

Original Research Paper

Morphometric characterization of the local highlands' dogs in West Cameroon

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Abstract

Cameroonian local dogs are members of the indigenous Cameroonian gene pool, although there are no studies on phenotypic identification and genetic characterization. This study was conducted to determine the distribution of body measurements of the local dog in different sexes and localities bred in the western highlands of Cameroon. Sixteen morphometric variables were measured in 320 unrelated adult animals (160 males and 160 females). The impact of sex on body measurements was assessed using t-test and that of sampling areas using one-way ANOVA. Mean values of Height at withers, Height at rump, Head length, Skull length, Face length, Rump length, Body length, Tail length, Head width, Rump width Shoulder width, Chest depth, Shin circumference, Back-sternal diameter, Anterior girth, Chest posterior girth were as follows: 52.53, 51.17, 20.66, 10.73, 9.81, 14.41, 53.64, 28.96, 10.73, 11.45, 11.27, 17.50, 54.80, 14.03, 11.38 and 10.38 cm, respectively. The results showed that there was an impact of region on body measurements and sexual dimorphism in the studied populations, males had more developed some measurable traits than females. This is the first study to comprehensively describe the genetic diversity and population structure of the Cameroonian dog breed. Particular attention should be paid to protecting this breed as soon as possible.

Keywords: Cameroon, highlands, local dog, Morphometric characterization.

ملخص

عدم وجود دراسات حول تحديد النمط الظاهري الكلاب المحلية الكاميرونية هي أعضاء في مجموعة الجينات الكاميرونية الأصلية، على الرغم من في المرتفعات الغربية يتألف من وصف الجيني. أجريت هذه الدراسة لتحديد توزيع قياسات الجسم للكلب المحلي في مختلف الجنسين والمناطق المرب (أنثى). تم تقييم تأثير الجنس على قياسات 160 و 160 كذا (كلص يذ ربع أغلاب أنويح 320 يف أي رتموفروم ار يغتم رشع قنس سابق مت الجسم t وتأثير مناطق أخذ العينات باستخدام ANOVA نوريماكل قيم الارتفاع عند الذراعين، الارتفاع عند الردف، أحادي الاتجاه متوسط. باستخدام اختبار طول الرأس، طول الجمجمة، طول الوجه، طول الردف، طول الجسم، طول الذيل، عرض الرأس، عرض الردف عرض الكتفين عمق الصدر، 52.53، 51.17، 20.66، 10.73، 9.81، 14.41، 53.64، 28.96، 10.73، 11.45، 11.27، 17.50، 54.80، 14.03، 11.38، 10.38 محيط الصدر الخلفي كان على النحو التالي: الأمامي، محيط الساق، القطر الخلفي، المحيط سم على التوالي. أظهرت النتائج أن هناك تأثير للمنطقة 10.38، 11.38، 14.03، 54.80، 17.50، 11.27، 11.45، 10.73، 28.96، 53.64، في بعض السمات القابلة للقياس من الإناث. هذه هي اروطت رتكا روكذا ناكو، مسوردمعلى قياسات الجسم ومثنوية الشكل 53.64، 28.96، الجنسي في المجتمعات ال ه السلالة فيالدراسة الأولى التي تصف بشكل شامل التنوع الجيني والبنية السكانية لسلالة الكلاب الكاميرونية. وينبغي إيلاء اهتمام خاص لحماية هذ. أقرب وقت ممكن

الكلمات المفتاحية : الكاميرون، الهضاب العليا، الكلاب المحلية، التوصيف المورفومتري

Introduction

While phenotypic studies are important for classifying dog breeds and explaining kinship relationships between breeds, data from genetic studies can show that seemingly unrelated species can belong to the same breeds. There are over 400 dog breeds in the world, and this number is increasing every year (Pugnetti, 2011). Among dog species, we have some that are generally large, robust and impressive (Yilmaz & Ertugrul, 2011). Over the centuries, man's influence in the selection and breeding of this © 2024 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 3.0 license.

species has been very profound (changes in size, changes in coat colour, changes in character and behaviour, depending on their function, etc.). This selective action has helped to determine different populations, depending on their types of function (hunting dogs, guard dogs, cattle dogs, racing dogs, etc.) (González *et al.*, 2011). In Africa in general, dog breeding is of great importance for hunting and breeding, but also as a source of income; it is exploited by over 80% of the population and plays an important role in the rural and urban economy. In Cameroon, the local dog remains the species poor in investment and supervision because it is bred in a rudimentary breeding system that results in the loss of its natural aptitudes (Diffo *et al.*, 2019). This explains the low yield reported in various research studies (Kwendem, 2021), which could be due not only to the breeding system, but also to unconscious crossbreeding that has led to uncontrolled gene flow and the loss of genetic diversity and their unique characteristics (Diffo *et al.*, 2020). In the highlands of West Cameroon, the most widespread species is the local dog (73%), but insecurity and growing urbanization are leading to an increase in exotic dogs (27%) (Diffo *et al.*, 2020). Although there are no studies to morphologically define this breed, there is no data found on its genetic characteristics. This study was carried out to determine the morphological characteristics of local dogs, which are an important member of Cameroon's indigenous gene pool.

Materials and methods

Study area

The study took place in the highland Sudano-Guinean zone of western Cameroon (LN 3°5', LE 8°20'). Average altitude varies from 1400 to 2700 m. The Western Highlands of Cameroon are located between latitudes 0520' and 700'N North and longitudes 10 03' and 12 00' East. They are characterized by a highly diversified relief with altitudes ranging from 800 to 2740 m. Temperatures range from 16 to 27°C, with relative humidity fluctuating between 40% and 100%. Average rainfall, spread over a single season from mid-March to mid-November, is 1,900 mm/year, with a minimum of 1,179 mm and a maximum of 2,630 mm. The climate is Sudano-Guinean, modified by altitude. Our study was carried out in the highlands of West Cameroon, in eight different zones where the distribution of livestock breeders is more widespread. These zones are called Bamboutos, Haut-Nkam, Haut-Plateaux, KoungKhi, Menoua, Mifi, Noun and Nde. Agriculture and livestock farming are widely practiced by almost all the populations of this region. There is no coastal region in our study as represented by Figure 1.

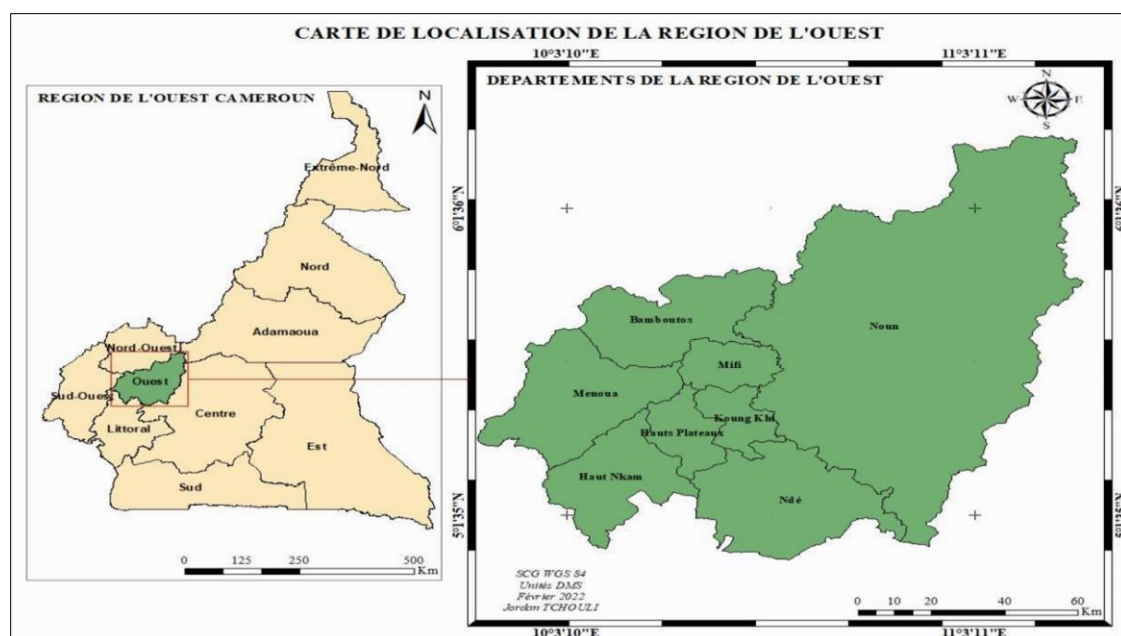


Figure 1 : Representation of the study zones in western Cameroon highlands

Choice of animals

Our work was based on studying the morphological characteristics of 320 unrelated indelicate dogs (examples in figure 2), as we excluded all related individuals and presumed purebreds from our study. We ensured that all individuals selected and studied were in perfect health and showed no signs of disease. The breeders and owners of the dogs were in full agreement before any manipulations, blood tests or measurements were carried out on the animals. The individuals are grouped according to geographical areas and sex as showed in the table below.

Table 1. Distribution of the studied samples set by geographical areas and sex

Geographical areas	Males	Females	Total
Bamboutos	15	25	40
Haut-Nkam	16	24	40
Haut – Plateaux	20	20	40
Koung-khi	20	20	40
Menoua	20	20	40
Mifi	23	17	40
Nde	22	18	40
Noun	24	16	40
Total	160	160	320



Figure 2 : Photos of some studied dogs (Original photos)

Morphometric variables

Measurements were taken using an ordinary tape measure for all quantitative variables. Sex and coat colour were also recorded. The measurement points are shown in figure 3 thus Sixteen quantitative traits were selected as shown in the table below and according to the recommendations of González *et al.*, 2011; Haddam *etal.*, 2021; Haddam *etal.*, 2024a and Haddam *et al.*, 2024b.

Table 2. Morphometric traits studied in the considered local Cameroonian dog.

Traits	Abbreviations
Height at withers	HaW
Height at rump	HR
Head length	HL
Body length	BL
Rump length	RL
Skull length	SL
Face length	FL
Tail length	TL
Head width	HW
Rump width	RW
Shoulder width	SW
Chest depth	ChD
Back-sternal diameter	BsD
Shin circumference	SC
Chest anterior girth	ChaG
Chest posterior girth	ChpG

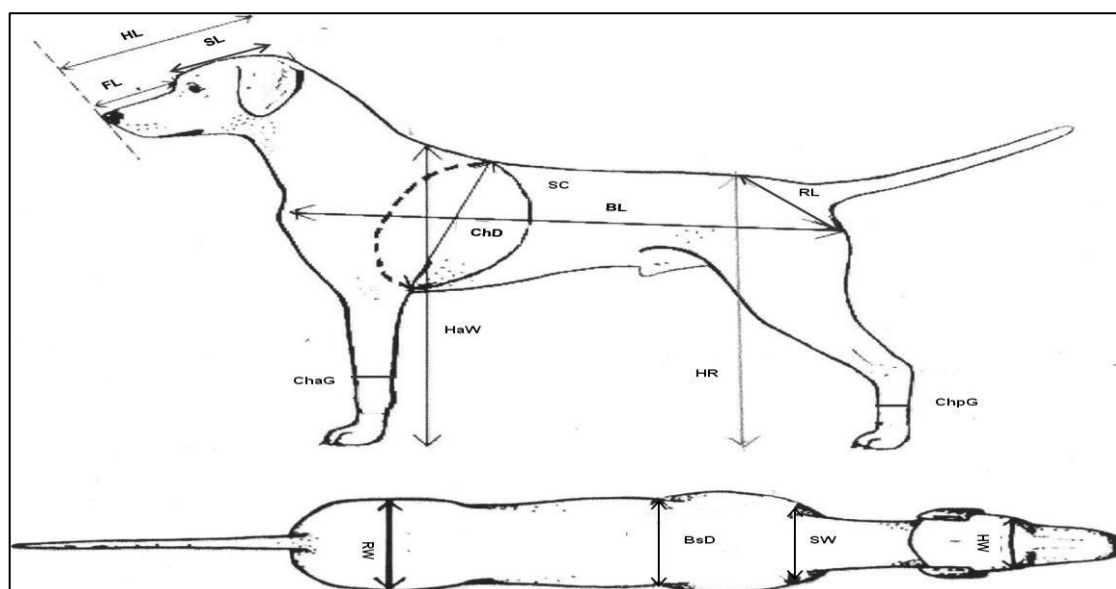


Figure 3. Overview of body measurement points in this study (González et al., 2011)

Statistical analysis.

Generally, the examination of morphometric variables using discriminate analysis techniques (simple, stepwise, cluster and canonical) has enabled the differentiation of breeds and varieties of various domestic species (Capote *et al.*, 1998; Crepaldi *et al.*, 2001; Macciotta *et al.*, 2002; Rodero *et al.*, 2003; Lanari *et al.*, 2003; Zaitoun *et al.*, 2005; Luque *et al.*, 2006; Dossa *et al.*, 2007; Marrube *et al.*, 2007; Vargas *et al.*, 2007; González *et al.*, 2011; Haddam *et al.*, 2024b). Data were analysed using R-software version 4.3.1 for Windows. The impact of sex on body measurements was determined using the t-test and the impact of localities on body measurements was assessed using ANOVA. A Principal Components Analysis (PCA) was performed in order to identify clusters of animals with similar body measurements. A Hierarchical Ascendant Classification (HAC) was also used to obtain the optimal number of groups in the considered Cameroonian highlands dogs.

Results and discussion

Body measurements

Means, standard errors, standard deviations, minima, maxima, and variances of body measurements with ANOVA and signification are summarized in the table below.

Table 3. Descriptive analysis of body measurements in the studied population in each studied zone

Traits (cm)	N	Mean±SD	CV (%)	Minimum	Maximum	Significance
HL	320	20,66±2,08	10,06	10	25	***
HaW	320	52,53±5,19	9,88	40	64	*
BL	320	53,64±6,20	11,55	30	70	**
RL	320	14,41±1,67	11,59	9	19	ns
HR	320	51,17±5,31	10,37	39	63	**
SL	320	10,76±0,93	8,63	8	13	**
FL	320	9,81±1,10	11,25	7	14	***
HW	320	10,73±1,47	13,71	7	15	***
RW	320	11,45±3,30	28,83	7	27	***
SW	320	11,27±2,06	18,26	6	17	***
ChD	320	17,50±2,16	12,33	13	24	*
BsD	320	14,03±2,75	19,58	8	25	***
SC	320	54,80±6,41	11,70	34	70	***
ChaG	320	11,38±1,24	10,88	8	15	**
TL	320	28,96±6,14	21,19	3	50	ns
W	320	14,22±2,11	14,83	11	24	***
ChpG	320	10,38±1,31	12,60	7	14	**

N: number of samples, SD: Standard deviation, CV: Coefficient of Variation, Significance: very highly significant $p \leq 0.001$ (***), highly significant $p \leq 0.01$ (**), significant $p \leq 0.05$ (*), Not significant (ns).

The table above shows the results of the descriptive analysis of the body measurements of dogs from each locality in our study area. The analysis of variances shows that there are statistically significant differences between individuals in the different localities of the study area. These differences are highly significant for the variables HL, BL, FL, HW, RW, SW, BsD, SC, P ($P \leq 0.001$); highly significant for the variables BL, HR, SL, ChaG, ChpG ($P \leq 0.01$) and significant for the variables HaW and ChD ($P \leq 0.05$). Thus, locality would have an influence on the variables cited above regardless of their age and gender. In other words, the measurements cited above are particularly different from one locality to another, reflecting the presence of genes responsible for these measurements that are specific to each of the localities considered. Some studies showed that body measurements could be impacted by the geographical area, in Turkey, especially in the Tazi breed, there were a difference among the three subpopulations (Yilmaz & Ertugrul, 2011). In the Algerian Sloughi the results reported by Haddam *et al.*, 2024b showed that there were differences among the three studied regions of Algeria. These results are approximately similar and confirm that the geographical areas could have a direct impact to the development of some body measurements of dogs' populations.

The results of the impact of sex on body measurement are presented in the table below.

Table 4. The impact of sex on body measurements

Traits	Sex		Significance
	Males	Females	
HL	20,74±2,05	20,59±2,11	ns
HaW	53,53±5,08	51,53±5,12	***
BL	54,64±6,56	52,64±5,66	**
RL	14,49±1,69	14,32±1,65	ns
HR	52,14±5,38	50,20±5,07	***
SL	10,77±0,88	10,74±0,97	*
FL	9,90±1,03	9,71±1,17	ns
HW	10,88±1,52	10,58±1,41	ns
RW	11,40±3,13	11,50±3,47	ns
SW	11,35±1,99	11,20±2,12	ns

ChD	17,70±2,10	17,31±2,21	ns
BsD	14,04±2,58	14,01±2,91	ns
SC	55,60±6,43	54,01±6,31	*
ChaG	11,53±1,26	11,23±1,20	*
TL	28,86±6,80	29,06±5,41	ns
W	14,33±2,11	14,10±2,11	ns
ChpG	10,55±1,34	10,21±1,26	*

*, significant difference ($p < 0.05$), **, highly significant difference ($p < 0.01$), ***, very highly significant difference ($p < 0.001$), ns: no significant difference ($p > 0.05$).

The table above shows the results of the impact of gender on the body measurements of the dogs in the study area. The analysis of variances shows that there are highly statistically significant differences between individuals of different sexes. These differences are highly significant for the variables HaW and HR, ($P \leq 0.001$); highly significant for the variable BL, ($P \leq 0.01$) and significant for the variables SL, SC, ChaG and ChpG ($P \leq 0.05$). Thus, the sex of the dogs could have an influence on the aforementioned variables regardless of the locality and age of the dog. In other words, the results presented in this table may suggest that the genetic traits expressed through these measurements are gender-specific. Similar results on some of these parameters have been reported by the work of (O. Yılmaz & M. Ertuğrul, 2011) on dog breeds such as the Turkish Tazi, in the Algerian sighthound raised in the northwest of Algeria (Haddam *et al.*, 2021) and in the Algerian Sloughi (Haddam *et al.*, 2024b) and in the Spanish Podenco (González *et al.*, 2011).

A principal components analysis (PCA) was applied on body measurements variables in order to study the different correlations among groups of variables in the studied population and also with the aim of grouping dogs with similar body measurements. The results of the PCA are presented in the figure below.

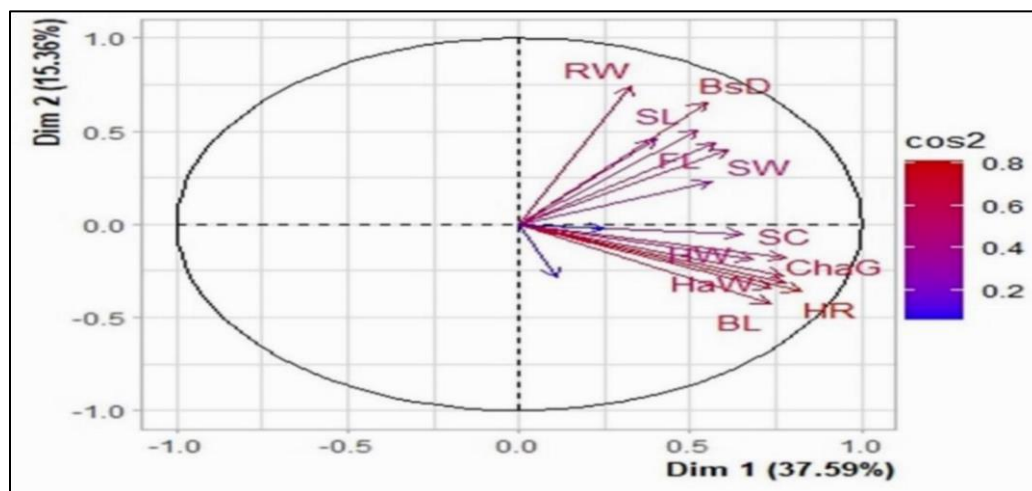


Figure 2 : PCA of body measurements of the local Cameroonian dog considered samples

The results of the principal component analysis (PCA) on body measurements showed that these variables presented 52.95 % of the total inertia on axes 1 and 2 (Dim 1 = 37.59% and Dim 2 = 15.36%). The figure above illustrates the variables considered in the study according to their correlation coefficients (representational quality) with the principal components. The blue arrows illustrate variables with low correlation coefficients, and the red arrows illustrate variables with high correlation coefficients. Thus, among the measurements considered, only those related to the variables W, TL and HL are very poorly represented, while the variables BL, HR, BsD, RW and ChpG are fairly well represented in the plan and can therefore be used as elements of comparison between the dogs in the study.

A hierarchical clustering on principal components was applied in order to check the adequate number of possible clusters that constitute this population of dogs. The factor map of individuals (dogs) is represented in the figure below

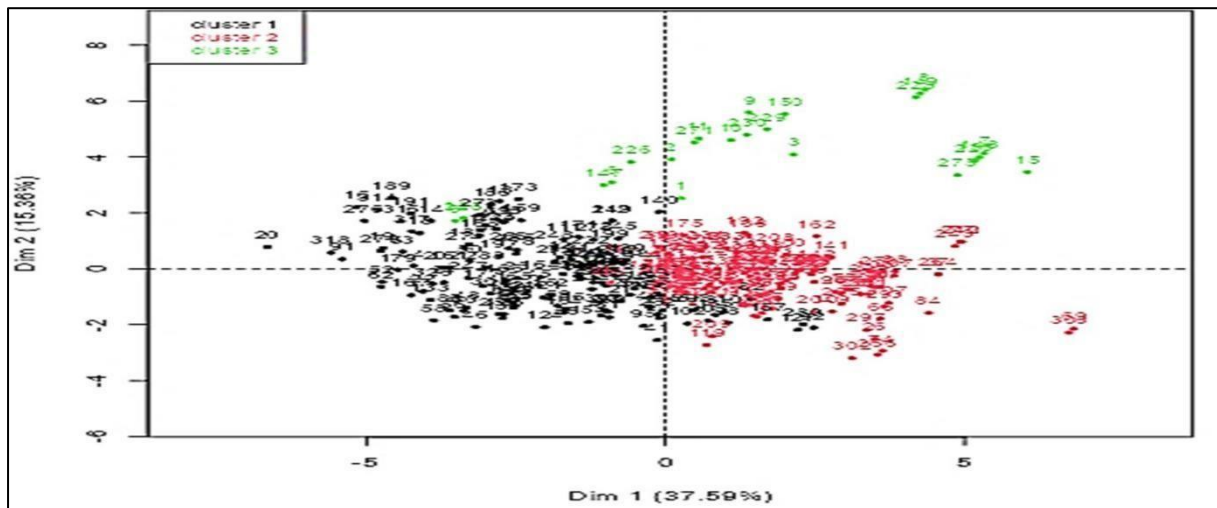


Figure 5: Representations of dog clusters in the plane

The figure above illustrates the representation of individuals (dogs) from the three classes in the plane. The black, red and green dots represent dogs belonging to classes 1, 2 and 3 respectively. Indeed, the coloured points closest to the origin show the dogs of the corresponding class weakly represented in the plane, while the coloured points furthest away show the dogs of the corresponding class strongly represented in the plane. As a result, classes 1 and 2 are quite similar to each other, and are less well represented than class 3.

Using the results of Principal Component Analysis represented in Figure 4 and those of the Hierarchical Ascendant Classification represented in Figure 5, we can infer the presence of three different Classes of animals in the studied sample set; these classes are morphometrically heterogeneous which reflects a high rate of variability.

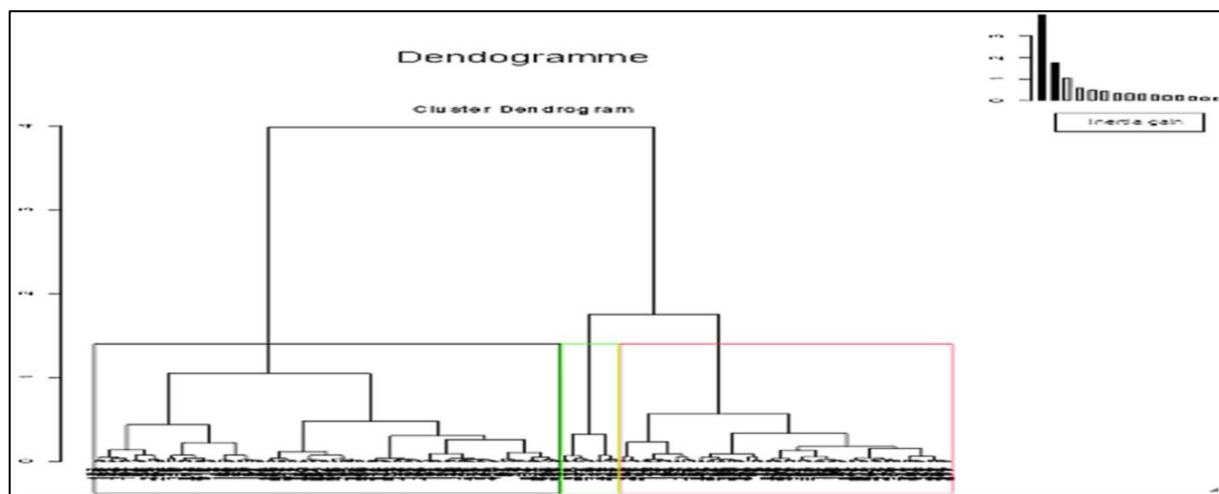


Figure 6: Hierarchical tree of the local Cameroonian dog using average distance (among classes).

It should be noted that clades located at the same level in the dendrogram illustrate the most similar individuals (dogs) in terms of their characteristics, while clades not located at the same level illustrate individuals (dogs) that differ in terms of their characteristics. In fact, this dendrogram shows that class 1 (shown in black) has individuals (dogs) that are quite distinct from one another, as the Euclidean distances between the different clades that make up this class are quite large, but these dogs have a number of common characteristics that enable them to be differentiated from those of the others. Class 2 (shown in yellow) has individuals (dogs) that are very close in terms of measurements, as the distances between the clades that make up this class are very small compared with those of the other classes. Class 3 (shown in red) has individuals (dogs) that are quite distinct from one another, as the Euclidean distances between the different clades that make up this class are quite large, but these dogs have a number of common characteristics that allow them to be differentiated from those of the others. Thus, from a general point of view, the dogs in each of the three classes are different from one another. However, the dogs in classes 1 and 3 are very different from one another in terms of measurements,

The figure above illustrates the individuals (dogs) with the most similar characteristics grouped into classes with the Euclidean distances separating them. Thus, it can be seen that dogs in class 1 and class 2 have Euclidean distances very close to each other, i.e. most dogs in class 1 have characteristics similar or close to those of class 2. Similarly, class 3 dogs were found to have Euclidean distances quite distant from classes 1 and 2, meaning that most of the dogs in this class have characteristics different from or distant from those of dogs in classes 1 and 2.

Means and standard deviations of each body measurements in each cluster are reported in the table below. whereas they are fairly close to those in class 2.

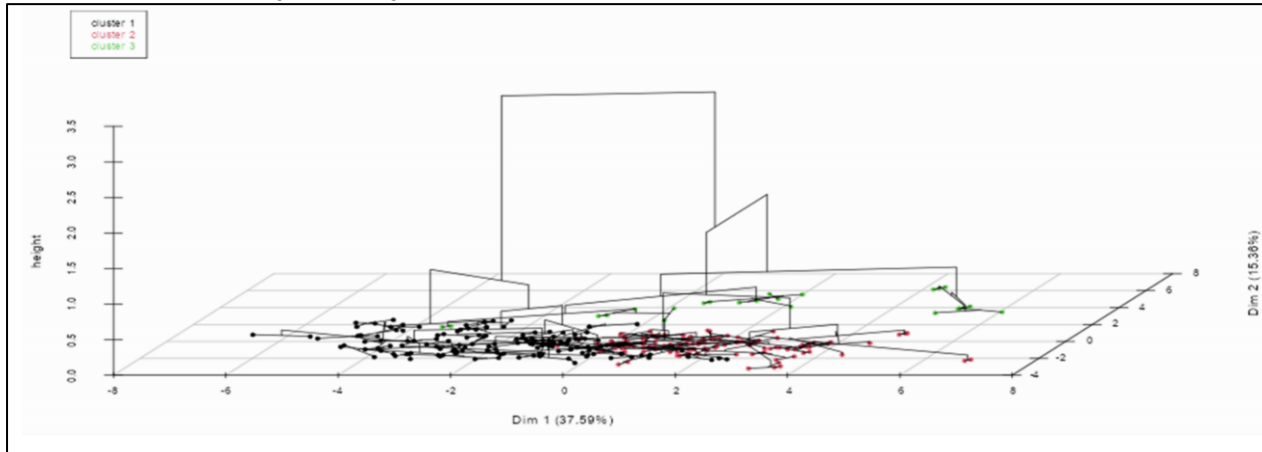


Figure 7: Hierarchical tree of dogs divided into classes based on similarity traits

Table 5. Variations between classes identified by Hierarchical classification.

Traits	Cluster 1	Cluster 2	Cluster 3
HL	20.18±2.06	21.00±1.84	22.59±1.85
HaW	49.86±4.28	56.52±3.57	52.53±5.19
BL	50.56±4.86	58.52±4.58	50.54±5.77
RL	13.72±1.42	15.04±1.48	16.27±1.63
HR	48.11±4.17	55.64±3.32	51.17±5.31
SL	10.40±0.79	11.06±0.80	11.91±1.04
FL	9.44±0.96	10.07±0.86	11.18±1.69
HW	9.99±1.198	11.72±1.25	10.73±1.47
RW	10.33±1.70	58.52±6.19	21.77±3.19
SW	10.30±1.62	11.95±1.58	15.13±1.32
ChD	16.55±1.93	18.61±1.66	18.82±2.55
BsD	12.80±1.36	14.03±2.75	21.68±2.26
SC	51.33±5.31	59.31±4.40	54.80±6.41
ChaG	10.70±1.00	12.35±0.85	11.38±1.24
TL	27.86±6.34	30.33±5.90	28.96±6.14
W	14.22±2.11	14.61±2.28	14.42±2.01
ChpG	9.64±1.07	11.41±0.88	10.38±1.31

The table above shows the characteristics (variations) of the different classes according to hierarchical ascending classification (HAC). Class 1 includes dogs with low values for the variables TL, HL, FL, RW, SL, RL, ChD, BsD, SW, BL, HW, HaW, SC, ChaG, ChpG, HR, from localities in the Menoua and Hauts Plateaux regions. Class 2 includes dogs with high values for the variables HR, ChpG, BL, ChaG, HaW, SC, HW, ChD, RL, SW, SL, FL, TL, W, HL, mainly from the Hauts Plateaux, Mifi and Koungkhi. Class 3 includes dogs with high values for the variables lc, BsD, SW, FL, SL, RL, HL, ChD, low values for the variable BL and coming mainly from the Bamboutos locality.

Conclusion

This study is the first to examine the morphometric characterization of indigenous Cameroonian dogs. The overall results of our study reveal that the local dog (bred in the western highlands) is a medium-sized dog, this study revealed that there are varieties with extremely short and extremely long bodies in relation to withers height. This is very important, because when formulating an official breed standard, all possible variations of the breed must be taken into account. This study also shows that the difference between the animals is due to their body size and sex. This study represents a first step in the characterization of indigenous dogs in western Cameroon; the impact of the study is currently limited by the restricted sampling area. Extending this approach to other geographical areas will be necessary to obtain a clear idea of the morphological diversity of the native Cameroonian dog. A clear picture of the morphological diversity of the breed under consideration and to obtain information, possibly coupled with the study of polymorphic molecular markers, on the dogs of western Cameroon. The study of polymorphisms in molecular markers and the genetic diversity and structure of the native Cameroonian dog is very recommended in order to clarify the genetic structure of the Cameroonian dog populations.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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