Genetics and Biodiversity Journal

Journal homepage: http://ojs.univ-tlemcen.dz/index.php/GABJ

OPEN ACCESS

Original Research Paper

Biodiversity of indigenous *Djallonke* sheep (*Ovis aries*) in Sudano Guinean region in Cameroon

Baenyi P[1]., Meutchieye F[2*]., Ayagirwe B.R [1,2]., Bwihangane B. A[1]., Karume K[1]., Mushagalusa N. G[1]., Ngoula F[2]

[1] *Faculté d'Agronomie et des Sciences de l'Environnement, Université Evangélique en Afrique Centrale, Bukavu, Democratic Republic of Congo*
[2] *Department of Animal Production, FASA, University of Dschang, Cameroon*

***Corresponding Author**: F. Meutchieye, Faculty of Agronomy and Agricultural Sciences /University of Dschang, Dschang, Cameroon; **Email**: fmeutchieye@gmail.com ; fmeutchieye@univ-dschang.org*

Article history: Received: July 12th- 2018; Revised: July 30th-2018; Accepted: August, 5th -2018

Abstract:
In order to study the biodiversity of Cameroon indigenous Djallonke sheep, a study was conducted between July and September 2016 in the Sudano-Guinean zone of Cameroon. A total of 280 adult sheep (24 months old) including 77 males and 203 females from 112 farms in 13 districts of 4 divisions was measured and analyzed. The variance analysis showed variability in the population. According to the principal components analysis, the body length, chest circumference, withers height and the live weight were potentially discriminating characters of the ovine population studied. The discriminant analysis revealed a population made of three genetic types with genetic type I having the highest characteristics. The phylogenetic analysis showed that type II and III are closer and type I and III are genetically more distant. High intra-genetic variability was observed within the population studied. The linear regression equation (LW = 0.8092CG + 58.923) with a coefficient of determination (R2 = 0.66) predicts better the liveweight. This results offer possibilities for genetic improvement. Characterization, leading to conservation andsustainable use of indigenous sheep genetic resources in Cameroon's smallholder production system. The possiblethreats to the current potentials may be genetic erosion, climate change, low productivity and disease susceptibility.
Keywords: Sudano-Guinean, biodiversity, sheep.

Introduction

Small ruminants contribute to 17% of meat consumption in Africa (FAO, 2009). Sheep represent an important economic value breed (Boutonnet, 2003) and can be raised in all agro-climatic zones around the World due to its hardiness, hunger resistance, disease resistance and his relative trypanotolerance (FAO, 2008).

In Cameroun, Sheep are estimated to be 3 million heads and have an undeniable socio-economic importance (Manjeli et al., 1995, Sounchio 2003, Ngoula et al., 2008, Wikondi, 2010 and Tendonkeng et al., 2013). *Djallonke* breed which is common in West and Central Africa seems to be the most encountered in 4 of 5 Cameroon agro ecosystems (Manjeli et al., 1995). This valued breed is well accepted in Cameroon farming system (Djoufack, 2015; Jafe, 2016). However, very little information on their phenotypic and genetic diversity, particularly sheep from the Sudano-Guinean region is available.

According to the priority given to the improved and exotic breed, local breeds are now largely endangered and may be extinct in the near future. This continued disappearance of local breeds constitutes a disaster for the gene pool which could cause the lost of performance, disease resistance, tolerance to extreme environmental conditions. Knowledge on animal genetic resources (FAO, 2012) and their performances (Bouchel et al., 1997) constitute strategies for analyzing domestic animal populations and are fundamental for their sustainable use, improvement and their conservation. As emphasized by Food and Agriculture

Organization, information provided by phenotypic characterization studies is essential for planning the management of animal genetic resources for food considered particularly as a crucial key for development of developing countries where the level of livestock knowledge is insufficient. Traoré et al. (2008) demonstrate that phenotypic characterization of breeds is the pillar for genetic improvement and conservation of domestic animals. However, in the Sudano-Guinean zone of Adamaoua in Cameroon, no literature has mentioned on phenotypic characterization of sheep, hence the need for this study.

The aim of this study is to characterize phenotypically sheep population in the Sudano-Guinean zone of Cameroon using quantitative traits which will contribute to their improvement and conservation. Specifically, its aim is to assess morphbiometric traits, to establish barymetric equation for weight determination, and to analyze the genetic variability and structure of this native sheep ecotype.

Material and Methods

Description of the study Area

This study was conducted from July to September 2015 in Sudano-Guinean region of Adamaoua plateaux which covers an area of 720000 km^2. The region is a vast plateau and has an altitude varying between 900 and 1500m with peaks reaching 1800m. The region is located between 6°to 8˚ latitude north and between 10° to 16˚ longitude east. The climate type is Sudano-Guinean. The average temperature is around 20 ° C. The region, sometimes records up to 7 months of rainfall per year and averages of 1772mm with a maximum of 2172.5mm registered at Tibati in the Djerem Division. The vegetation cover is mainly made up of Sudano-Guinean savanna (SDRADDT, 2002). Many rivers of the country (for example the Sanaga and the Logone Rivers) have their sources from this region (SDRADDT, 2002). Livestock is the basic economic activity of the population. Cattle, sheep, goats, poultry and pigs are animals raised in the region.

Sampling and data collection

Sample size and its distribution in the different divisions of the region depended on the required precision and the variability of sheep population. Sample size was determined according to the recommendations from FAO (2013). The repartition of samples in the region was made according to the statistical data provided by the regional delegation of MINEPIA on the distribution of sheep populations in the different divisions of the Adamaoua region.

A total of 203 female sheep and 77 rams from local breed, known as *Djallonke* ecotype were sampled in 112 farms from 4 divisions: Vina, Djerem, Mbere and Mayo Banyo (Table 1). The choice of animals was based on observations made on the field: the physical appearance of the animals (vertebral prominence, scapular and lumbar bone, prominence of the flanks, absence of injuries), health apparent state (peel gloss, absence of discharge, respiratory rate and pulse, color of the mucous membranes) and the age (at least 24 months old) which was determined on the basis of the dentition (Bouchel et al., 1997). The target population consisted of all breeders who had at least five (5) sheep in their flock.

Data were collected according to the snowball method. All measurements for the morphobiometric characterization were taken according to Lauvergne approach (1986) and the FAO (2013) recommendations. Measurements were done in the morning before the animals were released for grazing on a total of 18 quantitative traits (Table. 2) and using the same materials (portable electronic scales, metric maps and measuring sticks) on all animals measured.

Table 1: Sample distribution in the region of study

Sex	Divisions				Total
	Vina	Mbere	Djerem	Mayo Banyo	
Rams	35	13	9	20	77
Ewes	78	55	32	38	203
Total	103	68	41	58	280

Table 2: Quantitative measures considered for Sudano Guinean local sheep breed Characterization

Quantitative variables	Symbol	Definition
Head Length[2]	HL	Distance between the upper limit of the forehead to the tip of the nose
Neck Length[2]	NL	Distance from the throat to the tip of the shoulder in the medium
Ear Length[2]	EL	Distance from the base to the tip of the right ear, along the dorsal surface
Body Length[2]	BL	Distance from the base of the neck to the base of the tail
Trunk Length[2]	TL	Distance between the front of the scapula to pin bone
Pelvis Length[2]	PL	Distance between the two points of coxal bone
Tail Length[2]	TL	Distance from the root of the tail to the tip
Withers Height[3]	WH	Height from the top of the withers to the ground
Back Height[3]	BH	Height from the high point of the back to the ground
Sacrum Height[3]	SH	Height from the top of the rump to the ground
Chest Circumference[2]	CC	Perimeter of the chest
Chest Depth[2]	CD	Vertical distance from the top of the withers to the xyfoid process of the sternum
Chest Width[2]	CW	Maximum intercostal diameter at the level of the 6th rib behind the elbows
Hip Width[2]	HW	Larger of the hip
Ischium Width[2]	IW	Distance between Ischia
Cannon Circumference[2]	CC	Perimeter of the canon on the anterior leg
Flank Depth[2]	FD	Vertical distance of the flank
Body weight[1]	BW	Live weight

The numbers indicated the measuring tools used: 1: portable electronic scales, 2: metric maps and 3: Measuring stick

Statistical analysis

All the quantitative traits were submitted to the variance analysis (ANOVA); means, standard deviation, standards errors and coefficients of variation were computed. When the effect of the division was significant, the test of Duncan was used for mean separation. The meaning and the association degree of the biometric parameters were tested by the Pearson correlation coefficient at the significance level of 1% and 5%. A barymetric equation for the estimation of live weight was determined through the regressions made on the quantitative variable. Principal Component Analysis permitted to determine the degree of similarity and the genetic variability of the population. Discriminant factor analysis was applied to determine the population structure. The relationship between the different genetic types within the population was determined by the construction of the phylogenetic tree according to the Hierarchical Ascending Classification protocol. All these analyze were done with SPSS 21.0 and XLSTAT statistical software.

Results

Main metric characteristics

The average values of the measurements (Table 3) vary according to the division; the division of Vina recorded high average of body weight and most of the measurements at the significance level ($p<0.05$) compared to animals from other divisions; this would be justified by the fact that in the Vina division, semi-extensive breeding system is the most practiced by famers. In this system, animals are supplemented with feeds and dewormed. There were no significant differences between ($p <0.05$) the horn lengths for animals from all the divisions. The coefficient of variation for body weight and all measurements varied between 21.94% (Ear length for which sheep are more heterogeneous) in Mayo Banyo division and 6.12% (wither height for which sheep are more homogeneous) in Djerem division. Body weight and all measurements were significantly ($p <0.01$) and positively correlated with each other except with neck length (Table 3). However, the highest positive correlation ($p <0.01$) was observed between body weight and thoracic girth (0.816). The Pelvis length was positively correlated only with the head length.

Table 3: Mean, standards errors and coefficients of variation of quantitative traits on local sheep breed from Sudano Guinean zone in Cameroon

	Divisions									
	Vina		Mbere		Djerem		Mayo Banyo		Total	
Measurements (in cm)	M ± S.E (n= 113)	CV (%)	M ± S.E (n= 68)	CV (%)	M ± S.E (n= 41)	CV (%)	M ± S.E (n= 58)	CV (%)	M ± S.E (n= 280)	CV (%)
BW	31.11±0.63^{b}	21.63	29.79±0.61^{ab}	11.05	28.06±0.72^{a}	16.50	29.04±0.74^{ab}	19.52	29.91±0.35	19.85
HL	20.60±0.22^{c}	11.60	19.86±0.17^{ab}	7.15	19.29±0.22^{a}	7.56	20.05±0.18^{bc}	7.13	20.11±0.11	9.59
EL	15.85±0.30^{b}	20.31	13.28±0.24^{a}	15.43	13.06±0.22^{a}	11.17	12.73±0.43^{a}	26.00	14.17±0.18	21.94
NL	20.72±0.21^{a}	11.19	20.30±0.20^{a}	8.27	20.34±0.31^{a}	9.83	20.93±0.23^{a}	8.45	20.60±0.12	9.85
BL	67.14±0.74^{b}	11.79	61.40±0.56^{a}	7.55	59.28±0.74^{a}	8.02	59.58±0.63^{a}	8.15	63.03±0.45	11.29
TL	41.38±0.68^{c}	17.66	37.30±0.32^{ab}	7.13	36.76±0.75^{a}	13.16	38.80±0.36^{b}	7.06	39.18±0.33	14.39
PL	19.42±0.23^{a}	13.02	19.50±0.17^{a}	7.23	20.43±0.21^{b}	6.70	20.92±0.27^{b}	10.13	19.90±0.12	10.80
CC	84.72±0.61^{c}	7.73	82.36±0.56^{b}	5.69	80.08±0.72^{a}	5.76	83.09±0.74^{bc}	6.83	83.13±0.35	7.08
CD	31.95±0.53^{b}	17.87	28.38±0.28^{a}	8.35	28.58±0.39^{a}	19.41	27.06±0.39^{a}	11.04	29.58±0.27	15.58
CW	20.54±0.25^{d}	13.24	18.77±0.21^{c}	9.58	17.85±0.33^{b}	12.04	16.79±0.33^{a}	15.00	18.94±0.16	14.83
HW	21.95±0.24^{b}	11.89	19.30±0.25^{a}	10.72	19.53±0.20^{a}	6.81	19.67±0.21^{a}	8.28	20.48±0.14	12.01
IW	10.86±0.16^{b}	16.39	9.54±0.15^{a}	12.89	9.31±0.15^{a}	10.52	9.66± 0.16^{a}	13.25	10.06±0.09	15.90
WH	72.33±0.48^{b}	7.13	69.07±0.39^{a}	4.70	68.34±0.44^{a}	4.18	69.00±0.40^{a}	4.46	70.26±0.26	6.24
BH	69.77±0.45^{b}	6.95	66.58±0.37^{a}	4.64	66.02±0.42^{a}	4.07	66.70±0.38^{a}	4.43	67.81±0.24	6.12
SH	71.23±0.48^{b}	7.18	67.91±0.37^{a}	4.49	67.53±0.43^{a}	4.16	67.84±0.39^{a}	4.37	69.18±0.25	6.23
FD	26.65±0.38^{b}	15.23	24.27±0.26^{a}	9.02	23.43±0.34^{a}	9.43	25.03±0.29^{a}	13.46	25.03±0.20	13.46
Cc	9.20±0.13^{b}	15.32	8.25±0.11^{a}	11.27	8.53±0.15^{a}	11.25	8.44±0.12^{a}	11.13	8.71±0.07	14.00
TL	44.67±0.66^{b}	15.93	42.79±0.57^{ab}	11.05	40.92±0.64^{a}	10.09	42.00±0.75^{a}	13.64	43.11±0.36	14.08

Head Length (HL). Ear Length (EL). Neck Length (NL).Body Length (BL). Trunk Length (TL). Hip Width (HW). Pelvis Length (PL). Ischium Width (IW). Chest. Circumference (CC). Chest Depth (PP). Chest Width (LP). Withers Height (WH). Sacrum Height (SH). Back Height (BH). Flank Depth (FD). Cannon Circumference. (Cc). Tail Length (TL). Body Weight (BW)

Table 4: Correlation between quantitative traits

	HL	EL	NL	BL	TL	HW	PL	IW	CC	CD	CW	WH	SH	BH	FD	Cc	TL	BW
HL	1																	
EL	0.341**	1																
NL	0.59	0.077	1															
BL	0.533**	0.360**	0.181**	1														
TL	0.479**	0.307**	0.231**	0.637	1													
HW	0.371**	0.375**	0.128*	0.456**	0.387**	1												
PL	0.190**	-0.047	- 0.074	0.057	0.010	0.000	1											
IW	0.313**	0.246**	0.057	0.498**	0.339**	0.359**	0.055	1										
CC	0.571**	0.162**	0.79	0.599**	0.410**	0.468**	0.369**	0.408**	1									
CD	0.413**	0.471**	0.75	0.491**	0.370**	0.382**	0.090**	0.292**	0.385**	1								
CW	0.304**	0.447**	0.068	0.518**	0.306**	0.420**	-0.032	0.240**	0.456	0.513**	1							
WH	0.633**	0.517**	0.122*	0.614**	0.461**	0.575**	0.210**	0.384**	0.674**	0.546**	0.542**	1						
SH	0.614**	0.523**	0.151*	0.611**	0.446**	0.536**	0.216**	0.366**	0.656**	0.522**	0.537**	0.938**	1					
BH	0.624**	0.514**	0.136**	0.621**	0.453**	0.545**	0.242**	0.381**	0.671**	0.519**	0.518**	0.969**	0.955**	1				
FD	0.499**	0.494**	0.187**	0.581**	0.590**	0.486**	0.110	0.355**	0.554**	0.477**	0.522**	0.635**	0.640**	0.641**	1			
Cc	0.435**	0.405**	0.051	0.498**	0.442**	0.387**	0.109	0.357**	0.459**	0.376**	0.361**	0.585**	0.560**	0.581**	0.524**	1		
TL	0.292**	0.455**	0.091	0.263**	0.150**	0.256**	0.179**	0.275**	0.290**	0.210**	0.276**	0.531**	0.538**	0.537**	0.385**	0.330**	1	
BW	0.581**	0.241**	0.095	0.586**	0.394**	0.495**	0.366**	0.393**	0.816**	0.432**	0.453**	0.677**	0.661**	0.665**	0.605**	0.427**	0.338**	1

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

Head Length (HL). Ear Length (EL). Neck Length (NL).Body Length (BL). Trunk Length (TL). Hip Width (HW). Pelvis Length (PL). Ischium Width (IW). Chest. Circumference (CC). Chest Depth (PP). Chest Width (LP). Withers Height (WH). Sacrum Height (SH). Back Height (BH). Flank Depth (FD). Cannon Circunference. (Cc). Tail Length (TL). Body Weight (BW)

Live weight predictive equations

Different forms of barymetric equations to predict the live weight (Table 5) were elaborated from thoracic girth (TG), wither height and body length which was significantly (p <0.01) and strongly correlated with live weight (noted LW). The regression made on these variables showed that the linear equation as follows, LW = 0.8092TG + 58.923 could better predict the live weight of this sheep population studied according to its simplicity in handling.

Table 5: Predictive equations for the live weight determination on sheep population from Sudano Guinean zone in Cameroun

Equations Models	Variables	Equations	R^2
Linear	Withers Height	$BW = 0.5002WH + 55.301$	0.45
	Body Length	$BW = 0.7015BL + 42.047$	0.34
	Chest Circumference	$BW = 0.8092CC + 58.923$	0.66
Logarithmic	Withers Height	$BW = 14.595\ln(WH) + 20.947$	0.47
	Body Length	$BW = 20.133\ln(BL) - 5.001$	0.30
	ChestCircumference	$BW = 24.087\ln(CC) + 1.7375$	0.64
Polynomial	Withers Height	$BW = 0.0092WH^2 - 0.0885WH + 64.365$	0.47
	Body Length	$BW = 0.0204BL^2 - 0.6042BL + 62.149$	0.37
	ChestCircumference	$BW = 0.0054CC^2 + 0.4615CC + 64.277$	0.66
Power	Withers Height	$BW = 35.26WH^{0.2035}$	0.42
	Body Lenght	$BW = 22.455BL^{0.3037}$	0.31
	ChestCircumference	$BW = 31.583CC^{0.2857}$	0.64
Exponential	Withers Height	$BW = 57.001e^{0.0069WH}$	0.45
	Body Length	$BW = 45.792e^{0.0105BL}$	0.34
	ChestCircumference	$BW = 62.377e^{0.0095CC}$	0.66

Genetic variability and population structure

The principal component analysis based on the contribution of 18 quantitative traits for the genetic variability analysis (Table6) shows that the cumulative variance of the 15 first components explained at 98.59% the genetic variability observed in the study population. In addition, the 2 first components (head length and ear length) contributed for 54.99% to the genetic variability observed within sheep population.

The population structure obtained from discriminant factor analysis (DFA) revealed that three genetic types I, II and III constitute the sheep population studied. The genetic type I has high values of traits studied, followed by genetic type II and genetic type III (Table 7). Within the same sheep population, the intra-genetic type variability (59.56%) was higher compared to inter- genetic type variability (40, 35%) (Table 8).

The relationship between genetic types was illustrated by the phylogenetic tree (Figure1). While confirming the structure of the population, the phylogenetic tree (Figure 2) revealed that genetic types II and III are very close while the genetic type I is farther away from II and III. This approximation should be probably related to the genetic distance that should exist between the 3 genetic types. Moreover, the population consists of two subgroups with a subgroup made of genetic types II and III which seem to have a very large number of alleles in common and could have a common origin and the second subgroup constituted by the genetic type I. These results can be verified by a molecular characterization of this studied sheep population.

Table 6: Contribution of 18 main components on the variability analysis of the indigenous sheep from Sudano Guinean zone of Cameroun

Components	Variables	Proper value	Variance (%)	Cumulative variance
CP1	Head Length (HL)	8.248	46.823	46.823
CP2	Ear Length (EL)	1.470	8.168	54.991
CP3	Neck Length (NL)	1.231	6.837	61.829
CP4	Body Length (BL)	0.992	5.510	67.339
CP5	Trunk Length (TL)	0.854	4.745	72.084
CP6	Hip Width (HW)	0.771	4.285	76.369
CP7	Pelvis Length (PL)	0.685	3.804	80.173
CP8	Ischium Width (IW)	0.583	3.239	83.412
CP9	ChestCircumference (CC)	0.565	3.137	86.550
CP10	ChestDepth (PP)	0.527	2.929	89.479
CP11	ChestWidth (LP)	0.417	2.314	91.793
CP12	Withers Height (WH)	0.365	2.027	93.821
CP13	Sacrum Height (SH)	0.347	1.930	95.751
CP14	Back Height (BH)	0.283	1.573	97.324
CP15	Flank Depth (FD)	0.229	1.274	98.598
CP16	Cannon Circunference (Cc)	0.166	0.920	99.518
CP17	TailLength (TL)	0.061	0.339	99.857
CP18	Body Weight (BW)	0.026	0.143	100.00

Table 7: Genetic types characteristics of indigenous sheep

	Measurements																	
Genetic types	HL	EL	NL	BL	TL	HW	PL	IW	CC	CD	CW	WH	SH	BH	FD	Cc	TL	BW
I	24.76	19.46	21.73	80.65	50.96	26.07	20.38	12.42	96.42	36.76	23.03	81.88	80.73	78.57	33.00	10.84	52.07	43.31
II	20.65	15.10	20.72	65.29	40.60	21.00	20.20	10.47	84.96	31.08	19.91	72.43	71.31	69.98	26.19	9.16	45.50	32.57
II	19.26	12.93	20.41	59.59	36.96	19.51	19.61	9.52	80.43	27.69	17.77	67.43	66.39	65.06	23.36	8.16	40.33	26.51

Head Length (HL). Ear Length (EL). Neck Length (NL).Body Length (BL). Trunk Length (TL). Hip Width (HW). Pelvis Length (PL). Ischium Width (IW). Chest. Circumference (CC). Chest Depth (PP). Chest Width (LP). Withers Height (WH). Sacrum Height (SH). Back Height (BH). Flank Depth (FD). Cannon Circumference. (Cc). Tail Length (TL). Body Weight (BW)

Table 8: Intra and Inter genetic type variability

Genetic types	Absolute Variable	Variation degree (%)
Intra-genetic type	189.492	59.65%
Inter-genetic type	128.189	40.35%
Total	317.681	100.00%

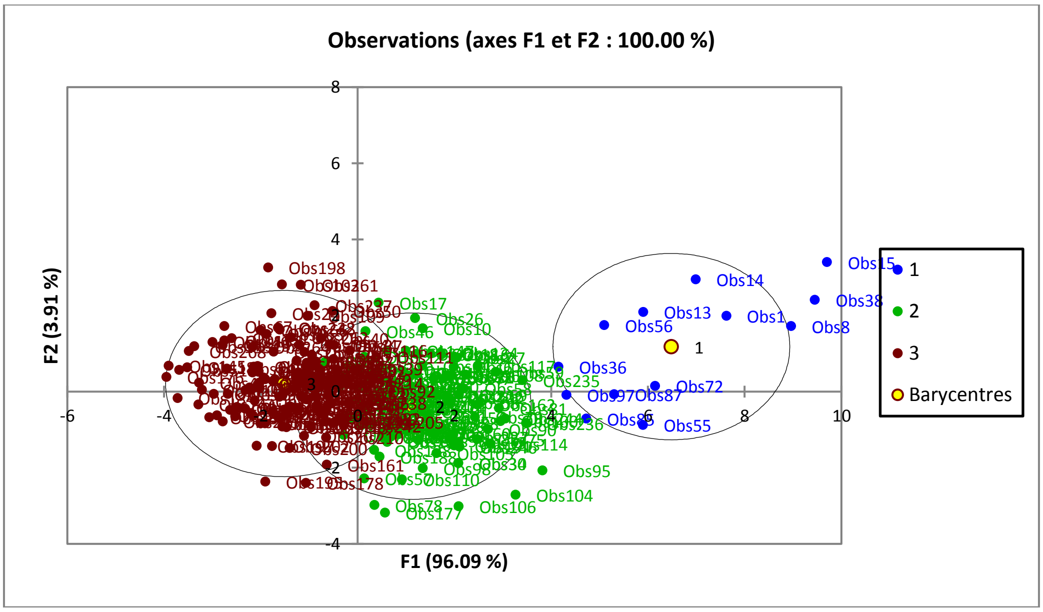
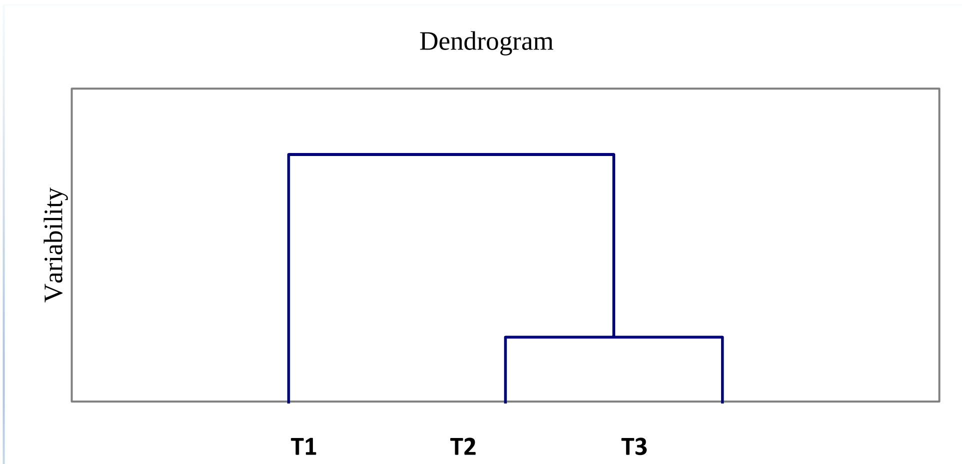


Figure1. Relation sheep between genetic types



Legend **T**1: Genetic Type I; **T**2: Genetic Type II; **T**3: Genetic Type III

Figure 2: Phylogenetic tree of native sheep types

According to Esquivelzeta et al. (2011), the genetic variability is an important factor for the improvement of animal performances through selection. However, the coefficient of variation of 18 quantitative traits from *Djallonke* sheep ecotype of Sudano Guinean varies between 6.12 % and 21.94% showing variability within individuals according to the different divisions. The results are similar to those obtained by Jafe (2016) on *Djallonke* sheep ecotype in North-West Cameroon (CV varying between 6.75% and 22.2%). The quantitative variable shows strong variability considering the factor division. The Vina division sheep sample was clearly distinct from sheep in other three divisions.

Some measurements such as the average of wither height (70.26 ± 0.26cm), head length (20.11 ± 0.11cm), ear length (14.17 ± 0.18cm), tail length (43.11 ± 0.36cm), hips width (20.48 ± 0.14cm), pelvis length (19.90 ± 0.12cm), canon circumference (8.71 ± 0.07cm) were close to findings obtained by Djoufack (2015) and Belaid et al. (2012) respectively on *Djallonke* sheep from Western Cameroon and the Sélif region in Algeria, while were slightly different from those obtained by Jafe (2016) on *Djallonke* sheep in North West Cameroon. These differences could be explained by the variation of endogenous factors (breed, ecotype, genetic distance, etc.) or exogenous factors (climate, forage availability, flock management etc.). Belaid et al (2012) obtained on Sélif sheep in Algeria relatively higher averages values for than our results on the sacrum height (69.18 ± 0.25cm) and the wither height (67.81 ± 0.24cm).

The results obtained on the thoracic girth (83.13 ± 0.35cm), body length (63.03 ± 0.45cm) are similar to those found by Charray and al. (1980) on *Macina* sheep. Tobit (1990) and Wilson (1992) found on *Djallonke* sheep a body length varying between 60 and 65 cm. On the other hands, the figures in these results are slightly higher to the results found by Jafe (2016) in North-West Cameroon and slightly lower than the results obtained by Yunusa et al.. (2013) with an average thoracic girth of 66.93 ± 0.43cm, 69.97 ± 0.42cm, 71.06 ± 0.67cm respectively on *Yankasa*, *Uda* and *Balami* sheep breeds in Nigeria. The value of the thoracic depth (29.58 ± 0.27cm) was slightly higher than that obtained by Birteeb et al. (2014) on *Djallonke* sheep in northern Ghana (27.73 ± 0.52 cm), Vallerand and Brankaert (1975) on *Djallonke* sheep in Cameroon, Charray et al. (1980), Tobit (1990) and Wilson (1992) on the same sheep and Sibomana (1998) in local Rwandese and Burundian sheep for which relatively lower values (25cm) were obtained.

Vallerand and Branckaert (1975) found a mean of the body weight varying between 20-30kg on *Djallonke* sheep population in Cameroon, which encompasses the observations (29.91 ± 0.35kg) in this study. On the other hands, these figures are slightly higher than the results obtained by Djoufack (2015) in West Cameroon (25.77kg), Salako (2006) on the *Djallonke* sheep in South-West Nigeria (25.03kg), Traoré et al. (2008) on the *Mossi* sheep in Burkina (23.3kg), and Birteeb and Donkor (2016) on the *Djallonke* sheep (26.92kg). These differences observed on Sudano Guinean sheep from others *Djallonke* and African sheep breeds or population demonstrated the existence of a particular type of sheep population due to a specific production system, genetic make-up and other environmental conditions.

Differences observed between the degree of intra and inter genetic variation could be explained as the consequence of a possible uncontrolled mating system between flocks on a restricted forage areas. Migrations or exchanges of breeding stock in this environment could also explain this low degree of inter-genetic variation. These factors had been high lited earlier by Esquilvezeta et al. (2011) and Agiviezor et al. (2012) as sources of difference between intra and inter genetic variation within a sheep population.

Conclusion

About the biodiversity of indigenous sheep population of Sudano-Guinean zone in Cameroon, the main results showed the existence of diversity in the local *Djallonke* sheep population. However, ear length was the most dispersed character and the height at withers was the least dispersed in this population. Body length, thoracic girth, height at withers and live weight were potentially discriminating characters of the ovine population studied. The linear equation based on the thoracic girth with a high coefficient of determination predicts better the live weight. Three genetic types with high intra-genetic variability clustered into 2 sub-groups exist in this local sheep population. Due to the observed variability, selection is the most appropriate method to improve this sheep population.

Acknowledgement

The authors of this study are grateful to MINEPIA staff and sheep keepers for data collection facilitation.

Author's Contributions

Meutchieye designed and monitored the whole study; **Baenyi** led the data collection and primary data analysis; **Ayagirwe** contributed to statistical analyses and paper write-up; **Bwihangane, Karume, Mushagalusa** and **Ngoula** contributed each to the paper write-up at different level.

Ethics

Authors declare that there are ethical issues that may arise after the publication of this manuscript.

References

Agaviezor BO. Peters SO. Adefenwa MA.Yakubu A. Adebambo OA. Ozoje M. Ikeobi CON. Wheto M. Ajayi OO. Amusan SA. Ekundayo OJ. Sanni TM. Okpeku M. Onasanya GO. De Donato M. Ilori BM. Kizilkaya K. Imumorin IG 2012. Morphological and Microsatellites DNA diversity of Nigerian indigenous sheep. *Anim.Sci. Biotechnol*. 3:38. https://doi.org/10.1186/2049-1891-3-38

Belaib I 2012. Morphologic characterization on sheep in Setifregion (Algeria). *Veterinary Medecine magazine*: University of Farhat Abbas-Setif. 199.

Birteeb PT. Donkor D 2016. Phenotypic Variances in 'Djallonke' Sheep reared under Extensive Management System in Tolon District of Ghana. *Journal of Veterinary Science and Technology*; Volume 5. Issue 1. ISSN: 2319-3441(online), ISSN: 2349-3690(print). www.stmjournals.com.

Bouchel D. Lauvergne JJ. Guibert E. Minvielle F 1997. Etude morpho-biométrique de la chèvre du Rove. I. Hauteur au garrot (HG), profondeur du thorax (PT), vide sous-sternal (VSS) et indice de gracilité sous-sternale (IGs) chez les femelles. *Revue de Médecine Vétérinaire* 148(1). 37-46. https://www.revmedvet.com/affiche.php?id=1997

Boutonnet JP 2003. Intensification of small ruminant production: pitfalls and promises - Which intensification process for small ruminant production in Africa? National Institute of Agronomic Research; Rural economy and sociology station. 34060 Montpellier Cedex 1 (France).

Charray J. Coulomb J. Haumesser JB. Planchenault D. Pugliese, P-L 1980. Les petits ruminants d'Afrique Centrale et d'Afrique de l'Ouest : synthèse des connaissances actuelles. Provost Alain (ed.). Maisons-Alfort : GERDAT-IEMVT-Ministère de la coopération. 295 p. ISBN 2-85985-048-1.

Djoufack TY 2015. Biodiversity of sheep (*Ovis aries*) of western highlands Cameroon. Unpublished Master of Science thesis. FASA University of Dschang. 91p.

Esquivelzeta C. Fina M. Bach R. Mudruga C. Caja G. Casellas, J. Piedrafita J 2011. Morphological analysis and subpopulation characterization of Ripollesa sheep breed. *Animal Genetic Resources*. 49.9-17. https://doi.org/10.1017/S2078633611000063

FAO. 2008. The state of food and agriculture. *www.fao.org/3/a-i0100e.pdf*

FAO. 2009. Statistical yearbook. cattle and buffalo herds. sheep and goats: pp30-35. *www.fao.org/3/a-i3621e.pdf*

FAO. 2012. Food and Agriculture Organization of the United Nation. *http://faostat.org*.

FAO. 2013. Phenotypic characterization of animal genetic resources. FAO for animal production and animal health. No. 11. Rome.152p. *www.fao.org/docrep/015/i2686e/i2686e00.htm*

Jafe N 2016. Biodiversity of sheep (*Ovis aries*) in the northwestern highlands of Cameroon. Unpublished Master of Science thesis: FASA / University of Dschang.108p.

Lauvergne JJ 1986. Traditional populations and first standardized races of Ovicaprinae in the Mediterranean basin. Gontard / Manosque colloquium (France). Coll. INRA n ° 47. Paris. 298p

Manjeli Y. Njwe RM. Teguia A. Tchoumboue J. Tangang 1995. Survey on sheep breed in the eastern forest region of Cameroon. *Cam. Bull. An. Prod*. 3 (1) 1-6.

Salako AE 2006. Application of morphological indices in the assessment of type and function in sheep. *International Journal Morphol.*. 24(1):13-18. https://pdfs.semanticscholar.org/0910/3c4176afd575044ab8af9af3ca19b987e3cb.pdf

SDRADDT. 2002. Schéma Directeur Régional d'aménagement et de développement durable du territoire.

Sibomana J-B 1998. Farming of sheep with fat tail in the Byumba region (Rwanda): Socio-economic and zoo technical aspects. Unpublished Veterinary Medicine Thesis. Dakar, 85p.

Sounchio M 2003. Characterization of small ruminant production in Dschang subdivision (West province-Cameroun). Unpublished Engineer thesis. FASA/ University of Dschang. 68p.

Tadesse A. Gebremariam T 2010. Application of linear body measurements for live body weight estimation of highland sheep in Tigray Region. North-Ethiopia. Journal of the Drylands. 3: 203-207. ISSN 1817-332

Tendonkeng F. Pamo TE. Boukila B. Defang FH. NjikiE W. Miégoué E. Fogang ZB. Lemoufouet J. Djiomika TJ 2013. Socioeconomic and Technical Characterization of Small Ruminant Production in the Province of South Cameroon; department of Nvila. Livestock Research for Rural Development 25 (4) http://www.lrrd.org/lrrd25/4/fern25064.htm

Ngoula F. Tchoumboué J. Boukila. B. Benga LN. Ninzeko B. Kenfack A. Watcho P. Tendonkeng. F. Mingoas JP 2008. Exteriorisation des chaleurs chez la bredis djallonké. Bulletin of Animal Health and Production. 56 (2): 144-153. ISSN: 0378-9721

Tobit 1990. Small ruminant production in the United Republic of Cameroon. Unpublished Thesis of Veterinary Medicine: Dakar. 77p.

Traoré A. Tamboura HH. Kaboré A. Royo LJ. Fernández I. Álvarez I. Sangaré M. Bouchel D. Poivey. JP. Francois D. Toguyeni A. Sawadogo L. Goyache F 2008. Multivariate characterization of morphological traits in Burkina Faso sheep. Small Ruminant Research. 80: 62–67. DOI: https://doi.org/10.1016/j.smallrumres.2008.09.011

Vallerand F. Branckaert R 1975. La race ovine Djallonke au Cameroun. Potentialites zootechniques, conditions d'elevage, avenir. Revue d'Elevage et de Medecine Veterinaire des Pays Tropicaux 28(4): 523-545. http://remvt.cirad.fr/revue/notice.php?dk=433277

Wikondi J 2010. Caractéristiques socio-economiques et techniques de l'élevage des petits ruminants dans le Département du Mayo Danay (North Cameroon). Engineer thesis. FASA / University of Dschang. 70p.

Wilson TR 1992. Small ruminants: production and genetic resources in tropical Africa. FAO. Rome. pp-90

Yunusa AJ. Salako AE. Oladejo OA 2013. Morphometric characterization of Nigerian indigenous sheep using multifactorial discriminant analysis. International journal of Biodiversity and Conservation 5 (10): 661-665. https://doi.org/10.5897/IJBC2013.0592.