Effects of Gram-positive, Gram-negative, and Other clinical mastitis on probability of conception in New York State Holstein dairy cows

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ABSTRACT

Our objective was to estimate the effects of different types of clinical mastitis (CM) (Gram-positive, Gram-negative, Other) on the probability of conception in New York Holstein dairy cows. We used generalized linear mixed models to model conception after an insemination attempt.

Of the inseminations, 42.5 percent were the first in the lactation, 27.5 percent were the second, 18.3 percent were the third, and 11.7 percent were the fourth. Conception probability decreased with each successive insemination. If she did not have CM, a cow's probability of conceiving on her first insemination was 0.29. This decreased to 0.26, 0.23, and 0.19 for the second, third, and fourth inseminations, respectively. Three-quarters of the lactations were CM-free. The rest contained similar numbers of Gram-positive and Gram-negative, and more Other, CM cases.

CM occurring between 14 days before until 35 days after an insemination reduced conception probability. Gram-negative CM had a larger effect than did the other types. CM was most detrimental when it occurred near time of breeding. Gram-positive or Gram-negative CM in the week before insemination reduced conception by half; Other CM reduced it by one fourth. Gram-negative CM in the week after an insemination reduced conception by 80 percent; Gram-positive or Other CM reduced it by 49 and 47 percent, respectively.

Information about CM (its timing relative to insemination; whether the causative agent is Gram-positive, Gram-negative, or Other) appears beneficial in determining why some cows have difficulties conceiving. These findings should be helpful in managing CM cows before and after insemination.

KEYWORDS

Gram-positive, Gram-negative, mastitis, conception, dairy cows

INTRODUCTION

Fertility has a key role in successful dairy cow management. If a cow does not conceive, her productive life will soon end, after her milk production drops to unprofitable levels. Although many farms, including those in this study, use ovulation synchronization and planned breeding programs, to circumvent heat detection and expression problems, some cows still do not conceive, for reasons including heat stress[3] and diseases, such as clinical mastitis (CM)[6]. Our objective was to estimate the effects of different types of CM (Gram-positive (GP), Gram-negative (GN), Other) on the probability of conception in Holstein dairy cows.

MATERIALS AND METHODS

Data were collected on 55,372 artificial insemination attempts (AI) in 23,695 lactations in 14,148 New York State Holstein dairy cows in 7 herds, for 3-5 years. All lactating cows who had been inseminated at least once between 40 and 90 days in milk were eligible for inclusion.

We modeled, in a generalized mixed model (SAS PROC GLIMMIX[5]), the effects of CM (GP, GN, Other) and other factors (insemination attempt, farm, parity, season of AI, and other diseases) on the probability of conception associated with a particular AI (first, second, third, fourth), using the following specification:

$$P = (\exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k)) / (1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k)) \quad [1]$$

where P is the probability of conception associated with a particular AI, β_0 is the regression parameter for the intercept, and β_1, β_2, …, β_k are the regression parameters for the effects x_1, x_2, …, x_k, respectively.

Only CM cases occurring between 6 weeks before until 6 weeks after an AI were included. Dummy variables for each type of CM (GP, GN, Other) in relation to when CM occurred with respect to an AI were created. Separate variables were created for these time periods: 36-42 days (d), 29-35 d, 22-28 d, 15-21 d, 8-14 d, 1-7 d before, and 0-7 d, 8-14 d, 15-21 d, 22-28 d, 29-35 d, and 36-42 d after an AI.

RESULTS AND DISCUSSION

E. coli was most commonly isolated, followed by *Strep.* spp. and *Klebsiella* spp. (Table 1). Although we identified specific agents, we had too little data to analyze by agent. In the data, 73% of the lactations did not have CM. The rest had similar numbers of GP and GN CM cases, and more Other CM cases.

Table 1 Clinical mastitis (CM)-causing organisms in 7 New York State Holstein herds, 2003-2008.

Gram-positive	N[1]	Gram-negative	N[1]	Other	N[1]
Streptococcus spp.	1,911	*Escherichia coli*	2,189	*Arcanobacterium pyogenes*	193
Staphylococcus aureus	546	*Klebsiella* spp.	1,073	*Mycoplasma*	98
Staph. spp.	535	*Citrobacter*	81	*Corynebacterium bovis*	40
		Enterobacter	55	*Pseudomonas*	4
				Yeast	220
				Other findings	1,935
				No growth	1,928

[1]Total number of CM cases (comprising first, second, third, and fourth occurrences) in which the organism was identified. A cow may have a mixture of organisms in any one episode.

Of the AIs, 42.5% were the first in the lactation, 27.5% were the second, 18.3% were the third, and 11.7% were the fourth attempt. If she did not have CM in the 6 weeks before or after an AI, a cow's probability of conceiving after her first AI was 0.29. Probability of success was lower for successive AIs: 0.26, 0.23, and 0.19 for second, third, and fourth attempts, respectively. This agrees with previous research: cows bred ≥4 times were less likely to become pregnant than ones needing fewer AIs, by a factor of 0.73[1]. Repeat breeders may have high levels of stress factors, which can inhibit establishment of a pregnancy[4]. Repeat breeding is due to various factors, including diseases, e.g., CM[2].

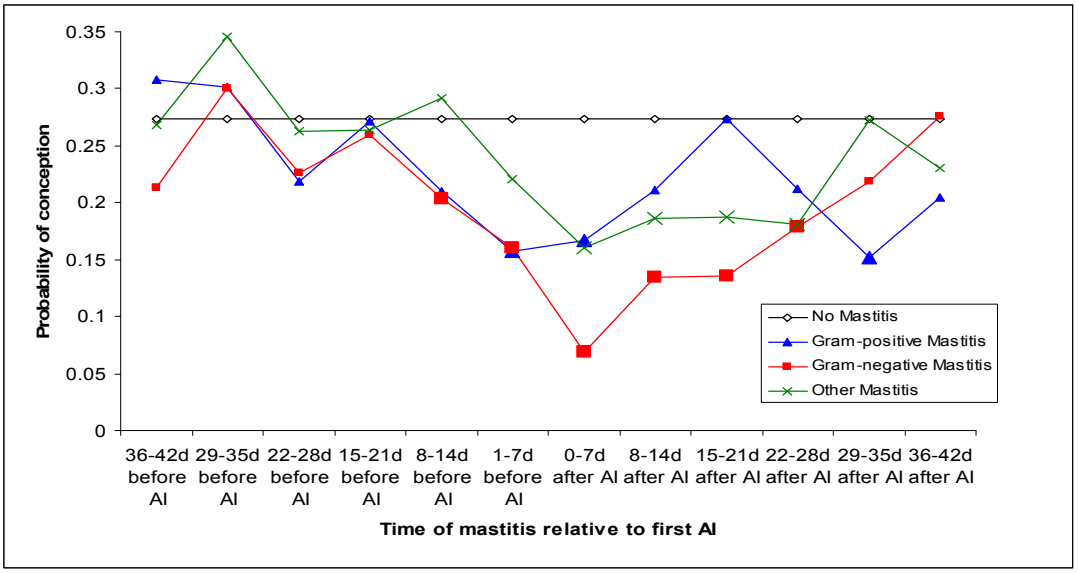

Figure 1 Probability of conception on first artificial insemination (AI) attempt, for a Parity 2 cow bred in spring, without mastitis, or with Gram-positive, Gram-negative, or Other mastitis. Larger symbols indicate probabilities that were significantly different (*P*<0.05) from that of No Mastitis in the interval.

CM occurring near time of insemination (before or after) significantly reduced the subsequent probability of conception. From 14 d before until 35 d after an AI, CM's effect on probability of conception varied with both its type and timing with respect to an AI (Figure 1; Table 2). Outside this interval, CM had no significant effect

on conception. Its effect was larger closer in time to an AI, especially if CM occurred just after an AI. GN CM was generally more deleterious than either GP or Other CM. E.g., GP and Other CM reduced probability of conception by 47% (1-exp(-0.63)) and 49% (1-exp(-0.67)), respectively, when they occurred 0-7 d after an AI. GN CM occurring then had a much larger effect: probability of conception was reduced by 80% (1-exp(-1.63)). Our findings may help farmers determine if it is worth inseminating a particular cow, e.g., one with CM (especially with GN CM), or wait until the next cycle.

One can find the probability of conception for a cow with any combination of factors (Table 2). E.g., a Parity 3 cow, on her second AI, has a probability of conception of (exp(-0.90 -0.32 -0.13)) / (1 + exp(-0.90 -0.32 -0.13)) = 0.21. If this cow had GP CM one week before insemination, her conception probability is (exp(-0.90 -0.32 -0.13 -0.70)) / (1 + exp(-0.90 -0.32 -0.13 -0.70)) = 0.11. If, instead, this cow had GN CM in the week after insemination, her conception probability is (exp(-0.90 -0.32 -0.13 -1.63)) / (1 + exp(-0.90 -0.32 -0.13 -1.63)) = 0.05.

Table 2 Generalized mixed model for the effects of different types of clinical mastitis (CM) (Gram-positive (GP), Gram-negative (GN), Other) and other factors on probability of conception in 23,695 lactations in 14,148 Holstein cows in 7 New York State herds.[1]

Parameter	Level	Estimate (standard error)
Intercept		-0.90*** (0.04)
Parity	1	--[2]
	2	-0.18*** (0.02)
	3	-0.32*** (0.03)
	4+	-0.33*** (0.03)
Insemination attempt	First	--
	Second	-0.13*** (0.02)
	Third	-0.17*** (0.03)
	Fourth	-0.22*** (0.03)
CM occurring 8-14 d before an insemination	GP	-0.35 (0.23)
	GN	-0.39* (0.20)
	Other	0.09 (0.21)
CM occurring 1-7 d before an insemination	GP	-0.70* (0.28)
	GN	-0.68* (0.27)
	Other	-0.28 (0.25)
CM occurring 0-7 d after an insemination	GP	-0.63* (0.27)
	GN	-1.63*** (0.29)
	Other	-0.67** (0.25)
CM occurring 8-14 d after an insemination	GP	-0.34 (0.22)
	GN	-0.88*** (0.23)
	Other	-0.50* (0.23)
CM occurring 15-21 d after an insemination	GP	-0.00 (0.22)
	GN	-0.87*** (0.22)
	Other	-0.49* (0.25)
CM occurring 22-28 d after an insemination	GP	-0.34 (0.23)
	GN	-0.55** (0.21)
	Other	-0.53* (0.25)
CM occurring 29-35 d after an insemination	GP	-0.75** (0.26)
	GN	-0.30 (0.20)
	Other	-0.01 (0.20)

[1]This model also contained season of breeding, farm, and retained placenta (estimates not shown).
[2]--Reference level; for CM, the reference is no CM in the interval
* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$

CONCLUSIONS

Added information on CM (e.g., its timing with respect to AI; whether the causative agent is GP, GN, or Other) seems beneficial in determining why some cows have trouble conceiving. It may also help in management of CM cows before and after AI. This information could be instrumental in improving a dairy's profitability.

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