly (46.71±0.64cm) and short-rough (46.83±0.15cm). Long and curly hair type donkeys recorded the widest NC (63.79±1.19cm) while the smallest NC (62.07±1.19cm) was recorded in short-rough hair type. Largest HG (112.71±1.15cm) was observed in long-curly hair type donkeys whereas the least HG (109.79±1.15) was observed in

short-smooth hair type. Adult donkeys with long-curly hair type recorded the longest BL (107.29±1.03cm). Shortest BL (105.86±1.03cm) was recorded in short-rough hair type. The longest TL (59.29±1.82cm) was recorded in long-curly hair type. However, adult donkeys with short-rough hair type recorded the shortest TL (56.79±1.82cm). The result of this study for hair type in weaner donkeys agreed with the report of Yakubu *et al*, (2010) who reported the occurrence of short-smooth hair type over short-rough and long-curly hair type. This is similar with the results obtained in weaner donkeys, but at variance with the results obtained in young and adult donkeys. The differences observed among the hair types might be attributed to the differences in age categories or the sampling method used. This implies that the propensity towards smooth hair structure could be an advantage as it provides a medium for conventional heat loss from the animal body surface from the tropical environment. This is supported by the assertion that hair structures have an important role to play in the adaptability of animals to different ecological zones (Banerji, 1984).

Table 1. Effect of hair type on morphometric traits of weaner, young and adult donkeys

Age group/traits	Long - curly	Short - rough	Short - smooth	LOS
Weaner				
Body weight (kg)	106.6±5.49^{b}	116.9±5.19^{a}	117.6±4.58^{a}	**
Head length (cm)	38.3±0.55^{b}	40.4±0.51^{a}	40.6±0.45^{a}	**
Head width (cm)	11.8±0.19^{c}	12.2±0.19^{b}	12.6±0.16^{a}	**
Ear length (cm)	22.5±0.14^{c}	22.8±0.14^{b}	23.1±0.12^{a}	**
Neck length (cm)	37.3±0.51^{b}	39.0±0.48^{a}	39.1±0.42^{a}	**
Neck circumference (cm)	47.7±0.64^{b}	51.1±0.60^{a}	50.7±0.53^{a}	**
Shoulder width (cm)	16.2±0.34^{c}	17.5±0.32^{b}	18.2±0.28^{a}	**
Height at withers (cm)	89.9±0.64^{c}	93.1±0.61^{b}	94.5±0.54^{a}	**
Heart girth (cm)	89.9±0.93^{c}	94.6±0.88^{b}	97.1±0.77^{a}	**
Body length (cm)	87.9±0.93^{c}	92.3±0.88^{b}	94.5±0.77^{a}	**
Tail length (cm)	44.1±1.13^{b}	46.2±1.13^{a}	46.7±0.99^{a}	**
Young				
Body weight (kg)	112.1±7.69^{b}	113.1±2.57^{b}	115.2±0.79^{a}	**
Head length (cm)	47.5±1.90^{a}	45.2±0.63^{b}	45.2±0.19^{b}	**
Head width (cm)	14.0±0.90	13.8±0.30	13.8±0.09	NS
Ear length (cm)	22.5±0.79^{c}	24.0±0.27^{b}	24.1±0.08^{a}	**
Neck length (cm)	47.0±2.10^{a}	43.5±0.70^{c}	44.1±0.22^{b}	**
Neck circumference (cm)	58.5±3.11^{a}	59.0±1.04^{a}	57.6±0.32^{b}	**
Shoulder width (cm)	22.0±1.92^{a}	20.2±0.64^{c}	20.7±0.19^{b}	**
Height at withers (cm)	97.0±2.00^{c}	99.5±0.67^{b}	100.2±0.21^{a}	**
Heart girth (cm)	102.0±2.92^{c}	104.1±0.97^{b}	105.1±0.29^{a}	**
Body length (cm)	103.0±2.89^{a}	100.1±0.96^{c}	102.0±0.29^{b}	**
Tail length (cm)	57.0±5.50^{a}	49.6±1.83^{c}	53.0±0.56^{b}	**
Adult				
Body weight (kg)	142.8±26.95	134.8±26.95	143.02±6.35	NS
Head length (cm)	47.5±0.49^{a}	47.6±0.49^{a}	47.3±0.12^{b}	**
Head width (cm)	14.7±0.27^{c}	15.2±0.27^{a}	15.0±0.06^{b}	**
Ear length (cm)	24.8±0.24^{c}	25.2±0.24^{a}	25.0±0.06^{b}	**
Neck length (cm)	46.7±0.64^{b}	47.7±0.64^{a}	46.8±0.15^{b}	**
Neck circumference (cm)	63.7±1.19^{a}	62.0±1.19^{c}	62.6±0.28^{b}	**
Shoulder width (cm)	24.0±0.67^{a}	24.0±0.67^{a}	22.7±0.16^{b}	**
Height at withers (cm)	104.5±20.78	103.3±20.78	111.2±4.89	NS
Heart girth (cm)	112.7±1.15^{a}	109.7±1.15^{c}	111.0±0.27^{b}	**
Body length (cm)	107.2±1.03^{a}	105.8±1.03^{c}	106.6±0.24^{b}	**
Tail length (cm)	59.2±1.82^{a}	56.7±1.82^{c}	57.7±0.43^{b}	**

BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, NS: Non-significant difference at (P>0.05), SEM= Standard Error of Mean, LOS= Level of significance, ^{abc}Means with different superscripts along same row shows significant differences **P<0.01.

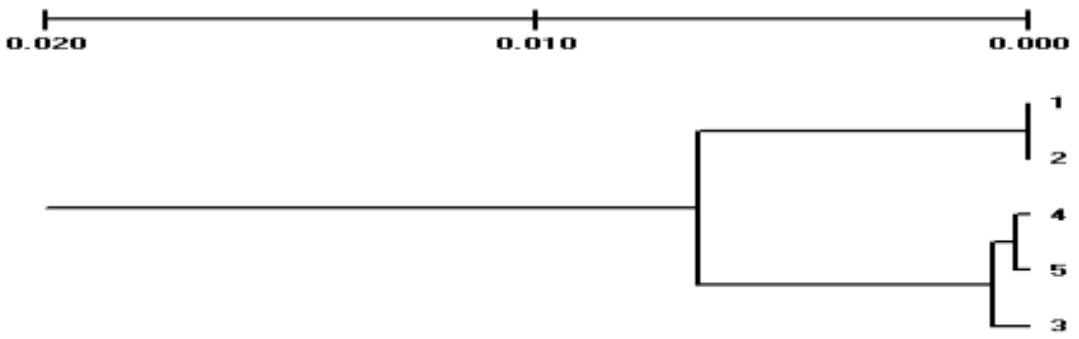

Fig. 1: Dendrogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Hair type.

Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

In figure 1, the node containing group 1 (Auraki) and 2 (Duni) were farther from node containing 4 (Idabari), 5 (Idabari-fari) and 3 (Fari) for hair type, indicating that Auraki and Duni are closer and similar for hair type but distant from Idabari, Idabari-fari and Fari.

The effect of skin type on morphometric traits of weaner, young and adult donkeys are shown in Table 2. Skin type of weaner donkey significantly (P<0.001) affected shoulder width (SW), height at withers (HW), heart girth (HG), body length (BL) and tail length (TL). Other morphometric traits were however not significantly (P>0.05) affected by skin type. Thick skin type had high value for SW (17.78±0.28cm), HW (93.57±0.54cm), HG (95.44±0.79cm) and BL (92.83±0.79cm). Widest SW (17.78±0.28cm) was observed in thick skin type while the smallest SW (17.21±0.25cm) was observed in thin skin type. Highest HW (93.57±0.54cm) was observed in weaner donkeys with thick skin type. The lowest HW (92.24±0.19cm) was obtained in thin skin type. Weaner donkeys with the thick skin type had the largest HG (95.44±0.79cm) with thin skin type being the least (93.46±0.71cm). Weaner donkeys with thick skin type recorded the longest BL (92.83±0.79cm) whereas the shortest BL (91.34±0.69cm) was recorded in thin skin type. Longest TL (46.95±0.85cm) was obtained in weaner donkeys with thin skin type. However, the shortest TL (44.51±0.94cm) was obtained in weaner donkeys with thick skin type.

Skin type of young donkeys significantly (P<0.01) affected body weight (BWT), head length (HL), head width (HWD), shoulder width (SW), height at withers (HW), heart girth (HG) and tail length (TL). Other morphometric traits were however not significantly affected. Thick skin type had higher values for BWT (115.20±0.78kg), HL (45.28±0.19cm), HW (100.25±0.20cm), HG (105.12±0.29cm) and TL (52.85±0.56cm). Young donkeys with thick skin type recorded the heaviest BWT (115.20±0.78cm) while thin skin type recorded the least BWT (112.94±2.63kg). Longest HL (45.28±0.19cm) was recorded in donkeys with thick skin type whereas the least HL (45.06±0.65cm) was recorded in thin skin type. The thin skin type donkeys had the widest HWD (15.59±0.31cm) than thick skin type (13.88±0.09cm). Longest EL (24.19±0.08cm) was observed in young donkeys with thick skin type whereas thin skin type recorded the least EL (23.65±0.27cm). The SW (22.00±0.65cm) of thin skin type was broader than the ones with thick skin (20.65±0.19cm). The values of the HW (100.25±0.20cm), HG (105.12±0.29) and TL (52.85±0.56cm) of thick skin type were higher than the HW (98.94±0.69cm), HG (104.35±1.00cm) and TL (52.35±1.90cm) of young donkeys with thin skin type.

Skin type of adult donkeys significantly (P<0.01) affected head length (HL), head width (HWD), shoulder width (SW), heart girth (HG) and body length (BL). Other morphometric traits were however not significantly (P>0.05) affected. Thin skin type had higher values for HL (47.82±0.29cm), HWD (15.18±0.16cm) and SW (24.10±0.39cm) compared to the HL (47.30±0.12cm), HWD (14.98±0.06cm) and SW (22.63±0.16cm) of adult donkeys with thick skin type. The values of HG (111.12±0.28cm) and BL (106.75±0.25cm) obtained in thick skin type donkeys were higher compare to the HG (110.46±0.69cm) and BL (105.85±0.61cm) of adult donkeys with thin skin type. The results of this study in weaner, young and adult donkeys for skin type agreed with the findings of John *et al*., 2017 who reported that the occurrence of thick skin type is three times higher than thin skin type. Donkeys with thick skin type predominated, which were associated with brown colour (465) while the thin skin type was the least, which was associated in brown-white donkeys (John *et al*., 2017). The differences observed between the skin types might be attributed to the effect of age or management practices of donkeys.

Table 2. Effect of skin type on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**			**Young**			**Adult**		
Traits	Thick	Thin	LOS	Thick	Thin	LOS	Thick	Thin	LOS
BWT(kg)	113.4±4.39	115.0±3.92	NS	115.2±0.78	112.9±2.63^{b}	**	143.6±6.48	136.2±16.12	NS
HL(cm)	40.1±0.44	39.7±0.39	NS	45.2±0.19^{a}	45.0±0.65^{b}	**	47.3±0.12^{b}	47.8±0.29^{a}	**
HWD(cm)	12.3±0.16	12.3±0.14	NS	13.8±0.09^{b}	15.5±0.31^{a}	**	14.9±0.06^{b}	15.1±0.16^{a}	**
EL(cm)	23.0±0.12	22.8±0.10	NS	24.1±0.08^{a}	23.6±0.27^{b}	**	25.0±0.06	25.0±0.15	NS
NL(cm)	38.8±0.41	38.4±0.38	NS	44.0±0.21	44.1±0.72	NS	46.9±0.15	46.6±0.38	NS
NC(cm)	50.0±0.53	49.9±0.47	NS	57.7±0.32	57.8±1.07	NS	62.5±0.29	62.9±0.72	NS
SW(cm)	17.7±0.28^{a}	17.2±0.25^{b}	**	20.6±0.19^{b}	22.0±0.65^{a}	**	22.6±0.16^{b}	24.1±0.39^{a}	**
HW(cm)	93.5±0.54^{a}	92.2±0.49^{b}	**	100.2±0.20^{a}	98.9±0.69^{b}	**	111.6±4.99	103.7±12.42	NS
HG(cm)	95.4±0.79^{a}	93.4±0.71^{b}	**	105.1±0.29^{a}	104.3±1.00^{b}	**	111.1±0.28^{a}	110.4±0.69^{b}	**
BL(cm)	92.8±0.79^{a}	91.3±0.69^{b}	**	101.9±0.29	101.4±0.99	NS	106.7±0.25^{a}	105.8±0.61^{b}	**
TL(cm)	44.5±0.94^{b}	46.9±0.85^{a}	**	52.8±0.56^{a}	52.3±1.90^{b}	**	57.8±0.44	57.3±1.09	NS

BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, NS: Non-significant difference at (P>0.05), SEM= Standard Error Mean, LOS= Level of significance, ^{ab}Means with different superscripts along same row shows significant differences **P<0.01.

Influence of coat colour pattern on morphometric traits of weaner, young and adult donkeys are presented in Table 3. All the biometric traits of weaner donkeys were significantly affected (P<0.01) body weight, head length, head width, neck length, neck circumference, shoulder width, height at withers, heart girth and body length. Other morphometric traits were however not affected (P>0.05). Weaner donkeys with solid coat colour pattern were superior in terms of BWT (114.92±2.91kg), HL (39.98±0.29cm), HWD (12.34±0.11cm), NC (50.05±0.35cm), SW (17.49±0.19cm), HW (92.89±0.36cm), HG (94.44±0.53cm) and BL (92.12±0.52cm) compared to BWT (52.25±29.64cm), HL (36.50±3.02cm), HWD (10.50±1.08cm), EL (23.00±0.79cm), NL (37.00±2.82cm), NC (45.50±3.59cm), SW (15.00±1.91cm), HW (86.50±3.72cm), HG (83.50±5.39cm) and BL (80.00±5.31cm) of weaner donkeys with patches.

Influence of coat colour pattern on morphometric traits of adult donkeys was significant (P<0.01) on head length (HL), head width (HWD), ear length (EL), neck length (NL), neck circumference (NC), shoulder width (SW), heart girth (HG), body length (BL) and tail length (TL). Other morphometric traits were not affected (P>0.05). Adult donkeys with patches were superior in terms of HWD (16.00±1.01cm), EL (26.00±0.91cm), NL (52.00±2.37cm) HG (115.00±4.33cm), BL (108.00±3.85cm) and TL (60.00±6.81cm) compared to HWD (15.01±0.06cm), EL (25.00±0.05cm), NL (46.85±0.14cm), HG (111.02±0.26cm), BL (106.62±0.23cm) and TL (60.00±6.81cm) in donkeys with solid coat colour pattern. Adult donkeys with solid pattern were superior in terms of HL (47.38±0.11cm), NC (62.67±0.27cm) and SW (22.86±0.15cm) compared to HL (46.00±1.86cm), NC (57.00±4.46cm) and SW (17.00±2.49cm) of donkeys with patches. Donkeys with solid coat colour pattern (brown) were superior to the ones with patches except in some few animals sampled. This is similar to the findings of (Blench *et al*, 1990) who reported high occurrence of donkeys with solid coat colour pattern over patches. This is similar with the findings of (John *et al*., 2017) revealed that donkeys with solid coat colour (93%) predominated compared to the ones with patches (3%). Contrary to the findings of Birteeb and Lomo (2015) who reported that Coat colour had no influence on anybody measurements in the flock under study. The differences observed in the coat colour variations might be attributed to the territorial distribution, nature of the sampling techniques employed or genetic constitution of donkeys.

Table 3. Influence of coat colour pattern on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**			**Young**			**Adults**		
Traits	Solid	Patches	LOS	Solid	Patches	LOS	Solid	Patches	LOS
BWT(kg)	114.9±2.91^{a}	52.2±29.64^{b}	**	115.0±0.75	-	-	142.5±6.03^{a}	147.3±100.67	NS
HL(cm)	39.9±0.29^{a}	36.5±3.02^{b}	**	45.2±0.19	-	-	47.3±0.11^{a}	46.0±1.86^{b}	**
HWD(cm)	12.3±0.11^{a}	10.5±1.08^{b}	**	13.8±0.09	-	-	15.0±0.06^{b}	16.0±1.01^{a}	**
EL(cm)	22.9±0.08	23.0±0.79	NS	24.1±0.08	-	-	25.0±0.05^{b}	26.0±0.91^{a}	**
NL(cm)	38.6±0.28^{a}	37.0±2.82^{b}	**	44.0±0.20	-	-	46.8±0.14^{b}	52.0±2.37^{a}	**
NC(cm)	50.0±0.35^{a}	45.5±3.59^{b}	**	57.7±0.30	-	-	62.6±0.27^{a}	57.0±4.46^{b}	**
SW(cm)	17.4±0.19^{a}	15.0±1.91^{b}	**	20.7±0.19	-	-	22.8±0.15^{a}	17.0±2.49^{b}	**
HW(cm)	92.8±0.36^{a}	86.5±3.72^{b}	**	100.1±0.19	-	-	110.5±4.65	107.0±77.63	NS
HG(cm)	94.4±0.53^{a}	83.5±5.39^{b}	**	105.0±0.29	-	-	111.0±0.26^{b}	115.0±4.33^{a}	**
BL(cm)	92.1±0.52^{a}	80.0±5.31^{b}	**	101.9±0.28	-	-	106.6±0.23^{b}	108.0±3.85^{a}	**
TL(cm)	45.8±0.64	45.5±6.53	NS	52.8±0.54	-	-	57.7±0.41^{b}	60.0±6.81^{a}	**

BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, ******P<0.01, NS: Non-significant difference at (P>0.05), SEM= Standard Error Mean, LOS= Level of significance, ^{ab}Means with different superscripts along same row shows significant differences ******P<0.01.

The influence of tail shape on morphometric traits of weaner, young and adult donkeys are shown in Table 4. Tail shape of weaner donkeys affected (P<0.01) all the linear body measurements. Weaner donkeys with high-set tail shape were superior in terms of BWT (120.39±6.03kg HL (41.12±0.60cm), HWD (12.69±0.22cm), EL (23.22±0.16cm), NL (39.51±0.57cm), NC (51.35±0.72cm), SW (18.51±0.38cm), HW (94.69±0.74cm) HG (93.69±0.60cm), BL (94.18±1.07cm) and TL (48.61±1.30cm) compared to the pendent tail shape of weaner donkeys.

Tail shape of young donkeys significantly affected (P<0.01) head length (HL), head width (HWD), neck length (NL), neck circumference (NC), shoulder width (SW) and tail length (TL). Other morphometric traits were however not affected (P>0.05). Y oung donkeys with high-set tail shape were superior in terms of HL (45.67±0.25cm), HWD (14.06±0.12cm), NL (44.32±0.28cm), NC (58.19±0.42cm), SW (21.17±0.26cm) and TL (55.12±0.71cm) compared to the young donkeys with pendent tail shape.

Body weight and linear body measurements head width (HWD), ear length (EL), neck circumference (NC), heart girth (HG), and tail length (TL)of adult donkeys were significantly (P<0.01) affected. Other biometric traits were however not affected (P>0.05). Adult donkeys with high-set tail shape were superior in terms of BWT (149.35±8.52cm), HWD (15.09±0.09cm), EL (25.11±0.08cm), NC (62.94±0.38cm), HG (111.47±0.37cm), and TL (58.74±0.57cm) than adult donkeys with pendent tail shape. The results of this study is similar with the findings of John and Iyiola-Tunji, 2019) who reported significant effects of tail shape on body weight and body linear measurements of donkeys in Northwest Nigeria. Similar study carried out by (John *et al*., 2017) revealed that donkeys with high-set tail shape predominated compared to pendent tail shape. The significant effects of tail shape of donkeys on body weight and body linear measurements of donkeys observed in this study might be due to the differences in sizes, growth or body linear traits. The preponderant of donkeys with high-set tail shape over pendent tail shape might be attributed to the genetic constitution of the animals or nature of the sampling techniques adapted.

Table 4. Influence of tail shape on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**			**Young**			**Adult**		
Traits	Pendent	High-set	LOS	Pendent	High-set	LOS	Pendent	High-set	LOS
BWT(kg)	112.4±3.33^{b}	120.3±6.03^{a}	**	114.8±1.08	115.1±1.04	NS	135.9±8.46^{b}	149.3±8.52^{a}	**
HL(cm)	39.5±0.33^{b}	41.1±0.60^{a}	**	44.7±0.26^{b}	45.6±0.25^{a}	**	47.4±0.16	47.3±0.16	NS
HWD(cm)	12.2±0.12^{b}	12.6±0.22^{a}	**	13.6±0.12^{b}	14.0±0.12^{a}	**	14.9±0.08^{b}	15.0±0.09^{a}	**
EL(cm)	22.8±0.09^{b}	23.2±0.16^{a}	**	24.0±0.11	24.2±0.11	NS	24.9±0.08^{b}	25.1±0.08^{a}	**
NL(cm)	38.3±0.31^{b}	39.5±0.57^{a}	**	43.8±0.29^{b}	44.3±0.28^{a}	**	46.7±0.20	46.9±0.20	NS
NC(cm)	49.6±0.39^{b}	51.3±0.72^{a}	**	57.2±0.44^{b}	58.1±0.42^{a}	**	62.3±0.38^{b}	62.9±0.38^{a}	**
SW(cm)	17.1±0.21^{b}	18.5±0.38^{a}	**	20.3±0.27^{b}	21.1±0.26^{a}	**	22.9±0.21	22.7±0.21	NS
HW(cm)	92.2±0.41^{b}	94.6±0.74^{a}	**	99.9±0.28	100.3±0.27	NS	110.0±6.54	110.0±6.58	NS
HG(cm)	93.6±0.60^{b}	96.4±1.09^{a}	**	105.0±0.41	105.1±0.39	NS	110.6±0.36^{b}	111.4±0.37^{a}	**
BL(cm)	91.3±0.59^{b}	94.1±1.07^{a}	**	101.8±0.41	102.0±0.39	NS	106.4±0.32	106.7±0.33	NS
TL(cm)	45.0±0.72^{b}	48.6±1.30^{a}	**	50.3±0.74^{b}	55.1±0.71^{a}	**	56.8±0.57^{b}	58.7±0.57^{a}	**

BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, NS: Non-significant difference at (P>0.05), SEM= Standard Error of Mean, LOS= Level of significance, ^{ab}Means with different superscripts along same row shows significant differences ******P<0.01.

Influence of eye colour on morphometric traits of weaner, young and adults donkeys are reflected in Table 5. Influence of eye colour on the linear body measurements of weaner donkeys were significantly affected (P<0.01) body weight (BWT), head width (HWD), neck length (NL), shoulder width (SW) and body length (BL). Other biometric traits were not affected (P>0.05). Black eyed donkeys recorded the heaviest BWT (115.01±2.96kg) than brown eyed (94.59±15.95cm) ones. Widest HWD (12.86±0.58cm) were observed in brown eyed donkeys with the least HWD (12.30±0.11cm) in black eyed ones. Longest NL (38.69±0.28cm) was obtained in black eye donkeys with the short NL (37.43±1.50cm) in brown eyed weaner donkeys. Wider SW (17.86±1.02cm) were observed in brown eyed with the least SW (17.45±0.19cm) in black eyed donkeys. Brown eyed donkeys recorded the longest BL (92.10±0.53cm) with the short BL (89.00±2.87cm) in brown eyed weaner donkeys.

Influence of eye colour on biometric traits of young donkeys affected (P<0.001) BWT, HWD, NL, NC and HG while the other biometric traits were however not affected (P>0.05). BWT (117.07±3.84cm), HWD (14.38±0.45cm), NL (45.00±1.05cm), NC (58.50±1.56cm) and HG (105.88±1.46cm) of young donkeys with brown coloured eyes were superior to black coloured eyes.

The eye colour of adult donkeys affected (P<0.01) all the linear body measurements except body weight (P>0.05). Longer head length was obtained in black eye (47.36±0.11cm) and brown eye (47.86±0.49cm) with the shortest head length (45.00±1.85cm) being recorded in white eye. Widest HWD (15.14±0.27cm) was observed in brown eyed adult donkeys with the smallest HWD (14.00±1.01cm) in white eye. White donkeys recorded the longest EL (26.00±0.19cm) while the shortest EL (24.86±0.24cm) was recorded in black eyed donkeys. Longest NL (52.00±2.37cm) was observed in white with short NL in brown (46.71±0.63cm) and black (46.86±0.15cm) eyed donkeys. The neck circumference and shoulder width in black eyed was similar to brown eyed donkeys. Brown eyed adult donkeys had the highest HW (168.00±20.48cm) while the shortest HW (101.00±76.63cm) was recorded in white adult donkeys. Longest BL (110.00±3.85cm) was obtained in white whereas the shortest BL (106.00±1.03cm) was in brown. Black eyed adult donkeys recorded the longest TL (57.86±0.42cm). However, the shortest TL (52.00±6.81cm) was recorded in white eyed donkeys. High level of occurrence of donkeys with black eye was observed in weaner, brown eye in young and; equal proportions of black and brown eyes in adult donkeys. The results of this study is similar with the work of John *et al*. (2017) who reported that donkeys with black and brown eyes had high level of occurrence in Idabari donkey strains compared to those with white eyes.

Table 5. Influence of eye colour on morphometric traits of weaner, young and adult donkeys

Age group/Traits	Black	Brown	White	LOS
Weaner				
Body weight (kg)	115.0±2.96[a]	94.5±15.95[b]	-	**
Head length (cm)	39.9±0.30	39.5±1.62	-	NS
Head width (cm)	12.3±0.11[b]	12.8±0.58[a]	-	**
Ear length (cm)	22.9±0.08	23.0±0.43	-	NS
Neck length (cm)	38.6±0.28[a]	37.4±1.50[b]	-	**
Neck circumference (cm)	50.0±0.36	50.0±1.92	-	NS
Shoulder width (cm)	17.4±0.19[b]	17.8±1.02[a]	-	**
Height at withers (cm)	92.8±0.37	92.4±2.00	-	NS
Heart girth (cm)	94.3±0.54	93.8±2.91	-	NS
Body length (cm)	92.1±0.53[a]	89.0±2.87[b]	-	**
Tail length (cm)	45.8±0.65	47.0±3.49	-	NS
Young				
Body weight (kg)	114.94±0.77[b]	117.07±3.84[a]	-	**
Head length (cm)	45.25±0.19	45.50±0.95	-	NS
Head width (cm)	13.84±0.09[b]	14.38±0.45[a]	-	**
Ear length (cm)	24.15±0.08	24.25±0.40	-	NS
Neck length (cm)	44.04±0.21[b]	45.00±1.05[a]	-	**
Neck circumference (cm)	57.73±0.31[b]	58.50±1.56[a]	-	**
Shoulder width (cm)	20.75±0.19	20.88±0.96	-	NS
Height at withers (cm)	100.15±0.20	99.88±1.01	-	NS
Heart girth (cm)	105.03±0.29[b]	105.88±1.46[a]	-	**
Body length (cm)	101.93±0.29	101.88±1.46	-	NS
Tail length (cm)	52.78±0.55	53.63±2.77	-	NS
Adult				
Body weight (kg)	143.1±6.19	133.7±26.95	131.1±100.83	NS
Head length (cm)	47.3±0.11[a]	47.8±0.49[a]	45.0±1.85[b]	**
Head width (cm)	15.0±0.06[b]	15.1±0.27[a]	14.0±1.01[c]	**
Ear length (cm)	25.0±0.06[b]	24.8±0.24[c]	26.0±0.91[a]	**
Neck length (cm)	46.8±0.15[b]	46.7±0.63[b]	52.0±2.37[a]	**
Neck circumference (cm)	62.6±0.27[a]	63.0±1.19[a]	55.0±4.45[b]	**
Shoulder width (cm)	22.8±0.15[a]	22.9±0.67[a]	18.0±2.51[b]	**
Height at withers (cm)	107.5±4.71[b]	168.0±20.48[a]	101.0±76.63[c]	**
Heart girth (cm)	111.0±0.27[a]	110.0±1.16[b]	111.0±4.34[a]	**
Body length (cm)	106.6±0.24[b]	106.0±1.03[c]	110.0±3.85[a]	**
Tail length (cm)	57.8±0.42[a]	56.9±1.82[b]	52.0±6.81[c]	**

BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, NS: Non-significant difference at (P>0.05), SEM= Standard Error of Mean, LOS= Level of significance, [abc]Means with different superscripts along same row shows significant differences **P<0.01.

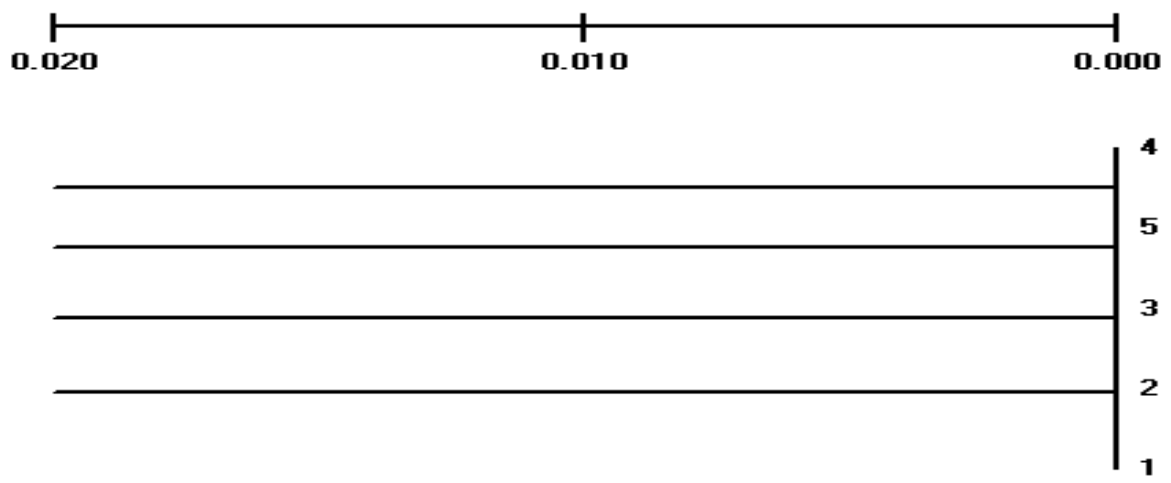

Fig. 2: Dendrogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Eye colour.
Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

In figure 2, the node containing 1. 2, 3, 5 and 4 are similar and closer to one another. For head profile, 1 (Auraki), 2 (Duni) 3 (Fari) 5 (Idabari-fari) and 4 (Idabari) are also similar and closer to one another

Influence of head profile on morphometric traits of weaner, young and adult donkeys are presented in Table 6. The head profile of weaner donkeys significantly affected (P<0.01) head length (HL), head width (HWD), ear length (EL), neck circumference (NC), shoulder width (SW), height at withers (HW) and body length (BL). However, other morphometric traits were not affected (P>0.05). Weaner donkeys with straight head profile were superior in terms of HL (40.15±0.36cm), HWD (12.44±0.13cm), EL (23.02±0.09cm), NC (50.41±0.43cm), SW (17.66±0.23cm), HW (93.54±0.44cm) and BL (92.98±0.63cm) compared to weaner donkeys with sub-concave head profile.

Head profile of young donkeys significantly affected (P<0.01) body weight (BWT), head length (HL), neck length (NL), neck circumference (NC), shoulder width (SW), height at withers (HW), heart girth (HG), body length (BL) and tail length (TL) with other morphometric traits not affected (P>0.05). BWT (121.82±4.08kg), HL (46.43±1.01cm), NL (46.57±1.11cm), NC (60.71±1.65cm), SW (21.57±1.02cm), HW (101.57±1.07cm), HG (108.57±1.55cm), BL (103.29±1.55cm) and TL (55.00±2.96cm) of young donkeys with sub-concave head profile were superior to those of young donkeys with straight head profile.

Head profile of adult donkeys significantly affected (P<0.01) shoulder width other linear body measurement were not affected (P>0.05). Adult donkeys with sub-concave head profile recorded the widest SW (23.40±0.56cm) while narrow SW (22.79±0.16cm) was recorded in adult donkeys with straight head profile. The results of this study are in consonant with the report of John *et al.* (2017) who revealed that head profile of donkeys would more often than not be straight (83-88%) with moderate occurrence of sub-concave type (11-16%). John *et al.* (2018) reported significant effect of head profile on zoometric characteristics of donkeys. The differences observed between the head profile of donkey might be due to their genetic constitution.

Table 6. Influence of head profile on morphometric traits of weaner, young and adult donkeys

Age group	**Weaner**			**Young**			**Adult**		
Traits	Straight	Sub-concave	LOS	Straight	Sub-concave	LOS	Straight	Sub-concave	LOS
BWT(kg)	111.5±3.58	115.7±5.06	NS	114.7±0.76^{b}	121.8±4.08^{a}	**	142.9±6.24	138.1±22.51	NS
HL(cm)	40.1±0.36^{a}	39.5±0.51^{b}	**	45.2±0.19^{b}	46.4±1.01^{a}	**	47.3±0.12	47.5±0.42	NS
HWD(cm)	12.4±0.13^{a}	12.0±0.18^{b}	**	13.8±0.09	14.0±0.48	NS	15.0±0.06	15.0±0.23	NS
EL(cm)	23.0±0.09^{a}	22.7±0.13^{b}	**	24.1±0.08	24.1±0.43	NS	25.0±0.06	24.9±0.20	NS
NL(cm)	38.7±0.34^{a}	38.4±0.48^{a}	NS	43.9±0.21^{b}	46.5±1.11^{a}	**	46.8±0.15	46.5±0.53	NS
NC(cm)	50.4±0.43^{a}	49.2±0.60^{b}	**	57.6±0.31^{b}	60.7±1.65^{a}	**	62.6±0.28	62.4±0.99	NS
SW(cm)	17.6±0.23^{a}	17.0±0.32^{b}	**	20.7±0.19^{b}	21.5±1.02^{a}	**	22.7±0.16^{b}	23.4±0.56^{a}	**
HW(cm)	93.5±0.44^{a}	91.4±0.62^{b}	**	100.0±0.19^{b}	101.5±1.07^{a}	**	110.9±4.81	104.2±17.35	NS
HG(cm)	95.5±0.63^{a}	91.8±0.89^{a}	**	104.9±0.29^{b}	108.5±1.55^{a}	**	111.0±0.27	110.8±0.97	NS
BL(cm)	92.9±0.63^{a}	90.0±0.89^{b}	**	101.8±0.29^{b}	103.2±1.55^{a}	**	106.5±0.34	106.9±0.86	NS
TL(cm)	46.1±0.78	45.2±1.10	NS	52.7±0.55^{b}	55.0±2.96^{a}	**	57.7±0.42	58.5±1.52	NS

BWT: Body weight; HL: Head length; HWD: Head width; EL: Ear length; NL: Neck length; NC: Neck circumference; SW: Shoulder width; HW: Height at withers; HG: Heart girth; BL: Body length; TL: Tail length, NS: Non-significant difference at (P>0.05), SEM= Standard Error of Mean, LOS= Level of significance, ^{ab}Means with different superscripts along same row shows significant differences **P<0.01.

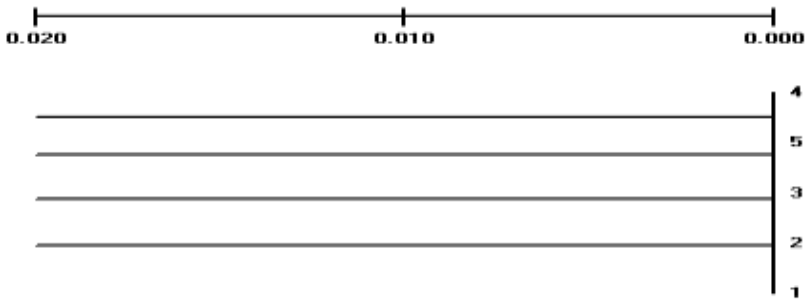

Fig. 3: Dendrogram showing relationship among Auraki, Duni, Fari, Idabari and Idabari-fari for Head profile.
Key 1: Red (Auraki); 2: Black (Duni); 3: White (Fari); 4: Brown (Idabari); and 5: Brown-white (Idabari-fari).

In figure 3, the head profile for 1 (Auraki), 2 (Duni) 3 (Fari) 5 (Idabari-fari) and 4 (Idabari) are also similar and closer to one another.

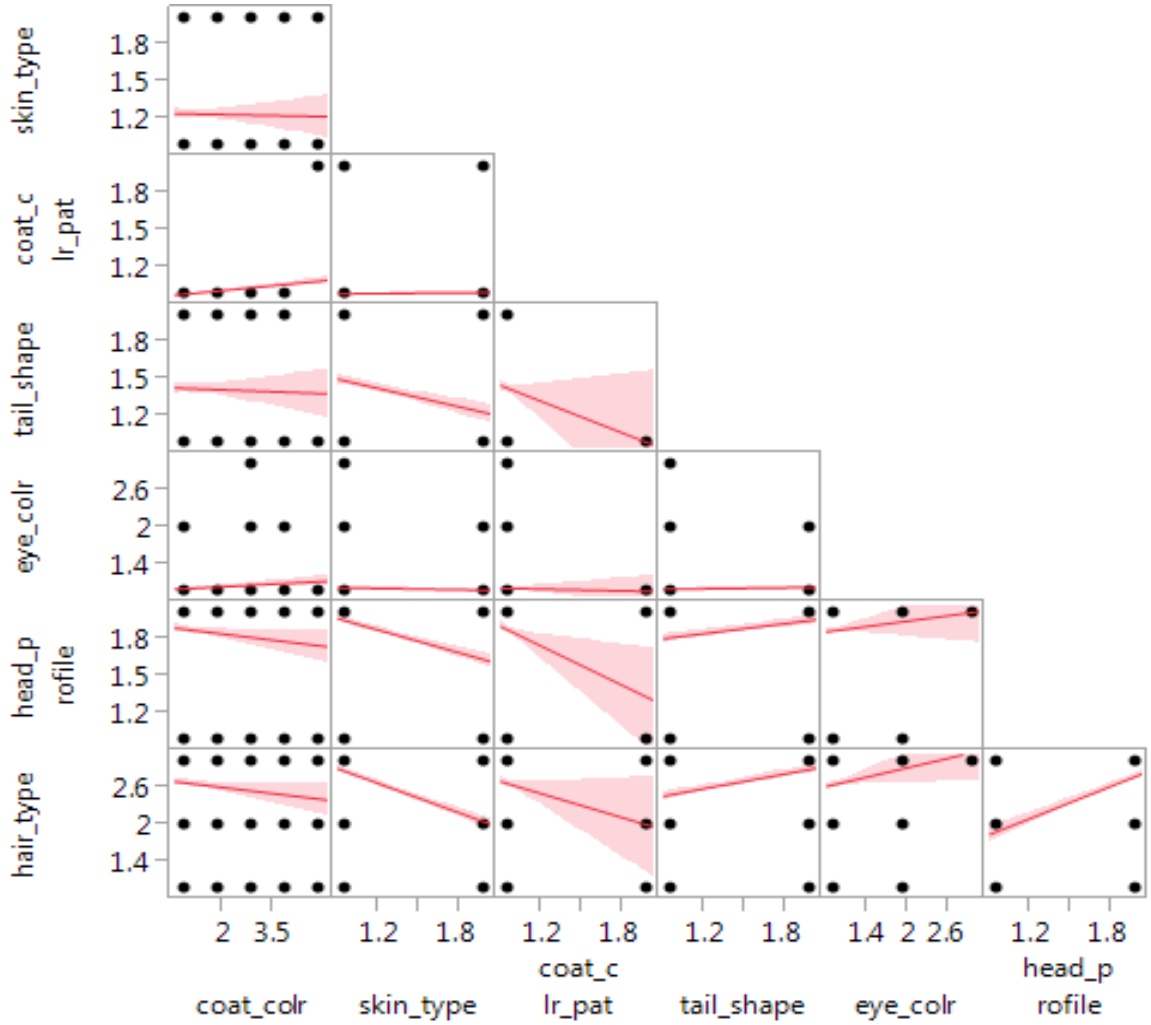

Fig. 4: Correlated relationships among qualitative traits of donkeys. Skin type had positive and high correlations with tail shape, head profile and hair type but negatively correlated with coat colour pattern which implies that all the qualitative traits are under the influence of similar gene action.

CONCLUSION AND RECOMMENDATION

The zoometric traits of adult body size measures of donkeys in Northwestern Nigeria revealed significant variations among body weight (149.3kg), body length (108.6cm), heart girth (118.0cm), height at withers (111.6cm), shoulder width (24.0cm), neck circumference (63.0cm), neck length (52.0cm), head length (47.4cm), head width (16.0cm), ear length (26.0cm) and tail length (60.0cm).

Qualitative traits of donkeys such as short-smooth hair type, brown coat colour, thick skin type, solid coat colour pattern, high-set tail shape, brown eye colour and straight head profile across the age categories of weaner, young and adult donkeys were preponderant in the studied population.

Further investigation should be carried out for determination of genetic diversity that exists among strains of donkeys in Nigeria using molecular studies.

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