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# Prevalence and Associated Risk Factors of Genital Abnormalities of Does and Ewes in the West Region of Cameroon

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**Abstract:**
The present study was conducted at the Bafoussam III municipal slaughterhouse of the West Region of Cameroon in a bit to record the prevalence and associated risk factors of morpho-pathological conditions of the genitals organs of does and ewes. A total of 404 genital tracts were examined, including 360 and 44 for does and ewes, respectively. Prior to slaughter, the animals were characterized by their species, breed, age, live weight, and Body Condition Score (BCS). After slaughter and evisceration, the entire genital tract of each female was thoroughly inspected for gross pathological abnormalities. The left and right ovaries of each animal were removed, stored in physiological saline, and transported to the Bamougoum Veterinary and Zootechnical Center (BVZC) laboratory within two (02) hours of organ collection in order to determine the follicular population and ovarian pathologies. The mean age (months), weight (kg) and BCS were 43.54 ± 2.34, 19.32 ± 5.97 and 2.45 ± 0.63, respectively. The mean follicular population was 18.15±8.17 per ovary with 18.68 ± 8.17 and 13.93±6.91 for does and ewe respectively (P = 0.082). A gravid rate of 44.60% was recorded. The overall prevalence was 33.91% with species prevalence of 31.19% and 2.72% for does and ewes respectively (P = 0.238). Genital pathologies were most prevalent in the ovaries, followed by the uterus, the vagina, and vulva, the oviducts with prevalence of 22.5%, 13%, 8.3%, and 5.90%, respectively. The most common ovarian pathologies were cystic ovaries (7.2%), oophoritis (3.7%), ovarian adhesions (11.4%); those of the uterus included endometritis (3.2%), *Cysticercus tenuicollis* cysts (6.2%); salpingeal disorders included para-ovarian cysts (3.7%), hydrosalpinx (2.2%). Affections of the vagina and vulva were in majority represented by vulvitis followed by *Cysticercus tenuicollis* cysts with prevalence of 5.2% and 2.1% respectively. Age and live weight were the two main risk factors correlated with the prevalence of genital tract abnormalities. On one hand, age (months) of animals studied correlated significantly with ovaro-bursal adhesion (P<0.01, r=0.08), uterine abscess (P<0.05, r= -0.13), and vulvitis (P<0.05, r=0.12). Whereas live weight correlated significantly (P<0.01, r = -0.05) with uterine *Cysticercus tenuicollis* cysts. The prevalence of female genital tract abnormalities may suggest that genital diseases are a serious limitation to small ruminant reproduction.
**Keywords:** Small ruminants, genital, morpho-pathological, risk factors, Bafoussam, Cameroon.

## INTRODUCTION

Small ruminants occupy an important place in the livestock sector and the economy of many developing countries (Killanga and Traoré, 1999). Sub-Saharan Africa possesses about 53% of the small ruminants' worldwide population (Tchouamo *et al*., 2005). The small ruminants sector in Cameroon, with a national population estimated at 9 million, provides for about 20% of present meat consumption. In the West region, their breeding offers more advantages to smallholder rural farmers compared to cattle breeding at a zootechnical level (easier adaptation to various nutritional diets like scrubs and climatic conditions prevailing in the different agro-ecological zones, faster reproduction) and an economic level (low initial investments, consolidating savings, the spread of capital over a large number of animals) not leaving its sociocultural level ("piggy bank" breeding already integrated into agricultural activities, religious festivals, funeral ceremonies, customary wedding feasts among others) (Johann *et al*., 1988). The huge demand for livestock products driven almost entirely by population growth and increasing urbanization could present an opportunity for small livestock producers. Given that the recommended daily animal protein intake is 34 grams, the need to increase and diversify its supply is essential (Geoff Pollott *et al.,* 2009). This is achievable through the efficient use of promising indigenous animals such as goats and sheep (Rotimi *et al*., 2017).

Improving small ruminant production is therefore an important element to ensure food security. However, a vital condition for this improvement is the control of reproduction. The need to improve the genetic potential of indigenous livestock breeds is a major constraint to promoting sustainability in small ruminant production. This entails early attainment of sexual maturity and raising of two crops of kids or lambs per year with a twinning rate of 10% - 30% during a doe's reproductive life (Cupps *et al*., 1991). In this context, trends towards intensification of livestock production will no doubt be the source of an upsurge in reproductive abnormalities with serious consequences.

The information on the prevalence of female genital abnormalities may suggest the role of genital diseases in limiting reproductive performance. Genital abnormalities play an important role in animal breeding by either causing infertility or sterility thus causing serious economic losses to livestock owners (Hatipoglu *et al*., 2002). Reproductive tract diseases are poorly controlled in our traditional farming systems (Pollot and Wilson, 2009). Abattoirs, therefore, provide a useful source of information on the types and prevalence of genital tract lesions and abnormalities (Fathalla *et al*., 2000). Investigation of ovine and caprine reproductive abnormalities based on the abattoir survey of specimens provides information on the prevalence of reproductive disorders and their incidence (Winter and Dobson, 1992; Alosta *et al.,* 1998; Smith *et al*., 1998). It is against this backdrop that the present abattoir survey was designed with the general objective to investigate the prevalence and associated risk factors of diverse genital tract abnormalities. Specifically, we will have to characterize Does and Ewes before slaughter; inspect abattoir specimens, post mortem, for the presence of genital tract morpho-pathologies, and investigate the influence of animal characteristics on the prevalence of the reproductive tract abnormalities.

## MATERIALS AND METHODS

### Study area

The present study was carried out in the Bafoussam III municipal abattoir situated at the "Casablanca" market. Bafoussam is the chief town of the West region, the latter of which is one of the two regions of the Western Highlands of Cameroon. The West region borders the Northwest Region to the northwest, the

Adamawa Region to the northeast, the Centre Region to the southeast, the Littoral Region to the southwest, and the Southwest Region to the west. Bafoussam has a Global Positioning System (GPS) coordinates, latitude 5°28'39.90''N, and longitude 10°25 3.32''E. The climate that prevails in the west region is that of the equatorial -Guinea type. High elevations and moderate to high humidity give the West Region one of Cameroon's more pleasant climates. Temperatures vary from about 20°C to 24°C and the annual rainfall is 1,000-2,000 mm (Ngachie, 1992).

#### Ethical statement

The study was approved by the Ethical Committee of the School of Veterinary Medicine and Sciences of the University of Ngaoundere as well as the ministry of livestock, fisheries, and animal industries and care as described in the European Community guidelines; EEC Directive86/609/EEC, of the 24th November 1986.

#### Animals

A gross majority of animals slaughtered at the abattoir were purchased on-site at the "Casablanca" market from traders who obtain these animals from diverse peri-urban markets in localities like Foumbot, Foumban, Dschang, Bandjoun, Kumbo, and on rear occasions from the Northern regions. The study subjects comprised of does and ewes destined for slaughter at the Bafoussam III municipal abattoir. The breeds were determined based on phenotypic characteristics, such as coat color, body conformation (horn structure, length of legs, tail length, face profile, length/wideness/carriage of ears) as described by Wangbitching (1990) and Mason (1996). The age groups were considered based on the age of eruption of the permanent incisors and age of incisor wear. Animals having no permanent incisors were classified as "young" (less than 18 months), those with at least one pair of permanent incisors were classified as "adults" [18 to 48] months) and animals whose incisors experienced wearing (more than 48 months) were classified as "aged" (Salami, 1990). The Body condition scoring (BCS) was obtained as described by Ghosh et al. (2019).

#### Sample collection

Prior to obtaining specimens, the animals were weighed (using a hook spring balance), their ages (through dentition), BCS as well as breed were equally determined. The genitalia were separated and inspected immediately after evisceration at the slaughterhouse. It is at this point that the physiological status (gravid or non-gravid) was determined. The sample collection technique was comprised of ensuring that the broad ligaments, the loose connective tissues, and the fat surrounding the vulva and retroperitoneal part of the vagina and the rest of the genitalia were removed as far as possible to clear the reproductive organs for a better examination. The flexures of the uterine tubes were straightened out by freeing them from the mesosalpinx. The resulting eviscerated genital tract was then spread on an inspection table against a dark background. The ovaries were removed and placed individually in collection tubes containing an isotonic solution (NaCl, 0.9%) supplemented with penicillin (0.5 mg/ml) and bearing the identification labels for each female. These tubes were placed in a flask at a temperature of 30-32 °C and were transported to the laboratory not more than 2 hours after slaughter (Kouamo *et al*., 2014).

#### Gross examination of genital organs of Does and Ewes

The inspection was done by visual appraisal, palpation, and incision. Lesions were examined for their size, consistency, color, shape, smell, or location and the malformation of the different parts of the genital tracts was also observed and recorded. Each reproductive tract was dissected with a pair of Mayo scissors, starting from the vulva, into the vagina through the cervix, uterine body, and into each horn. The cervical mucosa and endometrium were carefully inspected for gross abnormalities. Each ovary was carefully observed for the presence of different types of gross lesions like tumors, cysts (follicular, luteal, and para ovarian cyst), inflammatory conditions, congestion, and other visible changes. Ovaries with follicles greater than 10 mm in diameter were considered pathological cysts; classified into follicular (thin wall and easily depressible) and luteinized cysts (thicker wall) (Winter and Dobson, 1992). The ovarian bursa is examined for adhesions. In the laboratory, the ovaries were individually debrided from excess tissue and then rinsed with warm physiological serum, and lightly massaged to remove all traces of blood. The follicles visible on the surface of each female's ovaries were counted.

**Statistical analysis**

The data collected were saved in Microsoft Excel 2013 and statistical analysis was carried out using SPSS software version 25.0. All data has been represented as mean ± SD (Standard Deviation of the mean) and percentages were used to report the prevalence and gravid rates. The one-way ANOVA was used to compare means whereas the chi² test was used to compare prevalence among animal groups (age group, breeds, and BCS) at the 5% significance level or 95% confidence interval (that is, P-value was considered significant at $P < 0.05$). The strength of the linear association between variables was computed using Pearson's correlation test. Prevalence of genital abnormalities expressed in percentage was determined using the relationship:

$$\text{Prevalence rate}(\%) = \frac{\text{number of animals affected}}{\text{total number of animals}} \times 100$$

CI = $\left[p - 1{,}96 \times \sqrt{P \times \frac{q}{n}}; P + 1.96 \times \sqrt{P \times \frac{q}{n}}\right]$ where *p* is the prevalence and *q=1-P*

Where CI is the confidence interval for the reported prevalence rates

## RESULTS

**Characterization of slaughtered animals**

Four hundred and four (404) small female ruminants were characterized prior to slaughter; most being of the caprine species (89.1%, n = 360) compared to the ovine species (10.9%, n = 44). The most common breeds were the West African dwarf goat (71.8% n = 290), kirdi goat (8.9% n = 36), for goat breeds, and the West African dwarf sheep (5.4% n = 22) for sheep breeds. The mean body condition score (BCS) of the animals was 2.45± 0.63 with a minimum of 1.0 and a maximum of 4.0. Animals with a BCS (1-2) were the modal class in both does (178) and ewes (34). The average body weight of the animal sampled was 19.32±5.97kg. The average age of 43.54±2.34 months was recorded during this study, with the modal group being (18 – 48 months) (80.4%; n = 325). This was similar for does (72.03%) and ewes (08.16%). Regarding the physiological status of animals studied, 180 were gravid (44.60 %) and 224 were non-gravid (55.4 %). The gravid rate of does (43.18%) was higher than that of ewes (44.72%) (Table 1).

**Table 1.** Frequency distribution of slaughtered does and ewes by breed, functional status, age groups, and body condition score.

| Species | Breeds | Frequency | Percentage (%) |
|---|---|---|---|
| **Does** | West African Dwarf goat | 290 | 71.8 |
| | Kirdi goat | 36 | 8.9 |
| | Sahel goat | 34 | 8.4 |
| **Ewes** | West African dwarf sheep | 22 | 5.4 |
| | Kirdi sheep | 10 | 2.5 |
| | Poulfouli sheep | 10 | 2.5 |
| | Oudah sheep | 2 | 0.5 |
| | **Total** | **404** | **100** |
| | **Physiological status** | | |
| **Does** | Non-gravid | 199 | 55.28 |
| | Gravid | 161 | 44.72 |
| | **Total** | **360** | **100** |
| **Ewes** | Non-gravid | 25 | 58.82 |
| | Gravid | 19 | 43.18 |
| | **Total** | **44** | **100** |
| | **Age group (months)** | | |
| **Does** | < 18 Young | 14 | 3.47 |
| | 18-48 Adult | 291 | 72.03 |
| | >48 Aged | 55 | 13.14 |
| | **Total** | **360** | **100** |
| **Ewes** | < 18 Young | 02 | 0.50 |
| | 18-48 Adult | 34 | 08.16 |
| | >48 Aged | 08 | 02.5 |
| | **Total** | **44** | **100** |
| | **Body condition score** | | |
| **Does** | Thin (1-2) | 178 | 49.44 |
| | Normal (3) | 172 | 47.78 |
| | Fat (4-5) | 10 | 02.78 |
| | **Total** | **360** | **100** |
| **Ewes** | Thin (1-2) | 34 | 77.27 |
| | Normal (3) | 10 | 22.73 |
| | Fat (4-5) | 0 | 0 |
| | **Total** | **44** | **100** |

### Follicular population

The mean follicular population was 18.15 ± 8.17 per ovary with 18.68 ± 8.17and 13.93± 6.91, in does and ewes respectively (P = 0.082).

Ewes were significantly heavier than does (P value=0.049). As concerns the BCS, there was a significant difference between thin, normal, and fat animals in terms of average body weight and follicular population. In terms of age, there was a significant difference (P-value =0.000) in mean body weights between the age group <18 months, and the age group 18-48 months. Regarding physiological status, mean body weights, and follicular populations of non-gravid animals were significantly different from those of gravid animals (Table 2).

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**Table 2.** Variation of body weight and follicular population by species, breed, BCS, age, and functional status.

| | | | Bodyweight of females | Follicular population/ovary | | |
|---|---|---|---|---|---|---|
| **Animal characteristics** | | N | Mean body weight of females Mean ± SD [Min-Max] | Mean ovarian follicular population Mean ± SD [Min-Max] | Left ovary Mean ± SD [Min-Max] | Right ovary Mean ± SD [Min-Max] |
| **Species** | Caprine | 360 | 19.04±5.95$^{a}$<br>[8.00-41.00] | 18.68 ±8.17$^{a}$<br>[4.00-52.50] | 18.60±8.97$^{a}$<br>[3.00 – 55] | 18.75±8.97$^{a}$<br>[2.00 – 58] |
| | Ovine | 44 | 21.55±5.70$^{b}$<br>[6.00-32.00] | 13.93± 6.91$^{a}$<br>[4.00 – 30.50] | 13.80±6.92$^{a}$<br>[3.00 – 28.00] | 14.07±7.85$^{a}$<br>[4.00 – 35.00] |
| | P-value | | 0.049 | 0.082 | 0.579 | 0.316 |
| **Caprine breeds** | WADG | 290 | 18.96±5.81$^{a}$<br>[8.00-41.00] | 18.61±8.26$^{a}$<br>[4.50 – 52.50] | 18.49±8.96$^{a}$<br>[4.00 – 55.00] | 18.73±9.10$^{a}$<br>[2.00 – 58.00] |
| | KG | 36 | 19.57±7.15$^{a}$<br>[8.00-40.00] | 19.61±8.20$^{a}$<br>[5.00 – 41.00] | 19.11±9.40$^{a}$<br>[3.00 – 39] | 20.11±9.14$^{a}$<br>[4.00 – 46] |
| | SG | 34 | 19.22±5.97$^{a}$<br>[11.00-36.00] | 18.25±7.85$^{a}$<br>[4.00 – 40.50] | 19.00±8.88$^{a}$<br>[3.00 – 41] | 17.5±7.72$^{a}$<br>[5.00 – 42.00] |
| | P-value | | 0.836 | 0.748 | 0.893 | 0.476 |
| **Ovine breeds** | WADS | 22 | 21.57±4.90$^{a}$<br>[15.00-32.00] | 15.57 ±7.81$^{a}$<br>[4.00 – 30.50] | 14.77±7.12$^{a}$<br>[3.00 – 27.00] | 16.36±9.25$^{a}$<br>[4.00 – 35] |
| | KS | 10 | 16.70±5.46$^{ab}$<br>[6.00-24.00] | 13.85±5.66$^{a}$<br>[5.50 – 23.50] | 14.5±6.72$^{a}$<br>[5.00 – 28.00] | 13.20±5.71$^{a}$<br>[6.00 – 25.00] |
| | PS | 10 | 25.30±4.52$^{b}$<br>[18.00-32.00] | 10.45±5.44$^{a}$<br>[4.50 – 19.50] | 11.40±6.96$^{a}$<br>[4.00 – 22.00] | 9.5±4.77$^{a}$<br>[4.00 – 17] |
| | OS | 02 | 27.00±1.41$^{b}$<br>[26.00-28.00] | 13.75±6.01$^{a}$<br>[9.50 – 18.00] | 11.50±7.78$^{a}$<br>[6.00 – 17.00] | 16.12±4.24$^{a}$<br>[13.00 – 19.00] |
| | P-value | | 0.002 | 0.293 | 0.596 | 0.136 |
| **Body condition Score** | Thin (1-2) | 212 | 16.83±4.87$^{a}$<br>[6.00-32.00] | 16.66±7.42$^{a}$<br>[4.00 – 44.00] | 16.58±8.00$^{a}$<br>[3.00 – 44.00] | 16.73±8.33$^{a}$<br>[2.00 – 49.00] |
| | Normal (3) | 182 | 21.48±5.15$^{b}$<br>[8.00-40.00] | 19.54±8.49$^{a}$<br>[5.00 – 52.00] | 19.51±9.46$^{ab}$<br>[4.00 – 55.00] | 19.56±9.06$^{a}$<br>[4.00 – 54.00] |
| | Fat (4-5) | 10 | 32.80±7.96$^{c}$<br>[18.00-41] | 24.90±10.48$^{b}$<br>[13.00 – 48.00] | 23.60±10.68$^{b}$<br>[13.00 – 41.00] | 26.20±12.98$^{b}$<br>[13.00 – 41.00] |
| | P-value | | 0.000 | 0.001 | 0.000 | 0.000 |
| **Age group in months** | < 18 young | 16 | 12.94±2.98$^{a}$<br>[9.00-19.00] | 18.86±6.24$^{a}$<br>[8.00 – 29.50] | 18.50±7.16$^{a}$<br>[9.00 – 35.00] | 19.25±6.92$^{a}$<br>[7.00 – 28.00] |
| | 18 – 48 adults | 325 | 19.22±5.93$^{b}$<br>[6.00-14.00] | 18.45±8.27$^{a}$<br>[4.00 – 52.50] | 18.36±9.00$^{a}$<br>[3.00 – 55.00] | 18.53±9.08$^{a}$<br>[2.00 – 58.00] |
| | >48 aged | 63 | 21.44±5.48$^{b}$<br>[12.00-40.00] | 16.49±8.02$^{a}$<br>[4.00 – 40.00] | 16.50±8.69$^{a}$<br>[3.00 – 39.00] | 16.5±8.73$^{a}$<br>[4.00 – 42] |
| | P-value | | 0.000 | 0.208 | 0.306 | 0.231 |
| **Physiological status** | Non-gravid | 224 | 17.90±6.07$^{a}$<br>[6.00-40.00] | 16.57±8.00$^{a}$<br>[4.00 – 52.00] | 16.64±8.77$^{a}$<br>[3.00 – 55.00] | 16.50±8.47$^{a}$<br>[2.00 – 54.00] |
| | Gravid | 180 | 21.08±5.34$^{b}$<br>[11.00-41.00] | 20.14±7.97$^{b}$<br>[4.00 – 48.00] | 19.86±8.75$^{b}$<br>[3.00 – 52.00] | 20.41±9.12$^{b}$<br>[4.00 – 58.00] |
| | P-value | | 0.000 | 0.039 | 0.017 | 0.001 |

West African dwarf goat (WADG), West African dwarf sheep (WADS), Kirdi goat (KG), Kirdi sheep (KS), Sahel goat (SG), Poulfouli sheep (PS), Oudah sheep (OS). Figures with the same superscript are not significantly different (P values <0.05).

## Prevalence of pathologies of the reproductive tract of does and ewes

### Overall prevalence

Of 404 slaughtered small ruminants examined at the Bafoussam 3 municipal abattoir, 33.91% were affected with at least one genital disorder giving an overall prevalence of 31.19% for does and 2.72% for ewes (Table 3).

**Table 3.** The overall prevalence of genital diseases of study animals according to species, breed, physiological status, age groups, and BCS.

| Animal characteristics | | N | N* | Pr. (%) | P-value |
|---|---|---|---|---|---|
| **Species** | Caprine | 360 | 126 | 31.19[a] | 0.24 |
| | Ovine | 44 | 11 | 2.72[a] | |
| **Doe breeds** | WADG | 290 | 101 | 25.00[a] | 0.84 |
| | KG | 36 | 11 | 2.72[a] | |
| | SG | 34 | 14 | 3.46[a] | |
| **Ewe breeds** | WADS | 22 | 06 | 1.49[a] | 0.56 |
| | KS | 10 | 07 | 1.73[a] | |
| | PS | 10 | 09 | 2.23[a] | |
| | OS | 02 | 01 | 0.25[a] | |
| **physiological status** | Non-gravid | 224 | 120 | 29.70[a] | 0.00 |
| | Gravid | 180 | 17 | 4.21[b] | |
| **Age (months)** | > 18 Young | 16 | 3 | 0.74[a] | 0.43 |
| | 18 – 48 Adults | 325 | 112 | 27.72[a] | |
| | >48 Aged | 63 | 22 | 05.45[a] | |
| **Body condition score** | Thin (1-2) | 212 | 82 | 20.30[a] | 0.09 |
| | Normal (3) | 182 | 53 | 13.12[a] | |
| | Fat (4-5) | 10 | 2 | 0.50[a] | |

[a, b, c]= prevalence rates in a column (based on animal characteristics) with different superscripts are significantly different at P <0.05, N=number of animals examined, N*=number affected, pr.=prevalence.

### Overall prevalence according to the portions of the genital tract

Table 4 illustrates the prevalence of gross abnormalities according to the various portions of the genitalia.

**Table 4.** Prevalence of pathologies in different parts of the genital tract.

| | Portion | Genital lesion | Frequency | Pr. (%) |
|---|---|---|---|---|
| **Glandular portion** | Ovaries | Oophoritis | 15 | 3.7 |
| | | Hematoma | 1 | 0.2 |
| | | Ovaro-bursal adhesion | 46 | 11.4 |
| | | Follicular cysts | 16 | 4 |
| | | Luteal cyst | 13 | 3.2 |
| | | Total | 91 | 22.5 |
| **Tubular portion** | Oviduct | Para-ovarian cysts | 15 | 3.7 |
| | | Hydro salpinx | 9 | 2.2 |
| | | Total | 24 | 5.9 |
| | Uterus | Segmental aplasia of uterine horn(s) | 2 | 0.5 |
| | | Mummified foetuse(s) | 3 | 0.7 |
| | | Endometritis | 13 | 3.2 |
| | | Metritis | 7 | 1.7 |
| | | Uterine abscess | 1 | 0.2 |
| | | Mucometra | 2 | 0.5 |
| | | Uterine *Cysticercus tenuicolis* cyst | 25 | 6.2 |
| | | Total | 53 | 13 |
| **Copulatory portion** | Vagina and vulva | Vulvitis | 21 | 5.2 |
| | | Vaginal *Cysticercus tenuicolis* cyst | 9 | 2.1 |
| | | Vaginal abscess | 4 | 1.0 |
| | | Total | 34 | 8.3 |

Table 5 portrays the variation of average follicular populations concerning genital disorders as well as the different portions of the genitalia.

**Table 5.** Variation of the follicular population according to the genital pathologies.

| The portion of the genital tract | Genital lesion | Mean follicular population | Variation coefficient (%) |
|---|---|---|---|
| **Glandular portion: Ovaries** | Oophoritis | 13.17± 5.07[a] | 38.50 |
| | Hematoma | 14.17±2.25[a] | 15.88 |
| | Ovaro-bursal adhesion | 13.14 ± 5.62[a] | 42.77 |
| | Follicular cysts | 13.00±8.15[a] | 62.69 |
| | Luteal cyst | 18.69±11.69[a] | 62.55 |
| | P value | 0.153 | |
| **Tubular portion: oviduct** | Para-ovarian cysts | 15.83±10.28[a] | 64.94 |
| | Hydro salpinx | 12.89±1.47[a] | 11.40 |
| | P value | 0.406 | |
| **Tubular portion: uterus** | Segmental aplasia of uterine horn(s) | 17.00±0.87[a] | 5.12 |
| | Mummified foetuse(s) | 16.33±4.54[a] | 27.80 |
| | Endometritis | 21.17±13.43[a] | 63.44 |
| | Metritis | 18.86±12.17[a] | 64.53 |
| | Uterine abscess | 15.17±1.04[a] | 6.86 |
| | Mucometra | 18.13±3.84[a] | 21.18 |
| | Uterine *Cysticercus tenuicolis* cyst | 15.22±5.22[a] | 34.30 |
| | P value | 0.615 | |
| **Copulatory portion: Vagina and vulva** | Vulvitis | 17.64±6.87[a] | 38.94 |
| | Vaginal *Cysticercus tenuicolis* cyst | 22.83±10.37[a] | 45.42 |
| | Vaginal abscess | 23.88±11.71[a] | 49.04 |
| | P value | 0.194 | |

a, b, c = means of the follicular population in a column (based on portions of the genital tract) with different superscripts are significantly different at $P < 0.05$.
There was no significant variation of the mean follicular population with the different genital pathologies.

## Prevalence of concomitant pathologies

A total of 32 animals were affected by concomitant abnormalities and the most frequent association of genital lesions was ovaro-bursal adhesion and oophoritis (Table 6).

**Table 6.** Prevalence of concomitant pathologies.

| Genital lesions | Number of lesions | Frequency |
|---|---|---|
| Ovaro-bursal adhesion + Segmental aplasia of uterine horn(s) + Uterine *Cysticercus tenuicolis* cyst + Vulvitis | 4 | 1 |
| Ovaro-bursal adhesion +Follicular cysts +Uterine *Cysticercus tenuicollis* cyst | 3 | 1 |
| Ovaro-bursal adhesion + Para-ovarian cysts +Uterine *Cysticercus tenuicollis* cyst | 3 | 2 |
| Ovaro-bursal adhesion + Uterine *Cysticercus tenuicollis* cyst +Vulvitis | 3 | 1 |
| Ovaro-bursal adhesion + Metritis + Vulvitis | 3 | 1 |
| Ovaro-bursal adhesion + Para-ovarian cysts + Vulvitis | 3 | 1 |
| Luteal cyst + Para-ovarian cysts+Vaginal *Cysticercus tenuicollis* cyst | 3 | 1 |
| Oophoritis + Para-ovarian cysts+Uterine *Cysticercus tenuicollis* cyst | 3 | 1 |
| Ovaro-bursal adhesion + Follicular cysts | 2 | 4 |
| Ovaro-bursal adhesion + Para-ovarian cysts | 2 | 2 |
| Ovaro-bursal adhesion + Oophoritis | 2 | 5 |

| | | |
|---|---|---|
| Ovaro-bursal adhesion + Uterine *Cysticercus tenuicollis* cyst | 2 | 2 |
| Ovaro-bursal adhesion + metritis, | 2 | 1 |
| Ovaro-bursal adhesion + Vulvitis | 2 | 1 |
| Ovaro-bursal adhesion + Luteal cyst | 2 | 1 |
| Luteal cyst + Uterine abscess | 2 | 1 |
| Luteal cyst + Para-ovarian cysts | 2 | 1 |
| Hydro salpinx + Metritis | 2 | 2 |
| Hydro salpinx+ Uterine *Cysticercus tenuicollis* cyst | 2 | 1 |
| Para-ovarian cysts + Vulvitis | 2 | 1 |
| Uterine *Cysticercus tenuicollis* cyst + Vulvitis | 2 | 1 |
| Segmental aplasia of uterine horn(s) + Endometritis | 2 | 1 |
| Para-ovarian cysts + Hydrosalpinx | 2 | 1 |
| Total | // | 32 |

**Influence of species, breed, age, body condition score (BCS), and functional status on genital pathologies.**

As far as ovarian disorders are concerned, the prevalence rate of luteal cysts in ewes was significantly (P =0.006) higher in Kirdi Sheep than Oudah Sheep. Similarly, the prevalence rates of ovaro-bursal adhesion, follicular cysts, luteal cyst, and oophoritis were higher in non-gravid than gravid animals. The prevalence rates for both salpingeal disorders recorded (Para-ovarian cysts, Hydrosalpinx) were significantly higher in non-gravid than in gravid animals. The prevalence rate of the mummified fetus was significantly higher (P = 0.018) in young and adult animals than in aged animals. On the other hand, the prevalence of uterine abscess was significantly higher in young than in adults and aged animals. With regards to the physiological status of female animals, the prevalence of endometritis, metritis, and uterine *Cysticercus tenuicollis* cysts was significantly higher (with P values: 0.001, 0.017, 0.001 respectively) in non-gravid than gravid animals (Supplementary File: Tables S1 to S3).

## Correlation between risk factors and genital pathologies

The degree of association between risk factors and the different gross genital disorders observed was assessed using the correlation analysis (Tables 7, 8, 9, and 10).

**Table 7.** Inter-correlations between risk factors (age, BCS, live weight) and prevalence of ovarian pathologies in Does and Ewes.

| | Age (months) | BCS | Live weight | Oba | Fc | Lc | Oo | He |
|---|---|---|---|---|---|---|---|---|
| Age (months) | 1.00 | | | | | | | |
| BCS | 0.02 | 1.00 | | | | | | |
| Live weight | 0.23b | 0.50 | 1.00 | | | | | |
| Oba | 0.08a | -0.09 | -0.02 | 1.00 | | | | |
| Fc | 0.00 | 0.09 | 0.05 | 0.21 | 1.00 | | | |
| Lc | -0.05 | -0.01 | 0.06 | 0.07 | 0.11a | 1.00 | | |
| Oo | 0.01 | -0.08 | -0.05 | 0.18 | -0.04 | -0.04 | 1.00 | |
| He | -0.01 | -0.05 | -0.08 | -0.02 | -0.01 | 0.00 | 0.00 | 1.00 |

[a, b] = superscripts represent correlations that are significant at the 0.01 and 0.05 levels respectively. Oba= Ovaro-bursal adhesion, Fc=follicular cysts, Lc=luteal cysts, Oo=oophoritis, He=hematoma

Age (months) correlated significantly (P<0.01) and positively (r= 0.08) with ovaro-bursal adhesion. Follicular cysts correlated significantly (P<0.01) and positively (r = 0.11) with luteal cysts.

**Table 8.** Inter-correlations between risk factors (age, BCS, live weight) and prevalence of salpingeal pathologies in Does and Ewes.

| | Age (months) | BCS | Live weight | Para-ovarian cysts | Hydrosalpinx |
|---|---|---|---|---|---|
| Age (months) | 1.00 | | | | |
| BCS | 0.02 | 1.00 | | | |
| Live weight | 0.23b | 0.50 | 1.00 | | |
| Para-ovarian cysts | -0.05 | -0.04 | -0.09 | 1.00 | |
| Hydrosalpinx | -0.04 | -0.02 | -0.04 | 0.06 | 1.00 |

[a, b] = superscripts represent correlations that are significant at the 0.01 and 0.05 levels respectively.

There was a significant (P<0.05) correlation between age (months) and live weight.

**Table 9.** Inter-correlations between risk factors (age, BCS, live weight) and prevalence of uterine pathologies in Does and Ewes.

| | **Age (months)** | **BCS** | **Live weight** | **Sa** | **End** | **Met** | **Mm** | **Ua** | **Muc** | **Uct** |
|---|---|---|---|---|---|---|---|---|---|---|
| Age (months) | 1.00 | | | | | | | | | |
| BCS | 0.02 | 1.00 | | | | | | | | |
| Live weight | 0.23[b] | 0.50 | 1.00 | | | | | | | |
| Sa | 0.06 | -0.06 | 0.02 | 1.00 | | | | | | |
| End | 0.05 | -0.04 | 0.00 | 0.19 | 1.00 | | | | | |
| Met | 0.01 | 0.02 | 0.06 | 0.00 | -0.02 | 1.00 | | | | |
| Mm | -0.02 | -0.03 | 0.03 | 0.00 | -0.02 | -0.01 | 1.00 | | | |
| Ua | -0.13[b] | -0.05 | -0.09 | 0.00 | 0.00 | 0.00 | 0.00 | 1.00 | | |
| Muc | -0.02 | 0.06 | 0.02 | 0.00 | 0.19[b] | 0.00 | 0.00 | 0.00 | 1.00 | |
| Uct | 0.07 | -0.20 | -0.13[a] | 0.13[a] | -0.05 | -0.03 | -0.02 | -0.01 | -0.02 | 1.00 |

[a, b] = superscripts represent correlations that are significant at the 0.01 and 0.05 levels respectively. SA= segmental aplasia, End=endometrits, Met=Metritis, Mm= Mummified foetus (es), Ua=Uterine abscess, Muc= Mucometra, Uct=Uterine *Cysticercus tenuicollis* cysts.

The age (months) correlated significantly (P<0.05) and negatively (r = -0.13) with uterine abscess. The live weight correlated significantly (P<0.01) and negatively (r = -0.05) with uterine *Cysticercus tenuicollis* cysts. There was a significant (P<0.05) correlation between endometritis and mucometra. Segmental aplasia correlated significantly (P<0.01) and positively (r = 0.13) uterine *C. tenuicollis* cysts.

**Table 10.** Inter-correlations between risk factors (age, BCS, live weight) and prevalence of vulvo-vaginal pathologies in Does and Ewes.

| | Age (months) | BCS | Live weight | Vulvitis | Vct | Va |
|---|---|---|---|---|---|---|
| Age (months) | 1.00 | | | | | |
| BCS | 0.02 | 1.00 | | | | |
| Live weight | 0.23[a] | 0.50 | 1.00 | | | |
| Vulvitis | 0.12[b] | -0.05 | 0.08 | 1.00 | | |
| Vct | 0.04 | 0.02 | 0.06 | -0.04 | 1.00 | |
| Va | -0.03 | -0.05 | 0.08 | -0.02 | -0.02 | 1.00 |

[a, b] = superscripts represent correlations that are significant at the 0.01 and 0.05 levels respectively. Vct= Vaginal *Cysticercus tenuicollis* cyst, Va= Vaginal abscess.

The age (months) correlated significantly (P<0.05) and positively (r = 0.12) with Vulvitis.

## DISCUSSION

The gravid rate of 44.60% corroborated with that reported by Kouamo *et al*. (2019) (45.30%) at the Maroua slaughterhouse but was higher than obtained by Ahmed *et al*. (2011) (29.80%) in Birnin Kebbi Modern Abattoir, Nigeria. This difference could be related to the study period, breed, and sample size. Small ruminants in the tropics do not experience seasonal anestrus, but goats and ewes in temperate regions experience a variation in ovarian activity depending on the season. To add, the lack of ante mortem inspection at the abattoir and lack of enforcement of legislation against the slaughtering of pregnant animals may also have contributed to the numbers recorded. The average weight of the animals examined was lower (19.32±5.97Kg) than what was reported by Ngona *et al*. (2012) (20.50±4.90 kg) in the Democratic Republic of Congo. The body condition score (2.45±0.63) which was slightly lower than that reported by Kouamo *et al*. (2019) (2.74±0.63) and in line with that registered by Ngona *et al*. (2012) (2.5±0.6) could be associated with the study period which was in the heart of the dry season (November - February) characterized by a drastic drop in the quantity and quality of pasture combined with inadequate nutritional supplement (in terms of energy and protein sources). The average age (3.63±0.20 years) was higher than that reported by Kouamo *et al*. (2019) (2.59±1.49years). This could be associated with the choice of older animals for slaughter which would have been dictated by fact that animals take longer to mature (attain market weight). Meat from older animals fits well in food preparation practices and eating habits because of its tough muscle fibers, desired in African traditional dishes (Clottey, 2011).

The overall prevalence of genital tract diseases (33.91%) was lower than that obtained by Moghaddam (2006) and Agrawal (2016) who reported prevalence of 25.8% and 24.8% respectively but higher than that registered by Karim *et al.* (2017), Ahmed (2019) and Kouamo *et al*. (2019) who reported 37.35%, 46.7%, and 36.30% respectively. The difference may be due to diverse influences like breed, sample size, environmental and nutritional factors. A high number of genital lesions in small ruminants are probably due to extrinsic factors such as poor housing, inadequate knowledge of the owner's, poor management, insufficient nutritional level, and increased contamination (Alwan and Amin, 2010).

Ovarian pathologies were the most frequently represented (22.5%). This prevalence was higher than that obtained by Agrawal (2016) (10.24%), in agreement with what Karim *et al*. (2017) reported (21.64%) but is lower than obtained by Ahmed (2011). The disparity may be linked to the difference in breeds, sample size, environmental and nutritional factors. Cystic ovaries were identified in 7.2% of genital tracts. A majority (4%) of these were follicular cysts; of which 37.5% were on the right ovary, 31.25% on the left ovary, and 31.25% on both ovaries. Luteal cysts were detected in 3.2% of specimens. The prevalence of ovarian cysts was in line with that reported by Agrawal (2016) (7.54%) and lower than that registered by Ahmed (2011) (9.23%). This might be attributed to insufficient luteinizing hormone before or at the time of ovulation, age of animals, and nutrient deficiency (Karsch, 2002). In addition, an important cause of cyst formation is the lack of a hypothalamic or pituitary response to the positive effect of estrogen secreted by the dominant follicle (Wiltbank *et al*., 2002). The development of cysts has been associated with many causes, including clinical, nutritional (phosphorus deficiency in goats), environmental, stress, hereditary and uterine infections (Peter *et al*., 1989; Smith *et al.,* 1998). Ovaro-bursal adhesion was observed in 11.4% of specimens; out of these, 67.74% were unilateral and 32.26 were bilateral. This result is higher than that recorded by Karim *et al*. (2017) and Agrawal (2016) who reported 8.235% and 2.69% respectively. Ovaro-bursal adhesion may have resulted from inflammatory processes (Regassa *et al*., 2009). Ogunbodede et al. (2014) reported that chronic pelvic inflammatory reactions sequential to previous abortions or post-partum complications seem to be the cause of ovaro-bursal adhesions. Adhesions cause infertility by interfering with ovulation and/or egg passage in the oviduct and cystic degeneration of the follicles (Kouamo *et al.,* 2019).

Para-ovarian cysts were observed in 3.7% of the does and ewes examined. These findings were lower than the results of Karim et al. (2017) who recorded 6.74% but higher than that of Sattar and khan (1988) who registered 1.36% in Pakistan. Para-ovarian cysts are derived from the mesonephros (Kennedy and Miller, 1993). Hydrosalpinx was recorded in 2.2% of cases which was inconsistent with the 0.27% reported by Agrawal (2016). Hydrosalpinx can lead to infertility and subfertility since intraluminal fluid interferes with embryo attachment (Chien *et al*., 2002).

Pathological conditions of the uterus (13%) were lower than reports of 53.24%, 41.34%, and 70% by Beena et al. (2015), Archana *et al.* (2013), and Kassim et al. (2007) in Iranian and India does, respectively, but comparable with that reported by Ogunbodede *et al*. (14.6%) (2014). Endometritis in this study (3.2%) was lower than obtained by Ahmed *et al*. (2011) and Ogunbodede *et al.* (2014) who recorded a prevalence of 3.8% and 3.9% respectively. Endometritis is usually associated with varying degrees of infertility depending on the extent of endometrial damage. The variation of the prevalence observed may be dependent on nutritional deficiencies and parasite infestations. Metritis with a prevalence of 1.7%, in this study, was higher than reports of 0.5% by Benchaib and Aldahash (2002) and 0.45% by Timurkaan and Karadas (2000). The endometrial epithelium is easily damaged by mild inflammation (Acland, 2001; Bollo *et al.,* 1990). The prevalence of uterine *Cysticercus tenuicollis* cysts of 6.2 % in this study was higher than reports of 0.1% by Mutebi (2009) and 5.70% registered by Kouamo *et al*. (2019). In this study, they were found on the uterine body, bilaterally and/or unilaterally attached to the ovarian pole. This agreed with previous reports by Smith *et al*. (1999). *Cysticercus tenuicollis* cysts and para-ovarian cysts can impair fertility if exerting pressure on the oviduct (Smith *et al*.,1999). Improper disposal of offal at abattoirs, backyard slaughter, the presence of freely roaming stray dogs especially around the abattoir premises, on the roadside, and the deeply rooted habit of feeding dogs with poorly cooked ruminant offal are important extrinsic factors that could contribute to the prevalence of genital diseases in small ruminants at the Bafoussam III abattoir. This may lead to the perpetuation of infection or infestation in the environment (Jibat *et al*., 2008). Mummified fetuses were recorded in 0.7% of specimens, higher than that registered by Amit

Sharma *et al*. (2014) (0.53%) and Smith *et al*. (1999) (0.03%). No specific cause of mummification could be established in the present study but it may be associated with genetic or chromosome abnormalities, progesterone deficiency, impartial regression of corpus luteum among other causes.

Vulvitis was recorded in 5.2% of cases. The abnormalities of the vulva in this study could be due to trauma from parturition, coitus (Lawal-Adebowale, 2012), an extension of utero-cervical hemorrhages (Beena *et al*., 2015), or infections (Martins *et al*., 2009).

## CONCLUSION

Gross lesions observed in the genitalia of slaughtered does and ewes in this study could be considered as the cause of varying degrees of infertility or sterility depending on the extent of damage and may constitute a major technical constraint working against successful improvement in small ruminant productivity. The results suggest *Cysticercus tenuicollis* is common and may constitute a health problem. The genital offals obtained after evisceration are sold to the public as meat for dogs. Thus, emphasizing the need for proper meat inspection, handling of offals (removal and proper disposal of *Cysticercus tenuicollis* cysts attached to the peritoneum or visceral), proper boiling of genital offals prior to serving dogs, and the restriction of entry of stray dogs into the slaughter premises. Control strategies for the prevention of occupationally-related infections in abattoir workers should integrate educating them on the need to respect good hygienic practices (regular hand-washing) and use of personal protective equipment (PPE). Reducing the gravid rate (44.60%) reported during the present study could be achieved by education stakeholders (livestock merchants, butchers, animal owners) together with the enforcement of prohibitory measures against the slaughter of pregnant and young animals irrespective of the species in conformity with provisions of the law regulating the breeding, movement and exploitation of livestock.

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## CONFLICT OF INTEREST

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

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