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Morpho-biometric characterization of the indigenous Djallonke sheep in Ngaoundere (Adamawa, Cameroon)

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Abstract

In order to study the morpho-biometric characterisation of the indigenous Djallonke sheep Ngaoundere, 126 adult indigenous Djallonke sheep (38 males and 88 females) were sampled from January to December 2020. The results of this study show that the coat colour is dominated by white; the horns, mane and Pendulous are less present; the facial profile is convex and the ears are semi-pendent. In addition, ear length, body length, chest depth, croup length and tail length showed significant differences ($p<0.05$). The correlation ($r=0.844$) between the substernal gracility index and the auriculo-thoracic index revealed the existence of sub-populations of indigenous Djallonké sheep that can be the subject of an improvement and preservation programme.

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Introduction

The average level of animal protein consumption is estimated at 13.3kg/capita/year against the 42kg/ capita/year recommended by the FAO and WHO (MINEPIA, 2012).

This is a deficit of about 28.7kg/capita/year, accentuated by the low existing production of livestock, which remains lower than the population growth (2.5% and 2.7% respectively) (INS, 2011). To solve this problem, particular emphasis is placed on small ruminants in general and sheep in particular, which contribute 17% of meat consumption in Africa (FAO, 2013). Because of its hardiness, resistance to hunger and thirst and relative trypanotolerance, sheep can be raised in all agro-climatic zones. It has a small size which makes it easy to handle. Its reproductive cycle is short and the female can give birth twice a year (FAO, 2008). Africa has about 265 million sheep, i.e. 23.4% of the world's sheep population and is second only to Asia (FAO, 2008). Lebbie and Ramsay (1999) counted 61 genetic groups of sheep in sub-Saharan Africa and Planchenault and Boutonnet (1997) identified 28 groups in French-speaking sub-Saharan African countries.

The sheep population in Cameroon is estimated at 3 million head (MINEPIA, 2011). Sheep farming is practised throughout the national territory and is of undeniable socio-economic importance (Tchouamo *et al.*, 2005). However, although a study on the biodiversity of the indigenous Djallonke sheep has been carried out in the Sudano-Guinean zone of Cameroon (Baenyi *et al.*, 2018), little information exists on their morphological and biometric characteristics. However, a better knowledge of these characteristics could contribute to improving its productivity and preservation (Traoré *et al.*, 2006). Thus, morpho-biometric characterisation was used with the main objective of contributing to a better knowledge of the genetic diversity of the indigenous Djallonke sheep in the peripheral areas of Ngaoundere (Cameroon). Specifically, the aim was to Describe morphological characteristics; Evaluate body measurements and assess biometric indices.

Materials and methods

Study area

The study was carried out from January to December 2020 in the outlying areas of Ngaoundere. Ngaoundere is located in the Adamawa region of Cameroon, at a northern latitude of 7°15'53.35" and an eastern longitude of 13°32'53.44", at an average altitude of 1,200 meters, with an average annual rainfall of 1,700mm. The average annual temperature of the area is 22°C and the soil is basaltic with a pH of 5.4.

Animal material

Sampling

With the support of the Adamawa regional delegation of livestock, fisheries and animal industries, the main sheep farming areas were identified in the outlying areas of Ngaoundere. In addition, farmers were identified by the snowball method and according to the accessibility of the site.

Selection of animals

For this study, 126 adult Djallonke sheep (38 males and 88 females) were selected and were randomly chosen from each of the herds on the selected farms.

Collection of morpho-biometric data

Information on morpho-biometric traits was collected using a survey form adapted from FAO (2013).

Morphological characteristics

Morphological description was carried out by direct observation of the animals in daylight using the standards established by Lauvergne (1992). This information included:

- -Presence/absence (Pendulous, horn, mane, black pattern on the flank);
- -Shape of horns: curled or spiral;
- -Orientation of ears: erect, horizontal and drooping;
- -Profile of the head: concavilinear, convexilinear and rectilinear;
- -Coat colour.

Biometric characteristics

Body measurements were taken using a tape measure, a graduated measuring stick and a graduated ruler:

-Body length (BL): from the bun to the vertical plane tangent to the buttock;
-Scapulo-ischial length (SIL): from the point of the shoulder to the point of the buttock;
-Croup length (CL): from the point of the hips to the point of the buttocks;
-Height at the withers (Hw): distance from the high point of the withers to below the hoof of the foreleg.

This is the most frequently cited parameter for assessing the animal's size (Laoun, 2007);
-Thoracic circumference (TC): at the level of the passage of the straps;
-Chest depth (CD): from the passage of the straps to the withers/back limit;
-Circumference of cannon (Cc); corresponds to the perimeter taken in the middle of the front barrel;
-Tail length (LT): distance from the point of attachment of the tail to the tip;
-Head length (HL): distance from the high limit of the forehead to the point of attachment of the two nostrils;
-Head width (HW): distance between the frontal limits of the head;
-Neck length (NL): distance from the point of the shoulder to the point of attachment between the lower jaw and the throat;
-Ear length(EL), is taken from the outside, from its birth to its tip.

Biometric indices
The body measurements were used to calculate the biometric indices as defined by Lauvergne *et al*, (1993a) and Bourzat *et al*, (1993). These are:
Sub-sternal gracility index (IGs): it highlights the stubby or wading character of the animal. In general, the more brevipes the animal is, the heavier it is, and therefore its carcass and meat potential is higher.
-GIs = (Hw-DC) /DC where HG is the height at the withers and Hw is the depth of the chest;
-Auriculo-thoracic index (AIt): this is used to assess the development of the sheep's ear.
AIt = EL/DC where EL is the length of the ear and DC is the depth of the chest;
-Size Index (SI): IF = BL/Hw or BL, is body length and Hw, height at withers;
-Longhorn Index (LI): IL = (Hw-DC)/Hw where Hw is height at withers and DC is depth of chest;
-Massiveness Index (MI): IM = TC/Hw where PT is the thoracic circumference and HG is the height at withers;
-Thoracic Index (TI): TI = CD/TC where LP is chest width and TC is thoracic circumference;
-Bone Index (BI): BI = Cc/Hw or Cc is the cannon circumference and Hw is the height at the withers;
-Body Index (BOI): BOI = SIL/PT where SIL, is the scapulo-ischial length and TC, the thoracic circumference;
-Dactylo-thoracic index (TDI): IDT = Cc/TC where PC, is the cannon circumference and TC, the thoracic circumference;

These indices were used to evaluate the archaism of the herds considered:
-The ear index: length of the ear/height at the withers;
-The caudal index: length of tail/height at withers.

Statistical Analysis
Descriptive statistics were used to describe the distribution of qualitative characteristics. Analysis of variance (ANOVA) was used to evaluate the influence of certain factors on the different body measurements and indices considered.

The following statistical model will be used:
$y_{ijh} = \mu + \alpha_i + \beta_j + (\alpha\beta)_{ij} + e_{ijh}$;
y_{ijh} = Observation on block h having received treatments i and j ;
μ = overall mean; α_i=effect of locality i; β_j=effect of sex j; Ω_k = effect of age k; e_{ijh} = residual error of the mean and variance.

To separate the means when differences were significant, Duncan's test at the 5% and 1% threshold was used. The direction and degree of association between traits was determined by means of Pearson's correlation coefficients.

Results
Morphological characteristics of indigenous Djallonke sheep in the outlying areas of Ngaoundere. Modalities, numbers, frequencies and Chi-square test

of the phanerotic profiles of the indigenous Djallonke sheep in the outlying areas of Ngaoundere. Table 1 presents the modalities, numbers, frequencies and Chi-square test of the phaneroptic profiles of Djallonke sheep in the outlying areas of Ngaoundere. The table 1 shows that the facial profile of the animals was significantly influenced at the 1% level. Indeed, 111 sheep (75 females and 36 males) recorded a convex facial profile. This convex profile was present in all sheep (80% females and 20% males) in Ngaoundere 1, compared to those in Ngaoundere 2 (64% and 36%, respectively for females and males) and Ngaoundere 3 (56% and 44%, respectively for females and males) In addition, no significant difference (p>0.05) was observed between the other parameters.

Table 1. Modalities, numbers, frequencies and chi-square test of the phaneroptic profiles of Djallonke sheep in the peripheral zones of Ngaoundere.

Parameters	Modalities		Ngdré1	Ngdré2	Ngdré3	Total	Pearson Chi-square test (measure of association)	
			Eff(%)	Eff(%)	Eff(%)	Eff(%)	Khi-deux	p-value
	No	Males	8(34)	14(34)	16(38)	38(31)		
		Females	30(79)	27(66)	26(62)	83(69)		
Pendulous	yes	Males	0(0)	0(0)	0(0)	0(0)	0,428	0,807
		Females	2(100)	1(100)	2(100)	5(100)		
Type of Pendulous	bilateral	Males	0(0)	0(0)	0(0)	0(0)		
		Females	2(100)	1(100)	2(100)	5(100)		
	Convex	Males	8(20)	14(36)	14(44)	36(32)		
Facial profile		Females	32(80)	25(64)	18(56)	75(68)	16,22	0,000***
	Straight	Males	0(0)	3(100)	10(83)	13(87)		
		Females	0(0)	0(0)	2(13)	2(13)		
	yes	Males	0(0)	7(64)	10(71)	26(54)		
Spotlight (black pattern on the side)		Females	12(100)	6(36)	4(29)	22(46)	0,032	0,984
	no	Males	8(29)	7(24)	6(20)	21(24)		
		Females	20(71)	22(76)	24(80)	66(76)		
Coat colour	white	Males	8(20)	14(35)	16(38)	38(31)		
		Females	32(80)	26(65)	26(62)	84(69)	1,92	0,382
	white-black	Males	0(0)	0(0)	0(0)	0(0)		
		Females	0(0)	2(100)	2(100)	4(100)		

*: Significance at the 5% threshold; ***: Significance at the 1% threshold; Ngdré: Ngaoundere; Eff: Effect.

Table 2. Modalities, numbers, frequencies and measure of association of morphological characteristics in Djallonke sheep in the peripheral zones of Ngaoundere.

Parameters	Modalities		Ngdre1	Ngdre2	Ngdre3	Total	Pearson Chi-square test (measure of association)	
			Eff(%)	Eff(%)	Eff(%)	Eff(%)	Khi-deux	P-value
	Yes	males	6(75)	11(79)	12(75)	29(23)		
Presence of horns	No	Males	2(6)	3(10)	4(13)	9(9)	2,139	0,343
		Females	32(94)	28(90)	28(87)	88(91)		
Horn shape	Curved		2(33)	7(64)	12(100)	21(72)	6,67	0,354
	Right		4(67)	4(36)	0(0)	8(28)		
Horns orientation	Backwards		6(100)	6(86)	9(75)	25(86)	8,049	0,235
	Laterale		0(0)	1(14)	3(25)	4(14)		
	Horizontal	Males	2(33)	1(33)	0(0,0)	3(33)		
		Females	4(67)	2(67)	0(0,0)	6(67)		
Ear orientation	Hanging	Males	6(60)	2(50)	4(50)	12(55)	11,280	0,024*
		Females	4(40)	2(50)	4(50)	10(45)		
	Semi-pendent	Males	0(0)	11(31)	12(33)	23(24)		
		Females	24(100)	24(69)	24(67)	72(76)		
	yes	Males	4(29)	5(56)	8(100)	17(55)		
Mane		Females	10(71)	4(44)	0(0)	14(45)	3,537	0,171
	No	Males	4(15)	9(27)	8(22)	21(22)		
		Females	22(85)	24(73)	28(78)	74(78)		

*: Significance at the 5% threshold; ***: Significance at the 1% threshold; Ngdre: Ngaoundere; Eff: Effect.

Modalities, numbers, frequencies and measure of association of morphological characteristics in Djallonke sheep in the peripheral areas of Ngaoundere

Table 2 presents the modalities, numbers, frequencies and measure of association of morphological characteristics in Djallonke sheep in the peripheral zones of Ngaoundere. This table 2 shows that the orientation of the ears was significantly influenced ($p>0.05$). In fact, 72 females and 23 males had semi-pendent ears. This trait was present in all female sheep in Ngaoundere 1, compared to those in Ngaoundere 2 (24% and 11%, respectively for females and males) and Ngaoundere 3 (24% and 12%, respectively for females and males). In addition, no significant difference ($p>0.05$) was observed between the other parameters.

Biometric characteristics of Djallonke sheep in the urban fringe of Ngaoundere

Table 3 shows the biometric characteristics of Djallonke sheep according to locality. This table 3 shows that the length of the ears (12.45±1.45cm) of the sheep in Ngaoundere 3 was more homogeneous (CV=11.6%) and significantly different ($p<0.05$) from those in Ngaoundere 1 and 2 which remained comparable. In addition, the body length (50.60±8.46cm) of sheep in Ngaoundere 3 was significantly higher ($p<0.05$) than in the other localities. Despite the fact that the depth of the chest of the sheep in Ngaoundere 1 was more homogeneous (CV=23.1%), the depth of the chest (33.93±10.20cm) of the sheep in Ngaoundere 2 was significantly higher ($p<0.05$) compared to that of the localities of Ngaoundere 1 and 2, which otherwise remained comparable. The length of the tail (36.77±5.58cm) of the sheep in Ngaoundere 3 was significantly higher ($p<0.05$) than in the other two localities (Ngaoundere 3> Ngaoundere 2> Ngaoundere 1). Similarly, the rump length (17.87±3.89cm) of sheep in Ngaoundere 3 was significantly greater ($p<0.05$) than in the other two localities (Ngaoundere 3> Ngaoundere 2 Ngaoundere 1).

On the other hand, no significant difference ($p>0.05$) was observed between the other body measurements.

Table 3. Biometric characteristics of Djallonke sheep according to locality.

Parameters	Ngaoundere 1		Ngaoundere 2		Ngaoundere 3		Total		p
	$\bar{X}$ ± E.t (n=40)	CV (%)	$\bar{X}$ ± E.t (n=42)	CV (%)	$\bar{X}$ ± E.t (n=44)	CV (%)	$\bar{X}$ ± E.t (n=126)	CV (%)	
HL	21,65 ±3,61^a	19,8	21,95 ±3,57^a	18,6	22,36±3,38^a	17,2	22,00±3,50	44,8	0,647
HW	11,35 ±1,46^a	13,4	11,26 ±1,06^a	9,4	11,73±1,23^a	11,8	11,45±1,26	39,7	0,192
EL	10,68 ±1,93^b	19,5	11,40±1,80^b	15,7	12,45±1,45^a	11,6	11,54±1,87	36,7	0,000
NC	29,40 ±5,13^a	18,0	28,93±4,82^a	18,0	29,09±5,11^a	18,0	29,13±4,99	44,8	0,911
NL	27,43±4,80^a	21,3	28,07±4,91^a	21,2	29,27±4,93^a	18,6	28,29±4,93	43,8	0,217
HW	59,10±9,66^a	17,6	60,93±8,72^a	19,1	61,00±8,55^a	17,3	60,72±8,98	43,6	0,332
BL	44,10±5,96^b	17,4	46,90±7,73^b	18,3	50,60±8,46^a	18,6	47,32±7,90	40,1	0,001
HD	52,80±5,97^a	12,3	54,48±7,72^a	17,5	57,00±7,97^a	20,2	54,83±7,45	43,8	0,32
PP	29,42±5,89^b	23,1	33,93±10,20^a	34,3	29,05±5,83^b	36,0	30,80±7,87	62,4	0,006
PT	64,60±15,19^a	36,0	68,52±10,72^a	19,0	70,64±10,62^a	20,5	68,02±12,44	43,1	0,80
SIL	50,05±9,07^a	27,7	52,10±8,79^a	22,4	50,77±10,01^a	21,1	50,98±9,29	51,6	0,602
CH	60,15±9,96^a	20,4	62,33±8,29^a	16,0	64,45±8,70^a	17,5	62,38±9,09	43,1	0,95
CL	12,70±2,29^c	25,9	14,76±2,82^b	19,3	17,87±3,89^a	22,0	15,17±3,73	35,5	0,000
TL	27,66±6,335^c	24,2	31,55±6,48^b	23,8	36,77±5,58^a	22,4	32,13±7,15	35,2	0,000
Cc	11,70±1,28	12,7	12,19±1,40	12,8	12,36±1,34	11,5	12,10±1,36	40,9	0,071

a, b, c: Indices with the same letter in the same row indicate that there are no significant differences between departments ($p<0.05$); X⁻ ± E.t: Mean ± standard deviation. CV: Coefficient of variation; P: probability (5%); HL: head length; HW: head width; EL: ear length; NL: neck length; NC: neck circumference; BL: body length; HW: height at withers; HB: height at back; CD: chest depth; TC: thoracic circumference; SIL: scapulo-ischial length; CH: croup height; CL: croup length; Cc: Cannon circumference; TL: tail length.

Biometric index of Djallonke sheep in the urban fringe of Ngaoundere

Table 4 presents the biometric indices of Djallonke sheep according to locality. This table 4 shows that the auriculo-thoracic index (0.44±0.12) of Ngaoundere 3 was more homogeneous (CV=18.1%) and significantly high ($p<0.05$) compared to those of the other localities which remained comparable ($p>0.05$).

Similarly, the size index of sheep in Ngaoundere 3 was significantly high ($p<0.05$) compared to the other two localities which remained comparable. Regarding the longevity index, Ngaoundere 1 and 3 obtained comparable values and significantly ($p<0.05$) higher than Ngaoundere 2. In addition, the massiveness index recorded in Ngaoundere 2 and 3 was more homogeneous and significantly ($p<0.05$) higher than that of Ngaoundere 1. In addition, the thoracic index (5.7±0.84) in Ngaoundere 1 was less scattered (CV=13.9%) and significantly ($p<0.05$) different from the other localities (Ngaoundere 1> Ngaoundere 1> Ngaoundere 1). The ear index (0.21±0.2) of sheep in Ngaoundere 3 was less dispersed (CV=12.8%), comparable to that of Ngaoundere 2 but significantly higher ($p<0.05$) than that of Ngaoundere 1. The caudal index (0.59±0.08) obtained in Ngaoundere 3 was significantly ($p<0.05$) higher than in the other localities. On the other hand, no significant difference ($p>0.05$) was observed between the other biometric indices.

Table 4. Biometric indices of Djallonke sheep according to localities.

Parameters	Ngaoundere 1		Ngaoundere 2		Ngaoundere 3		Total		p
	$\bar{X}$ ± E.t (n=40)	CV (%)	$\bar{X}$ ± E.t (n=42)	CV (%)	$\bar{X}$ ± E.t (n=44)	CV (%)	$\bar{X}$ ± E.t (n=126)	CV (%)	
IGs	1,03±0,22^{a}	17,7	0,94±0,64^{a}	20,8	1,22±0,66^{a}	18,3	1,07±0,57	41,7	0,054
IAt	0,37±0,07^{b}	21,9	0,36±0,13^{b}	44,5	0,44±0,11^{a}	18,1	0,37±0,12	45,1	0,001
IF	1,22±0,11^{b}	8,7	1,23±0,12^{b}	10,2	1,29±0,13^{a}	9,3	1,25±0,12	39,2	0,026
IC	0,89±0,12^{a}	18,3	0,91±0,87^{a}	9,6	0,88±0,,61^{a}	7,8	0,89±0,09	43,1	0,320
IL	0,50±0,5 ^{a}	17,51	0,43±0,19 ^{b}	19,1	0,52±0,88^{a}	18,1	0,48±0,13	41,5	0,002
IM	1,08±0,13^{b}	16,5	1,12±0,07^{a}	6,4	1,14±0,09^{a}	7,4	1,11±0,10	39,4	0,022
IT	5,7±0,84^{a}	13,9	5,16±0,73^{b}	15,6	4,63±0,91^{c}	21,5	5,15±0,94	58,0	0,000
IO	0,20±0,021^{a}	10,2	0,20±0,022^{a}	11,5	0,20±0,02^{a}	11,2	0,2±0,02	42,5	0,942
ICo	0,79±0,11^{a}	12,2	0,76±0,10^{a}	11,8	0,72±0,14^{a}	17,5	0,75±0,12	50,3	0,051
IDT	0,18±0,03^{a}	16,5	0,18±0,02^{a}	13,0	0,17±0,02^{a}	14,0	0,18±0,02	44,8	0,167
IA	0,18±0,32^{b}	16,8	0,19±0,32^{ab}	16,7	0,20±0,24^{a}	12,8	0,19±0,3	44,8	0,012
ICa	0,47±0,78^{c}	17	0,51±0,08^{b}	17,3	0,59±0,08^{a}	13,2	0,52±0,94	35,3	0,029

a, b, c: Indices with the same letter in the same row indicate that there are no significant differences between sub-divisions ($p<0.05$); X⁻ ± E.t: Mean ± standard deviation. CV: Coefficient of variation; P: probability (5%); IGs: substernal gracility index; IAt: auriculo thoracic index; IF: format index; IC: compactness index; IL: longilignity index; IM: massiveness index; IT: thoracic index; IO: bone index; ICo: body index; IDT: dactylo-thoracic index; IA: auricular index; Ica: caudal index.

Table 5. Correlation between body measurements of Djallonke sheep in the outlying areas of Ngaoundere.

	HL	HW	EL	NL	NC	BL	Hw	DC	TC	SIL	HC	CL	TL	Cc
HL	1													
HW	,505**	1												
EL	,457**	,329**	1											
NL	,181	,150	-,073	1										
NC	,444**	,429**	,195*	,490**	1									
BL	,677**	,507**	,589**	,708**	,461**	1								
Hw	,809**	,619**	,466**	,491**	,609**	,754**	1							
DC	,261**	,184*	,076	-,094	,179*	,168*	,352**	1						
TC	,794**	,673**	,458**	,454**	,582**	,793**	,895**	,357**	1					
SIL	,657**	,436**	,410**	,217	,415**	,655**	,701**	,252**	,678**	1				
CH	,728**	,635**	,566**	,452**	,627**	,797**	,881**	,317**	,870**	,677**	1			
CL	,416**	,391**	,443**	,544**	,358**	,559**	,512**	,042	,590**	,304**	,542**	1		
TL	,555**	,428**	,542**	,074	,343**	,705**	,622**	,060	,678**	,433**	,708**	,701**	1	
Cc	,594**	,578**	,506**	,063	,451**	,495**	,697**	,227**	,679**	,525**	,573**	,562**	,422**	1

**: correlation significant at 0.01; *: correlation is significant at 0. 05; HL: head length; HW: head width; EL: ear length; NL: neck length; NC: neck circumference; BL: body length; Hw: height at withers; HB: height at back; DC: depth of chest; TC: thoracic circumference; SIL: scapulo-ischial length; CH: croup height; CL: croup length; Cc: cannon circumference; TL: tail length.

Correlation between body measurements and biometric indices of Djallonke sheep in the outlying areas of Ngaoundere

Correlation between body measurements of Djallonke sheep in the outlying areas of Ngaoundere

The correlations between the body measurements of Djallonke sheep in the outlying areas of Ngaoundere are presented in Table 5. This table 5 shows that the highest (0.895) and significant (p<0.01) correlation was obtained between thoracic circumference and height at withers. The other measurements were weakly correlated with each other.

Correlation between biometric indices of indigenous Djallonke sheep in the peripheral areas of Ngaoundere

The correlations between the biometric indices of indigenous Djallonke sheep in the outlying areas of Ngaoundere are presented in Table 6.

Table 6 shows positive (0.844) and significant (p<0.01) correlations between the substernal gracility index and the auriculo-thoracic index. In addition, the dactylo-thoracic index and the skeletal index were positively correlated (0.706) and significantly (p<0.01).

Table 6. Correlation between biometric indices of indigenous Djallonke sheep in the peripheral zone of Ngaoundere.

	Igs	IAT	IF	IC	IM	IT	IL	IO	Ico	IDT	IA
Igs	1										
IAT	,844**	1									
IF	,013	,192*	1								
IC	-,094	-,265**	-,580**	1							
IM	-,071	-,058	,387**	,517**	1						
IT	-,094	-,159	,183*	-,337**	-,230**	1					
IL	,209*	-,045	-,300**	,487**	,229**	-,093	1				
IO	-,167	,086	,129	-,170	-,012	-,279**	-,678**	1			
Ico	,021	,107	,013	-,460**	-,509**	,253**	-,279**	,129	1	,	
IDT	-,087	,091	-,140	-,513**	-,695**	-,029	-,658**	,706**	,460**	1	
IA	-,088	,452**	,348**	-,335**	,032	-,176*	-,443**	,487**	,168	,337**	1

**: correlation significant at 0.01; *: correlation is significant at 0.05; IGs: substernal gracility index; IAt: auriculo-thoracic index; IF: size index; IM: massiveness index; IT: thoracic index; IO: bone index; ICo: body index; IDT: dactylo-thoracic index; IA: auricular index.

Discussion

The dominant coat colour was a uniform white. This result corroborates the work of Guiguigbaza *et al*, (2021) in Djallonké sheep in Guinea-Bissau. In contrast, N'goran *et al.* (2019) reported a predominantly white-black coat colour in Djallonke sheep in Togo. The dominance of the white colour, alone or in association with other colours, could be a form of adaptation to the environment (Traoré *et al.*, 2006).

Horns were present in only 23% of the sheep in this study. This result is in agreement with the work of N'goran *et al.* (2019) who obtained 23% in Djallonke sheep in Togo.

The convex facial profile was the most dominant. This result is in agreement with the work of Guiguigbaza *et al.* (2021) who reported a convex facial profile (100% and 90.18% respectively for males and females) in Djallonke sheep in Guinea-Bissau. In contrast, Salako (2012) observed a dominant straight facial profile in Djallonke sheep in Nigeria. According to him, a straight facial profile would characterise the wild sheep whereas a convex profile can be considered as a variant that appears during the domestication process through mutations.

In addition, the dominant orientation of the ears was semi-pendent and its average length (11.54cm) is different from those recorded by Guiguigbaza *et al.* (2021) who revealed that Djallonké sheep in Guinea-Bissau would have predominantly erect ears of length 10.62cm. In addition, Baenyi *et al.* (2018) reported an ear length of 14.17cm in the indigenous Djallonke sheep of the Sudano-Sahelian zone of Cameroon. These differences would be due to the breeding site. This would confirm the observations of Darwin (1859) who reported that animals exposed to less noise cease to use their ear muscles and develop long, hanging ears. The height at the withers was comparable between the 3 localities. The mean value (60.41cm) obtained is similar to Birteeb *et al.* (2014) (60.72cm) in Djallonke sheep in northern Ghana. This result is also close to the work of Djagba *et al*, (2019) (63.8cm) in Djallonke sheep in Togo. Similarly, Baenyi *et al.* (2018) had reported 70.26cm in the indigenous Djallonke sheep of the Sudano-Guinean zone of Cameroon. The average body length (47.32cm) and chest depth (30.80cm) recorded are close to the work of N'goran *et al.* (2019) (57.8cm and 33.8cm respectively for body length and chest depth in Djallonke sheep in Togo. In the same vein, Birteeb *et al.* (2014) reported 27.73cm for chest depth of Djallonke sheep in northern Ghana. On the other hand, Baenyi *et al*, (2018) reported a similar chest depth (29.80cm) and a different body length (29.91cm). Indeed, Lauvergne (2007) reported that chest depth would be an indicator of the metabolic potential of the animal.

The average thoracic circumference (68.02cm) and scapulo-ischial length (50.98cm) are lower than those reported by Djagba *et al.* (2019) (75.39cm and 63.99cm for thoracic circumference and scapulo-ischial length respectively). The same trend is observed in the work of Baenyi *et al.* (2018) who reported a thoracic circumference of 83.13cm. This difference could suggest a low respiratory amplitude for the indigenous Djallonke sheep of the peripheral areas of Ngaoundere.

The average rump length (15.17cm) recorded is not far from the work of Baenyi *et al.* (2018) (19.90cm). In contrast, Harkat *et al.* (2015) reported 21.04cm in Djallonke sheep from Algeria.

The average tail length (32.13cm) is lower than that of Baenyi *et al*, (2018) (43.11cm). On the other hand, this result is higher than that of Djagba *et al*, (2019) (27.4cm) in Djallonke sheep in Togo. The same trend is observed with the work of N'goran *et al.* (2019) (25.3cm). Similarly, Vallerand and Branckaert (1975) reported 25cm in Djallonke sheep in Cameroon.

This difference highlights the work of Lauvergne (1988) who revealed that the length of the tail would be one of the indicators of the animal's evolutionary stage. The average gracility index (1.07) recorded in the peri-urban area of Ngaoundere is higher than that obtained by Djagba *et al.* (2019) (0.28) in Djallonke sheep in Togo. On the other hand, this result is close to the work of Djoufack (2015) (1.08) in sheep from the highlands of West Cameroon. These different values would show that sheep in the peripheral areas of Ngaoundere would be of an intermediate gracility.

Concerning the auriculo-thoracic index, the average value (0.39) is in agreement with the work of Djoufack (0.38) in sheep from the highlands of West Cameroon. On the other hand, these results are higher than those of Djagba *et al.* (2019) (0.28) in Djallonke sheep in Togo.

The ear index (0.19) was similar to that of Djoufack (2015) (0.18). The highest (0.895) and significant ($p<0.01$) correlation between body measurements was observed between thoracic circumference and height at withers.

Furthermore, the dactylo-thoracic index and the bone index were positively correlated (0.706) and significantly ($p<0.01$). In addition, a positive (0.844) and significant ($p<0.01$) correlation was obtained between the substernal gracility index and the auriculo-thoracic index. This result could suggest the existence of sheep subpopulations in the study locality. This would confirm the work of Baenyi *et al.* (2018) who revealed the existence of 3 sub-populations of indigenous Djallonke sheep in the Sudano-Guinean zone of Cameroon.

Conclusion

At the end of this study on the morpho-biometric characterisation of the indigenous Djallonke sheep in Ngaoundere, it is clear that:

-The colouring of the coat is dominated by white; the horns, mane and Pendulous are less present; the facial profile is convex and the ears are semi-pendant.

-Ear length, body length, chest depth, rump length and tail length showed significant differences ($p<0.05$).

-The correlation between the sub-sternal gracility index and the auriculo-thoracic index revealed the existence of sheep sub-populations that can be the subject of an improvement and preservation programme.

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References

Baenyi P, Meutchieye F, Ayagirwe BR, Bwihangane BA, Karune K, Mushagalusa NG, Ngoula F. 2018. Biodiversity of indigenous Djallonke sheep (*Ovis areas*) in Sudano Guinean region in Cameroon. Genetics and Biodiversity Journal **2(2),** 1-10. https://ojs.univ-tlemcen.dz/index.php/GABJ/article/view/301

Birteeb, P.T., Peters, S.O and Ozoje, M.O. 2014. Analysis of the body structure of Djallonke sheep using a multideterminant approach. Animal Genetic Resources, **54,** pp 65-72. DOI: https://doi.org/10.1017/S2078633614000125

Bourzat D, Souvenir PZ, Lauvergne JJ, Zeuh V. 1993**.** Comparaison morpho- biométrique de chèvres au Nord Cameroun et au Tchad. Revue d'Elevage et de Médecine Vétérinaire des Pays tropicaux **46(4),** 667-674. https://agritrop.cirad.fr/398736/

Darwin C. 1859. On the origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life. London, Murray. Traduction française de la *6è édition*. (Murray, London, 1872) par Edmond Barbie : l'origine des espèces au moyen de la sélection naturelle, ou la lutte pour l'existence dans la nature pp. 25-35.

Djagba AY, Douti TL, Bonfoh N, Kanour N, Bassowa H, Pitala W, Gamadou AA. 2019. Caractérisation morphométrique des Ovins de la station de Kolokopé au Togo. Bulletin de la Recherche Agronomique du Bénin pp. 37-48.

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

FAO. 2008. L'état des ressources zoo génétiques pour l'alimentation et l'agriculture dans le monde pp. 320-350. https://agris.fao.org/agris-search/search.do?recordID=XF2008437095

FAO. 2013. Caractérisation phénotypiques des ressources génétiques animales. FAO sur la production et la santé animale. N° 11, Rome 152p. https://agritrop.cirad.fr/595381

Guiguigbaza KD, Houaga I, Somda BM, Awa L, Mamadou I, Konkobo M, bakar D, Joaos G, Mamadou S, Cassama B, Yapi-gnaoré CV. 2021. Morphological and microsatellite DNA diversity of Djallonke sheep in Guinea-Bissau. Research Square, DOI: https://doi.org/10.21203/rs.3.rs-275691/v1

Hamito D. 2009. Goat breeds of Ethiopia: A guide for identification and utilization. Ethiopia Sheep and Goat Productivity Improvement Program (ESGPIP). Technical Bulletin 23, 11p. http://www.univ-soukahras.dz/eprints/2020-992-47fd4.pdf

Harkat S, Boum A, Benali R, Outayeb D, Ferrouk M, Mafta A, Dasilva A, Lafri M. 2015. Phenotypic characterization of the major sheep breeds in Algeria. Revue de Médecine vétérinaire **166**(5-6), 138-147.

INS (Institut National de Statistique). 2011. Elevage et pêche. 18 P.

Laoun A. 2007. Magistère des sciences vétérinaires : Etude morpho-biométrique d'un échantillonnage d'une population ovines de la région de Djelfa, Option: Zootechnie, Algérie 115p.

Lauvergne JJ, Bourzat D, Souvenir-Zafindrajaona P, Zeuh V, Ngo Tama AC. 1993a. 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. https://agritrop.cirad.fr/398733

Lauvergne JJ. 1988. Populations traditionnelles et premières races standardisées d'Ovicaprinæ dans le bassin méditerranéen, colloque Gontard /Manosque (France), 30 juin – 02 juillet 1986, coll. INRA n° **47,** Paris, 298p.

Lauvergne JJ. 1992. Breed development and breed differentiation. Proc CEC Workshop and training course. Hannover pp. 53-64

Lauvergne JJ. 1993. Breed development and breed differentiation. Proc CEC Workshop and training course (D simon, D Buchenauer, Eds), Hannover 7-9 December pp. 53-64.

Lebbie SHB, Ramsey K. 1999. A perspective on conservation and management of small ruminant genetic resources in the sub-Saharan Africa. Small Ruminant Research **34,** pp231-247. DOI: https://doi.org/10.1016/S0921-4488(99)00076-0

MINEPIA. 2012. Annuaire statistique du Cameroun. Chapitre **15,** pp. 266-281.

N'goran KE, Kouadja GS, Kouassi NC, Loukou NE, Eka JY, Daya GKC, Sangaré M, Yapi-gnaoré CV. 2019. Primary morphological characterization of West African dwarf (Djallonk) ewes from Cte dIvoire based on qualitative and quantitative traits. Intenational Journal of Genetics and Molecular Biology. Vol **11(2),** 16-28.

Planchenault D, Boutonnet JP. 1997. Conservation de la diversité des ressources génétiques animales dans les pays d'Afrique francophone sub-saharienne. Animal Genetic resources **10,** p.

Salako AE. 2012. Genetic and phenotypic profiles of West African dwarf and Yankasa sheep breeds in Nigeria. International Journal of Biodiversity and Conservation Vol **5(2),** pp. 47-53.

Tchouamo IR, Tchoumboué J, Thibault L. 2005. Caractéristiques socio-économique et techniques de l'élevage de petits ruminants dans la province de l'ouest Cameroun. Tropicultura **23(4),** 201-211.

Traore A, Tamboura HH, Kaboré A, Yaméogo N, Bayala B, Zaré I. 2006. Caractérisation morphologique des petits ruminants (ovins et caprins) de race locale *Mossi* au Burkina Faso. Animal Genetic Resources Information **39,** 39-50. DOI: https://doi.org/10.1017/S1014233900002121

Vallerand F, Branckaert A. 1975. La race ovine Djallonké au Cameroun : Potentialités zootechniques, conditions d'élevage, avenir. Revue d'Elevage et de Médecine Vétérinaire des Pays Tropicaux **28(4),** 523-545. DOI : https://doi.org/10.19182/remvt.7988