

Original Research Paper

Morphobiometric characterisation of donkey resources (*Equus asinus*) in the North and Far North regions of Cameroon

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Abstract:

This study, conducted from April to October 2024 in the North and Far North regions of Cameroon, aimed to contribute to a better understanding of the phenotypic diversity of donkeys in Cameroon. More specifically, it sought to define the morphometric characteristics and biometric body indices of donkeys in the North and Far North regions of Cameroon in order to identify genetic variability and deduce their phenotypic structure and classification. A sample of 300 adult donkeys, including 139 females and 161 males, was observed in four locations. Nine body measurements were taken, namely chest circumference (CC), height at the withers (HW), neck length (NL), left ear length (LEL), right ear length (REL), body length (BoL), back height (BH), back length (BL) and head length (HL) were collected. In addition to these measurements, coat color and geographical location were also noted. The results show that, in terms of phenotypic characteristics, gray coats are dominant (71.33%) and black coats with a uniform cape are the least common (11.33%). The average values (in cm) of the measurements are respectively 107.99 ± 7.52 , 98.68 ± 4.33 , 30.59 ± 2.87 , 25.92 ± 1.41 , 25.99 ± 1.67 , 104.32 ± 7.12 , 102.75 ± 7.75 , 68.72 ± 5.53 , 44.72 ± 2.72 . These measurements were used to determine four body indices often used in literature. The body profile index ($BPI = 0.95 \pm 0.07$) enabled donkeys from the northern and far northern regions of Cameroon to be classified as slender, with a chest development index ($CDI = 1.086 \pm 0.06$) indicating their suitability for work. The hierarchical ascending classification (HAC) identified three phenotypic groups that differ in particular in terms of their size and chest circumference.

Keywords: Donkeys, Biodiversity, Body morphometry, Biometric index, Cameroon

Introduction:

According to FAO (2022), animal biodiversity is essential and fundamental to economic development and food security in developing countries. Many African countries are characterised by a great diversity of local animal genetic resources enabling them to meet the challenges of tomorrow (FAO, 2016). Based on statistics from the Food and Agriculture Organisation of the United Nations, the total world population of donkeys is estimated at over 50 million (Norris et al., 2021). The largest population of donkeys is found in Ethiopia, with approximately 9 million heads. African countries together account for about a quarter of the world's donkey population (Wang et al., 2022; Martha et al., 2026). In developing countries around the world, donkeys are the most important and reliable source of transport

and agricultural power for people with limited resources in rural, peri-urban and urban areas (Björkengren, 2016 ; Rodrigues et al., 2021). Donkey populations are not only important for the survival of poor families, but also for the livelihoods of the families that keep them (Jadhav et al., 2025). In Cameroon, the donkey population is estimated at around 50,000 (Norris et al., 2021) and donkeys are bred in almost all regions (Defeu et al., 2015). However, few studies on the morphobiometric characterisation of donkeys have been conducted in Cameroon to date (Ebangi and Vall, 1998, 2005 ; Defeu et al., 2015). It is in this context that the present study was conducted in the North and Far North regions of Cameroon, with the overall objective of contributing to a better understanding of the biodiversity of donkeys in Cameroon. Specifically, this involves (i) assessing the main morphobiometric parameters of donkeys in the North and Far North regions of Cameroon, in order to (ii) define their phenotypic diversity.

Materials and Methods:

Study area

This study was conducted from April 2024 to October 2024 in the North (6° - 10° N and 12° - 16° E) and Far North (10° - 12° N and 14° - 15° E) regions of Cameroon. In the North region, two departments were concerned, namely Bénoué (9° 18' 20" N and 13° 23' 39" E) and Mayo Louti (9° 56' 13" N and 13° 56' 38" E). In the Far North region (FN), the survey covered the departments of Diamaré (10°-11°N and 14°-15°E) and Mayo Tsanaga (10°-11°N and 10°-11°20'E). The Northern Region covers an area of 66,090 km². It has a Sudanese climate characterised by average annual rainfall ranging from 750 to 1,250 mm and an average temperature of 31.5°C. The vegetation is dry grassland savannah, shrub savannah and wooded savannah. The Far North covers an area of 34,246 km². It has a Sudano-Sahelian climate characterised by average annual rainfall of 800–900 mm and an average temperature of 35°C. The vegetation is of the thorny steppe and periodically flooded grassland type (MINEPAT, 2021, 2024).

Collection of Samples

A sample of 300 adult donkeys (97 in the north and 203 in the FN), including 139 females (45 in the north and 94 in the east) and 161 males (52 in the north and 109 in the FN), was observed. The criteria for selecting these locations were based on the existence of donkey breeding and accessibility to these locations. Data was collected only on animals that appeared healthy and in good physical condition.

Data collection

Information on morphological characteristics was collected using a specially adapted survey form (FAO, 2013) in order to describe their morphological characteristics according to a standard. For each animal, information on location (GPS coordinates of the locality), age, sex, coat colour and body measurements was recorded on a survey form. The age of the animals given by the breeders was supplemented by observation of their teeth (Davézé and Raveneau, 2002). Coat colour was identified by direct observation in daylight.

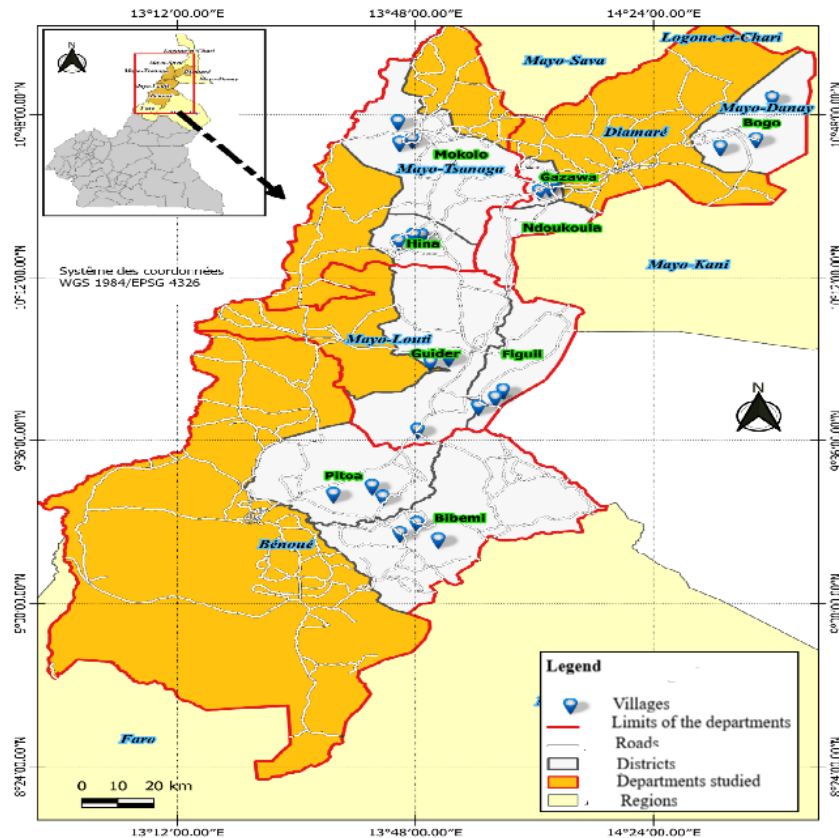


Figure 1: location of the study area (OCHA database, 2023).

Main measurements

Body measurements were obtained using a tape measure for length and circumference measurements and a height rod for height measurements. Live weight (LW) was determined using the equation proposed by Ebangi and Vall (1998):

$LW = CC \cdot 2,826 / 4434,7$ where CC is the chest circumference.

Based on the various measurements, four body indices developed for horses and adapted for donkeys (Folch and Jordana, 1997 ; Defeu et al., 2015) were calculated using the following formulas :

- Thoracic Development Index (TDI): chest circumference (CC) / height at the withers (HW)
- Profile Body Index (PBI) : height at the withers (HW) / body length (BoL)
- Compactness Index (CI): live weight (LW) / height at the withers (HW);
- Relative Body Index (RBI): body length (BoL) / chest circumference (CC)

Statistical analyses

Descriptive statistics were used to describe the morphobiometric characteristics. Analysis of variance (ANOVA) was used to test the influence of factors (sex, age, location) on the various measurements and biometric indices. However, as the effects of sex and age were not significant, the following model was used:

$$y_{ij} = \mu + \alpha_i + e_{ij}$$

Where

- μ : population mean;
- α_i : fixed effect of location (i varying from 1 to 4);
- e_{ij} : error specific to each animal.

When the location factor was significant, Duncan's test was used to separate the means. The direction and degree of association between traits were tested using Pearson's correlation coefficient. Principal component analysis (PCA) was performed to evaluate the linear relationships between the 11 biometric parameters and live weight and to determine which ones discriminate between genetic types of donkeys. Based on this PCA, an ascending hierarchical classification (AHC) analysis was performed to divide the animals into genetic types and establish the dendrogram. Finally, a discriminant factor analysis (DFA) was performed to classify the groupings of individuals according to their geographical location. All of these statistical analyses were performed using R software version 4.3.3 (R Core Team, 2023) from data previously recorded in Excel (Microsoft Corporation, 2018).

Results

The use of donkeys in the North and Far North regions of Cameroon

In these two regions of Cameroon, the present survey revealed that for the vast majority, donkeys are mainly used for farm work, either exclusively (86%) or in combination with transport (7%) or breeding (6%) (Table 1).

Table 1 : Use of donkeys in the North and Far North regions of Cameroon :

Use	Number	Percentage (%)
Field work only	258	86.00
Transport only	01	0.33
Breeding only	02	0.67
Field work and breeding	18	6.00
Field work and transport	21	7.00

Characteristics of the coat

The different coat colour (Figure 2) and their frequencies observed in donkeys in the North and Far North regions of Cameroon show that the vast majority (71.33%) have a grey coat with stripes forming a dark band across the back and withers (St Andrew's cross). This is followed by bay coats (17.33%) with a light shade around the nostrils, lips and chin. The least common coat colour (11.33%) is black with a uniform cape.



Grey coat



Bay coat



Black coat

Figure 2: Different donkeys coats in the North and Far North regions of Cameroon

Morphobiometric characteristics of donkeys in the North and Far North regions of Cameroon

In general, the morphobiometric characteristics studied were quite variable (Table 2). The average live weight of adult donkeys in the North and Far North regions of Cameroon is 127.26 ± 23.74 kg with a coefficient of variation of 18.65%. The average chest circumference was 107.99 ± 7.52 cm, while the average height at the withers was 98.68 ± 4.33 cm, demonstrating the small size (<100 cm) of this population. The Thoracic Development Index (TDI) is 1.09 ± 0.06 , indicating that the donkey populations studied have a conformation that makes them suitable for work. The body profile index was 0.95 ± 0.07 , which allows our donkeys to be classified as long-limbed. This morphology is confirmed by the relative body index, which is 0.97 ± 0.06 . The Compactness Index (CI) is 1.29 ± 0.22 , indicating that the donkey population under study is fairly compact.

Table 2 : Minimum and maximum values, mean, standard deviation and coefficient of variation for morphobiometric parameters and body indices of donkeys in the North and Far North regions of Cameroon

Variables	n	Min	Max	Mean	St.dev	CV in %
BW	300	55.70	185.80	127.26	23.74	18.65
CC	300	81.00	124.00	107.99	7.52	6.96
HW	300	83.00	115.30	98.68	4.33	4.39
NL	300	23.00	36.00	30.59	2.87	9.38
LEL	300	22.00	30.40	25.92	1.41	5.44
REL	300	20.60	29.70	25.99	1.67	6.43
BoL	300	71.50	119.00	104.32	7.12	6.83
HB	300	70.30	198.60	102.75	7.75	7.54
BL	300	54.00	80.40	68.72	5.53	8.05
HL	300	38.00	49.50	44.72	2.72	6.08
CDI	300	0.73	1.30	1.09	0.06	5.50
BPI	300	0.82	1.42	0.95	0.07	7.37
CI	300	0.50	1.78	1.29	0.22	17.05
RBI	300	0.66	1.33	0.97	0.06	6.19

BW : body weight ; CC : chest circumference ; HW : height at withers ; NL : neck length ; LEL : left ear length ; REL : right ear length ; BoL : body length ; HB : height at the back ; BL : back length ; HL : head length ; CDI : chest development index ; BPI : body profile index ; CI : compactness index ; RBI : relative body index.

Correlation between body measurements

The correlations between body measurements in donkeys from the North and Far North regions of Cameroon are all positive at the 5% or 1% significance level (Table 3). The highest coefficients are obtained between live weight and chest circumference ($r=0.99$), back length and chest circumference ($r=0.61$), body length and chest circumference ($r=0.60$), height at the withers and chest circumference ($r=0.56$), and height at the withers and live weight ($r=0.56$), while the lowest coefficient ($r=0.09$) is obtained between the length of the right ear and the length of the head, as well as between the height at the back and the length of the neck.

Table 3 : Correlations between body measurements in donkeys from the North and Far North regions of Cameroon

	BW	CC	HW	NL	LEL	REL	BoL	HB	BL	HL
BW	1.00									
CC	0.99**	1.00								
HW	0.56**	0.56**	1.00							
NL	0.36**	0.36**	0.25**	1.00						
LEL	0.36**	0.36**	0.29**	0.24**	1.00					
REL	0.41**	0.41**	0.23**	0.24**	0.80**	1.00				
BoL	0.60**	0.60**	0.50**	0.20**	0.17**	0.19**	1.00			
HB	0.41**	0.42**	0.37**	0.09	0.15**	0.09	0.39**	1.00		
BL	0.60**	0.61**	0.45**	0.22**	0.14*	0.20**	0.63**	0.45**	1.00	
HL	0.46**	0.47**	0.42**	0.22**	0.11	0.09	0.48**	0.44**	0.57**	1.00

** $P < 0.01$. * $P < 0.05$ (bilateral) ;

BW : body weight ; CC : chest circumference ; HW : height at withers ; NL : neck length ; LEL : left ear length ;
 REL : right ear length ; BoL : body length ; HB : height at the back ; BL : back length ; HL : head length ;

Correlation between biometric indices

With regard to the correlation coefficients between the various biometric indices in donkeys from the North and Far North regions of Cameroon (Table 4), only the compactness index and the body index show a positive correlation ($r=0.89$). The highest negative coefficient is obtained between the profile body index and the relative body index ($r=-0.55$).

Table 4 : Correlations between body indices in donkeys from the North and Far North regions of Cameroon

	TDI	BMI	RMI	CI
IDT	1.00**			
ICP	-0.41**	1.00		
IC	0.89**	-0.33**	1.00	
ICR	-0.50**	-0.55**	-0.49**	1.00

** $P < 0.01$ * $P < 0.05$ (bilateral) ;

TDI : Thoracic Development Index ; BMI : Body Mass Index ; RMI : Relative Body Mass Index ; CI : Compactness Index

Genetic variability of the population

The first two components of principal component analysis (PCA) alone account for 52.4% of the genetic variability of the donkey population in the northern and far northern regions of Cameroon (Figure 3). The variables that contribute most to the first axis (39.8% of genetic variability) are chest circumference and live weight, followed by body length and back length, and finally ear length.

Given the strong linear relationship observed between chest circumference and live weight, and between back length and body length, the four variables to be considered efficiently in the analysis of genetic variability are, in descending order of importance: chest circumference, body length, left ear length and right ear length.

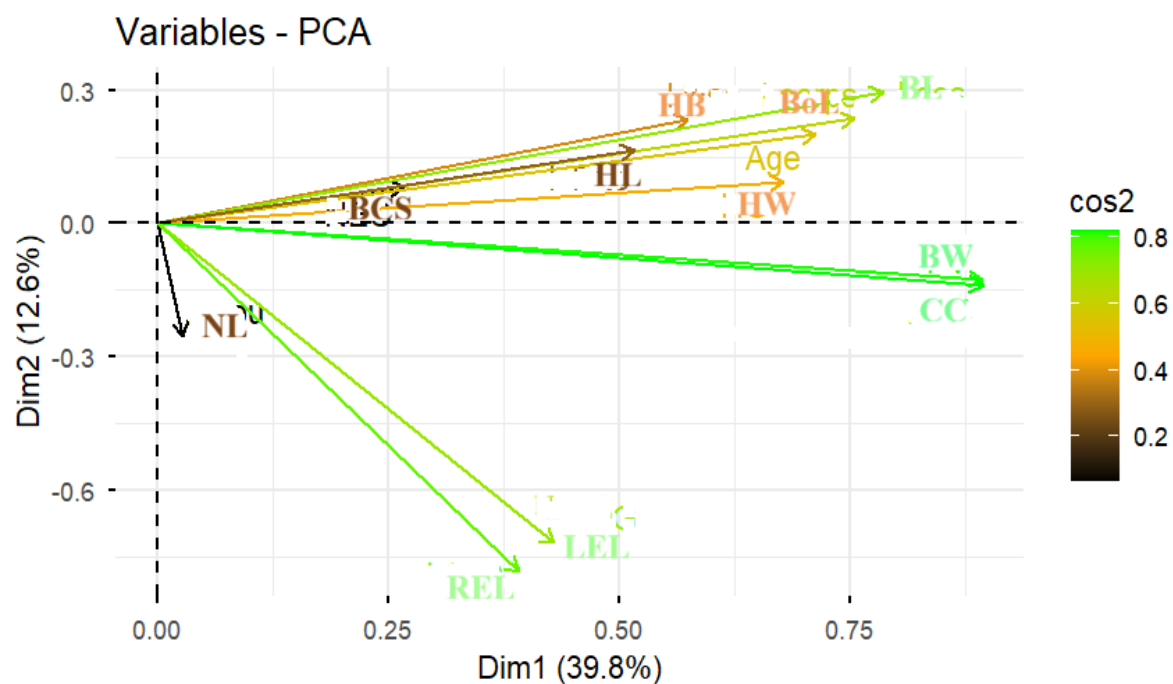


Figure 3: Main components of genetic variability in the donkey population in the North and Far North regions of Cameroon

Population structure

Discriminant factor analysis (DFA) shows that the first two axes account for nearly 46.99% of the total variability (Figure 4), with an uneven distribution: the first axis accounts for 36.53% of the total variability, while the second explains 10.44%. The distribution of animals across the four departments studied is very homogeneous.

The hierarchical ascending classification (HAC) obtained from the various morpho-biometric parameters (Figure 4) highlights three distinct genetic types, designated A, B and C. Genetic types A and C are phenotypically closer, while genetic type B is the most distant.

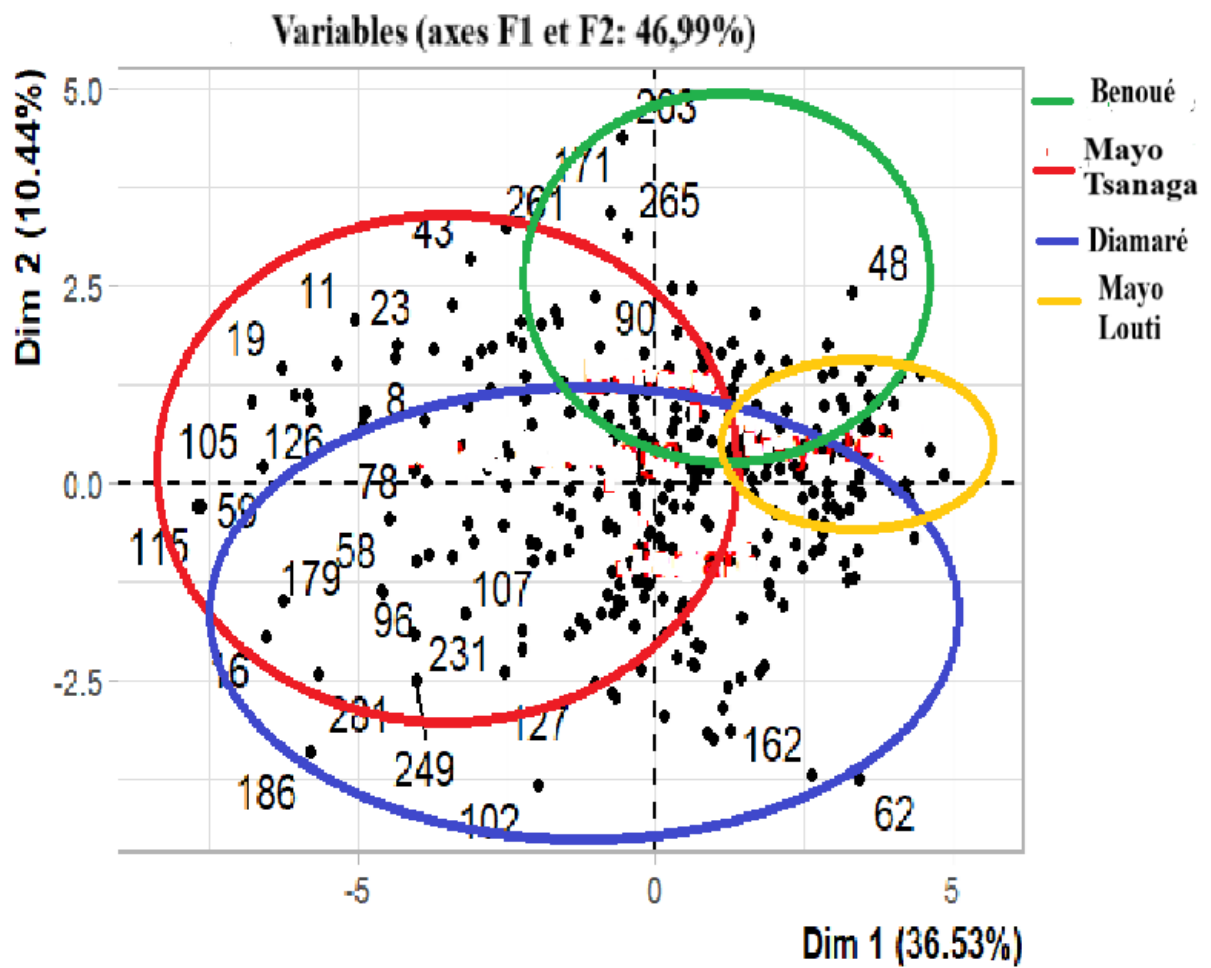


Figure 4: Structure of the donkey population in the North and Far North regions of Cameroon by AFD according to the departments under study

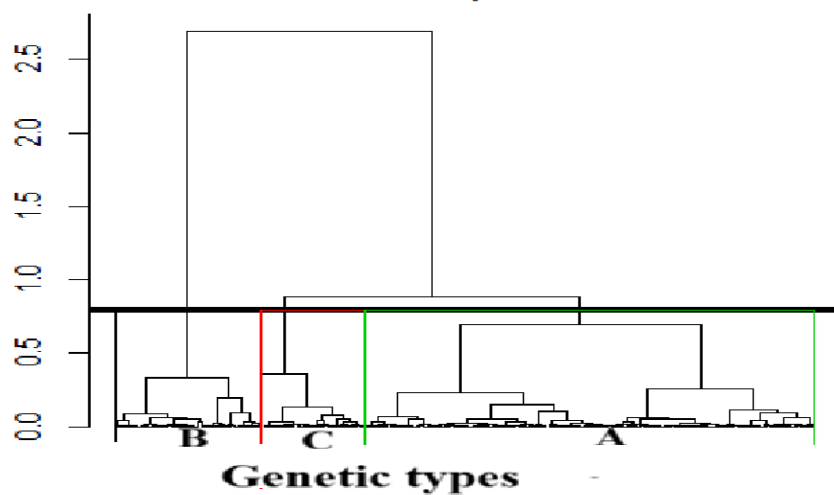


Figure 4: Phenogram of genetic types of donkeys in the North and Far North regions of Cameroon

The characteristic morphobiometric parameters for each group of donkeys are presented in Table 5. Genetic type A corresponds to large donkeys, with an average height at the withers of 100.4 cm and a height at the back of 104.7 cm. They have a relatively large chest circumference (112.8 cm on average). Donkeys of genetic type B are medium-sized (average height at the withers of 95 cm) but have a back height of 105 cm. Genetic type C includes relatively small donkeys, with an average height at the withers of 94.5 cm and a back height of 95.9 cm. It should be noted that most of the genetic types identified have a grey coat with stripes forming a dark band across the back and withers (St Andrew's cross).

Table 5: Characteristics of donkey classes identified after PCA analysis

Morphobiometric Parameters (cm)	Genetic Type A			Genetic Type B			Genetic Type C		
	Mean	SD	CV(%)	Mean	SD	CV(%)	Mean	SD	CV(%)
CC	112.76	4.52	4.01	99.34	6.36	6.40	98.54	6.08	6.17
BW	142.63	16.02	11.23	100.24	17.21	17.17	97.87	16.43	16.79
BoL	107.10	4.22	3.94	107.01	4.76	4.45	95.12	6.67	7.01
LEL	26.86	0.75	2.79	24.70	1.04	4.21	25.30	1.49	5.89
REL	26.98	0.81	3.00	24.68	1.17	4.74	25.37	1.56	6.15
BL	70.89	4.48	6.32	70.06	3.97	5.67	62.41	4.28	6.86
HB	104.71	3.44	3.29	105.00	11.61	11.06	95.87	4.08	4.26
HW	100.37	3.39	3.38	95.01	3.93	4.14	94.48	3.63	3.84
NL	31.61	2.06	6.52	29.57	2.66	9.00	29.55	2.41	8.16
HL	45.46	1.94	4.27	45.58	2.11	4.63	42.09	1.94	4.61

CC: chest circumference; BW: body weight; BoL: body length; LEL: left ear length; REL: right ear length; BL: back length; HB: height at the back; HW: height at withers; NL: neck length HL: head length.

Discussion

This survey revealed that donkeys play an important economic role due to their contribution to the agricultural system. In the North and Far North regions of Cameroon, they are mainly used for farm work and transport. A similar situation is described in the Kabylie region of Algeria (Meutchieye et al., 2016; Ayad et al., 2019) in the period prior to the use of agricultural machinery. In a study on the socio-economic characteristics of donkeys in the Far North region of Cameroon, Nguekeng et al. (2017) found that transport was the main activity. This difference could be due to the fact that in the North region of Cameroon, unlike the Far North region, cotton is grown on a large scale, hence the need to use donkeys for farm work. However, in Tunisia (Aroua et al., 2020) and in Africa in general (Fernando and Starkey, 2004), donkeys are mainly used to transport water, people or goods.

The predominant coat colour is grey with stripes forming a dark band across the back and withers. This description corresponds to that given by Davézé and Raveneau (2002) for *Equus asinus nubicus* or *Equus asinus africanus*, which originates from the Horn of Africa in northern Sudan. In Cameroon, in the Sudano-Sahelian region, Ebangi and Vall (1998) found 94% of individuals to be grey in colour, while Nguekeng et al. (2017) found 80.02% to be grey in the Far North region. In the highlands of north-western Cameroon, Defeu et al. (2015) found 86.3% to be grey, with three shades: light, brown and

dark. This could indicate that Cameroon's donkeys originated in northern Sudan, according to research by Davézé and Raveneau (2002). In Nigeria, Khaleel et al. (2020) also found that the majority (44.5%) of donkeys in Kano State were grey. According to Ibeagha-Awemu et al. (2025), these grey donkeys with a dark stripe running down their backs and withers are probably of the Idabari breed or common African donkey.

The main morphometric data concerned means, standard deviation and coefficient of variation. The coefficients of variation for most of the morphometric traits measured ranged from 4 to 8%. This result is corroborated by those of Khaleel et al. (2020) in Nigeria, Defeu et al. (2015) in Cameroon and Ayad et al. (2019) in Algeria. Greater variability was observed in weight, undoubtedly reflecting the wide range of ages within the population studied, given that age has a significant impact on the weight of donkeys (Nininahazwe et al., 2017).

The average live weight reported in this study is comparable to the 128.68 kg obtained in Cameroon by (Defeu et al., 2015) and the 122.11 kg found by (Nguekeng et al., 2017). However, it is higher than the average of 118.1 kg obtained by (Nininahazwe et al., 2017) in West Africa. In North Africa (Ayad et al., 2019 ; Aroua et al., 2020), the average live weight of donkeys is higher than the average for donkeys in this study. The differences observed are undoubtedly due not only to environmental factors (feed, health, housing) and genetic factors (breed) but also to the weight formula used.

The morphometric data obtained from the donkey population in the North and Far North regions of Cameroon are similar to those previously reported in Cameroon (Ebangi and Vall, 1998; Defeu et al., 2015) and West Africa (Nininahazwe et al., 2017). They are consistent with the description by Ibeagha-Awemu et al. (2025), who conclude that donkeys in Central and West Africa are small to medium in size and dimensions. However, the size and dimensions of donkeys in North Africa are relatively larger (Aroua et al., 2020 ; Madani et al., 2022) than those recorded in the present study. The explanation for this situation could lie in diet, habitat conditions or work intensity (Ayad et al., 2019). Donkeys in Cameroon have a shorter body length than those in Tunisia, with 115.120 cm (Aroua et al., 2020), those in Chad, which measure 109.32 cm (Daloum et al., 2015), and those in Italy, which measure 143.75 cm on average for Martina Franca donkeys (De Berardinis et al., 2024).

In general, the correlations between the different morphological parameters are strong and positive ($p < 0.05$). This situation is similar to that obtained by many authors (Daloum et al., 2015 ; John et al., 2017 ; Ayad et al., 2019).

Live weight and chest circumference proved to be the most strongly correlated parameters in this study. This finding is consistent with studies conducted by De Berardinis et al. (2024) in Italy, Defeu et al. (2015) in Cameroon, and Nininahazwe et al. (2017) in Burkina Faso, Mali, Niger and Senegal. Chest circumference is therefore the most reliable biometric parameter for determining weight in donkeys.

The zootechnical indices obtained provide a better understanding of the conformation of the animals in this study. Thus, the body profile index obtained (0.95) indicates animals whose body length is greater than their height at the withers, i.e. long-bodied ($ICP < 1$). This type is confirmed by the relative body index obtained ($ICR = 0.95$). However, according to Madani et al. (2022), when the profile body index is between 0.90 and 1.10, the body shape can be considered to be broadly square. This result is consistent with those obtained by Defeu et al. (2015) in Cameroon and Daloum et al. (2015) in Chad. According to Madani et al. (2022), when the $IDT > 1.2$, the animal has a significantly developed thorax. This is not the case in the present study, where a value of 1.1 was observed, still indicating appreciable development of the rib cage in donkeys from the North and Far North regions of Cameroon, as well as a conformation that makes them suitable for work. The Compactness Index (CI) is 1.29 ± 0.22 kg/cm, indicating that the donkey population under study is fairly compact for its size. This description is consistent with the results of Defeu et al. (2015) in Cameroon and Daloum et al. (2015) in Chad.

With regard to correlations between morphometric indices, only the correlation between IDT and IC is positive ($r = 0.89$). The same result was obtained by Defeu et al. (2015) in Cameroon.

According to the results of the analysis of genetic variability in the population under study, the first two principal components alone account for more than 50% of this variability. Furthermore, chest circumference, body length and ear length alone account for more than 30%. These are therefore the characteristics that must be taken into account in any genetic improvement or conservation project for donkeys in the northern and far northern regions of Cameroon.

Three genetic types have been identified among donkeys in the North and Far North regions of Cameroon based on quantitative characteristics. However, AFD was unable to make a clear distinction between these different classes based on coat colour. In Albania, a study of donkeys identified two distinct types of Albanian donkeys based on their size, height at the withers, chest circumference and ear length (Papa and Kume, 2012). However, in West Africa (Burkina Faso and Senegal), authors have found a homogeneous population (Kabore, 2014 ; Roamba, 2014).

Conclusion

Donkeys in the North and Far North regions of Cameroon exhibit substantial morphological diversity and are mainly used for farm work and transport. Grey coat colour, often with a dark dorsal and shoulder stripe, is the most common phenotype. Chest circumference is the best predictor of live weight. Zootechnical indices indicate that these animals are long-limbed and hypermetric, which makes them well-suited for draught tasks. Morphobiometric parameters such as chest circumference, body length, and ear length should be integrated into any conservation or genetic improvement programme for this population. Three phenotypic types have been identified based on quantitative traits, but molecular characterisation is required to confirm the underlying genetic diversity and to better support the sustainable management of these donkey resources.

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Author's Contributions

Patrick Jolly Ngono Ema and Victor Ngu Ngwa conceived the study, supervised field work, and wrote the manuscript.

Ernest Apramko Yaya conducted field work and analysis.

Justin Ntsoli reviewed and edited the manuscript

Conflict of Interest

There is no conflict of interest for this study.

Ethics

Standard ethical considerations were followed for the donkeys used for this study.

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