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Research Article

Morpho-Biometric Characterization of Goats in the Agro-Ecological Zone of the Guinean High Savannahs of Adamaoua Cameroon

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Abstract

A genetic characterization of goats based on visible polymorphisms and on the calculation of primacy indices was conducted from August to September 2013 on a sample of 101 farms, (relatively similar production conditions) each with at least 06 animals with different phenotypes and at least 2 origins of animal acquisition were sampled for a total of 249 goats (168 females, 49 males and 32 castrated) taken from traditional farms in the agroecological zone of the Guinean High Savannahs of Cameroon. The main results show that: almost all goats have horns with the exception of one motte goat probably because of its young age. The color is mostly brown and all pigmentary patterns identified in the goat species are present with a predominance of five types: illegible, eumelanic, chamois, eumelanic and light belly and phaeomelanic. The type of eumelanin is mostly illegible. The facial profile is mostly concavilinear (95%), the horns dominated by those of straight types are in most cases oriented backwards (72.30%), the tassels are rare (3.61%); The ears are erect (79.9%), semi-drooping (6%) or drooping (6.6%). Frosting is rare as well as variegation. The prime ratings are 0.84 and 0.84 respectively for the segregated loci primarity index (IPs) and the locus agouti primarity index (IPa). The polynomial regression equation (Live Weight (PV) = 56.13-1.71PT +0.018PT2) better predicts live weight with R2 = 0.77. Principal component analysis shows that the cumulative variances of the first two components (weight and body length) explain 65.07% of the genetic variability within the local goat population. These results confirm the degree of belonging of goat populations or breeds to the primary population category (initially traditional population) and the possibility of using selection as a means of genetic improvement.

Keywords: Population Genetics; Visible Polymorphism; Goats; Guinean High Savannahs of Adamaoua-Cameroon; Barium Equation; Population Structure

Introduction

In Cameroon, small ruminants, which contribute more than 17% to the coverage of protein needs, remain among the most widespread livestock on the globe and the most adapted to their environment of origin [11]; however, they play an undeniable socio-economic role and are increasingly competing with cattle even in the most intensified systems thanks to their productivity and the potential organoleptic quality of their milk and meat [1,13,18]. However, their productivity remains low due to the abandonment of local livestock practices [25] and the insufficient control of these genetic resources. However, the need to increase economic gains has led to the crossing between local and imported breeds, resulting in the replacement of local breeds by exotic breeds, resulting in their susceptibility to genetic erosion [11,14,15], loss of viability, fertility, disease resistance and frequent onset of congenital diseases due to the presence of recessive genes [11,22,44]. Knowledge of these genetic resources, namely their morphobiometric, genetic and zootechnical characterization, and their cultural interest, are the main areas of conservation activities in livestock farming [9,41]. The characterization of local genetic resources depends on knowledge of the variation in morphological traits that has played a fundamental role in the classification of animal genetic resources [12,51]. The first step for the characterization of animal genetic resources is the determination of the variability of morphological traits [5].

Although various studies have focused on goats in northern and western Cameroon, to our knowledge, there is no precise genetic information on the goat of the Guinean high savannahs of Adamawa-Cameroon. The goat population is said to be very varied. Studies [26] have established the existence of major and standardized groups, types of goats within breeds after the domesticatory phase. Color diversity and morphobiometric characterization have been proposed as strategies for domestic population analysis [3,27,29].

The general objective of this work is to contribute to a better knowledge of the goat population in the Agro-ecological Zone of the Guinean High Savannahs of Adamaoua-Cameroon. More specifically, it is a question of describing morpho biometric characteristics, determining barium equations from measurements and analyzing genetic variability and population structure through the use of principal component analyses.

Methodology

Presentation of the study area

The Adamaoua is located between the 6th and 8th degrees north latitude and between the 11th and 15th degrees east longitude. It has 05 Departments with a population of 681,362 inhabitants, an area of 63,701 km 2 for a density of 10.7 inhabitants per km^2 It consists in all of highlands that cross it from West to East [16]. Its borders are as follows: to the north, by the northern region, to the south, by the central, north-west and west regions, to the east, by the Central African Republic, to the west, by Nigeria. Attached is the map of the study area.

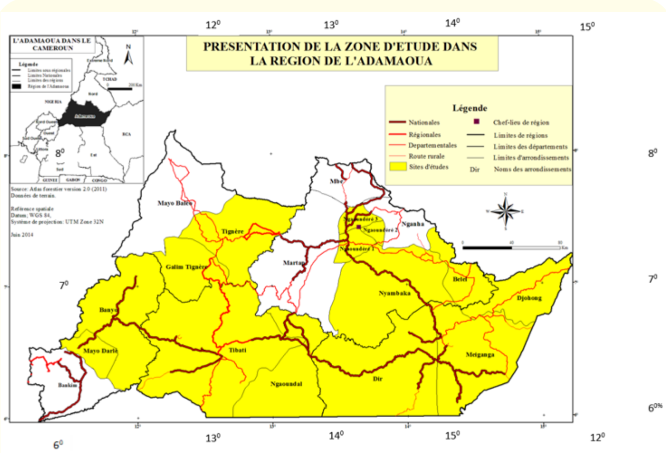

Figure 1: Map of the agro-ecological zone of the Guinean high savannahs.

Sudano-Guinean type, the climate remains temperate and generally very rainy. Average cool temperatures hover around 20°C. Up to 7 months of rainfall per year are sometimes recorded and averages of 1772 mm with a maximum of 2172.5 mm recorded in Tibati in the Department of Djerem. Due to its geographical position, the Adamawa plateau has a buffer vegetation between the forest to the south and the steppe to the north. But this vegetation gradually degrades to become a grassy savannah in the northern plain. The Adamawa plateau benefits from a discontinuous vegetation cover consisting in some areas of grasses based on Hyparrhénia, while in others Panicum and Sporobolus prevail [16]. Of volcanic origin, the soils are predominantly basaltic with very high aluminum toxicity which does not favor the intensive cultivation of cereals on which populations depend mainly for their food. They deteriorate considerably due to the abundant rainfall that the plateau records each year, associated with overgrazing and bush fires [16]. The Adamawa plateau is the water tower of Cameroon. It gives rise to many rivers that feed three of the four basins of the repetitive East African national hydrographic [16].

Sampling and animal material

With the support of the services of the Regional Delegation of Livestock, Fisheries and Animal Industries (DREPIA) of Adamawa and the services of the National Agricultural Extension and Research Program (PNVRA), the main goat production areas of the Region were identified and the rest of the breeders were identified by the snowball method. 101 farms (relatively similar production conditions) each with at least 06 animals with different phenotypes and at least 2 animal acquisition origins were sampled. This sample was distributed in 05 Departments, 14 districts, 38 villages and 1village market of the Region.

The animals taken were chosen according to the information obtained from the breeders and our observations carried out on site, in particular relating to the physical appearance of the animals (prominence of the bones of the vertebral, scapular and lumbar processes, prominence of the flanks, absence of injuries) and the apparent state of health of these (shine of the coat, absence of throwing, breathing rate and pulse, color of mucous membranes). The following table 1 gives the distribution of animals by department and sex.

Collection of morphobiometric data

The data were collected using the Lauvergne-derived Meutchieye approach [27,28].

Sex	Departments					Total
	Djérem	Faro and Deo	Swimsuit Bathroom	Mbere	Blame	
Males	6	5	5	11	22	49
Castrated	6	7	6	2	11	32
Females	20	12	29	35	72	168
Total	32	24	40	48	105	249

Table 1: Distribution of the study sample by department and gender.

Morphological data

Concerning the appendoroptic characters, the information was obtained by direct observation relating on the one hand to the presence/absence (beard, pampille, horn, frosting, variegation, roan etc.) and on the other hand to the orientation (of the tips, horns, and ears).

Coat colour was identified by direct daylight observations and based on the visible detection scale developed by Meutchieye (2008) and derived from Lauvergne., *et al.* (1993a) and Danchin Burge (2005).

The facial profile (concaviline, covexiline, and rectilinear) and rear profile (straight, curved and raised) of the animal were obtained by observing the shape of the animal's head and rear end respectively with the naked eye.

The proportions (brevilinear, elongated and mediologist) and the format (epilometric and hypermetric eumetric) were made by observation with the naked eye and were confirmed by the calculation of the substernal gracility index.

Biometrics

Biometric data (thoracic perimeter (PT), chest depth (PrT), withers height (HG), body length (Lcrps), ear length (LO), tail length (LO), scapuloischial length (LSI), hip width (LH), pelvic length (LB), chest circumference (TP), anterior barrel circumference (TCA) , and head length (LT) were obtained using a tape measure for a cutter (1 mm near precision) according to the method described by Katongole., *et al*. [21] and Laoun, [30] and a toise. These measurements were taken as follows in figure 2.

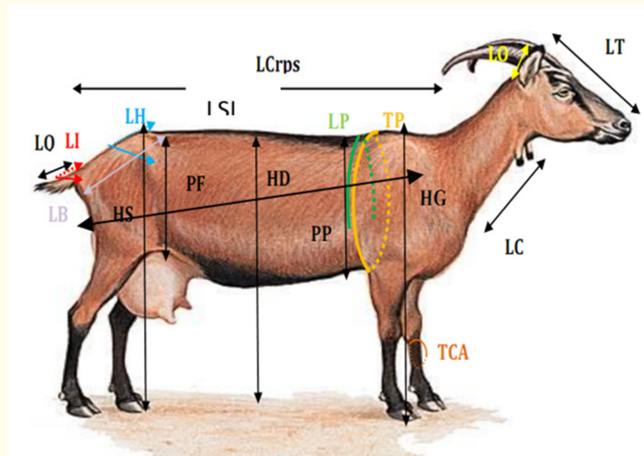

Figure 2: Different measurements considered in goats. Source: Mannallah I, 2011.

Live weight (PV in kg) was obtained using an electronic scale with a capacity of 50kg and sensitivity of 10g.

Calculated parameters

Morphological indices

These indices were calculated on the basis of pigmentary alterations observed in the animal and on the traits linked by the genes with visible effects. Here we note the presence by 1 and the absence by 0.

Primarity index ''segregated visible effect locus'' (IPs): IPs = $n\ s/N_s$

Where ns is the number of segregated visible effect loci observed at the site, and Ns is the number of visible effect loci identified in the species [28].

IPs indicates the degree of primary character of the population of goats studied, the higher it is, the less the selection has taken place, hence the primary character of the population

Primarity index ''allele at the agouti'' locus (IPa)

The estimation of this index is based on the observation of the segregation effect of alleles at the agouti locus. The traits considered are qualitative depend on a low number of genes. The presence is denoted by 1 and the absence by 0. IPa = $(n_{a-1})/(N\ a-1)$

Where ''na'' is the number of alleles identified in the population, and Na is the total number of agouti alleles considered in that population [28].

The clues that made it possible to estimate the archaism of the herds considered are live weight prediction equations on body measurements were established in accordance with the requirements [2,34,40,47].

Statistical analysis

Descriptive statistics were used to describe the distribution of qualitative traits: coat colour, horning, beard, frosting, tassel and ears.

As all other effects of factors (sex, age, and interactions) were not significant, only the locality factor (Department) was considered according to the model

The ANOVA model was: $Y_{ij} = \mu + ß_i + e_{ij}$

µ: Average population

$ß_{i:}$ Effect of locality

$e_{ij:}$ Effect specific to each animal.

The analysis of variance (ANOVA) made it possible to test the influence of the factor (localities) on the different body measurements considered. To separate the means when the effects of the factors were significant, the Duncan test was used.

SPSS21.0 software (SPSS Inc, 2010) and R-gue software were used for all local goat analyses. To identify the different phenotypes, a typology of goats was performed using principal component analyses based on the 13 collected measurements and multiple correspondence factor analysis (AFCM) followed by hierarchical ascending classification (CAH) according to the criterion of Ward's jump and discrimination. Quantitative variables and their modalities have been codified, and redundant and non-usable variables have been removed. The groups were assessed by multiple comparison of the means of the following biometric characters and the Fisher test at $p < 0.05$. These different analyses were performed using the software R i386 3.0.2 and XLSTAT 7.5.3 (42, 19) for the dendrogram we used Mahalanobis distances between genetic types.

Results and Discussion

Results

Morphological characters of the local goat of the Guinean High Savannahs of Adamawa-Cameroon

Pantereric characters

a-Horns, tassels, frosting, colour and curling

Table 2 summarizes the modality, numbers and frequencies of the phaneroptic profiles of the local goat of the Guinean High Savannahs of Adamawa-Cameroon.

Pantereoptic profile	Modality	Actual	Frequency (%)
Colour	White	30	12,05
	Brown	124	49,80
	Black	95	37,75
Bouclure	Absent	249	100,00
	This	0	0,00
Horns	Present	248	99,60
	Absent	1	0,40
Shape of horns	Spirals	18	7,20
	Curved	138	55,40
	Straight	93	37,30
Horn orientation	Side	5	2,00
	Backwards	180	72,30
	Forward	64	25,70
Ear orientation	Upright	199	79,9
	Horizontal erects	33	13,30
	Semi-drooping	3	1,20
	Drooping	14	5,6
Panachure	Present	14	95,38
	Absent	235	5,62
Pampilles	Present	9	3,61
	Absent	240	96,39
Frosting	Present	12	4,82
	Absent	237	95,18
Goatee	Present	54	21,69
	Absent	195	78,31

Table 2: Modalities, numbers and frequencies of the phaneroptic profiles of the local goat of the Guinean High Savannahs of Adamaoua-Cameroon.

Table 2 shows that the coat is brown (50%) or black (38%). The local goat has no curl (100%) and the horns are mostly present (99.60%) and generally curved (55.4%) or straight (37.30%) and rarely spiral (7.20%). The ears are erect (79.90%), the tassels rare (3.61%) as well as the frosting (4.82%) and the variegation (5.62%) while the goatee is moreor less present (21.69%). The frosting, tassels and beards are illustrated by photo 1, the orientation of the horns by photo 2 and that of the ears by photo 2.

Photo 1: Presence of frosting, tassels and goatee.

Photo 2: Horn orientation in the local goat.

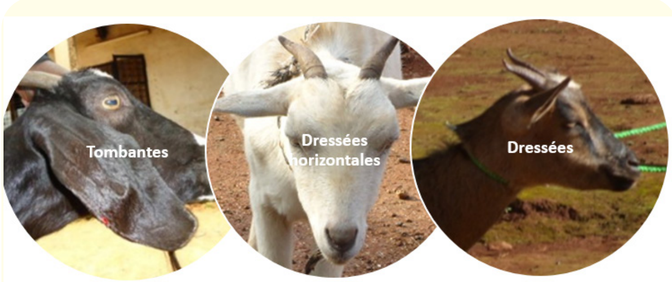

Photo 3: Different ear orientations.

b-Colorful patterns

The coloured patterns of the study population are shown in figure 3.

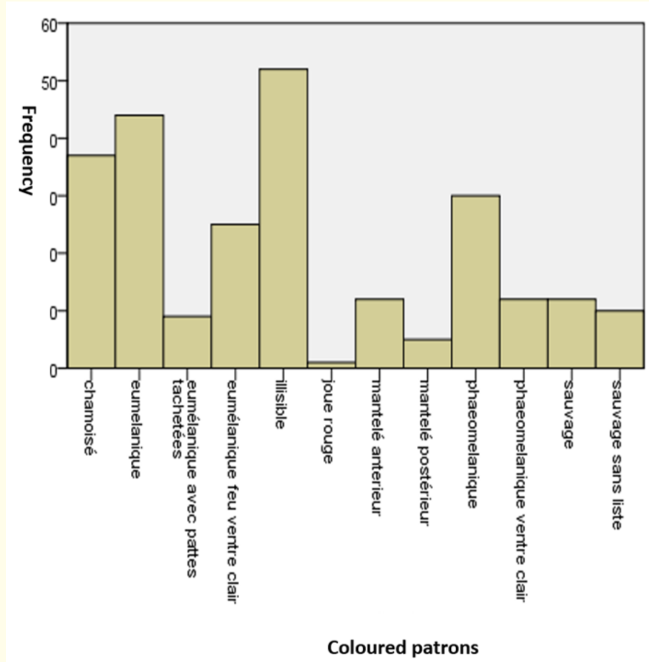

Figure 3: Main colored patterns of the study area.

The illegible type is dominant, followed by the eumelanic pattern, chamois and phaeomelanic. The distribution of staff within each Department is shown in table 3.

Table 3 shows that the illegible pigment pattern is the most dominant (20.88%) followed by the eumelanic pattern (17.67%) while the red cheek pattern is the least represented (0.41%).

The viability of coloured patterns in the study population is illustrated in photo 4.

In our study area, all the variants of the colored patterns described by [28,29]; [4] are present. The relative proportions of pigmentary types reported by [17] within the goat population of

Northern Cameroon are not confirmed in our observations. The unidentified pigment pattern in the North Cameroon region (Eumelanic and light belly fire) was observed in our study. Our results are close to those of [37] in Northern Cameroon and those of [36] in the highlands of West Cameroon. The diversity of colored patterns is an indicator of the lack of rationalized selection within goat populations this is confirmed again in our sample with the high percentage of the illegible pattern.

c-Morphological indices (IPa and IPs)

Primarity indices ''identified at locus agouti ''IPa''

The primacy indices at the agouti locus are presented in table 4.

It appears in table 15 that the primacy index is generally close to 1 (0.73 -1) throughout the area and suggests the primary (wild) level of the population.

Primarity index identified with «segregated visible effects loci» IPs

The index of primarity with visible effects in segregation according to the Departments is presented in table 5.

Table 5 shows that the SPI varies from 0.77 to 1 between the Departments slightly lower than the IPA, suggesting once again that the population studied is primary.

Colorful patterns	Departments					All Departments
	Djérem	Faro and Deo	Swimsuit Bathroom	Mbéré	Blame	
Eumelanique	1	1	1	1	1	1
Red cheek	1	0	1	1	1	1
Eumelanic with tached legs	1	0	1	1	1	1
White-bellied eumelanic	1	1	1	1	1	1
Anterior mantle	1	1	1	1	1	1
Mantelé posterieur	1	0	1	1	0	1
Chamoisé	1	1	1	1	1	1
Wild	1	1	1	1	1	1
Wild without list	0	1	1	1	1	1
Phaeomelanique	1	1	1	1	1	1
White-bellied phaeomelanic	1	1	1	1	1	1
Unreadable	1	1	1	1	1	1
On	12	12	12	12	12	12
on	11	9	12	12	11	55
IPa	0,91	0,73	1	1	0,91	1

Table 4: Primarity indices (IPa) identified at the agouti locus by department.

IPa = (na-1)/ (Na-1): primacy index of alleles at agouti locus; Na: Number of Alleles Considered; na: Number of alleles observed. Presence is denoted by 1 and absence 0.

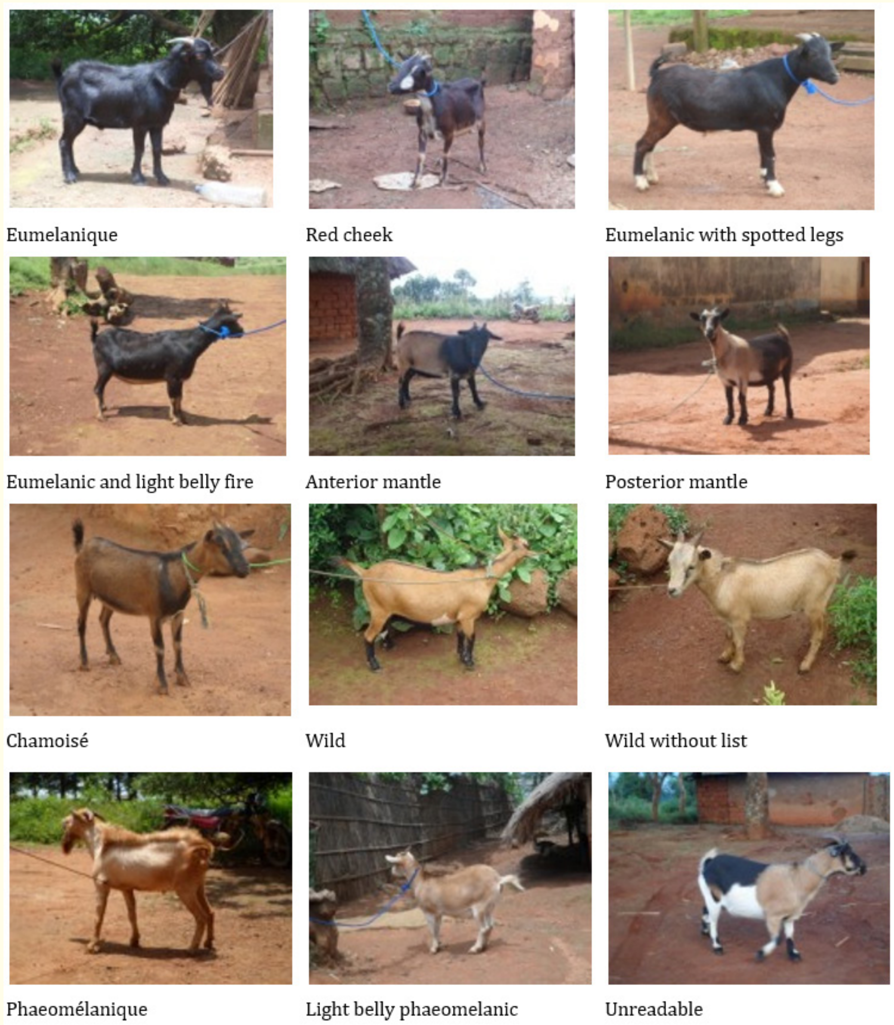

Photo 4: Colourful patterns of the goat populations studied.

Locus	Departments					All Departments
	Djérem	Faro and Deo	Swimsuit Bathroom	Mbéré	Blame	
Agouti (Ab, At, Ao)	1	1	1	1	1	1
Brown (Bb, Br+)	1	1	1	1	1	1
Frosting (FrD, Fr+)	1	1	1	1	1	1
Beard (Bdb, Bd+)	1	1	1	1	1	1
Roan (RnR, Rn+)	1	1	1	1	1	1
Horns (HoP, Ho+)	0	0	0	1	0	1
Hairs (HLl, HL+)	1	1	1	1	1	1
Wattles (Waw, Wa+)	0	1	1	0	1	1
Spotting (S)	1	1	1	1	1	1
ns	7	8	8	8	8	1
Ns	9	9	9	9	9	1
IPs	0,77	0,88	0,88	0,88	0,88	1

Table 5: Indices of visible effect traditionality in segregation (IPs) by Department.

IPs = (ns/Ns): primacy index at the loci visible effect in segregation; ns: number of loci observed in segregation; Ns: number of loci considered. The presence is denoted by 1 and the absence by 0.

The IPa is 1 for the entire study area. It should therefore be noted that, in general, low IPa values correspond to small population sizes. The primary character of the local goat of the Guinean high savannahs of Adamaoua Cameroon corroborates with the thesis of Droutressolle. [8,10] who describe African goat populations as variegated and «traditional». Studies carried out with the calculation of primacy indices confirm this hypothesis in Chad, [28] northern Cameroon (28.37), Algeria [23], France (Lauvergne., *et al.* 1997) and western Cameroon [36].

There is some variation from one site to another for the index of primacy with visible effect in segregation (IPs) but in general it is close to 1, which reflects a great variability and shows that all the variants that have segregated since the domestication of the goat species are present in the goat population of the Guinean high savannahs of Cameroon. We can thus conclude that this population is of primary type, the absence of certain mutant such as horns and reduced ears leads to a lower value than that of IPa.

These values are comparable to those obtained in the first survey in Cameroon [36] and Chad [28] in both the Mediterranean basin and Brazil. Similarly, the same data were obtained in Algeria both in the steppes and in the desert [23].

Visible profiles

The local goat of the Guinean high savannahs of Adamaoua-Cameroon is of the concavilinear type (Figure 4).

Figure 4 shows that the facial profile is more than 95% concaviline.

Biometric characters of the local goat of the Guinean High Savannahs of Adamaoua-Cameroon

Perimeter of thorax, depth of thorax and circumference of anterior barrel

Table 6 summarizes the thoracic and anterior cannon measurements in the local goat of the Guinean high savannahs of Adamawa Cameroon.

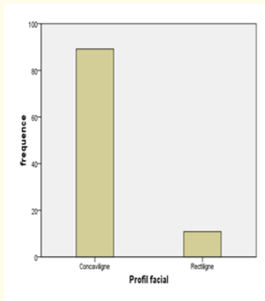

Figure 4: Facial profile of the goat studied.

Chest circumference

The average value of the thoracic circumference in all subjects is 65.79cm, comparable between departments with an average coefficient of variation of 11%. However, the goats of Vina are more dispersed (CV = 12.31%) compared to those of Faro and Deo which are more homogeneous (CV = 8.88%).

Chest depth

The depth of the thorax is statistically comparable between departments with an average of 25.15cm and a coefficient of variation ranging from 7.81% (Faro and Deo) to 10.59% (Vina).

Departments	N	Circumference thoracic		Depth chest		Perimeter of the anterior barrel	
		µ ± and	CV (%)	µ ± and	CV (%)	µ ± and	CV %
Djérem	24	64,73 ± 6,25[a]	9,65	24,74 ± 2,14[a]	8,65	7,69 ± 0,53[a]	6,89
Faro and Deo	22	66,52 ± 5,91[a]	8,88	25,48 ± 1,99[a]	7,81	7,69 ± 0,33[a]	4,39
Swimsuit Bathroom	35	65,30 ± 6,59[a]	10,09	24,88 ± 2,060[a]	8,28	7,51 ± 0,45[a]	5,99
Mbéré	39	65,83 ± 6,95[a]	10,55	25,22 ± 2,19[a]	10,39	7,73 ± 1,12[a]	14,49
Blame	90	66,12 ± 8,14[a]	12,31	25,48 ± 2,69[a]	10,56	7,75 ± 1,07[a]	13,81
Total	210	65,79 ± 7,22	10,97	25,15 ± 2,37	9,814	7,69 ± 0,89	11,57

Table 6: Perimeter of the thorax, depth of the thorax and circumference of the anterior barrel by Department.

a, b, c etc.: Numbers assigned the same letters in the same column indicate that there is no significant difference at the 5% threshold.

µ ± et=Mean ± Standard Deviation; N: Number of Animals

Anterior barrel tower

The circumference of the anterior barrel is statistically comparable from one Department to another with an average of 7.69cm, and an average coefficient of variation of 11.57. However, the highest coefficient of variation is observed in the Department of Mother (14.49%) followed by that of Vina (13.81%) and the lowest in the Department of Faro and Deo (4.39%) where animals appear more homogeneous.

Body length, scapulo-ischial length and height at withers

Table 7 summarizes the average body lengths, scapuloischial lengths and withers heights.

Body length

The average body length of the studied goat population is 57.88 cm. The study population seems to form 2 groups for this parameter, the Vina group significantly smaller ($P < 0.05$) and that of the Mbéré significantly ($P < 0.05$) larger. However, the population of Djérem is the least dispersed (CV = 9.38%) compared to that of Vina (CV = 11.65%) for this parameter.

Scapuloischial length

The average scapulo-ischial length of the population studied is 49.42cm, while those of Mayo Banyo and Mbéré had significantly higher averages ($P < 0.05$) than those of the other Departments and

Departments	N	Length of the body		Scapuloischial length		Height at withers	
		μ ± and	CV (%)	μ ± and	CV (%)	μ ± and	CV %
Djérem	24	58,42 ± 5,39[from]	9,38	49.96 ± 4.18[from]	8,52	50,31 ± 3,22[a]	6,4
Faro and Deo	22	56,86 ± 5,77[from]	10,17	49.18 ± 4.21[from]	8,56	50,53 ± 3,22[a]	6,372
Swimsuit Bathroom	35	58,40 ± 6,18[from]	10,83	49,10 ± 3,83[from]	7,93	48,73 ± 4,03[a]	8,27
Mbéré	39	59,59 ± 6,58[b]	11,35	50,69 ± 5,22[b]	10,54	50,29 ± 6,78[a]	13,48
Blame	90	56,12 ± 6,47[a]	11,65	48,17 ± 5,30[a]	11,11	50,31 ± 5,97[a]	11,87
Total	210	57,88 ± 6,28	10,85	49,42 ± 4,85	9,81	50,02 ± 5,47	10,9

Table 7: Body length, scapuloischial length and height at withers by department.

a, b, c etc.: Numbers assigned the same letters in the same column indicate that there is no significant difference at the 5% threshold. μ ± et = Mean ± standard deviation.

Vina a significantly smaller value (P < 0.05). However, the populations of the Departments of Djérem and Faro and Déo showed similar variations (CV = 8.5-2% and CV = 8.56%) respectively.

Height at withers

The average height at the withers of the animals of the 5 Departments is 50.02cm which confirms that the goats of the Guinean high savannahs belong to the dwarf type (Devendra and Burns, 1983). The coefficients of variation are relatively low for this parameter although that of Mbéré is higher (13.48cm) compared to that of Djerem (CV = 6.4%).

Pelvic length, hip width and chest width

Table 8 summarizes the averages of pelvic length, hip width and chest width.

Departments	N	Length of the basin		Width of hip		Chest width	
		μ ± and	CV (%)	μ ± and	CV (%)	μ ± and	CV %
Djérem	24	18,46 ± 1,38[b]	7,47	13,24 ± 1,71[b]	12,92	14,19 ± 2,12[a]	14,94
Faro and Deo	22	19,57 ± 2,18[b]	11,19	13,03 ± 2,23[b]	17,11	15,92 ± 2,40[c]	15,08
Swimsuit Bathroom	35	18,56 ± 2,39[b]	12,88	13,36 ± 2,19[b]	16,39	14,28 ± 2,26[b]	15,83
Mbéré	39	19,14 ± 2,43[b]	12,70	13,74 ± 2,43[b]	17,68	15,44 ± 2,08[bc]	14,64
Blame	90	15,97 ± 1,99[a]	12,46	11,78 ± 2,42[a]	20,54	11,90 ± 2,08[a]	17,48
Total	210	17,67 ± 2,98	16,86	12,72 ± 2,16	16,98	14,98 ± 2,89	21,25

Table 8: Pelvic length, hip width and chest width by department.

a, b, c etc.: The numbers assigned the same letters in the same column indicate that there is no significant difference at the 5% threshold. *μ* ± et = Mean ± standard deviation.

Length of the basin

The length of the average basin is 17.67 cm with 2 different groups distributed between the departments. La Vina on one side and the other Departments on the other side.

Hip width

The average hip width is 12.72cm with a coefficient of variation of 16.98%. The Department of Vina had the width significantly ($p < 0.05$) lower than that of the other 4 Departments for this parameter. In addition, coefficients of variation are generally high in all departments.

Chest width

The average breast width is 14.98cm with an average coefficient of variation of 21.25% revealing 03 distinct groups, the goats of Vina and Djerem smaller ($p < 0.05$), and those of Faro and Déo larger ($P < 0.05$).

Length of horns, ears and tail (cm)

The mean values representing the length of the ears, horns and tail are grouped in table 9.

Departments	N	Horn length		Ear length		Tail length	
		μ ± and	CV (%)	μ ± and	CV (%)	μ ± and	CV %
Djérem	24	11.15 ± 2.18[from]	19,55	11.11 ± 1.06[from]	9,54	10,04 ± 0,73[a]	7,29
Faro and Deo	22	11.37 ± 2.34[from]	20,58	10,88 ± 1,09[ab]	10,02	9,94 ± 0,69[a]	6,94
Swimsuit Bathroom	35	10,84 ± 2,37[a]	21,86	10,50 ± 0,85[a]	8,48	9,82 ± 0,51[a]	7,03
Mbéré	39	10.98 ± 2.49[from]	22,68	10,60 ± 1,26[a]	11,89	10,07 ± 0,75[a]	7,45
Blame	90	11,75 ± 2,54[b]	21,62	11,42 ± 1,68[c]	14,71	10,24 ± 1,15	11,23
Total	210	11,24 ± 2,51	33,25	11,02 ± 1,41	10,34	10,02 ± 0,93	9,09

Table 9: Horn, ear and tail length by department in the local goat studied.

a, b, c etc.: The numbers assigned the same letters in the same column indicate that there is no significant difference at the 5% threshold. μ ± et=Mean ± standard deviation.

Horn length

The average length of the horns of the local goat of the Guinean high savannahs of Adamaoua-Cameroon is 11.24cm. The population of Djerem is distinguished by a significantly smaller horn length ($P < 0.05$) than that of other Departments.

Ear length

The average ear length of the local goat of the Guinean high savannahs of Adamaoua Cameroon is 11.02cm. The goats of Mayo Banyo and Mbéré have comparable and significantly smaller averages ($P < 0.05$) followed by those of Djérem and Faro and Déo while the goats of Vina have significantly longer lengths ($P < 0.05$).

Tail length

The average length of the tail is 10.02cm. The departments have comparable values for the parameter, however, Vina has the highest coefficient of variation (CV = 11.23%) and therefore the most dispersed population.

The intervals of the thoracic circumference in the Guinea dwarf goat as described by Doutressoulle. (1947); and Dossa., *et al.* (2007) range from 60 to 75cm. This is in agreement with the data found in our study. This data corroborates with the values found by Meutchieye [36] on local goats in West Cameroon.

The depth of the thorax (25.15cm) of our population is close to that reported in Northern Cameroon or 24.05cm [17], and 26.30cm [37]. It is the same as that recorded (24.04cm) on goats in Burkina Faso [48], by [51] in the African dwarf goat (26.43 cm) and by 543) 24.37cm on the Mubende goat.

Higher chest depth values of 27.34 cm were recorded on the local goat of West Cameroon [36]; on the Mubende goat (31.4 cm) [31] and 31.42 cm on the Rousse of Maradi Yakubu., *et al. (*2010). The depth of the thorax of our intermediate sample between those of North Cameroon and that of West Cameroon could be explained by the intermediate position of the study area.

The value of the anterior barrel turn is close to the 8.15cm recorded by [33] with a coefficient of variation of 12.08% in goats in the Set if area in Algeria and lower than that found by. [51] on the Redhead of Maradi in Nigeria (9.83 cm). Moreover, this value of the turn of the anterior barrel is higher than that described by [51] in the West African dwarf goat (6.97cm).

The body length data obtained in our study area is in perfect agreement with the data obtained by Meutchieye. [36] in local goats in the western highlands of Cameroon and by Taoré., *et al.* [48] in goats in Burkina Faso (56.66 cm). However, lower body length values of 45.59cm and 42.28cm have been described in Uganda on the Mubende goat and on the East African dwarf goat [43].

The scapuloischial length recorded in goat populations in the study area is less than those described by Meutchieye. (2008) in the local goat of the western highlands Cameroon (51.30cm) and par [35] in the small goat of the east of Burundi (56 and 66cm).

So Devendra and Burns [6] classify goats into dwarfs (HG < 51cm), small formats (51-65cm) and large formats (above 65cm); they qualify Cameroonian goats as kosi with an HG ranging from 45-50cm.

These HG values are close to those found by [36] in local goats in the highlands of West Cameroon. However, these values were lower than those (53cm) found by [38] in the Lubumbashi goat in the Democratic Republic of Congo; by Semakula., *et al.* (2010) in the small East African goat (56.42 cm) in Uganda; and by Traore., *et al.* (2008) in Burkina Faso.

The length of the pond in our study is shorter than that reported (20.49 ± 3.79cm) in goats in the high plains of Set if [33]. But higher (11.80cm) than that described respectively on the West African dwarf goat and on the Maradi redhead (11.44 cm and 14.51cm) in the same locality.

The width of the hips obtained in our study (12.72 cm) is less than the 18.84 cm reported by the Red Goat of Maradi in Nigeria [51] and on the goats of the high plains of Set if (15.69 cm) [33]. However, 9.69cm reported on the West African dwarf goat [51].

If we consider these data our goats seem closer to the red goat breed of Maradi encountered in Nigeria and different from the dwarf goats of West Africa.

The width of the breast found in our sample (13.60cm) is much smaller than that (24.19cm) in the high plains of Set if [33]; but comparable to that described on the West African dwarf goat (14.24cm) [51]. These data clearly explain the similarity between our goat populations and those described by these authors.

The presence of short horns in the Guinean dwarf goat without indication of value [10,49]. In local goats of the highlands of West Cameroon it was found horn lengths of 9.71cm [36], in Northern Cameroon it was observed horn lengths of 6.65cm [17] and 12.20cm [28]. These values confirm our observations. Similar data (11.14cm) have been described in goats from Burkina Faso [48]. However, the Maradi Redhead from Nigeria has slightly longer horns (13.07cm) than the dwarf goats (7.03cm) of the same locality [51] and those in our study.

It has been established that the local goat of the western highlands Cameroon has an average ear length of 10.32cm [36]. In northern Cameroon the average ear value was 12.66cm [37] and

12.42cm [17]. The length of the ear is small in the dwarf goat of guinea (13cm) [49]. The ear-shortening gene in the Haute Roya goat induces an ear length of 6.66 cm far shorter than those we obtained. However, goats in Burkina Faso have an average ear length of 13.48 cm [48] and the Maradi Redhead from Nigeria an average of 14.52 cm [51] while the dwarf goat from the same locality had an average ear length close to that of this study.

Higher ear length values (15.4cm) were obtained in the Rove de France goat (Moulin C., 1980); in goats (16.3cm) in Brazil and Morroco [31] and 18.54cm in goats in the high plains of Set if [33]. These variations of the ear Bouchet associates a role in thermoregulation [3]. As the thermal equator is located further south of the study area, there should be a relative increase in ear length. This would explain the values obtained which are closer to those obtained in local goats in western Cameroon and lower than that of northern Cameroon by the respective climates prevailing in these areas.

The length of the tail between 5 and 14cm corresponds well to the observations described [10]. Close results (9.70cm) were described in the local goat of West Cameroon [36]. A relatively comparable tail length 11.22cm and 13.52cm respectively in the West African dwarf goat [51]. Higher values (18.38cm) were also obtained on goats from the high plains of Set if [33].

In the northern region of Cameroon it was described the goat of the humid regions of West and Central Africa as having an adult live weight of 20kg [8] and in the local goat of the western highlands Cameroon 36) found a live weight of 21.79 kg values which seems close to our observations (22.04kg); Alive weight range from 18 to 25kg in the so-called guinea type. The West African dwarf goat was described with a live weight of 15.37kg in southern Nigeria [39].

Average live weight in local goat

The live weight of the local goat in the Guinean high savannah zone of Adamawa-Cameroon is shown in table 10.

Departments	N	Average live weight (Kg)	
		µ ± and	CV (%)
Djérem	24	24,06 ± 5,56^{b}	23,13
Faro and Deo	22	19,88 ± 5,33^{a}	26,81
Swimsuit Bathroom	35	22,49 ± 6,03^{from}	26,81
Mbéré	39	24,11 ± 6,38^{b}	26,46
Blame	90	21,01 ± 6,79^{from}	32,30
Total	210	22,06 ± 6,44	29,19

Table 10: Comparison of average adult live weights in local adult goat by Department.

a, b, c etc.: The digits assigned the same letters in the same column indicate that there is no significant difference at the 5% threshold.

µ ± et = Mean ± Standard Deviation; N = Number of Animals

The average weight within the sampled population as presented in table 10 is 22.06kg with a tendency to form 2 groups: the Faro and Déo population whose weight is significantly smaller ($P < 0.05$) and that of the Mbéré whose live weight is significantly higher.

Biometric clues

i- Substernal gracility indices (IGs), atrithoracic (IAt) and dactylothoracic (IDt)

Substernal, atrithoracic and dactylothoracic gracility indices for the study populations are presented in table 11.

Substernal gracility index (IGs)

The average GI is 0.99 and the animals of the 5 Departments are comparable for this parameter ($P > 0.05$). This GI value suggests that Adamawa goats belong to the sheep goat group ($0.5 < GIs < 1$) although a slender group exists (histogram of the GIs in Appendix 3).

Atrithoracic index (Atrithoracic index)

The average value of the population tIA is 0.45 although the populations studied tend to form 2 groups: The populations of Mbéré

Departments	IGs		IAt		IDt	
	μ ± and	CV (%)	μ ± and	CV (%)	μ ± and	CV (%)
Djérem	0,98 ± 0,17a	17,35	0.44 ± 0.043from	9,71	0,12 ± 0,009a	8,21
Faro and Deo	0,99 ± 0,12a	12,12	0.42 ± 0.047from	10,87	0,011 ± 0,009a	8,55
Mbére	0,99 ± 0,15a	15,15	0,42 ± 0,045a	10,55	0,12 ± 0,016a	13,28
Blame	1,01 ± 0,23a	22,77	0,45 ± 0,063b	14,02	0,12 ± 0,015a	13,08
Swimsuit Bathroom	0,99 ± 0,18a	18,18	0,42 ± 0,029a	7,03	0,11 ± 0,009a	8,11
Total	0,99 ± 0,118	11,92	0,44 ± 0,053	12,18	0,12 ± 0,0135	11,52

Table 11: Comparison of the averages of the indices (GIs, IAt, IDt) of the goat population by department.

a, b, c etc.: The numbers assigned the same letters in the same column indicate that there is no significant difference at the 5% threshold. μ ± et = Mean ± standard deviation.

IGs: Substernal Gracility Index; IAT: Atriculothoracic Index; IDt: Dactylothoracic Index

and Mayo Banyo smaller ($P < 0.05$) and those of the other larger Departments.

Dactylothoracic index (IDt)

The average TDI of the total population is 0.12 with a coefficient of variation of 11.52%. The populations of the 5 Departments seemed comparable for this index.

Ngo Ntama., *et al.* (1996), recorded a GI value of 0.87, which is in agreement with our observations. In Benin relatively similar values (GIs of 0.79) were recorded [7]. In addition, values of 1.06; 1.14; 1.48 and 1.46 were recorded on the Rove goat from France; small goats from northern Cameroon, intermediate goats and large goats from Chad respectively [28]. Finally, values of 0.86 were recorded in the local goat of the highlands of West Cameroon [36]. According to our observations there is a fraction of intermediate population in local goats of Adamawa Cameroon because the histogram of the GIs has values greater than 1.

The tIA values recorded in the local goat of the Guinean high savannahs of Adamaoua Cameroon are close to those recorded on the goats of Northern Cameroon [37], and those obtained on the local goats of West Cameroon [36] and on the local goat in Burkina Faso [48]. Similar values were recorded by Luanna., *et al.* (2012) on goats in Brazil (0.5). Dhe values of IAt of 0.49; 0.52, 0.75 and 0.75 on the Rove goat of France; the small goat of northern Cameroon, the goats of intermediate size and the large goats of Chad respectively [29].

GIs and IAt close to 1 and 0.5 respectively are characteristic of goat populations of the first waves of migration. We can therefore conclude that the local goats of Adamawa Cameroon would belong to this group. The local goat of Adamawa Cameroon is brevipes with a depth of the middle thorax and a weak IAt which will approach the Rove goat [29]. These values suggest from [3] and [28] that the biometric measurements and indices obey Bergman's rules concerning the weight and Allen variables applicable to the size of the appendages as a function of heat. Indeed, the climatic constants between the highland and Sudano-Sahelian wetlands differ significantly.

Bivariate correlations

i- Correlations between body measurements

The correlations between the main measurements are presented in table 12.

	Weight	Lcrps	HG	PT	LP	LrH	LC	The	LSI	LQ	PrT	TCA
Weight	1											
Lcrps	0,793**	1										
HG	0,283**	0,314**	1									
PT	0,812**	0,631**	0,376**	1								
LrP	0,295**	0,424**	-0,058	0,121	1							
LrH	0,578**	0,567**	0,097	0,405**	,485**	1						
LC	0,335**	0,392**	0,227**	0,352**	0,170*	0,208*	1					
The	0,113	0,213**	0,588**	0,181*	-0,032	-0,097	0,195*	1				
LSI	0,373**	0,459**	0,227**	0,366**	0,222**	0,333**	0,190*	-0,015	1			
LQ	0,285**	0,232**	0,455**	0,295**	-0,001	0,004	0,223**	0,583**	0,149	1		
PrT	0,673**	0,535**	0,470**	0,821**	0,058	0,317**	0,310**	0,286**	0,329**	0,276**	1	
TCA	0,146	0,184*	0,815**	0,229**	-0,028	0,003	0,250**	0,582**	0,193*	0,453**	0,339**	1

Table 12: Correlation between body measurements in the local goat.

*. = $p < 0.05$); ** = $p < 0.01$)

Lcrps: Body Length; HG: Height at Withers; PT: Thoracic Circumference; LrP: Chest Width; LrH: Hip Width; LC: Horn Length; LB: Pelvis Length; LO: Ear Length; LSI: Scapuloischial Length; LQ: Tail Length; PrT: Chest Depth; TCA: Anterior Barrel Turn

From table 12, it appears that most correlations are significant and positive apart from the correlations between ear length and scapuloischial length, tail length and chest width, ear length and chest width and chest length and chest length and anterior barrel circumference.

Correlations between genetic indices in local goats

Table 13 presents the bivariate correlations between the indices calculated within the local goat populations of the agro-ecological zone of the Guinean high savannahs of Adamawa-Cameroon.

Equations barymétriques

The different live weight prediction equations based on measurements (chest circumference, body length and chest depth) are summarized in table 13.

Table 13 shows that the thoracic circumference better predicts the live weight of the local goat of Adamawa-Cameroon (R 2 ranging from 0.72 to 0.77) followed by body length (R 2 ranging from 0.53 to 0.55) or chest depth (R 2 ranging from 0.53 to 0.55) for all types.

The best live weight prediction equation is polynomial and with the thoracic circumference.

$PV = 56.13-1.71PT + 0.018PT^2$ and $R2 = 0.77$

In general, the thoracic circumference was found to be the best predictor of live weight in the local goat in the study area. However, the logarithmic equation had the best regression coefficient (0.77). The thoracic circumference is the best predictor of live weight, although the coefficient of determination ranges from 0.34 to 0.80 in

Type of equation	Independent variable	Equations	R^2
Linear	PT	PV = -28,74 + 0,74PT	0,74
	Lcrps	PV = 42,03 + 0,70Lcrps	0,55
	PrT	PV = 19, 39 + 0,3PrT	0,55
Logarithmic	PT	PV = - 129,11 + 50,75lnPT	0,72
	Lcrps	PV = 7,78 + 16,256lnLcrps	0,55
	PrT	PV = 5,31+6,76lnPrT	0,53
Polynomial	PT	$PV = 56{,}13-1{,}71PT +0{,}018PT^2$	0,77
	Lcrps	$PV = 39{,}42+ 0{,}93Lcrps + 0.0045\ Lcrps^2$	0,55
	PrT	$PV = 19{,}888 + 0{,}26PrT+0{,}0009PrT^2$	0,55
Power	PT	$PV = 0{,}0021PT^{2{,}192}$	0,72
	Lcrps	$PV = 24{,}28Lcrps^{0{,}28}$	0,54
	PrT	$PV = 11{,}906PrT^{0{,}2538}$	0,52
Exponential function	PT	$PV = 2{,}4335e^{0{,}318PT}$	0,72
	Lcrps	$PV = 43{,}972e^{0{,}012Lcrps}$	0,53
	PrT	$PV = 20{,}246e^{0{,}0112PrT}$	0,53

Table 13: Different live weight prediction equations.

PT: Chest Circumnavigation; Lcrp: Body Length; PrT: Chest Depth; PV: Live Weight

adulthood [6]. Moreover, the importance of the thoracic circumference in the prediction of live weight is the result of the fact that the muscles and certain fats surrounding the thorax bones contribute considerably to weight [24]. The determination of a formula for predicting carcass yield from live weight is a perspective of our study.

Positive correlations between withers height and all other measurements as well as face length have been demonstrated [36]. However, our results are consistent with those of other authors regarding weight and other body measurements in males and females in goat populations in southern Nigeria. Moreover, they corroborate with the work carried out in West Cameroon [36] for positive correlations but differ in terms of negative and weak correlations (between thorax depth and horn and face lengths) observed by the latter.

Population structure and phylogenetic analysis of the local goat of the Guinean high savannahs of Adamaoua-Cameroon

The phylogenetic variability of the local goat of the Guinean high savannahs is grouped in figure 5.

i-Principal component analysis (PCA)

The principal component analysis was performed on the basis of quantitative variables (body length, thoracic circumference, tail length, scapuloischial length, height at withers, width at ischiums, width of chest, width at ischium, circumference of barrel, length of horns, length of tail, length of ears, depth ofthorax and length of head) studied. table 14 provides an analysis of the 14 main components in determining the genetic variability observed within the population.

Component	Variable	Eigenvalue	Variance %	Cumulative variance
CP1	Weight	2,69	51,48	51,48
CP 2	Lcrps	1,38	13,59	65,07
CP 3	HG	1,15	9,441	74,511
CP 4	PT	0,86	5,335	79,846
CP 5	LP	0,78	4,29	84,136
CP 6	LB	0,69	3,39	87,523
CP 7	LrH	0,63	2,79	90,321
CP 8	LC	0,61	2,648	92,969
CP 9	The	0,51	1,873	94,842
CP 10	LSI	0,45	1,767	96,609
CP 11	LQ	0,40	1,154	97,763
CP 12	PrT	0,37	0,942	98,705
CP 13	Lt	0,33	0,782	99,487
CP 14	TCA	0,27	0,515	100,00

Table 14: Summary of variances and ACP eigenvalue.

Lcrps: Body Length; HG: Height at Withers, PT: Thoracic Circumference; LrP: chest width; Lrb: Hip Width; LC: Horn Length; LB: Pelvis Length; LO: Ear Length; LSI: Scapuloischial Length; LQ: Tail Length; PrT: Chest Depth; LT: Head Length; TCA: Turn of the Anterior Barrel

The cumulative variance of the first 10 components is 96.61% within the study population. In addition, the first 02 components (weight and body length) contribute to 65.07% of the genetic variability observed in our sample at a rate of 51.48% and 13.59%. The contribution of the different components used is illustrated in figure 5.

Figure 5 completes the explanation in table that the variance of weight (51%) is the highest followed by that of body length (14%). Figure 5 also shows that the curve represents the cumulative variance while the bar graph represents the individual variations.

It has been shown on dairy cows that the first main component contributes 54.8-70% and the second contributes 8.2-13.3% to the explanation of the total genetic variability observed within animal populations [45]. Other studies explain that the first 2 main components contribute to 77% of the genetic variability observed within the goat population in Bresil [31]. Withers height, ear length and chest height can be used to explain the variability of the 4 main components selected to explain the variability observed within goat populations in Brazil. Other results obtained showed that the two main components explain 94.15% (females) and 97.67% (Males) of the variation in the West African dwarf goat in southern Nigeria. They were able to determine that in his goats the parameters neck length, body length and height at withers in females and height at withers, body length and thoracic circumference in males helped to best differentiate groups of Nigerian dwarf goats.

The slight differences observed in the contributions of the first two main components to group variation within goat populations could be explained by differences in the species considered, the va-

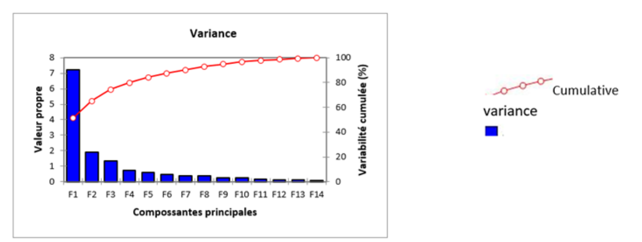

Figure 5: Contribution of the main components to the variability within the local goat population of the Guinean High Savannahs zone of Adamaoua-Cameroon.

riables used and their number on the one hand and the other by the groups considered (male or female). Despite the slight differences between the variables contributing to these variations, height at withers, thoracic circumference and body length are common to the majority of authors.

Population structure

Analyse discriminative

Multiple correspondence factor analyses using R-Gue software revealed that the study population consists of 4 genetic types. The distribution of genetic types in the departments of the study area is presented in table 15.

	Departments					Total region	
Type	**Djérem**	**Faro and Deo**	**Swimsuit Bathroom**	**Mbéré**	**Blame**	**Total**	**Percentage**
I	1	1	3	4	19	28	11,24
II	13	8	14	22	30	87	34,94
III	7	6	12	9	37	71	28,51
IV	11	9	11	13	19	63	25,30
Total	32	24	40	48	105	249	100,00

Table 15: Distribution of genetic types by department.

Table 15 shows that genetic type 2 is the most represented in our sample (34.94%) followed by type 3 (28.51%). Table presents the biometric description of the genetic types of goat populations in the agro-ecological zone of the Guinean High Savannahs of Adamaoua-Cameroon.

Main components	Type I		Type II		Type III		Type IV	
	Min	**Max**	**Min**	**Max**	**Min**	**Max**	**Min**	**Max**
Weight (kg)	08,48	16,00	21,02	42,10	12,20	26,02	11,49	21,27
LtCrp (cm)	43,00	50,30	55,00	77,00	49,50	63,9	46,90	69,00
HG (cm)	33,30	63,00	43,70	70,10	45,40	65	39,50	54,90
PT (cm)	44,30	63,00	53,00	89,00	59,70	74,6	52,80	66,90
LP (cm)	11,00	18,20	12,50	24,40	11,60	23,4	11,00	21,70
LB (cm)	06,50	16,40	08,00	21,00	07,50	20,3	08,500	17,50
LrB (cm)	07,70	11,60	09,00	17,60	10,10	19,8	09,20	13,70
LC (cm)	02,50	09,00	02,70	18,50	03,00	14,2	00,50	10,40
LO (cm)	08,10	12,00	08,50	19,50	08,70	18,2	08,70	12,70
LSI (cm)	34,00	44,80	42,90	58,00	43,00	54,5	41,50	52,00
LQ (cm)	08,00	11,00	07,50	13,00	08,00	13	07,00	12,00
PrT (cm)	19,00	25,00	23,75	33,00	23,50	29	20,50	25,50
TCA (cm)	05,00	08,00	07,20	12,00	07,00	12,00	5,00	08,00

Table16: Minimum and maximum values of the main components (weights and measurements) according to genetic types.

Max: Maximum; Min: Minimum

Genetic type 2 has significantly higher mean values of parameters (P < 0.05) than those of the other 3 genetic types and is mostly represented in the study area. However, types 3 and 4 are comparable but inferior to type 1. However, the horn length variable was the most dispersed within populations with CVs ranging from 23.87 to 30.27% while body length is the least dispersed CV ranging from 3.42 to 6.47.

The comparison of the means of the parameters by type is summarized in Annex 5.

The relationships between genetic types are illustrated in Figures 6 and 7.

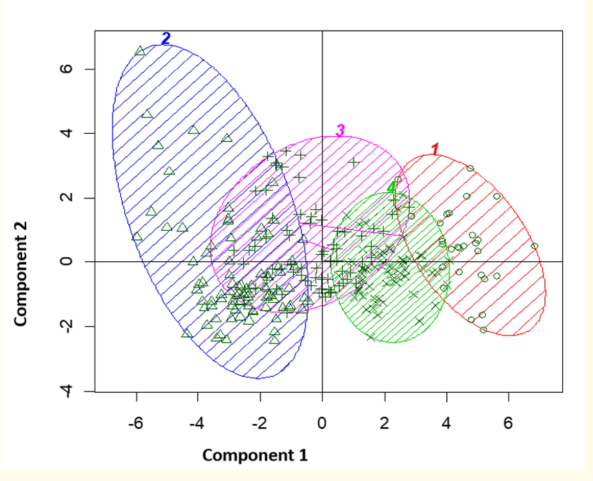

Figure 6: Schematization of genetic types.

Figure 6 shows that the first 2 components (weight and body length respectively) explain 65.07% of the variability observed within the goat population studied. These first two components made it possible to map the genetic types. However, type 2 is the most distant from the others and the most abundant in the study population.

Phylogenetic analysis

The dendrogram based on Mahalanhobis distances between genetic types of goat populations is shown in figure 7.

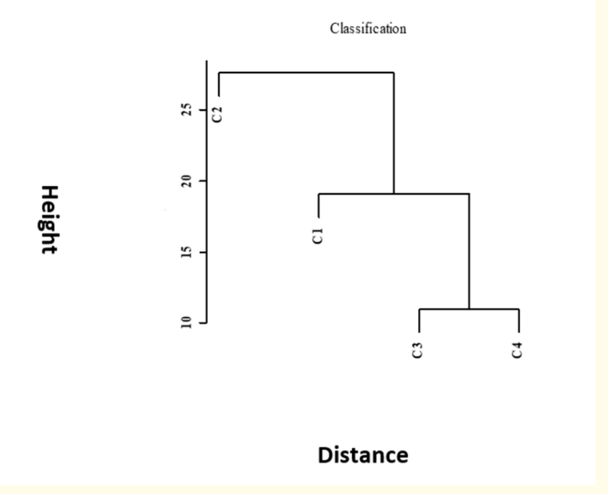

Figure 7: Dendrogram illustrating the links (distances) between the 4 genetic types.

Figure 7 shows that types 3 and 4; 1 and 4 and finally 2 and 1 are the closest. Types 3 and 4 are closer together with common characteristics compared to others. However, although different types 3 and 4 would constitute practically the same group. Also, the 4 genetic types can be grouped into 2 large groups with on the one hand the 3, 4 and 1 and on the other hand the type 2.

Similarities exist between the dendrogram carried out on the basis of the calculation of Mahalanhobis distances between genetic types and the studies made by [24] on the Kejonbong, Jawarandu, Etawa and Kacang breeds in Indonesia because they have grouped globally into 2 subtypes as in the case of our study.

Conclusion

At the end of this study with the objective of the morphobiometric characterization of the local goat population of the Guinean high savannahs of Adamaoua Cameroon, the main results show that:

There is great phenotypic variability within local goats in the Guinean High Savannahs of Adamawa Cameroon. Regarding morphological characters, the local goat of the Guinean high savannahs is bearded, horned and rarely bears tassels. The illegible pigment pattern is dominant followed by the eumelanic pattern while the red cheek pattern is the rarest. The Primacy Indices (IPa and IPs) made it possible to understand that the local goat studied belongs to a primary type population. The main body measurements showed the diversity of the local goat of the Guinean high savannahs of Cameroon. However, horn length was most dispersed and body length was least dispersed within the study population. The substernal gracility index (IGs) determined that the study population is brevipe and the histogram of the IGs made it possible to understand that there would be a slender subgroup within this population. Live weight prediction equations based on measurements have made it possible to understand that the thoracic circumference better predicts live weight. Moreover, the logarithmic equation explained this regression the most because it had the highest coefficient of determination. The structuring of the goat population studied through the main component analysis with discrimination revealed that it consists of 04 genetic types (type I, II, III and IV). Type II had the highest measurements significantly followed by Type I with mean measurements and Type III and IV have low and comparable measurements. However, the dendrogram made on the basis of Mahalanobis distances, allowing to see the links between genetic types shows that the 4 genetic types can be grouped into 2large groups with on the one hand type II and on the other hand types I, III and IV. The following recommendations can be made.

To the researchers

- Molecular analyses must be carried out to verify the genetic types obtained in order to better describe breeds constituting the goat population studied
- That a breeding program be put in place to conserve pure local genetic resources with the aim of developing other genetic resources better adapted to our living conditions and with high zootechnical yield
- That efforts be made to provide the selected animals with conditions (housing, feeding, health care) that allow them to best express their genetic potential
- That studies be done to determine regression equations to predict carcass yield from live weight.

In Government

- That an effort be made to establish and maintain a conservation station for selected animal genetic resources
- That conventions be established to provide funding to facilitate studies on genetic resources in Cameroon.

To breeders

- That initiatives be taken to encourage farmers to provide animals with environmental conditions that allow them to better express their genetic potential
- That animals are well monitored in order to avoid random crossing causes the phenomenon of genetic erosion.

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