Interrelationships of Milk Yield, Body Weight, and Reproductive Performance

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ABSTRACT

Records (2263) from a single north Florida herd for 3 yr were evaluated in a series of analyses. Environment was subtropical. Data set included only cows that had normal milk records and became pregnant. Holsteins and Jerseys averaged 6799 and 4504 kg milk, 587 and 418 kg postpartum body weight, 164 and 141 days open, and 2.3 and 2.1 services per subsequent pregnancy. Pooled within breed, repeatabilities and heritabilities of these performance measures were .37, .15; .53, .25; .20, .06; and .30, 0. Estimable genetic correlations were milk yield and body weight -.09, milk yield and services per conception .38, and services per conception and body weight .37; range of standard errors was .22 to .39. Substantial genetic antagonism may exist between milk yield and body weight, and efficient reproduction. If results of this research are verified elsewhere, breeders should be aware that selection for increased weight could lead to decreased reproductive efficiency.

INTRODUCTION

Progress has been substantial in selection of dairy cattle for high milk production in recent years (17). Of practical importance are effects of genetic change of milk yield on reproductive performance. Several field studies indicated marked genetic antagonisms between high milk yield and fertility (3, 8, 9, 12, 13), but other research showed little association of yield and fertility (1, 18, 19, 23).

Spalding et al. (21) reported that cows with milk yields more than 907 kg above herdmates were 20.5% lower for conception rates of first service than cows 907 kg below herdmates. Earlier Everett et al. (8) found that phenotypic correlations of 120-day milk yield with measures of fertility essentially were zero, but genetic correlations were approximately .50. In 1981 Berger et al. (3) reported genetic correlations for measures of reproductive performance with 305-day yield from .48 to .62. Smith and Legates (20) stated that phenotypic relationships between 305-day yield and days open could be due largely to influences of gestation on yield. These positive relationships (e.g., yield and days open) indicate an antagonistic (i.e., undesirable) relationship.

Review by Martin (14) indicated that heritabilities for services per conception and days open ranged from -.15 to .10 and .01 to .09. Repeatabilities for services per conception were from .0 to .11. Low heritabilities for measures of fertility have led many workers (4, 6, 8) to conclude that selection for reproductive traits would be slow. In contrast, numerous studies [e.g., (24)] indicated that heritability for 305-day milk yield was approximately .20 to .25.

Most investigators agreed that large cows gave more milk than small cows (7, 15, 16). However, relationship between body weight and yield was such that heavier cows possessed little, if any, superiority of production efficiency (5, 15). Our objectives were to evaluate relationships of milk yield and body weight to fertility in lactating Holstein and Jersey cows in a commercial dairy herd in a subtropical environment (30°32'N latitude).

MATERIALS AND METHODS

Detailed breeding records from a purebred dairy herd in Monticello, FL, for January 1, 1975, to December 31, 1977, were matched
TABLE 1. Means and standard deviations (SD) for response variables.

<table>
<thead>
<tr>
<th>Traits</th>
<th>Pooled Holstein Jersey (2263)</th>
<th>Holstein (1584)</th>
<th>Jersey (679)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>( \bar{X} )</td>
<td>SD</td>
<td>( \bar{X} )</td>
</tr>
<tr>
<td>Milk yield, kg</td>
<td>6110</td>
<td>2080</td>
<td>6799</td>
</tr>
<tr>
<td>Body weight, kg</td>
<td>537</td>
<td>90</td>
<td>587</td>
</tr>
<tr>
<td>Days open</td>
<td>157</td>
<td>121</td>
<td>164</td>
</tr>
<tr>
<td>Services per conception</td>
<td>2.2</td>
<td>1.6</td>
<td>2.3</td>
</tr>
</tbody>
</table>

\( ^1 \) Number of records.  
\( ^2 \) At beginning of lactation.

with DHI (Dairy Herd Improvement) records for milk yield. After screening, resulting data set consisted of 2263 reproductive and lactation records. Measures of postpartum reproductive performance were days open and services per conception. Body weight (tape measure on day of parturition), days in milk, sire of cow, and month, year, and age of cow at parturition were recorded. Routine inseminations were initiated at 45 days postpartum. Details of herd management and climate are presented (2). Records were included in the study only if parturition was followed by a diagnosed pregnancy.

Data were analyzed by method of least squares analyses of variance by computer programs of Harvey (11). General linear mixed model was:

\[
Y_{ijklm} = \mu + B_i + S_{ij} + C_{ijk} + F_1 + e_{ijklm}
\]

where \( Y_{ijklm} \) is the response for each dependent variable, \( \mu \) is the overall mean, \( B_i \) is breed effect (fixed), \( S_{ij} \) is sire effect nested in breed (random), \( C_{ijk} \) is cow effect nested in sire and breed (random), \( F_1 \) is a set of other fixed effects (i.e., days in milk, year and month of parturition, and age of cow), and \( e_{ijklm} \) is remainder, representing variability among records of the same cow with usual assumptions for residuals. Age and days in milk were continuous independent variables to the third degree of polynomial regression. Milk yield was included as a fixed independent variable in several analyses. Estimates of repeatability and heritability were by intraclass correlation; daughters by the same sire were considered to be half-sisters. Models from which estimates of variance and covariance were obtained are demonstrated in (11).

RESULTS AND DISCUSSION

Means and standard deviations for measures of performance are in Table 1. As expected, Holsteins produced more milk and were heavier at initiation of lactation than Jerseys. However, the latter had fewer days open and tended to require fewer services per conception than Holsteins. This agreed with other reports of fertility of Jerseys and Holsteins in warm climates (10, 22). Differences in fertility between breeds likely reflected differences associated with milk yield and ratios of surface to body weight. High milk yield is associated with increased metabolic heat production, which may affect thermal

TABLE 2. Repeatabilities (t) and heritabilities (h^2) for response variables.

<table>
<thead>
<tr>
<th>Traits</th>
<th>t</th>
<th>h^2</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield</td>
<td>.37</td>
<td>.15</td>
<td>.08</td>
</tr>
<tr>
<td>Body weight</td>
<td>.53</td>
<td>.25</td>
<td>.08</td>
</tr>
<tr>
<td>Services per conception</td>
<td>.20</td>
<td>.06</td>
<td>.07</td>
</tr>
<tr>
<td>Days open</td>
<td>.30</td>
<td>0^2</td>
<td>. .</td>
</tr>
</tbody>
</table>

\( ^1 \) Approximate standard errors.  
\( ^2 \) Negative estimate.
TABLE 3. Phenotypic and genetic correlations.

<table>
<thead>
<tr>
<th></th>
<th>Milk yield</th>
<th>Services per conception</th>
<th>Days open</th>
<th>Body weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milk yield</td>
<td></td>
<td>.12</td>
<td>.21</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Services per conception</td>
<td>.38 (.39)</td>
<td>...</td>
<td>.05</td>
<td>.01</td>
</tr>
<tr>
<td>Days open</td>
<td>NE</td>
<td>.37 (.34)</td>
<td>NE</td>
<td>&lt;.02</td>
</tr>
<tr>
<td>Body weight</td>
<td>-.09 (.22)</td>
<td>...</td>
<td>...</td>
<td></td>
</tr>
</tbody>
</table>

1 Genetic correlations below diagonal.

2 Approximate standard errors in parentheses.

3 Not estimable because of negative sire variances.

balance of high-producing cows. In contrast, tendency of Jerseys to maintain fairly good reproductive performance in subtropical environments more likely is due to lower heat production and greater ratio of surface to body weight (25).

Repeatabilities of milk yield, body weight, and measures of fertility are in Table 2. Estimates for days open and services per conception (.30 and .20) were higher than those reported by Martin (14). Heritabilities for yield, weight, and fertility also are in Table 2. Estimates for milk yield (.15) and services per conception (.06) were similar to other reports (3, 14, 24).

Phenotypic (r_p) and genetic (r_A) correlations are in Table 3. Correlations between milk yield and services per conception were positive (r_p = .12; r_A = .38). These indicated that high-producing cows required more services per conception than low-producing cows. As indicated by (3, 8), substantial genetic antagonism may exist between high yield and fertility in dairy cattle. Phenotypic correlation between milk yield and days open was .21.

Phenotypic correlation between body weight at initiation of lactation and subsequent services per conception was essentially zero (r_p = .01), whereas the genetic correlation was positive (r_A = .37). Differences in services per conception associated with body weight may be attributable partially to differences in thermoregulatory responses. Heavier cows have reduced ratios of surface to body weight and, therefore, were more vulnerable to high environmental temperatures than smaller cows with higher rates of heat dissipation. Thus, care should be taken in selection for increased body weight to avoid possible associated decreases of fertility if results reported here are confirmed elsewhere. A host of other factors also may account for this association. We hypothesize that heavier cows may have a greater incidence of other problems (i.e., ketosis, milk fever, dystocia, fatty infiltration of the oviduct, etc.) that may compromise fertility.

Phenotypic and genetic correlations between milk yield and body weight in this herd were low (Table 3). As suggested by McDaniel and Legates (15), milk yield can be improved without materially increasing body weight of dairy cattle. Because body weight is heritable, selection for increased weight should result in larger cows with little or no correlated increase in milk yield. Because larger cows cost more to maintain, this clearly would not be a profitable selection scheme. Substantial genetic antagonism may exist between high milk yield and fertility as in this and other research relationship was positive between yield and services per conception. Body weight genetic correlation with services per conception likewise was positive.

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REFERENCES


