

## Trends in Reproductive Performance in Southeastern Holstein and Jersey DHI Herds

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### ABSTRACT

Trends in average days open and services per conception from 1976 to 1999 were examined in 532 Holstein and 29 Jersey herds from 10 Southeastern states. Three-year averages for eight intervals (time) were calculated (first: 1976 to 1978; eighth: 1997 to 1999). Milk, fat, fat-corrected milk, and number of cows increased across time. Herds of both breeds had linear, quadratic, and cubic effects of time on days open and services per conception. For 1976 to 1978, respective averages of days open and services per conception were  $122 \pm 2.8$  d and  $1.91 \pm 0.08$  for Jerseys,  $124 \pm 0.7$  d and  $1.91 \pm 0.02$  for Holsteins. Days open increased nonlinearly to  $152 \pm 2.8$  d for Jerseys and  $168 \pm 0.7$  d for Holsteins by 1997 to 1999, resulting in a breed  $\times$  time interaction. Services per conception also increased nonlinearly, reaching  $2.94 \pm 0.04$  services for both breeds in 1994 to 1996, changing only slightly after 1996. Fat-corrected milk and number of cows had small but significant effects. Five subregions (one to three states) differed in mean days open and services per conception, but changes in those measures across time among subregions were similar. Days to first service increased by 16 (Holsteins) and 18 d (Jerseys) during the last five 3-yr periods, associated with increasing days open. Estrus detection rates generally declined from 1985 to 1999, associated inversely with services per conception. Reduced reproductive performance in Southeastern dairy herds is of concern. Multiple strategies are needed to attenuate further declines.

(**Key words:** Holstein, Jersey, reproduction, days open)

**Abbreviation key:** DRMS = Dairy Records Management Systems.

### INTRODUCTION

Recent purported declines in fertility of high producing dairy cows are of widespread concern (British Society of Animal Science, 2001; Lucy, 2001) but are not well documented. Using data from 70 DHI Holstein herds in Kentucky, Silvia (1998) reported that both days open and services per pregnancy had increased between 1972 and 1996. This apparent temporal decline in fertility is associated with both genetic improvement and modern management practices that have led to a rapid increase in milk production per cow. Although high fertility is most critical in herds in which seasonal breeding is desired, fertility is also important to long-term productivity in herds with year round breeding, as is prevalent in the United States.

Because the temporal decline in reproductive performance has had only limited, quantitative documentation, a more extensive examination of this phenomenon is warranted. Our objective was to examine temporal trends in days open and services per conception during the period from 1976 through 1999. We also examined potential relationships between reproductive measurements and changes in milk production and herd sizes. Both Holstein and Jersey herds from the 10-state, Southeastern region of the United States were studied.

### MATERIALS AND METHODS

Data were obtained from the Dairy Records Management Systems (DRMS) at Raleigh, North Carolina, and included dairy herd summary records from 561 herds from 10 states in the Southeastern region (Table 1). The dataset was edited to include only herds that had records for at least 23 of the 24 year-end (September or October) herd summaries for the years 1976 through 1999. Also, herds with average services per conception lower than 1.4 in any year (apparent conception rate of  $\geq 71\%$ ) were deleted because of the high probability that some AI breedings were not reported or that there was extensive use of natural service. To reduce the impact of missing data or unusual averages for any

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**Table 1.** Southeastern states with dairy herds included and number of herds per state.<sup>1</sup>

State	AL	FL	GA	KY	LA	MS	NC	SC	TN	VA
Holstein herds	19	9	47	34	24	10	97	30	50	212
Jersey herds	4	0	0	6	2	1	2	6	4	4

<sup>1</sup>Total number of herds was 561, and 532 Holstein herds and 29 Jersey herds. All herds included had at least 23 of 24 yearly DHI annual summaries for the consecutive years 1976 through 1999.

single year, the data were further processed by averaging information within herd for each of eight 3-yr time periods (1, 1976 to 1978; 2, 1979 to 1981; 3, 1982 to 1984; 4, 1985 to 1987; 5, 1988 to 1990; 6, 1991 to 1993; 7, 1994 to 1996; and 8, 1997 to 1999). The edited dataset included summaries from 532 Holstein herds and 29 Jersey herds across each of the eight time intervals. Variables maintained in the dataset included herd, breed, days open, services per conception, time period, number of cows per herd, and rolling herd averages for milk and fat. Also, average intervals from calving to first insemination and estimated average estrus detection rates were used for years 1985 through 1999. Reproductive measures of services per conception and average days open were of primary interest, as those data were consistently available for the entire 24-yr period. In those data, services per conception included all inseminations in all cows divided by the number of pregnant cows. Pregnant cows were determined either by reported pregnancy codes or by nonreturn to a breeding 60 d or more before the most recent herd test date. Average days open included actual intervals for pregnant cows plus estimates on nonpregnant cows based either on the most recent insemination dates or the number of days from calving to test date for cows 60 d or more postpartum but without insemination dates (DRMS). Also, FCM standardized at 4.0% fat was calculated using the formula:  $FCM = 0.4 \text{ times kilograms of milk} + 15 \text{ times kilograms of fat}$  (National Research Council, 1989).

### Statistical Analyses

Data were analyzed using the general linear models procedure in SAS (1997). Data were examined using several approaches. Numbers of cows per herd and kilograms of milk, fat, and FCM were dependent variables in a model to describe changes in those variables across time (3-yr periods). Independent variables included breed, herd within breed, time, and the breed  $\times$  time interaction. Breed effects were determined using the mean square of herd within breed as the error term, and other effects were tested using the residual mean square for error. An analysis was done using days open and services per conception as dependent variables and effects of breed, herd within breed, time, breed  $\times$  time,

FCM, and number of cows as independent variables, again with effects of breed tested using herd within breed as the error term. Another analysis examined days open and services per conception within breed using linear, quadratic, and cubic effects of time, FCM, and number of cows as independent variables. When functions of FCM or number of cows were significant within breed, regression coefficients generated by the model were used to calculate the relative magnitude of those effects on days open and services per conception.

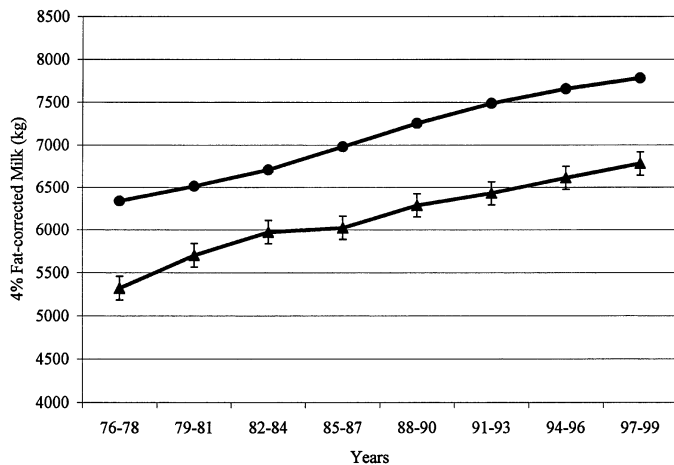
Also of interest was whether or not the changes in days open and services per conception differed by states within the 10-state region. Five subregions were established as follows: 1) AL, MS, LA; 2) GA, FL; 3) KY, TN; 4) NC, SC; and 5) VA. In this analysis, only Holstein herds were included, and comparison of means of various subregions along with interactions of time with subregion were of primary interest.

Because data on the intervals from calving to first service and for estimated estrus detection rates were not available for the years 1976 through 1984, those measures could not be used in regression equations for all eight 3-yr periods but were included in regressions using the more recent data including the five 3-yr periods from 1985 through 1999. Intervals from calving to first service and estimated estrus detection rates were examined for changes across time and were also used as independent variables in regressions to examine relationships to days open and services per conception.

## RESULTS

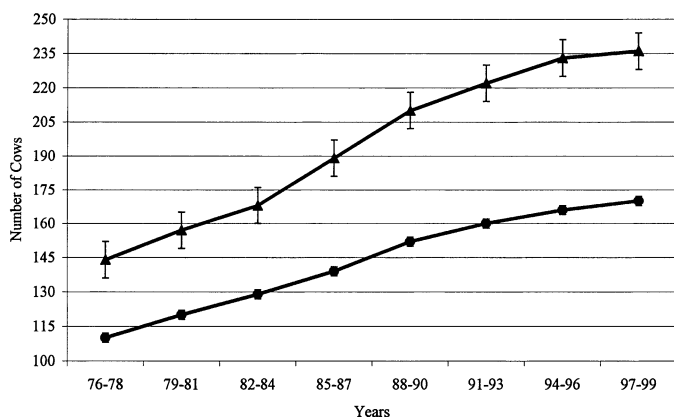
### Production and Herd Size Trends

As expected, least squares means for rolling herd averages for milk and fat yields increased linearly across time for both Holstein and Jersey herds. Means  $\pm$  standard errors for Jersey herds were  $4753 \pm 105$  kg of milk and  $228 \pm 8$  kg of fat per cow in 1976 to 1978 and increased to  $6375 \pm 105$  kg of milk and  $282 \pm 8$  kg of fat in 1997 to 1999; Holstein herds averaged of  $6802 \pm 24$  kg of milk and  $241 \pm 2$  kg of fat per cow in 1976 to 1978 and increased to  $8687 \pm 24$  kg of milk and  $287 \pm 2$  kg of fat in 1997 to 1999. Least squares means for

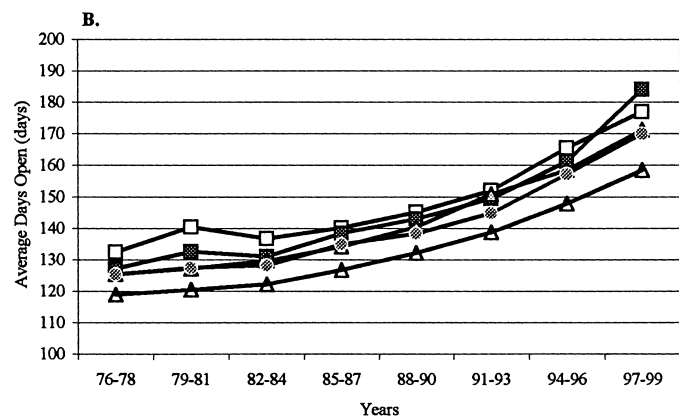
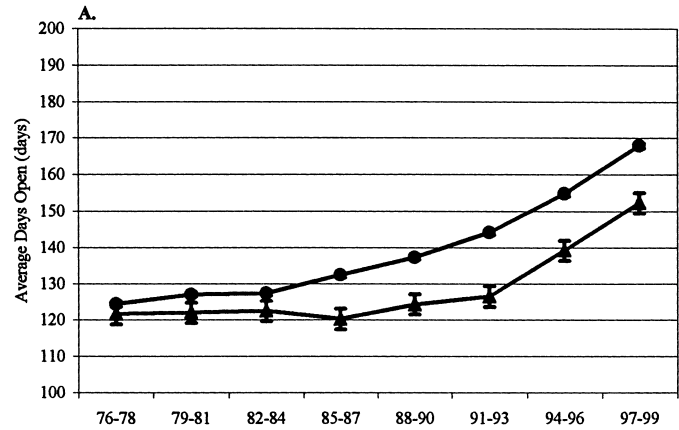


**Figure 1.** Least squares means ( $\pm$  SE) for 4% FCM for 532 Holstein (●, SE = 32 kg) and 29 Jersey (▲, SE = 137 kg) herds for 3-yr periods from 1976 to 1978 until 1997 to 1999. Breed averages differ ( $P < 0.01$ ) and linear effects of time are significant within and across breeds ( $P < 0.01$ ).

Holstein and Jersey herd averages for FCM (Figure 1) and for number of cows per herd (Figure 2) for each of the eight 3-yr time periods illustrate the changes across breed groups in herd size and FCM over time. Increases in FCM were linear across time, and Holstein and Jersey herds had similar average increases. Jersey herds had more cows at the beginning and throughout ( $P < 0.01$ ) and increased herd size by 64% compared with an increase of only 55% for Holstein herds during this period, accounting for the significant breed  $\times$  time interaction ( $P < 0.01$ ).



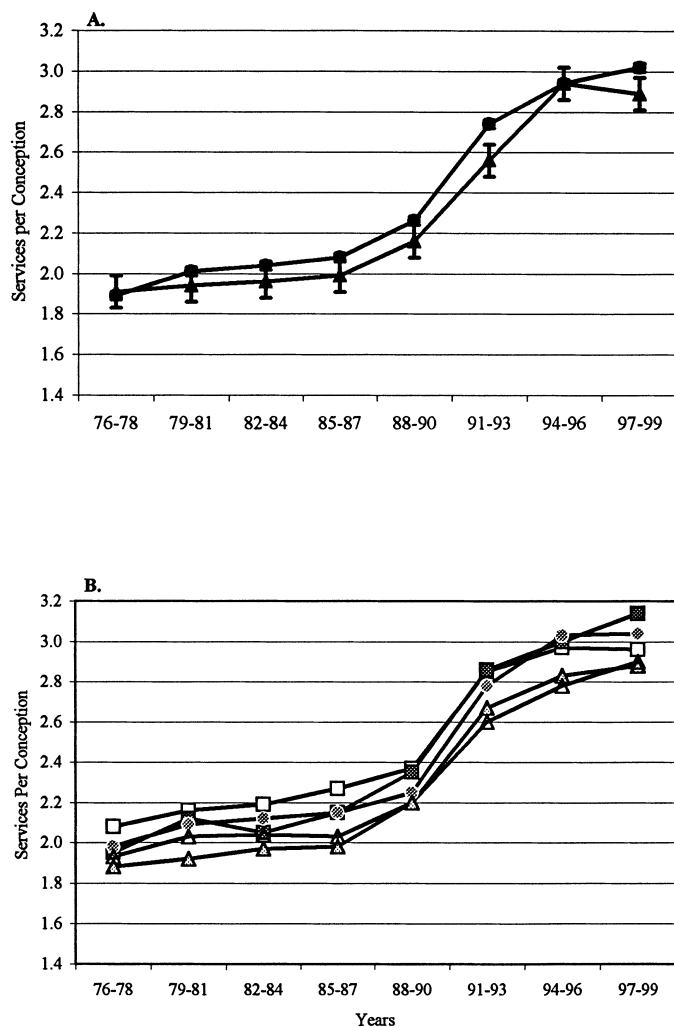
**Figure 2.** Least squares means ( $\pm$  SE) for numbers of cows in 532 Holstein (●, SE = 2 cows) and 29 Jersey (▲, SE = 8 cows) herds for 3-yr periods from 1976 to 1978 until 1997 to 1999. Breed averages differ ( $P < 0.01$ ) and linear effect of time are significant within and across breeds ( $P < 0.01$ ). There was also a significant breed  $\times$  time interaction ( $P < 0.05$ ) as breed differences in number of cows per herd increased after 1984.



**Figure 3A.** Least squares means ( $\pm$  SE) of average days open for 532 Holstein (●, SE = 0.7 d) and 29 Jersey (▲, SE = 2.8 d) herds for 3-yr periods from 1976 to 1978 until 1997 to 1999. Breed differences were highly significant ( $P < 0.001$ ) as were linear, quadratic, and cubic functions of time and the breed  $\times$  time interaction ( $P < 0.001$ ). Within Holstein herds but not Jersey herds, linear, quadratic, and cubic effects of both number of cows and FCM were significant ( $P < 0.05$ ) after adjusting for those functions of time. **B.** Least squares means of average days open within Holstein herds for five subregions of one to three states: AL-MS-LA (□); GA-FL (■); KY-TN (▲); NC-SC (●); and VA (△). Standard errors ranged from 1.4 to 2.7 d for individual points. Overall means differed ( $P < 0.001$ ) among subregions but the subregion  $\times$  time interaction was not significant.

### Trends for Reproductive Measures

There was a highly significant effect of breed ( $P < 0.001$ ) on average days open with Holstein herds averaging  $139.4 \pm 0.7$  d versus  $128.6 \pm 3.1$  d for Jersey herds across the eight 3-yr periods. Days open was affected both by time ( $P < 0.001$ ) and by the breed  $\times$  time interaction (Figure 3A;  $P < 0.001$ ; model  $R^2 = 0.70$ ). The increase in days open was greater for Holstein than for Jersey herds, with the increase in Holstein herds being evident after 1984, while averages for Jersey herds var-



**Figure 4A.** Least squares means ( $\pm$  SE) for services per conception for 532 Holstein ( $\bullet$ , SE = 0.02 services) and 29 Jersey ( $\blacktriangle$ , SE = 0.08 services) herds for 3-yr periods from 1976 to 1978 until 1997 to 1999. Breed differences were not significant, but linear, quadratic, and cubic functions of time were highly significant ( $P < 0.001$ ). Within Holstein herds, after adjusting for functions of time, quadratic and cubic effects of number of cows per herd were significant ( $P < 0.05$ ). Also, within Jersey herds, linear, quadratic, and cubic functions of FCM were significant ( $P < 0.05$ ). **B.** Least squares means of services per conception within Holstein herds for five subregions of one to three states: AL-MS-LA ( $\square$ ); GA-FL ( $\blacksquare$ ); NC-SC ( $\bullet$ ); and VA ( $\triangle$ ). Standard errors ranged from 0.4 to 0.7 d for individual points. Overall means differed ( $P < 0.001$ ) among subregions but the subregion  $\times$  time interaction was not significant.

ied little until after 1990. Increases in days open in the past decade have been nearly parallel across breed groups (Figure 3A).

In contrast to days open, there were no effects of breed or interactions involving breed on services per conception (Figure 4A; Holsteins =  $2.37 \pm 0.02$  vs. Jerseys =  $2.29 \pm 0.07$ ,  $P > 0.2$ ). However, effects of time, FCM (linear), and herd size (linear) on services per

conception were evident ( $P < 0.01$ ; model  $R^2 = 0.71$ ). The reciprocal of services per conception is an approximation of conception rate. Therefore, average conception rates for herds of both breeds decreased from about 52 to 53% in the late 1970s to about 33 to 35% in the late 1990s, a change of over 35%.

With type III sums of squares, linear, quadratic, and cubic functions of time were significant ( $P < 0.05$ ) for services per conception within both breeds, but only cubic effects of time were significant for days open in both breeds. Linear ( $+1.92 \times 10^{-2}$ ), quadratic ( $-3.43 \times 10^{-6}$ ), and cubic ( $+1.68 \times 10^{-10}$ ) effects of FCM and linear ( $+4.1 \times 10^{-2}$ ), quadratic ( $-8.1 \times 10^{-5}$ ), and cubic ( $+3.0 \times 10^{-8}$ ) effects of number of cows were significant ( $P < 0.05$ , type III) for days open within Holstein herds (overall model  $R^2 = 0.69$ ). Using regression coefficients generated by the model, the number of days open is estimated to decrease in Holstein herds as FCM increases. For example, those effects were such that Holstein herds would have expected decreases in days open of 7 d open as annual FCM increases from 5000 to 7000 kg or 14 d as FCM increases from 5000 to 9000 kg. The effect of herd size was small within Holstein herds, as use of generated regression coefficients indicated that days open would be expected to increase by fewer than 3 d as cow numbers increased from 100 to 400 cows. Within Jersey herds, no significance was indicated for functions of FCM nor number of cows using type III sums of squares (overall model  $R^2 = 0.77$ ).

Along with time effects, quadratic ( $+2.86 \times 10^{-6}$ ) and cubic ( $-1.3 \times 10^{-9}$ ) effects of number of cows were ( $P < 0.05$ ) associated with services per conception using type III sums of squares in Holstein herds (overall model  $R^2 = 0.70$ ). With regression coefficients generated by the model, increasing herd size from 100 to 200 cows would be expected to increase services per conception by only 0.03 services but increasing from 200 to 400 cows would add another 0.23 services per conception in Holstein herds. In addition to time, linear ( $-1.9 \times 10^{-3}$ ), quadratic ( $+3.16 \times 10^{-7}$ ), and cubic ( $-1.76 \times 10^{-11}$ ) functions of FCM had small but significant ( $P < 0.05$ , type III) effects on services per conception within Jersey herds (overall model  $R^2 = 0.71$ ). As FCM increases from 5000 to 7000 kg, using the regression coefficients of the model predicted that services per conception in Jersey herds would be expected to decrease by 0.05 services.

Within Holstein herds by subregion, there were differences ( $P < 0.05$ ) in the overall 24-yr means for both days open (Figure 3B) and services per conception (Figure 4B). Overall means (pooled SE = 0.8) for days open ranked as follows: AL-MS-LA, 148.7 d > GA-FL, 145.9 d > KY-TN, 142.1 d ~ NC-SC, 140.7 d > VA, 133.1 d. However, the time  $\times$  subregion interaction was not significant, and herds in all states increased days open

between 39 (VA) and 57 d (GA-FL) over the eight 3-yr periods. Mean increases in days open for other subregions were AL-MS-LA = 44 d, NC-SC = 45 d, and KY-TN = 46 d.

Means (pooled SE = 0.02) for services per conception ranked as follows: AL-MS-LA, 2.48 > GA-FL, 2.45 ~ NC-SC, 2.43 > VA, 2.31 ~ KY-TN, 2.29. Again the time  $\times$  subregion interaction was not significant, and herds in all states increased services per conception between 0.88 services (AL-MS-LA) and 1.19 services (GA-FL) over the eight 3-yr periods. Mean increases in services per conception for other subregions were VA = 0.97, KY-TN = 1.00, and NC-SC = 1.06 services.

Time effects on the intervals from calving to first service and for estimated estrus detection rates were significant ( $P < 0.01$ ) across the five 3-yr periods for which data were available. Least squares means ( $\pm$  SE) for days to first service increased from  $84.4 \pm 0.5$  d in 1985 to 1987 to  $100.4 \pm 0.5$  d in 1997 to 1999 in Holstein herds and from  $78.2 \pm 1.7$  d to  $96.2 \pm 1.6$  d in Jersey herds. Nearly half (6.9 d) of that change in Holstein herds occurred in the last 3-yr interval, and 12.2 d of the 18-d change over 15 yr in Jerseys occurred in the last two 3-yr intervals (1994 through 1999). In contrast, least-squares means ( $\pm$  SE) of estimated estrus detection rates had a general but inconsistent declining trend across time: 50.9, 45.7, 47.1, 44.9, and  $41.5 \pm 0.3\%$ , respectively, for five consecutive 3-yr periods beginning in 1985 to 1987 through 1997 to 1999 in Holstein herds and similarly in Jersey herds: 59.6, 56.1, 57.4, 55.4, and  $49.5 \pm 1.6\%$ , respectively.

Inclusion of intervals to first service in models for days open during the five 3-yr periods beginning in 1985 accounted for significant ( $P < 0.001$ ) variation in both Holstein and Jersey herds and the regression coefficients for the interval to first service was 0.89 (Holstein) and 0.84 (Jersey), or nearly a one-to-one relationship to increasing days open. However, time effects remained highly significant ( $P < 0.001$ ) in both breeds, and estrus detection rates had a small but significant relationship to days open only in Holstein herds (regression coefficient =  $-0.08$ ;  $P < 0.05$ ). The model  $R^2$  for days open was 0.86 for Holsteins and 0.89 for Jerseys, and effects of herd size and FCM were not significant in those models.

For services per conception during the five 3-yr periods beginning in 1985, adding estrus detection rates to models accounted for significant variation in both Holstein ( $P < 0.001$ ) and Jersey ( $P < 0.05$ ) herds along with significant effects of time ( $P < 0.001$ ) for both breeds and effects of herd size (Holstein herds only;  $P < 0.05$ ). Small positive regression coefficients (0.029 for Holsteins; 0.015 for Jerseys) were found in relating estimated estrus detection rates to services per conception,

meaning that services per conception increased as estrus detection rates increased. The model  $R^2$  for services per conception was 0.79 for Holsteins and 0.78 for Jerseys and effects of days to first service and FCM were not significant.

## DISCUSSION

Reproductive trends across time for these 561 herds from 10 Southeastern states were similar to those reported by Silvia (1998), who summarized data from 70 Kentucky Holstein herds. Years of data included and censoring for services per conception differed between those reports. Therefore, only 34 of 70 Kentucky herds in the report of Silvia (1998) were included in the current dataset. Linear increases in milk, fat, and FCM over the eight 3-yr periods were expected, based on continuing genetic gains for production. Herd size increased steadily, with Jersey herds starting with more cows and adding more cows than Holstein herds over time. We included effects of FCM in the regression models because of negative genetic correlations of milk yields with reproductive traits (Philipsson et al., 1994; Pryce and Veerkamp, 2001). Because of the increasing trends of FCM and herd size across time, those relationships were not independent of time.

Close similarity between Holstein and Jersey herds in services per conception or the reciprocal measure, conception rate, was not expected. Fonseca et al. (1983) had reported significant differences in first-service conception rates (72% for Jerseys vs. 49% for Holsteins) in a comparison of the two breeds managed in separate herds with data from 1977 and 1978. Those years correspond to the early part of the current study (1976 to 1978) in which conception rates in commercial herds for Jerseys and Holsteins were 52 and 53%, respectively. Washburn et al. (2002) also reported that Jersey cows had higher conception than Holsteins (59.6 vs. 49.5%) when managed in the same herd for data collected from 1995 to 1998, corresponding to latter periods of the current study. Those percentages are much higher than the average herd conception rates (32% for Holsteins and 33% for Jerseys) observed in the current study for 1997 to 1999 data. The study of Washburn et al. (2002) differed from the current study in that breeding was concentrated in two 75-d periods each year that completely avoided summer or early fall breeding when conception rates are known to be low. Perhaps, because of a possible perception of higher fertility among Jersey cows, managers of those commercial herds may be inclined to breed cows more uniformly across the year, whereas Holstein breeders often try to avoid summer inseminations.

The increasing rate of services per conception during the late 1980s through most of the 1990s reflects the higher order effects of time. With the cubic effect of time being significant, perhaps the rate of increasing services per conception has slowed since 1996 (Figure 4). However, current average services per conception in those herds is at or near three services, which should be of major concern to dairy producers and to the AI industry. Interestingly, within Jersey herds but not within Holstein herds, higher milk production was associated with a slight but significant decrease in services per conception, suggesting that other effects must contribute to the decline in fertility.

The shorter average days open in Jersey herds is consistent with work of Fonseca et al. (1983) and also with Silva et al. (1992), who reported that Jerseys in Florida had shorter calving intervals than Holsteins. Both breed groups in the current study had similar days open of 122 to 124 d in the mid 1970s. By the late 1990s, days open had increased by about 30 d in Jersey herds and by 43 d in Holstein herds. However, in this case, the higher-order time effects (Figure 3) would indicate that average days open is still very much an increasing trend for both Jersey and Holstein herds.

Data on the interval from calving to first service and estimates of estrus detection rates were available only for years 1985 through 1999. As one would expect, there is a close relationship with average intervals to first breeding and average days open. There has been experimental evidence that intentional delayed breeding may be economically feasible using modern Holstein genetics in year-round calving herds (Arbel et al., 2001). In that study, primiparous cows averaging 189 d open and multiparous cows averaging 160 d open had a calculated economic advantage compared with earlier-inseminated control cows averaging 128 (primiparous) or 110 d open (multiparous). Perhaps some of the recent increases in average days to first insemination and in average days open among Southeastern dairy herds is due to a growing perception that delayed breeding is a viable strategy. However, even with the effect of the interval to first insemination in the model, changes in days open across time were still quite evident. If current trends in increasing days open continue, there may certainly be a point of diminishing returns even in non-seasonal herds. An effect of management on days open within Holstein herds in the current study is reflected in the observation that the statistical model projected fewer days open intervals for higher producing herds. Similar observations have previously been reported from dairy herd improvement data (Nebel and McGilliard, 1993).

Means for average days open and services per conception differed for different subregions of states within

the 10-state region, as might be expected and were lower in general for more southerly states, likely due to longer periods of hot humid weather. However, similarity of changes in reproductive measures across time in the various subregions is indicative of a widespread trend that is of potential economic consequence.

Southeastern dairy herds are all subject to heat stress for periods of varying lengths every year. With increasing production levels, the impact of heat stress may both become more acute and could have residual effects for even longer intervals. The follicle that ovulates after a cow is in estrus actually began to grow several weeks before then. Therefore stressors that occur in early postpartum (negative energy balance, periparturient diseases) can potentially affect fertility some 2 to 3 mo later (Britt, 1994).

Genetic factors may also contribute directly to the reduction in dairy cow fertility. Negative genetic correlations have been reported between milk yield and reproductive traits such as calving interval, days open, days to first service, and first-service conception (Pryce and Veerkamp, 2001). The sire selection system as it exists now in the United States actually has negative effects on cow fertility, not only due to the adverse genetic correlation, but fertility is further antagonized due to failure to adjust daughter records for current days open. If some bulls consistently sire fewer fertile daughters, as indicated in data presented by McDaniel et al. (1999), the PTA for milk production would benefit from their daughters' resultant higher production. In a study of over 247,000 Holstein cows with records adjusted for current lactation milk yield up to 120 d, Lee et al. (1997) reported that first-lactation cows that were open 85 d produced 175 kg less milk in 305 d than cows that were open for 140 d. The comparable difference for second-lactation cows was 264 kg of milk in 305 d. Although historical estimates of heritability of most reproductive traits in dairy cattle are low (Freeman, 1984; Pryce and Veerkamp, 2001), there is evidence of sufficient variation to expect that genetic improvement of reproductive performance in dairy cattle is possible, and incorporation of measures of cow (daughter) reproduction into sire selection decisions has been recommended (Clay et al., 2000; Philipsson et al., 1994; Weigel and Rekaya, 2000).

In some countries where seasonal breeding and calving is widely practiced, an association of declining reproduction with increasing use of modern Holstein genetics has been found. In Ireland, a study comparing medium genetic merit cows to high genetic merit cows produced by use of US or Dutch Holstein semen showed that high genetic merit cows had lower pregnancy rates after two services and much higher culling for infertility (20 vs. 6%) after 13-wk breeding seasons regardless of

supplemental feeding regimen (Buckley et al, 2000). Similar observations have been reported from New Zealand (Harris and Kolver, 2000), where Holstein-Friesian cows with mostly North American genetics had 11% lower survival after one lactation and 27% lower survival after five lactations compared with New Zealand Friesians when both groups were managed in a seasonal calving regimen.

Several important physiological changes have been documented in high genetic merit cows (Lucy, 2001). Lower production of progesterone in cows selected for high production in Minnesota (Lucy and Crocker, 2001), delayed onset of postpartum estrus cycles, and irregular estrus cycles among cows selected for high yield have been reported (Lamming and Darwash, 1998; Opsomer et al., 1998). Irregular estrous cycles may be indicative of increased embryonic loss. These physiological changes that have accompanied genetic selection programs in the past may make the dairy cow population more susceptible to other factors that could lower reproductive performance.

Another factor that might contribute to reduced reproductive performance is inbreeding. Most breeds have experienced a gradual increase in the average inbreeding coefficient. Jerseys increased from an average inbreeding estimate of 1.3% in 1976, up to 6.0% in 1999, and Holsteins increased from 0.7% up to 4.6% over the same period (<http://www.aipl.arsusda.gov/>). Inbreeding could be eliminated by crossbreeding. Crossbreeding has been shown to increase herd life, perhaps due, in part, to improved reproductive performance (Hocking et al., 1988).

Herd size was not highly associated with days open in the current study, but the regression analysis showed that larger Holstein herds had significantly greater services per conception than smaller herds. There may be more difficulty in detection of estrus in large herds because cows are more likely kept on concrete, and there is potentially less understanding and concern about good estrus detection practices within a larger hired labor force. However, this may be partially offset by having enough workers to have specific assigned duties for reproductive management in larger herds. One of the changes in the past 25 yr has been increased use of on-farm insemination technicians compared with earlier use of professional technicians. This likely has increased variability in insemination skills and contributed to lower conception rates.

Another recent change in management procedures has been the increased use of bST since 1994. However, many of the negative changes in reproductive measures were evident before 1994 (Figures 3 and 4), and the percentage of cows receiving bST probably does not exceed 40%. Also, countries where bST is not used have

experienced fertility declines as well (British Society of Animal Science, 2001). In some cases, cows that have failed to rebreed can be kept productive for longer periods of time with use of bST, and some continued increases in days open in recent years could be attributed to that factor. Conversely, starting the use of bST in combination with estrus synchronization has resulted in improved AI conception in Florida (Moreira et al., 2000).

It might be that our selection system in the United States has led to highly productive dairy cows that can be reasonably fertile under optimal conditions but that may be more susceptible to nutritional and environmental stressors leading to compromised reproductive performance on many commercial farms. Changes in management practices such as intentional delayed breeding and less intensive estrus detection can accentuate such results.

## CONCLUSIONS

Trends of declining reproductive performance of dairy herds in the Southeastern United States are of concern, particularly the severe decline observed in the past 10 to 15 yr. Specific causes of the decline are not clear, but multiple factors have likely contributed. There may be diverse strategies for differing herd management situations in approaching herd reproductive management. Some herd managers may choose to concentrate on high production and long lactations and not be as concerned about reproduction. In some cases, this may include use of induced lactations to keep infertile cows productive. Other producers may make significant improvements in herd reproduction by reviewing management strategies and initiating operating procedures to improve it. Herd managers interested in seasonal breeding and calving may also need to consider the genetic components of a herd reproduction system. Longer term, it may become important to include measures of reproductive performance routinely in genetic selection indices in order to attenuate the rate of reproductive decline.

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