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<https://www.youtube.com/watch?v=IZKzjSSatHw>

Characterization of mastitis and its associated agents in meat sheep flocks in the central region of the state of Mexico

Caracterización de la mastitis y sus agentes asociados en rebaños ovinos de carne en la región central del estado de México

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ABSTRACT

Small ruminants' mastitis affects the economy by decreasing milk production and lamb development. To determine the frequency of mastitis in meat sheep and its associated agents, 38 family-farmed sheep flocks in municipalities in central Mexico were studied. A total of 822 individual sheep milk samples were obtained to perform the California mastitis test and microbial isolation. Results were evaluated using the Chi-square test ($p < 0.05$). Isolations were achieved in 21.9 % of the samples evaluated, with 19.89 % in animals with subclinical mastitis and 2.79 % in animals with clinical mastitis. The most isolated agents were *Staphylococcus aureus* 34.18 %, coagulase-negative *Staphylococcus* (CNS) 21.94 %, and coliform bacteria 16.33 % ($p < 0.001$); followed by non-agalactiae *Streptococcus* 8.68 %, *Mannheimia haemolytica* 4.60 %; non-coliform bacteria 2.04 %, *Pasteurella multocida* 2.04 %, and *Streptococcus agalactiae* 0.51 % ($p < 0.05$). The least frequently isolated pathogens were *Bacillus* spp., *Corynebacterium* spp., *Truperella pyogenes*, and yeast. Subclinical and clinical mastitis was associated with *Staphylococcus aureus* and coagulase-negative *Staphylococcus* (CNS) infection ($p < 0.001$), showing a widespread distribution in meat sheep flocks in the central region of the State of Mexico.

Keywords: ovine mastitis, *Staphylococcus aureus*, meat sheep, family production.

RESUMEN

La mastitis de los pequeños rumiantes afecta la economía, al disminuir la producción de leche y el desarrollo de los corderos. Para determinar la frecuencia de mastitis ovina en ovejas de carne y sus agentes asociados se estudiaron 38 rebaños ovinos de producción familiar en municipios de la región central del México. Se obtuvieron 822 muestras individuales de leche ovina; para realizar la prueba de mastitis California y el aislamiento microbiano. Los resultados se evaluaron mediante la prueba de Ji-cuadrada ($p < 0.05$). Se lograron aislamientos en el 21.9 % de las muestras evaluadas distribuyéndose 19.89 % en animales que



presentaban mastitis subclínica y 2.79 % de animales con mastitis clínica. Los agentes mayormente aislados fueron: *Staphylococcus aureus* 34.18 %, *Staphylococcus coagulasa* negativos (SCN) 21.94 % y bacterias coliformes 16.33 % ($p < 0.001$); seguidos de *Streptococcus* no agalactiae 8.68 %, *Mannheimia haemolytica* 4.60 %; bacterias no coliformes 2.04%, *Pasteurella multocida* 2.04 %, *Streptococcus agalactiae* 0.51 % ($p < 0.05$). Los agentes menos frecuentes aislados fueron: *Bacillus* spp., *Corynebacterium* spp., *Truiperella pyogenes* y levaduras. La mastitis subclínica y clínica, se asoció a la infección por *Staphylococcus aureus* y *Staphylococcus coagulasa* negativos (SCN) ($p < 0.001$), lo que muestra una amplia distribución en los rebaños ovinos de carne en la región central del Estado de México.

Palabras clave: mastitis ovina, *Staphylococcus aureus*, ovejas de carne, producción familiar.

INTRODUCCIÓN

In Mexico, sheep production stands out in the highlands region where the State of Mexico is located, which is considered an important socio-economic integrating activity of the livestock sector (SIAP, SAGARPA, 2016). The State of Mexico is the leading national producer of meat sheep; in this entity, family-based sheep farming is widely distributed, with marked differences in the level of technification and productivity (Orona *et al.*, 2015; Garza-Camargo *et al.*, 2025). Ovine mastitis affects milk production and quality, resulting in poor lamb development and a lower number of weaned lambs (Contreras *et al.*, 2007; Gelasakis *et al.*, 2015; Bramis *et al.*, 2016). Inflammation of the mammary gland is usually caused by a bacterial infection that leads to pathological changes in mammary tissue and physicochemical alterations in milk (Leitner *et al.*, 2004; Pisanu *et al.*, 2015). The clinical importance of mastitis in the population has been evidenced in sheep slaughterhouses, where 10 % of slaughtered animals presented mammary gland lesions (Cooper *et al.*, 2016). In addition to causing direct economic losses due to decreased milk production, increased treatment costs per animal, deaths, and premature replacement of ewes (Page *et al.*, 2021). The occurrence of mastitis increases during lactation; likewise, overcrowding in the pens of lactating ewes favors disease spread within the flock (Suarez *et al.*, 2002). In a study by Gonzalo *et al.* (2002), it was established that ewes' susceptibility to mastitis increases at the onset of the lambing period and during lactation. Coagulase-positive and negative staphylococci tend to be predominant pathogens in the sheep population; Gram-negative bacteria, mainly enterobacteria, are also capable of causing mastitis in sheep, although less frequently than observed in cattle (Pisanu *et al.*, 2015). On the other hand, it has been established that lentivirus infection in the sheep population increases mammary gland susceptibility to mastitis (Junkuszew *et al.*, 2016). Likewise, cases of contagious ecthyma in sheep increase the occurrence of *S. aureus* mastitis (Government of Western Australia, 2018). Studies by Menzies & Ramanoon (2001), suggest that oropharyngeal colonization by *Mannheimia haemolytica* in lambs increases the infection level in the mammary gland and consequently the occurrence of mastitis caused by this agent.



Mastitis can present as clinical or subclinical; the former is characterized by inflammatory signs in the udder or visible changes in milk; the latter shows no apparent clinical signs; however, important functional changes in the mammary gland occur that can alter normal milk parameters and cause an increase in somatic cells in milk. Diagnosis requires studies to determine the increase in the number of somatic cells in milk directly or indirectly (Peixoto *et al.*, 2010).

Diagnosis of clinical or subclinical mastitis in sheep populations is necessary to develop and implement prevention and control strategies during lactation and at drying off (Arsenault *et al.*, 2008; Le Maréchal *et al.*, 2013). The California Mastitis Test (CMT) shows high sensitivity and specificity in detecting subclinical mastitis cases in field diagnosis, through strategic monitoring of ewes during lactation and drying off (González-Rodríguez *et al.*, 1995). The California Mastitis Test can be used in prevention and control programs for ovine mastitis in flocks (Legarra & Ugarte, 2005; Rupp *et al.*, 2019; Alba *et al.*, 2019). The objective of this study was to determine the frequency of pathogens related to subclinical and clinical mastitis in lactating meat ewes in family-based flocks in the central region of Mexico.

MATERIAL AND METHODS

A cross-sectional longitudinal study was conducted in meat sheep flocks in the central region of Mexico, in the Mexican highlands, during the period 2018-2019 from November to April, coinciding with the lambing season. A convenience sampling was carried out in family-based sheep production units (FBSPU), following prior acceptance by the participating producers. A total of 38 flocks were studied across four geographical regions of the State of Mexico, classified as: north, center, east, and west (Figure 1). The family-based meat sheep production units in the northern region were located in the municipalities of Jilotepec, Temascalcingo, Acambay, and Atlacomulco; in the central region, in Toluca, Tenango del Valle, and Xalatlaco; in the eastern region, in Jocotitlán, San Bartolo Morelos, Ixtlahuaca, Chapa de Mota, Villa del Carbón, and Jiquipilco; and finally, in the western region, in the municipalities of El Oro, San Felipe del Progreso, and San José del Rincón (Figure 1). The inclusion criteria for the study were: FBSPU on small agricultural landholdings with rustic facilities; a flock size of between 15 and 50 sheep, with traditional productive management involving partial daytime grazing and nighttime confinement.

Milk samples were obtained from ewes by manual milking of each mammary gland, following cleaning and disinfection of the teats with 70 % (v/v) ethyl alcohol; the first streams of milk were discarded, and samples were collected in sterile tubes at an approximate volume of 10 mL. The samples were kept at 4 °C until microbiological



analysis, within the first 4 hours. Milk samples were incubated at 25 °C in a water bath and homogenized to inoculate 0.01 mL of milk onto blood agar, MacConkey agar, and mannitol salt agar plates. The plates were incubated at 37 °C for 18 to 24 hours. Agar plates were considered positive when 3 to 5 colony-forming units (CFU) were observed. CFU were described and identified using microbiological procedures (National Mastitis Council, 2005).

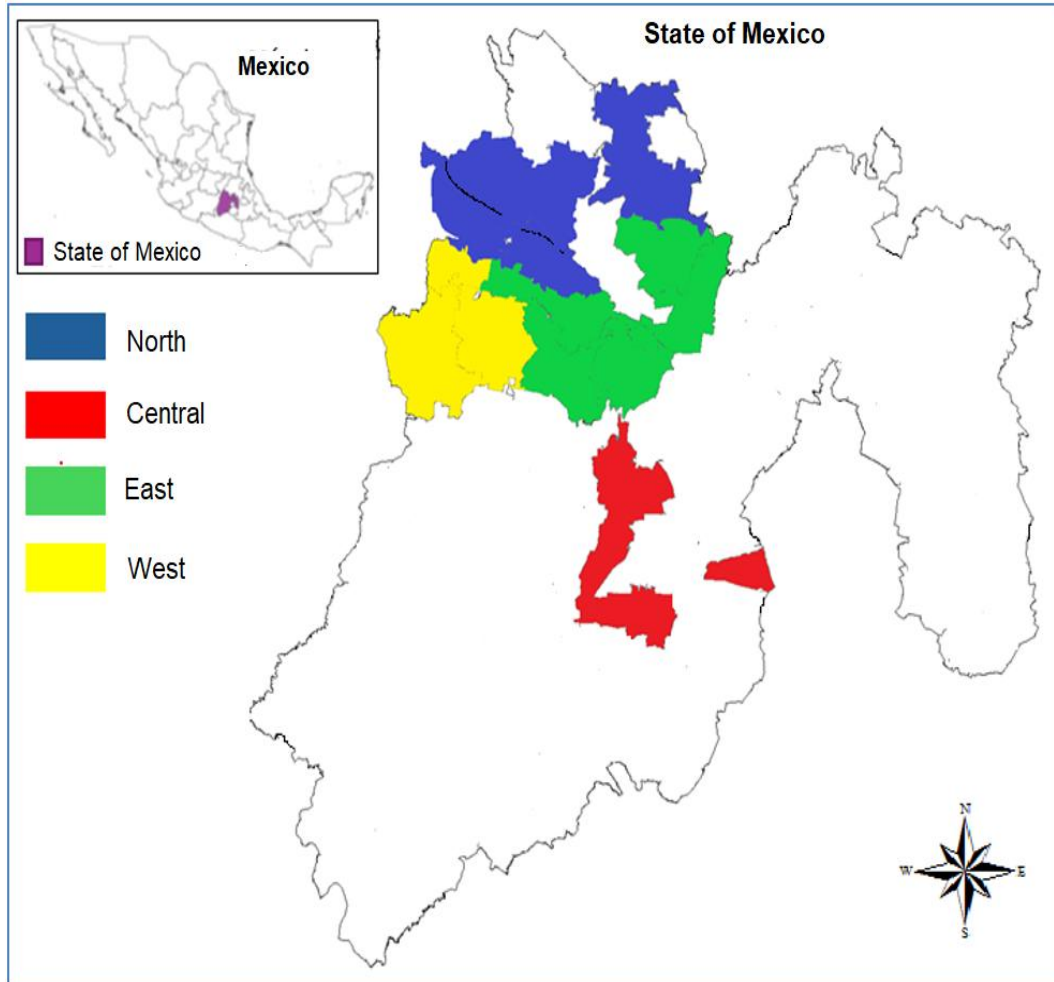


Figure 1. Distribution of sampled municipalities in the State of Mexico

Gram staining was performed, as well as catalase and tube coagulase tests; Voges-Proskauer reaction, anaerobic fermentation of mannitol, and aerobic fermentation of trehalose and arabinose. When applicable, CAMP reactions, esculin hydrolysis, blood broth, and carbohydrate utilization tests were also carried out. Oxidase test, urea hydrolysis in tube, triple sugar iron agar, motility, sulfide, and indole tests were performed.



Final confirmation of *S. aureus* and *M. haemolytica* isolates was carried out using the Api-Staph and Api-20 E systems (bioMérieux, France) and the API WEB system.

The California Mastitis Test (CMT) was performed in the laboratory using the individual milk samples employed for the microbiological study. In the test paddle, 2 mL of milk and a similar volume of California reagent were added. Test reactions were interpreted based on gel formation in the milk suspension, considered negative (N) when no gel formation was observed, and graded as traces (T), one (1), two (2), and three (3) when gel formation of varying structure and consistency was observed (Blowey & Edmondson, 1999).

Results were analyzed from tables and graphs using descriptive statistics based on observed frequencies of bacterial isolates. Distribution and association of observed frequencies were evaluated using the chi-square test ($p < 0.05$), with the Epi Info 6 software, free version, CDS Atlanta, GA, USA, 2010.

RESULTS

In the central region of Mexico, 38 meat sheep flocks were studied, with a flock size of 22.6 ± 7.2 , under the family-based sheep production system, located in 16 municipalities of the State of Mexico. From 822 ewes examined across the geographical regions designated as north, center, east, and west, an average isolation frequency of 21.9 % was obtained (Table 1).

Table 1. Percentage of microbial isolates from milk of meat sheep flocks

Geographic Region	No. of ewes	Microbial isolation	
		No.	%
North	222	26	11.7
East	167	37	22.2
Central	230	67	29.1
West	203	50	24.6
Total	822	180	21.9

The average frequency of subclinical mastitis in the four studied regions was 19.89 %, while the average frequency of clinical mastitis was 2.79 % (Table 2).



Table 2. Clinical udder inspection findings in meat sheep flocks

Geographic Region	No. of Municipalities	Number of Flocks	Number of Ewes Examined	Mammary Glands Examined	California Mastitis Test			
					Negatives	% Mammary Glands		
					SCM ^{1**}	CM ²	NF ³	
North	4	12	222	444	75.00	19.14	4.27	1.57
East	6	8	167	334	86.22	10.17	2.68	0.89
Central	3	7	230	460	74.13	21.73	3.20	0.86
West	3	11	203	406	72.10	26.60	0.73	0.49
Total	16	38	822	1644	76.33±6.36	19.89±6.89	2.79±1.48	0.97±0.45

SCM¹ Subclinical mastitis, reactions 1, 2, and 3 of the California Mastitis Test; CM² Clinical mastitis; NF³ Non-functional mammary glands

The overall frequency of microbial isolates (Table 3) was 21.9 % (196/822), with *S. aureus* standing out as the main agent, followed by CNS (coagulase-negative staphylococci), coliform bacteria, and *M. haemolytica*. The proportion of isolates from mammary glands of ewes across the different geographical regions was as follows: the highest isolation proportion, ranging from 25.0 to 42.18 %, was observed in Atlacomulco, San José del Rincón, El Oro, Villa del Carbón, and Xalatlaco municipalities ($p < 0.001$). A medium isolation proportion, between 21.23 and 23.46 %, was observed in the municipalities of Chapa de Mota, Jocotitlán, and San Felipe del Progreso. The lowest proportion of microbial isolates, ranging from 10.29 to 13.20 %, was observed in ewes from the municipalities of Toluca, San Bartolo Morelos, Ixtlahuaca, and Acambay.

The distribution of California Mastitis Test reactions in the milk of ewes from the studied flocks and the isolates obtained from them (Table 4) showed that in trace and grade 1 reactions, coagulase-negative staphylococci (CNS), coliform and non-coliform bacteria, and *Bacillus spp.* were identified ($p < 0.05$). In contrast, grades 2 and 3 yielded a higher number of agents: *S. aureus* and CNS (*S. epidermidis* and *S. haemolyticum*), *Streptococcus agalactiae*, non-*agalactiae* streptococci, *Bacillus sp.*, *Pasteurella sp.*, *M. haemolytica*, and *Pseudomonas spp.* In cases of clinical mastitis, *S. aureus*, CNS, *T. pyogenes*, and *M. haemolytica* were identified.

DISCUSSION

The pathogens associated with the occurrence of subclinical and clinical mastitis in family-managed meat sheep flocks were identified. A notably high isolation frequency of *S. aureus* and coagulase-negative staphylococci (CNS) was observed, which were related to high-grade California Mastitis Test reactions. Subclinical mastitis showed a wide distribution across the studied flocks. In the family-based sheep production system, a frequency of 19.89 % for subclinical mastitis and 2.79 % for clinical mastitis was



determined. The results obtained in the central region of Mexico agree with those reported by [Drescher et al., \(2010\)](#), who described an annual incidence of subclinical mastitis in sheep ranging from 5 to 30 %, and clinical mastitis of less than 5 %.

Table 3. Microbial agents identified in meat ewes with mastitis

AGENTS	Number of isolates	(%)
<i>Staphylococcus aureus</i>	67	34.18
Coagulase-negative staphylococci (CNS)* <i>S.epidermidis</i> [17], <i>S. simulans</i> [3], <i>S.intemedius</i> [5], <i>S. haemolyticus</i> [2], <i>Micrococcus spp</i> [4], <i>S.xylosus</i> [2], other CNS [10].	43	21.94
Coliform bacteria <i>Escherichia coli</i> [12], <i>Pseudomonas spp</i> [6], <i>Enterobacter spp</i> [3], <i>Proteus spp</i> [3], <i>Citrobacter spp</i> [2], <i>Kleibsiella spp</i> [4], <i>Flavobacterium</i> <i>spp</i> [1], <i>Acinetobacter spp</i> [1],	32	16.33
Non-coliform bacteria <i>Salmonella spp.</i>	4	2.04
<i>Streptococcus agalactiae</i>	1	0.50
<i>Streptococcus no agalactiae</i>* <i>Str.dysgalactiae</i> [4], <i>Str.uberis</i> [2], <i>Str.faecalis</i> [3], <i>Aerococcus viridans</i> [2], <i>Str.suis.</i> [1], <i>Str.spp.</i> [5],	17	8.68
<i>Pasteurella multocida</i>	4	2.04
<i>Mannheimia haemolytica</i>	9	4.60
<i>Corynebacterium spp</i>	4	2.04
<i>Truperella pyogenes</i>	3	1.53
<i>Bacillus spp</i>* <i>Bacillus subtilis</i> [5], <i>Bacillus cereus</i> [3]	8	4.08
Yeast	4	2.04
TOTAL	196	100.00

[n] Number of isolates; coagulase-negative staphylococci. (p<0.001)

These data are consistent with the results obtained by [Contreras et al., \(2007\)](#), who reported a prevalence of subclinical mastitis of 5 to 30 % in their study on small ruminants, and a lower proportion of less than 5 % for clinical mastitis. For their part, [Peckler et al., \(2024\)](#), determined that as lactation in ewes progressed and weaning approached, the prevalence of subclinical mastitis increased from 26.0 to 47.1 %.

In dairy sheep flocks, the proportion of clinical mastitis has been determined to be less than 5 %; however, epidemic outbreaks of clinical mastitis can occur, affecting up to 30 % and 50 % of animals in production, thereby increasing the culling rate of productive ewes ([Bergonier & Berthelot, 2003](#)). In chronic mastitis, infection by agents of the families *Micrococcaceae* and *Streptococcaceae*, with isolation of antimicrobial-resistant strains, tends to become relevant ([Mavrogianni et al., 2011](#)).



Table 4. California Mastitis Test (CMT) reactions and distribution of microbial isolates

CMT Reactions	Number of ewes Total=822	Number of mammary glands Total=1644	Mammary glands (%)	Bacteria isolated
N	627	1254	76.33	Coliforms, <i>Bacillus spp.</i> , Non-coliformes, Yeast
1	46	92	5.5	CNS, <i>Str no agalactiae</i> , <i>Pasteurella spp.</i>
2	35	70	4.25	<i>Mannheimia haemolytica</i> , <i>Str. Agalactiae</i>
3	83	166	10.09	<i>S. aureus</i> , <i>Corynebacterium spp.</i> , <i>T. pyogenes</i>
MC	23	46	2.79	<i>S. aureus</i> , CNS, <i>Str. agalactiae</i> , <i>Str. no agalactiae</i> , <i>T. pyogenes</i> , <i>M. haemolytica</i>
NF	8	16	0.97	No sample was obtained

CMT reaction grades: N (negative), 1, 2, 3; CM: Clinical mastitis; NF: Non-functional mammary glands

When subclinical mastitis occurs during lactation in ewes, physico-chemical and cellular alterations in milk are produced that affect its quality (Ariznabarreta *et al.*, 2002a). As milk production and quality decrease due to mastitis, lamb growth and weight are considerably affected (Huntley *et al.*, 2012). The negative effect of ovine and caprine mastitis on milk production and quality is greater than that observed in dairy cows (Blowey & Edmondson, 1999), characterized in sheep by a significant reduction in milk production due to subclinical mastitis (Leitner *et al.*, 2004; Nunes *et al.*, 2008). The above highlights the importance of designing and implementing new disease prevention strategies in flocks (McLaren *et al.*, 2018). In the present study, the importance of mastitis in lactating meat ewes is highlighted, with possible negative effects on milk production and lamb development (Grant *et al.*, 2016). Other studies have shown that experimentally induced mastitis with *Staphylococcus simulans* in sheep affects the development of lambs reared by experimentally infected ewes, which had significantly lower weaning growth rates than the control group of lambs reared by healthy ewes (Arsenault *et al.*, 2008; Rupp *et al.*, 2009).

The study demonstrated the usefulness of the CMT in detecting subclinical mastitis, detecting a frequency of 10 to 35.8 % in meat sheep flocks. The CMT results obtained indicated that grade 1 reactions accounted for 5.55 %, a reaction that may exceed the normal somatic cell count in ewe milk (Suarez *et al.*, 2002; Bergonier & Berthelot, 2003). Likewise, grades 2 and 3 of the CMT yielded the highest frequency of microbial isolation (42.86 %), which may indicate a causal association of the agents with subclinical mastitis in the studied ewes (Ariznabarreta *et al.*, 2002a). In the study by Zafalon *et al.*, (2016), when determining the confidence limit for subclinical mastitis detection, somatic cell count



and CMT were compared; grade 1 reaction ($>400 \times 10^3$ somatic cells/mL) indicated adequate sensitivity and specificity when monitoring different lactation periods in ewes. In the study of sheep flocks in the regions of the State of Mexico, it stands out that as CMT reactions increased, the frequency of microbial isolation in milk also increased. This finding may be related to chronic infection and inflammation of the mammary gland, which could contribute to mastitis severity, low milk production, and deterioration in milk quality, with consequences for lamb rearing (Grant *et al.*, 2016; Abdalhamed *et al.*, 2018). CMT grades higher than 1 during ewe lactation are often indirectly related to chronic inflammation and progressive development of fibrotic lesions in the glandular parenchyma (Menzies & Ramanoon, 2001; McLaren *et al.*, 2018). Coinciding with the study by Suarez *et al.*, (2002), in a group of Pampinta dairy ewes, a 65 % relationship was established between somatic cell count and CMT reaction. When the cell count was 225×10^3 cells/mL of milk, no glandular infection was found; however, when the cell count rose to 1004×10^3 cells/mL, it was associated with the presence of CNS, *Micrococcus*, and *Corynebacterium spp.*, and when it increased to 2045×10^3 cells/mL, *S. aureus* and *E. coli* were identified. In mastitis diagnostic techniques, somatic cell count is an indicator of mammary gland health in ruminants (Ariznabarreta *et al.*, 2002b; Peixoto *et al.*, 2010). In turn, the CMT indirectly determines the somatic cell level in milk, allowing the use of the CMT under field conditions (González-Rodríguez, 1995).

In family-based meat sheep flocks, the overall frequency of microbial isolation from mammary glands was high, with a predominance of *S. aureus*, which coincides with other studies, indicating the importance of this pathogen (Alba *et al.*, 2019), coagulase-negative staphylococci (CNS) isolates followed in order of importance, with *S. epidermidis*, *S. simulans*, and *S. intermedius* identified in this group, which have also been identified in sheep flocks from other latitudes (Gelasakis *et al.*, 2015), and were also distributed in lower proportions across different CMT reaction grades (Menzies & Ramanoon, 2001).

Clinical mastitis cases in the present study were associated with isolates of *S. aureus*, CNS, *M. haemolytica*, and *Trueperella pyogenes*. The study determined the importance of *S. aureus* in the occurrence of subclinical and clinical mastitis in meat ewes in the central region of Mexico in family-based flocks. This confirms the importance of *S. aureus* as a cause of mastitis in small ruminants (Ünal *et al.*, 2012; Smith *et al.*, 2015; Vasileiou *et al.*, 2019), which may lead to progressive decline in milk production in chronic infection (Benchaoui, 2010). Furthermore, the risk of gangrenous mastitis occurrence in sheep flocks due to *S. aureus* during lactation has been established, which agrees with observations in various studies (Ariznabarreta *et al.*, 2002a; Vautor *et al.*, 2009; Le Maréchal *et al.*, 2013). In turn, persistence of intramammary infection by *S. aureus* increases the culling of chronically affected animals (Mavrogianni *et al.*, 2011).



The relevance of *S. aureus* and CNS in meat sheep flocks has also been confirmed in Canada, where a prevalence of 28.8% for subclinical mastitis caused by these agents was obtained (Arsenault *et al.*, 2008). In another study conducted in Greece by Vasileiou *et al.* (2018), staphylococci (*S. aureus* and CNS) were reported as the main etiological agents in subclinical mastitis cases. These causal agents have also been reported in sheep flocks in Egypt, identified as responsible for 31.1 and 19.1 % of subclinical mastitis cases, respectively (Abdalhamed *et al.*, 2018). Mørk, *et al.* (2007) in Norway have reported *S. aureus* as the prevalent pathogen in the country in clinical mastitis cases in meat and wool sheep.

The CNS isolated in the present study corresponded to: *S. epidermidis*, *S. simulans*, *S. intermedius*, *S. haemolyticus*, *Micrococcus* spp., and other CNS at a lower frequency than *S. aureus*. These results differ from other authors who identify CNS as the main causative agents of ovine mastitis, denoting seasonal variation in the frequency of infection in sheep (Narenji Sani *et al.*, 2015); a wide variety of CNS species has been observed during intramammary infection in ewes (Vasileiou *et al.*, 2019). The presence of CNS in sheep shows differences in pathogenicity, being identified in milk with somatic cell counts $< 200 \times 10^3$ cells/mL (Menzies & Ramanoon, 2001). In Assaf ewes in Israel, an increase in somatic cell count $> 1500 \times 10^3$ cells/mL associated with CNS infection was observed, indicating a higher susceptibility to infection in dairy ewes, which marks important differences from infection in dairy cows (Leitner *et al.*, 2001). Simultaneous infections by CNS and *S. aureus* are possible, causing severe mammary gland lesions (Petridis & Fthenakis, 2014).

In the present study, a low frequency of glandular infection by *Str. agalactiae* and non-*agalactiae* streptococci was determined. The presence of these agents in the sheep flock may be explained by sources of infection such as a contaminated production environment and deficient hygienic-sanitary management of the flock. Likewise, infected ewes may contribute to the spread of mastitis during lactation. Furthermore, the presence in the sheep operation of other animal species carrying agents such as *Str. agalactiae*, *Str. uberis*, *Str. suis*, and *Str. equi subsp. zooepidemicus* (*S. zooepidemicus*) may contaminate the environment (Marguet *et al.*, 2000).

Other pathogens identified in the study were *E. coli* and other coliform bacteria; these were observed in a low proportion in subclinical mastitis cases. This finding may represent a risk in cases of acute mastitis during the perinatal period and at the end of lactation (Berriatua *et al.*, 2001). The increase in subclinical and clinical mastitis cases caused by coliform and non-coliform bacteria in sheep flocks may be due to facilities with damp and unsanitary areas, bedding contaminated with excreta, and the presence of vapors from



decomposing organic waste in sheep confinement sheds ([Bergonier et al., 2003](#); [Mørk et al., 2005](#); Plummer & Plummer, 2012).

In the present study, a low proportion of *M. haemolytica* isolates was reported, identified in both subclinical and clinical infections in meat ewes. It has been established that *M. haemolytica* may be present on the teat skin immediately after lambing, due to the presence of lambs with pneumonia and the production environment contaminated by secretions from affected animals, which may increase the risk of *M. haemolytica* mastitis in the flock. This may suggest horizontal transmission among the sheep population with different *M. haemolytica* genotypes, particularly under adverse climatic conditions ([Omaleki et al., 2016](#)).

Clinical mastitis cases in the study in family-based meat sheep flocks were identified as associated with major pathogens such as *S. aureus*, *M. haemolytica*, and *T. pyogenes*, causing opportunistic infection, which coincides with descriptions in other studies ([Omaleki et al., 2011](#); [Rogovskyy et al., 2018](#)).

CONCLUSIONS

Subclinical mastitis in family-based meat sheep flocks showed a high frequency and wide distribution. *Staphylococcus aureus* and coagulase-negative staphylococci (CNS), non-agalactiae streptococci, and *Mannheimia haemolytica* were the most frequent isolates in meat sheep flocks of the central region of the State of Mexico. Clinical mastitis cases in this study were related to isolates of *Staphylococcus aureus*, CNS, *M. haemolytica*, *Trueperella pyogenes*, and *Streptococcus agalactiae*. The high frequency of subclinical mastitis observed in sheep flocks during lactation highlights the need to implement prevention and control programs to reduce the negative economic impact on milk production and lamb rearing.



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