



## **Phenotypic Characterization of Camels (*Camelus dromedarius*) in Selected Herds of Katsina State**

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### **Authors' contributions**

*This work was carried out in collaboration between all authors. Author GT designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors DSG and PAA managed the analyses of the study. Author PAA managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

The aim of this study was to characterize and identify dromedary in selected herds of Katsina state of Nigeria to which selection can be applied for improvement of body weights. Phenotypic data of 111 mature camels (48 camel bulls and 63 camel cows) within age range 4 to 9 years were obtained from three herds (Daura, Mani and Mashi) in Katsina state of Nigeria. Camels were grouped into 4-6 and 7-9 years to take body linear measurements and body weight. At 4-6 years, neck length, height at withers, hump length, hump circumference, body length, abdominal circumference, footpad circumference tail length and body weight among camel bulls varied ( $P < 0.05$ ) across herds; Daura herd had the highest body weights. Neck length, width of the shoulder, height at withers anterior limb length and body weight showed significant ( $P < 0.05$ ) variation among camel cows. Mani herd had the highest body weights. At 7-9 years, distance between the eyes, neck length, height at withers, anterior limb length, height at hump, hump length, hump circumference and hump height, body length, tail length and body weight among camel bull was significant ( $P < 0.05$ ). Mashi and Mani measured higher with similar body weights. Neck length, height at withers, anterior limb length, thoracic girth, body length, abdominal circumference,

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posterior limb length, and body weight varied significantly ( $P<0.05$ ) across herds. Mashi herd had the highest body weights. There were similar morphological features in the three herds: straight, convex face profile; erect ears and hump orientation; dominant coat colours were: grey, brown and white. Because of the heavily built body of the Katsina camels, they are also called Arabi or packed camels.

**Keywords:** Camels; body linear measurements; body weights; herd; description; classification.

## 1. INTRODUCTION

The total population of dromedary in Nigeria according to Food and Agricultural Organization statistics FAOSTAT [1] is 20,500 heads of camel. These animals are found in the northern states of Nigeria. Camels play important role in the economy of these states. The northern states of Nigeria where *Camelus dromedarius* (one hump camel) are found include: Borno, Yobe, Jigawa, Kano, Katsina, Kebbi, Sokoto and Zamfara James - Rugu and Jidayi, [2,3]. According to Timothy et al. [4], 80% of the total populations of the camels in Nigeria are found in Sokoto state, Katsina state, Kano state, and Borno state which cover a combined area of 70, 714 km<sup>2</sup> and are desert gateways with important camel trade.

According to Raymod [5] camels, horses, mules and donkey belong to domestic animals referred to as beast of burden among which camel is capable of doing many functions competently. Camels are important livestock species that contributes significantly to the livelihood of the pastoralists and agro-pastoralists in the fragile environments of the desert and semi-desert of Africa and Asia [6]. Abdussamad et al. [7] reported that the functions of camels around the Nigerian-Niger corridor include milk for household consumption, meat, and cash from sale of camels, transport, culture, and draught power, hump fat for cooking, social security, and skin for leather.

Despite camel's considerable contribution to food security in semi-arid and arid regions as compared to other domestic animals, study on camel production system, phenotypic and genetic characterization is scanty [8] and there is dearth of information on camel production potential and production systems for genetic improvement in Nigeria. This information is required for the design of appropriate selection and breeding strategy for utilization and improvement of the potential of camel genetic resources. Given the current importance of camels in contributing to the livelihoods of human populations in the arid land and semi-arid

regions of Nigeria, it can be explored for introduction into other zones to mitigate climate change impact.

The aim of this study was to characterize and identify dromedary in selected herds of Katsina state of Nigeria to which selection can be applied for improvement of body weights.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

The study was carried out in Katsina state situated within North western region of Nigeria, which lies on the tropical region of the world on latitude 12°59N/ longitude 7°36' E and latitude 12.983° N and 7.600° E of the Greenwich Meridian (GMT) with latitude of 182.82 to 457 meters above sea level. Most of the camels in Katsina state are owned by the nomads who resides in three Local Government Areas located in Northern Katsina State, they include: Daura(Sharawar Labo), Mashi(Gana Jigawa) and Mani(Shirinya). Daura lies on latitude 13°3N and longitude 8°32E; Mashi lies on latitude 12°98N and longitude 7°94E; Mani lies on latitude 12°98N and longitude 7°87E Google Map [9]. However, there are migrant camel owners within Dutsi Local Government Area but they stay there only during rainy season grazing on thorny shrubs.

### 2.2 Data Collection

A total number of 111 (48 camel bulls and 63 camel cows) mature camels were sampled through stratified random sampling from three herds (Daura-herd, Maani-herd, and Mashi-herd). Camel's age was determined by dentition and grouped into 4-6 and 7-9 years for body linear measurements.

Qualitative traits were evaluated in line Food and Agricultural Organization guideline FAO [10]. Traits evaluated include: face profile, ear size, ear orientation, body colour, colour pattern, hair type, hair length, hump size, hump location, hump orientation, udder size, and teat size.

Body weight and linear body measurements were taken using a specially designed tape (WEBO MALEBAND®). This tape is designed to take care of linear measurements in centimeters (cm), meters (m) and the approximate weight equivalents of animals like pigs, goats, sheep, cattle, camels, buffaloes. It is graduated from 0 meter to 2.26 meter (0-226 cm) for linear measurements and 30 kg to 880 kg for weight estimation. Body weights were measured by taking readings round the circumference of the chest girth or heart girth. Camels were measured in a standing position (Plate 1).

### 2.3 Statistical Analysis

Data collected were proofread against any mistake. The data were subjected to analysis of variance (ANOVA) and descriptive statistics using SPSS 21. An analysis was carried out

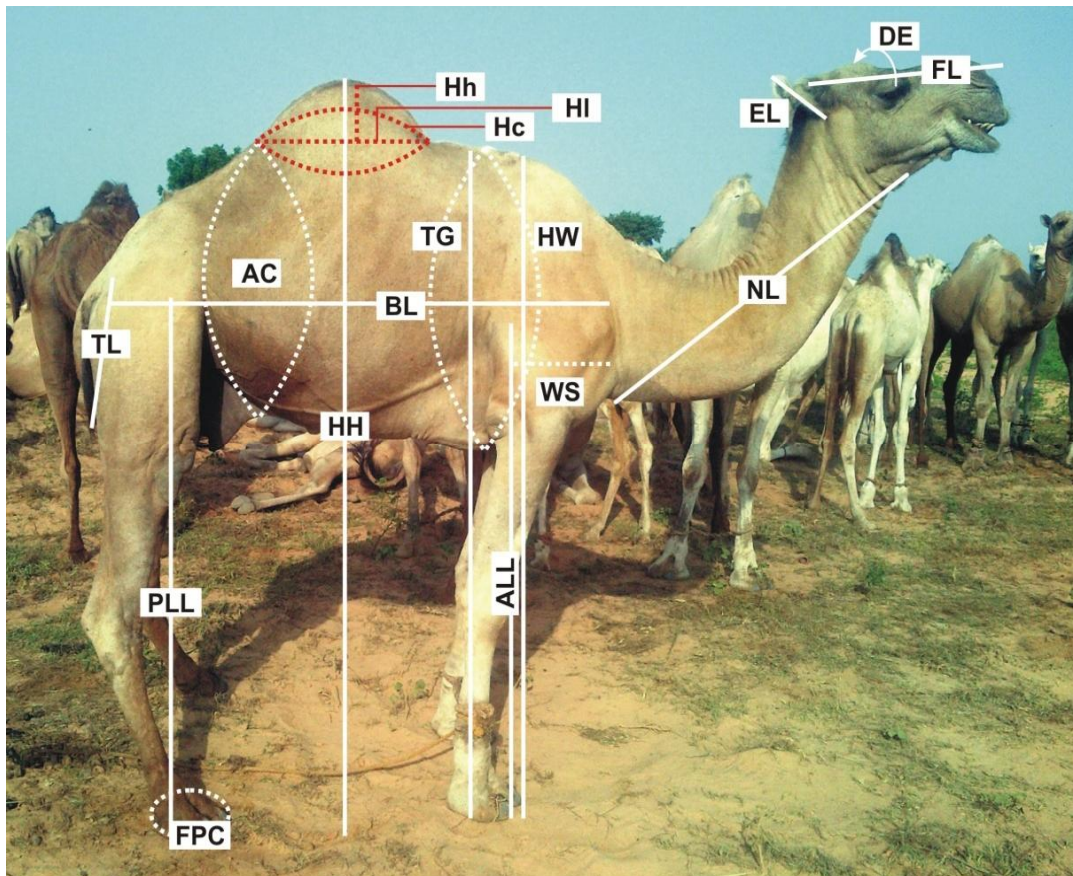
separately for male and female animals. The existence of significant differences among means was separated using Duncan's Multiple Range Test Duncan [11]. The probability used for determining level of significance was ( $P < 0.05$ ), treatment means with probability of ( $P > 0.05$ ) were not significant.

The model employed for estimation of body weights and linear body measurements (LBM) is:

$$Y_{jkl} = \mu + A_j + H_k + e_{jkl}$$

Where:

- $Y_{jkl}$  = observation of the  $l^{\text{th}}$  animal
- $\mu$  = overall mean
- $A_j$  = effect of  $j^{\text{th}}$  age groups
- $H_k$  = effect of  $k^{\text{th}}$  herd
- $e_{jkl}$  = random residual error



**Plate 1. Description of the various body measurements**

FL = face length, DE = distance between the eyes, EL = ear length, NL = neck length, WS = width at shoulders, HW = height at withers, ALL = anterior limb length, TG = thoracic girth, HH = height at hump, HI = hump length, Hc = hump circumference, Hh = hump height, BL = body length, AC = abdomen circumference, PLL = posterior limb length, FPC = foot pad circumference, TL = tail length and BW = body weight

### 3. RESULTS

#### 3.1 Qualitative Traits Description of Daura Camel Herds

The camels have straight to convex shaped face with small to medium ears. Body colours are grey, white, sand brown which are uniformly distributed throughout the body; their hair is glossy, sheen when looked upon, the hair is straight with lengths between 1-2 mm long. The Daura camels have small to medium size erect hump located in the middle of the back. The camel cows have well developed udder with rudimentary, medium-large size teats (Table 1). Figs 1, 2, 3 and 4 are pictures of camels Daura herd describing their years and body coat colour.

#### 3.2 Qualitative Traits Description of Mani Camel Herds

These camels have straight, convex shape face profile with medium sized erect upstanding ears. The dominant colour of camels seen around Mani is sand brown, grey and white which are uniformly distributed; the hair is glossy and straight though a few have curly hairs. The distribution of hair is throughout the body with hair length of 1-2 mm. They have medium sized hump with erect orientation middle to the back. The camel cows within this location have medium and large udder with medium sized teats (Table 1). Figs 5, 6, 7, are pictures of camels from Mani herd describing their years and body coat colour.

#### 3.3 Qualitative Traits Description of Mashi Camel Herds

Mashi camels have straight to convex face profile with erect and medium size ears. The dominant colour type is grey, grey-white, white, brown and dark-brown which are uniformly distributed throughout the whole body. The wool is found on the entire body, hair type is glossy and dull; some are straight while some are curly. Their hair length is medium (1-2 mm), while some are long (>2 mm) mostly found around the back region where the hump is located. These camels have medium and large erect humps located middle to the back. The camel cows have medium and large udders with medium to large teats (Table 1). Figs 9, 10, 11, and 12 are pictures of camels from Mashi herd describing their years and body coat colour.

#### 3.4 Phenotypic Characterization by Use of Quantitative Trait

At 4-6 years, neck length, height at withers, hump length, hump circumference, body length, abdominal circumference, footpad circumference tail length and body weight among camel bulls was significant ( $P < 0.05$ ) due to herd effect. The Daura herd had the highest body weight (Table 2) whereas neck length, width at shoulder, height at withers anterior limb length, height at hump and body weight showed significant variation ( $P < 0.05$ ) among camel cows. Mani had highest body weight followed by Mashi then Daura (Table 3).

Camel bulls at 7-9 years there was significant ( $P < 0.05$ ) differences on neck length, height at withers, anterior limb length, height at hump, the hump factor (hump length, hump circumference and hump height), body length, tail length and body weight. Mashi and Mani herd measured higher than the Daura camel bulls in body weight (Table 4). Whereas, neck length, height at withers, anterior limb length, thoracic girth, body length, abdominal circumference, posterior limb length, and body weight among camel cows varied significantly ( $P < 0.05$ ) due to herd effect. Mashi herd had the highest body weight followed by Mani then Daura herd (Table 5).

### 4. DISCUSSION

The result of this study showed that the three herds (Daura, Mani and Mashi) had some similar morphological characters which were: straight to convex face profile; erect ear and hump orientations, most of the dominant colours found in the three herds were: grey and white, however there were variations as Daura and Mani herd had sand-brown while Mashi herd had grey-white, brown and dark-brown coat colours which are uniformly distributed throughout the whole body. The existence of similar morphological features may be attributed to the fact that pastoralist was mostly involved in sharing of sire of the desired trait with those from other herds. This finding corroborates with the report of Berhanu [12] who reported the existence of similar morphological traits (grey, brown and yellow) among the Sudanese camel breeds.

Body measurements and body weights were used to study the effect of herd location on camel bulls and cows. There exist significant difference on: neck length, height at withers, hump length,

hump circumference, body length, abdominal circumference, footpad circumference tail length among camel bulls at 4-6 years; neck length, width at shoulder, height at withers anterior limb length, height at hump for their counterparts camel cows at the same age; agreed with the findings of Berhanu [12]. At 7-9 years, neck

length, height at withers, anterior limb length, height at hump, hump length, hump circumference and hump height, body length, tail length among camel bull varied significantly; on the other hand neck length, height at withers, anterior limb length, thoracic girth, body length, abdominal circumference, posterior limb length



**Fig. 1. 8 year sand- brown camel bull**



**Fig. 2. 9 year brown camel cow**



**Fig. 3. 6 year white camel cow and a calf**



**Fig. 4. 4 year sand-brown camel bull**



**Fig. 5. 9 year grey camel bull**



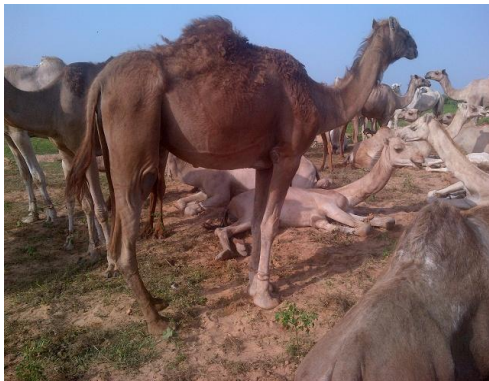
**Fig. 6. 7 year white camel cow**



**Fig. 7. 9 year sand-brow camel cow**



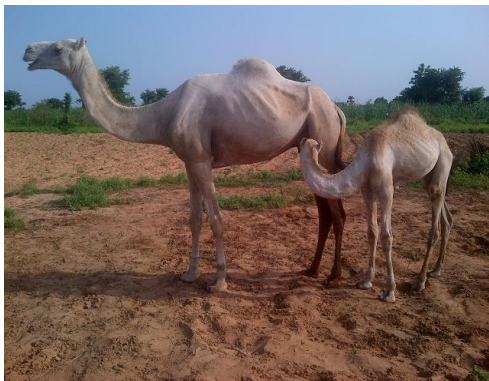
**Fig. 8. 8 year grey camel bull**



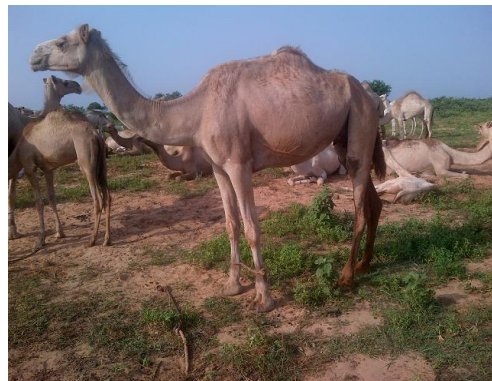
**Fig. 9. 8 year brown camel bull**



**Fig. 10. 9 year sand-brown camel cow**



**Fig. 11. 5 year white camel cow**



**Fig. 12. 4 year grey camel bull**

among camel cows varied significantly due to herd effect. The variation in neck length may be due to source of browse materials because the three herds practice the nomadic and trans-human system of management; variations notice on anterior limb and posterior limb length, height at hump, height at withers may be attributed to

work done, and transport work done by camels; other variations may be due to the camels genetic make-up and the interaction with its environment. This agrees with Ahmed et al. [13] who reported that phenotypes are also linked to geographical distribution as observed in other countries.

**Table 1. A summary of phenotypic (qualitative) descriptor for camels within selected population in Katsina state**

Qualitative traits	Daura	Mani	Mashi
Face profile	Straight to convex	Straight to convex	Straight to convex
Ear size	Small-medium	Medium	Medium
Ear orientation	Erect	Erect	Erect
Body colour	Grey, White, Sand brown	San-brown, Grey, white	Grey, Grey-white, white Brown, Dark brown
Colour pattern	Uniform	Uniform	Uniform
Wool distribution	Whole body	Whole body	Whole body
Hair type	Glossy, straight, sheen	Glossy, curly, straight,	Glossy, dull, curly, straight
Hair length: medium (1-2 mm), long (>2 mm)	Medium	Medium, Long	Medium-long
Hump size	Small, Medium	Medium	Medium-large
Hump location	Middle	Middle to the back	Middle to front Erect
Hump orientation	Erect	Erect	
Udder size	Medium to large	Medium to large	Medium, large
Teat size	Medium to large	Medium	Medium to large

**Table 2. Mean values of body weight and body linear measurements of camel bulls at 4-6 years by locations**

Quantitative traits	Mean $\pm$ SEM			P-value
	Daura	Mashi	Mani	
N	8	10	7	
<b>LBM</b>				
FL (cm)	46.75 $\pm$ 0.95 <sup>a</sup>	45.20 $\pm$ 1.16 <sup>a</sup>	46.07 $\pm$ 1.10 <sup>a</sup>	0.29
DE (cm)	25.25 $\pm$ 1.12 <sup>a</sup>	27.00 $\pm$ 0.63 <sup>a</sup>	26.50 $\pm$ 0.50 <sup>a</sup>	0.32
EL (cm)	12.25 $\pm$ 0.63 <sup>a</sup>	11.10 $\pm$ 0.46 <sup>a</sup>	10.75 $\pm$ 1.75 <sup>a</sup>	0.31
NL (cm)	108.5 $\pm$ 2.09 <sup>a</sup>	105.4 $\pm$ 1.67 <sup>b</sup>	101.0 $\pm$ 1.48 <sup>c</sup>	0.05
WS (cm)	35.25 $\pm$ 1.89 <sup>a</sup>	37.20 $\pm$ 1.11 <sup>a</sup>	38.25 $\pm$ 0.63 <sup>a</sup>	0.43
HW (cm)	179.3 $\pm$ 3.50 <sup>a</sup>	172.8 $\pm$ 2.12 <sup>c</sup>	176.5 $\pm$ 1.55 <sup>b</sup>	0.01
ALL (cm)	149.8 $\pm$ 3.97 <sup>a</sup>	147.3 $\pm$ 1.80 <sup>a</sup>	146.8 $\pm$ 1.89 <sup>a</sup>	0.78
TG (cm)	197.4 $\pm$ 2.93 <sup>a</sup>	186.2 $\pm$ 3.70 <sup>a</sup>	184.0 $\pm$ 6.75 <sup>a</sup>	0.31
HH (cm)	196.3 $\pm$ 2.95 <sup>a</sup>	194.5 $\pm$ 3.00 <sup>a</sup>	194.0 $\pm$ 2.12 <sup>a</sup>	0.91
HI (cm)	44.75 $\pm$ 2.50 <sup>a</sup>	39.70 $\pm$ 2.24 <sup>b</sup>	39.50 $\pm$ 4.17 <sup>b</sup>	0.04
Hc (cm)	106.0 $\pm$ 5.48 <sup>a</sup>	106.9 $\pm$ 4.29 <sup>a</sup>	99.25 $\pm$ 6.30 <sup>b</sup>	0.05
Hh (cm)	18.50 $\pm$ 1.44 <sup>a</sup>	21.50 $\pm$ 1.58 <sup>a</sup>	17.00 $\pm$ 2.71 <sup>a</sup>	0.26
BL (cm)	152.8 $\pm$ 2.95 <sup>a</sup>	153.0 $\pm$ 1.33 <sup>b</sup>	143.5 $\pm$ 3.71 <sup>c</sup>	0.02
AC (cm)	170.0 $\pm$ 4.55 <sup>a</sup>	159.7 $\pm$ 3.00 <sup>b</sup>	157.0 $\pm$ 6.01 <sup>c</sup>	0.01
PLL (cm)	162.5 $\pm$ 3.66 <sup>a</sup>	161.9 $\pm$ 2.04 <sup>a</sup>	160.5 $\pm$ 2.33 <sup>a</sup>	0.89
FPC (cm)	59.50 $\pm$ 0.50 <sup>a</sup>	54.40 $\pm$ 1.03 <sup>b</sup>	52.50 $\pm$ 1.89 <sup>c</sup>	0.01
TL (cm)	54.00 $\pm$ 1.47 <sup>a</sup>	50.30 $\pm$ 1.02 <sup>b</sup>	44.00 $\pm$ 2.08 <sup>c</sup>	0.00
BW (kg)	616.8 $\pm$ 25.1 <sup>a</sup>	537.6 $\pm$ 29.7 <sup>b</sup>	538.3 $\pm$ 55.5 <sup>b</sup>	0.03

*"Means with different superscript are significantly different (P < 0.05), means with the same superscript are not significantly different (P > 0.05)"* LBM = Linear body measurement, FL=Face length, DE=Distance between the eyes, EL=Ear length, NL=Neck length, WS=Width at shoulders, HW=Height at withers, ALL=Anterior limb length, TG=Thoracic girth, HH=Height at hump, HI=Hump length, Hc=Hump circumference, Hh=Hump height, BL=Body length, AC=Abdomen, circumference, PLL=Posterior limb length, FPC=Foot pad circumference, TL=Tail length and BW=Body Weight

**Table 3. Mean values of body weight and body linear measurements of camel cows at 4-6 years by locations**

Quantitative traits	Mean $\pm$ SEM			P-value
	Daura	Mashi	Mani	
N	10	11	9	
<b>LBM</b>				
FL (cm)	44.33 $\pm$ 1.22 <sup>a</sup>	45.75 $\pm$ 1.22 <sup>a</sup>	43.83 $\pm$ 1.27 <sup>a</sup>	0.53
DE (cm)	24.00 $\pm$ 0.65 <sup>a</sup>	26.00 $\pm$ 0.85 <sup>a</sup>	24.17 $\pm$ 0.95 <sup>a</sup>	0.96
EL (cm)	11.22 $\pm$ 0.36 <sup>a</sup>	11.25 $\pm$ 0.37 <sup>a</sup>	10.50 $\pm$ 0.43 <sup>a</sup>	0.54
NL (cm)	103.22 $\pm$ 1.53 <sup>b</sup>	109.25 $\pm$ 1.40 <sup>a</sup>	101.83 $\pm$ 2.20 <sup>c</sup>	0.04
WS (cm)	33.44 $\pm$ 1.24 <sup>c</sup>	34.00 $\pm$ 1.02 <sup>b</sup>	36.83 $\pm$ 1.08 <sup>a</sup>	0.01
HW (cm)	167.33 $\pm$ 3.82 <sup>b</sup>	172.87 $\pm$ 2.74 <sup>a</sup>	162.33 $\pm$ 12.14 <sup>c</sup>	0.00
ALL(cm)	132.11 $\pm$ 2.38 <sup>b</sup>	147.25 $\pm$ 2.62 <sup>a</sup>	147.18 $\pm$ 4.42 <sup>a</sup>	0.02
TG (cm)	180.22 $\pm$ 3.03 <sup>a</sup>	181.37 $\pm$ 3.56 <sup>a</sup>	182.18 $\pm$ 5.45 <sup>a</sup>	0.95
HH (cm)	183.44 $\pm$ 3.57 <sup>c</sup>	189.25 $\pm$ 3.32 <sup>a</sup>	187.13 $\pm$ 4.04 <sup>b</sup>	0.05
HI (cm)	38.78 $\pm$ 1.72 <sup>a</sup>	39.62 $\pm$ 2.93 <sup>a</sup>	37.00 $\pm$ 2.25 <sup>a</sup>	0.88
Hc (cm)	98.00 $\pm$ 3.13 <sup>a</sup>	94.37 $\pm$ 6.41 <sup>a</sup>	93.50 $\pm$ 4.61 <sup>a</sup>	0.92
Hh (cm)	14.89 $\pm$ 1.51 <sup>a</sup>	16.87 $\pm$ 1.47 <sup>a</sup>	16.50 $\pm$ 2.23 <sup>a</sup>	0.57
BL (cm)	144.78 $\pm$ 3.17 <sup>a</sup>	153.75 $\pm$ 2.55 <sup>a</sup>	145.67 $\pm$ 3.19 <sup>a</sup>	0.11
AC (cm)	152.78 $\pm$ 3.03 <sup>a</sup>	155.87 $\pm$ 3.22 <sup>a</sup>	154.33 $\pm$ 5.30 <sup>a</sup>	0.93
PLL (cm)	150.89 $\pm$ 2.58 <sup>a</sup>	160.50 $\pm$ 2.58 <sup>a</sup>	158.33 $\pm$ 3.79 <sup>a</sup>	0.19
FPC (cm)	53.44 $\pm$ 1.74 <sup>a</sup>	51.75 $\pm$ 1.35 <sup>a</sup>	51.67 $\pm$ 1.76 <sup>a</sup>	0.58
TL (cm)	48.44 $\pm$ 2.36 <sup>a</sup>	48.13 $\pm$ 0.95 <sup>a</sup>	47.00 $\pm$ 2.57 <sup>a</sup>	0.95
BW (kg)	489.67 $\pm$ 23.17 <sup>c</sup>	499.13 $\pm$ 28.36 <sup>b</sup>	506.17 $\pm$ 44.04 <sup>a</sup>	0.00

*Means with different superscript are significantly different ( $P < 0.05$ ), means with the same superscript are not significantly different ( $P > 0.05$ )* LBM = Linear body measurement, FL=Face length, DE=Distance between the eyes, EL=Ear length, NL=Neck length, WS=Width at shoulders, HW=Height at withers, ALL=Anterior limb length, TG=Thoracic girth, HH=Height at hump, HI=Hump length, Hc=Hump circumference, Hh=Hump height, BL=Body length, AC=Abdomen, circumference, PLL=Posterior limb length, FPC=Foot pad circumference, TL=Tail length and BW=Body Weight.

Body weights of camels were affected by herd location which agreed with Berhanu [12] who observed significant variation in body weights among herds in two different locations. Camel bulls at 4-6 years from Daura herd weight higher than their counterparts in Mashi herd and Mani herd which were statistically similar. On the other hand camel cows from Mani herd weight higher than females from Mashi herds and those from Daura herd which had the least body weight. The average body weights of camel bulls at 4-6 years in this study were higher than body weight of Kenani, Rashaidi, Lahweel, Bishari, Kabbashi, Maganeen, Shanbali, Maalia and Butana breeds reported by Ishag et al. [14]; however they were similar like the weights of Auadi, Asail and Hadhana breeds of Arabia as reported by Abdallah and Bernard [15]. Camel cows from Mani herds had higher body weights than the values reported for Sudanese camel breed by Ishag et al. [14]; and the body weight of Ethiopian camels [12]. Camel cows from Mashi herd were also higher in body weight than body weights of all the Sudanese breeds except the Shanbali. The Daura camel cows lie within the body weight range of the Sudanese breed. At 7-9

years Mashi and Mani herd had similar weights and were higher than the camel bulls from Daura whereas amongst camel cows at the same age, Mashi herd had the highest body weights followed by those from Mani and Daura herd. Body weights of mature camels at 7-9 years as revealed by this study are higher than those reported by Ishag et al. [14] among the Sudanese camel breeds, [12] among Ethiopian camels; however, it falls below the weights some Arabian camel breeds as reported by Abdallah and Bernard [15]. The reason for higher measurements displayed by the Mashi, Mani camels may be attributed to the migratory movement exhibited by the pastoralist within these areas in search of better grazing area as compared to their counterparts in Daura who are not involved in long-distance movement in search of food but graze around their place of residence. The current study shows that they were more significant variation at 7 to 9 years due to herd location in linear body parameters and body weights of camel bulls and camel cows; however, at 4 to 6 years, there were no many significant differences.



**Table 4. Mean values of body weight and body linear measurements of camel bulls at 7-9 years by locations**

Quantitative traits	Mean $\pm$ SEM			P-value
	Daura	Mashi	Mani	
N	8	8	7	
<b>LBM</b>				
FL (cm)	49.67 $\pm$ 1.45 <sup>a</sup>	49.00 $\pm$ 0.46 <sup>a</sup>	50.60 $\pm$ 0.68 <sup>a</sup>	0.31
DE (cm)	30.33 $\pm$ 0.33 <sup>a</sup>	29.88 $\pm$ 0.83 <sup>a</sup>	30.00 $\pm$ 0.83 <sup>a</sup>	0.06
EL (cm)	12.33 $\pm$ 0.67 <sup>a</sup>	12.63 $\pm$ 0.42 <sup>a</sup>	11.40 $\pm$ 0.40 <sup>a</sup>	0.17
NL (cm)	112.10 $\pm$ 6.08 <sup>b</sup>	110.4 $\pm$ 2.62 <sup>a</sup>	108.2 $\pm$ 1.46 <sup>c</sup>	0.05
WS (cm)	43.00 $\pm$ 1.53 <sup>a</sup>	41.37 $\pm$ 0.67 <sup>a</sup>	41.60 $\pm$ 1.21 <sup>a</sup>	0.47
HW (cm)	191.10 $\pm$ 4.04 <sup>a</sup>	179.1 $\pm$ 1.39 <sup>b</sup>	180.0 $\pm$ 1.09 <sup>c</sup>	0.04
ALL(cm)	157.3 $\pm$ 4.48 <sup>a</sup>	153.7 $\pm$ 1.54 <sup>b</sup>	151.6 $\pm$ 2.34 <sup>c</sup>	0.05
TG (cm)	202.3 $\pm$ 2.03 <sup>a</sup>	205.6 $\pm$ 2.08 <sup>a</sup>	207.2 $\pm$ 2.52 <sup>a</sup>	0.99
HH (cm)	204.7 $\pm$ 3.84 <sup>b</sup>	207.4 $\pm$ 3.45 <sup>a</sup>	200.6 $\pm$ 1.21 <sup>c</sup>	0.04
HI (cm)	40.33 $\pm$ 5.78 <sup>c</sup>	46.37 $\pm$ 3.92 <sup>a</sup>	44.80 $\pm$ 2.37 <sup>b</sup>	0.02
Hc (cm)	106.3 $\pm$ 9.56 <sup>b</sup>	112.9 $\pm$ 7.06 <sup>a</sup>	103.4 $\pm$ 2.87 <sup>c</sup>	0.04
Hh (cm)	16.33 $\pm$ 1.67 <sup>b</sup>	22.13 $\pm$ 1.93 <sup>a</sup>	21.67 $\pm$ 1.93 <sup>a</sup>	0.01
BL (cm)	157.0 $\pm$ 1.53 <sup>b</sup>	164.4 $\pm$ 2.20 <sup>a</sup>	150.4 $\pm$ 1.25 <sup>c</sup>	0.03
AC (cm)	178.0 $\pm$ 3.61 <sup>a</sup>	178.6 $\pm$ 2.32 <sup>a</sup>	178.4 $\pm$ 2.06 <sup>a</sup>	0.99
PLL (cm)	170.0 $\pm$ 4.04 <sup>a</sup>	170.8 $\pm$ 2.58 <sup>a</sup>	165.0 $\pm$ 2.49 <sup>a</sup>	0.57
FPC (cm)	60.67 $\pm$ 0.58 <sup>a</sup>	59.13 $\pm$ 1.09 <sup>a</sup>	58.60 $\pm$ 2.32 <sup>a</sup>	0.50
TL (cm)	59.00 $\pm$ 1.53 <sup>a</sup>	51.25 $\pm$ 1.39 <sup>b</sup>	50.20 $\pm$ 1.69 <sup>b</sup>	0.00
BW (kg)	700.7 $\pm$ 18.8 <sup>b</sup>	716.6 $\pm$ 19.5 <sup>a</sup>	715.1 $\pm$ 23.9 <sup>a</sup>	0.02

"Means with different superscript are significantly different ( $P < 0.05$ ), means with the same superscript are not significantly different ( $P > 0.05$ )" LBM = Linear body measurement, FL=Face length, DE=Distance between the eyes, EL=Ear length, NL=Neck length, WS=Width at shoulders, HW=Height at withers, ALL=Anterior limb length, TG=Thoracic girth, HH=Height at hump, HI=Hump length, Hc=Hump circumference, Hh=Hump height, BL=Body length, AC=Abdomen, circumference, PLL=Posterior limb length, FPC=Foot pad circumference, TL=Tail length and BW=Body Weight

**Table 5. Mean values of body weight and body linear measurements of camel cows at 7-9 years by locations**

Quantitative traits	Mean $\pm$ SEM			P-value
	Daura	Mashi	Mani	
N	10	13	10	
<b>LBM</b>				
FL (cm)	48.25 $\pm$ 1.03 <sup>a</sup>	48.69 $\pm$ 0.57 <sup>a</sup>	50.60 $\pm$ 0.60 <sup>a</sup>	0.25
DE (cm)	28.50 $\pm$ 1.73 <sup>a</sup>	29.06 $\pm$ 0.35 <sup>a</sup>	29.00 $\pm$ 0.71 <sup>a</sup>	0.16
EL (cm)	11.75 $\pm$ 0.63 <sup>a</sup>	11.56 $\pm$ 0.22 <sup>a</sup>	11.80 $\pm$ 0.58 <sup>a</sup>	0.79
NL (cm)	110.0 $\pm$ 1.58 <sup>b</sup>	111.7 $\pm$ 0.73 <sup>b</sup>	114.2 $\pm$ 0.86 <sup>a</sup>	0.03
WS (cm)	41.00 $\pm$ 0.58 <sup>a</sup>	41.38 $\pm$ 0.49 <sup>a</sup>	41.40 $\pm$ 1.40 <sup>a</sup>	0.16
HW (cm)	178.8 $\pm$ 2.40 <sup>b</sup>	182.5 $\pm$ 1.89 <sup>a</sup>	179.8 $\pm$ 2.43 <sup>b</sup>	0.05
ALL(cm)	150.3 $\pm$ 3.12 <sup>b</sup>	154.3 $\pm$ 1.05 <sup>a</sup>	124.4 $\pm$ 27.1 <sup>c</sup>	0.01
TG (cm)	200.6 $\pm$ 1.25 <sup>c</sup>	206.5 $\pm$ 1.09 <sup>a</sup>	202.6 $\pm$ 1.80 <sup>b</sup>	0.04
HH (cm)	198.5 $\pm$ 4.05 <sup>a</sup>	201.3 $\pm$ 2.29 <sup>a</sup>	197.8 $\pm$ 2.22 <sup>a</sup>	0.73
HI (cm)	41.50 $\pm$ 5.42 <sup>a</sup>	45.50 $\pm$ 2.21 <sup>a</sup>	44.00 $\pm$ 1.30 <sup>a</sup>	0.85
Hc (cm)	102.3 $\pm$ 9.52 <sup>a</sup>	113.6 $\pm$ 3.59 <sup>a</sup>	109.2 $\pm$ 1.93 <sup>a</sup>	0.52
Hh (cm)	20.75 $\pm$ 2.66 <sup>a</sup>	19.62 $\pm$ 1.47 <sup>a</sup>	18.60 $\pm$ 1.63 <sup>a</sup>	0.96
BL (cm)	155.0 $\pm$ 2.91 <sup>c</sup>	162.7 $\pm$ 1.90 <sup>a</sup>	157.4 $\pm$ 3.57 <sup>b</sup>	0.05
AC (cm)	176.0 $\pm$ 0.91 <sup>b</sup>	178.0 $\pm$ 1.31 <sup>a</sup>	175.2 $\pm$ 1.65 <sup>b</sup>	0.03
PLL (cm)	162.7 $\pm$ 2.90 <sup>c</sup>	169.7 $\pm$ 1.13 <sup>a</sup>	167.2 $\pm$ 1.15 <sup>b</sup>	0.02
FPC (cm)	59.75 $\pm$ 1.65 <sup>a</sup>	58.00 $\pm$ 0.98 <sup>a</sup>	58.60 $\pm$ 0.87 <sup>a</sup>	0.81
TL (cm)	52.50 $\pm$ 2.02 <sup>a</sup>	55.37 $\pm$ 1.24 <sup>a</sup>	52.80 $\pm$ 2.61 <sup>a</sup>	0.39
BW (kg)	682.7 $\pm$ 11.2 <sup>c</sup>	717.6 $\pm$ 10.8 <sup>a</sup>	697.8 $\pm$ 16.4 <sup>b</sup>	0.01

"Means with different superscript are significantly different ( $P < 0.05$ ), means with the same superscript are not significantly different ( $P > 0.05$ )" LBM = Linear body measurement, FL=Face length, DE=Distance between the eyes, EL=Ear length, NL=Neck length, WS=Width at shoulders, HW=Height at withers, ALL=Anterior limb length, TG=Thoracic girth, HH=Height at hump, HI=Hump length, Hc=Hump circumference, Hh=Hump height, BL=Body length, AC=Abdomen, circumference, PLL=Posterior limb length, FPC=Foot pad circumference, TL=Tail length and BW=Body Weight

Blanc and Hennesser [16] distinguished between three types of camel the big size camel living in desert plain, the medium size camel used for riding, and the small size camel living in mountainous areas. In Saudi Arabia, [17,18]; reported that this classification is linked to different purposes: The big size camels are used for dairy production which adapts to desert areas and is able to undergo intensification within urban settlement. The small size camels are found in coastal or hilly area with more favorable climatic environment use for small-scale camel farming and other purposes. The medium size camels which are kept under proper management and undergo special exercise are used for racing Abdallah and Bernard [15]. Currently there is no classification for any camel ecotype in Katsina state for specialized function, however, the main purpose of camels are: meat, milk and draught power. The use of camels for draught power and transportation of heavy loads is mostly attributed to camel bulls. Camels in the three herds (Daura, Mani and Mashi) are heavily built body animals with large humps, this is similar to the Awr, Homor, Hadhana, Majaheem, Shaele, Sofor, Waddah, shageh and Asail and Zargah breeds of Arabian camels among camel bulls and camel cows as reported by Abdallah and Bernard [15]. The heavily built body of camels in Katsina state also corroborates with the report of Gillespie [19] who reported that almost 90% of the total numbers of camels in Sudan were heavily built camels with large humps (packed or Arabi camels), the Katsina camels can also be referred to as packed or Arabi camels.

## 5. CONCLUSION

This study shows phenotypic variation among camels due to location herd effect, Mashi and Mani herd had higher body weights. This information can be used for selection and subsequent improvement of body weights; however, the potentials of camels in Katsina and Nigeria as a whole remain untapped. Therefore further studies with large number of camels in Nigeria is needed to evaluate the performance in meat, milk, draught, transportation racing and to introduce them into the humid tropics of Nigeria under the transhumant management practice as a mitigation against climate change impact.

## ETHICAL APPROVAL

As per international standard or university standard written ethical permission

has been collected and preserved by the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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