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Determination of Age and Weight of Djallonke Fetus (*Capra hircus*) by Biometry

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Abstract:
In order to determine the age of Djallonke goat fetuses through biometric measurements, a study was carried out on 201 fetuses from 114 gravid goats slaughtered at the Bantaï slaughterhouse in Ngaoundere (Adamawa Region). The gravid goats were characterized according to their breed, weight, age, litter size and body condition score (BCS). A total of 21 measurements were taken for each fetus. The prevalence for simple, twin, triple and quadruple litter sizes was 40.4%, 44.7%, 13.1%, and 1.8% respectively. The sex ratio of the fetuses was 0.86 and their ages varied from 58.78 ± 4.23 to 114.73 ± 3.60 days. Correlations between crown-rump length (CRL), weight and fetal biometric measurements through polynomial, logarithmic and power equations using the best correlation coefficient were established. Globally, head, body, limbs, CRL measurements and fetal weight were strongly correlated; more specifically, head length (R^2_{CRL}= 0.959; R^2_{Poids}= 0.9384), face width ($R^2_{CRL=}$ 0.9542), biparietal diameter (R^2_{Poids}= 0.9276), fore head-tail base side length (R^2_{CRL}= 0.9875), nose-rump length (R^2_{CRL}= 0.9964; R^2_{Poids}= 0.9666) and the tarsometatarsal length (R^2_{CRL}= 0.9818; R^2_{Poids}= 0.9564). There was a weak correlation between CRL, weight with regards to umbilical cord length (R^2_{CRL}= 0.5436; R^2_{Poids}= 0.5374), number of placentomes (R^2_{CRL}= 0.0652; R^2_{Poids}= 0.0577), and placentome sizes (R^2_{CRL}= 0.3933; R^2_{Poids}= 0.3839). Therefore, the utilization of parameters positively correlated to the CRL and the weight could contribute to the use of ultrasonography in small ruminants especially in Djallonke.
Keywords: Djallonke goat, biometric, fetus, age, weight, ultrasonography.

INTRODUCTION

Small ruminants in general and goats in particular hold a great importance in the animal production industry in the economy of many developing countries (Iniguez, 2011). Sub-saharian Africa possesses about 53% of the small ruminants worldwide population with 29.2% goats (Tchouamo *et al.,* 2005). Their breeding is one of the most important activities of rural families in Cameroon with a population estimated at 6 million heads (MINEPIA, 2014). An increase in the productivity of goats is therefore necessary, through the improvement of their reproductive performance. Factors like physiological state, ovarian cysts, embryonic mortalities, which constitute real problems could be solved by ultrasonography. Nowadays, ultrasonography has by its immediate results, taken the lead on other methods of gestation diagnosis (hormonology and rectal palpation) (Pitala *et al*., 2012). It has become a reproductive management tool and is used in daily practice for the diagnosis of gestation. This technique can solve some reproductive problems such as selection of gestating goats, detection of non-gestation, embryonic mortalities, determination of the stage of the gestation and the number of fetuses, or even their morphology and predict the weight of the fetus (Ali and Hayder, 2007; Vural *et al*., 2008). Though discreet all these problems play a very important role in the overall productivity of the herd and constitute a hindrance for farmers in the management of their flocks.

In tropical farms where males and females are kept together, the breeders do not control the reproductive process which rather occurs randomly. They generally diagnose gestations by the non-return of estrus, transabdominal palpation and on external signs such as abdominal and mammary development. However, these methods are subjective, late and do not detect pseudo-gestations. Information on the age, number and weight of the fetus allows producers to group animals according to their nutritional needs and to organize appropriate rationing during the second half of gestation, to dry up the females at appropriate times and prepare them for parturition (Vural *et al*., 2008).

It is in this context that this study was conducted with the main objective of determining the fetal age and weight through biometry of Djallonke goat slaughtered at the Bantaï slaughterhouse in order to allow a better determination of the farrowing periods. Specifically, this implied characterizing the gestating goats slaughtered; determining the sex ratio, the weight and the age of the fetuses; establishing the measurements of fetuses at different ages; and finally establishing a correlation between the cranio-caudal length (CRL), the weight and the measurements of the fetus.

MATERIALS AND METHODS

Study area and animal characteristics

This study was carried out in the town of Ngaoundere, Vina division, Adamawa region. Located in central Cameroon between latitude 7 ° 19 '39 N and longitude 13 ° 35' 4E, Adamawa is a vast, quadrangular pastoral area of about 70000 square kilometers. The study was conducted on 201 fetuses from 114 gravid Djallonke goats at the Bantaï slaughterhouse, in the sub-division of Ngaoundere II. The weight, age and body condition score (BCS) of the slaughtered females were between 12 and 34 kg, 1 and 4 years; and 2 and 4, respectively. The animals came from the surrounding towns (Tchabal, Djalingo, Belel, Nganha, Mbé ...).

Collection of uteri and fetal measurements

After bleeding and eviscerating the animals, the gravid uteri thrown by the butchers were collected, then dissected using a pair of scissors and a scalpel and then the number of fetuses per uterus was noted. Measurements were made on the fetuses using a meter tape and a calliper as described by Joubert (1956):

CRL = taken with the flexible tape between the two eyes across the back to the base of the tail; Eye-rump length straight = grip with the inflexible ribbon from the front to the base of the tail; Nose-rump length =hold with a flexible ribbon of the muzzle, through the back to the base of the tail; Ear-rump length = grip with the flexible tape between the base of the head (mid-distance of both ears) to the base of the tail; Length of the head = grip between the muzzle and the base of the head (mid-distance of both ears);BPD=bi-parietal diameter Width of the face = catch using the caliper between the two eyes; Length of the head = socket using the ribbon, distance between the two ears; Head circumference = measured at the biggest place of the head (at the height of the ears); Body cross= gap between the spine of the scapula and the base of the tail; Chest depth= taken vertical to the line of the 6th rib (immediately behind the thoracic limbs) from dorsal surface of the back ; Chest circumference ; Length of radius-ulna; Length of the metacarpus; Length of tibia; Length of tarsal-metatarsal; The length of the umbilical cord; The circumference of the umbilical cord; The size and the number of the placentomes.

Determination of age of fetus

The age of the fetus was determined from the following formula: X = 2.1(Y + 17); X = age of fetus in days and Y = CRL in cm (Arthur *et al*., 2001) and ranged from 50 to 125 days.

Determination of sex and weight of fetuses

In goats, the migration of the genital tubercle starts from day 45 of gestation. Sex is determined between day 55 and 70. In the male fetus, the genital tubercle is located caudally immediately after the point of attachment of the umbilical cord and / or when the scrotum has been observed between the hind limbs. In the female fetus, the genital tubercle is located towards the base of the tail and or when the mammary gland is present between the thighs (Ali and Fahmy, 2008). The sex ratio was calculated as the ratio of male to female fetuses. The weight of the fetus was obtained using an SF-400 electronic scale with an accuracy of 0.1g and range of 9 to 1774 grams.

Statistical analysis

Data was analyzed using Statgraphics Centurion XVI. II software and comparison of means was performed with the ANOVA and Kruskal-Wallis tests for normative and non-normative variables, respectively.

RESULTS

Litter Size

The greatest proportion of gravid goats slaughtered had twins (44.7%). However, the rates of single (40.4%), triple (13.1%) and quadruple (1.8%) gestations were considerable.

Sex ratio

Out of the 201 fetuses identified, 108 were females and 93 males, thus sex ratio was 0.86.

Fetal measurements in relation to the gestation period

After measurement and counting at the slaughterhouse, 21 fetal parameters were measured as shown in the table 1. The fetuses were grouped by period of 15 days in order to determine the average age of these periods. Fetuses were thus found to have an average age of 114.13 ± 3.60 days with a CRL of 37.63 ± 1.71 cm. With respect to age, there was a significant difference (P= 0.00) in the parameters measured, with the exception of four, namely:

- The diameter of the umbilical cord which varied significantly until about day 80 of gestation;

- The length of the umbilical cord varied significantly until around the 80th day of gestation;

- The size of placentomes varied significantly between the 50th and 80th days of gestation;

- The number of placentomes varied significantly between the 50th and 65th day of gestation, and varied again from the 110th day.

Table 1. Average of the fetal parameters as a function of the age of gestation.

Fetal characteristics	Gestation period (days)					
	[50-65[	[65-80[	[80-95[	[95-110[	[110-125[	P-value
Effective	59	62	54	20	6	
Average age (days)	58.78±4.23^{a}	72.62±4.34^{b}	87.26±3.88^{c}	103.73±4.53^{d}	114.73±3.60^{e}	0.00
Weight (g)	32.83±22.24^{a}	120.48±52.80^{b}	349.30±86.34^{c}	823.1±224.26^{d}	1303.33±346.08^{e}	0.00
CRL (cm)	10.99±2.01^{a}	17.58±2.07^{b}	24.55±1.85^{c}	32.40±2.16^{d}	37.63±1.71^{e}	0.00
Occipito-scrotal length (cm)	7.68±1.61^{a}	12.79±1.8^{b}	18.24±1.77^{c}	24.78±1.99^{d}	29.58±2.01^{e}	0.00
Muzzle-tail base length (cm)	12.07±2.17^{a}	19.5016±2.4^{b}	27.37±2.07^{c}	35.83±2.28^{d}	40.93±2.07^{e}	0.00
Fore-head – side shannk lenght (cm)	9.7±1.95^{a}	15.96±2.07^{b}	22.2±1.9^{c}	29.31±2.26^{d}	35.4±2.25^{e}	0.00
Muzzlle-head base (cm)	3.75±0.82^{a}	6.3±0.8^{b}	8.49±0.84^{c}	10.53±0.9^{d}	12.05±0.77^{e}	0.00
Head width (cm)	2.09±0.33^{a}	3.15±0.42^{b}	3.96±0.36^{c}	4.64±0.49^{d}	5.58±0.38^{e}	0.00
Face width (cm)	1.95±0.31^{a}	2.95±0.40^{b}	3.77±0.29^{c}	4.54±0.29^{d}	5.05±0.26^{e}	0.00
Head circomference (cm)	5.28±1.10^{a}	8.3±1.51^{b}	11.31±1.88^{c}	14.1±1.48^{d}	16.1±1.29^{e}	0.00
BPD (cm)	1.74±0.31^{a}	2.72±0.36^{b}	3.58±0.33^{c}	4.41±0.28^{d}	4.87±0.27^{e}	0.00
Tronc lenght (cm)	5.95±1.25^{a}	9.88±1.41^{b}	14.13±1.51^{c}	19.29±1.89^{d}	23.43±1.45e	0.00
Chest size (cm)	2.92±0.67^{a}	4.9±0.74^{b}	7.21±0.75^{c}	9.45±1.11^{d}	11.98±1.50e	0.00
Thoracic perimeter (cm)	5.80±1.12^{a}	9.74±1.55^{b}	13.99±1.42^{c}	18.58±2.67^{d}	23.02±1.29e	0.00
Radio-ulna length (cm)	1.72±0.38^{a}	3.05±0.56^{b}	4.61±0.61^{c}	6.87±0.86^{d}	8.58±0.92^{e}	0.00
Length of Metacarp (cm)	0.93±0.31^{a}	1.79±0.34^{b}	2.82±0.48^{c}	4.33±0.87^{d}	5.72±0.45^{e}	0.00
Length of tibia (cm)	2.07±0.47^{a}	3.84±0.72^{b}	6.04±0.80^{c}	9.16±1.16^{d}	11.85±1.13e	0.00
Tarso-metatarsian length (cm)	1.25±0.37^{a}	2.45±0.52^{b}	4.06±0.56^{c}	6.13±0.87^{d}	7.83±0.66^{e}	0.00
Umbilical cord circumference (cm)	0.4±0.08^{a}	0.45±0.07^{b}	0.52±0.1^{c}	0.74±0.20^{d}	0.72±0.15^{d}	0.00
Length of umbilical cord (cm)	4.35±0.76^{a}	5.65±0.99^{b}	6.30±1.15^{c}	7.1±1.44^{d}	6.88±1.57^{cd}	0.00
Number of placentomes (cm)	60.88±10.71^{a}	66.73±10.92^{b}	64.96±12.54^{ab}	67.55±12.79^{b}	79.0±19.79^{c}	0.00
Size of Placentomes (cm)	3.13±0.75^{a}	4.47±0.95^{b}	4.71±1.04^{bc}	4.94±1.12^{c}	5.05±0.56^{c}	0.00

Correlation between CRL, weight and fetal measurements

Head of the fetus

The following equations were the most expressive:

Power of type $y = ax^b$ (y = CRL (mm), and x = fetal head measurement (mm) y = weight(mg); a = coefficient and b = exponent);

Polynomial of type $y = ax^2 + bx + c$ (y = CRL (mm), x = fetal head measurement (mm), a and b = coefficients and c = constant);

Logarithm of type y = a ln (x) -b (y = weight (mg), x = fetal head measurement (mm), (a = coefficients and b = constant);

There was a positive correlation between CRL, weight and head measurements (table 2). The length of the head showed strong correlations with CRL (R2 = 0.959) and fetal weight (R2 = 0.9384). Head measurements showed a better correlation with CRL than weight (minimum values R^2_{CRL} = 0.8995 and $R^2_{weights}$ = 0.8887 and maximum values R^2_{CRL} = 0.959 and $R^2_{weights}$ = 0.9384). There was no significant difference between males and females (p> 0.05).

Table 2. Correlation between fetal head measures (x) with weight (y) and CRL (y).

Parameters	Sex	CRL (mm)		Weight (mg)	
		Regression	R^2	Regression	R^2
Head length (mm)	Total	$y = 3.2413x^{0.9734}$	0.959	$y = 1.5306x^{0.3147}$	0.9384
	Male	$y = 3.4742x^{0.9576}$	0.9429	$y = 1.3671x^{0.3227}$	0.9369
	Female	$y = 3.011x^{0.9902}$	0.9748	$y = 1.7014x^{0.3072}$	0.9443
Head circumference (mm)	Total	$y = 2.4106x^{0.9752}$	0.8995	$y = 2.5632x^{0.2961}$	0.8887
	Male	$y = 2.1566x^{0.996}$	0.911	$y = 2.5198x^{0.2979}$	0.8941
	Female	$y = 2.6687x^{0.9561}$	0.8926	$y = 2.5984x^{0.2945}$	0.8841
Head width (mm)	Total	$y = 2.8256x^{1.2092}$	0.9093	$y = 1.8178x^{0.2413}$	0.8981
	Male	$y = 2.882x^{1.1979}$	0.9122	$y = 1.7131x^{0.2467}$	0.8857
	Female	$y = 45.969x^{1.2195}$	0.9099	$y = 1.9136x^{0.2367}$	0.9112
Face width (mm)	Total	$y = 0.0978x^2 + 1.5202x + 45.624$	0.9542	$y = 7.2854\ln(x) - 54.769$	0.9173
	Male	$y = 0.1079x^2 + 0.8763x + 53.024$	0.9678	$y = 7.4584\ln(x) - 56.896$	0.9108
	Female	$y = 0.0879x^2 + 2.1445x + 38.273$	0.9422	$y = 7.1303\ln(x) - 52.857$	0.9246
BPD (mm)	Total	-		$y = 1.069X^{0.2748}$	0.9276
	Male			$y = 0.9633X^{0.2827}$	0.9221
	Female			$y = 1.1766X^{0.2676}$	0.9362

Body of the fetus

The following equations were the most expressive:

- ✓ Polynomial of type $y = ax^2 + bx + c$ and Power of type $y = ax^b$ (y = CRL (mm), x = fetal head measurement (mm), a and b = coefficient, c = constant);
- ✓ Power of type $y = ax^b$ (y = weight (mg), x = fetal head measurement (mm), a = coefficient, b = exponent)

There was a very good correlation between CRL, weight and body measurements (table 3). The muzzle-base tail length showed a better correlation with CRL and weight (R^2_{CRL} = 0.9964; $R^2_{weights}$ = 0.9666). There was no significant difference between males and females ($p > 0.05$).

Limbs of the fetus

The following equations are the most expressive:

- ✓ Polynomial of type $y = ax^2 + bx + c$ (y = CRL (mm), x = fetal head measurement (mm), a and b = coefficients, c = constant).
- ✓ Power of type $y = ax^b$ (y = weight (mg), x = fetal head measurement (mm), a = coefficient, b = exponent).

There was a strong correlation between the CRL, the weight and limb measurements (table 4). The length of the tibia has a strong correlation with CRL and weight. The measurements of the limbs have a stronger correlation with the CRL than weight (minimal weight values R^2_{CRL} = 0.9499 and R^2weight = 0.935 and maximal values R^2_{CRL} = 0.9818 and R^2_{weight} = 0.9564). There was no significant difference between males and females at $p > 0.05$.

Table 3. Correlation between CRL (y) and weight (y) with body measurements (x).

Parameters (mm)	Sex	CRL (mm)		Weight (mg)	
		Regression	R^2	Regression	R^2
Muzzle-tail base length	Total	$y = 0.9374x^{0.9931}$	0.9964	$y = 4.6703x^{0.3191}$	0.9666
	Male	$y = 0.9454x^{0.9914}$	0.9957	$y = 4.2809x^{0.3254}$	0.9668
	Female	$y = 0.9301x^{0.9946}$	0.9971	$y = 5.0652x^{0.3133}$	0.9688
Chest size	Total	$y = 5.963x^{0.8697}$	0.9709	$y = 0.7454x^{0.3581}$	0.9581
	Male	$y = 5.58x^{0.8833}$	0.9733	$y = 0.727x^{0.3602}$	0.9621
	Female	$y = 6.3536x^{0.8563}$	0.9706	$y = 0.7625x^{0.3563}$	0.9546
Forehead-side shank length	Total	$y = -0.0001x^2 + 1.1062x + 3.9464$	0.9875	$y = 3,4526x^{0.3271}$	0.9543
	Male	$y = -7E-05x^2 + 1.0874x + 4.6409$	0.9925	$y = 3.1419x^{0.3345}$	0.9574
	Female	$y = -0.0001x^2 + 1.1117x + 4.2741$	0.9832	$y = 3.7621x^{0.3204}$	0.9527
Occipito-scrotal length	Total	$y = -0.0005x^2 + 1.4009x + 6.3465$	0.986	$y = 2.2484x^{0.3454}$	0.9581
	Male	$y = -0.0005x^2 + 1.3983x + 5.6626$	0.9903	$y = 2.1146x^{0.3493}$	0.9601
	Female	$y = -0.0006x^2 + 1.4231x + 5.7233$	0.9821	$y = 2.3852x^{0.3416}$	0.9584
Body length	Total	$y = -0.0014x^2 + 1.9072x + 2.4581$	0.9839	$y = 1.6747x^{0.3487}$	0.9655
	Male	$y = -0.001x^2 + 1.7926x + 7.9243$	0.9852	$y = 1.4634x^{0.3595}$	0.9715
	Female	$y = -0.0017x^2 + 2.0093x – 2.4231$	0.9837	$y = 1.8917x^{0.339}$	0.9618
Thoracic perimeter	Total	$y = -0.0016x^2 + 1.9735x + 1.691$	0.9681	$y = 1.7103x^{0.3454}$	0.9546
	Male	$y = -0.0006x^2 + 1.7288x + 11.298$	0.9758	$y = 1.5552x^{0.3536}$	0.9592
	Female	$y = -0.0025x^2 + 2.1981x – 7.194$	0.9652	$y = 1.8601x^{0.3382}$	0.9511

Table 4. Correlation between fetal leg measures (x) and weight (y) with CRL (y)

Parameters (mm)	Sex	CRL (mm)		Weight (mg)	
		Regression	R^2	Regression	R^2
Radio-ulna length	Total	$y = -0.0206x^2 + 5.8551x + 17.969$	0.971	$y = 0.2847x^{0.4004}$	0.9412
	Male	$y = -0.0206x^2 + 5.9026x + 16.094$	0.9703	$y = 0.2701x^{0.4038}$	0.9445
	Female	$y = -0.0211x^2 + 5.8523x + 19.08$	0.9718	$y = 0.2994x^{0.397}$	0.9391
Metacarpian length	Total	$y = -0.0561x^2 + 9.0009x + 35.22$	0.9499	$y = 0.0792x^{0.4626}$	0.935
	Male	$y = -0.0506x^2 + 8.7712x + 35.314$	0.954	$y = 0.0708x^{0.4715}$	0.9447
	Female	$y = -0.063x^2 + 9.2924x + 34.391$	0.9474	$y = 0.0877x^{0.4545}$	0.9267
Tibial length	Total	$y = -0.0124x^2 + 4.3841x + 26.445$	0.9818	$y = 0.2474x^{0.4323}$	0.9564
	Male	$y = -0.0126x^2 + 4.4275x + 24.479$	0.9836	$y = 0.0235x^{0.4358}$	0.952
	Female	$y = -0.0124x^2 + 4.3604x + 27.956$	0.9801	$y = 0.2603x^{0.4288}$	0.9612
Tarso-metatarsian length	Total	$y = -0.0228x^2 + 5.9651x + 42.256$	0.9753	$y = 0.0939x^{0.4761}$	0.9512
	Male	$y = -0.0221x^2 + 5.9774x + 41.608$	0.9725	$y = 0.084x^{0.4836}$	0.9521
	Female	$y = -0.0244x^2 + 6.0279x + 41.914$	0.9785	$y = 0.1044x^{0.4688}$	0.953

Umbilical cord and placentomes of the fetus

The power equation $y = ax^b$ (y = weight (mg), y = CRL (mm) and x = fetal head measurement (mm)) is the most expressive. There was a weak correlation between CRL, weight and umbilical cord parameters and placentomes (table 5). There was no significant difference with sex ($p > 0.05$).

Table 5. Correlation between umbilical cord measurements, placentomes (x) and weight (y) with CRL (y).

Parameters (mm)	Sex	CRL (mm)		Weight (mg)	
		Regression	R^2	Regression	R^2
Umbilical cord circumference	Total	$y = -4.3996x^2 + 92.277x - 142.06$	0.5436	$y = -2E\text{-}12x^2 + 6E\text{-}06x + 3.7868$	0.5374
	Male	$y = -3.4906x^2 + 82.373x - 122.12$	0.5152	$y = 0.0008x^2 - 0.0387x + 4.4958$	0.5089
	Female	$y = -5.6863x^2 + 106.22x - 172.72$	0.5831	$y = -3E\text{-}12x^2 + 6E\text{-}06x + 3.6396$	0.5534
Umbilical cord length	Total	$y = 1.7069x^{1.1656}$	0.4973	$y = 11.043x^{0.1357}$	0.4826
	Male	$y = 1.5912x^{1.1792}$	0.5541	$y = 9.0503x^{0.1525}$	0.5398
	Female	$y = 1.86x^{1.1475}$	0.4435	$y = 13.179x^{0.1209}$	0.4318
Number of placentomes	Total	$y = 15.299x^{0.5937}$	0.0652	$y = 43.182x^{0.0333}$	0.0577
	Male	$y = 12.878x^{0.6302}$	0.0593	$y = 44.889x^{0.0298}$	0.055
	Female	$y = 17.44x^{0.5664}$	0.0704	$y = 41.763x^{0.0364}$	0.0601
Size of placentome	Total	$y = 6.5295x^{0.8977}$	0.3933	$y = 7.7904x^{0.1398}$	0.3839
	Male	$y = 4.8168x^{0.9724}$	0.4081	$y = 8.4137x^{0.134}$	0.3849
	Female	$y = 8.1519x^{0.844}$	0.3875	$y = 7.2576x^{0.1451}$	0.3854

DISCUSSION

This study shows percentages for quadruplet, triplet, twin and single pregnancies. These results are similar to the work of Ngona *et al*. (2012) in the DRC (Democratic Republic of Congo) with 3.7%, 43.2% and 53.1 and Kazadi et al. (2015) with 0.43%, 47.05% and 52.2%, respectively for triple, twin and single pregnancies in African goat where cases of triplet gestations were rare and high frequencies of simple gestations and twin were found. On the other hand, Pineda (2003) indicated the scarcity of simple pregnancies in most goat breeds. This difference could be explained by the effects of breed, feeding and rearing environment. The slaughter of gravid goats cause huge losses and thus constitutes a shortfall for the breeders and a handicap for the country. The losses observed during this study at the Bantaii slaughterhouse amounted to 201 fetuses. Considering the estimated annual abortion rate in traditional farming in tropical areas by CIRAD-EMVT (1991) at 2.3%, mortalities and losses of young animals and adults by Bonfoh and Bassowa (2005), the number of adult goats lost from the original 201 fetuses is 70.21. With an average price of adult goats in the Bantaii market at 20.000 CFA francs, the losses would be about 1.404.200 CFA francs for 4 months, approximately 351.050 CFA francs per month and that's only for the Djallonke breed. The importance of these losses confirms the necessity and the interest of an ultrasound diagnosis of the females before their slaughter.

The sex ratio of 0.86 is similar to those obtained by Ngona et al. (2012) on goat fetuses at the slaughterhouse in Lubumbashi, DRC with a sex ratio of 0.53 and Kouamo et al. (2018) on zebu fetuses at the Ngaoundere slaughterhouse with a sex ratio of 0.82. In animal production, females are the most important, proper follow-up would be necessary to overcome these losses through an ultrasound diagnosis.

In this study, the different biometric parameters measured increased significantly with the evolution of pregnancy. This is similar to the work of Barone (2001) and Noakes *et al.* (2001) who reported that the size of the fetus evolves gradually during and especially in the last term of gestation. CRL is the most representative measurement in the post-mortem determination of age of gestation in most species (Chavatte-Palmer *et al*., 2006; Kohan Ghardr *et al*., 2008), but it cannot be used for the determination of age and weight of the fetus throughout gestation in small ruminants because

after 90-100 days of gestation, the estimation of age becomes difficult mainly because of the difficulties encountered in locating the fetus (Bretzlaff and Romano, 2001). CRL is the best parameter for determining the age of the fetus during the first semester of gestation and BPD during the second semester (James *et al*., 2015). In several studies, age and weight were found to be better correlated with other fetal parameters, thus allowing ultrasonography to measure the most accessible parameter and to determine age (Yaseen, 2017).

Polynomial, logarithmic and power equations were established to find the best correlation between age, fetal weight and biometric parameters. From this, head measurements generally have a good correlation with the CRL and the weight but more particularly the length of the head and the width of the face which have a better correlation. Biparietal diameter (BPD) and length of the head express a better correlation with the weight of the fetus. This result is similar to that reported by Zongo et al. (2014) in the Sahelian goat, where the weight of the fetus had a greater correlation with BPD; but does not support results reported by Nwaogu et al. (2010) in Nigeria on Red Sokoto goat where DBP and head length were strongly correlated with fetal age.

There is a very good correlation with the CRL and the fetal weight, especially the forehead-side shank and muzzle-tail base lengths as reported by Kouamo et al. (2018) on zebu fetuses at the Ngaoundere slaughterhouse.

As for the limbs, there is a strong correlation with the CRL and the fetal weight, especially the length of the tibia. This result is similar to that reported by Zongo et al. (2014, 2018) in sahelian goats. These parameters could also be used to determine fetal age.

On the other hand, very weak correlations were found between CRL, fetal weight, cord length, cord circumference and placentomes size and number. Theses parameters evolve till a certain point during the gestation where they become constant. These results are similar to those reported by kouamo et al. (2018) for zebu fetuses but Zongo et al. (2014) reported that umbilical cord diameter was the best parameter to determine fetal weight throughout gestation. It was measurable throughout the gestation and presented a strong correlation with fetal weight in Sahelian goat.

This work also shows that there was no significant difference between single and twin pregnancies as reported by Doize et al. (1997). On the other hand, Kaulfuss et al. (1998) reported a higher placental growth in multiple litter gestating females during the last month of gestation.

CONCLUSION

Fetal measurements evolve progressively with the gestation age. There are strong correlations between CRL, fetal weight and fetal measurements (head length, face width, biparietal diameter, forehead-tail base on the side, muzzle-tail base length and tibial length) and weak correlations between CRL, weight, umbilical cord and placentomes measurements.

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CONFLICT OF INTEREST

All the authors have declared that no conflict of interest exists.

REFERENCES

Ali, A., Fahmy, S., 2008. Ultrasonographic fetometry and determination of fetal sex in buffaloes (Bubalus bubalis). Anim. Reprod. Sci., 106(1-2): 90-9.

Ali, A., Hayder, M., 2007. Ultrasonography assessment of embryonic, fetal and placental development in ossimi sheep. Small Ruminants Res., 73: 277-282.

Arthur, G.H., Noakes, D.E., Pearson, H., 2001. Pregnancy and Parturition In: Veterinary Reproduction and Obstetrics. Eighth Edition. Bailliere Tindall, London, UK. p. 68.

Barone, R., 2001. Splanchnologie II, In: Anatomie comparée des Mammifères domestiques. 3ème éd. Editions Vigot, Paris, Tome 4. 510: 635-636.

Bonfoh, B., Bassowa, H., 2005. Elevage des ovins et des caprins au Togo. CRA-SH/ ITRA: 35-54.

Bretzlaff, K.N., Romano, J.E., 2001. Advanced reproductive techniques in goats. Vet. Clin. North Am. (Food Anim. Pract), 17: 421-434.

Chavatte-Palmer, P., De Sousa, N., Laigre, P., Camous, S., Ponter, A.A., Beckers, J.F., 2006. Ultrasound fetal measurements and pregnancy associated glycoprotein secretion in early pregnancy in cattle recipients carrying somatic clones. Theriogen., 66: 829-840.

CIRAD, EMVT et Ministère de la Coopération et du Développement (eds)., 1991. Enquêtes par suivi individuel du cheptel. II. Exemples de résultats obtenus sur petits ruminants au Sénégal. (Productions animales). Fiche technique d'élevage tropical N°4, Maisons Alfort, 8p.

Doizie, F., Vaillancourt, D., Carabin, H., Belanger, D., 1997. Determination of gestational age in sheep and goats using transrectal ultrasonographic measurements of placentomes. Theriogen., 48: 449-460.

Iniguez, L., 2011. The challenges of research and development of small ruminant production in dry areas. Small Ruminants Res., 98: 12-20.

James, A. A., Chom, N. D., Fadason, S. T., Andrew, A., Emmanuel, E. G., 2015. Ultrasonographic Determination of Gestational Age in Yankasa Ewes. J. Vet. Adv., 5(11): 1169-1175

Joubert, D.M., 1956. A study pre-natal growth and development in the sheep. J. Agr. Sci. Cambridge, 47: 382-427.

Kaulfuss, K. H., Uhlich, K., Gille, U., 1998. Ultrasonographic examination of the placentome development in pregnant sheep. Dtsch. Tierarztl. Wochenscrh., 105: 162-167.

Kazadi, K.E., Ngona, I.A., Khang'Maté, A.B., 2015. Diagnostic de mortalités embryonnaires par la détermination du nombre de corps jaunes chez la chèvre gestante, étude ex-vivo. J. Applied Biosci., 89: 8329-8336.

Kohan-Ghardr, H.R., Lefebvre, R.C., Fecteau, G., 2008. Ultrasonography and histological characterizationof the placenta of somatic nuclear transfer-derived pregnancy in dairy cattle. Theriogen., 69: 218-230.

Kouamo, J., Saague, A.M.N., Zoli, A.P., 2018. Determination of age and weight of bovine fetus (Bos indicus) by biometry. J. Livest. Sci., 9: 9-15.

MINEPIA, 2014. Rapport d'activités, Division des Etudes, DIP., de la Coopération et des Statistiques., pp. 1-137.

Ngona, J.M., Beduin, A.B.F., Khang'Maté C. H., 2012. Etude descriptive des caractéristiques morphométriques et génitales de la chèvre de Lubumbashi en République démocratique du Congo. Rev. Elev. Med. Vet. Pays Trop., 65(3-4): 75-79.

Noakes, D.E., Arthur, G.H., Parkinson T.J., England, G.C.W., 2001. Arthur's Veterinary Reproduction and Obstetrics. Saunders Ltd.

Nwaogu, I.C., Anya, K.A., Agada, P.C., 2010. Estimation of fetal age using ultrasonic measurements of different fetal parameters in red Sokoto goats (Capra hircus). Veterinarski Arhiv., 80: 225-233.

Pineda, M.H., 2003. Reproductive patterns of sheep and goats. Pineda MH and Dooley MP (Editors). 5th ed. Iowa state press, USA.p. 597.

Pitala, W., Arouna, A., Kulo, A.E., Zongo, M., Boly, H., Gbeassor, M., 2012. Impacts de l'abattage des brebis en gestation sur l'élevage au Togo. Livestock Res. Rural Dev., 24(11): Article 209.

Tchouamo, I.R., Tchoumboue, J., Thibault, L., 2005. Caractéristiques socio-économiques et techniques de l'élevage de petits ruminants dans la province de l'ouest du Cameroun. Tropicultura, 23(4): 201-221.

Vural, M. R., Sel, T., Karagul, H., Ozenc, E., Orman, M., Izgur, H., Kuplulu, S., 2008. Ultrasonographic examinations of embryonic-fetal growth in pregnant Akkaraman ewes fed selenium supply and dietary selenium restriction. Rev. Med. Vet., 159: 628-633.

Yaseen, M.R., 2017. Assessment of gestational age in goats by Real-Time Ultrasound measuring the fetal crown rump length, and bi-parietal diameter. *The Iraqi* J.Vet. Med., 41(2):106-112.

Zongo, M., Moussa, K.K., Essozimna, A., Drissa, S., 2018. Fetal growth monitoring using ultrasonographic assessment of femur and tibia in Sahelian goats. J. Anim. Plant Sci., 36(1): 5763-5768.

Zongo, M., Rubio Pellicer, M.T., Boly, H., Ababneh, M.M., Sanou, I., Belemtougri, R., Sawadogo, L., 2014. Evaluation de la technique de sexage et de foetotomie par échographie chez la chèvre du sahel. Int. J. Biol. Chem. Sci., 8(6): 2516-2522.