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Prevalence, Etiology and Risk Factors Associated With Chronic Metritis in Small Ruminants in Adamawa Region (Cameroon)

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Abstract

The objective of the study was to determine the prevalence, etiology and risk factors of chronic metritis in female small ruminants slaughtered at the Bantaï slaughterhouse. A total of three hundred and ninety (390) non-gravid females were characterized, their uterus were collected and examined. Clinical endometritis and pyometra were diagnosed. For subclinical endometritis, the presence of an inflammatory state of the endometrium in the absence of abnormal secretions in the vagina and the anatomopathological examination of histological sections from the cervix, body and horn of the uterus to confirm the diagnosis were used. Uteri with clinical endometritis or pyometra were subjected to microbiological sampling to detect the bacterial species involved. An overall prevalence of 16.15% was recorded, with prevalences of 11.02%, 3.07% and 2.05% corresponding to clinical, subclinical and pyometrial endometritis respectively. In positive females, the bacterial species *Salmonella spp, Shigella spp, Non-pathogenic E.coli, Pathogenic E. coli, Campylobacter spp, D Streptococci, Staphylococcus aureus, Staphylococcus epidermidis, MRSA (Methicillin-resistant Staphylococcus aureus), Pseudomonas aeruginosa, Aeromonas hydrophila, Salmonella cholerae arizonae, Proteus spp or Provendencia spp, Citrobacter koseri* and *Vibrio fluvialis* were isolated. Body condition score (BCS) was found to be the main risk factor in the occurrence of chronic metritis while factors such as species, age and weight were found to be at risk for subclinical endometritis and pyometra. The origin of the animals was significantly associated with the average number of co-infesting bacteria. In conclusion chronic metritis is present in the goat and sheep populations of Adamawa region.

Keywords: Chronic metritis, etiology, prevalence, risk factors, small ruminants

Introduction

Cameroon's livestock population is mostly made up of cattle, sheep, goats, pigs and poultry. Despite its importance, this livestock is still insufficient to meet the demand of the Cameroonian population for meat and dairy products. In order to meet the nutritional needs of the population and generate surpluses for export, the Cameroonian government's strategy for animal production till the year 2035 focuses in the short term on the development of short-cycle livestock species (non-conventional livestock, small ruminants, pigs, poultry, aquaculture and fisheries) (1).

In Cameroon, the rearing of small ruminants is one of the main activities of rural households (2). In rural areas, small ruminants are a credit card for meeting a number of daily needs and many families live on the income from their rearing. Their rearing has many advantages: they are easy to handle because of their small size, and they require little fodder. The quantity of meat produced by one animal can satisfy the needs of a family, the management of the breeding is easy and does not require any previous training, no religion forbids their consumption. In addition, they are resistant to trypanosomiasis and can be raised in all agroecological zones (3). In Cameroon, the livestock population is estimated at nearly 9 million heads in 2016, with the northern regions (Adamawa, North and Far North) accounting for more than three-quarters of national production (4) compared to 9 million in 2011 (5). This stability may be due to the fact that the genetic material is not well mastered as well as the managerial aspect such as feeding, health and reproduction. As reproduction is the keystone of all animal sectors, it seems important to consider fertility carefully, as a key parameter of the herd's productivity and a way to manage the whole system. The health status of the uterus plays a significant role in the poor results related to fertility and fertility of the herd (6). Any disease of the uterus has a double aspect: medical, because it is usually accompanied by clinical signs that allow the diagnosis leading to treatment, and zootechnical, because it is responsible for infertility (decrease in the percentage of pregnancy at first insemination) and infertility (increase in the interval between calving and fertilizing insemination, increase in the risk of anoestrus and culling), and therefore sometimes seriously hinders the economic profitability of the farm.

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During and after parturition, environmental and fecal germs from the perineal area ascend to the uterus as natural physical barriers such as the vulva, vestibule, mucus, and cervix are broken down (7). A few days after parturition, 90% of cows show bacterial contamination in utero, the lochia present being an excellent culture medium for microorganisms (8). Metritis is the most important and dramatic postpartum condition that disrupts the reproductive performance of cows and reduces the profitability of beef farms. Most of the data on metritis are related to the cow, in which this condition is frequent. It is in this context that we proposed to determine the prevalence, aetiology and risk factors of chronic metritis in small ruminants in the Adamawa region.

Material and Methods

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, Cameroon and strictly conformed with the internationally accepted standard ethical guidelines for laboratory animal use and care as described in the European Community guidelines; EEC Directive 86/609/EEC, of the 24th November 1986.

Study site

This study was conducted from August 2020 to January 2021. Samples were collected at the small ruminant slaughterhouse in Ngaoundere and analysed at Veterinary Research Laboratory, IRAD-Wakwa in the Adamawa Region of Cameroon.

The Adamawa Region is located between 6° and 8° North latitude and between 11° and 15° East longitude. It covers an area of 62,000 km² (9). Its climate is of the Sudano-Sahelian type and is characterized by a dry season (from November to March) and a rainy season (from April to October). The average rainfall is 1496.7mm per year. The average minimum temperature recorded is 15.2°C and the average maximum temperature is 29°C (Ngaoundere weather station).

Study animals

This study involved 390 goats and sheep, mainly from the Divisions of Vina (Adamawa region), Mayo Rey (Northern region), and Mbam-et-Kim (Center region). These sites correspond to the livestock markets where the animals were purchased, as the actual origins of these animals are difficult to determine.

Characterization of study animals

Sampling was based on the availability of animals and the consent of the owners present on the work days at the slaughterhouse (Monday through Saturday). Each female had to be at least one year old and not pregnant. Each animal underwent a general examination before and after slaughter to record key characteristics such as species, breed, age, body condition score (BCS), animal weight, and presence or absence of fetuses. The different breeds were determined on the basis of phenotypic characteristics (10, 11). Body condition score (BCS) was determined on a scale of 0 to 5 by visual assessment of certain body regions (or anatomical points) of the hindquarters and flank proposed by Hervieu et al. (12). Weight was determined using a Mini Mechanical Pocket Scale 50kg. The age of the females was determined based on the method developed by Salami (13), on the observation of the wearing out of the milk incisors, the eruption, the growth of the permanent incisors and finally the wear of the latter.

Evaluation of the prevalence of chronic metritis

After identification, slaughter, the uterus was removed, debrided and separated from its attachments:

Clinical endometritis was diagnosed on the basis of the presence of mucopurulent (approximately 50% pus and 50% mucus) or purulent (>50% pus) discharge into the vagina or uterus, in the absence of any other clinical sign (14).

Pyometra was diagnosed on the basis of an accumulation of pus in the uterine cavity, most often associated with a functional corpus luteum and consequent complete or partial closure of the cervix (14).

Subclinical endometritis was diagnosed on the basis of an inflammatory state of the endometrium in the absence of abnormal secretions in the vagina, and pathological examination of a uterine biopsy confirmed the diagnosis, including the presence of leukocytic infiltration and vascular congestions (15). This examination consisted of preserving the uterine tissue in formalin (fixing the structures) and then taking histological sections. The histological sections were read using a light microscope (brand: Leica) at a magnification of 10× for morphometric analyses. These analyses were carried out using the histo-morphometry software "ImageJ 1.48v". Microscopic observation at 40× magnification was used to assess the quality of the histological architecture of the uterine wall.

Determination of the etiology of chronic metritis

Uteri with features of clinical endometritis and pyrometry were incised with a scalpel blade at the uterine horns or body. The contents of the cavity were then revealed with forceps and collected with a sealed sterile swab as described by Williams et al. (16). The swabs were transported to the laboratory in an insulated cabinet containing dry ice. These swabs were analysed microbiologically.

The microbiological analysis consisted firstly of reactivating or reviving the bacteria by introducing each swab into peptone water, then using a platinum loop, each sample was inoculated onto the selective culture media which are : SALMONELLA-SHIGELLA AGAR, BILE ESCULIN AZIDE AGAR, BAIRD PARKER BASE AGAR, MAC CONKEY SORBITOL AGAR, MANNITOL SALT AGAR (allow the isolation and identification of each type of bacteria) and also on a non-selective medium which is MUELLER HINTON AGAR (allows the growth of all bacteria). Unidentified bacterial colonies were sampled and subcultured on SIMMON CITRATE AGAR and KLIGLER IRON AGAR for presumptive identification. Finally, the use of API 20 E kits (Biomérieux, Lyon, France) accompanied by APIWEBTM software (Biomérieux, Lyon, France) allowed the precise (biochemical) identification of bacterial species. Gram staining was used as a confirmatory test.

Data analysis

The collected data were recorded in Microsoft Excel 2013 and the statistical analysis was performed by SPSS version 23.0 software. Descriptive statistics were performed for the

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different variables (calculation of means for quantitative variables and calculation of frequencies for qualitative variables). The prevalence for both tests was obtained using the following formula:

$$\text{Prevalence} = \frac{\text{number of positive samples tested}}{\text{number of total samples}} \times 100$$

For the analysis of risk factors for the spread of chronic metritis, the Chi-square test at the significance level set at $p < 0.05$ was used to test the association between the occurrence of the disease and the different qualitative and quantitative variables.

Results

Characterization of slaughtered females

According to surveys of butchers, the majority of ewes and goats slaughtered at the Bantaï slaughterhouse (Ngaoundere) came from the Vina Division (53.33%). The Djallonke breed was the most represented for both species (67.94%). The mean values for BCS, weight and age of the slaughtered females were 2.42 ± 0.52; 25.54 ± 5.58 Kg; 2.74 ± 0.94 years respectively (Table 1).

Anatomopathological examinations

The results of confirmed positive cases of subclinical endometritis are shown in figure 1 below.

Prevalence of chronic metritis

Of the 390 ewes and goats in the study, 63 were diagnosed with chronic metritis, for an overall prevalence of 16.15%, as shown in Table 2.

Table 1. Characterization of slaughtered females according to species, origin, breed, BCS, age, origin and season (E:Ewe; G:Goat)

Characteristics		Frequencies	Percentages
Species	Sheep	134	34.35
	Goats	256	65.64
	Djallonke E	74	18.97
	Djallonke G	191	48.97
Breeds	Kirdi E	19	04.87
	Peul E	41	10.51
	Sahelian G	65	16.67
	[1-2[Youth	43	11.03
Age (years)	[2-3] Adults	257	65.90
	[≥ 4] Old	90	23.08
	Lean [2]	210	53.84
BCS	Medium [3]	155	39.74
	Fat [4]	25	6.41
	[10-20]	78	20.00
Weight (kg)	[20-30]	216	55.38
	[30-40]	96	24.62
	Mayo Rey	120	30.77
Origin	Mbam-et-Kim	62	15.90
	Vina	208	53.33
Season	Rainy	195	50
	Dry	195	50

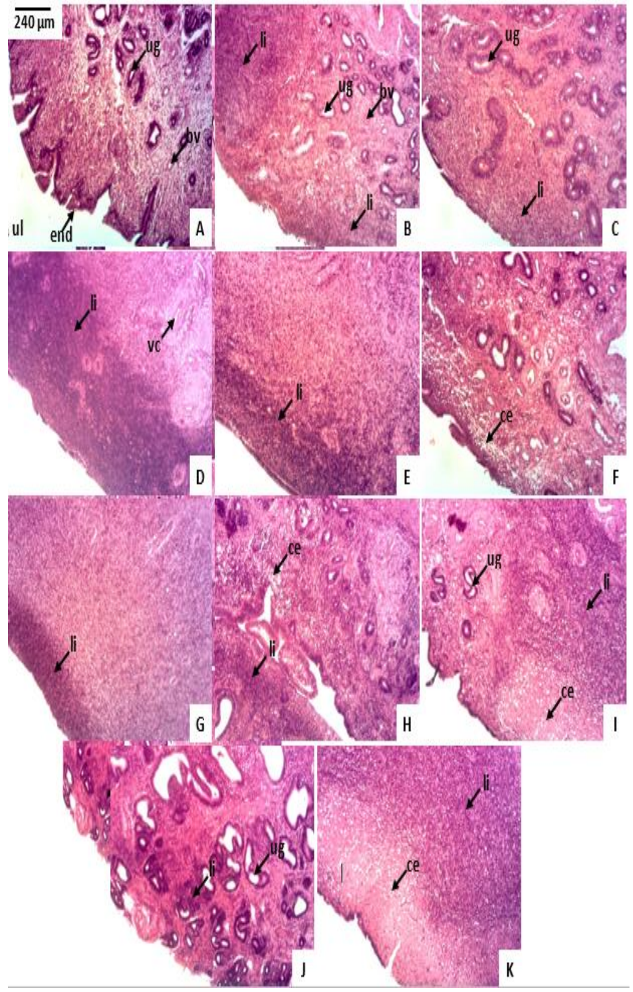

Figure 1. Microphotographs of the uterus (Hematoxylin-eosin X 40). **A** represents healthy endometrium. B, C, D, E, F, G, H, I, J and K correspond to subclinical cases of endometritis, marked by the presence of leukocyte infiltration, vascular congestion, and cytolysis. **ug** = Uterine gland ; **end** = Endometrium ; **li** = Leukocyte infiltration ; **ul** = Uterine lumen ; **bv** = Blood vessel ; **vc** = Vascular congestion ; **ce** = Cytolysis of endometrial cells. Comments: A = Normal uterus; B, C, D, E, F, G, H, I, J, K = Uterine alterations marked by the presence of leukocyte infiltration, vascular congestion, and cytolysis.

Table 2. Prevalence of chronic metritis. CE = Clinical Endometritis SCE = Subclinical Endometritis. Pyo = Pyometra

Characteristics		Frequency	Prevalence rate (N=390)
Health status	Infected	63	16.15
	Healthy	327	83.85
Conditions	CE	43	11.02
	SCE	12	3.07
	Pyo	08	2.05

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Etiology: Bacterial species

The use of differential culture media and API 20 E kits made it possible to isolate fifteen (15) bacterial varieties or types responsible for chronic metritis in sheep and goats.

Table 3. The proportion of bacterial species responsible for chronic metritis

Species (notifications)	Number of positives	Percentages (%)
***Salmonella spp* (a)**	51	100
***Shigella spp* (b)**	51	100
***Non-pathogenic E.coli* (c)**	51	100
***Pathogenic E.coli* (d)**	44	86.27
***D Streptococci* (e)**	41	80.39
***Staphylococcus aureus* (f)**	48	94.11
***Staphylococcus epidermidis* (g)**	31	60.78
***Methicillin-resistant Staphylococcus aureus (MRSA)* (h)**	26	50.98
***Aeromonas hydrophila* (i)**	26	50.98
***Proteus spp or Provendencia spp* (j)**	22	43.13
***Pseudomonas aeruginosa* (k)**	20	39.21
***Citrobacter koseri* (l)**	19	37.25
***Salmonella cholerae arizonae* (m)**	16	31.37
***Vibrio fluvialis* (n)**	15	29.41
***Campylobacter spp* (o)**	14	27.45

From table 3, it appears that the most represented bacterial species are *Salmonella spp, Shigella spp, Non-pathogenic E.coli* (100%), and the least represented species are *Campylobacter spp* (27.45%), *Vibrio fluvialis* (29.41%), and *Salmonella cholerae arizonae* (31.37%).

Prevalence of chronic metritis according to risk factors

Table 4 shows the variation in prevalence according to species, breed, BCS, age, weight, origin, and season. It shows that only BCS was significantly elevated in lean and average females (P<0.05). No significant difference was observed according to other characteristics (P>0.05).

Prevalence's of different types of chronic metritis according to risk factors

Table 5 shows the variation in prevalence for each type of condition as a function of species, breed, BCS, age, weight, origin and season.

Table 4. Relationship between animal health status and endogenous and exogenous characteristics

Characteristics		Health status: Infected (%)	Health status: Healthy (%)	P-value
Species	Sheep	25 (39.7)^a	109 (33.3)	0.35
	Goats	38 (60.3)^a	218 (66.6)	
Breeds	Djallonke E	15 (23.8)^a	59 (18.0)	0.8058
	Djallonke G	31 (49.2)^a	160 (48.9)	
	Kirdi E	3 (4.8)^a	16 (4.9)	
	Peul E	6 (9.5)^a	35 (10.7)	
	Sahelian G	8 (12.7)^a	57 (17.4)	
Age (years)	[1-2[Youth	8 (12.7)^a	35 (10.7)	0.6762
	[2-3] Adults	43 (68.3)^a	214 (65.4)	
	[≥ 4] Old	12 (19.0)^a	78 (23.9)	
BCS	Lean [2]	30 (47.6)^a	180(55.04)	0.047*
	Medium [3]	31 (49.2)^a	124 (37.9)	
	Fat [4]	2 (3.2)^b	23 (7.03)	
Weight (kg)	[10-20[	10 (15.9)^a	68 (20.8)	0.2392
	[20-30[	41 (65.1)^a	175 (53.5)	
	[30-40[	12 (19.0)^a	84 (25.7)	
Origin	Mayo Rey	17 (27.0)^a	103 (31.5)	0.7653
	Mbam-et-Kim	11 (17.5)^a	51 (15.6)	
	Vina	35 (55.6)^a	173 (52.9)	
Season	Rainy	36 (57.1)^a	159 (48.6)	0.2156
	Dry	27 (42.9)^a	168 (51.4)	

^{a,b} All values in the same column with the same superscript letter are not statistically different at $p < 0.05$.

From table 5, it can be seen that the prevalence of clinical endometritis varied significantly with age, weight and of course BCS (P<0.05). It was higher in adults compared to young and old animals, higher in animals with at least 20 kg than in those with less than 20 kg, and finally higher in females with a BCS below or equal to the average (3).

The prevalence of subclinical endometritis varied significantly with species, age, and obviously with BCS (P<0.05). It was higher in goats compared to ewes, higher in adults than in young or old, and finally higher in females with BCS below or equal to the average (3).

The prevalence of pyometra varied significantly with species, age, weight, and of course BCS (P<0.05). It was higher in goats compared to ewes where we had no cases, higher in young and mature animals than in old ones where we had no cases, higher in females under 30 kg compared to those with at least 30 kg, and finally higher in lean animals (BCS = 2) than in medium and fat ones where we had no cases. However, no significant difference was observed according to origin and season (P>0.05).

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Table 5. Relationship between disease types and endogenous and exogenous characteristics

Characteristics		Type of condition: CE (%)	SCE (%)	Pyo (%)	P value
Species	Sheep	21 (48.8)^a	04 (33.3)^a	00 (0.0)^a	0.025*
	Goats	22 (51.2)^a	08 (66.7)^b	08 (100.0)^b	
Breeds	Djallonke E	13 (30.2)^a	2 (16.7)^a	0 (0.0)^a	0.341
	Djallonke G	16 (37.2)^a	8 (66.7)^a	7 (87.5)^a	
	Kirdi E	3 (7.0)^a	0 (0.0)^a	0 (0.0)^a	
	Peul E	5 (11.6)^a	1 (8.3)^a	0 (0.0)^a	
	Sahelian G	6 (14.0)^a	1 (8.3)^a	1 (12.5)^a	
Age (years)	[1-2[Youth	3(7.0)^a	1(8.3)^a	4(50.0)^a	0.004*
	[2-3] Adults	28(65.1)^b	11(91.7)^b	4(50.0)^a	
	[≥ 4] Old	12(27.9)^a	0(0.0)^a	0(0.0)^b	
BCS	Lean [2]	16(37.2)^a	6(50.0)^a	8(100.0)^a	0.012*
	Medium [3]	25(58.1)^a	6(50.0)^a	0(0.0)^b	
	Fat [4]	2(4.7)^b	0(0.0)^b	0(0.0)^b	
Weight (kg)	[10-20[	3(7.0)^a	3(25.0)^a	4(50.0)^a	0.018*
	[20-30[	29(67.4)^b	8(66.7)^a	4(50.0)^a	
	[30-40[	11(25.6)^b	1(8.3)^a	0(0.0)^b	
Origin	Mayo Rey	12(27.9)^a	3(25.0)^a	2(25.0)^a	0.725
	Mbam-et-Kim	8(18.6)^a	3(25.0)^a	0(0.0)^a	
	Vina	23(53.5)^a	6(50.0)^a	6(75.0)^a	
Season	Rainy	26(60.5)^a	7(58.3)^a	3(37.5)^a	0.541
	Dry	17(39.5)^a	5(41.7)^a	5(62.5)^a	

^{a,b} All values in the same column with the same superscript letter are not statistically different at $p < 0.05$.

Proportions of co-infections

The following table shows the co-infections and the bacteria involved.

From table 6 it emerges that the minimum number of bacteria identified per animal presenting a purulent or mucopurulent affection was six (6) and the maximum thirteen (13). The modal class is nine (9) bacteria with a frequency of twelve (12) animals. The most recurrent co-infection appears on three animals and involves the following eight bacteria: *Salmonella spp, Shigella spp, Non-pathogenic E.coli, Pathogenic E.coli, D Streptococci, Staphylococcus aureus, Methicillin-resistant Staphylococcus aureus, Vibrio fluvialis* (a,b,c,d,e,f,h,n).

Relationship between mean co-infections and endogenous and exogenous characteristics

Only the origin of the animals was significantly associated with the mean number of co-infecting bacteria (P<0.05).

Table 6. Proportions of co-infections

Number of co-infesting bacteria	Frequencies (N=51)	Different associations
6	3	a,b,c,f,h,o ; a,b,c,d,e,f ; a,b,c,f,i,o
7	3	a,b,c,d,e,g,m ; a,b,c,d,f,m,o ; a,b,c,f,i,j,l
8	10	a,b,c,d,e,f,h,n^3 ; a,b,c,d,e,f,g,i^2 ; a,b,c,d,f,i,j,k ; a,b,c,d,e,f,g,k ; a,b,c,e,f,g,k,m ; a,b,c,d,e,g,i,l ; a,b,c,d,f,j,m,n
9	12	a,b,c,d,e,f,h,j,l^2 ; a,b,c,d,e,f,g,i,k^2 ; a,b,c,d,e,f,k,m,n^2 a,b,c,d,e,f,g,j,l^2 ; a,b,c,d,e,h,i,j,m ; a,b,c,e,f,i,j,m,o ; a,b,c,d,e,f,g,h,m ; a,b,c,e,f,g,h,j,m
10	9	a,b,c,d,e,f,g,h,k,l^2; a,b,c,d,f,h,i,k,l,n ; a,b,c,d,e,f,g,j,k,o ; a,b,c,d,e,f,g,h,k,n ; a,b,c,d,e,f,h,i,m,n ; a,b,c,e,f,g,i,j,l,o ; a,b,c,d,e,f,g,i,k,l ; a,b,c,d,f,g,i,j,k,o
11	11	a,b,c,d,e,f,g,h,i,j,m^2 ; a,b,c,d,e,f,g,h,j,k,l^2 ; a,b,c,d,e,f,g,h,i,j,l^2 ; a,b,c,d,e,f,g,i,k,n,o^2 ; a,b,c,d,f,g,h,i,j,l,o ; a,b,c,d,f,h,i,k,l,n,o; a,b,c,d,e,f,g,h,j,l,o
12	2	a,b,c,d,e,f,h,i,j,m,n,o a,b,c,d,e,f,g,h,i,m,n,o
13	1	a,b,c,d,e,f,g,h,i,k,l,m,n

The index number multiplies the association.

Discussion

The average age of slaughtered sheep and goats was 2.74 ± 0.94 years. This is in line with the ages recorded by Kouamo et al. (17); (2.59 ± 1.49 years), Dawood (18); (1- 6 years) and Benchaib (19); (6 months- 3 years). The poor financial situation of farmers plays a major role in the premature sale of animals, so the farmer sells his animal without taking into account its age or physiological condition (20). Small ruminant farming in rural areas generally constitutes easily mobilized savings (21).

The average BCS obtained was 2.42± 0.52. This average below the normal ([3]) can be explained by the extensive type of farming because it is more difficult for an animal left to its own devices to find good quality food that can make it grow; in addition to that, it spends a lot of its energy on non-productive movements. The difference between this average BCS and the one obtained by Kouamo et al. (17) (2.74± 0.63) could be explained by one of the exclusion factors that is gestation for this work because the pregnant state of an animal can lead to a wrong appreciation of its BCS.

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Table 7. Relationship between mean co-infections and endogenous and exogenous characteristics

Characteristics		Mean number of bacteria ± standard deviation	**P-value**
Type of condition	CE	9.3 ± 1.5[a]	0.90
	Pyo	9.2 ± 2.2[a]	
Species	Sheep	9.3 ± 1.6[a]	0.80
	Goats	9.2 ± 1.6[a]	
Breeds	Djallonke E	9.3 ± 1.7[a]	0.31
	Djallonke G	9.3 ± 1.3[a]	
	Kirdi E	8.0 ± 1.0[a]	
	Peul E	10.4 ± 0.8[a]	
	Sahelian G	8.8 ± 2.4[a]	
Age (years)	[1-2[	10.1 ± 0.8[a]	0.34
	[2-3]	9.2 ± 1.7[a]	
	[≥ 4]	9.0 ± 1.3[a]	
BCS	Lean [2]	9.3 ± 1.6[a]	0.96
	Medium [3]	9.3 ± 1.6[a]	
	Fat [4]	9.0 ± 2.8[a]	
Weight (kg)	[10-20[	9.4 ± 1.7[a]	0.92
	[20-30[	9.2 ± 1.6[a]	
	[30-40[	9.4 ± 1.5[a]	
Origin	Mayo Rey	10.2 ± 1.7[a]	0.02*
	Mbam-et-Kim	9.6 ± 1.5[b]	
	Vina	8.7 ± 1.3[b]	
Season	Rainy	9.1 ± 1.6[a]	0.30
	Dry	9.5 ± 1.5[a]	

[a,b] All values in the same column with the same superscript letter are not statistically different at $p < 0.05$.

The average weight of the animals (25.54 ±5.58 Kg) was higher than that reported by Kouamo et al. (17) (23.00 ±2.90 kg). This difference may be attributed to the inadequate grazing in the Far North region (Cameroon) compared to the Adamawa region (Cameroon).

For this study, the prevalence of chronic metritis was 16.15% distributed as follows: 11.02% for clinical endometritis, 3.07% for subclinical endometritis, and 2.05% for pyometra, respectively. This prevalence value (16.15%) is higher than 0.32% obtained by Kouamo et al. (17). Prevalences higher than 16.15% were also recorded; 24.02% and 24.8% were obtained by Beena et al. (22) and Dawood (18), respectively. These differences could be related to the breed, type of production (meat or milk), and number of animals studied, but also to their geographical origin, environment (season), health status, and/or nutritional level. Chun-Jie Liu et al. (23) showed that there was a significant difference in the prevalence of endometritis between animals raised in semi-intensive and intensive systems. The method of diagnosis, the timing of examination in relation to parturition, and the definition of endometritis used by the different studies could also be explanations. De Boer et al. (24) and Chethan (25) showed that the value of prevalence depends on the technique used to diagnose endometritis. Thus, the prevalence of endometritis would vary within a herd from 5 to 26% or depending on the animals sampled i.e. 10 to 27% according to Gautam et al. (26) and Pothmann et al. (27).

From a quantitative point of view, this study reveals that the main bacterial species responsible for chronic metritis in small ruminants are: 100% *Salmonella spp*, 100% *Shigella spp*, 100% *Non-pathogenic E.coli*, 94.11% *Staphylococcus aureus*, 86.27% *Pathogenic E. coli*, 80.39% *D Streptococci*, 60.78% *Staphylococcus epidermidis*, 50.98% *MRSA (Methicillin-resistant Staphylococcus aureus)*, 50.98% *Aeromonas hydrophila*, 43.13% *Proteus spp* or *Provendencia spp*, 39.21% *Pseudomonas aeruginosa*, 37.25% *Citrobacter koseri*, 31.37% *Salmonella cholerae arizonae*, 29.41% *Vibrio fluvialis*, 27.45% *Campylobacter spp.* These results are different from those obtained by: Victor et al. (28) (41.86% *Citrobacter braakii*, 20.93% *Actinomyces pyogenes*, 11.62% *Proteus mirabilis*, 9.30% *Enterobacter cloacae*, 4.65% *Escherichia coli*, 4.65% *Aeromonas hydrophila*, 2.32% *Bulkhoderia cepacia*, 2.32% *Provendencia stuartii*, and 2.32% *Salmonella spp*.) and Chun-Jie Liu et al. (23) (21.8% *Staphylococcus aureus*, 19.2% *Streptococcus sp* and 15% *Actinomyces pyogenes*) in bovine species. This could be because the isolation techniques of the bacteria were different.

Qualitatively, the results are consistent with the classification of bacteria into endometrial lesion-associated pathogens, other uterine pathogens, and bacteria not recognized as uterine pathogens (29). The bacterial species are also consistent with the uterine bacteriological classification of females performed by Pothmann et al. (27) & Puca and Hoyne (30).

This study found that females with a lean ([2]) or medium ([3]) BCS are at greater risk ($p = 0.047$) than fat females. Cows with very high or very low BCS may suffer prolonged pregnancy, dystocia, retained fetal membranes, persistent uterine infection, and endometritis (31). Kadivar et al. (32) showed that cows with clinical endometritis had significantly lower BCS than normal cows at all weeks before and after calving ($P < 0.05$). Moreover, the loss of 1 to 1.5 points of BCS between 30 days before calving to 30 days after calving was often associated with a high prevalence of clinical endometritis. This effect may have been associated with hepatic steatosis further to lipid mobilization (33). These observations were also confirmed for subclinical endometritis and it was found that cows with a low BCS (≤2.5) at 30 days postpartum had significantly higher prevalences of subclinical endometritis with an Odds ratio of 4.5 (34).

This study also showed that the prevalences of subclinical endometritis and pyometra were significantly ($p = 0.025$) higher in goats than in ewes so that the species stood out as a risk factor in the occurrence of subclinical endometritis and pyometra. Thus, the fact that Pineda (2003) (35) indicates the rarity of single pregnancies in most breeds of goats compared to ewes and that Dubuc et al. (36) reports the delivery of twins as a risk factor for the occurrence of endometritis could be an explanation for this.

Young and old females were found to be at lower risk ($p = 0.004$) than adult females for the occurrence of clinical and subclinical endometritis. This result could be because uterine involution in primiparous (young) females is faster than in multiparous females, and animals that have already had several births (old) have been in contact with bacteria more often and have a relatively higher state of immunity than others.

Animal weight was also found to be a risk factor ($p = 0.018$) for the occurrence of subclinical endometritis and pyometra.

Animals weighing less than 30 kg were more prone to both conditions than those weighing at least 30 kg. Susana et al. (37) believe that the weight and conformation of the ewe are important factors in determining when puberty is reached. Puberty is completed near the end of growth and is acquired when the youngster reaches 60-70% of its adult weight according to ADAS (38). However, Dumas (11) found that in extensive systems, animals are likely to breed too early, resulting in poor reproductive performance and an additional risk of parturition problems.

Animals from Mayo Rey had a significantly ($p = 0.02$) higher average (10.2 ± 1.7) bacterial co-infection than animals from Mbam et Kim (9.6 ± 1.5) and Vina (8.7 ± 1.3). Thus, the origin of the animals is a risk factor for the occurrence of chronic metritis. Mayo Rey is a subdivision in the northern region. Compared to Adamawa, this region is characterized by a very hot and dry climate with scarce pasture. Animals living there may have developed certain hardiness or resistance, so it will take a high dose of contaminants (bacteria) to trigger the disease process.

Conclusion

The study revealed that chronic metritis is present in the goat and sheep populations of the city of Ngaoundere with an overall prevalence of 16.15% of slaughtered females. The following bacterial species were isolated as being responsible for chronic metritis in proportions ranging from 100% to 27.45%: *Salmonella spp, Shigella spp, Non-pathogenic E. coli, Pathogenic E. coli, Campylobacter spp, D Streptococci, Staphylococcus aureus, Staphylococcus epidermidis*, *MRSA (Methicillin-resistant Staphylococcus aureus), Pseudomonas aeruginosa, Aeromonas hydrophila, Salmonella cholerae arizonae, Proteus spp* or *Provendencia spp, Citrobacter koseri* and *Vibrio fluvialis.* The BCS of the animals was found to be the main risk factor in the occurrence of chronic metritis; in particular, the animals most at risk were lean.

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Conflict of Interest

The authors declared that there is no conflict of interest.

Authors' contribution

All authors of this study have a complete contribution for data collection, data analyses, and manuscript writing.

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