RESEARCH ARTICLE

OVARIAN POTENTIAL OF LOCAL GOATS FOR *IN VITRO* EMBRYO PRODUCTION IN THE FAR NORTH OF CAMEROON

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ABSTRACT

The study was carried out on 281 local goats (257 Sahelian and 24 Kirdi) at the municipal small ruminant abattoir in Maroua, in the Far North region of Cameroon. A total of 562 ovaries were collected and transported in 0,9% NaCl solution to the laboratory. After clearing the ovaries of the surrounding tissue, the follicles on each ovary were counted, their diameter (Φ) measured and classified into small (Φ< 3 mm), medium (3 ≤ Φ ≤ 8 mm) and large (8 ≤ Φ< 10 mm). Subsequently, the oocytes were harvested in Dubelcco's Phosphate Buffered-Saline solution using the slicing technique, observed under a light microscope at 40X magnification, and classified into four groups according to the degree of cumulus cell compactness and ooplasm transparency. The mean follicular population was 25.38 ± 6.84 per ovary. Small, medium and large follicles were 5.87 ± 2.90, 15.64 ± 4.71 and 3.86 ± 1.69 in diameter, respectively. Oocyte yield was 33.39 ± 11.71 per ovary. Quality I, II, III, IV oocytes were 11.57 ± 3.33 (34.65%), 9.64 ± 3.05 (28.87%), 8.25 ± 3.26 (24.71%) and 3.93 ± 2.01 (11.77%), respectively. The oocyte quality index was 2.11. Oocytes with quality (grade I and II) acceptable for *in vitro* embryo production (IVEP) constituted 63.52% of the harvest. These results indicate that certain factors such as the age, body condition, pregnancy status and stage, ovarian weight and corpus luteum must be considered to increase the ovary's potential for *in vitro* embryo production.

Keywords: Cameroon, follicular population, goats, ovaries, oocyte quality

INTRODUCTION

Goats in Cameroon represent 64.52% of the 11,080,929 head of small ruminants. The Far North Region alone accounts for more than two-thirds (2 923 312) of the national goat population (INS, 2023). The herd is mainly made up of Sahelian and Kirdi goats. The productivity of these breeds remains under-utilised. Genetic, zootechnical, health and breeding problems are cited as the factors responsible for low productivity (Sousa et al., 2004).

In response to these shortcomings, governments have adopted various techniques through programmes of artificial insemination (AI) decades ago to increase the number of offspring with elite genetic merit by reducing the generation interval. Today, the generation interval has been further narrowed by *in vitro* fertilization. It shows the way in terms of the effectiveness of rapid genetic improvement, especially as farmers aim to speed up genetic selection. These techniques have revolutionized genetic selection by the female route (Leroy, 2022). *In vitro* maturation, positive *in vitro* fertilization and embryo transfer allow producers to make the same genetic progress in one generation that would traditionally take five generations using AI or natural reproduction. In addition, superior individuals from both parents are used to contribute to the genetic improvement of the next generation (Ax et al., 2005).

As oocytes form the basis of biotechnologies applied to the embryo, their collection and evaluation are a prerequisite for the success of these biotechnologies, which are mainly aimed at providing solutions to the lack of protein and the conservation of genetic values. The main objective of this study was to evaluate the ovarian potential of Sahelian and Kirdi goats slaughtered in Diamare for the production of fertilizable oocytes *invitro*. Specifically, the follicular population, oocyte yield and quality will be determined, and the effects of ovarian and non-ovarian factors on the follicular population, oocyte yield and quality will be assessed.

MATERIAL AND METHODS

Study area

This study was carried out at the Diamare municipal small ruminant abattoir in Maroua 2, and the samples were analysed in the laboratory of the 'Centre National de Formation Zootechnique et Vétérinaire' in Maroua in the Far North Region of Cameroon. Located between latitude 10° 35′ 37″ North and longitude 14° 18′ 52″ East (Benjamine and Wadou, 2023), it has a Sahelian climate with a long dry season from October to June and a short rainy season from July to September. Average annual rainfall and annual temperature recorded were 794 mm and 27.5°C, respectively. The 281 goats studied came from the Divisions of Mayo Sava (Tokombere, Mora, Pete, Mayo plata), Diamare and Mayo Kani.

Characteristics of the animals

A total of 281 local goats were studied: 257 of the Sahelian type and 24 of the Kirdi breed.

Before slaughter, thoracic perimeter (TP), height at withers, scapulo-ischial length, horn length, ear length and tail length were measured for each goat using the tape measure to enable us to determine breed (Mani et al., 2014). Then, the weight was measured using a 50 kg Mini Mechanical Scale accurate to 100 g. Body condition score (BCS) was based on determining the amount of muscle and fat over and around the vertebrae. Scoring was performed in goats using a BCS ranging from 1.0 to 5.0, with 0.5 increments, as described by Ghosh et al. (2019).

After slaughter, age was estimated by examining the dentition (the change between the milk incisors and the permanent ones): an animal with two permanent teeth is about 1 year old, four permanent teeth at 2 years, six permanent teeth at about 3 years, and when the goat has eight permanent teeth, the animal is about 4 years old, as described by Hutu (2019). In the case of pregnant goats (characterized by the presence of one or more fetuses), their proportion in relation to the goats studied was determined; the fetal age was determined by the formula X = 2.1 (Y + 17)

(Arthur et al., 2001), where Y represented cranio-caudal length in cm and X represented gestation length in days, and gestation length was classified into two groups: ≤ 50 days and 51-100 days.

Ovary collection and handling

After the identification and slaughter of each goat, the right and left ovaries were removed using scissors and placed in separate collection bottles containing an isotonic solution (NaCl, 0.9%). They were transported in an isothermal container (20-30°C) within two hours of slaughter. Ovaries with follicles > 10 mm in the absence of a corpus luteum (Cystic ovaries, Kouamo et al., 2020a) were excluded.

Determination of the weight and size of the ovary

In the laboratory, the ovaries were freed of tissue debris (broad ligament or mesovarium holding the ovary together) and then weighed using an MH-Series Pocket Scale 200g electronic balance with a precision of 0.01. Based on their weight, the ovaries were divided into three groups: small (<1 g), medium (1 to 2 g) and large (> 2 g) (Islam et al., 2007). The size (length, width and thickness) of the ovary was measured using a mechanical calliper. The ovaries were divided into two groups based on mean volume: ovarian volume less than 1.38 x 0.94 x 0.56 cm^3 and greater than 1.38 x 0.94 x 0.56 cm^3 (Ngona et al., 2012).

Determination of the follicular population

After rinsing each ovary in a physiological solution, the visible follicles were counted. Follicular diameters (Φ) were measured with a calliper and classified into 3 categories: small (Φ< 3 mm), medium (3 ≤ Φ ≤ 8 mm) and large (8 <Φ< 10mm), as described by Duygu et al. (2013). They were kept in an isothermal bag at a temperature of 30°C throughout their examination.

Collection and classification of oocytes

Each ovary was placed in a Petri dish containing 5 ml of Dulbecco's phosphate-buffered saline (DPBS). The slicing technique was used to collect the oocytes. The oocytes were examined and counted using a light microscope with a 40X magnification. The oocytes were then classified into 4 qualities (Q) taking into account the homogeneity of the cytoplasm and layers of the cumulus oophorus cells, according to Kouamo et al. (2020b). Quality 1 (Q1): the cumulus (granule cells) were compact and surrounded the oocyte (more than three layers). The oocyte ooplasm had a homogeneous appearance; Quality 2 (Q2): the cumulus was compacted with one or two layers, but the ooplasm had a more irregular appearance, with a darker area visible at its periphery; Quality 3 (Q3): the cumulus had a layer of irregular and less compacted cells, and the ooplasm was less regular with dark areas; Quality 4 (Q4): The cumulus was completely expanded or even absent (naked oocytes), and the ooplasm was irregular with dark areas. To assess overall oocyte quality, an index was calculated: [quality I x 1 + quality II x 2 + quality III x 3 + quality IV x 4] / total number of oocytes], as described by Kouamo et al. (2020b). A value tending towards 1 reflects good overall oocyte quality.

Statistical analysis

Data were analysed using R® software. One-way analysis of variance (ANOVA) was performed to assess the effect of ovarian (ovary localization, corpus luteum, ovary weight, ovary size) and non-ovarian (breed, age, BCS, pregnancy status, pregnancy length) factors on follicular population, yield and oocyte quality. Differences between means were tested by Duncan's test. Differences were significant at P<0.05.

RESULTS

Characteristics of the slaughtered goats

The average age (year), BCS and live weight (kg) of the goats were 1.64 ± 0.15, 2.74 ± 0.45 and 24.12 ± 4.62, respectively, with that of Sahelian type goats (24.45 ± 4.3 kg) significantly higher (P<0.05) than that of Kirdi type goats (20.64 ± 5.63 kg). A pregnancy rate of 43.45% and an average fetal age of about 61 days were recorded.

The mean weight (g) of the ovary was 1.34 ± 0.34, and the left ovary (1.43 ± 0.49 g) was significantly ($P<0.0001$) heavier than the right (1.25 ± 0.40 g). The length, width and thickness (cm) of the ovaries were 1.38 ± 0.19, 0.94 ± 0.14 and 0.56 ± 0.17, respectively. BCS and the presence of the corpus luteum significantly ($p<0.05$) increased ovarian thickness. The presence of the corpus luteum statistically increased the length, width and thickness. The average ovary weights of non-pregnant were greater ($P<0.05$) than those of pregnant goats (Table 1).

Follicular population

From 562 harvested ovaries, 14,262 follicles were counted with an average of 25.38 ± 6.84 per ovary. Small ($\Phi < 3$ mm), medium ($3 \leq \Phi < 8$ mm) and large ($8 \leq \Phi < 10$ mm) follicles accounted for 23.15%, 61.63% and 15.22% of the follicular population, respectively.

Oocyte yield and quality

Eighteen thousand seven hundred and sixty-five (18,765) quality I, II, III and IV oocytes were harvested from 562 ovaries, giving a mean oocyte yield per ovary of 33.39 ± 11.71. The quality of oocytes classified as I, II, III and IV (Figure 1) was 11.62 ± 3.34 (34%); 9.56 ± 3.03 (29%); 8.44 ± 3.45 (25%) and 3.99 ± 2.03 (12%), respectively. Oocytes judged to be of good quality for maturation and fertilization *in vitro* (Q. I and II) represented 63.52% (11,919) of the harvest. The oocyte quality index (OQI) was 2.11.

Effect of ovarian factors on follicular population, oocyte yield and quality

The total number of follicles increased with ovarian weight (g) and size (cm); however, oocyte yield and quality decreased with ovarian weight. Ovaries with a corpus luteum had more follicles and more fertilizable oocytes (Tables 2 and 3).

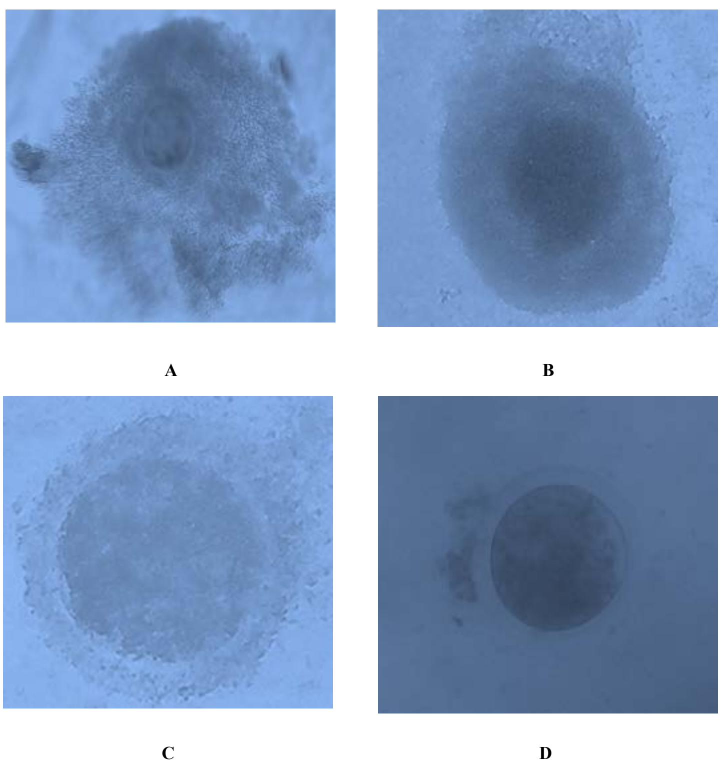

Figure 1 Quality of oocytes.(a) Quality 1: oocyte surrounded by a compact cumulus with more than three layers and presenting a homogeneous ooplasm; (b) Quality 2: oocyte surrounded by a compact cumulus having one or two layers and presenting an ooplasm with an irregular appearance, with a darker zone visible at its periphery; (c) Quality 3: the cumulus has a layer of irregular and less compact cells and the ooplasm is less regular with darker areas; (d) Quality 4 : The cumulus is completely expanded or even absent (naked oocytes) and the ooplasm is irregular with dark areas

Table 1 Variation in ovarian weight and size as a function of breed, BCS, age, pregnancy status and corpora lutea (mean ± SD)

Parameters	Variables	N	Right ovary weight (g)	Left ovary weight (g)	Ovary weight (g) per animal	Ovary length (cm)	Ovary width (cm)	Ovary thickness (cm)
Breed	Kirdi	24	1.42 ± 0.15^{a}	1.32 ± 0.26^{a}	1.37 ± 0.16^{a}	1.41 ± 0.15^{a}	0.97 ± 0.12^{a}	0.58 ± 0.14^{a}
	Sahelian	257	1.29 ± 0.11^{a}	1.30 ± 0.19^{a}	1.29 ± 0.11^{a}	1.35 ± 0.23^{a}	0.91 ± 0.16^{a}	0.55 ± 0.20^{a}
	P-value		***0.262***	***0.911***	***0.530***	***0.3***	***0.051***	***0.2***
BCS	Good (>3)	31	1.38 ± 0.15^{a}	1.25 ± 0.26^{a}	1.32 ± 0.15^{a}	1.36 ± 0.23^{a}	0.93 ± 0.22^{a}	0.57 ± 0.15^{b}
	Medium (2.5-3)	133	1.30 ± 0.12^{a}	1.23 ± 0.20^{a}	1.26 ± 0.12^{a}	1.35 ± 0.21^{a}	0.90 ± 0.14^{a}	0.51 ± 0.13^{a}
	Thin (<2.5)	117	1.37 ± 0.12^{a}	1.44 ± 0.22^{a}	1.41 ± 0.13^{a}	1.36 ± 0.24^{a}	0.92 ± 0.16^{a}	0.59± 0.25^{b}
	P-value		***0.77***	***0.611***	***0.591***	***0.7***	***0.3***	***0.003***
Age (years)	< 1	5	1.48 ± 0.23^{a}	1.53 ± 0.41^{a}	1.51 ± 0.25^{a}	1.45 ± 0.14^{a}	0.99 ± 0.07^{a}	0.63 ± 0.12^{a}
	[1-2[	234	1.30 ± 0.07^{a}	1.39 ± 0.13^{a}	1.34 ± 0.08^{a}	1.36 ± 0.23^{a}	0.91 ± 0.16^{a}	0.55 ± 0.21^{a}
	[2-3[	39	1.34 ± 0.10^{a}	1.34 ± 0.17^{a}	1.34 ± 0.10^{a}	1.31 ± 0.21^{a}	0.89 ± 0.16^{a}	0.55 ± 0.13^{a}
	[3-4]	3	1.29 ± 0.31^{a}	0.97 ± 0.55^{a}	1.13 ± 0.33^{a}	1.37 ± 0.24^{a}	0.88 ± 0.12^{a}	0.55 ± 0.13^{a}
	P-value		***0.96***	***0.924***	***0.905***	***0.5***	***0.5***	***0.5***
Corpus luteum	Absent	106	1.26 ± 0.13^{a}	1.17 ± 0.23^{a}	1.21 ± 0.14^{a}	1.30 ± 0.22^{a}	0.87 ± 0.15^{a}	0.51 ± 0.13^{a}
	Present	175	1.45 ± 0.11^{b}	1.44 ± 0.20^{b}	1.44 ± 0.12^{b}	1.39 ± 0.22^{b}	0.94 ± 0.16^{b}	0.58 ± 0.22^{b}
	P-value		***0.008***	***0.029***	***0.002***	***0.003***	***0.001***	***0.002***
Pregnancystatus	Non-pregnant	159	1.27 ± 0.11^{a}	1.51 ± 0.19^{a}	1.39 ± 0.11^{a}	1.37 ± 0.05^{a}	0.91 ± 0.03^{a}	0.56 ± 0.04^{a}
	Pregnant	122	1.22 ± 0.14^{a}	1.34 ± 0.24^{a}	1.28 ± 0.14^{b}	1.34 ± 0.06^{a}	0.92 ± 0.04^{b}	0.54 ± 0.05^{a}
	P-value		***0.47***	***0.47***	***0.03***	***0.06***	***0.025***	***0.35***

a,b,c : In each column, different letters indicated significant difference between groups ($p<0.05$)

N=number of goats

SD=standard deviation

Table 2 Variation in the number of follicles according to ovarian factors (mean ± SD)

Parameters	Variables	N	Number of follicles			Average number of follicles /ovary
			Small (< 3mm)	**Medium (3-8 mm)**	**Large (> 8 mm)**	
Ovary localization	Right	281	5.68 ± 2.91^a	15.42 ± 4.53^a	3.84 ± 1.63^a	24.94 ± 6.40^a
	Left	281	6.06 ± 2.89^a	15.86 ± 4.89^a	3.89 ± 1.74^a	25.81 ± 7.34^b
	P-value		***0.894***	***0.254***	***0.299***	***0.035***
Corpus luteum	Absent	106	5.69 ± 2.56^a	15.57 ± 5.28^a	3.66 ± 1.51^a	24.92 ± 7.22^a
	Present	175	5.99 ± 2.98^a	15.68 ± 5.08^a	3.99 ± 1.71^a	25.66 ± 7.22^a
	P-value		***0.5***	***0.7***	***0.085***	***0.5***
Ovary weight (g)	<1	56	4.71 ± 3.07^a	12.68 ± 4.40^a	2.88 ± 1.48^a	20.28 ± 6.19^a
	[1-2]	209	6.05 ± 2.59^b	16.43 ± 4.99^b	4.07 ± 1.56^b	26.56 ± 6.74^b
	>2	16	7.59 ± 3.67^b	15.66 ± 6.12^b	4.59 ± 2.07^b	27.84 ± 8.93^b
	P-value		***<0.001***	***<0.001***	***<0.001***	***<0.001***
Ovary size (cm^3)	< 1.38 x 0.94 x 0.56	127	5.10 ± 2.70^a	14.80 ± 4.90^a	3.42 ± 1.53^a	23.31 ± 6.58^a
	≥ 1.38 x 0.94 x 0.56	154	6.51 ± 2.78^b	16.34 ± 5.26^b	4.23 ± 1.65^b	27.08 ± 7.29^b
	P-value		***<0.001***	***0.002***	***<0.001***	***<0.001***

a,b,c : In each column, different letters indicated significant difference between groups ($p<0.05$)
N=number of goats
SD=standard deviation

Table 3 Effects of ovarian factors on the number and quality of oocytes (mean ± SD)

Parameters	Variables	N	Average number of oocytes /ovary	Oocyte quality				Selected oocytes for IVEP. (I II)
				I	II	III	IV	
Ovary localization	Right	***281***	33.61 ±11.73^{a}	11.61 ±4.38^{a}	9.56 ±3.90^{a}	8.44 ±4.35^{a}	3.99 ±2.57^{a}	21.17 ±7.24^{a}
	Left	***281***	33.17 ±11.69^{a}	11.52 ±4.41^{a}	9.72 ±3.99^{a}	8.05 ± 3.99^{a}	3.86 ± 2.54^{a}	21.24 ±7.51^{a}
	P-value		***0.581***	***0.963***	***0.848***	***0.087***	***0.807***	***0.807***
Corpus luteum	Absent	106	32.4 ± 13.08^{a}	10.70 ± 3.19^{a}	9.21 ± 3.19^{a}	8.57 ± 4.20^{a}	3.92 ± 2.50^{a}	19.91 ± 5.45^{a}
	Present	175	34.27 ± 15.17^{b}	12.09 ± 3.82^{b}	9.77 ± 4.27^{a}	8.37 ± 4.46^{a}	4.04 ± 2.62^{a}	21.99 ± 6.61^{b}
	P-value		***0.019***	***0.002***	***0.3***	***0.7***	***0.8***	***0.022***
Ovary weight (g)	<1	56	31.19 ± 13.23^{a}	10.46 ± 3.34^{a}	9.55 ± 3.74^{ab}	7.29 ± 3.81^{ab}	3.89 ± 2.34^{a}	19.38 ± 5.61^{ab}
	[1-2]	209	34.7 ± 14.77^{a}	11.93 ± 3.75^{b}	9.73 ± 3.94^{b}	8.92 ± 4.43^{b}	4.12 ± 2.65^{a}	21.85 ± 6.41^{b}
	>2	16	26.94 ± 12^{a}	10.69 ± 2.61^{ab}	7.25 ± 3.44^{a}	6.31 ± 3.93^{a}	2.69 ± 2.02^{a}	19.13 ± 5.16^{a}
	P-value		***0.12***	***0.004***	***0.039***	***0.004***	***0.12***	***0.004***
Ovary size (cm^3)	< 1.38 x 0.94 x 0.56	127	32.94 ± 13.86^{a}	11.09 ± 3.39^{a}	9.80 ± 3.75^{a}	8.00 ± 4.21^{a}	4.05 ± 2.51^{a}	20.63 ± 5.82^{a}
	≥ 1.38 x 0.94 x 0.56	154	34.08 ± 14.94^{a}	11.96 ± 3.83^{b}	9.36 ± 4.03^{a}	8.81 ± 4.45^{a}	3.95 ± 2.63^{a}	21.68 ± 6.61^{a}
	P-value		***0.7***	***0.045***	***0.3***	***0.11***	***0.6***	***0.13***

a,b,c : In each column, different letters indicated significant difference between groups ($p<0.05$)
N=number of goats
SD=standard deviation

Table 4 Variation in follicular population according to non-ovarian factors (mean ± SD)

Parameters	Variables	N	Number of follicles			Average number of follicles/ovary
			Small (< 3mm)	**Medium (3-8 mm)**	**Large (> 8 mm)**	
Breed	Kirdi	24	6.88 ± 2.87[a]	14.90 ± 5.73[a]	4.13 ± 1.51[a]	25.90 ± 7.79[a]
	Sahelian	257	5.78 ± 2.81[a]	15.71 ± 5.10[a]	3.84 ± 1.66[a]	25.33 ± 7.18[a]
	P-value		***0.064***	***0.6***	***0.3***	***0.5***
Age (years)	< 1	5	9.80 ± 1.60[a]	19.10 ± 7.77[a]	4.60 ± 0.89[a]	33.50 ± 9.21[a]
	[1-2[	234	5.81 ± 2.79[b]	15.57 ± 5.21[a]	3.81 ± 1.68[a]	25.20 ± 7.34[a]
	[2-3[	39	5.96 ± 2.87[b]	15.77 ± 4.51[a]	4.14 ± 1.53[a]	25.87 ± 5.65[a]
	[3-4]	3	3.00 ± 1.80[ab]	13.50 ± 2.29[a]	2.83 ± 0.76[a]	19.33 ± 3.01[a]
	P-value		***0.007***	***0.6***	***0.3***	***0.074***
BCS	Good (>3)	31	5.98 ± 2.65[ab]	15.35 ± 5.02[a]	3.69 ± 1.61[a]	25.03 ± 7.02[a]
	Medium (2.5-3)	133	5.40 ± 2.72[b]	15.93 ± 4.88[a]	4.02 ± 1.49[a]	25.35 ± 7.13[a]
	Thin (<2.5)	117	6.38 ± 2.92[a]	15.38 ± 5.50[a]	3.74 ± 1.81[a]	25.50 ± 7.43[a]
	P-value		***0.008***	***0.9***	***0.3***	***0.9***
Pregnancy status	Non pregnant	159	11.75 ± 4.48[a]	31.65 ± 8.17[a]	7.92 ± 2.62[a]	51.33 ± 11.63[a]
	Pregnant	122	11.78 ± 4.88[b]	30.66 ± 8.26[a]	7.46 ± 2.65[a]	49.90 ± 11.66[a]
	P-value		***0.90***	***0.69***	***0.48***	***0.75***
Pregnancy length in days	≤50	96	11.61 ± 4.81[a]	31.06 ± 8.36[a]	7.41 ± 2.76[a]	50.08 ± 11.54[a]
	51 – 100	26	12.19 ± 5.13[a]	29.85 ± 7.83[a]	7.69 ± 2.20[a]	49.73 ± 12.16[a]
	P-value		***0.547***	***0.296***	***0.705***	***0.285***

a,b,c : In each column, different letters indicated significant difference between group ($p<0.05$)
N=number of goats
SD=standard deviation

Table 5 Variation in oocyte yield and quality depending on non-ovarian factors (mean ± SD)

Parameters	Variables	N	Average number of oocytes/ovary	Oocyte quality I	II	III	IV	Selected oocytes for IVEP. I and II (%)
Breed	Kirdi	24	35.82 ±17.37[a]	12.81 ± 3.94[a]	10.75 ± 5.14[a]	8.13 ± 4.94[a]	4.13 ± 3.35[a]	23.44 ± 7.26 (65.44)[a]
	Sahelian	257	33.34 ±14.18[a]	11.45 ± 3.62[a]	9.44 ± 3.76[a]	8.47 ± 4.30[a]	3.98 ± 2.50[a]	21.00 ± 6.15 (62.99)[b]
	P-value		***0.10***	***0.059***	***0.10***	***0.9***	***0.7***	***0.016***
Age (years)	< 1	5	40.5 ±11.23[a]	14.90 ± 1.92[a]	10.20 ± 1.30[a]	10.40 ± 4.93[a]	5.00 ± 3.08[a]	26.10 ± 3.25 (64.44)[a]
	[1-2[	234	33.47 ±14.66[a]	11.68 ± 3.72[ab]	9.52 ± 3.97[a]	8.40 ± 4.44[a]	3.87 ± 2.53[a]	21.28 ± 6.39 (63.58)[a]
	[2-3[	39	33.37 ±13.66[a]	10.50 ± 3.08[b]	9.74 ± 3.89[a]	8.49 ± 3.91[a]	4.64 ± 2.78[a]	20.22 ± 5.62 (60.59)[a]
	[3-4]	3	31.33 ±11.72[a]	11.33 ± 4.65[ab]	8.67 ± 2.08[a]	8.00 ± 3.46[a]	3.33 ± 1.53[a]	19.67 ± 6.83 (62.78)[a]
	P-value		***0.2***	***0.030***	***0.9***	***0.9***	***0.5***	***0.081***
BCS	Good (>3)	31	32.64 ±15.61[a]	10.61 ± 4.33[a]	9.16 ± 4.01[a]	8.13 ± 4.35[a]	4.74 ± 2.92[a]	19.81 ± 7.10 **(60.69)**[a]
	Medium (2.5-3)	133	33.43 ±12.77[a]	11.21 ± 3.11[a]	9.57 ± 3.37[a]	8.59 ± 3.88[a]	4.06 ± 2.41[a]	20.87 ± 4.97 (62.43)[a]
	Thin (<2.5)	117	33.96 ±15.87[b]	12.23 ± 3.95 [a]	9.64 ± 4.43[a]	8.37 ± 4.86[a]	3.72 ± 2.63[a]	21.95 ± 7.25 (64.63)[a]
	P-value		***0.009***	***0.055***	***0.8***	***0.8***	***0.2***	***0.4***
Pregnancy status	Non pregnant	159	67.02 ± 9.47[a]	23.41 ± 5.53[a]	19.24 ± 5.32[a]	16.40 ± 5.72[a]	7.96 ± 3.32[a]	42.65 ± 9.47[a]
	Pregnant	122	65.66 ± 3.14[b]	22.80 ± 5.21[b]	19.35 ± 4.80[a]	16.50 ± 5.60[a]	7.69 ± 3.06[a]	42.15 ± 8.61[b]
	P-value		***0.040***	***0.047***	***0.084***	***0.073***	***0.162***	***0.029***
Pregnancy length in days	≤50	96	67.79 ± 14.68[a]	23.03 ± 4.46[a]	19.72 ± 4.78[a]	16.79 ± 14.68[a]	8.24 ± 3.18[a]	42.75 ± 8.92[a]
	51 - 100	26	61.58 ± 12.91[b]	21.85 ± 4.34[b]	17.85 ± 4.73[a]	16.04 ± 5.04[a]	5.85 ± 2.24[b]	39.69 ± 7.66[b]
	P-value		***0.022***	***0.029***	***0.055***	***0.188***	***0.037***	***0.021***

a,b,c : In each column, different letters indicated significant difference between group ($p<0.05$)
N=number of goats
SD = standard deviation

Effect of non-ovarian factors (breed, age, BCS, pregnancy status and duration) on follicular population, oocyte yield and oocyte quality

The total number of follicles, oocyte yield and oocyte quality were higher in goats under 3 years old and with a BCS less than or equal to 3. Small follicles (< 3mm) decreased significantly with age ($P < 0.05$) (Tables 4 and 5).

DISCUSSION AND CONCLUSION

The average body condition score of slaughtered goats is similar to 2.75 reported by Ngona et al. (2012) in the Democratic Republic of Congo, but lower than 3.2 ± 0.6 obtained by Kouamo et al. (2021) in the Sudano-Guinean zone of Cameroon. Indeed, the live weight of Sahelian-type goats is higher than 23.00 ± 2.19 kg reported by Kouamo et al. (2019) in Far North of Cameroon, and that of Kirdi is higher than that reported by Djagba et al. (2019) on Djallonke goats (17.45 ± 4.33 kg) in Togo. However, even if the results of the goats studied in this work are within the ranges predicted by the previous authors, it should be noted that these values are low compared with the average for the Sahelian and Kirdi breeds used in this study. This could be explained by the uncontrolled interbreeding among the breeds, which compromises the individual potential of each breed because they are bred together in traditional systems with anarchic cross-breeding and under poor feeding and sanitary conditions; in addition to the effects of climate change, which are forcing morphological changes in response to the new conditions, with a consequent impact on reproduction (Mandonnet et al., 2011).

The pregnancy rate was higher than 38.60% observed by Manjeli et al. (1996) at the Garoua and Maroua abattoirs; however, it was lower than 49% reported by Nana et al. (2014) in the town of Dschang and 45.30% by Kouamo et al. (2019) at the Maroua municipal abattoir. The difference could be linked to the study period and breed. The slaughter of gravid goats causes huge losses and thus constitutes a shortfall for the breeders and a handicap for the country. An important factor contributing to the increased slaughter of pregnant animals in Cameroon is the poor enforcement of existing livestock legislation. Decree N° 2018/759 of 10 December, 2018 strictly prohibits livestock producers, middlemen and butchers from transporting and/or slaughtering young and pregnant animals of all breeds. No sanctions or punitive measures are imposed on those who violate the existing regulations. Poor enforcement of government regulations on livestock, therefore, perpetuates the slaughter of pregnant animals.

The average ovary weight of the goats studied was higher than 1.30 ± 0.23 g and 0.69 ± 0.01g reported by Islam et al. (2007) and Ngona et al. (2012), respectively. On the other hand, it is less than 3-5 g reported by Meyer (2008). This difference may be due to the breed effect. Specifically, the ovaries (g) of the Kirdi breed are not different (1.37 ± 0.16) than those of Sahelian-type goats (1.29 ± 0.11) ($P \geq 0.05$).

The presence of the corpus luteum increased the weight and the length, width and thickness of the ovaries. Similar results have been reported by El-Sharawy et al. (2021) in ewes, which could be explained by the fact that the corpus luteum formed from the ovulating follicle develops in all directions on the surface of the ovary. The presence of the corpus luteum on the left ovary was observed in majority of goats, indicating that ovulation is more marked on the left ovary, contrary to the results of the studies by Islam et al. (2007) and Alsafy and El-Shahat (2011). In all of domesticated ruminants, the right ovary is usually more active than the left. Local paracrine and autocrine factors and differences in lymphatic drainage of the right and left ovaries may contribute to the observed variation in their activities (Habibizad et al., 2021). The right ovaries are also more functional in ruminants because of the presence of the rumen which reduces blood supply to the left ovary, consequently GnRH. The difference is unknown and may be due to less number of ovaries processed.

The mean number of follicles was higher than 4.9 ± 0.89, 7.46 ± 0.14 and 10.38 ± 5.48 reported by

Alsafy and Shahat (2011), Wani et al. (2013) and Kouamo et al. (2019), respectively. The number of follicles with a diameter greater than 8 mm was low. This result is similar to those of Zongo et al. (2019) who had 5 to 9 pre-ovulatory follicles, and Zarrouk et al. (2001) who had mature follicles of 9 to 10 mm in goats. These proportions could be explained by the fact that the study took place during the sexual season and the females were at different stages of the estrus cycle (Lassoued and Rekik, 2005). During the estrus cycle, the ovaries undergo a series of morphological (follicular recruitment and growth), biochemical (follicle maturation) and physiological (endocrine regulation) changes, which lead to ovulation and would affect their diameter. Each weighed 0.5 to 3 grams dependent on the stage of the reproductive cycle (Osman et al., 2021). The number of follicular waves, with a new recruitment every 5 to 7 days, could explain this consistent number of follicles of different sizes. If the slicing technique is applied correctly, all the oocytes present in all the follicles can be recovered, regardless of their location on the ovarian cortex. The oocyte yield was higher than 5.87 ± 0.08 and 6.04 ± 1.01 observed by Wani et al. (2013) and Kouamo et al. (2020b), respectively. These differences could be due to the technique used (slicing), which could trap a large number of oocytes in tissues that have not been sufficiently incised.

The number of cultivable oocytes was significantly higher in the ovaries of non-pregnant goats than in the others. The same observations were made by Islam et al. (2007). This could be explained by the persistence of the corpus luteum and its production of progesterone, which inhibits follicular growth in pregnant goats. On the other hand, the negative effect of progesterone may not be effective in non-pregnant goats, which explains the role of hormonal balance on folliculogenesis in goats.

In conclusion, this study has indicated that the ovaries of local Cameroonian goats have a fairly good potential to produce fertilizable oocytes for *in vitro* embryo production. Factors such as the age, body condition, pregnancy status and stage, ovary weight and corpora lutea should be take into account to maximise the success of *in vitro* embryo production.

CONFLICT OF INTEREST

The authors declared that there is no conflict of interest.

AUTHORS CONTRIBUTION

JK designed and planned the study; JBM collected the data; JK and JBM analyzed the data and wrote the first version of the manuscript; all authors have revised the article and authorize submission of the final version for publication.

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OVARIJALNI POTENCIJAL LOKALNIH KOZA ZA *IN VITRO* PROIZVODNJU EMBRIJA NA DALEKOM SJEVERU KAMERUNA

SAŽETAK

Istraživanje je provedeno na 281 lokalnoj kozi (257 Sahel i 24 Kirdi) u klaonici za male preživače u općini Maroua, u regiji Daleki Sjever u Kamerunu. Prikupljena su ukupno 562 jajnika koja su potom prevezena u laboratorij u 9% NaCl otopini. Nakon što je odstranjeno okolno tkivo, na svakom jajniku su prebrojani i izmjereni folikuli, čiji je dijametar (Φ) klasificiran kao mali ($\Phi < 3$ mm), srednji ($3 \leq \Phi \leq 8$ mm) i veliki ($8 \leq \Phi < 10$ mm). Nakon toga su korištenjem tehnike rezanja prikupljene oocite koje su uskladištene u Dulbeko fosfatni slani pufer i analizirane svjetlosnim mikroskopom s povećanjem 40X. Oocite su klasificirane u četiri grupe na osnovu stupnja razvoja kumulusnih stanica i transparentnosti ooplazme. Srednji broj folikula po jajniku je iznosio 25.38 ± 6.84. Dijametar malih, srednjih i velikih folikula je iznosio 5.87 ± 2.90, 15.64 ± 4.71 i 3.86 ± 1.69. Broj oocita po jajniku je iznosio 33.39 ± 11.71. Oociti su prema kvaliteti I, II, III, IV klasificirani kao 11.57 ± 3.33 (34.65%), 9.64 ± 3.05 (28.87%), 8.25 ± 3.26 (24.71%) i 3.93 ± 2.01 (11.77%). Indeks kvalitete oocita je iznosio 2.11. Kvalitetni oociti (grupa I i II) koji su prihvatljivi za *in vitro* proizvodnju embrija (IVEP) su činili 63.52% prikupljenih oocita. Ovi rezultati pokazuju da određeni faktori kao što su dob, tjelesna kondicija, stanje i stadij trudnoće, težina ovarija i korpus luteum moraju biti uzeti u obzir kako bi se povećao potencijal jajnika za *in vitro* proizvodnju embrija.

Ključne riječi: Kamerun, koze, kvalitet oocita, ovariji, populacija folikula