Efficacy of vaccination on *Staphylococcus aureus* and coagulase-negative staphylococci intramammary infection dynamics in 2 dairy herds (2014)

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1. Introduction

Mastitis is one of the most frequently occurring and costly diseases in dairy cows. Several preventative strategies have been applied to minimize the incidence of bovine mastitis, including optimization of milking procedures and milking hygiene, antibiotic therapies, vaccinations, segregation, and culling of persistently infected cows. However, mastitis remains an important disease on many dairy farms and, due to the high costs of clinical mastitis, reduction in the severity of the symptoms of mastitis and obtaining a more rapid clearance of established infections is of great value to dairy farmers.

2. Vaccination

Efficacy of vaccination against *Staphylococcus aureus* and CNS (coagulase-negative staphylococci) is a very different concept than efficacy of vaccination against *E. coli.* Whereas, with *E. coli* the vaccine is mostly expected to reduce severity of infection, with *S. aureus* and CNS vaccine is particularly valuable when vaccination results in a reduction of incidence and duration of infection, the key contributors to within herd infection dynamics. **Experimental challenge studies with *S. aureus* have shown an effect of vaccination on the amount of bacterial shedding after challenge;** however, such experimental studies were not able to demonstrate a reduction in infection transmission. Therefore it is necessary to determine the overall vaccine efficacy both at herd as linked to certain disease parameters and population.

3. The study

The aim of this study was to evaluate vaccine efficacy of a commercial vaccine (STARTVAC®, HIPRA) aimed at reducing intramammary infections (IMI) with *Staphylococcus aureus* and CNS under field conditions.

During the 21-mo duration of the study, 1,156 lactations from 809 cows were enrolled in 2 herds (A and B), with a total of approximately 450 dairy cows milking at any point in time. The herds had a known prevalence of *S. aureus* of at least 5% of cows (Figure 1) and a bulk milk SCC/mL between 250,000-400,000. No segregation of cows based on IMI status or SCC level was done on either farm. Vaccination took place according to label directions in the dry period and early lactation. The first vaccination was at 45 d (±3d) before the expected parturition date, the second vaccination at 35 d thereafter (±3d), corresponding to 10 d before the expected parturition date, and the third vaccination

	Farm A		Farm B	
Pathogen	N	Percent	N	Percent
Staph. aureus	929	3.8	2151	15.6
CNS	1139	4.6	937	6.8
Str. bovis	50	0.2	0	0.0
Str. canis	4	0.0	1	0.0
Str. dysgalactiae	176	0.7	19	0.1
Str. mitis	36	0.1	14	0.1
Str.uberis	217	0.9	132	1.0
Streptococcus spp.	117	0.5	89	0.6
Corynebacterium spp.	63	0.3	40	0.3
Enterococcus faecalis	55	0.2	38	0.3
Lactococcus lactis	70	0.3	11	0.1
Aerococcus viridans	88	0.4	58	0.4
E. coli	191	0.8	81	0.6
Enterobacter spp.	17	0.1	19	0.1
Other Gram-negatives	36	0.1	52	0.4
Klebsiella spp.	116	0.5	6	0.0
Pasteurella spp.	8	0.0	2	0.0
Proteus spp.	65	0.3	63	0.5
Prototheca	0	0.0	3	0.0
Serratia spp.	15	0.1	4	0.0
Trueperella pyogenes	2	0.0	0	0.0
Bacilli	26	0.1	5	0.0
Dry quarters	539	2.1	260	1.9
Missing/Contaminated	1452	3.5	671	2.0
Culture negative	19936	80.5	9503	69.0

Figure 1. Bacterial results of all samples collected.

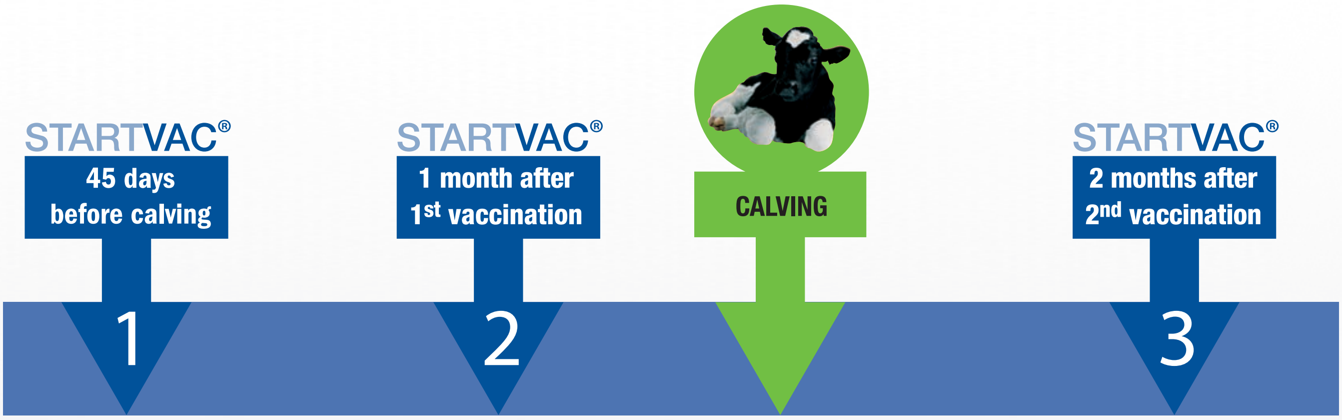


Figure 2. Vaccination protocol.

was at 52 DIM (±3d)(Figure 2). Cows going through a second dry period during the study were kept in the same treatment group (vaccinated or control). No placebo or sham vaccination was used in this trial.

During the first phase of the trial, all cows that were due to calve were vaccinated until approximately 50% of cows in the milking herd were vaccinated (at ~6mo). At that point, when 50% vaccination coverage was reached, cows that were due to calve were randomly assigned to be vaccinated or left as negative controls. We thereby assume that this was essentially a randomized controlled and single-blinded trial, as the herd staff was not aware of the vaccination. Monthly quarter sampling of all lactating cows in herds was done during the trial period. In addition, quarters were sampled by the farm staff when a case of clinical mastitis occurred, when cows were dried off, upon calving, and at culling. Cure rate, rate of new infection (Figure 3), prevalence (Figure 4), and duration of infections (Figure 5) were analyzed. The chosen study design, with commingling of vaccinated and control cows, allowed us to estimate population vaccine efficacy within herd using a within-herd randomization schedule.

Vaccine efficacy was moderate in our field trial in 2 commercial dairy herds. Vaccination was able to reduce the basic reproduction ratio of CNS and *S. aureus* in both herds. The data indicated that vaccination will result in **reduction of the basic reproduction ratio of *S. aureus* by approximately 45% (Figure 6) and the basic reproduction ratio for CNS by approximately 35%.** Efficacy was dependent upon the age group of the animals, particularly for *S. aureus*, where first lactation animals showed a significantly higher value compared with animals in third and higher lactation.

The observed vaccine efficacy may vary depending on farm management practices, as we identified significant differences between farms. Prevalence of *S. aureus* remained the same or slightly increased in farm A but dropped dramatically to a very low prevalence in farm B. For example, on farms with good management practices, the basic reproduction ratio (R_0) for *S. aureus* would be reduced from 1.5 to 0.83, whereas vaccination on farms with poor management would reduce R_0 from 5 to 2.75. In the latter example, *S. aureus*

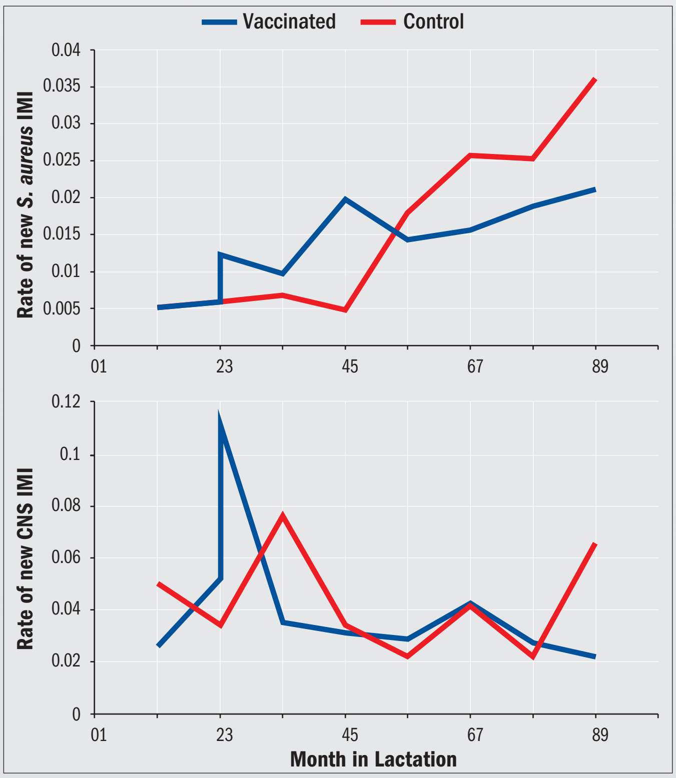


Figure 3. Rate of new infections.

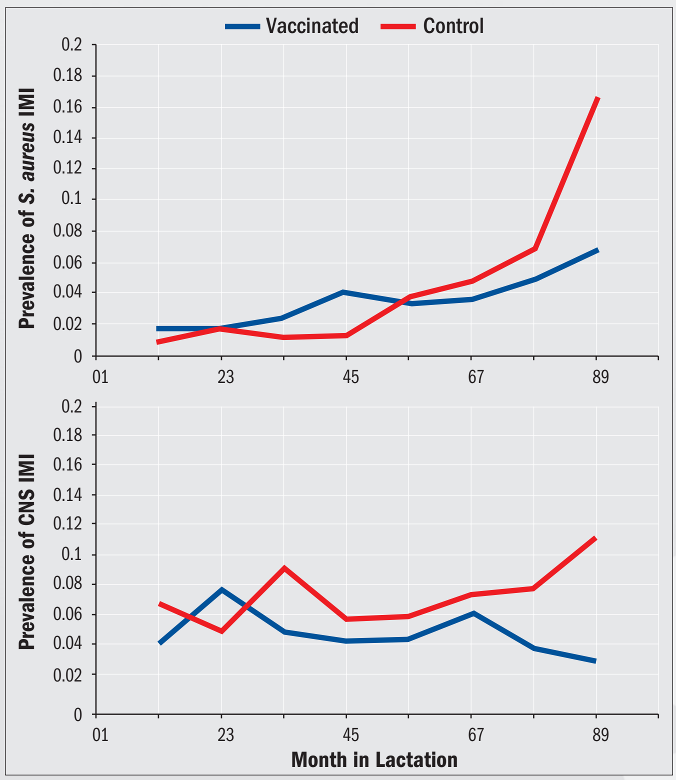


Figure 4. Prevalences.

would show a reduced prevalence but remain endemic despite vaccination, whereas, in the first example, *S. aureus* would eventually be eliminated due to vaccination.

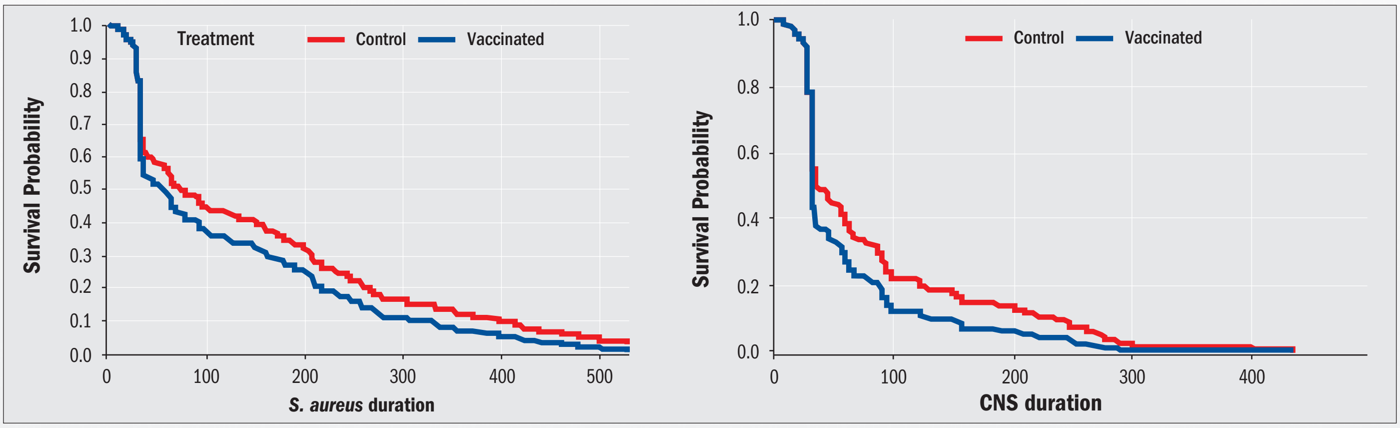
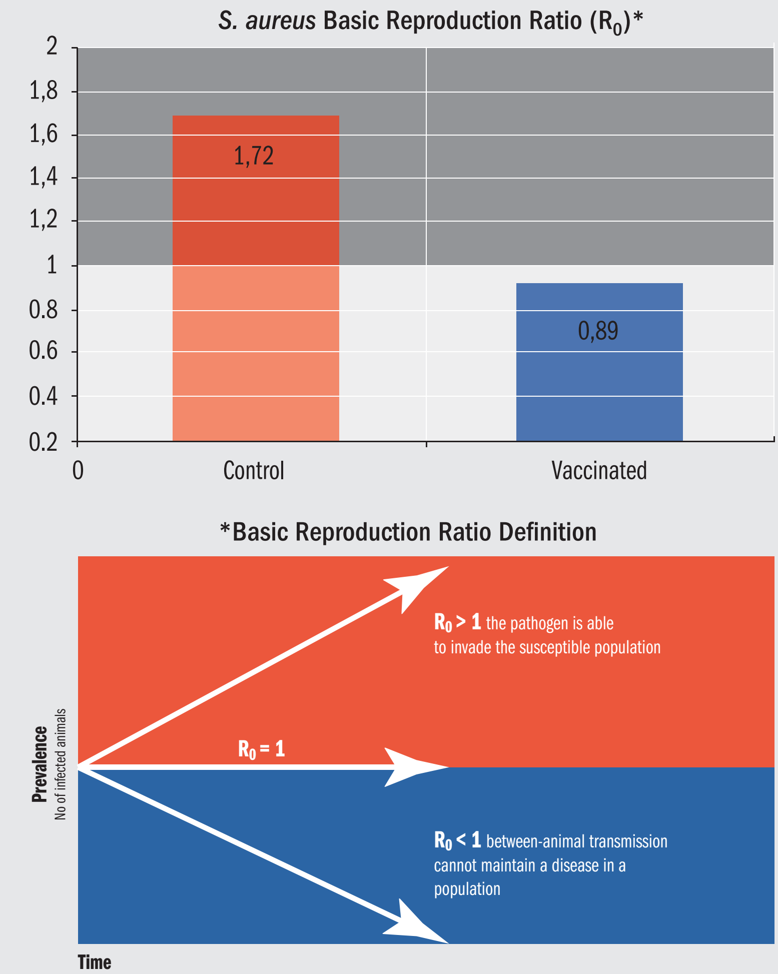


Figure 5. Duration of infection.



Transmission parameter and cure rate parameter combined into the overall basic reproduction ratio, R0, for S. aureus resulted in an R0 value of 0.89 (95% CI = 0.44–1.57) for vaccinated animals and a value of 1,72 for controls.
R0: This overall efficacy parameter is expected to provide the best summary of the overall effect of vaccination on infection dynamics in a vaccinated population

Basic Reproduction Ratio is the expected number of secondary cases produced by a primary infectious case in a wholly susceptible population.

Figure 6. *S. aureus Basic* Reproduction ratio.

4. Conclusions

Vaccination is a valuable tool in reducing incidence. The utilization of vaccine in combination with other infection-control procedures, such as excellent milking procedures, treatment, segregation, and culling of known infected cattle, will result in an important reduction in incidence and duration of intramammary staphylococcal infections.

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