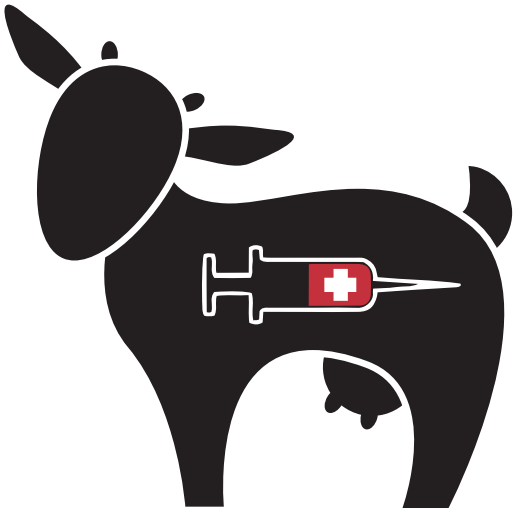
Control of Mastitis and Milk Quality



in Dairy Goats through Immunization

By Stephen C. Nickerson, professor; Felicia M. Kautz, research associate; and Lane O. Ely, professor
Department of Animal and Dairy Science

The total goat inventory in the U.S. is presently 2.76 million head, with approximately 355,000 does used in milk production. Milk and cheese made from dairy goats are considered specialty foods, and product sales have grown steadily as consumers have become more aware of the potential health benefits of goat milk, such as higher protein and lower allergen and cholesterol concentrations. Just as in dairy cattle, mastitis (inflammation of the mammary gland caused by bacteria) adversely affects milk production as well as milk quality in dairy goats, and for a herd to be profitable, this disease must be controlled. Prevalence of mastitis in small ruminants, such as goats and sheep, ranges between 5% and 30%, with Staphylococcus *spp., otherwise known as the coagulase-negative staphylococci (CNS), identified as the most frequent cause of infection. The CNS produce persistent subclinical mastitis with markedly elevated somatic cell counts (SCC), which may lead to clinical symptoms.* ***Prevention is the key to controlling staphylococcal mastitis in dairy goats,*** *as once this disease becomes established, chronic inflammation of mammary tissues and elevated SCC will follow, resulting in reduced milk yield. The SCC legal limit for goat milk destined for human consumption is currently 1,500,000/ml, and mastitis is largely responsible for elevated bulk milk and individual doe SCC.*

UGA extension

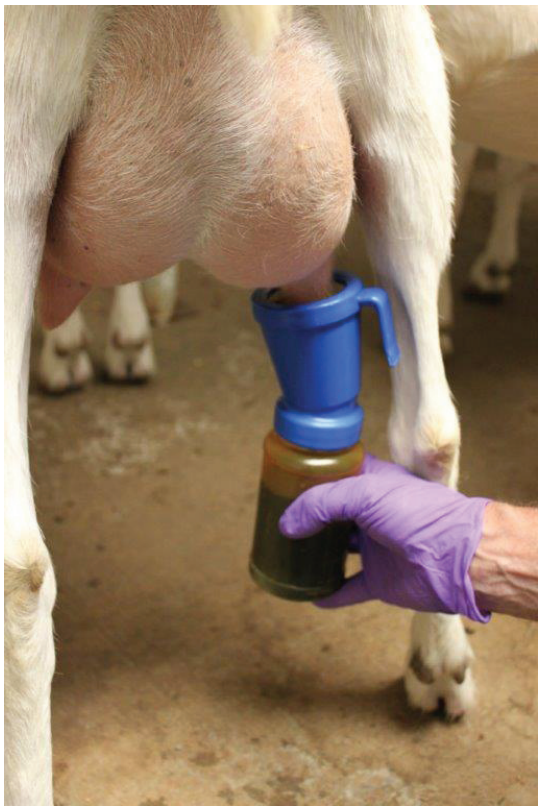
Sound Husbandry Practices and Sanitation Are Instrumental in Mastitis Control

While mastitis cannot be totally eliminated, its incidence can be minimized through sound husbandry practices and sanitation. For example, the barn, milking parlor, holding area, and pasture should be well-drained and ventilated. Manure and other litter should be minimized, providing a clean, dry, and comfortable environment. Animals should be dehorned and hooves trimmed as necessary, which will reduce the potential for traumatic injury to teats and udders.

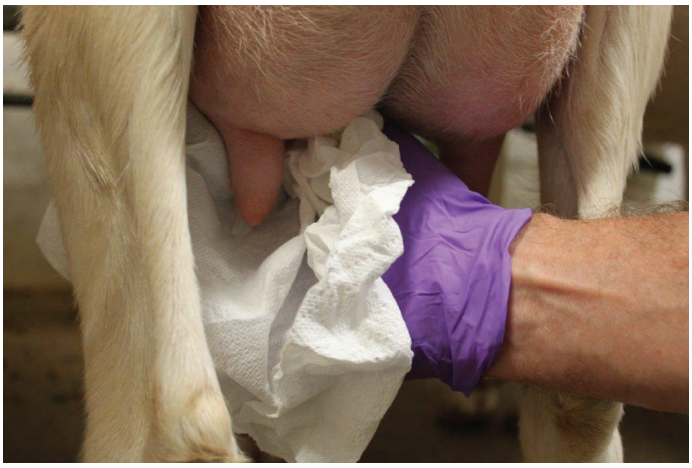
Proper milking-time hygiene and milking procedures are also critical in reducing mastitis. Udder and flank hair should be clipped to minimize dirt, manure, and water. Prior to machine attachment, the foremilk should be examined for abnormalities using a strip cup or by stripping onto the parlor floor. Next, teats should be predipped in a sanitizing solution for 20–30 seconds to kill mastitis-causing bacteria and loosen organic debris, followed by drying with single-service paper or cloth towels. Predipping will help to reduce new cases of mastitis with the environmental pathogens such as *Streptococcus uberis* and *Escherichia coli*. Milkers should keep their hands as clean and dry as possible during the entire milking process to prevent transfer of mastitis-causing bacteria among does, and they should preferably wear gloves. Immediately after the milking unit is removed from the udder, teats should be immersed in a post-milking germicide (postdip) to kill bacteria on the teat surface that were in contact with the teat cup liner. Postmilking teat dipping is one of the most effective means of reducing the incidence of new infections with the contagious pathogens such as *Staphylococcus aureus* and the CNS.

Another husbandry practice used to control mastitis is intramammary therapy at the time of drying off because it eliminates existing infections and prevents establishment of new infections. Because all currently available antibiotic infusion products for mastitis are labeled for cattle, their use in does is extra-label, and a treatment protocol must be developed by the herd veterinarian who has a valid relationship with the owner. Although use of lactating cow antibiotics is often beneficial in treating udder halves exhibiting clinical symptoms of mastitis, treatment of subclinical infections during lactation is less beneficial and is not currently recommended. Does that exhibit chronically infected glands with clinical flare-ups that do not respond to treatment serve as sources of infection for the rest of the herd and should be culled or at least segregated from other lactating does to reduce potential spread of mastitis.

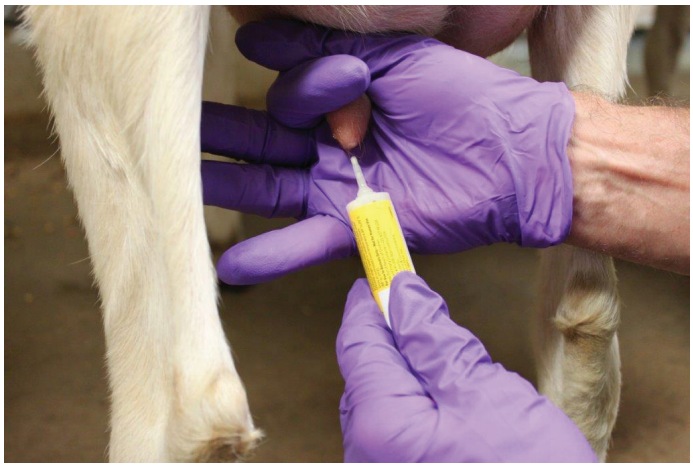
Prior to machine attachment, the foremilk should be examined for abnormalities using a strip cup or stripping onto the parlor floor.



Next, teats should be predipped in a sanitizing solution.



After allowing the predip sanitizing solution to remain on teat surfaces for 20–30 seconds to kill the mastitis-causing bacteria, the germicide residues and organic load are removed by drying with single-service paper or cloth towels.



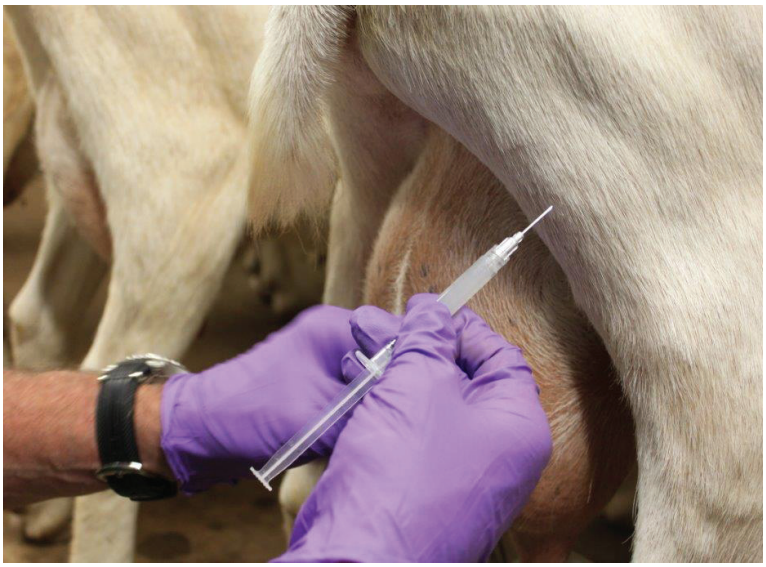
Prior to administering approved nonlactating antimicrobial therapy at the end of lactation, teat end orifices must be sanitized with the alcohol swabs that are provided. This is then followed by inserting only the distal end of the cannula into the orifice and slowly infusing the contents, followed by dipping teats in a germicide.

Vaccination as a Potential Means to Control Mastitis in Ruminants

Several mastitis vaccines labeled for dairy cows are currently on the market to aid in preventing infections with coliforms (such as *E. coli*), *S. aureus*, and mycoplasma. No vaccines are currently approved for dairy goats. However, immunization could be an integral part of a goat herd mastitis control program if this tool was demonstrated to reduce the prevalence of infection and lower SCC. With this in mind, two research trials were carried out to determine the effectiveness of using vaccination to reduce mastitis and improve milk quality in a commercial dairy goat herd in Georgia. Results presented herein suggest that a vaccination protocol, developed in conjunction with the herd veterinarian, can be instrumental in lowering the incidence of mastitis and improving milk quality in dairy goat herds that are experiencing issues with poor quality milk.

Trial 1: Comparison of vaccinated and unvaccinated control does in reducing the prevalence of mastitis.

Study design: This investigation included 30 Saanen does at various stages of lactation in a commercial milking goat herd that was in jeopardy of losing its milk market due to elevated herd SCC caused by staphylococcal (CNS) mastitis. Does were milked twice daily in a parlor using DeLaval milking equipment. Strict milking hygiene was followed including pre- and postmilking sanitization of teats using a chlorine-based germicide. Goats were divided into two groups: 1) vaccinates (14 does) and 2) nonvaccinated controls (15 does), and balanced by udder infection status, days in milk, average daily milk yield, and SCC. The vaccinated does were injected with a 3-ml dose of Lysigin® (Boehringer Ingelheim, Vetmedica, Inc., St. Joseph, MO) intramuscularly in the



The vaccinated does were injected with a 3-ml dose of Lysigin® intramuscularly in the semimembranosus muscle of the rear leg.

right semimembranosus muscle of the rear leg with a booster given two weeks later. Thereafter, does were injected at six-month intervals per label instructions. Injection sites were alternated between right and left sides and were monitored for any adverse reactions; none were noted. Herd data were collected from April 2009 through April 2011.

Methods used: Milk samples were taken from each udder half of all does in the herd three times at monthly intervals prior to vaccination to establish a baseline, and at six-week intervals throughout a 2-year period. Samples were processed to determine presence of bacterial infections as well as to perform SCC. All milk samples were classified as visibly normal, and udder halves from which bacteria were isolated were classified as subclinically infected as no clinical symptoms were observed in any of the study animals during the trial.

Determination of new infections and cure rates: Over the postvaccination trial period, numbers of new infections that were diagnosed in previously uninfected udder halves of vaccinates and controls were determined. A new infection was confirmed if the same bacteria were cultured from at least two consecutive sampling times, and differences in the new infection rates between vaccinated and control does were analyzed. Additionally, the ability of an infected udder half to resolve naturally without antibiotic intervention (spontaneous cure) was determined in udder halves of vaccinates and controls. An infection was considered as a spontaneous cure if an infected half cultured negative at the subsequent sampling time and for the duration of that lactation.

Milk quality assessment based on SCC: SCC were determined on milk samples collected before and during the trial as a measure of milk quality using a DeLaval Cell Counter (DCC, DeLaval International AB, Tumba, Sweden). A total of 530 fresh milk samples, which were stored on ice for up to 24 hours, were analyzed using the DCC and recorded. Subsequently, these samples were frozen at -20°C, and approximately five weeks later, they were thawed to room temperature and processed again through the DCC. The purpose of reanalyzing milk samples was to determine whether SCC results from the processing of fresh milk samples could be accurately repeated after freezing of the same samples. This information was considered important because, at times, it is unfeasible to immediately analyze milk samples that have been freshly collected, thus requiring freezing of samples for storage over extended periods of time prior to counting. The SCC of fresh samples were compared with paired frozen samples collected on the same date.

Trial 1 results—Effect of vaccination on prevalence of mastitis: Overall prevalence of infected does (percentage of does with at least one udder half infected) for vaccinated and controls combined during the trial period was 68.1% (range of 55-83%). This percentage of infected does is greater than the 5% to 30% reported in the literature and underscores the focus of this trial on reducing the development of new infections and lowering the herd SCC. Prevalence of infection among does was lower for vaccinates (64.0%) compared with controls (71.7%). Likewise, after herd immunization, 48.1% of udder halves from vaccinated does were infected, which was lower than the infection rate for controls at 55.6% (Table 1).

A comparison of the new infection rate between treatments revealed a rate of 1.64 new infections per doe among vaccinates, which was lower than controls at 2.67 new infections per doe (Table 1). For example, over the trial, 23 new infections occurred in 14 vaccinated does (12 new infections in the right half and 11 in the left half), and 40 new infections occurred in 15 control does (15 new infections in the right half and 25 in the left half). Overall, the majority (55.6%) of new infections were caused by *S. caprae* (31.7%) and *S. xylosus* (23.9%).

An evaluation of the spontaneous cure rate, or the ability of an infected udder half to resolve or cure naturally without antibiotic intervention, revealed a cure rate of 1.28 cures per doe among vaccinates, which was higher than the rate of 0.6 cures per doe among controls (Table 1). For example, over the trial, 18 infected halves of 14 does cured spontaneously among vaccinated animals (1.28 per doe), and 9 infected halves of 15 does cured spontaneously among unvaccinated controls (0.60 per doe). Overall, the majority (66.7%) of cures occurred with *S. caprae* (44.4%) and *S. xylosus* (22.3%).

The types of bacteria cultured from udder halves of vaccinated and control does are presented in Table 2. Among vaccinated does, *S. caprae* made up 51.9% of positive cultures, followed by *S.*

xylosus (13.4%), *Enterococcus faecium* (7.9%), *S. chromogenes* (7.9%), and various other staphylococci. Among nonvaccinated does, *S. caprae* made up 33.1% of positive cultures, followed by *S. xylosus* (17.6%), *S. simulans* (16.8%), *S. chromogenes* (8.1%), and various other staphylococci, streptococci, and gram-positive and gram-negative bacilli. Thus, the distribution of bacteria in both treatment groups was similar except for more frequent infections with *E. faecium* in vaccinates (7.9% vs. 0%) and more frequent infections with *S. simulans* in controls (16.8% vs. 3.1%). *S. caprae* (42.5%), *S. xylosus* (15.5%), and *S. simulans* (10.0%) were the predominant bacterial infections from both treatments (Table 2), and supports previous findings that identified the staphylococci as the most prevalent causes of mastitis in dairy goat herds.

Table 1. Percentage of udder halves infected, new infection rate, and spontaneous cure rate among vaccinated and unvaccinated (control) does.

Result	Vaccinated	Control
Does infected (%)	64.0	71.7
Udder halves infected (%)	48.1	55.6
New infections (no.)	1.64	2.67
Spontaneous cures (no.)	1.28	0.60

Table 2. Percentages of bacterial infections among infected halves of vaccinated and unvaccinated (control) does.

Isolate	Vaccinated	Control	Average
Enterococcus faecium	7.9	0	3.9
Gram-negative bacillus	0	2.0	1.0
Gram-positive bacillus	0	0.7	0.4
Staphylococcus aureus	1.6	3.4	2.5
Staphylococcus capitis	1.6	4.6	3.1
Staphylococcus caprae	51.9	33.1	42.5
Staphylococcus chromogenes	7.9	8.1	8.0
Staphylococcus epidermidis	5.6	2.7	4.2
Staphylococcus hyicus	0.8	2.7	1.8
Staphylococcus lentus	2.4	1.4	1.9
Staphylococcus sciuri	0	1.4	0.7
Staphylococcus simulans	3.1	16.8	10.0
Staphylococcus spp.	3.1	1.4	2.3
Staphylococcus warneri	0	2.7	1.4
Staphylococcus xylosus	13.4	17.6	15.5
Streptococcus agalactiae	0	1.4	0.7
Streptococcus spp.	0.8	0	0.4

Trial 1 results—Effect of vaccination on milk quality (SCC): The average SCC of all samples collected before and after the trial regardless of treatment or infection status for fresh and frozen milk samples combined for both halves was 1,403,000/ml (Table 3). This figure is similar to previous reports for lactating does, ranging from 1,000,000/ml to 2,000,000/ml, but approaches the legal SCC limit for goat milk. The average SCC for uninfected halves was 1,001,000/ml while average SCC for infected halves was 1,805,000/ml. Average SCC of vaccinated does (1,274,000/ml) was lower than that of control does (1,529,000/ml) (Table 3), suggesting that immunization helped to reduce the herd level of mastitis as well as the SCC.

The SCC of all fresh samples (right and left sides combined) was very similar to SCC for frozen samples (1,390,000/ml vs. 1,401,000/ml) (Table 4). Likewise, there were no differences between fresh and frozen samples for right and left halves. Thus, the DCC was equally effective in enumerating somatic cells in goat milk samples that had been frozen for five weeks as it was in enumerating cells in fresh milk samples.

Table 3. SCC differences between milk samples from uninfected and infected halves and from vaccinated and control (unvaccinated) does.

Udder half	SCC/ml
Both halves	1,403,000
Infected halves	1,805,000
Uninfected halves	1,001,000
Vaccinated does	1,274,000
Unvaccinated does	1,529,000

Table 4. SCC differences between fresh and frozen milk samples from udder halves.

Udder half	Fresh SCC/ml	Frozen SCC/ml
Both halves	1,390,000	1,401,000
Right half	1,395,000	1,416,000
Left half	1,385,000	1,387,000

The average SCC associated with each bacterial species cultured are shown in Table 5. Among the CNS, the highest SCC were associated with infections caused by *S. simulans* (3,253,000/ml) followed by *S. sciuri* (3,109,000/ml), and *Staphylococcus* spp. (2,286,000/ml). Overall, CNS SCC ranged between 1,067,000/ml and 3,253,000/ml.

The bulk tank SCC were observed to decrease over the trial (Figure 1). Bulk tank SCC averaged 1,293,000/ml for the five prevaccination sampling dates. For the 14 postvaccination dates, bulk tank SCC averaged 1,052,000/ml, a decrease of 241,000 cells/ml.

Trial 1 conclusions: Vaccination resulted in a decrease in the new infection rate among the immunized goats and an increase in the spontaneous cure rate compared with unvaccinated controls. Likewise, SCC were reduced in vaccinated animals compared with controls (1,274,000/ml vs. 1,529,000/ml). The legal SCC limit for herd milk in dairy goats is 1,500,000/ml; thus, even a small reduction in herd SCC (e.g., a reduction to 1,274,000/ml, as in this case for vaccinates) is sufficient to allow the sale of goat milk for human consumption and maintain the producer within the allowable SCC limit. In addition, results revealed that the DCC was equally effective in enumerating somatic cells in goat milk samples that had been frozen for up to five weeks as it was in enumerating cells in fresh milk samples. Thus, this somatic cell counting device can be used to accurately determine the SCC in milk samples that need to be frozen prior to processing.

Table 5. Somatic cell counts (SCC) associated with bacterial isolates from milk samples.

Isolate	SCC x 1000
Uninfected	1,001
Enterococcus faecium	4,520
Gram-negative bacillus	2,503
Gram-positive bacillus	5,778
Staphylococcus aureus	2,019
Staphylococcus capitis	1,890
Staphylococcus caprae	1,526
Staphylococcus chromogenes	1,067
Staphylococcus epidermidis	2,112
Staphylococcus hyicus	1,137
Staphylococcus lentus	1,327
Staphylococcus sciuri	3,109
Staphylococcus simulans	3,253
Staphylococcus spp.	2,286
Staphylococcus warneri	1,430
Staphylococcus xylosus	1,529
Streptococcus agalactiae	127
Streptococcus spp.	3,026

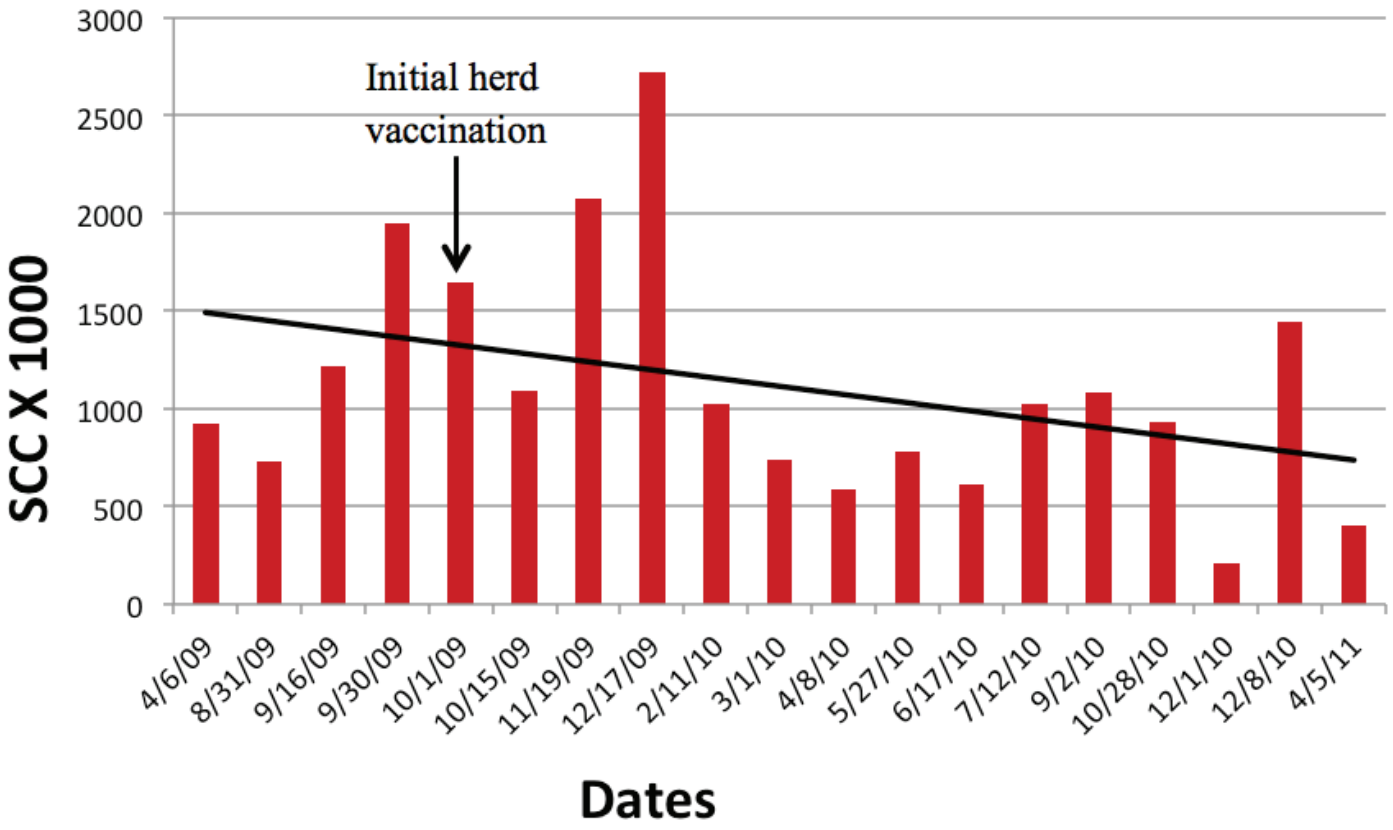


Figure 1. Bulk tank somatic cell counts observed during Trial 1.

Trial 2: Comparison of mastitis prevalence and milk quality before/after herd vaccination.

Study design: The second investigation included 29 Saanen does at various stages of lactation in the same commercial milking goat herd that was used in Trial 1. At the end of Trial 1, vaccination was discontinued (the last injection given in late 2010). By the spring of 2013, the goat herd was again in jeopardy of exceeding the legal limit of 1,500,000/ml for bulk milk SCC, and the level of mastitis among does had reached a high of nearly 80%. Thus, the objective of this investigation was to determine if the process of whole herd vaccination with the same staphylococcal mastitis bacterin (Lysigin®) could result in a sufficient immune response to the CNS bacteria already established in this herd. Such a response may reduce the inflammatory effects of ongoing infections and/or result in spontaneous cures, leading to a reduction in the prevalence of mastitis and lowering of the herd SCC.

Methods used: Milk samples were collected from each udder half of all does four times prior to vaccination over a four-month period during the summer and fall of 2013 to establish a baseline for udder infection status and SCC. Bulk tank somatic cell and bacteria counts were also determined using the same procedures used in Trial 1. It was deemed necessary to vaccinate all lactating does, and a comparison of the rate of infection and milk quality in the four months prior to vaccination with the rate of infection and milk quality after whole herd vaccination was made. This increased the odds of reducing the infection rate among all milking herd animals, thereby maintaining the bulk tank SCC below the legal limit and keeping the herd milk quality "in grade" to ensure the production of a saleable product.

Thus, all 29 goats were inoculated with a 3-ml dose of Lysigin® administered as in Trial 1. However, in attempts to potentially increase and maintain higher antibody titers and increase protection, vaccination was repeated at two-month intervals for six months, with a booster given two weeks after the initial vaccination. Beginning at two weeks after the vaccine booster was administered, milk samples from each udder half were collected to culture for presence of mastitis pathogens and to determine SCC. Thereafter, milk samples were collected and analyzed monthly for the duration of the six-month trial.

Determination of new infections and cure rates: Prevalence of infection among does (animals with at least one udder half infected) was determined as the percentage of infected does among the 29 animals on trial. Prevalence of infection among udder halves was determined as the percentage of infected udder halves among the 58 udder halves of the 29 animals on trial. A new infection developing over the trial was confirmed in an udder half that was uninfected for at least two consecutive samplings, which developed a new infection that persisted for at least two consecutive samplings. Additionally, the ability of an infected udder half to resolve naturally without antibiotic intervention (spontaneous cure) was determined in udder halves before and after vaccination. A spontaneous cure was defined as an established infection of at least two consecutive positive cultures of the same bacteria followed by at least two consecutive negative cultures. The prevalence of infection, as well as the SCC and bacteria counts during the months prior to vaccination were compared to the prevalence after vaccination.

Trial 2 results—Prevalence of mastitis before and after vaccination: Results of the monthly herd samplings prior to vaccination demonstrated an unusually high prevalence of mastitis among udder halves (Figure 2) and does (Figure 3), which was reduced by herd vaccination. From August through November, the average prevaccination prevalence of infection among udder halves was 60.7%, and after vaccination, the average prevalence was 45.9% (Figure 2). Likewise, among does, the average prevaccination prevalence of infection was 77.0%, and after vaccination, the average prevalence was 63.9% (Figure 3).

Comparisons of the prevalence of half udder infections (average number of udder halves with mastitis per doe) and animal infections (percentage of does with mastitis) for the prevaccination and postvaccination periods are in Table 6. The average number of udder halves with mastitis per doe decreased from 1.20 before vaccination to 0.91 after vaccination, and the percentage of does with mastitis decreased from 77% to 63.9%.

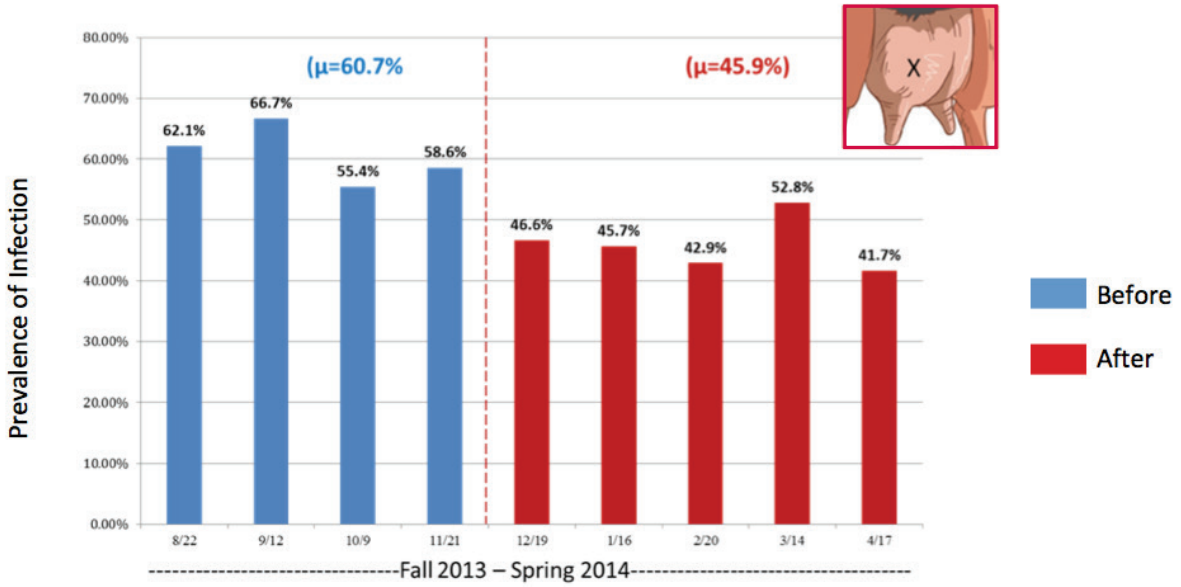


Figure 2. Prevalence of infections among udder halves before and after herd vaccination.

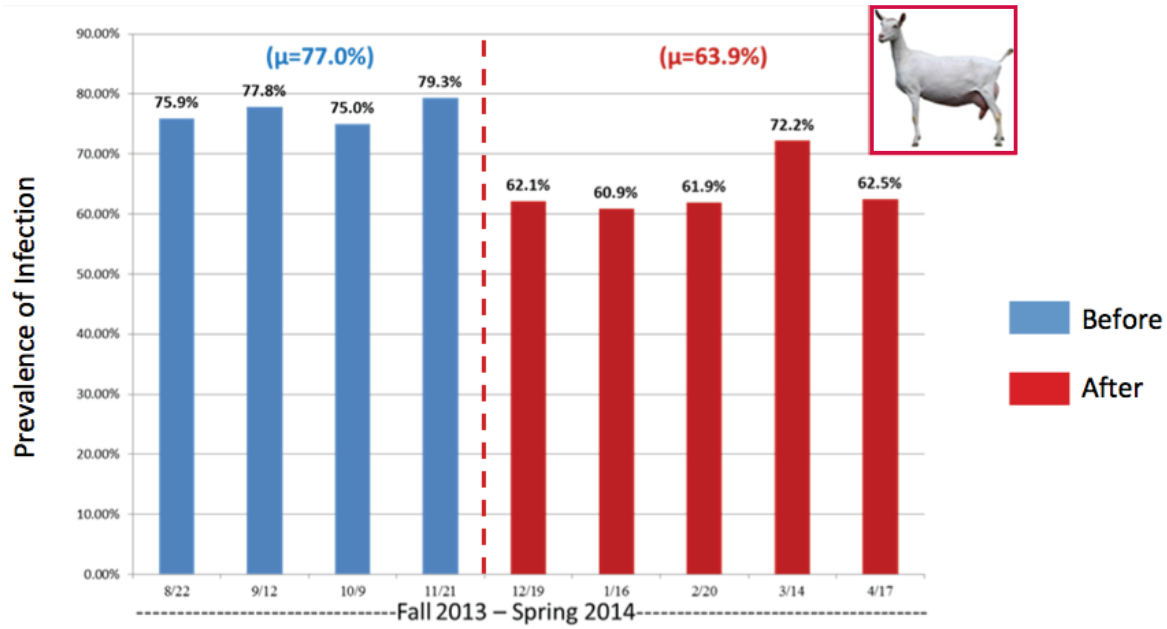


Figure 3. Prevalence of infections among does before and after herd vaccination.

Table 6. Comparison of the prevalence of half udder infections (average number of udder halves with mastitis per doe) and animal infections (percent of does with mastitis) before and after vaccination.

	Before Vaccination	After Vaccination
Half udder infections (no.)	1.20	0.91
Animal infections (%)	77.0	63.9

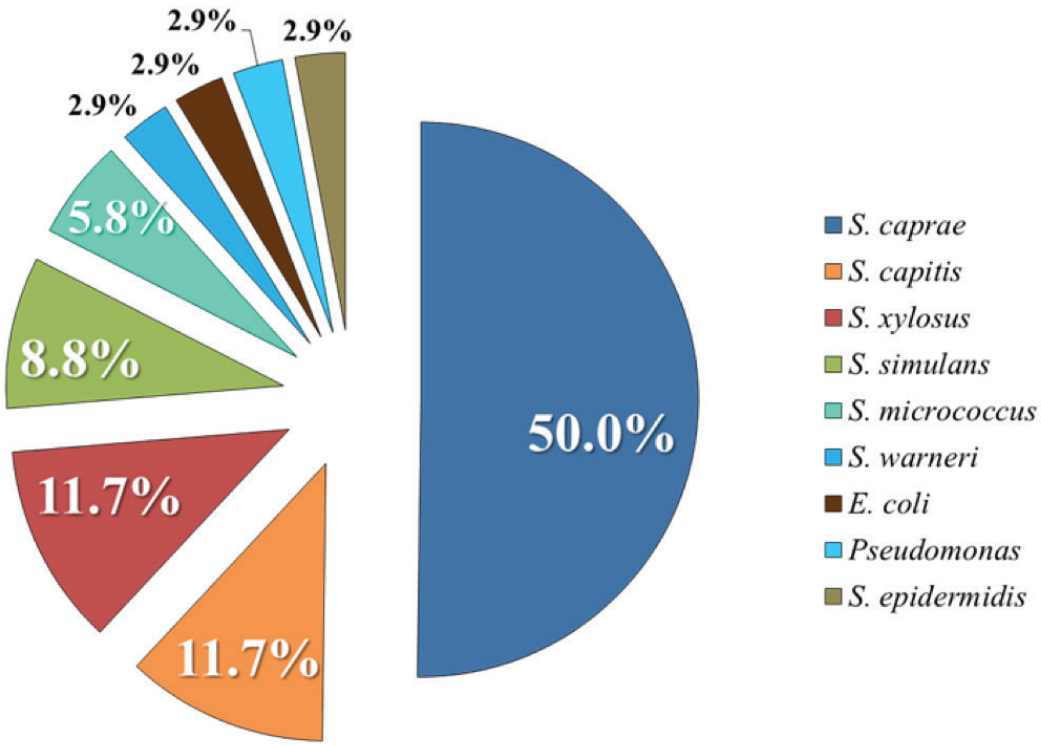


Figure 4. Distribution of bacterial species in Trial 2.

The frequency of infection with various bacterial species did not change over the trial; *S. caprae* (50.0%) was the most prevalent isolate followed by *S. capitis* (11.7%), *S. xylosus* (11.7%), and *S. simulans* (8.8%) (Figure 4).

An analysis of the development of new infections indicated than only one new infection was confirmed after vaccination, and it was a new infection with *S. caprae* in one udder half. On the other hand, spontaneous cures were confirmed in eight udder halves after vaccination: seven *S. caprae* infections cured and one micrococcus infection cured.

The average bulk tank SCC prior to vaccination was 1,118,625/ml with a low of 702,000/ml in September and a high of 1,406,000/ml in November (Figure 5). The average SCC after vaccination was 886,600/ml with a low of 694,000/ml in December and a high of 1,178,000/ml in March. The SCC in November at 1,406,000/ml prior to vaccination was quite elevated and dangerously close to the 1,500,000/ml legal limit for salable milk, but it decreased to 694,000/ml one month later; however, the SCC slowly increased through the March sampling then decreased in April to 729,000/ml.

The bulk tank bacteria counts may be used as a measure of the quality of the milk being produced. Prior to vaccination, the bacteria counts recorded for each month from the bulk tank sample were elevated and indicated an issue with overall milk quality (Figure 6). The average bacteria count from the bulk tank sample prior to vaccination was 14,900/ml. After vaccination had been administered, the average count was 6,216/ml, demonstrating a general improvement in milk quality.

The CNS or *Staphylococcus* spp. were the most prevalent causes of mastitis, with *S. caprae, S. capitis, S. xylosus*, and *S. simulans* representing the most prevalent microorganisms cultured from milk samples both before and after vaccination. Overall, prevalence of infected does (percentage of does with at least one udder half subclinically infected) across the study (before and after vaccination) was 69.7% (range of 60.9–79.3%). This percentage of infected does was considered extremely high and underscores the focus of this second trial in reducing the development of new infections and lowering the herd SCC.

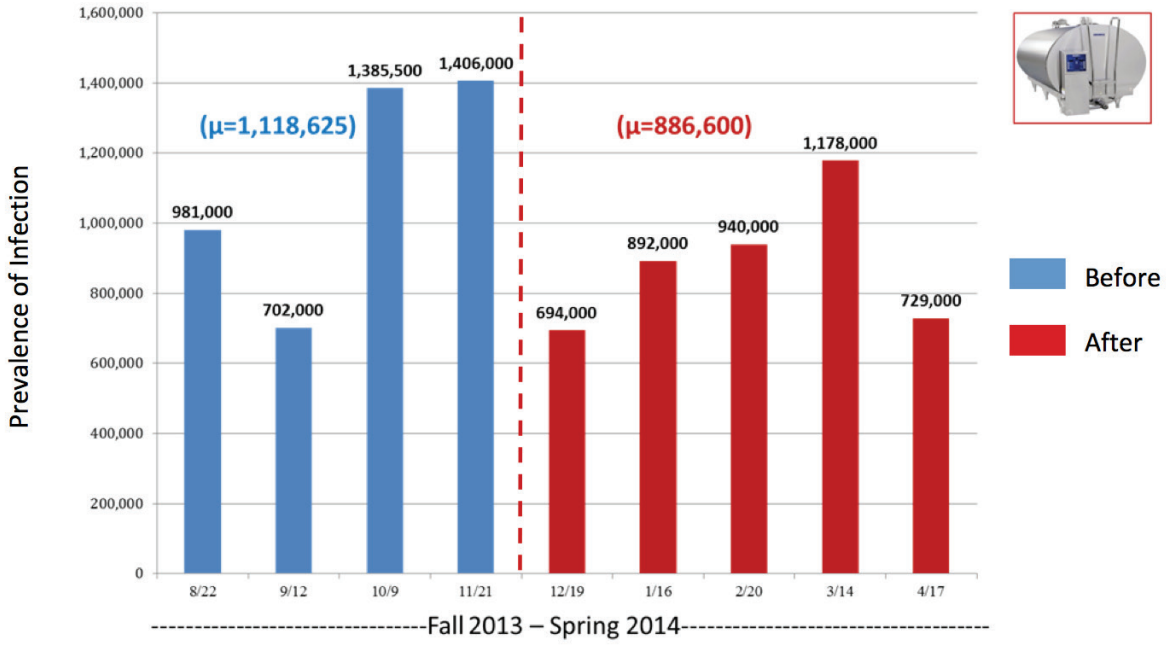


Figure 5. Bulk tank somatic cell counts before and after herd vaccination.

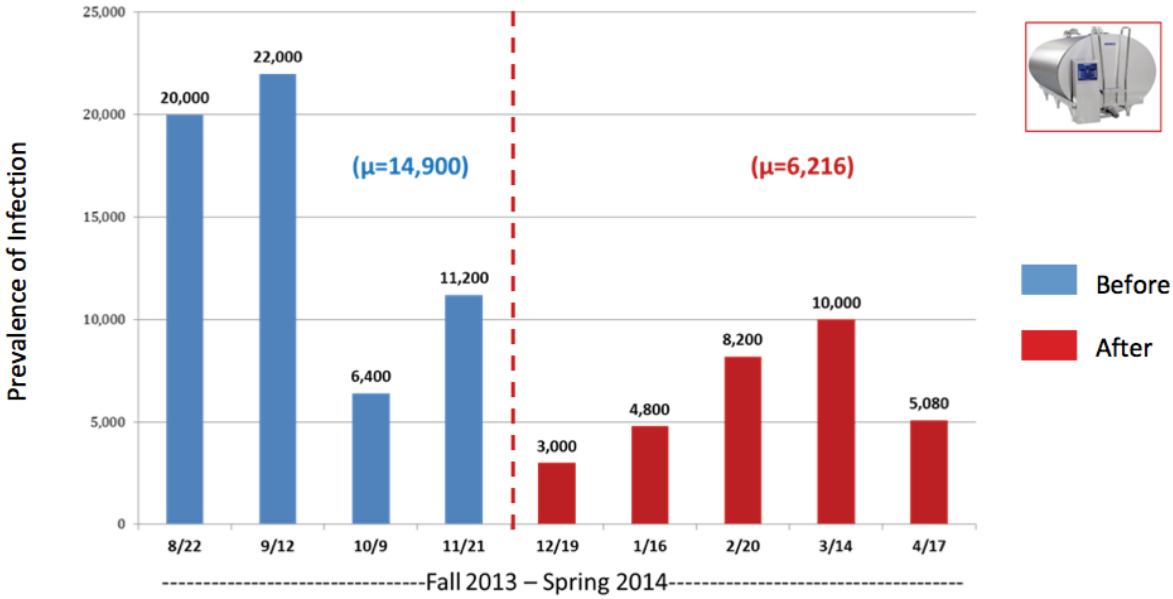


Figure 6. Bulk tank somatic bacteria count before and after herd vaccination.

Trial 2 conclusions: Vaccination lowered the overall prevalence of staphylococcal infection among does from 79.3% just prior to vaccine administration to 61.2% one month later (Figure 3), and prevalence averaged 63.9% over the five months after vaccination. Use of this management tool also lowered the SCC from a high of 1,406,000/ml to 694,000/ml one month later (Figure 5), and SCC averaged 886,600/ml over the five months after vaccination. Additionally, the average bacteria count in the bulk tank was reduced over 50% after vaccination compared with prevaccination figures (14,900/ml vs. 6,216/ml).

Overall take home message from Trials 1 and 2.

Although vaccination successfully reduced mastitis and lowered SCC, thereby improving milk quality, the effects were limited and of short term. Either protocol (Trial 1 or 2) can be implemented to help resolve mastitis and SCC issues in problem herds, but further research is needed to optimize the use of vaccination to control mastitis in goats for a more long-term approach toward managing this disease. It is important to emphasize that vaccination should only be included as part of the whole herd approach to mastitis control. Any vaccination program must be carried out in conjunction with other important management factors such as proper nutrition; provision of a clean, dry, and comfortable environment; proper milking machine function; use of adequate udder hygiene practices; and administration of nonlactating antibiotic therapy at drying off.

extension.uga.edu/publications

Bulletin 1446 **Published August 2015**