Comparative analysis of quantitative phenotypic parameters of Djallonke and hybrid (Djallonke × Sahelian) goats in Benin.

KOUATO Orou Gédéon[1]*, HOUNDONOUGBO Venant Pascal[1], OROUNLADJI Boko Michel[2], CHABI ADJOBO Marc Aurèle[3], GLELE KAKAÏ Romain[3], CHRYSOSTOME Christophe Achille Armand Mahussi[1]

[1]Laboratory of Poultry Research and Zoo-Economics, Faculty of Agricultural Sciences, University of Abomey-Calavi, 01 P.O.Box 509 Recette Principale, Cotonou 01, E-mail: orougdonkuato@gmail.com , Phone. : (+229) 97590906, Republic of Benin, E-mail: venuspascal69@gmail.com , Phone: (+229) 97198155, Republic of Benin. E-mail: cchrysostome@gmail.com , Phone: (+229) 97487357, Republic of Benin

[2]University of Lomé, Regional excellence Center on Avian Science, Laboratory of Poultry Techniques production, BP 1515 Lomés, Togo, Phone. : (+228) 90928030, Republic of Togo, E-mail: oromib@gmail.com .

[3]Laboratory of Biomathematics and Forest Estimation, Faculty of Agricultural Sciences, University of Abomey-Calavi; chamaurele@yahoo.fr, Phone: (+229) 97559405, Republic of Benin, romain.glelekakai@fsa.uac.bj / glele.romain@gmail.com , Republic of Benin.

** Corresponding author, E-mail: orougdonkuato@gmail.com*

Keywords: breeds, goat, quantitative traits, Benin

Publication date 28/02/2021, http://m.elewa.org/Journals/about-japs/

1 SUMMARY

The characterization of small ruminants in developing countries would play an important role in the conservation of animal genetic resources. This study aimed to identify and characterize indigenous goats in the districts of Kouandé, Kérou, and Péhunco (2KP) in Benin. A sample of 826 goats aged up to 3 years old was studied considering 18 quantitative traits: live weight, heart girth, height at withers, rump height, body length, pin-bone length, pin-bone width, neck girth, chest depth, shoulder length, tail length, ear length, head length and width, horn length and shinbone circumference. Multivariate analyses (Principal Component Analysis and Multivariate Analysis of Variance) revealed that goat population had two morphological subtypes. The breeds identified were dwarf goats with middle size (44.17 ± 7.51 cm for height at withers and 45.73 ± 7.54 cm for rump height) with ears (9.71 ± 1.37 cm for the left ear and 9, 57 ± 1.26 cm for the right ear) and short horns (5.3 ± 2.29 cm for the left horn and 5.34 ± 2.28 cm for the right horn). Djallonké × Sahelian had a large size (53.49 ± 8.12 cm for height at withers and 54.59 ± 8.13 cm for rump height). Their ears showed 11.69 ± 1.27 cm for the left and 11.6 ± 1.27 cm for the right longhorns (9.73 ± 3.02 cm for the left horn and 9.62 ± 3.06 cm for the right horn). A multivariate analysis of the variance also showed that there is a highly significant difference ($p < 0.001$) between the two breeds as regards biometric parameters. The present study could greatly help in designing management and conservation policies for the sustainable production of goat breeds in Benin.

2 INTRODUCTION

Benin is a country with an agriculture-based economy where livestock is the second largest activity after crop production (Aplogan, 2013). Breeding and other related activities have significant importance in the economic life of households, the majority of social, cultural, and/or religious events (Alary *et al.,* 2011). Among animal genetic resources raised in Benin, small ruminants take an important place and are found in every part of the country (DE, 2014). The ruminant population is estimated at 4,742,000, including 18.14% of sheep, 36.19% of goats, and 45.67% of cattle (DE, 2014). In Benin, goat species presents major socio-economic advantages due to its hardiness and unlike sheep, they are not affected by any ethnic or cultural restrictions (Dossa *et al.,* 2008). Among goat breeds studied, some have characteristics of the Guinean dwarf goat also called djallonké goat, Sahelian goats from Niger, or goats resulting from the crossing of dwarfs goat and Sahelian goat from Niger (Aplogan, 2013). However, little work has been done on the characterization of goats in Benin to better assess their state of purity (Dehoux and Hounsou-vè, 1993; Bassossa Baguima, 2012). In the current context of climate change, evolving systems, and the market, it is necessary to establish morphometric data of goats to propose strategies for the characterization of goats reared in Benin. Therefore, this study was carried out to establish a comparative description of the morpho-biometric parameters between dwarf goats (djallonkés), the Sahelian goat of Niger, and the goat populations of hybrids resulting from their crossing encountered in the farms. In the north-west of Benin, specifically in the districts of Kouandé, Kérou, and Péhunco. As quantitative parameters are directly correlated with production parameters (FAO, 2013), knowing them will enable the implementation of a system to improve the production performance of goats in Benin.

3 MATERIALS AND METHODS

3.1 Presentation of the study sites: The study was carried out in the districts of Kouandé, Kérou, and Péhunco, located in the north-west of Benin. The climate of this sudanian zone is characterized by a rainy season, from mid-April to mid-October, and a dry season from mid-October to mid-April. The average rainfall in the study area is 1000 mm of water per year. The average temperature varies from 25°C in August to 31°C in April. There blows a dry and cold wind between December and mid-March, sometimes causing a thermal amplitude of more than 10°C. The distribution map of the sampled farms is presented in figure 1.

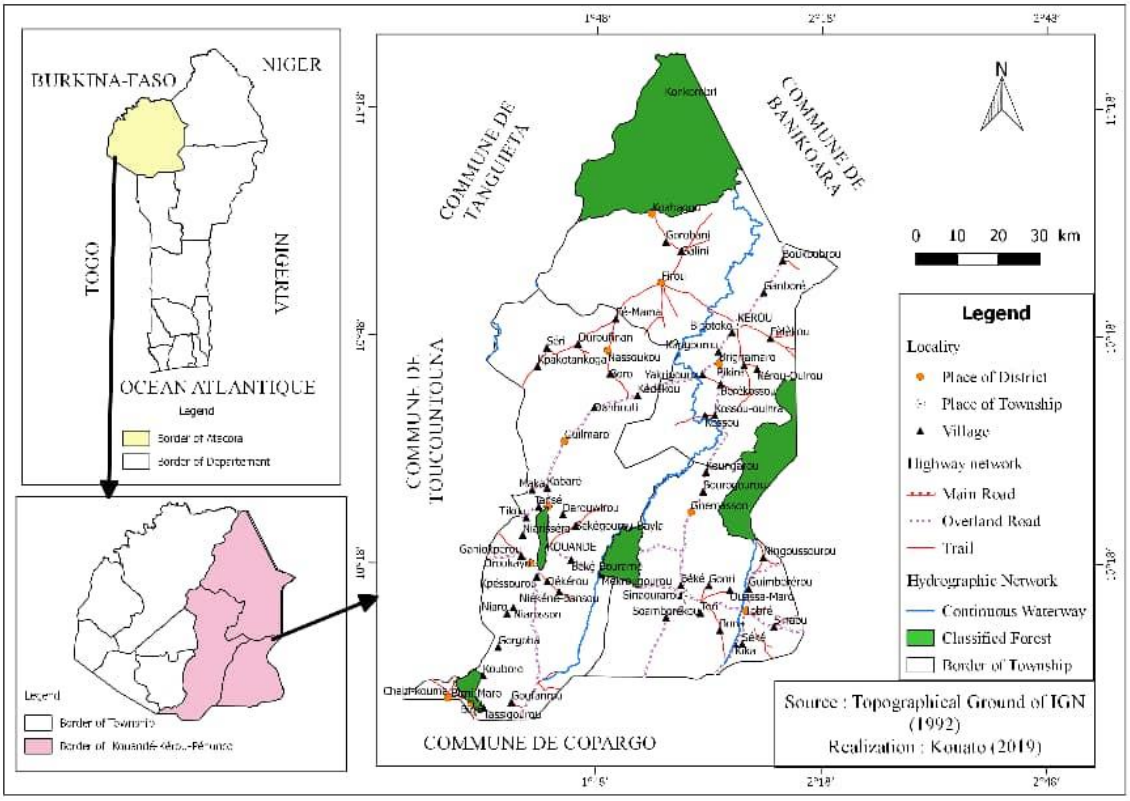

Figure 1: Presentation of the study area

3.2 Sampling: The study was conducted in rural areas of the north-west of Benin, where three districts were randomly chosen (figure 1). The morpho-biometric measurements have been taken on goats for four months in the districts of Kouandé, Kérou, and Péhunco. These districts were selected because of the presence of the two breeds reported during the study of the farming production system (Kouato, 2016). Three localities per district have been taken into account for this study: Kérou (Firou, Kérou, and Brignamarro), Kouandé (Tikou, Guilimaro, and Oroukayo), and Péhunco (Tobré, Gnémasson, and Pehunco). Morpho-biometric measurements were carried out on 826 goats, of which 278 in Kouandé, 252 in Kérou, and 296 in Péhunco. Body measurements can only be taken on a representative sample of adult animals (age estimated from dentition examination); about 100 to 300 females and 10 to 30 males for the characterization of small ruminants (FAO, 2013) were considered. Thus, at each farm, 1 to 6 individuals were chosen at random and according to the presence of breeds for the measurements.

3.3 Data collection : The guidelines of the Food and Agriculture Organization of the United Nations (FAO, 2013) were used to describe morpho-biometric traits. In total, 18 quantitative traits (live weight, heart girth, height at withers, rump height, body length, pin-bone length, pin-bone width, neck girth, chest depth, shoulder length, tail length, ear length, head length and width, horn length and shinbone circumference) have been taken. Figure 2 below shows the different measurements.

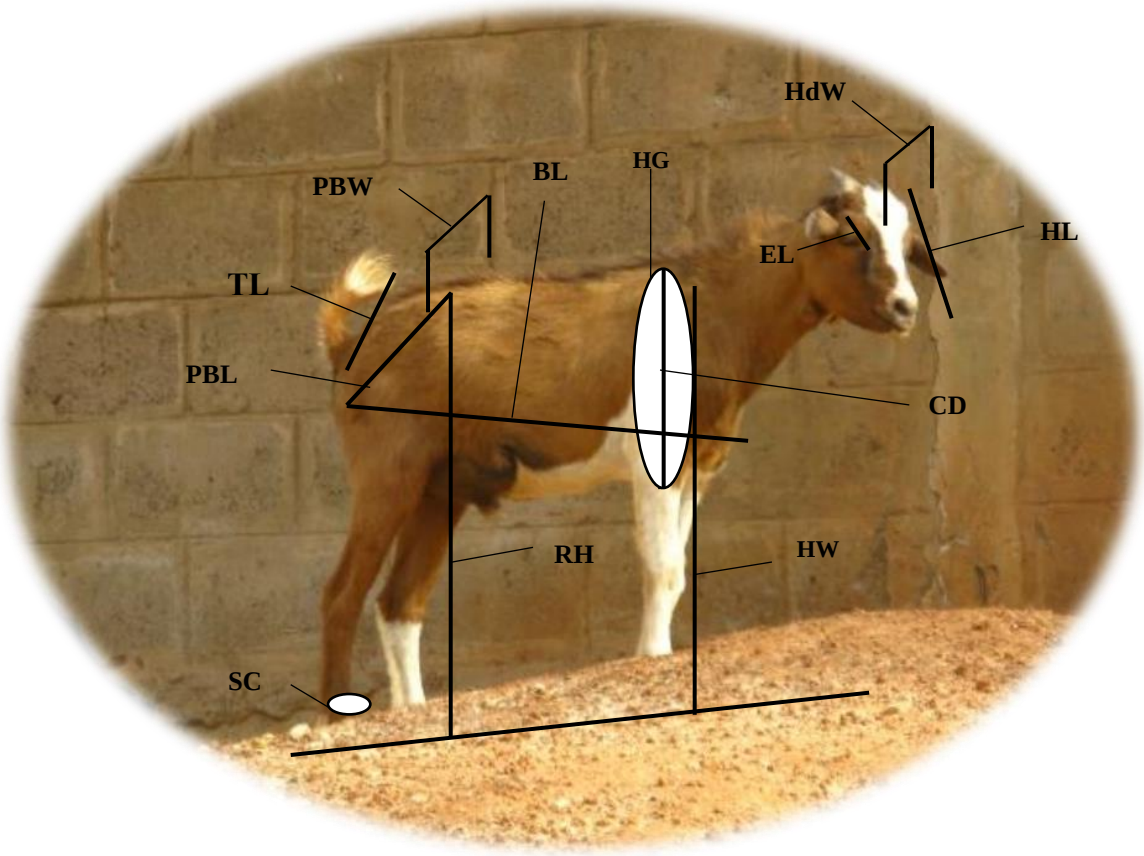

Figure 2: Morphobiometric parameters recorded in the study
HG: Heart girth, HW: Height at withers, RH: rump height, BL: Body length, PBL: Pin-bone length, PBW: Pin-bone width, CD: chest depth, TL: tail length, EL: ear length, HL: head length, HdW: head width, SC: shinbone circumference.

The morphobiometric data establishes the biometric index as defined by Lauvergne *et al.*(1993) and Mani *et al.*(2014). It is about:

• Substernal Slenderness Index (SSI): ratio of empty beneath sternal (the difference between Height at withers (HW) and Heart girth (HG)) over Heart girth (HG).

SSI = (HW-HG) / HG

• Atrial Thorax Index (ATI): ratio of ear length (EL) and Heart girth (HG).

ATI = EL / HG

3.4 Biometric Index: The biometric index calculated in this study to classify goat species give the following results:

Substernal Slenderness Index of crossbreed djallonke × Sahelian type: 0.42 ± 0.105

Substernal Slenderness Index of djallonke: 0.39 ± 0.090

Atrial Thorax Index of crossbreed djallonke × Sahelian: 0.35 ± 0.094

Atrial Thorax Index of djallonke: 0.21 ± 0.084

3.5 Statistical analysis: Statistical analysis (descriptive statistics, Principal Component Analysis, and multivariate analysis of variance) were performed with R software version 3.0.2 (R core Team, 2019). The significance level used is 5% for the interpretation of statistical tests. The principal component analysis (PCA) was used to determine the links between quantitative variables using the FactoMineR package implemented in R software (Husson *et al.,* 2014). The classification of goats according to quantitative variables was carried out to see if the groups consist of animals of one or more breeds. The multivariate analysis of variance was used to establish the correlations between the variables studied.

4 RESULTS

4.1 Structure of the goat flocks studied:

Table 1 shows the flock structure of the farming surveyed. Three age categories were measured:
- 0-1year-old goats including 40.1% Djallonké and 4.48% hybrids (djallonkés × Sahelians);
- 1-2-year-old goats made up of 12.7% Djallonké and 8.7% hybrids and
- 2-3-year-old goats including 27.3% Djallonké and 6.8% hybrids.

Males represented 36.16% while females represented 63.82% of the study sample.

Table 1: Configuration according to age, sex, and breeds of goats in the study sample in 2KP'

Age	Male		Female			Total	
	Djallonke	Djallonke×Sahelian	Djallonke	Ddjallonke×Sahelian		Djallonke	Djallonke×Sahelian
	%	%	%	%		%	%
0-1 year	18.6	0.49	21.4	4		40.1	4.48
1-2 years	0	6.9	12.7	1.82		12.7	8.7
2-3 years	6.3	3.87	20.9	2.9		27.3	6.8
Total	24.9	11.26	55.1	8.72		80	19.98

4.2 Descriptive analysis of quantitative data

4.2.1 Morphobiometric parameters by breed: Table 2 describes the means ± standard deviations and the extreme values of the quantitative characteristics according to breeds of goats studied.

Djallonke × Sahelian goats have significantly higher mean values ($p < 0.001$) than those of Djallonke goats for the quantitative variables.

Table 2: Morphobiometric characteristics by breed

Variables	Measure	Djallonke	Djallonke ×Sahelian	p-value
Live weight (LW)	min-max	6 - 32	12 - 32	***
	μ±σ	17.84^{a}±5.92	24.71^{b}±4.71	
Heart girth (HG)	min-max	40 - 75	48 - 76	***
	μ±σ	56.85^{a}±7.21	65.93^{b}±5.06	
Height at withers (HW)	min-max	22 - 61	43 - 71	***
	μ±σ	44.17^{a}±7.51	53.49^{b}±8.12	
Rump height (RH)	min-max	24 - 62	45.5 - 71.5	***
	μ±σ	45.73^{a}±7.55	54.59^{b}±8.13	
Body length (BL)	min-max	16 - 61	42 - 69.5	***
	μ±σ	45.63^{a}±7.35	51^{b}±4.69	
And pin-bone length (ABL)	min-max	10 - 20	13 - 19	***
	μ±σ	14.97^{a}±1.69	16.18^{b}±1.16	
And pin-bone width (ABW)	min-max	6- 16	9 - 14	***
	μ±σ	9.73^{a}±2.03	11.85^{b}±1.35	
Tail length (TL)	min-max	6 - 17.5	12 - 19	***
	μ±σ	13.22^{a}±1.91	14.92^{b}±1.05	
Ear length left (ELL)	min-max	6 - 15	8 - 15	***
	μ±σ	9.71^{a}±1.37	11.69^{b}±1.27	
Ear length right (ELR)	min-max	6- 14	8 - 14	***
	μ±σ	9.57^{a}±1.26	11.6^{b}±1.26	
Head length (HL)	min-max	11 - 19	14 - 23	***

Head width (HW)	μ±σ	15.18^{a}±1.59	17.67^{b}±2.20	***
	min-max	5.5 - 17	6- 9.5	
Horn length left (HLL)	μ±σ	7.54^{a}±0.86	8.13^{b}±0.46	***
	min-max	1 - 11	4- 15	
Horn length right (HLR)	μ±σ	5.37^{a}±2.29	9.73^{b}±3.02	***
	min-max	1 - 11	4 - 15	
Neck girth (NG)	μ±σ	5.34^{a}±2.28	9.62^{b}±3.07	***
	min-max	10- 33	23 - 33	
Shinbone circumference (SC)	μ±σ	24.36^{a}±3.32	27.99^{b}±2.34	***
	min-max	5.5 - 10	6- 10	
Chest depth (CD)	μ±σ	7.24^{a}±0.76	8.61^{b}±0.84	***
	min-max	15 - 38	21 - 32	
Shoulder length (SL)	μ±σ	25^{a}±4.16	27.80^{b}±2.64	***
	min-max	10 - 22	12 - 23	
	μ±σ	14.48^{a}±2.06	17.89^{b}±2.57	***

Means within a line with different superscript differ (p < 0, 05), μ: mean, σ: standard deviation, min: minimum, max: maximum

4.2.2 Influence of sex on morphobiometric characteristics: The gender factor has a significant effect on all the quantitative parameters as shown in Table 3:

- Sexual dimorphism is observed in Dwarf goat × Sahelian goats;
- As for Dwarf goat, sexual dimorphism is not observed and females have significantly (p < 0.05) the highest values for all the quantitative variables (except for neck girth, shinbone circumference, and chest depth) compared to the males;
- Dwarf goat ×sahelian females show higher values (p < 0.05) for all quantitative variables compared to Dwarf goat females;
- Dwarf goat ×sahelian males also show (p < 0.05) higher values for all the quantitative variables compared to Dwarf goat males.

Table 3: Effect of sex on morphobiometric characteristics by goat type

Variables	Goat type	Sample		μ±σ		P-value		
		Female	Male	Female	Male	P.T	P.S	P.TS
Live weight (LW)	djallonke	455	206	19.25±5.44	14.72±5.73	***	***	***
	djallonke×sahelian	72	93	21.24±4.82	27.39±2.24			
Heart girth (HG)	djallonke	455	206	59.01±6.24	52.08±6.92	***	***	***
	djallonke×sahelian	72	93	62.81±4.99	68.34±3.59			
Height at withers (HW)	djallonke	455	206	45.26±6.44	41.74±9	***	***	***
	djallonke×sahelian	72	93	49.51±4.36	56.57±9			
Rump height (RH)	djallonke	455	206	46.98±6.38	42.97±9.06	***	**	***
	djallonke×sahelian	72	93	50.63±4.27	57.66±9.05			
Body length (BL)	djallonke	455	206	47.3±6.64	41.94±7.52	***	***	***
	djallonke×sahelian	72	93	49.10±3.64	52.47±4.90			
Pin-bone length (PBL)	djallonke	455	206	15.28±1.53	14.26±1.81	***	***	ns

	djallonke×sahelian	72	93	16.49±1.31	15.94±0.97			
	djallonke	455	206	10.36±1.95	8.32±1.42	***	***	***
Pin-bone width (PBW)	djallonke×sahelian	72	93	11.58±1.30	12.05±1.35			
	djallonke	455	206	13.63±1.79	12.31±1.84	***	***	***
Tail length (TL)	djallonke×sahelian	72	93	14.99±1.13	14.87±0.99			
	djallonke	455	206	10.08±1.27	8.90±1.24	***	***	***
Ear length left (ELL)	djallonke×sahelian	72	93	11.32±1.30	11.98±1.17			
	djallonke	455	206	9.87±1.15	8.9±1.23	***	***	***
Ear length right (ELR)	djallonke×sahelian	72	93	11.14±1.27	11.96±1.13			
	djallonke	455	206	15.63±1.37	14.21±1.62	***	***	***
Head length (HL)	djallonke×sahelian	72	93	16.42±1.11	18.65±2.34			
	djallonke	455	206	7.66±0.76	7.29±1	***	***	***
Head width (HdW)	djallonke×sahelian	72	93	8.08±0.61	8.17±0.28			
	djallonke	455	206	5.59±2.23	4.87±2.35	***	***	***
Horn length left (HLL)	djallonke×sahelian	72	93	6.92±1.42	11.91±1.93			
	djallonke	455	206	5.55±2.22	4.89±2.25	***	***	***
Horn length right (HLR)	djallonke×sahelian	72	93	6.88±1.38	11.75±2.20			
	djallonke	455	206	24.5±2.47	24.06±4.68	***	ns	***
Neck girth (NG)	djallonke×sahelian	72	93	26.32±1.57	29.29±1.98			
	djallonke	455	206	7.36±0.80	6.96±0.57	***	ns	***
Shinbone circumference (SC)	djallonke×sahelian	72	93	7.85±0.61	9.19±0.40			
	djallonke	455	206	25.32±3.91	24.30±4.59	***	ns	***
Chest depth (CD)	djallonke×sahelian	72	93	26.92±3.13	28.48±1.94			
	djallonke	455	206	14.96±1.97	13.42±1.85	***	***	***
Shoulder length (SL)	djallonke×sahelian	72	93	16.13±1.60	19.26±2.33			

P.T: probability linked to the breed; P.S: ¨probability linked to sex; P.TS: Probability of interaction between breed and sex; μ: mean, σ: standard deviation

4.2.3 Influence of age on morphobiometric characteristics: The mean values ± Standard deviations of the quantitative traits of the goat breeds concerning age, as well as the results of the comparisons of the different age groups are presented in Table 4. The analysis of variances shows significant differences ($p < 0.05$) between breeds for some variables and between different age groups. According to breeds, the results of the comparison (Table 4) show that: Djallonkés × Sahelian hybrids are

greater than Djallonkés for all variables according to all age categories;
- at 2 years old, goats of all types are globally at their optimum for measurements of morphobiometric parameters;
- at 3 years, no significant difference ($p > 0.05$) has been observed for the following biometric parameters of the breeds: Body diagonal length (LDC), Neck circumference (NC), rump length (RL), head length (HL), and head width (HW).

4.2.4 Multivariate analysis of morphobiometric parameters: The PCA brings out the correlations between the morphobiometric parameters studied as main variables. Following the principle of minimum inertia, the first three axes of the PCA give approximately 73.49% of the observations (Figure 3). The correlation circle illustrates the explanatory force of the orthogonal planes in which the point clouds are projected. Figure 3 shows that axis 1 is positively correlated by all variables. It is strongly correlated with the variables LW, HG, HW, RH, BL, ABL, ABW, HL, HLL, HLR, NG, SC, CD, and SL; moderately correlated with TL, ELL, ELR, and HW variables. ELR and ELL variables contribute positively to the achievement of axis 2 while the variables CD, NG, BL, RH, contribute relatively to the achievement of this axis. As for axis 3, it is moderately correlated with only the TL variable. Djallonke goats are much more located on the negative side of axis 1, while crossbreed djallonke×sahelian are located on the positive side of this axis (Figure 4).

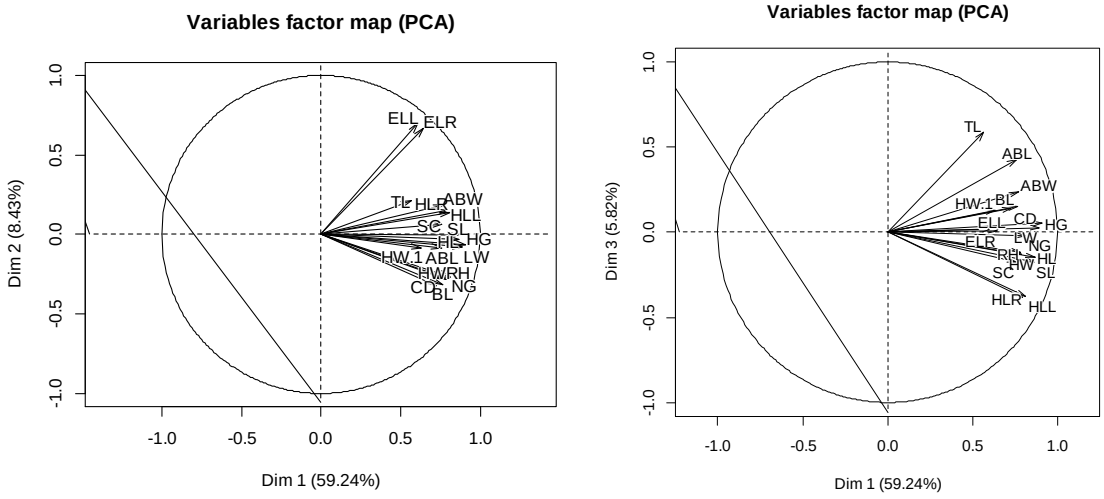

Figure 3: Correlation of quantitative variables with the axis

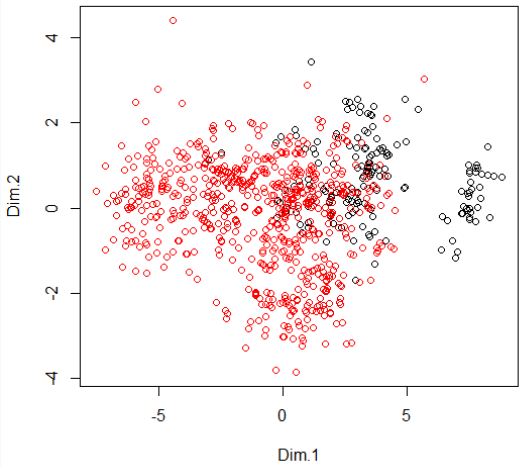

Figure 4: Distribution of goats along axis djallonke×sahelian (black colour), djallonke (red colour)

Table 4: Morphobiometric parameters by goat type and by age

Variables	Goat type	Age (year)			P-value		
		0-1	1-2	2-3	P.T	P.A	P.TA
Live weight (LW)	Djallonke	13.56±3.88	20.82±3.76	22.74±4.35	***	***	ns
	Djallonke×sahelian	18.05±3.90	26.94±3.37	26.22±1.64			
Heart girth (HG)	Djallonke	51.82±5.66	60.93±4.41	62.34±4.63	***	***	***
	Djallonke×sahelian	60.88±4.63	68.49±4.20	65.96±3.66			
Height at withers (HW)	Djallonke	40.47±7.15	47.72±6.53	47.94±5.55	***	***	**
	Djallonke×sahelian	47.55±2.88	58.15±9.79	51.42±3.29			
Rump height (RH)	Djallonke	42.05±7.26	49.37±6.62	49.44±5.46	***	***	**
	Djallonke×sahelian	48.61±2.73	59.45±9.64	52.3±3.42			
Body length (BL)	Djallonke	41.14±6.13	50.64±5.25	49.90±5.59	***	***	***
	Djallonke×sahelian	49.41±4.48	53.35±5.26	49.02±1.88			
Pin-bone length (PBL)	Djallonke	14.08±1.62	15.5±1.12	16.027±1.24	***	***	***
	Djallonke×sahelian	15.61±1.00	16.56±0.95	16.07±1.33			
Pin-bone width (PBW)	Djallonke	8.81±1.90	10.34±1.88	10.79±2.01	***	***	**

Tail length (TL)	Djallonke×sahelian	10.8±1.00	12.45±1.25	11.76±1.23	***	***	*
	Djallonke	12.85±1.24	13.67±1.57	13.56±1.96			
	Djallonke×sahelian	15.11±1.22	14.85±1.02	14.9±0.97			
Ear length left (ELL)	Djallonke	9.55±1.15	9.96±1.47	9.84±1.48	***	*	ns
	Djallonke×sahelian	10.93±0.97	12.15±1.20	11.6±1.27			
Ear length right (ELR)	Djallonke	9.38±1.39	9.70±1.31	9.78±1.35	***	***	ns
	Djallonke×sahelian	10.69±1.04	12.04±1.16	11.63±1.19			
Head length (HL)	Djallonke	14.19±0.69	16.05±0.89	16.24±1.17	***	***	***
	Djallonke×sahelian	15.68±0.90	19.28±2.28	16.92±0.67			
Head width (HW)	Djallonke	7.11±2.00	7.85±0.52	8.04±0.89	***	***	0.00224
	Djallonke×sahelian	7.91±0.59	8.24±0.36	8.13±0.42			
Horn length left (HLL)	Djallonke	4.13±2.00	5.84±1.72	6.96±1.81	***	***	***
	Djallonke×sahelian	7.14±1.52	11.67±2.86	8.96±2.26			
Horn length right (HLR)	Djallonke	4.16±3.20	5.62±1.68	6.95±1.84	***	***	***
	Djallonke×sahelian	6.96±1.36	11.72±2.86	8.7±2.20			
Neck girth (NG)	Djallonke	22.76±0.58	25.09±2.01	26.37±2.73	***	***	***
	Djallonke×sahelian	26.11±1.85	29.71±2.06	27.04±1.16			
Shinbone circumference (SC)	Djallonke	6.89±3.60	7.52±0.73	7.61±0.77	***	***	ns
	Djallonke×sahelian	7.78±0.83	8.86±0.39	8.82±0.92			
Chest depth (CD)	Djallonke	23.07±3.60	25.90±3.55	27.42±3.78	***	***	ns
	Djallonke×sahelian	25.08±2.34	29.33±2.11	27.64±1.83			
Shoulder length (SL)	Djallonke	13.33±1.86	15.33±1.55	15.79±1.52	***	***	***
	Djallonke×sahelian	15.73±1.75	19.49±2.77	17.28±0.92			

P.T: probability linked to the breeds; P.A: ¨probability related to age; P.TA: Probability of breed x age

5 DISCUSSION

Genetic variation is vital for the populations to adapt to varying environments and to respond to artificial selection; therefore, any conservation and development scheme should start from assessing the state of variation in the population (Toro *et al.*2011). Following the results of Traore *et al.*(2008) and Mani *et al.*(2014), on indigenous goats (Sahelian goat) of Burkina Faso, measurements of the horns vary according to age and sex. Horns are more developed for hybrids (9.68 cm) than for djallonke (5.32 cm). The average length of horns observed for hybrids is close to the values obtained (9.95 cm) by Mani *et al.*(2014) in Niger on the Sahelian goat in the Tahoua region. This proximity is believed to be due to the presence of goats from the Sahel in the result, which was used to obtain hybrid (Djallonke × Sahelian). Taking into account, the averages of the biometric values obtained for Heart girth, Height at withers, rump height, Body length, and pin-bone width, chest depth, shoulder length, ear dimension as well for djallonke than for hybrids in Kouandé, Kérou, and Péhunco; the results obtained are lower than those presented by Mani *et al.*(2014) for the Sahelian goat in Niger and by Nafti *et al.*(2014), for the four subpopulations of goats in Tunisia. Thus, djallonke goats show low measurements of the biometric parameters while hybrids are characterized by average values of these biometric parameters. On average, biometric parameters obtained are also lower than those of

Mossi goats obtained by Traore *et al.*(2006) in Burkina Faso for the parameters: live weight, heart girth, body length, height at the withers, and rump height according to different age groups. The results of the principal component analysis show that regardless of age and sex, hybrids are positively correlated with all parameters of the first principal component. This axis expresses the general conformation of goats. Thus, hybrids present large values of the biometric parameters in comparison with djallonke goat. Multiple variance analysis (MANOVA) indicated that biometric parameters vary significantly according to age, sex, and different breeds (djallonke and hybrids). The analysis according to the sex shows that females have the greatest values of morphobiometrics parameters compared to males. Samuel and Salako (2008), Semakula *et al.*(2010), studying respectively the biometric characteristics of West African Dwarf Goat in Nigeria and the Mubende goat in Uganda, argue that age and sex are factors which significantly affects body weight and biometric parameters. Mani *et al.*(2014) in Niger drew the same conclusions, where females of indigenous goats were raised has presented biometric values higher than males regardless of the region. However, the results of Ebegbulem *et al.*(2011) indicate that in the Djallonke goat in Nigeria, males are greater than females for height at heart girth, height at withers, rump height, the dimension of the ear, horn, and pin-bone. The biometric values obtained are not only lower than those found for the four subpopulations Arbi Jerid, Arbi Nefzawa, Serti Jerid, and Serti Nefzawa in Tunisia but also than those of Sahelian and Sudanian (Djallonke goat) and Sahelo-Sudanian (Mossi) goats (Traore *et al.,* 2008; Samuel *et al.,* 2008; Abdulmojeed *et al.,* 2010; Ebegbulem *et al.,* 2011; Nafti *et al.,* 2014). Biometric indexes vary according to goat breeds. IGS varies from 0.21 to 0.56 for hybrids and 0.16 to 0.64 for Djallonke while IAT varies from 0.14 to 0.49 for hybrid and 0.10 to 0.50 for the dwarfs. The middle values of the primary index indicate that goats in the study area are small in height. This goat population would be close to the brevipe type of classification based on morphobiometric criteria. In addition, these results allow us to affirm that the product descended of crossbreed Djallonke × Sahelian goats is more oriented towards the type brevipe. The variations in IGS and IAT observed are lower than the values reported on goat populations in Niger (Mani *et al.,* 2014). The average values obtained for hybrids and Djallonke confirm the theory developed by Bouchel and Lauvergne (1996) according to which, the populations of dwarf goats would have differentiated from the brevipe goats. Heterogeneity between djallonke and hybrids in the study area are been observed. This heterogeneity is the consequence of uncontrolled crossings in farming systems. It is important to protect the dwarf goat population for its conservation.

6 CONCLUSION

According to this study, it appears that Djallonke goats in Kouandé, Kérou, and Péhunco remain a genetic resource that exhibits phenotypic performances appreciated by farmers. Despite these animals being reared in a traditional farming system, low to medium values of morphobiometric parameters were observed. The Djallonke goat from the northwest in Benin is an indigenous medium-sized breed that exhibits interesting production characteristics, such as disease resistance, high prolificacy rate. This is a breed with a primarily for meat. To meet professional and societal expectations, orientated towards obtaining better conformed and heavier carcasses; farmers crossbreed with Sahelian breeds. Given that the improvement of animal productivity must be achieved in a synergy of action, it, therefore, seems essential to combine this action with the improvement of the farming system associated with better management of the flocks. This could help

increase the performance of this already popular goat breed.

7 ACKNOWLEDGMENTS

A special thanks to the Ministry of Higher Education and Scientific Research of Benin. We cannot forget the technical support of the Laboratory of Poultry Research and Zoo-Economics.

8 REFERENCES

Abdulmojeed Y, Adebowale ES, Ikhide GI: 2010. Comparative multivariate analysis of biometric traits of West African Dwarf and Red Sokoto goats. *Tropical Animal Health and Production* 43: 561-566.

Aplogan HM: 2013. Etat des ressources génétiques animales au BENIN. Direction de l'Elevage Cotonou-Bénin.44p.

Alary V, Duteurtre G, Faye B: 2011. Élevages et sociétés: les rôles multiples de l'élevage dans les pays tropicaux. *INRA Prod. Anim.*, 2011, 24 (1), 145-156.

Bassossa baguima AM: 2012. Caractérisation zootechnique de la chèvre naine dans la commune de Parakou. http://www.memoireonline.com/03/15/8997/Caracterisation-zootechnique-de-la-chevre-naine-dans-la-commune-de-Parakou.html. Consulté le 07/02/2019.

Bouchel D, Lauvergne JJ: 1996. le peuplement de l'Afrique par la chèvre domestique. *Revue Elevage et de Médecine Vétérinaire des Pays tropicaux* 49 (1):80-90.

DE (Direction de l'élevage): 2014. Annuaires statistiques 2013. 85p.

Dehoux JP et Hounsou-ve G: 1993. Productivité de la race bovine Borgou selon les systèmes d'élevage traditionnels au Nord-Est du Bénin. *Revue Mondiale de Zootechnie*. 74-75 1993/1-2: pp.36-38.

Dossa LH, Rischkowsky B, Birner R and Wollny C: 2008. Socio-economic determinants of keeping goats and sheep by rural people in southern Benin. *Agric. Hum. Values* 25, 581-592.

Ebegbulem VN, Ibe SN, Ozung PO, Ubua JA: 2011. Morphometric trait characteristics of West African dwarf goats in Abia state, south east Nigeria. *Continental Journal of Agricultural Science* 5 (2): 1-6.

FAO: 2013. Caractérisation phénotypique des ressources génétiques animales. *Directives FAO sur la production et la santé animales* No. 11. Rome. 151p.

Husson F, Josse J, Le S et Mazet J: 2014. FactoMineR: Multivariate Exploratory Data Analysis and Data Mining with R, R package version 1.26. http://CRAN.R-project.org/package=FatoMineR

Kouato OG; 2016. Caractérisation morphologique des caprins (*capra hircus l.1758*) dans les communes de Kouandé, Kérou et Péhunco. Mémoire pour l'obtentien du Diplôme de d'Etude Approfondie, Management de Ressources Animales (MRA). 114p

Lauvergne JJ, Bourzat D, Souvenir ZP, Zeuh V ET Ngo Tama AC: 1993. Indices de primarité de chèvres au Nord Cameroun et au Tchad. *Revue d'Elevage et de Médecine Vétérinaire des pays Tropicaux* 46 (4): 651-665.

Mani M, Marichatou H, Issa M, Chaibou I, Sow A, Chaibou M, Sawadogo JG: 2014. Caractérisation de la chèvre du Sahel au Niger par analyse des indices biométriques et des paramètres phénotypiques quantitatifs. *Animal Genetic Resources*, 54, 11–19.

Nafti M, Khaldi Z et Haddad B: 2014. Multivariate characterization of morphological traits in local Tunisian

oases goats. *Animal Genetic Resources,* 55, 29-38.

Oseni SO and Ajayi BA: 2014. Phenotypic Characterization and Strategies for Genetic Improvement of WAD Goats under Backyard Systems. *Open Journal of Animal Sciences*, 2014, 4, 253-262.

R Core Team: 2019. A language and environment for statistical computing. Vienna, Austria, R Foundation for Statistical Computing. http://www.R-projetc.org/

Samuel FOK and Salako AE: 2008. Body measurement characteristics of the West African Dwarf (WAD) Goat in deciduous forest zone of Southwestern Nigeria. *African Journal of Biotechnology* 7 (14): 2551-2526.

Semakula J, Mutetikka D, Kugonza RD, Mpairwe D: 2010. Variability in Body Morphometric Measurements and Their Application in Predicting Live Body Weight of Mubende and Small East African Goat Breeds in Uganda. *Middle East Journal of Scientific Research* 5 (2): 98-105.

Toro MA, Meissen THE, Fernandez J, Shaat I and Maki- Tanila A: 2011. Assessing the genetic diversity in small farm animal populations, Animal, 5, 1669–1683Traoré A, Tamboura HH, Kaboré A, Yaméogo N, Bayala B et Zaré I : 2006. Caractérisation morphologique des petits ruminants (ovins et caprins) de race locale "Mossi" au Burkina Faso. *Animal Genetic Resources Information*, No. 39. 12p.

Traoré A, Hamidou HT, Adama K, Luis JR, Ivan F, Isabel A, Sangaré M, Bouchel D, Jean Paul P, Dominique F, Sawadogo L and Goyache F : 2008. Multivariate analyses on morphological traits of goats in Burkina Faso. *Arch. Tierz, Dummerstorf* 51 (6): 588-600.

Yakubu A, Raji AO and Omeje JN: 2010. Genetic and phenotypic differentiation of qualitative traits in Nigerian indigenous goat and sheep populations. *ARPN Journal of Agricultural and Biological Science* 5 (2): 58-66.