Environmental Effects on Conception Rates of Holsteins in New York and Georgia

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ABSTRACT

The purpose of this study was to investigate the compounded impact on conception rates (CR) of the effects of milk production, service month, and days in milk (DIM) by using recent artificial insemination records of Holsteins in New York (NY) and Georgia (GA). Dairy Herd Improvement records were obtained from Dairy Records Management Systems in Raleigh, North Carolina. After removing records with lactations >1 and uncertain and extreme records (records without a calving or birth date, with days to service after calving of <21 or >250, and without the next calving date), the final data set comprised 298,015 service records for 160,879 cows and 23,366 service records for 12,184 cows in NY and GA, respectively, from 2000 to 2003. The analytical model included DIM class, milk-production level, service month, the covariate of cow's age at calving, and all 2-way interactions. The 2 states were analyzed separately. In general across the 2 states, CR declined as milk production increased, and CR declined during the hottest months. Conception rate was similar in NY and GA, at approximately 55% from December to April. In NY, CR declined by approximately 10% in May and June and mostly recovered by July. In GA, the CR started declining in May, bottomed at 31% in September, and did not recover until December. The difference in CR between high- and low-producing cows was 7% in NY and 6% in GA. That difference was the strongest from June to July in GA (15%) and was more uniform in NY. The increase in CR with increasing DIM varied across service season. The CR was nearly flat from 50 to 125 DIM in NY for all seasons, except for a large increasing trend in spring. In GA, there was also an increasing trend in fall. Conception rates were similar in NY and GA between December and May, and were strongly influenced by heat stress in GA from June to November. A decline in CR for reasons other than heat

stress was present in both states in late spring. High production resulted in a faster decline of the CR in GA under heat stress. Models analyzing service records should include the DIM × season × region interaction. **Key words:** conception rate, fertility, Holstein

INTRODUCTION

Holsteins have been known as the most productive breed of dairy cattle in the United States. However, their reputation has been changing slowly from very productive to less fertile. Factors such as milk production, DIM, and heat stress have been shown to have an impact on measures of fertility. Several studies have reported the existence of an antagonistic relationship between milk production and fertility (Dematawewa and Berger, 1998; Lucy, 2001; Pryce et al., 2004). Other studies have found that increased milk production has little to no impact on reproduction (Eicker et al., 1996; Weigel and Rekaya, 2000). Washburn et al. (2002) showed that several measures of cow fertility were level or slightly decreased during the 1970s and into the middle 1980s, but they began to decline drastically during the late 1980s and early 1990s as milk production continued to increase. For example, Washburn et al. (2002) reported that days open greatly increased in the latter years of the study, perhaps indicating that producers were having increased difficulty in getting cows bred in the early part of lactation. Clay and McDaniel (2001) showed that a cow bred before 50 DIM had a 5.5% greater chance of being rebred than a cow bred after 70 DIM, and a cow bred after 139 DIM had 3.3% less chance of rebreeding than a cow bred at 70 to 79 DIM.

Fertility in lactating dairy cows is also very sensitive to season, especially in hot climates. The negative impact of heat stress or season on reproductive efficiency has been a topic of many studies (Ravagnolo and Misztal, 2002; Oseni et al., 2003; de Vries et al., 2005). de Vries and Risco (2005) showed that a ratio of pregnancy rate comparing summer with winter decreased from 56% in the 1970s to 35% in 2002 in Georgia (GA) and

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Florida, indicating that the negative impact of heat stress on fertility has increased over time.

The purpose of this study was to analyze individual inseminations by using DHI records from Holsteins in GA and New York (NY) to determine the synergistic impact of milk production, DIM, and season on conception rate (CR).

MATERIALS AND METHODS

Data

Animal Care and Use Committee approval was not obtained for this study because field data were used. Insemination and production records in NY and GA collected from 2000 to 2003 were obtained from the Dairy Record Management System, Raleigh, North Carolina. Artificial insemination records with birth date, calving date, service dates, cow identification, and lactation number were considered as valid data. Only service records from primiparous cows during their lactation were considered. Further edits eliminated service records with <21 DIM or >250 DIM and first calving ages of <20 mo or >36 mo. A subsequent calving record was required to confirm a successful conception; therefore, cows that did not have a calving record linked to a possible breeding event during their first lactation were removed. If a calving record existed, a predicted last service date was calculated from the calving date initiating the second lactation minus 280 d. If the difference between the predicted last service date and the observed last service date was within ± 10 d, the observed service date included with the record was used as the successful conception date. If the difference was between 10 and 70 d or between -10 and -70 d, the predicted last service date was used as the successful conception date. If the difference was greater than 70 d or less than -70 d, the record was removed. For each service recorded for a cow, the cow received a score of 1 if she conceived as a result of the service or a score of 0 if she failed to conceive. Therefore, CR provides the probability of conception for a particular service, as previously indicated. Conception rate, as defined in this study, was computed only for cows conceiving during the first lactation.

Three milk-production levels (low, medium, high) were defined based on the average of either the last 2 or 3 test-day milk records before insemination. Cows were assigned to milk-production levels based on the mean and SD within a DIM group because test-day milk production changed with DIM. Cows that had only 2 milk test days recorded before insemination had their milk-production level assigned based on the average of the 2 test days, whereas cows that had at least 3 test days recorded before insemination had their milk-pro-

Table 1. Numbers of service records in New York and Georgia

Classification	New York	Georgia
DIM group		
21–50	13,425	1,307
51–75	72,222	4,430
76–100	63,846	4,558
101–125	49,409	3,847
126–150	36,314	2,912
151–175	25,368	2,286
176–200	17,315	1,645
201–225	11,516	1,317
226–250	8,600	1,064
Service month		
January	29,068	3,228
February	26,544	2,722
March	28,031	2,606
April	23,005	1,852
May	21,188	1,565
June	22,292	1,320
July	26,583	1,309
August	26,637	1,279
September	24,768	1,518
October	25,372	1,556
November	23,556	2,015
December	20,971	2,396
Milk-production level		
Low	47,038	3,814
Medium	204,872	15,876
High	46,105	3,676

duction level assigned by using the average of the 3 test days before insemination. Cows without test-day milk records or with only one test-day record before insemination were removed. After all edits, the final data sets consisted of 298,015 service records for 160,879 cows in NY and 23,366 service records for 12,184 cows in GA. The numbers of service records in NY and GA are shown in Table 1 by DIM group, service month, and milk-production level. The average test-day yields (in kg) for low, medium, and high production levels were 17.3 ± 6.0 , 27.8 ± 6.6 , and 38.2 ± 6.3 for NY, respectively, and 15.9 ± 5.6 , 26.3 ± 6.3 , and 36.1 ± 5.9 for GA, respectively.

Statistical Analyses

Data were initially analyzed by using both the GLM procedure and the LOGISTIC procedure in SAS (SAS Institute, 1996). Included in the model were the effects of age at calving as a covariate, DIM interval group, service month, milk-production level (less than the mean - 1 SD, between ± 1 SD from the mean, greater than the mean + 1 SD), and all 2-way interactions. Because the LOGISTIC procedure was time and memory intensive, and the initial results from the LOGISTIC procedure produced trends similar to those from the GLM procedure, the GLM procedure was used to conduct all subsequent analyses, and the resulting least

Figure 1. Conception rates across service month for low and high milk-production levels in New York (NY) and Georgia (GA).

squares means from this procedure are presented. The 2 states were analyzed separately.

RESULTS AND DISCUSSION

Impact of Service Month and Milk-Production Level in NY and GA

All CR reported are most likely overestimated because records that were incomplete or from those cows that failed to conceive were eliminated; more accurate editing was difficult with the available information. All effects in the model were highly significant ($P < 0.001$). The overall CR were 55, 51, and 48% in NY and 48, 45, and 42% in GA for low, medium, and high milk-production levels, respectively. The unfavorable effect of high milk production on CR agrees with several studies reporting that cows with high milk production generally have longer days open (Marti and Funk, 1994), longer calving intervals (Ojango and Pollott, 2001), a greater number of services (Dematawewa and Berger, 1998), and lower pregnancy rates (Oseni et al., 2004b).

Figure 1 presents CR across service months for low and high milk-production levels in NY and GA. For purposes of clarity, graphs for the medium milk-production level were not included; however, their trends were intermediate to high and low milk-production levels in NY and were somewhat intermediate to high and low

production levels in GA, particularly during the hottest months of the year. Milk production and reproduction are affected by seasonal factors such as feeding (pasture, hay, silage) and climate (temperature, humidity, wind). Several studies on different fertility traits have reported that cows under heat stress have longer days open and calving intervals (Marti and Funk, 1994; Oseni et al., 2003, 2004a) and have lower nonreturn pregnancy rates and CR (Ravagnolo and Misztal, 2002; Jordan, 2003; de Vries and Risco, 2005).

Figure 2 provides the average daily temperature-humidity index (THI) for each month in GA and NY. The average daily THI for each state was obtained from the mean of hourly temperature and humidity measures provided by 6 weather stations scattered across each state during the time frame in which the data were collected. The THI was computed according to Bohmanova et al. (2005). Research by Ravagnolo and Misztal (2002) indicated that reproduction was negatively influenced by average daily THI ≥ 70 . The average THI for GA during the months of June to September were above 70, and the month of May was above 68, whereas NY never reached an average THI of 70 in any month of the year, and only the months of July and August were above 68.

In Figure 1, the large drop in CR during the summer for cows in GA coincided with the high THI measures

Figure 2. Average daily temperature-humidity index (THI) by month for New York (NY) and Georgia (GA) for the years 2000 to 2003.

provided in Figure 2, thus providing strong evidence that cows in GA were under greater heat stress during the summer than those in NY. Conception rate was highest during the cool season (January to April) in both NY and GA, with a low for high milk-producing cows in NY of 49% in February to a high of 62% for low milk-producing cows in GA in March. There was a decline in both states for cows of all production levels beginning in May. For GA, this could be due to heat stress, and for both states, it could be due to some management factors, for example, the change to more pasture-based feeding systems. The CR for low- and medium-producing cows in NY declined in May (46%) and June (45%), and this decline was most likely due to cows being switched to grazing systems; however, the CR of both low- and medium-producing cows recovered after this period, which indicates that cows with medium to low milk production were under little to no heat stress during the summer in NY. High-producing cows in NY also improved in CR after 2 mo but did not return to cool season levels for several months, which may indicate that the energy demands of high milk production coupled with the increased temperature of summer may have caused some heat stress in these animals. The impact of heat stress for cows in GA was much more dramatic. The average CR during the months of June to September for low and high milk-producing cows were 40 and 30%, respectively, whereas

the average CR for low and high milk-producing cows in NY during the same time period were 55 and 45%, respectively. The CR for cows in GA for all 3 milk-production levels were severely influenced by heat stress for the entire summer into the fall, and the decrease in CR caused by heat stress was more substantial as milk production increased. López-Gatius (2003) found that the negative impact of milk production on fertility was far less severe in cool seasons as compared with hot seasons. A similar trend was found in this study, where the impact of high production on CR was far less severe in NY in the summer when compared with GA. Furthermore, fertility in GA did not recover to January to April levels for cows of all production levels until November to December because of the lingering effects of heat stress. Al-Katanani et al. (2002) reported that heat stress may cause damage to the ova, and it may take approximately 2 mo for the ova quality to return to normal after heat stress occurs. Morton et al. (2007) found that CR were affected by a high heat load before and after service. In particular, heat loads in wk 3 to 5 before service were associated with reduced CR. The CR trends in GA clearly showed that the heat stress during summer had a detrimental impact on cow fertility in the Southeast, and therefore, as reported by Oseni et al. (2003), some dairy producers probably chose to refrain from breeding cows during certain months of the summer because of low fertility during this season.

Figure 3. Conception rates across DIM classes for the months of February, May, August, and October in New York.

Impact of DIM and Season and DIM and Milk-Production Level in NY and GA

Conception rates averaged across all seasons, milk-production levels, and DIM were 51% in NY and 45% in GA. The average CR increased with DIM in both states, from 43% at 50 DIM to 52% at 175 DIM in NY, and from 33% at 50 DIM to 46% at 175 DIM in GA. Average CR continued to increase from 175 to 250 DIM for NY (52 to 63%) and for GA (46 to 54%). Some increases, especially at higher DIM, could be an artifact of editing. The results indicated that, in general, cows were less likely to conceive shortly after calving but were more likely to conceive later. Similar results were reported by Clay and McDaniel (2001), who found that breeding cows before 70 DIM had a negative impact on reproduction, and that cows improved in fertility up to d 139 of lactation. Averill et al. (2004) found a positive regression coefficient for the outcome of AI on DIM at insemination (0.003), which showed that cows bred shortly after calving were less likely to get pregnant.

Figures 3 and 4 provide CR for NY and GA, respectively, across DIM for 4 different months of the year. The months of February and August were chosen because they were representative months of winter and summer, respectively. May was chosen because it was a month when grazing might be used and when the weather transitioned toward summer, and October was

selected because it was a month that showed a large drop in THI after the summer. In NY (Figure 3), the greatest increase in CR was from 50 to 100 DIM during the month of May (31 to 37%), with the month of February showing the second-highest increase (44 to 50%). The month of October showed a small increase, whereas August showed no increase. It was also interesting to note that the month of May had the lowest CR for the first 175 DIM for cows in NY, and that the cows being bred during the month of August, in general, did not appear to experience much heat stress. Why CR increased with increasing DIM for cows being bred in May was not clear. One explanation is that switching to grazing systems could have resulted in the occurrence of nutritional imbalances in the first part of lactation when nutritional demands were the highest. Another explanation is that producers were very busy during the spring of the year with other farm activities, which could have taken away from emphasis on heat checking and general reproductive management. Both explanations require that cows at higher DIM had a higher chance of being bred, either because of a deliberate breeding strategy or by stronger heat expression in cows at higher DIM. No clear explanation was evident for the increase in CR with increasing DIM in February.

For GA (Figure 4), a large increase in CR between 50 and 150 DIM was observed in May (15 to 49%) and

Figure 4. Conception rates across DIM classes for the months of February, May, August, and October in Georgia.

in October (29 to 42%). Again, May is a month when increased grazing would occur or when other farm activities could interfere with reproductive management, or perhaps it was a transitional month when the THI began to increase dramatically and increased heat stress was beginning to occur. The CR trend in October was perhaps due to carryover effects from the heat stress experienced into September in GA. In August, no trend in CR with increasing DIM was observed up to d 175, and the range in CR for this range of DIM during this month was low (28 to 35%). The CR trend in DIM in August indicated that cows experienced tremendous heat stress during this month, and very little improvement was observed with increasing DIM until after 175 d. The increase after d 175 DIM is likely an artifact of editing. The trends for GA have higher fluctuations than those for NY, which may be due to the lower number of records for specific subclasses.

The comparison of differences between the 2 states for CR when DIM and milk production were considered simultaneously was of particular interest in this study. Figure 5 presents the CR across DIM for low and high milk-production levels in NY and GA. Again for purposes of clarity, graphs for the medium milk-production level were not included; however, their trends were similar to trends for the high milk-production level. The

CR at 50 d in GA for both high- and low-producing cows was much lower than that for high- and low-producing cows in NY. There was a large increase in CR from 50 to 100 DIM for both low-producing cows (30 to 43%) and for high-producing cows (32 to 43%) in GA. In NY, the increase in CR for both low (44 to 49%) and high (43 to 45%) milk-producing cows from 50 to 100 DIM was much smaller. The trend for increased CR with increasing DIM between 100 to 175 d was modest or negligible for high-producing cows in NY (45 to 47%), high-producing cows in GA (43 to 43%), and low-producing cows in GA (43 to 47%), whereas low-producing cows in NY greatly improved (49 to 57%).

de Vries and Risco (2005) stated that more dairy producers may be increasing their voluntary waiting periods past 70 d, because research has shown that CR increases with longer waiting periods before breeding. This increase in CR after 70 d postpartum is supported by physiological occurrences in the cow because dairy cattle can experience a negative energy balance during early lactation, which could delay intervals to first heat and ovulation, particularly in first-lactation cows (Lucy, 2001; Pryce et al., 2004). However, as shown previously, the increase in CR with increasing DIM in the early part of lactation appeared to be seasonal in nature, and some large seasonal differences were observed between

Figure 5. Conception rates across DIM for low and high milk-production levels in New York (NY) and Georgia (GA).

the 2 states. The low initial CR at 50 DIM in GA for both high and low milk-producing cows followed by an improvement at 100 DIM suggests that additional stress on the cow, other than negative energy balance caused by high milk production, may make a voluntary waiting period in GA of at least 70 to 100 d a necessity at certain times of the year. The dramatic improvements in CR observed in the months of May and October may indicate that either the increased amount of grazing or the onset of hot weather (May), or the carryover effect after the stressful summer (October) may necessitate longer voluntary waiting periods postpartum to obtain acceptable CR. It is also interesting to note that only low-producing cows in NY appeared to increase greatly from 100 to 175 DIM, whereas all other production levels in GA and NY experienced only modest gains throughout this period. This implies that in NY, it takes a period of time for the innate level of fertility to return in medium- to high-producing cows because of the lingering effects of the negative energy balance that occurs in the first part of lactation, whereas low-producing cows in NY were able to recover much more quickly.

The results from this study regarding increasing the CR for very large DIM should be treated with caution because the data were not complete and the editing

was strong. M. Faust (ABS Global Inc., DeForest, WI; personal communication, 2006) reported an experiment in Minnesota in which farms practiced a voluntary waiting period of >200 d. The CR did not improve, whereas various health problems were experienced and herds had problems with replacements. Barbat et al. (2005) analyzed the service records of French Holsteins. They reported little increase in CR after 100 d, which could be real or an artifact of a function used to model DIM.

CONCLUSIONS

Conception rates in NY and GA appeared to be similar during winter and early spring. A decline in CR for reasons other than heat stress was present in both states in late spring. In summer, the CR in GA dropped because of heat stress and slowly recovered in fall. The effect of DIM on CR varied by season. Conception rates appeared to increase with DIM in NY in spring only and were approximately flat otherwise. Conception rates appeared to increase with DIM in GA in spring and fall. Analyses of service records are difficult because of censoring and a number of management and environ-

mental factors. Models analyzing service records should include the DIM $\times$ season $\times$ region interaction.

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