Effect of Season of Birth on Milk, Fat, and Protein Production of Israeli Holsteins

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ABSTRACT
The effects of birth month on production of milk, fat, and protein and percentages of fat and protein were analyzed based on production records of 101,653 first parity, 77,541 second parity, and 51,856 third parity Israeli Holstein cows. Each parity was analyzed separately. The analysis model also included the effects of herd-year, DIM, calving age, and calving month. First parity Type III sums of squares for birth month were nearly as large as those for calving month but decreased for later parities. Similar results were obtained using multiplicative models in which the dependent variables were the logarithms of the production traits. The effects of calving month and birth month were not similar, but birth month had similar effects for milk, fat, and protein production. Production was lowest by cows born in the early spring and highest by cows born in the fall. Analyses of the log-transformed traits showed that the F values for calving month were greater than, and the F values for birth month were nearly identical to, the F values for the untransformed trait analyses. The physiological basis for these trends was not clear. (Key words: birth month, calving month, Israeli-Holsteins, photoperiod)

Abbreviation key: BM = birth month, CM = calving month.

INTRODUCTION
The process by which mammary epithelial cells in the embryo develop into secretory cells that are capable of producing milk involves a series of growth and developmental changes occurring over a relatively long period. In general, mammary growth takes place in a discontinuous manner during five distinct periods: fetal, prepubertal, postpubertal, pregnancy, and early lactation. The basic structures of the mammary gland are formed during fetal life, but epithelial tissue is still rudimentary at birth (10, 13, 15). The extent of mammary gland development during the prepubertal period is much less pronounced than that during pregnancy, but clearly is important for future milk production of heifers (6, 13, 14).

Some environmental effects during pregnancy have long-term effects on the newborn mammal. For beef cattle, twin births induced by embryo transfer resulted in reduced BW compared with those of single births by embryo transfer even after 490 d of growth (4). Photoperiodic experience in utero affects the onset of puberty in goats, sheep, red deer, and in some rodent species. In these species, melatonin of maternal origin crosses the placenta, gives rise to a diurnal pattern of circulating melatonin concentrations, and influences prolactin secretion in the fetus (1, 2, 3, 20).

Differences in photoperiod in Israel are moderate because of its latitude, about 32° N. However, summer temperatures are high and can influence various physiological parameters, including hormonal concentrations in the blood of dairy cows (8, 9, 11, 19). The long-term effect of in utero season on future milk production has not been studied. The objective of this study was to determine the existence and magnitude of this effect in the Israeli dairy population.

MATERIALS AND METHODS
Data were total lactation records for production of milk, fat, and protein and percentages of fat and protein of Israeli Holsteins calving between 1985 and 1994. Fat and protein percentages were calculated from monthly test day samples analyzed by the central laboratory of the Israel Cattle Breeders Association at Bitan Aharon using a Milkoscan® 605AB automated spectrophotometer (Foss Electric, Hillerød, Denmark). Data were discarded if DIM were <250 or >350, if days dry were >150, if milk production was >20,000 kg, if fat production was >650 kg, or if protein production was <10 kg or >600 kg. First parity records were deleted if calving age was <640 d or >1000 d. Similarly, second parity records were deleted if calving age was <940 d or >1300 d, and third parity records were deleted if calving age was <1260 d or >1660 d. Records with <250 DIM were deleted to

Received July 24, 1995.
Accepted December 27, 1995.
remove data for cows that were culled for illness and because the effect of DIM was not linear in the early part of the lactation. Records with $>350$ DIM were deleted because cows allowed to produce lactations of this length were a selected sample (17). About 45% of the recorded lactations were deleted because DIM was outside the required range. Less than 1% of the remaining records were deleted because of the other edits. Preliminary analyses indicated that effects on different parities were not similar. Therefore, first, second, and third lactations were analyzed separately. The analysis model was

$$Y_{ijkl} = \text{DIM} + \text{CA} + (\text{DIM})^2 + (\text{CA})^2$$
$$+ \text{HY}_i + \text{CM}_j + \text{BM}_k + e_{ijkl} \quad [1]$$

where

- $Y_{ijkl}$ = production of milk, fat, or protein or percentages of fat or protein per lactation,
- $\text{DIM}$ = effect of DIM,
- $\text{CA}$ = effect of calving age in days,
- $(\text{DIM})^2$ = effect of $(\text{DIM})^2$,
- $\text{HY}_i$ = effect of herd-year $i$,
- $\text{CM}_j$ = effect of calving month $j$,
- $\text{BM}_k$ = effect of birth month $k$, and
- $e_{ijkl}$ = random residual effect.

Effects $\text{HY}$, $\text{CM}$, and $\text{BM}$ were class effects; the other effects were continuous. The herd-year was defined from January through December of each year. In addition, the base 10 logarithm for production of milk, fat, and protein was also analyzed with the same model. The logarithmic analysis assumed that effects were multiplicative.

Analysis was by PROC GLM of SAS (12). The herd-year effect, which had over 4500 levels for the first parity analysis, was absorbed. Therefore, least squares means could not be computed, and solutions for calving month ($\text{CM}$) and birth month ($\text{BM}$) are presented relative to December, the final month. Because $\text{CM}$ and $\text{BM}$ were highly correlated, Type III sums of squares were used to compare the relative importance of their effects on the production traits analyzed.

RESULTS AND DISCUSSION

The number of records, means, and standard deviations of the traits analyzed are given in Table 1 for each parity. As expected, production of milk, fat, and protein increased as parity increased. The relatively low standard deviation for DIM was due to the limitations described. Mean first parity calving age was 2 yr and 6 d, and the standard deviation was 50 d or 1.7 mo. Thus, confounding between CM and BM should not have been a problem.

![Figure 1](https://via.placeholder.com/150)  
**Figure 1.** First parity effects on milk production for birth month ($\bullet$) and calving month ($\circ$). The base month for both effects is December.
A decreased. Thus, as cows grew older, the effect of BM on milk production was less pronounced. In the analyses of the log-transformed traits, the $F$ values for CM were greater than, and the $F$ values for BM were nearly identical to, the untransformed trait analyses. Thus, unlike CM, the effect of BM on milk production traits was not multiplicative.

The solutions for the effects of CM and BM on milk production are given in Table 4. For all parities, the BM with lowest production was March, and the BM with the highest production varied between June and September. The CM with the lowest production was March for first parity cows and July for later parity cows. The highest production recorded was for first parity cows calving in December. Results were similar for fat and protein production (data not shown).

Effects of first parity on milk production for CM and BM by month are plotted in Figure 1. The two curves are not very similar, despite the fact that BM and CM were the same for a large fraction of first parity cows. The effect of BM began to decline after November and reached a minimum in March; the effect of CM declined rapidly after December but then remained relatively constant from January through July. Thus, the effect of CM was low as long as the first 9 mo of the lactation included the period of July through September, the hottest period of the year.

First parity effects of BM by month for milk, fat, and protein are plotted in Figure 2. The effects of all three traits were quite similar; production was lowest for cows born in the early spring and highest for cows born in autumn. Thus, milk production was lowest when the shortest day fell within the second trimester of pregnancy and highest when the longest day fell within the second trimester of pregnancy.

### Table 2. The continuous effects on the milk production traits included in the analysis by parity.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Factor</th>
<th>Effect</th>
<th>SE</th>
<th>Effect</th>
<th>SE</th>
<th>Effect</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk</td>
<td>DIM</td>
<td>69.9</td>
<td>3.3</td>
<td>100.9</td>
<td>4.02</td>
<td>103.7</td>
<td>5.14</td>
</tr>
<tr>
<td></td>
<td>CA</td>
<td>12.2</td>
<td>1.3</td>
<td>11.8</td>
<td>1.95</td>
<td>9.22</td>
<td>2.60</td>
</tr>
<tr>
<td></td>
<td>DIM$^2$</td>
<td>-0.0586</td>
<td>0.0054</td>
<td>-0.119</td>
<td>0.00663</td>
<td>-0.123</td>
<td>0.00849</td>
</tr>
<tr>
<td></td>
<td>CA$^2$</td>
<td>-0.0060</td>
<td>0.0008</td>
<td>-0.0040</td>
<td>0.00085</td>
<td>-0.0023</td>
<td>0.00095</td>
</tr>
<tr>
<td>Fat</td>
<td>DIM</td>
<td>1.744</td>
<td>0.110</td>
<td>2.665</td>
<td>0.143</td>
<td>3.152</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td>CA</td>
<td>0.370</td>
<td>0.042</td>
<td>0.330</td>
<td>0.069</td>
<td>0.291</td>
<td>0.103</td>
</tr>
<tr>
<td></td>
<td>DIM$^2$</td>
<td>-0.00142</td>
<td>0.000179</td>
<td>-0.00288</td>
<td>0.000236</td>
<td>-0.003672</td>
<td>0.000313</td>
</tr>
<tr>
<td></td>
<td>CA$^2$</td>
<td>-0.00017</td>
<td>0.000027</td>
<td>-0.00011</td>
<td>0.000030</td>
<td>-0.000073</td>
<td>0.000034</td>
</tr>
<tr>
<td>Protein</td>
<td>DIM</td>
<td>1.815</td>
<td>0.0895</td>
<td>2.691</td>
<td>0.111</td>
<td>2.908</td>
<td>0.143</td>
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<tr>
<td></td>
<td>CA</td>
<td>0.324</td>
<td>0.0343</td>
<td>0.313</td>
<td>0.053</td>
<td>0.273</td>
<td>0.078</td>
</tr>
<tr>
<td></td>
<td>DIM$^2$</td>
<td>-0.00154</td>
<td>0.000146</td>
<td>-0.00294</td>
<td>0.000182</td>
<td>-0.003296</td>
<td>0.000256</td>
</tr>
<tr>
<td></td>
<td>CA$^2$</td>
<td>-0.00015</td>
<td>0.000022</td>
<td>-0.00011</td>
<td>0.000023</td>
<td>-0.000073</td>
<td>0.000026</td>
</tr>
</tbody>
</table>

$^1$CA = Calving age.
The effect of birth season on production could be attributed to changes in either temperature or photoperiod. Although cattle are not seasonal breeders, blood concentrations of prolactin are positively correlated with both photoperiod and temperature (7, 16, 18). The duration of the photoperiod or temperature would most likely affect future milk production during at least one of the three significant stages of udder development prior to the onset of first lactation: the last trimester of pregnancy, the period of sexual maturation, and the rapid development of the mammary gland prior to parturition (6, 13, 15). Any effect related to mammary gland development prior to calving is completely confounded with the effect of CM. Furthermore, udder development during the prepubertal stage was apparently not affected by day length or temperature (13). Consequently, effects of photoperiod or temperature during the second and third trimesters of pregnancy on hormones such as prolactin, are probable causes of the effect of BM. Prenatal development of the mammary gland is most dynamic in humans during the second and third trimesters of pregnancy. During those stages, the mammary gland of rats also becomes sensitive to prolactin (5).

In an analysis of field data, effects of photoperiod and temperature could not be separated. A controlled experiment is therefore suggested to determine which factor is responsible for the observed effect.

CONCLUSIONS

The effect of BM on first parity cows was nearly as large as the effect of CM and was distinctly different. For later parity cows, the effect of CM became more important, and the effect of BM became less important. For first parity cows, the effect of BM was similar for production of milk, fat, and protein; production was lowest for cows born in the early spring and was highest for cows born in autumn. The effect of BM on production could be attributed either to changes in temperature or to changes in photoperiod.

ACKNOWLEDGMENTS

This research was supported by the United States-Israel Binational Agricultural Research and Develop-
ment Fund, project number IS-1939-91R, and the Israel Milk Marketing Board. Data were provided by the central laboratory of the Israel Cattle Breeders Association.

REFERENCES