Effects of intramammary infection and parity on calf weaning weight and milk quality in beef cows


The online version of this article, along with updated information and services, is located on the World Wide Web at:
http://jas.fass.org
Effects of intramammary infection and parity on calf weaning weight and milk quality in beef cows

M. J. Paape*, M. I. Duenas†, R. P. Wettemann‡, and L. W. Douglass†

*Immunology and Disease Resistance Laboratory, USDA-ARS, Beltsville, MD 20705; †Department of Animal and Avian Sciences, University of Maryland, College Park 20742; and ‡Department of Animal Science, Oklahoma Agricultural Experiment Station, Stillwater 74078

ABSTRACT: The objectives of this study were to determine 1) the effect of intramammary infection on calf weaning weight, milk somatic cell count, and milk composition, and 2) the effect of parity on percentages of infected cows, infected quarters, and blind quarters. The number of infected quarters, milk somatic cell counts, milk components, and intramammary infection were studied at weaning in 164 beef cows. The percentage of infected cows ranged from 61.9% at first parity to 66.7% at fifth to ninth parities. Cows with three or four infected quarters had higher \( P < .01 \) milk somatic cell counts than cows with zero, one, or two infected quarters. Among bacterial isolates, \textit{Staphylococcus aureus}-infected quarters had the highest \( P < .01 \) milk somatic cell count. Percentages of butterfat and lactose were lower \( P < .01 \) in milk from infected quarters than from uninfected quarters. Infections by \textit{S. aureus} and coagulase-negative staphylococci were the most common and accounted for 67 to 78% of the infections. Percentages of infected quarters and infections caused by \textit{S. aureus} increased with parity \( P < .01 \). Intramammary infections did not affect \( P > .10 \) calf weaning weight. In conclusion, intramammary infection had no effect on calf weaning weight but increased milk somatic cell count and decreased the percentage of protein, lactose, solids-not-fat, and butterfat. The number of infected and blind mammary quarters increased with parity.

Key Words: Beef Cows, Infection, Mastitis, Somatic Cell Counts

Introduction

Most studies conducted on mastitis in cows have focused their attention mainly on dairy animals (Eberhart et al., 1987; Harmon, 1994; Nickerson et al., 1994). The types and prevalence of intramammary infections in dairy cows have been determined (Jain, 1983). Approximately 50% of dairy cows are infected in an average of two quarters, each with a pathogenic bacterium (Philpot and Nickerson, 1991). Losses associated with mastitis in dairy cows are estimated to be over $2 billion annually (Philpot and Nickerson, 1991). Mastitis in dairy cows causes decreased milk production, increased milk somatic cell count (MSCC), and alters milk components (Crossman et al., 1950; Philpot, 1967). On the contrary, mastitis in beef cows has received little attention. Milk yield accounts for more than 60% of the variation in calf preweaning weight gains (Rutledge et al., 1971; Boggs et al., 1980; Neville, 1962). Several studies conducted in beef cows have demonstrated that specific bacterial isolates, the total number of infected quarters, and cow age are capable of affecting calf weaning weight because of reduced milk production (Haggard et al., 1983; Watts et al., 1986; Newman et al., 1991). In addition, MSCC might vary according to the type of bacterial isolates identified. Several studies have demonstrated that the prevalence of mastitis in beef cows ranges from 7 to 54% of the cows and 2.6 to 29.2% of the quarters (Wilson et al., 1971; Haggard et al., 1983; Newman et al., 1991).

The objectives of this study were to determine 1) the effect of the number of infected quarters and pathogen group on calf weaning weight; 2) the effect of the number of infected quarters, regardless of the type of pathogen, on calf weaning weight and MSCC; 3) the effect of the types of bacterial isolates on MSCC and milk composition; and 4) the effect of parity on percentages of infected cows and infected quarters.

Materials and Methods

Experimental Animals. One hundred and sixty-four Hereford and Hereford × Angus cows at the Oklahoma...
Agricultural Experimental Station in Stillwater were used. Cows were divided into three parity groups. The first group consisted of cows in their first parity \((n = 21)\), the second group consisted of cows in their second through fourth parities \((n = 76)\), and the third group consisted of cows in their fifth through ninth parities \((n = 67)\).

Cows were maintained on native range and Bermuda grass pastures. When pastures were dormant, 20 to 40% CP supplements were fed to maintain cow body condition score between 4 and 5.5 (Wagner et al., 1988). When snow and ice covered standing forage, hay was fed. Cows calved from February through May on pasture. Cow weight and body condition score were obtained at least every 2 mo to assess nutritional management practices. Weaning weights of calves were adjusted to 205 d of age.

**Milk Sampling.** All animals were sampled at weaning in October following standard procedures (NMC, 1990). Calves were separated from their dams 2 to 3 h before milk collection to ensure the collection of adequate volumes of milk. Cows were directed into conventional milk collection to ensure the collection of adequate volumes of milk. Cows were divided into three parity groups. The Agricultural Experimental Station in Stillwater for analyses.

Milk samples for MSCC and milk composition were sent to USDA Natl Agricultural Library on March 11, 2008. Copyright © 2000 American Society of Animal Science. All rights reserved. For personal use only. No other uses without permission.
within parity group was the random variable for the PROC MIXED procedure.

For weaning weight, data were analyzed according to the number of infected quarters in association with pathogen group that consisted of either major or minor pathogens, and also by the number of infected quarters regardless of the type of isolated pathogen. In both cases, the same model was used adjusting for sex of calf. Major pathogens included only S. aureus, whereas minor pathogens included Bacillus spp., CNS, C. bovis, Streptococcus spp. not Streptococcus agalactiae, and undetermined isolates. In cases in which both minor and major pathogens were found in different quarters of the same cow, the most pathogenic isolate was considered regardless of the number of quarters infected with either one. Calf weaning weight was also analyzed according to cow parity group (one, two to four, and five to nine parities), type of pathogen, and number of infected quarters regardless of type of pathogen present.

Actual counts for MSCC were transformed to natural logarithm for analysis. Cow weight at weaning, calf birth weight, julian birth date, and cow body condition score were used as covariates to adjust the different models.

The effect of parity on the percentage of cows and quarters infected, and percentage of quarters infected with CNS, S. aureus, and other bacteria were analyzed by chi-square (Ostle, 1964). Effect of parity on the percentage of blind quarters was not analyzed because some expected values were too small and the chi-square statistic may not be a valid test.

Least squares means and specific contrasts of interest are reported for weaning weight, MSCC, and milk composition. Means are reported for percentage of infected cows, percentage of infected quarters, percentage quarters infected with CNS, percentage quarters infected with S. aureus, and percentage quarters infected with other bacteria.

Results and Discussion

Bacteriology. In this study, pathogen group was divided as either major (S. aureus) or minor (Bacillus spp., CNS, C. bovis, Streptococcus spp. not Streptococcus agalactiae, and undetermined isolates). This criterion was used because only a few isolates (.3%) of Streptococcus spp. were found, and we preferred looking at the effect of S. aureus alone.

The percentage of infected quarters was 31.7% (Table 1). This percentage was similar to the 27.5% reported previously in purebred (one through five lactations) and crossbred (one through eight lactations) beef cows in late lactation (Newman et al., 1991) but higher than the 18.1% reported in purebred and crossbred cows (Watts et al., 1986) and the 4.6 and 2.7% reported for confinement and range pasture beef cow operation systems, respectively (Haggard et al., 1983).

Of the infected quarters, infections with CNS, S. aureus, and other bacterial isolates were 16.5 ± 1.5, 8.2 ± 1.1 and 7.0% ± 1.0, respectively (Table 1). Staphylococcus hyicus, Staphylococcus chromogenes, and Staphylococcus epidermidis accounted for 6.1, 10.3, and 0.1% of the CNS-infected quarters. In another study with beef cows in late lactation (Newman et al., 1991), 2.5% of the quarters were infected with S. hyicus, which is less than the percentage observed in the present study for both subspecies of S. hyicus. In dairy cows, infections by CNS averaged 11% of the quarters (Hogan et al., 1987). Although CNS causes a slight increase in MSCC, it is considered as a minor intramammary pathogen. For the other bacterial isolates, C. bovis, Streptococcus spp. not Strep. agalactiae, Bacillus spp. and undetermined isolates accounted for 5.9, .3, .3, and .5%, respectively. The pathogenicity of C. bovis is debatable and its presence in the bovine udder may not be suggestive of a serious mastitis problem (LeVan et al., 1985). In fact, presence of C. bovis might prevent infection by more virulent mastitis pathogens (Nickerson and Boddie, 1994). The 5.9% infection rate observed for C. bovis in this study was lower compared with 18.2% found in another study during late lactation (Newman et al., 1991).

Gram-negative bacteria were never isolated. This is quite different from the situation in dairy cows. Because of the confined housing of dairy cows, exposure to environmental pathogens is high. Eighty-one percent of clinical infections in commercial dairy herds came from clinical cases of mastitis (Smith et al., 1985). Streptococcus agalactiae has rarely been isolated from infected quarters of beef cows (Sobari et al., 1976; Kirkbride, 1977). In the current study, Streptococcus agalactiae was not isolated from any of the infected quarters. The absence of this bacteria is in accordance with previous studies in beef cows (Wilson et al., 1971; Watts et al., 1986; Newman et al., 1991). In a study on cows that were used for nursing calves (Hunter and Jeffrey, 1975), an unexpected 18% of the quarters were infected with Strep. agalactiae. Possibly because some of the cows might have been dairy cows before becoming nurse cows, infection with Strep. agalactiae may have spread into the beef cow population by cross-suckling. In the present study, infections by Streptococcus spp. nonagalactiae were low and averaged only .3% of the quarters.

The average percentage of infected cows found in this study was 66.1% (Table 1). This percentage was higher than the 54.4% found in purebred (one through five lactations) and crossbred (one through eight lactations) beef cows in late lactation (Newman et al., 1991), the 42.3% (Sobari et al., 1976), the 40% (LeVan et al., 1985), the 37% found in purebred Hereford and crossbred Hereford × Brahman and Hereford × Brown Swiss (Watts et al., 1986), and the 11.9% (Haggard et al., 1983) reported previously. Reasons for these differences are not obvious because similar isolation techniques were used. In the present study, the greater overall percentage of infected cows might be attributed to cross-suckling, which is known to occur in beef cows (Newman et al., 1991).
Because of the uneven distribution of cows by parity group, the data set was unbalanced and chi-square was used to evaluate infection in cows and quarters by parity group, the data set was unbalanced and chi-square was found in dairy cows with respect to parity (Philpot and Nickerson, 1991). In studies on purebred and crossbred primiparous and multiparous cows, an increase in the prevalence of infected quarters has also been found as cow age and stage of lactation increase (Sobari et al., 1976; Newman et al., 1991). Compared with the results in the current study, a lower percentage (32%) found in another study (Newman et al., 1991) or the 7.1% (Watts et al., 1986) found in other studies and less than the 9.8 and 10.7% found in confined and range pasture herds (Haggard et al., 1983). The range of prevalence of S. aureus infection found in beef cows falls in the lower ranges for that reported in dairy cows (Fox and Hancock, 1989).

In dairy cows, S. aureus is considered a contagious organism, easily spread among cows during milking. Common management practices, such as teat dipping and dry cow therapy, in dairy cows help reduce its prevalence (Eberhart et al., 1983; Philpot and Nickerson, 1991). For beef cows, differences in management could explain why its prevalence varies considerably from herd to herd (Newman et al., 1991). Because teat dipping and dry cow therapy are not practiced in beef cows, percentages of S. aureus infections would be expected to be greater in beef cows. The advantage for beef cows of not having infections by S. aureus spread from cow to cow during milking might be counteracted by the nursing calf. The calf may act as a vector in spreading infections from one quarter to another in the same cow and from one cow to another cow (Day et al., 1987).

**Blind Quarters.** The percentages of blind quarters appeared to increase with parity group (Table 1); however, this could not be tested because of the small inci-

### Table 1. Percentage of cows with infected mammary quarters and percentage of total infected quarters within each parity group

<table>
<thead>
<tr>
<th>Variable, %</th>
<th>1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>2 to 4&lt;sup&gt;b&lt;/sup&gt;</th>
<th>5 to 9&lt;sup&gt;a&lt;/sup&gt;</th>
<th>P &lt;sup&gt;c&lt;/sup&gt;</th>
<th>Overall&lt;sup&gt;d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infected cows</td>
<td>61.9</td>
<td>66.8</td>
<td>66.7</td>
<td>NS&lt;sup&gt;d&lt;/sup&gt;</td>
<td>66.1</td>
</tr>
<tr>
<td>Infected QT</td>
<td>25.0</td>
<td>27.2</td>
<td>39.1</td>
<td>.01</td>
<td>31.7</td>
</tr>
<tr>
<td>CNS&lt;sup&gt;e&lt;/sup&gt;</td>
<td>21.4</td>
<td>17.2</td>
<td>14.1</td>
<td>NS</td>
<td>16.5</td>
</tr>
<tr>
<td>S. aureus&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1.2</td>
<td>4.4</td>
<td>15.0</td>
<td>.01</td>
<td>8.2</td>
</tr>
<tr>
<td>Other&lt;sup&gt;f&lt;/sup&gt;</td>
<td>2.3</td>
<td>5.6</td>
<td>10.0</td>
<td>NS</td>
<td>7.0</td>
</tr>
<tr>
<td>Blind QT</td>
<td>0</td>
<td>.7</td>
<td>3.7</td>
<td>NA&lt;sup&gt;e&lt;/sup&gt;</td>
<td>1.8</td>
</tr>
</tbody>
</table>

<sup>a</sup>n = 21, 76, and 67 cows for parity groups 1, 2 to 4, and 5 to 9, respectively.  
<sup>b</sup>Chi-square analysis showed significance for infected quarters and Staphylococcus aureus.  
<sup>c</sup>Represents overall results of the herd (n = 164 cows).  
<sup>d</sup>NS = not significant.  
<sup>e</sup>CNS = Coagulase-negative staphylococci.  
<sup>f</sup>Other grouped the following species: Bacillus spp., Corynebacterium bovis, Streptococcus spp. not Streptococcus agalactiae, and undetermined isolates.  
<sup>e</sup>NA = Not analyzed.

Copyright © 2000 American Society of Animal Science. All rights reserved. For personal use only. No other uses without permission.
dence of dry quarters. Primiparous cows had no blind quarters; in cows with two to four parities, 7% of the quarters were blind; and, in cows with five to nine parities, 3.7% of the quarters were blind. The overall percentage of blind quarters observed in this herd was 1.8%. In a study using primiparous Simmental cows, a total of 4% of the quarters were nonfunctional during some point of the study (Simpson et al., 1995). Blind quarters in beef cows may result from intramammary infections, physical injury, or other unknown factors.

Milk Somatic Cell Count. Average milk somatic cell count for all quarters of a cow increased as the number of infected quarters in each cow increased (Table 2). Milk somatic cell count was higher for one to two infected quarters \((P < .01)\) and for three to four infected quarters \((P < .001)\) when each was compared to zero infected quarters. The values for MSCC obtained for infected quarters were similar to those reported in another study for uninfected quarters (Watts et al., 1986) but lower than those reported by Newman et al. (1991). Calf weaning weight and MSCC analysis according to the number of infected quarters regardless of type of pathogen are presented (Table 2). Calf weaning weight did not change \((P > .10)\) as the number of infected quarters increased from zero to four. One study reported that 210-d weaning weight of calves was influenced by the number of infected quarters of the cow (Watts et al., 1986). Calves nursing cows with one, two, three or four infected quarters had lighter weaning weights than those nursing uninfected cows. Mean calf weaning weight observed in the current study is similar to the mean adjusted 205-d weaning weight reported for Angus cows in a confinement operation system (Haggard et al., 1983).

Milk somatic cell count was not influenced \((P > .10)\) as parity group increased from one to nine (Table 3). In agreement with this study, Wilson et al. (1971) showed that in crossbred Angus \(\times\) Holstein cows of one to five parities, the number of parities had no effect on MSCC. Values for MSCC for the different parity groups found in the current study were lower than reported in the previous study. The average MSCC for beef cows in this study were similar to those reported for dairy cows (Paape et al., 1973, 1975).

Calf Weaning Weight. Neither the number of infected quarters (Table 2) nor pathogen group (data not shown) affected calf weaning weight \((P > .10)\). This is in agreement with a previous study in which no difference was found for 205-d weight between calves nursing quarters infected with \(S.\) aureus or Streptococcus dysgalactiae and calves nursing cows infected with other isolates (Simpson et al., 1995). In a study with Polled Hereford and Charolais cows, infection with \(S.\) aureus in the dam had no effect on calf weaning weight (Simpson et al., 1994).

Other investigators have found opposite results. Adjusted weaning weights of calves nursing cows infected with \(S.\) aureus were less than calves nursing uninfected cows (Haggard et al., 1983; Watts et al., 1986; Newman et al., 1991). In a study in which the level of infection was determined in early lactation, significant differences in calf weight gain between calves nursing from \(S.\) aureus-infected and -uninfected cows was observed during the preweaning period \((0\) to \(205\) d) (Newman et al., 1991). In the same study, calves nursing cows infected with any kind of pathogen during d 60 to 100 of the preweaning period and calves nursing cows infected with \(S.\) aureus or \(C.\) bovis during the 60- to 205-d preweaning period had lower weight gains than calves nursing uninfected cows.

In dairy cows, there is a negative correlation between milk production and intramammary infections (Philpot and Nickerson, 1991). The same correlation probably also occurs in beef cows. Therefore, as the number of infected quarters in a cow increases, milk production likely decreases, resulting in lower calf weaning weight. We failed to find such differences because of the confounding effect of nutritional and environmental factors that influenced calf weaning weight. Any difference in calf weaning weight due to lower production would probably be detected in calves from cows that had three or four infected quarters. In this study, when the number of infected quarters increased from one to four, only a nonsignificant numerical reduction for calf weaning weight was observed. Other studies (Gleddie and Berg, 1968; Rutledge et al., 1971; Boggs et al., 1980) demonstrated that milk production of beef cows accounted for 60 to 71.3% of the variation of adjusted calf weaning weight and calf preweaning weight gains. Failure to find differences in weaning weight in this study could be due to lower milk production of younger cows, and more healthy quarters.

<table>
<thead>
<tr>
<th>Table 2. Calf weaning weight and milk somatic cell count (MSCC) according to the number of infected quarters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variable</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Weaning weight, kg&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>MSCC, cells (\times 10^9/mL)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Overall ANOVA was significant for MSCC.

<sup>b</sup>SE = pooled standard error based on 164 calves.

<sup>c</sup>Calves were weaned in mid-October 1993 at an average age of 235 ± 1.6 d. Range of julian birth date was 5 to 111 d.

<sup>d</sup>NS = not significant \((P > .10)\).

<sup>e</sup>Analysis was performed on data transformed to natural log.
Milk Composition. Analysis of percentages of milk composition according to parity group showed a different pattern for each component (Table 3). Percentages of protein and solids-not-fat were not different (P > .10) among cow parity groups. However, butterfat tended to be less (P < .10) in cows with one parity than in cows with two to nine parities. Within multiparous cows, cows with two to four parities produced milk with a greater (P < .05) percentage of butterfat than cows with five to nine parities. Lactose tended to be greater (P < .10) in primiparous cows than in multiparous cows. Lactose percentage for cows of two to four parities compared with cows of five to nine parities was not different (P > .10). The major constituents reported in this study for beef cows were similar to those reported for dairy cows (Schalm et al., 1971).

The type of bacterial isolates found in milk affected all of the milk components (Table 4). Percentages of protein (P < .05), lactose (P < .001), and solids-not-fat (P < .001) were greater and, butterfat tended to be greater (P < .10) in milk from uninfected quarters than in milk from cows with infected quarters; in particular, the percentages were less in milk from S. aureus-infected quarters. Within infected quarters, butterfat percentage was not different (P > .10), protein percentage tended to be less (P < .10), and lactose percentage and of solids-not-fat were lower (P < .001) in milk from quarters infected by S. aureus than in quarters infected by CNS and other bacterial isolates. Similarly, in another study, S. aureus-infected quarters were also associated with lower values for milk protein percentage than uninfected quarters (Watts et al., 1986). Comparing the effects of type of bacterial isolate with MSCC and milk components, one can observe that the lowest MSCC in infected quarters was associated with the highest percentage of milk components, whereas the opposite was true for quarters infected with S. aureus. The opposite was found in a previous study in which cows with high MSCC had greater percentage of protein and butterfat in late lactation than cows with low MSCC (Simpson et al., 1995).

On the basis of the results of this study, we conclude that intramammary infections in beef cows did not affect calf weaning weight. Coagulase-negative staphylo-
cocc were the most common organisms isolated from early-parity cows, whereas *S. aureus* was the most common organism for later-parity cows. Intramammary infection increased MSCC and decreased the percentages of protein, lactose, solids-not-fat, and butterfat.

**Implications**

Results indicate that 66% of beef cows on pasture have subclinical mastitis, and 15% of all mammary quarters for cows with five to nine parities are infected with *Staphylococcus aureus*. For beef cows with fewer parities, only 1 to 4% of the quarters are infected. This organism is a serious mastitis pathogen that destroys mammary secretory tissue and causes decreased milk production. It is spread from cow to cow through the transfer of infected milk from one mammary quarter to another by suckling. Weaning weight of calves from cows with subclinical mastitis in four mammary quarters was 5 kg less than herd mates free from intramammary infection. A mastitis control program for beef cows may reduce incidence of mastitis and the spread of *S. aureus* and increase calf weaning weight.

**Literature Cited**


Ostle, B. 1964. Statistics in Research. 2nd ed. The Iowa State University Press, Ames, IA.


