Prevalence and risk factors of subclinical mastitis in goats in western Algeria

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Abstract

Subclinical mastitis (SCM) is a frequent disease in dairy goats that negatively impact milk quality and yield, leading to substantial economic losses. This cross-sectional study was conducted to estimate the prevalence of SCM and its associated risk factors among dairy goats in western Algeria. The study included 22 farms, and data on risk factors were collected using a questionnaire administered to the farmers. A total of 150 goats, with no clinical signs of mastitis, were randomly selected to determine the prevalence of SCM, using the California Mastitis Test. The Generalised Linear Mixed Model was used to identify the risk factors. The estimated prevalence of SCM was 20.7%. The results of the model indicated that the risk of SCM is significantly higher in does that had dirty udders, raised in unclean barns, were multiparous or in the late stage of lactation. Our findings emphasise the importance of appropriate herd management practices in reducing the prevalence of SCM in dairy goat herds.

Key words: *Subclinical mastitis; Goat; Prevalence; Risk factors; Algeria*

Introduction

In recent years, goat farming in Algeria has been undergoing profound changes, gradually moving from family-type extensive farming to an intensive system to meet the growing demand for meat and milk (Saidi et al., 2020). In 2020, the Algerian goat population was estimated at 5.2 million head, of which 2.8 million were does, contributing approximately 10% of the national milk production (FAO, 2020).

Mastitis, particularly subclinical mastitis (SCM), which is a discreet disease and without apparent clinical signs, is a major problem in dairy goat herds, and can have a negative impact on the health of goats and the economic performance of farms.

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In fact, SCM is the most frequent cause of voluntary culling of animals (Bergonier et al., 2003) and a decrease of around 30% in milk production (Leitner et al., 2004).

The prevalence of SCM in goats has been well documented in several countries, and shown to vary widely: 11.2% in Ethiopia (Megersa et al., 2010), 13% in Pakistan (Ali et al., 2010), 19.9% in India (Mishra et al., 2018), 22.03% in Brazil (Schmidt et al., 2009), 22.7% in Italy (Marogna et al., 2012), 27.3% in the USA (McDougall et al., 2001), 38.75% in Bangladesh (Ferdous et al., 2018) and 45.8% in China (Zhao et al., 2015).

SCM in goats is influenced by several intrinsic and extrinsic risk factors (Bergonier et al., 2003). Intrinsic factors correspond to goat traits (breed, parity and milk yield) (Megersa et al., 2010; Razi et al., 2012); whereas extrinsic factors are related to herd management practices such as milking practices, farming system, previous history of mastitis and the frequency of litter removal (Megersa et al., 2010; Schreiner and Ruegg, 2003).

In western Algeria, especially in the south-west, goat farming occupies an important place in the local economy, both in terms of the number of animals and milk production. However, data on the prevalence and epidemiology of caprine mastitis in this region are scarce. Since epidemiological studies are crucial for the implementation of appropriate preventive measures, we conducted this study to estimate the prevalence of SCM and to determine the associated risk factors in goat herds in western Algeria.

Material and methods

Study area

The present study was conducted in two provinces (Chlef and Beni Abbès) in western Algeria (Fig. 1). The province of Chlef is located in north-west (35°09 N, 01°20 E), covering an area of 4,791 km², an average annual rainfall of 458 mm and a total population of 61,980 goats, including 29,855 does (DSA, 2021).

The province of Beni Abbès is located in the Algerian Sahara (29°30 N, 02°45 W), covering an area of 101,350 km², is characterised by a desert climate with a low average of annual rainfall (32 mm) and contains a total population of 77,853 goats, including 39,109 does (DSA, 2021).

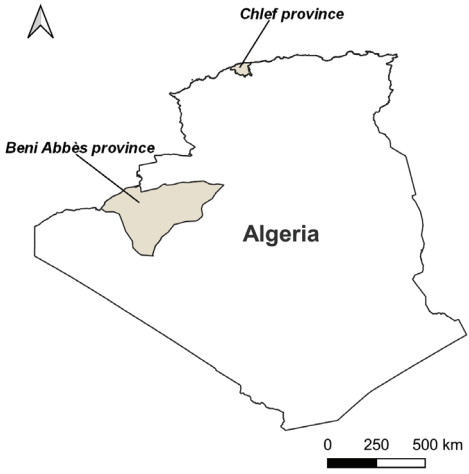

Figure 1. Map of the study area

Ethics approval

This study was performed in line with the principles of the Helsinki Declaration. Approval was granted by the ethics committee of the Faculty of Nature and Life Sciences, University Hassiba Benbouali of Chlef, Algeria (24/01/2023, Ref. No. SO-07-2023).

Type of study, sample size and data collection

This cross-sectional study was conducted between February and April 2022 in the Chlef and Beni-Abbès provinces. Sample size (n) was calculated using the following formula (Dohoo et al., 2009):

$$n = \frac{z_{\alpha}^{2} * P_t * (1 - P_t)}{e^2}$$

where P_t is the theoretical prevalence of SCM in dairy goats, is the (1-α/2) percentile of a standard normal distribution and e is the absolute precision. Therefore, the optimal sample size (n) was 81 goats, which was calculated using a theoretical prevalence of 5.6%, as estimated by Gabli et al., (2019) in goat farms in eastern Algeria, with 95% confidence level and 5% absolute precision. However, in order to consider the inter-herd variability of SCM prevalence, a total of 150 goats (Chlef: 62 goats; Beni Abbès: 88 goats) showing no clinical signs of mastitis were randomly selected. These goats were from 22 farms (12 in Chlef and 10 in Beni Abbès). The herd size of the selected farms ranged from 5 to 100 goats. Data on animal-level risk factors (age, parity, lactation stage, daily milk yield and udder hygiene state) and herd-level factors (herd size, herd management practices, barn hygiene state and previous history of mastitis in the herd) were collected from farmers using a pre-tested structured questionnaire.

Milk sampling and CMT Test

Milk samples were collected aseptically from goats during the first milking. The teats were disinfected with a 70% ethanol solution and wiped with an individual towel. The first few streams of milk were discarded. For each half-udder, 2 mL milk was collected in a CMT test cup and mixed with 2 mL CMT reagent (a surfactant agent, sodium alkyl aryl sulfonate) by circular rotation movement for 30 seconds. The viscosity of the mix was scored from 0 to 3 (Sargeant et al., 2001). Unlike in cows, a score of 2 in goats is considered a threshold for the detection of intramammary infections. This threshold is used to avoid false-positive results, because milk somatic cell counts for goats without intramammary infection are higher than that of cows (Paape et al., 2001). A does is considered "positive" when it shows at least one positive half-udder.

Statistical analysis

Statistical analysis was performed using R software (version 4.1.1, 2021). Descriptive analysis was conducted to analyse the data using absolute frequencies and percentages for categorical data. The association between risk factors, at both the animal and herd levels, and the prevalence of SCM was analysed using a Generalised Linear Mixed Model (GLMM), with the herd as a random effect. The best model selection was performed in multiple steps:

(i) Univariate analysis was conducted using a GLMM. The association between each risk factor and the prevalence of SCM was assessed by comparing each univariate model, with an empty model, using the likelihood ratio test. All variables with a p-value < 0.25 were retained for multivariate analysis.

(ii) The multi-collinearity analysis between variables selected from the univariate analysis were performed to ensure a mean variance inflation factor (VIF) of < 10 (Dohoo et al., 2009).

(iii) Selection of variables to include in the final model. Variables with a proven biological impact on mastitis, such as lactation stage and parity, were included in the model as forced covariates. However, the selection of other variables retained in the univariate analysis (P-value<0.25) was performed by forward stepwise selection using the Akaike information criterion (AIC), and the model with the smallest AIC value was selected.

Table 1. Descriptive and univariate analysis of the relationship between risk factors and subclinical mastitis prevalence in goats (n = 150) included in this study

Variables	Category	n (%[a])	Positive	Prevalence	P-value
Herd size	< 11	45 (30)	13	28.9	0.45
	11 - 40	63 (42)	13	20.6	
	> 40	42 (28)	5	11.9	
Farming system	Extensive	52 (34.7)	7	13.5	0.23
	Semi-intensive	98 (65.3)	24	24.5	
Systematically hand watching before milking	No	13 (8.7)	6	46.2	0.07
	Yes	137 (91.3)	25	18.2	
Udder disinfection before milking	No	90 (60)	21	23.3	0.32
	Yes without wiping	44 (29.3)	6	13.6	
	Yes with wiping	16 (10.7)	4	25	
Removal of the first jet of milk	No	88 (58.7)	15	17	0.42
	Yes on the ground	30 (20)	10	33.3	
	Yes in a recipient	32 (21.3)	6	18.7	
Housing type	Traditional	114 (76)	23	20.2	0.78
	Modern	36 (24)	8	22.2	
Barn hygiene state	Clean or less dirty	129 (86)	22	17.1	0.03
	Dirty	21 (14)	9	42.8	
Presence of litter	No	53 (35.3)	6	11.3	0.08
	Yes	97 (64.7)	25	25.8	
Previous history of mastitis in the herd	No	64 (42.7)	18	28.1	0.28
	Yes	86 (57.3)	13	15.1	
Mixed with other ruminants	No	44 (29.3)	17	38.6	0.004
	Yes	106 (70.7)	14	13.2	
Parity	Primiparous	65 (43.3)	8	12.3	0.03
	Multiparous	85 (56.7)	23	27.1	
Lactation stage	< 3 months	21 (14)	2	9.5	0.08
	3-4 months	83 (55.3)	17	20.5	
	> 4 months	46 (30.7)	12	26.1	
Daily milk yield	< 0.5 kg/d	102 (68)	21	20.6	0.53
	> 0.5 kg/d	48 (32)	10	20.8	
Udder hygiene state	Clean or less dirty	142 (94.7)	26	18.3	0.001
	Dirty	8 (5.3)	5	62.5	
Province	Beni Abbès	88 (58.7)	14	15.9	0.22
	Chlef	62 (41.3)	17	27.4	
Total		150 (100)	31	20.7	

[a] Percentage by column

The Hosmer–Lemeshow test was used to assess model calibration. The significance level was set at 5%. The results of the final model are presented as an odds ratio and its 95% confidence interval (95% CI).

Results

Descriptive analysis

The results of the descriptive analysis are presented in Table 1. We observed that 65.3% of goats were raised in a semi-intensive system and none of the herds had a milking parlour (result not shown in Table 1). In terms of milking practices, 91.3% of goat farmers reported that hand washing is systematically practiced before each milking, but udder disinfection before milking was practiced on just 40% of goats. The results of our survey showed that the removal of the first jet of milk is applied on 41.3% of goats, of which 43.6% eliminated the milk on the ground (Table 1).

The goats were raised in barns which were traditionally built (76%), of good or medium hygiene state (86%) and which had straw bedding (64.7%). More than half of goats (57.3%) were from herds that have experienced mastitis in the past. We have also found that 70.7% of goats were raised with other ruminants (cattle or sheep) (Table 1).

The descriptive analysis of animal-level variables showed that 56.7% of does were multiparous, 14% were in their first two months of lactation, 68% had a daily milk yield less than or equal to 0.5 L/day, and 94.7% of goats had a good or medium udder hygiene state (Table 1).

In this study, the prevalence of SCM in goats (positive CMT) was 20.7% (31/150; 95% CI: 14.2% − 27.2%). At the province level, this prevalence is 27.4% (95% CI: 16.3% − 38.5%) in Chlef province and 15.9% (95% CI: 8.3% - 23.5%) in Beni-Abbès province (Table 1).

Risk factors

The results of the univariate analysis showed that the variables barn hygiene state, mixed with other ruminants, parity and udder hygiene state are risk factors for SCM in dairy goats (P-value<0.05). In addition, this analysis allowed the identification of farming system, systematically hand washing before milking, presence of litter, lactation stage and province as confounding variables (P-value<0.25) (Table 1). The results of the final model are presented in Table 2. Four variables were identified as risk factors for SCM in dairy goats: udder hygiene state, barn hygiene state, parity and lactation stage.

In fact, does with dirty udders had a higher risk of SCM compared to those with clean or less dirty udders (OR = 1.98; 95% CI: 1.27 – 3.32). Similarly, does raised in dirty barns were highly likely to have SCM (OR = 6.65; 95% CI: 1.17 – 9.39).

Multiparous does had a significantly higher risk of SCM compared to primiparous goats (OR = 1.17; 95% CI: 1.06 – 4.12). Finally, does that were in a lactation stage "5 months or more" had a higher risk of SCM compared to those in their first two months of lactation (OR = 1.14; 95% CI: 1.02 – 6.72). The Hosmer-Lemeshow value for goodness-of-fit of the final model was considered acceptable (P-value = 0.36).

Discussion

This cross-sectional study estimated the prevalence and risk factors of SCM in goats in two provinces in western Algeria (Chlef and Beni-Abbes). This study is the first of its kind to document the prevalence of SCM in goats in this part of the country.

The prevalence of SCM, estimated by the CMT test, was 20.7% (95% CI: 14.2% − 27.2%); which is in line with those re-

Table 2. Multivariable Generalised Linear Mixed Model analysis of risk factors for subclinical mastitis in the studied goats (*n*=150)

Variables	Category	OR	Confidence Interval at 95%	*P*-value[a]
Udder hygiene state	Clean or less dirty	*Reference*		0.02
	Dirty	1.98	1.27; 3.32	
Barn hygiene state	Clean or less dirty	*Reference*		0.01
	Dirty	6.65	1.17; 9.39	
Parity	Primiparous	*Reference*		0.03
	Multiparous	1.17	1.06; 4.12	
Lactation stage	< 3 months	*Reference*		0.04
	3-4 months	1.08	0.86; 2.56	
	> 4 months	1.14	1.02; 6.72	

[a] *P*-value of variable effect

ported in other countries, 18.64% in Bangladesh (Razi et al., 2012), 22.03% in Brazil (Schmidt et al., 2009), and 27.3% in the USA (McDougall et al., 2001). However, our prevalence was higher compared to that estimated by Gabli et al., (2019) in goat farms in eastern Algeria (5.64%). This heterogeneity between the two studies could be attributed to differences in herd management practices and the subjectivity of the CMT test (Megersa et al., 2010).

The multivariate analysis showed that four factors, i.e., udder hygiene state, barn hygiene state, parity and lactation stage, had a significant impact on the prevalence of SCM in goats.

We observed that udders which were excessively dirty constituted a risk factor for SCM (OR = 1.98; 95% CI: 1.27-3.32). This result is consistent with the study of Schreiner and Ruegg (2003), which reported that animals with dirty udders are 1.5 times more likely to have major pathogens in their milk than those with cleaner udders.

Similarly, the results of the model showed that does raised in dirty barns are at a higher risk of SCM compared to those raised in well-maintained barns (OR = 6.65; 95% CI: 1.17-9.39). This result is in line with that of Mahlangu et al. (2018), who reported a significantly higher prevalence of SCM in farms cleaned once every two weeks compared to those cleaned more frequently (OR = 1.05, *P*-value=0.02).

It is well established that poor hygiene conditions of udders and/or barns represent the main sources of infection by pathogens responsible for environmental mastitis (Schreiner and Ruegg, 2003; Megersa et al., 2010; Mahlangu et al., 2018).

Concerning the individual animal-associated risk factors, our results indicated that multiparous does had a significantly higher risk of SCM compared to primiparous does (OR = 1.17; 95% CI: 1.06 - 4.12). This was consistent with other studies, indicating that the prevalence of SCM is lower during the first lactation and significantly increases with age and parity (Moroni et al., 2005; Ferdous et al., 2018; Menzies, 2021).

Likewise, our study showed that does in a late lactation stage had a high risk of SCM (OR = 1.14; 95% CI: 1.02 - 6.72). This finding was expected, since it is well

known that the prevalence of mastitis is positively correlated with lactation stage (Moroni et al., 2005; Megersa et al., 2010; Akter et al., 2020). In addition, our results were in agreement with Akter et al., (2020), showing that does in a lactation stage greater than two months had a higher risk of SCM (OR = 5.1; 95% CI: 1.8 - 14.6), and that the higher risk of SCM in late-lactation was more likely due to a low self-cure rate in goats, leading to an increase in the prevalence of chronic cases with increasing lactation length (Akter et al., 2020).

A major limitation of our study was the use of the CMT test, as it is well established that the use of this test may overestimate the true value of the prevalence of SCM in goats, due to high somatic cell counts in milk from uninfected does udders. As such, a higher CMT positivity threshold (score ≥ 2) is recommended in goats to reduce the number of false positives (Paape et al., 2001).

Our study identified four main risk factors for SCM in dairy goat herds in western Algeria: udder hygiene, barn hygiene, parity and lactation stage; confirming that SCM is a multifactorial disease that results from the interaction between animal-associated factors and herd management practices. Our results highlight the importance of raising the awareness of farmers about good farming practices, particularly good hygiene, in order to reduce the prevalence of SCM in goats.

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Statements & Declarations

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Prevalencija i faktori rizika subkliničkog mastitisa u koza u zapadnoj regiji Alžira

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Subklinički mastitis (SCM) česta je bolest mliječnih koza koja negativno utječe na kvalitetu i prinos mlijeka, rezultirajući značajnim ekonomskim gubicima. Ova presječna studija provedena je za procjenu prevalencije SCM i s njim povezanih faktora rizika u mliječnih koza u zapadnoj regiji Alžira. U studiju su uključene 22 farme, a podatci o faktorima rizika su prikupljeni pomoću upitnika kojeg su popunili

farmeri. Nasumično je izabrano ukupno 150 koza, bez kliničkih znakova mastitisa, da bi se utvrdila prevalencija SCM, uporabom Kalifornijskog mastitis testa (CMT). Generalizirani linearni mješoviti model rabljen je za identifikaciju faktora rizika. Procijenjena prevalencija SCM bila je 20,7 % (95% interval pouzdanosti „95% CI": 14,2% - 27,2%). Rezultati modela su ukazali da je rizik od SCM značajno veći u koza koje su imale prljavo vime (omjer izgleda (OR) = 1,98; 95% CI: 1,27 – 3,32), koje se uzgajaju u nečistim stajama (OR = 6,65; 95% CI: 1,17 – 9,39), koje su bile multipare (OR = 1,17; 95% CI: 1,06 – 4,12) i koje su bile u kasnoj fazi laktacije (OR = 1,14; 95% CI: 1,02 – 6,72). Naši nalazi naglašavaju važnost prikladnih praksi upravljanja stadom za smanjenje prevalencije SCM u stadima mliječnih koza.

Ključne riječi: *subklinički mastitis, koza, prevalencija, faktori rizika, Alžir*