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Original Article

Ovarian potential of Cameroonian Zebu cattle (*Bos indicus*) slaughtered in Etoudi - Yaoundé

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ABSTRACT

Background: This study helps to evaluate the Ovarian potential of Cameroonian Zebu cattle (*Bos indicus*) slaughtered in Etoudi – Yaoundé for implementing Assisted Reproductive Techniques (ARTs). The aim was to enhance the productivity of the cattle sub-sector in Cameroon while conserving local genetic resources.

Methods: A total of 144 cows, including 94 cycled cows and 50 pregnant cows, were included in the study. Live weights were determined by measuring the thoracic perimeter of each cow using a Rondo measuring tape. Age was determined post-mortem through examination of dentition and horns, while the uterus and ovaries were removed, weighed, and classified based on physiological status (pregnant or non-pregnant). Follicles were counted, and their diameters were measured and categorized into small (Ø < 3 mm), medium (Ø 3-8 mm), and large (Ø > 8 mm).

Results: The results revealed an average follicular population of 32.02 ± 9.31 per cow, with 22.43 ± 8.45 small follicles, 8.42 ± 3.87 medium follicles, and 0.76 ± 0.34 large follicles. The weight of the right ovary was significantly higher than that of the left ovary ($p < 0.05$), and cows aged 6 to 9 years exhibited a higher number of follicles compared to other age groups. Cows with medium (BCS = 3) and large (BCS = 4-5) body reserves had the heaviest ovaries. Additionally, pregnant cows had heavier uteri compared to non-pregnant cows, and cows with a body condition score of 3 or higher had higher uterine weights than lean cows (BCS = 1-2).

Conclusions: This study demonstrates that age, body condition score, and pregnancy status influence ovarian weight. Body Condition Score serves as a reliable indicator of cow nutritional status, and cows with BCS of 3-5 are excellent candidates for *in vitro* production of embryos.

Keywords: cow breed, follicular population, *in vitro* production of embryos, ovarian characteristics

INTRODUCTION

Livestock production plays a vital role in Cameroon's agricultural economy, contributing significantly to the national investment budget (MINEPIA, 2019). However, the productivity of local cattle breeds in the country remains low, posing challenges to meet the growing demand for animal protein (FAO, 2007). Poor genetic makeup, nutritional deficiencies, pathologies and poor management of growth and reproduction have been identified as limiting factors in cattle productivity (Kouamo et al., 2016). To address these challenges, Assisted Reproductive Techniques (ARTs) such as Artificial Insemination (AI), *In Vitro* Embryo Production (IVEP), and Embryo Transfer (ET) have been developed to improve reproductive efficiency and genetic gain (Manik et al., 2003).

Artificial Insemination primarily focuses on improving male reproductive potential, necessitating the exploration of alternative reproductive technologies like IVEP and ET to enhance genetic improvement in local cattle breeds. For the success of these biotechnologies, the knowledge on the ovarian potential of slaughtered cows is obvious (Dorice et al., 2019; Hachim et al., 2023).

The collection of ovaries from slaughterhouses offers a feasible and abundant source of primary oocytes for the large-scale production of embryos through *in vitro* maturation (IVM) and *in vitro* fertilization (IVF) (Kouamo et al., 2014). However, the follicular population, oocyte yield, and quality of local cattle breeds are often suboptimal, influenced by various factors including breed, age, weight, body condition score (BCS), and physiological, nutritional, and pathological status of females (Dorice et al., 2019; Hachim et al., 2023).

In Cameroon slaughterhouses, a specially in Etoudi, Yaoundé in which more than 350 cows is slaughtered per day, there is limited research on physiological status of females slaughtered. Also, the lacks knowledge on the effects of environmental and genetic factors on follicular population, oocyte yield, and quality. Therefore, this study aimed to evaluate the impact of breed, age, BCS, and nutritional status on the follicular population, oocyte yield, and quality of local Zebu cows. By assessing the follicular population and oocyte quality and establishing their relationship with cow characteristics, nutritional status, and energy and protein parameters, this study aims to contribute to the improvement of reproduction in Cameroonian Zebu cattle.

Addressing the challenges in livestock production and enhancing reproductive biotechnologies are essential for improving livestock productivity in Cameroon and meeting the growing demand for animal protein. With cattle playing a crucial role in the country's economy and food security, understanding the factors influencing reproductive success and implementing effective ARTs can contribute to the genetic improvement of local cattle breeds and enhance their productivity.

MATERIALS AND METHODS

Study area

The study was carried out in Etoudi – Yaoundé, Centre Region, Cameroon with coordinates 3° 52" N and 11° 31" E. The climate of this zone is of the Savanna type according to the Koppen-Geiger classification with a mean annual temperature of 23.5℃ and mean annual pluviometry of 831.7 mm. The samples were collected at the SODEPA slaughterhouse Etoudi from February to June 2022.

Animal material

The study was carried out on a total of 144 *Bos indicus* cows of 3 breed types (Goudali, Red and White Fulani). This is mainly because these breeds are the most common in Cameroon (Paguem et al., 2020). Amongst these were 50 pregnant cows and 94 non-pregnant cows all hailing from different places but mostly from the Adamawa region of Cameroon. The animals were selected with respect to the level of responsiveness and cooperation of the butchers.

External measurements

Body weight was determined by measurement of Thoracic Perimeter using a Rondo Measuring tape graduated in cm. Thoracic perimeter (TP) is used to calculate bodyweight of cattle in the absence of a weighing balance because it is a relatively simple and accurate measurement to take. TP is the circumference of the chest at the level of the fifth rib, and it is correlated with bodyweight in cattle. The relationship between TP and bodyweight in cattle has been studied extensively, and a number of equations have been developed to predict bodyweight from TP. These equations are generally accurate to within 10-15%. The Thoracic Perimeters obtained were then substituted into the barymetric formulae established by Njoya et al. (1997) for the Bororo breeds and Assana et al. (2018) for the Goudali breed to determine the bodyweights (in Kg);

Bororo bodyweight (kg) = 124.69 - 3.171TP + $0.0276PT^2$ (r^2 = 0.96) (Njoya et al., 1997)

Goudali bodyweight (kg) = $0.000201305TP^{2.79759}$ (r^2 = 0.96) (Assana et al., 2018)

Where:

TP is Thoracic Perimeter

BCS and age of cows were determined as described by Natumanya et al. (2008) and Moussa et al. (2013), respectively.

Sample collection

After slaughter, the uteruses were excised and placed in labelled Ziplock bags and transported immediately (within 1 h) to the laboratory in a sterile cooler at 34–36℃.

In the laboratory, all uteruses were observed to know if they contained foetuses or not and then dissected free and weighed using an electronic balance of capacity 30 kg (Mettler PC 2000). In all 50 foetuses were observed from the 50 pregnant cows. Each of the foetuses were at different stages of development and were classified according to the pregnancy trimester.

For non-pregnant cows, only the weight of the whole uterus (kg) was measured. On the other hand, the following were measured: Weight of whole uterus with foetus (kg), Weight of whole uterus without foetus (kg) and Weight of foetus (kg) were recorded for pregnant cows. Neck-rump length of the foetus (cm) was also obtained using a measuring tape. The neck-rump length was used to get the approximate age of the foetus by using the following formula proposed by Santos et al. (2013).

$Y = X (X + 2)$

Where: X is the number of months of pregnancy, 2 is a constant, Y is the neck-rump length in centimetres.

Following this, the ovaries were separated from the fallopian tubes with the help of a bistoury blade and weighed using a precision balance as such: weight of left ovary (g) and weight of right ovary (g).

The cortical follicles in each ovary were measured using electronic digital callipers, meticulously counted, and then classified according to their diameters (Ø) into three categories: small (Ø < 3 mm), medium (3 ≤ Ø ≤ 8 mm), and large (Ø > 8 mm) follicles (Satrapa et al., 2011).

Statistical analysis

The collected data were recorded in Microsoft Excel 2019 and analysed using SPSS version 25.0. Analysis of variance 2 ways and Duncan test statistics were used to clarify the differences between means. The level of significance was recorded at 5%. The normality of data was tested using the Shapiro-Wilk Test.

RESULTS

Ovarian weight

1) Effect of breed and foetal age on ovarian weight

The effects of breed and foetal age on ovarian weight are summarized in Table 1. This shows that when comparing breeds independently of foetal age, the right ovary weight and mean weight of ovaries are significantly (p < 0.05) heavier compared to the other values in the study. The right ovary weight of the Goudali breed was significantly (p < 0.05) higher in the third trimester of gestation compared to the value obtained in the other breeds. However, this significant difference (p < 0.05) was only found on the left ovary in Red Fulani cows at the same stage of pregnancy.

When considering gestation age groups independently of breed, mean ovarian weight, left ovarian weight and right ovarian weight were significantly (p < 0.05) greater in the first, second and third trimester of gestation respectively. The left ovary weight of the White Fulani breed was significantly (p < 0.05) higher in the first trimester of pregnancy. This increase was significant (p < 0.05) in the red Fulani for mean ovarian weight in the first and third trimesters of gestation. In general, independent of breed and ovarian position, ovarian weight generally increased with increasing age of gestation.

2) Effects of breed and BCS on ovarian weights of cows

Table 2 shows the effects of breed and BCS on ovarian weight. It follows that when considering breeds independently of body condition score, the right ovary of the cows was significant (p < 0.05). These characteristic values were significant lower in Red and White Fulani cows in reference to that noted in Goudali. In cows with a body condition score [3], the right ovary weight was significantly higher (p < 0.05) in Goudali and Red Fulani cows as compared to the value recorded with the other body

Table 1. Effect of breed and foetal age on ovarian weight

Position of ovary	Breed	Age of foetus (months)			Mean ± standard deviation	*p*-value
		1st trimester	2nd trimester	3rd trimester		
Weight of right ovary (g)	Goudali n = 17	(8) 4.80 ± 0.414^{abA}	(5) 3.90 ± 0.35^{abA}	(4) 5.37 ± 0.80^{bA}	5.73 ± 0.31$^{\beta}$	0.02
	White Fulani n = 15	(7) 4.58 ± 0.54^{aA}	(5) 4.60 ± 1.40^{aA}	(3) 4.90 ± 0.29^{aA}	4.58 ± 0.50$^{\alpha}$	0.17
	Red Fulani n = 18	(9) 4.02 ± 0.63^{aA}	(5) 4.04 ± 0.16^{abA}	(4) 5.42 ± 0.59^{bA}	4.40 ± 0.26$^{\alpha}$	0.03
	Mean ± SD	4.45 ± 12.10$^{\alpha\beta}$	4.15 ± 13.40$^{\alpha}$	5.26 ± 12.21$^{\beta}$	4.94 ± 13.14	/
	p-value	0.21	0.21	0.03	_/	
Weight of left ovary (g)	Goudali n = 17	(8) 3.72 ± 0.44^{aAB}	(5) 3.77 ± 0.30^{aB}	(4) 3.90 ± 0.26^{aA}	3.60 ± 0.27$^{\alpha}$	0.21
	White Fulani n = 15	(7) 4.04 ± 0.54^{aB}	(5) 3.90 ± 0.98^{aA}	(3) 3.95 ± 0.26^{aA}	3.55 ± 0.36$^{\alpha}$	0.85
	Red Fulani n = 18	(9) 3.30 ± 0.15^{aA}	(5) 3.35 ± 0.37^{aAB}	(4) 3.72 ± 0.44^{aA}	3.57 ± 0.20$^{\alpha}$	0.39
	Mean ± SD	3.60 ± 2.74$^{\alpha\beta}$	3.35 ± 12.50$^{\beta}$	3.51± 3.11$^{\alpha}$	3.58 ± 3.45$^{\alpha}$	/
	p-value	0.02	0.01	0.24	_/	_
Mean weight of ovaries (g)	Goudali n = 17	(8) 4.26 ± 0.30^{abAB}	(5) 3.68 ± 0.320^{aA}	(4) 4.38 ± 0.42^{bAB}	4.17 ± 0.20$^{\beta}$	0.02
	White Fulani n = 15	(7) 3.31 ± 0.55^{aA}	(5) 3.67 ± 0.40^{aA}	(3) 4.40 ± 0.30^{aA}	3.44 ± 0.21$^{\alpha}$	0.13
	Red Fulani n = 18	(9) 4.66 ± 0.28^{aB}	(5) 3.70 ± 2.23^{abA}	(4) 4.57 ± 0.36^{bB}	3.92 ± 0.18$^{\alpha\beta}$	0.03
	Mean ± SD	4.57 ± 0.11$^{\beta}$	3.69 ± 0.24$^{\alpha}$	4.51 ± 0.11$^{\alpha\beta}$	3.78 ± 0.21	/
	p-value	0.04	0.12	0.17	_/	_

^{a,b}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$).

Table 2. Effects of breed and BCS on ovarian weights of cows

Position of the ovary	Breed	BCS			Mean ± standard deviation	*p*-value
		[1–2] n = 23	[3] n = 42	[4–5] n = 29		
Mean right ovary weight (g)	Goudali n = 28	(4) 4.45 ± 1.06^{abB}	(10) 4.47 ± 1.14^{bA}	(4) 3.66 ± 0.89^{aA}	4.23 ± 1.10$^{\beta}$	0.05
	White Fulani n = 29	(11) 3.29 ± 1.21^{aA}	(23) 4.03 ± 1.34^{abA}	(13) 4.57 ± 1.39^{bA}	3.99 ± 1.35$^{\alpha}$	0.04
	Red Fulani n = 47	(8) 2.94 ± 0.76^{aA}	(9) 4.13 ± 1.36^{bA}	(12) 3.93 ± 1.11^{abA}	3.76 ± 1.27$^{\alpha}$	0.03
	Mean ± SD	3.45 ± 1.12$^{\alpha}$	4.24 ± 1.29$^{\beta}$	3.96 ± 1.11$^{\alpha}$	3.88 ± 0.21	/
	p-value	0.00	0.42	0.13	_/_	
Mean left ovary weight (g)	Goudali n = 28	(4) 3.15 ± 0.98^{aA}	(10) 3.34 ± 1.18^{aB}	(4) 3.31 ± 1.70^{aA}	3.30 ± 1.10$^{\alpha}$	0.87
	White Fulani n = 29	(11) 2.82 ± 0.80^{aA}	(23) 3.03 ± 1.11^{aA}	(13) 4.00 ± 1.52^{bB}	3.08 ± 1.12$^{\alpha}$	0.06
	Red Fulani n = 47	(8) 2.63 ± 0.83^{aA}	(9) 3.00 ± 1.08^{aA}	(12) 0.08 ± 0.79^{aA}	2.92 ± 0.97$^{\alpha}$	0.32
	Mean ± SD	2.8 ± 0.87$^{\alpha}$	3.12 ± 1.12$^{\alpha}$	3.37 ± 1.11$^{\alpha}$	3.10 ± 0.19	
	p-value	0.25	0.03	0.21	__	__
Mean weight of ovaries (g)	Goudali n = 28	(4) 3.77 ± 1.01^{aA}	(10) 3.86 ± 0.95^{bA}	(4) 3.70 ± 0.75^{aA}	3.75 ± 0.92$^{\alpha}$	0.44
	White Fulani n = 29	(11) 3.06 ± 0.65^{aA}	(23) 3.41 ± 0.96^{aA}	(13) 4.29 ± 0.73^{bB}	3.41 ± 0.92$^{\alpha}$	0.01
	Red Fulani n = 47	(8) 2.58 ± 0.60^{aA}	(9) 3.54 ± 1.04^{aA}	(12) 3.50 ± 0.79^{aA}	3.26 ± 0.98$^{\alpha}$	0.20
	Mean ± SD	3.06 ± 0.85$^{\alpha}$	3.59 ± 1.00$^{\alpha}$	3.66 ± 0.80$^{\alpha}$	3.47 ± 0.14	/
	p-value	0.06	0.14	0.03	/	

^{a,b}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$). BCS: body condition score.

condition score in the same cows. When comparing body condition score groups independently of breed, medium cows (BCS = [3]) had the heaviest right ovaries compared to the other groups considered. In Goudali cows, right and left ovary weights were significantly ($p < 0.05$) higher in those with a body condition score of [1-2] and [3] compared to the values of this parameter recorded in fat cows (BCS = [4-5]). Generally, in all cows, the ovary weight increased non-significantly ($p > 0.05$) with an increasing body condition score.

3) Effects of breed and age on ovarian weight

The effects of breed and age on ovarian weight are listed in Table 3. The results show that when compar-

Table 3. Effects of breed and age on ovarian weight

Position of the ovary	Breed	Age (years)			Mean ± standard deviation	p-value
		[3–5] n = 31	[6–9] n = 49	[10–15] n = 14		
Mean right ovary weight (g)	Goudali n = 18	(5) 3.73 ± 1.19^{abB}	(7) 4.38 ± 1.15^{bB}	(6) 3.82 ± 0.89^{aA}	4.13 ± 1.10$^{\beta}$	0.05
	Red Fulani n = 47	(18) 3.38 ± 1.36^{aA}	(25) 4.09 ± 1.30^{bAB}	(4) 4.00 ± 1.41^{abA}	3.89 ± 1.35$^{\alpha}$	0.04
	White Fulani n = 29	(8) 3.25 ± 1.18^{aA}	(17) 3.94 ± 1.43^{bA}	(4) 3.44 ± 0.81^{abA}	3.66 ± 1.27$^{\alpha}$	0.03
	Mean ± SD	3.42 ± 1.23$^{\alpha}$	4.14 ± 1.30$^{\beta}$	3.74 ± 1.03$^{\alpha}$	3.78 ± 0.21	/
	p-value	0.00	0.42	0.13	/	
Mean left ovary weight (g)	Goudali n = 18	(5) 3.36 ± 1.20^{aA}	(7) 3.09 ± 1.28^{aA}	(6) 2.86 ± 1.23^{aA}	3.30 ± 1.10$^{\alpha}$	0.87
	Red Fulani n = 47	(18) 3.25 ± 0.57^{abA}	(25) 3.03 ± 1.11^{aA}	(4) 4.00 ± 1.52^{bB}	3.08 ± 1.12$^{\alpha}$	0.05
	White Fulani n = 29	(8) 2.63 ± 0.86^{aA}	(17) 3.14 ± 1.12^{aA}	(4) 2.69 ± 0.47^{aA}	2.92 ± 0.97$^{\alpha}$	0.32
	Mean ± SD	3.05 ± 0.95$^{\alpha}$	3.22 ± 1.17$^{\alpha}$	3.71 ± 0.96$^{\alpha}$	3.10 ± 0.19	/
	p-value	0.25	0.36	0.21	/	
Mean ovary weight (g)	Goudali n = 18	(5) 3.64 ± 1.36^{aA}	(7) 3.73 ± 0.84^{bA}	(6) 3.35 ± 0.60^{aA}	3.75 ± 0.92$^{\beta}$	0.44
	Red Fulani n = 47	(18) 3.13 ± 0.71^{aA}	(25) 3.58 ± 0.93^{aA}	(4) 3.36 ± 1.08^{aA}	3.41 ± 0.92$^{\alpha}$	0.01
	White Fulani n = 29	(8) 2.88 ± 0.95^{aA}	(17) 3.58 ± 1.07^{bA}	(4) 2.94 ± 0.44^{aA}	3.26 ± 0.98$^{\alpha}$	0.01
	Mean ± SD	3.16 ± 1.02$^{\alpha}$	3.71 ± 0.96$^{\alpha}$	3.21 ± 0.75$^{\alpha}$	3.47 ± 0.14	/
	p-value	0.06	0.14	0.06	/	

^{a,b}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$).

ing breeds independently of age, the right ovary weight was significantly ($p < 0.05$) heavier in Goudali relative to the other cows. In cows aged 6 to 9 years, the right ovary weight of the Goudali and Fulani breeds, and the mean weight of the Goudali cows were significantly ($p < 0.05$) higher. When considering age groups independently of breeds, cows aged [6–9] years had significantly ($p < 0.05$) greater right weights compared to others. The right ovary weight of the Red and white Fulani breeds was significantly ($p < 0.05$) lower in young ([3–5] years) cows compared to the value obtained in animals ([6–9] years). In general, independent of breed and ovary position, ovary weights were generally higher in cows aged 5–9 years compared to cows of the other age groups considered.

Follicular population

From 288 ovaries collected, 4,709 follicles were counted on their surface. The average follicular population per cow was 32.02 ± 9.31. The mean number of small (Ø < 3 mm), medium (3 ≤ Ø ≤ 8 mm) and large (Ø > 8 mm) follicles were 22.43 ± 8.45; 8.42 ± 3.87 and 0.76 ± 0.34 respectively per cow. Fig. 1 summarizes this.

Effect of breed and foetal age on follicular population

Table 4 shows that when comparing breeds independently of foetal age, the number of small follicles was significantly ($p < 0.05$) lower in Goudali cows in the reference to that of White Fulani. In the Goudali breed, the number of small and medium follicles was significantly ($p < 0.05$) higher in the second trimesters of pregnancy compared to the White Fulani breeds.

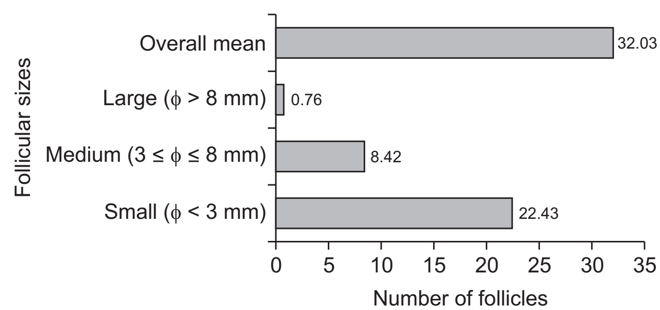

Fig. 1. Follicular population with respect to the follicular size.

When considering foetal age independently of breed, the average follicle number was significantly ($p < 0.05$) greater in the second trimester of gestation. The total number of follicles, small and large were significantly ($p < 0.05$) respectively higher in Goudali and Red Fulani cows in the first trimester of gestation. Red and White Fulani cows had significantly ($p < 0.05$) higher numbers of small and large follicles respectively in the second trimester of pregnancy. Independent of follicle size, the follicle population decreased with increasing length of pregnancy in the cows.

Table 4. Effect of breed and foetal age on follicular population

Size of follicles	Breed	Age of foetus			Mean ± standard deviation	*p*-value
		1st trimester	2nd trimester	3rd trimester		
Small	Goudali n = 17	(8) 30.30 ± 10.24^{bB}	(5) 27.21 ± 11.94^{abAB}	(4) 25.00 ± 10.34^{aA}	27.24 ± 7.63$^{\alpha}$	0.02
	White Fulani n = 15	(7) 27.79 ± 10.51^{aA}	(5) 26.21 ± 13.91^{aA}	(3) 27.00 ± 13.90^{aA}	29.32 ± 16.84$^{\beta}$	0.17
	Red Fulani n = 18	(9) 28.46 ±12.54^{aAB}	(5) 30.16 ± 12.54^{bB}	(4) 29.35 ± 13.44^{abA}	28.88 ± 11.15$^{\alpha\beta}$	0.30
	Mean ± SD	28.45 ± 12.10$^{\alpha}$	27.55 ± 13.40$^{\alpha}$	27.46 ± 12.21$^{\alpha}$	28.34 ± 13.14	/
	p-value	0.01	0.01	0.03	_/	
Medium	Goudali n = 17	(8) 7.34 ± 3.75^{abA}	(5) 9.50 ± 1.77^{bB}	(4) 5.13 ± 0.10^{aA}	7.77 ± 3.99$^{\alpha}$	0.01
	White Fulani n = 15	(7) 6.36 ± 3.11^{aA}	(5) 8.36 ± 3.31^{aA}	(3) 8.90 ± 2.39^{aA}	7.53 ± 2.23$^{\alpha}$	0.85
	Red Fulani n = 18	(9) 7.21 ± 2.46^{aA}	(5) 8.86 ± 2.14^{aAB}	(4) 6.12 ± 2.35^{aA}	7.57 ± 3.26$^{\alpha}$	0.39
	Mean ± SD	6.70 ± 2.74$^{\alpha\beta}$	8.45 ± 12.50$^{\beta}$	6.41 ± 3.11$^{\alpha}$	7.87 ± 3.45	/
	p-value	0.20	0.01	0.24	_/	
Large	Goudali n = 17	(8) 0.54 ± 0.18^{aA}	(5) 0.48 ± 1.00^{aA}	(4) 0.30 ± 0.00^{aA}	0.34 ± 0.19$^{\alpha}$	0.21
	White Fulani n = 15	(7) 0.65 ± 0.28^{aAB}	(5) 1.00 ± 0.38^{bB}	(3) 0.80 ± 0.29^{abA}	0.82 ± 0.19$^{\alpha\beta}$	0.03
	Red Fulani n = 18	(9) 0.74 ± 0.15^{abB}	(5) 0.94 ± 0.46^{bAB}	(4) 0.48 ± 0.15^{aA}	0.61 ± 0.11$^{\alpha}$	0.03
	Mean ± SD	0.57 ± 0.11$^{\alpha}$	0.77 ± 0.24$^{\alpha}$	0.59 ± 0.11$^{\alpha}$	0.58 ± 0.21	/
	p-value	0.04	0.02	0.17	_/	
Total follicles	Goudali n = 17	(8) 30.85 ± 12.08^{aB}	(5) 30.00 ± 0.00^{aA}	(4) 29.87 ± 10.09^{aA}	30.22 ± 10.89$^{\alpha}$	0.21
	White Fulani n = 15	(7) 29.79 ± 9.58^{aA}	(5) 30.55 ± 9.18^{aA}	(3) 28.51 ± 25.61^{aA}	29.66 ± 18.00$^{\alpha}$	0.68
	Red Fulani n = 18	(9) 30.28 ± 11.06^{aAB}	(5) 31.62 ± 0.13^{aA}	(4) 29.17 ± 13.02^{aA}	30.47 ± 13.86$^{\alpha}$	0.30
	Mean ± SD	30.65 ± 10.61$^{\alpha}$	30.71 ± 0.15$^{\alpha}$	29.25 ± 17.35$^{\alpha}$	30.42 ± 12.38	/
	p-value	0.04	0.44	0.17	_/	

^{a,b}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$).

Table 5. Effects of breed and physiological status on the follicular population

Size of follicles	Breed	Physiological status		Mean ± standard deviation	*p*-value
		Non-pregnant	Pregnant		
Small	Goudali n = 35	(18) 31.41 ± 11.44^{bB}	(17) 27.96 ± 10.34^{aAB}	29.33 ± 9.13$^{\beta}$	0.02
	White Fulani n = 62	(47) 28.44 ± 11.51^{aA}	(15) 6.50 ± 14.22^{aA}	27.50 ± 11.24$^{\alpha}$	0.17
	Red Fulani n = 47	(29) 29.16 ± 2.94^{aAB}	(18) 29.35 ± 16.64^{aB}	26.48 ± 13.11$^{\alpha}$	0.30
	Mean ± SD	29.15 ± 12.00$^{\alpha}$	27.56 ± 14.21$^{\alpha}$	27.14 ± 10.14	/
	p-value	0.01	0.17^{a}	/	
Medium	Goudali n = 35	(18) 9.71 ± 4.95^{aAB}	(17) 7.53 ± 3.10^{aA}	9.37 ± 4.99$^{\alpha}$	0.01
	White Fulani n = 62	(47) 8.34 ± 2.88^{aA}	(15) 7.27 ± 3.39^{aA}	7.87 ± 6.16$^{\alpha}$	0.85
	Red Fulani n = 47	(29) 11.41 ± 3.76^{bB}	(18) 8.12 ± 2.90^{aA}	8.57 ± 3.26$^{\alpha}$	0.39
	Mean ± SD	9.30 ± 4.54$^{\beta}$	7.21 ± 3.31$^{\alpha}$	8.60 ± 4.80	/
	p-value	0.02	0.24	/	
Large	Goudali n = 35	(18) 0.84 ± 0.28^{aA}	(17) 0.75 ± 0.27^{aA}	0.73 ± 0.16$^{\alpha}$	0.11
	White Fulani n = 62	(47) 0.65 ± 0.18^{aA}	(15) 0.59 ± 0.19^{aA}	0.61 ± 0.18$^{\alpha}$	0.68
	Red Fulani n = 47	(29) 0.72 ± 0.13^{aA}	(18) 0.58 ± 0.10^{aA}	0.61 ± 0.11$^{\alpha}$	0.30
	Mean ± SD	0.71 ± 0.15$^{\alpha}$	0.67 ± 0.19$^{\alpha}$	0.65 ± 0.21	/
	p-value	0.44	0.17	/	
Total follicles	Goudali n = 35	(18) 38.65 ± 14.98^{bB}	(17) 35.59 ± 10.09^{aA}	37.18 ± 13.09$^{\alpha}$	0.01
	White Fulani n = 62	(47) 35.58 ± 13.48^{aAB}	(15) 30.78 ± 15.61^{aA}	32.53 ± 12.00$^{\alpha}$	0.68
	Red Fulani n = 47	(29) 35.48 ± 3.06^{aA}	(18) 30.61 ± 19.02^{aA}	33.27 ± 13.86$^{\alpha}$	0.30
	Mean ± SD	36.36 ± 13.01$^{\alpha}$	32.55 ± 15.65$^{\alpha}$	34.47 ± 11.36	/
	p-value	0.04	0.17	/	

^{a,b}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$).

Effects of breed and physiological status on the follicular population

Table 5 shows the effects of breed and physiological status on the size and follicular population of cows. It appears that when comparing breeds independently of physiological status, the number of small follicles was significantly ($p < 0.05$) higher in Goudali compared to the value obtained with other cows. Total follicles collected from non-pregnant Goudali cows showed a significant ($p < 0.05$) number relative to pregnant. When considering only the physiological status, follicular population of medium follicles was higher in non-pregnant cows compared to the value obtained in pregnant cows. For other size, there was significant effect ($p > 0.05$).

Effects of breed and BCS on the follicular population of non-pregnant cows

From Table 6, which shows the effects of breed and body condition score on cow follicle size and population, it appears that the number of small follicles was significantly ($p < 0.05$) higher in Red Fulani compared to the number noted with the others cows. Apart of small follicles, the number of follicles was not significantly affected by the breed. When comparing body condition scores independently of breed, cows with BCS = [3] had significantly ($p < 0.05$) higher numbers of small follicles relative to others. In the Red Fulani cow, the number of small and medium follicles, as well as the number of total follicles were significantly ($p < 0.05$) higher in those with a body condition score of [3] compared to the values of this parameter recorded in lean [1-2] or fat [4-5] cows.

Effects of breed and age class on follicular population in non-pregnant cows

Table 7 shows the effects of breed and age on the follicular population in non-pregnant cows. It follows that When comparing breeds independently of age, the number of small follicles was significantly affected ($p < 0.05$). Independent of breed, the number of small follicles was significantly ($p > 0.05$) higher in cows aged [6-9] years. On the other hand, this significant difference was only found on the average follicles for the White Fulani breed aged between [6-9]. When comparing age groups independently of breed, animals aged [6-9] years had a sig-

Table 6. Effects of breed and BCS on the follicular population of non-pregnant cows

Size of follicles	Breed	BCS			Mean ± standard deviation	p-value
		[1–2] n = 23	[3] n = 42	[4–5] n = 29		
Small	Goudali n = 28	(4) 19.44 ± 7.50^{aA}	(10) 23.57 ± 12.09^{aA}	(4) 22.85 ± 8.39^{aA}	22.39 ± 9.38$^{\alpha}$	0.46
	White Fulani n = 29	(11) 24.23 ± 9.90^{abA}	(23) 26.35 ± 15.3^{bAB}	(13) 21.57 ± 10.99^{aA}	23.92 ± 10.99$^{\alpha}$	0.19
	Red Fulani n = 47	(8) 21.58 ± 8.55^{aA}	(9) 28.00 ± 17.44^{bB}	(12) 25.46 ± 11.72^{abA}	25.49 ± 13.12$^{\beta}$	0.04
	Mean ± SD	20.60 ± 7.88$^{\alpha}$	26.06 ± 15.31$^{\beta}$	24.43 ± 11.26$^{\alpha}$	23.71 ± 11.89	/
	p-value	0.43	0.25	0.36	/	
Medium	Goudali n = 28	(4) 10.54 ± 1.33^{aA}	(10) 9.97 ± 0.94^{aAB}	(4) 10.69 ± 0.95^{aA}	10.27 ± 3.62$^{\alpha}$	0.78
	White Fulani n = 29	(11) 7.54 ± 4.60^{aA}	(23) 8.94 ± 4.90^{aA}	(13) 9.57 ± 3.45^{aA}	8.14 ± 5.11$^{\alpha}$	0.47
	Red Fulani n = 47	(8) 7.79 ± 4.54^{aA}	(9) 10.41 ± 6.66^{bB}	(12) 9.25 ± 6.67^{bA}	9.47 ± 6.16$^{\alpha}$	0.03
	Mean ± SD	8.91 ± 5.43$^{\alpha}$	9.26 ± 5.76$^{\alpha}$	9.97 ± 4.83$^{\alpha}$	9.32 ± 0.21	/
	p-value	0.98	0.34	0.31	/	
Large	Goudali n = 28	(4) 0.54 ± 0.10^{aA}	(10) 0.77 ± 0.59^{aA}	(4) 0.69 ± 0.19^{aA}	0.63 ± 0.08$^{\alpha}$	0.52
	White Fulani=29	(11) 0.65 ± 0.20^{aA}	(23) 0.69 ± 0.12^{aA}	(13) 0.71 ± 0.21^{aA}	0.68 ± 0.18$^{\alpha}$	0.76
	Red Fulani n = 29	(8) 0.41 ± 0.25^{aA}	(9) 0.74 ± 0.34^{aA}	(12) 0.50 ± 0.38^{aA}	0.51 ± 0.28$^{\alpha}$	0.20
	Mean ± SD	0.54 ± 0.28$^{\alpha}$	0.71 ± 0.23$^{\alpha}$	0.62 ± 0.41$^{\alpha}$	0.61 ± 0.19	/
	p-value	0.12	0.36	0.21	/	
Total follicles	Goudali n = 28	(4) 30.81 ± 8.58^{aA}	(10) 34.09 ± 15.20$^{\alpha A}$	(4) 34.15 ± 11.95$^{\alpha A}$	33.28 ± 13.10$^{\alpha}$	0.69
	White Fulani n = 29	(11) 32.46 ± 10.84^{abA}	(23) 35.94 ± 14.57^{bAB}	(13) 31.86 ± 12.26^{aA}	33.33 ± 12.00$^{\alpha}$	0.58
	Red Fulani n = 47	(8) 31.33 ± 9.57^{aA}	(9) 36.27 ± 13.60^{bB}	(12) 35.53 ± 16.61^{ab}	35.47 ± 13.87$^{\alpha}$	0.02
	Mean ± SD	31.20 ± 9.42$^{\alpha}$	34.24 ± 13.23$^{\alpha}$	35.69 ± 14.52$^{\alpha}$	33.97 ± 0.92	/
	p-value	0.10	0.01	0.6	/	

^{a,b,c}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B,C}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$).

Table 7. Effects of breed and age class on follicular population in non-pregnant cows

Size of follicles	Breed	Age (years)			Mean ± standard deviation	p-value
		[3–5] n = 31	[6–9] n = 49	[10–15] n = 14		
Small	Goudali n = 18	(5) 18.54 ± 7.50^{aA}	(7) 24.47 ± 12.09^{bA}	(6) 23.35 ± 8.39^{abAB}	$22.39 \pm 9.38^{\alpha}$	0.04
	Red Fulani n = 47	(18) 24.63 ± 9.92^{abA}	(25) 25.345 ± 15.3^{bAB}	(4) 22.77 ± 10.99^{aA}	$24.92 \pm 10.99^{\alpha}$	0.03
	White Fulani n = 29	(8) 21.58 ± 8.55^{aA}	(17) 28.00 ± 17.44^{bB}	(4) 25.46 ± 11.72^{abB}	$25.49 \pm 13.12^{\beta}$	0.02
	Mean ± SD	$21.60 \pm 7.88^{\alpha}$	$26.46 \pm 15.31^{\beta}$	$23.63 \pm 11.26^{\alpha}$	23.71 ± 11.89	/
	p-value	0.43	0.02	0.03	/	
Medium	Goudali n = 18	(5) 9.54 ± 1.33^{abA}	(7) 9.87 ± 0.94^{aAB}	(4) 7.69 ± 0.95^{aA}	$8.27 \pm 3.62^{\alpha}$	0.78
	Red Fulani n = 47	(18) 7.54 ± 4.60^{aA}	(25) 8.94 ± 4.90^{aA}	(4) 9.57 ± 3.45^{aA}	$8.14 \pm 5.11^{\alpha}$	0.03
	White Fulani n = 29	(8) 10.79 ± 4.54^{a}	(17) 10.31 ± 6.66^{aA}	(4) 9.25 ± 6.67^{aA}	$9.47 \pm 6.16^{\alpha}$	0.02
	Mean ± SD	$8.91 \pm 5.43^{\alpha}$	$9.26 \pm 5.76^{\alpha}$	$9.97 \pm 4.83^{\alpha}$	8.62 ± 0.21	/
	p-value	0.98	0.34	0.31	/	
Large	Goudali n = 18	(5) 0.64 ± 0.10^{aAB}	(7) 0.76 ± 0.59^{aA}	(6) 0.68 ± 0.19^{aA}	$0.65 \pm 0.08^{\alpha}$	0.52
	Red Fulani n = 47	(18) 0.65 ± 0.20^{aB}	(25) 0.69 ± 0.12^{aA}	(4) 0.71 ± 0.21^{aA}	$0.68 \pm 0.18^{\alpha}$	0.76
	White Fulani n = 29	(8) 0.41 ± 0.25^{aA}	(17) 0.74 ± 0.34^{bA}	(4) 0.50 ± 0.38^{abA}	$0.51 \pm 0.28^{\alpha}$	0.02
	Mean ± SD	$0.54 \pm 0.28^{\alpha}$	$0.71 \pm 0.23^{\alpha}$	$0.62 \pm 0.41^{\alpha}$	0.61 ± 0.19	/
	p-value	0.02	0.36	0.21	/	
Total follicles	Goudali n = 28	(5) 30.81 ± 8.58^{aA}	(7) 35.09 ± 15.20^{bA}	(6) 34.15 ± 11.95^{abA}	$33.28 \pm 13.10^{\alpha}$	0.03
	White Fulani n = 29	(18) 32.46 ± 10.84^{abA}	(25) 35.74 ± 14.57^{aAB}	(4) 31.86 ± 12.26^{aA}	$33.33 \pm 12.00^{\alpha}$	0.58
	Red Fulani n = 47	(8) 32.33 ± 9.57^{aA}	(17) 36.27 ± 13.60^{aB}	(4) 36.53 ± 16.61^{aA}	$35.47 \pm 13.87^{\beta}$	0.22
	Mean ± SD	$31.20 \pm 9.42^{\alpha}$	$34.24 \pm 13.23^{\alpha}$	$35.69 \pm 14.52^{\alpha}$	33.97 ± 0.92	/
	p-value	0.10	0.04	0.03	/	

^{a,b,c}Values with the same letter in a row do not differ significantly ($p > 0.05$). ^{A,B,C}Values with the same letter in a column do not differ significantly ($p > 0.05$). $^{\alpha,\beta}$Values with the same letter in a column or a raw do not differ significantly ($p > 0.05$).

nificantly ($p < 0.05$) higher number of small follicles. In young cows [3-5] years, the Red Fulani breed recorded the significantly ($p < 0.05$) higher number of large and total follicles respectively in young [3-5] and medium-aged [6-9] animals while in the White Fulani breed, the number of small and large follicles was significantly ($p < 0.05$) higher in the [6-9] years and [10-15] years age groups compared to the value obtained in younger cows ([3-5] years).

DISCUSSION

In this study, the average Body Condition Score was 2.87 ± 0.56. This value is similar to those obtained by Fassi et al. (2005) and by Kouamo et al. (2017) for works carried out in Morocco and Cameroon respectively 2.94 ± 0.89 and 2.80 ± 0.04. This low BCS can be explained on one hand by insufficient food resources due to the breeding system applied to these cows and the effects of the dry season and on the other hand, the reproductive pathologies recorded on the farms, which have repercussions on the performance (Vall and Bayala, 2004).

The average age (min-max) was 6.19 ± 0.42 years (3-12 years) and the majority were between 6 and 9 years which was similar to those reported by Kouamo et al. (2014), (2016) and (2017) (6.80 ± 0.15 years; 6.62 ± 0.11 years and 6.56 ± 2.34 years respectively) in Cameroon on Bororo and Bokolo Zebu cows. The slaughter of older cows can be explained by the fact that in breeding, it is advisable to slaughter more animals at the end of their reproductive career, and the younger ones being devoted to reproduction.

The average weight of the cows was 327.28 ± 9.35 kg with a minimum of 135.09 kg and a maximum of 578.86 kg. This result is close to that reported by Kouamo et al., 2014 (382.08 ± 4.99 kg). However, it is higher than that obtained by Moussa et al. (2013) in Niger (Goudali: 116.31 ± 24.10 kg; Bororo: 117.34 ± 19.80 kg). These differences would be due to the environment, the breeding system and the different breeds exploited.

Independent of breed, the follicular population was significantly ($p > 0.05$) higher in cows aged [6-9] years. This corroborates with the results proposed by Fassi et al. (2005) and Dorice et al. (2019). This can be explained by the fact that the reproductive system is not yet fully active in young cows; and also, the deficiency of ovarian hormones. In aged cows, the apoptosis of follicles and oocytes are the main causes of the depletion of ovarian reserves. In principle, fertility and reproductive performance decreases with age in all species. Likewise, the work of Natumanya et al. (2008) and Kouamo et al. (2014) have shown that oocyte yield and quality for *in vitro* maturation decreases in cows aged 10 years and above.

This study found a weight inequality between the right ovary (3.88 ± 0.21 g) and the left ovary (3.10 ± 0.19 g). This result is similar to that obtained by Jaji et al. (2012) in Nigeria (4.89 ± 0.18 g vs 3.03 ± 0.11 g), Moussa et al. (2013) in Niger (2.9 ± 1.8 g vs 2.5 ± 1.6 g) and Kouamo et al. (2014) in Cameroon (4.99 ± 2.48 g vs 4.22 ± 2.15 g). Indeed, studies realised by Jaji et al. (2012), Ginther et al. (2013), have all shown that ovulations are more frequent on the right ovary. These results are consistent with the higher percentage of pregnancy in the right horn than in the left horn. In addition, the density of blood vessels that promote a high blood supply to the right ovary and/or the presence of more primordial follicles on the right ovary compared to that of the left ovary. Consequently, this greater physiological activity on the right ovary would be responsible for its higher weight (Ginther et al., 2013).

The mean ovarian weight was 3.47 ± 0.14 g. This result is similar to that reported by Cuq and Agba (1975) (2.8-3.7 g) in Senegal but lower than that proposed by Natumanya et al. (2008) on Ankole zebu cows (4.6 ± 2.3 g) in Uganda. This difference seems to be related to the breed, the physiological, nutritional status and the size of the animals. Indeed, the presence of corpora lutea and the state of gestation increase the size of the ovary and therefore its weight (Pierson and Ginther, 1987). Thus, lean cows (BCS 1-2) have lighter ovary compared to cows with BCS [3] and [4-5]. This would be justified by the fact that underfeeding impacts negatively both on the general condition of the animals and the quality of their ovaries. Moreover, during energy deficiency in cows, there is a slowing down of follicular growth due to a drop in Insulin Growth Factor 1 levels, which are mainly responsible for the stimulation of follicular growth, steroidogenesis and oocyte maturation (Monniaux et al., 2009). In addition, in older cows, the ovary becomes small, sclerotic and takes on a greyish colour (Cuq and Agba, 1975). The positive correlation observed between BCS and ovarian weight can be explained by malnutrition, which negatively influences the general condition of the animals (Kouamo et al., 2014).

Most of the ovaries in the present study were characterized by the presence of corpus luteum (CL) of pregnancy. This pregnancy Corpus Luteum became larger and firmer with advancing pregnancies along the trimesters of gestation. The development and further increases in size of the CL across the three stages of gestation were associated with level of significant increase in the overall size and weight of the ovaries throughout the period of gestation. This is in agreement with the observations of Hachim et al. (2023).

The high number of large follicles in oestrus (0.93 ± 0.35) during the follicular phase is consistent with the results of Kouamo et al. (2014). This is because at the beginning of each sexual cycle in the cow, many reserve follicles are continuously recruited to evolve and at oestrus, only one follicle reaches the maximum size (De Graff follicle at 8-12 mm) and ready to ovulate and the rest have to undergo atresia (Fieni et al., 1998). Furthermore, there is a close growth relationship between ovarian follicle diameter and oocyte quality (Yadav et al., 2007). Therefore, oocyte competence is altered during changes in follicular dynamics, as the follicle would transmit information to the oocyte to acquire competence (Hanzen et al., 2000). Thus, the follicular phase marks the period of the sexual cycle favourable to the emergence of good quality oocytes.

In the present study, gestation did not significantly influence the follicular population during the first trimester although Ginther et al. (1989) identified waves of follicular growth every 8-10 days without leading to selection and dominance between the 4th and 9th month of gestation. On the other hand, a reduction in the number of large follicles with foetal age was reported by Domínguez (1995). Similarly, the presence of the gestational corpus luteum has a negative effect on the growth of follicles larger than 7 mm in diameter after day 22 of gestation (Pierson and Ginther, 1987). The difference in the number of large follicles is explained by the fact that progesterone secretion during gestation inhibits the secretion of pituitary gonadotropins (FSH and LH). Furthermore, the poor oocyte quality observed in pregnant cows in this study is in agreement with the research work of Natumanya et al. (2008). Indeed, terminal folliculogenesis is dependent on a high level of gonadotropins. In the absence of these hormones, the growing follicles only reach the pre-antral follicle stages.

During the period of this study, the majority of cows slaughtered were less than 9 years old and the proportion of pregnant cows was 34.01%, with the majority of the cows (24) being in the first trimester of pregnancy. Similarly high values as regards the slaughter of cows were reported by Alaku and Orjiude (1991) in Nigeria (21.34% and 23.3%), and by Uduak and Samuel (2014) in Nigeria (22.4%). As regards the number of cows in the first trimester, our results corroborate with those found by Meaza et al. (2017) in Ethiopia. The high rate of slaughter of young and pregnant cows noted in this work would increase the potential for industrial-scale decline in bovine development and consequently the shortage of animal protein. Combined with the frequency of genital pathologies, reproductive capacity will be compromised with a decrease in the number of calvings, leading to a drop in the economy of the cattle sector. This would be attributed to the increased demand for beef, resulting from the high population growth associated with urbanisation; socio-economic problems that sometimes push some farmers to sell their animals independent of their physiological status; and on the inefficiency and poor ante-mortem inspection in slaughterhouses.

CONCLUSION

This study demonstrates the potential of zebu follicles as a viable resource for the implementation of innovative reproductive biotechnologies. It is evident that cows with good and excellent body reserves (BCS = 3-5) exhibit a higher follicular population compared to their leaner counterparts, emphasizing the significance of proper nutrition. Moreover, the age range of 6-9 years proved to be optimal for achieving successful outcomes in these procedures. Therefore, when conducting similar research, attention should be given to selecting cows within this age group to maximize performance.

Additionally, the findings of this study highlight the suitability of ovaries from local zebu cows in Cameroon as a cost-effective source of oocytes for *in vitro* embryo production (IVEP). Notably, oocyte donors with a BCS of 3 demonstrated the best potential for enhancing IVEP outcomes. It is crucial to prioritize adequate feeding and nutrition for selected cows to ensure the preservation of oocyte yield and quality. By focusing on these factors, researchers and practitioners can optimize the utilization of local zebu cows' ovaries for reproductive biotechnologies.

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REFERENCES

Alaku SO and Orjiude BA. 1991. Slaughter of pregnant animals for meat in sub-Sahelian environment of West Africa. Trop. Vet. 9:171-176.

Assana E, Doba E, Awah-Ndukum J, Soh GB, Mohamadou A, Mebanga AS, Zoli AP. 2018. Formule de barymetrie pour l'estimation du poids chez les zebus Goudali au Cameroun. Bull. Anim. Health Prod. Afr. 66:469-480.

Cuq P and Agba KM. 1975. Les organes génitaux de la femelle zébu [The genital organs of the female zebu]. Rev. Elev. Med. Vet. Pays Trop. 28:331-403.

Domínguez MM. 1995. Effects of body condition, reproductive status and breed on follicular population and oocyte quality in cows. Theriogenology 43:1405-1418.

Dorice AK, Ferdinand N, Justin K, Augustave K, Linda KK. 2019. Effects of breed, age, body condition score, and nutritional status on follicular population, oocyte yield, and quality in three Cameroonian zebus cattle *Bos indicus*. Adv. Agric. 2019:2979740.

FAO. 2007. The State of the World's Animal Genetic Resources for Food and Agriculture. FAO, Rome, pp. 77-100.

Fassi Fihri A, Lakhdissi H, Derqaoui L, Hajji K, Naciri M, Goumari A. 2005. Genetic and nongenetic effects on the number of ovarian follicles and oocyte yield and quality in the bovine local (Oulmes Zaer), exotic breeds and their crosses in Morocco. Afr. J. Biotechnol. 4:9-13.

Fieni F, Tainturuer D, Bruyas JF, Battut I. 1998. Examen échotomographique des ovaires chez la vache. Journ. Nationales GTV 27:411-415.

Ginther OJ, Bashir ST, Santos VG, Beg MA. 2013. Contralateral ovarian location between the future ovulatory follicle and extant corpus luteum increases the length of the luteal phase and number of follicular waves in heifers. Theriogenology 79:1130-1138.

Ginther OJ, Kastelic JP, Knopf L. 1989. Composition and characteristics of follicular waves during the bovine estrous cycle. Anim. Reprod. Sci. 20:187-200.

Hachim S, Tchoffo H, Jean-Pierre MK, Azafack DK, Ngoula F. 2023. Investigation of ovarian and non-ovarian associated factors related to follicular population and oocyte maturation of Chadian cattle breeds. World. Vet. J. 13:152-166.

Hanzen CH, Lourtie O, Drion PV. 2000. Le développement folliculaire chez la vache: aspects morphologiques et cinétiques. Ann. Med. Vet. 144:223-235.

Jaji AZ, Boyi N, Gambo B, Mahre MB, Luka J, Kachamai WA. 2012. Pregnancy related biometrical changes in the ovaries and uterus of the Red Bororo cattle in Maiduguri, Nigeria. Niger. Vet. J. 33:592-599.

Kouamo J, Dawaye SM, Zoli AP, Bah GS. 2014. Evaluation of bovine (Bos indicus) ovarian potential for in vitro embryo production in the Adamawa plateau (Cameroon). Open Vet. J. 4:128-136.

Kouamo J, Meyoufey B, Zoli AP. 2016. Pathological study of female reproductive organs of local zebus in Adamawa Region. Bull. Anim. Health Prod. Afr. 64:119-128.

Kouamo J, Nono Fambo SM, Zoli AP. 2017. Effect of the stage of sexual cycle, harvesting technique and season on follicular dynamics and oocyte quality of zebu cattle under Sudano-Sahelian climate. Integr. J. Vet. Biosci. 1:1-7.

Manik RS, Singla SK, Palta P. 2003. Collection of oocytes through transvaginal ultrasound-guided aspiration of follicles in an Indian breed of cattle. Anim. Reprod. Sci. 76:155-161.

Meaza M, Tamirat B, Demissie T. 2017. Fetal wastage and morphometrical study of reproductive organs of local zebu and crossbred female cattle slaughtered at Addis Ababa abattoir enterprise and Adama municipal abattoir, central Ethiopia. Glob. Vet. 18:376-382.

MINEPIA. 2019. Elevage et pèche. Annuaire Statistique du Cameroun, Institut National de la Statistique. P.211.

Monniaux D, Caraty A, Clement F, Dalbies-Tran R, Dupont J, Fabre S, Gérard N, Mermillod P, Monget P, Uzbekova S. 2009. Développement folliculaire ovarien et ovulation chez les mammifères. INRA Prod. Anim. 22:59-76.

Moussa Garba M, Marichatou H, Issa M, Abdoul Aziz ML, Hanze C. 2013. Tractus génital des vaches zébus (*Bos indicus*) au Niger. Rev. Elev. Med. Vet. Pays Trop. 66:137-142.

Natumanya R, Owiny OD, Kugonza DR. 2008. The potential of Ankole cattle abattoir ovaries for in vitro embryo production. Afr. J. Anim. Biomed. Sci. 3:1-5.

Njoya A, Bouchel D, Ngo Tama AC, Moussa C, Martrenchar A, Letenneur L. 1997. Systèmes d'élevage et productivité des bovins en milieu paysan au Nord-Cameroun. World Anim. Rev. 89:12-23.

Paguem A, Abanda B, Achukwi MD, Baskaran P, Czemmel S, Renz A, Eisenbarth A. 2020. Whole genome characterization of autochthonous Bos taurus brachyceros and introduced Bos indicus indicus cattle breeds in Cameroon regarding their adaptive phenotypic traits and pathogen resistance. BMC Genet. 21:64.

Pierson RA and Ginther OJ. 1987. Follicular populations during the estrous cycle in heifers. II. Influence of right and left sides and intraovarian effect of the corpus luteum. Anim. Reprod. Sci. 14:177-186.

Santos SS, Ferreira MA, Pinto JA, Sampaio RV, Carvalho AC, Silva TV, Costa NN, Cordeiro MS, Miranda MS, Ribeiro HF, Ohashi OM. 2013. Characterization of folliculogenesis and the occurrence of apoptosis in the development of the bovine fetal ovary. Theriogenology 79:344-350.

Satrapa RA, Nabhan T, Silva CF, Simões RA, Razza EM, Puelker RZ, Trinca LA, Barros CM. 2011. Influence of sire breed (Bos indicus versus Bos taurus) and interval from slaughter to oocyte aspiration on heat stress tolerance of in vitro-produced bovine embryos. Theriogenology 76:1162-1167.

Uduak A and Samuel AB. 2014. Incidence of foetal wastage and its economic implications in cattle slaughtered at Abak slaughter house Abak, Akwa-Ibom State. J. Reprod. Infertil. 5:65-68.

Vall E and Bayala I. 2004. Note d'état corporel des zébus soudaniens. In: Yaméogo (Ed(s).), Production Animale en Afrique de l'Ouest, Cirdes, Bobo-Dioulasso, pp. 1-8.

Yadav EN, Kharche SD, Goel AK, Jindal SK, Johri DK. 2007. Comparative efficacy of different techniques for oocytes recovery from prepubertal goat ovaries. Indian J. Anim. Sci. 77:988-990.