ABSTRACT

Feed intakes were obtained for d 71 through d 120 postpartum for 36 first lactation selection and 32 control cows during the last 3 yr of a 16-yr selection experiment for FCM yield in Holsteins. The ration consisted of concentrates fed according to production, limited alfalfa hay, and ad libitum corn silage. The higher estimated net energy intake by selection cows was due primarily to their significantly higher silage intake. Grain intake was slightly higher for the selection animals, but the control animals had a slightly higher hay intake. Neither differences was statistically significant. Only small and statistically nonsignificant differences in BW and weight change were found between the two groups. Selection animals had a 7.6% advantage in gross efficiency for the 50-d trial. Selection for yield gave a desired correlated change in gross feed efficiency.

(Key words: efficiency, selection, feed utilization)

INTRODUCTION

A primary objective in dairy cattle breeding is to develop animals that are more efficient, i.e., they should transform a larger proportion of feed energy into milk. Beyond the efficiency of the individual animal, net return or economic efficiency of a dairy enterprise is dependent on a host of additional factors, including size of operation, disease control, and market considerations. Information on feed intake of individual animals is costly and difficult to obtain. As a consequence, direct selection for feed efficiency has not been practiced. Indirect selection by emphasis on yield has been considered an effective alternate due to the relatively high heritability of gross feed efficiency, .30 to .40, and its estimated high genetic correlation with yield, .80 to .90 (3).

Evidence has been presented (2, 8) that daughters of superior sires also are more efficient in converting feed energy into milk energy, substantiating to a degree the genetic relationship between yield and efficiency. Correlated responses in feed efficiency from selection for production traits also have been reported. Hickman and Bowden (4), in a 12-yr selection experiment for milk solids yield in Holsteins, found a significant trend toward less TDN per kg of FCM during a 60-d feeding period. A contemporary and parallel experiment with Ayrshires did not reflect a significant improvement in efficiency. Smothers et al. (9), in a 14-yr selection experiment for milk yield in Jerseys, found a significant increase in efficiency during a 28-d trial for the selection line when gross efficiency was adjusted for the energy balance of the individual cow. Yerex et al. (10), in a 14-yr selection experiment with Holsteins for large and small body size, reported an approximate 2.8% advantage in feed efficiency for the small line on a lactation basis and a 5.0% advantage during 60 through 180 d of lactation.

The purpose of this study was to assess differences in feed efficiency between first lactation selection and control cows in response to selection where there were large differences in yields of milk and fat between the selection and control groups (5).
RESULTS AND DISCUSSION

Data were compiled for five 10-d intervals for d 71 through d 120 of lactation for 36 selection and 32 control animals. The intakes of the three ration components for these five intervals are shown in Figure 1. The major difference between the selection and control groups was in the silage intake, which was fed for ad libitum access. Of special interest was a possible differential response for the two groups as the lactation progressed. For the five 10-d intervals intraseason differences between selection and control cows weighted by the inverse of their variances were computed for 4% FCM, DM intake, estimated net energy intake, and BW change. Based on whether calving was in spring and summer or fall and winter, six year-season periods were identified over the 3 y in which data were obtained. These weighted within year-season differences are shown in Figure 2. Clearly, the two groups responded the same time and day of the week. Gross efficiency was computed as the fraction of the total estimated net energy consumed that was recovered in the milk. The 4% FCM was converted to megacalories of milk energy (7).

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RESULTS AND DISCUSSION

Institutional Breeding Program were used to breed the selection group females. Randomly chosen sons of cows within the control group were used to breed the control group females. Six males were used each sire generation, and least related matings were made to minimize inbreeding, which was consistent with the proportionate use of each control bull. Both groups were milked twice daily as one herd. Heifers were given every reasonable opportunity to complete one lactation. Cows were allowed 305 d to become pregnant before they were removed because of reproductive failure. To cull cows in the control group, those with at least one completed record were randomly removed until the desired number in the group remained. Selection group females with the lowest average deviations from herdmates were culled after involuntary removals had been taken into account. Further details regarding the breeding plan and management of the herd are given in a prior publication (5).

From November 1967 to January 1971, the final 3 yr of a 16-yr selection experiment, feed intakes were obtained on first lactation animals from d 71 through d 120 of lactation. The average 305-d lactation, twice daily milking, mature equivalent production of all lactations initiated by calvings during the 3 yr was 8748 kg of milk and 310 kg of fat for the selection females compared with 6736 kg of milk and 235 kg of fat for the controls.

Animals were placed on trial at least 1 wk prior to 71 d in lactation, housed in a stanchion barn, milked in a milking parlor, and allowed exercise in a paved lot. They were fed separately concentrates, corn silage, and alfalfa hay. Concentrates were limit-fed at 1 kg/2 kg of milk; corn silage was fed for ad libitum intake to permit a 10% weighback, and alfalfa hay was fed at the rate of approximately 1 kg/100 kg of BW. Grain and silage were fed twice daily, and weighbacks were obtained for all three ration components. The concentrate mixture, consisting of ground yellow shelled corn and soybean oil meal with mineral and vitamin supplements, was the same as was used through the selection experiment. Estimated net energy intakes were computed from feed intakes using net energy values for lactation for individual ingredients as provided by of Table 7-1 of Nutrient Requirements of Dairy Cattle (7). Body weights were obtained weekly at the same time and day of the week.
EFFICIENCY OF FEED UTILIZATION

Grain and hay. Year-season differences were significant for both hay and silage, but the group by year-season interactions were not significant for the three ration components.

Analyses of variance for variables relating directly to gross feed efficiency with F-values and residual mean squares are given in Table 2. In line with the mean differences shown in Table 1 and Figures 1 and 2, the group means for estimated net energy intake and FCM yield were significantly different, but the group by year-season interactions were not. The megacalories of intake per kilogram of FCM and gross efficiency as megacalories of FCM per megacalorie of intake are ratios utilizing the same variables. Efficiency values range for 0 to 1.0; hence, gross efficiency has the statistical properties of a binomial. Because the gross efficiency values were near .50, confusion from binomial variance would be minimal. Megacalories of intake for each kilogram of FCM is of practical significance and does not have the binomial statistical constraint of gross efficiency. Group and year-season differences were significant for both expressions of overall efficiency.

Based on the gross efficiency values of .507 for the selection groups and .471 for the controls, the selection group was 7.6% more efficient for the 50-d interval from d 71 through d 120 of lactation. When gross efficiency is used, a cow that consumes little but loses weight due to high production appears efficient until the...
TABLE 2. F-Values and residual mean squares for variables related to feed efficiency.\(^1\)

<table>
<thead>
<tr>
<th>Source</th>
<th>d/f</th>
<th>Estimated NE(_1) (Mcal)</th>
<th>FCM (kg)</th>
<th>Weight change (kg)</th>
<th>FCM (Mcal/kg)</th>
<th>Gross feed efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group (G)</td>
<td>1</td>
<td>10.20**</td>
<td>18.62**</td>
<td>2.57</td>
<td>5.10*</td>
<td>5.87*</td>
</tr>
<tr>
<td>Year-Season (Y-S)</td>
<td>5</td>
<td>2.86*</td>
<td>1.87</td>
<td>.82</td>
<td>3.76**</td>
<td>4.08**</td>
</tr>
<tr>
<td>G x Y-S</td>
<td>5</td>
<td>.40</td>
<td>1.16</td>
<td>1.62</td>
<td>.86</td>
<td>.46</td>
</tr>
<tr>
<td>Residual mean square</td>
<td>56</td>
<td>7.90</td>
<td>7.30</td>
<td>.337</td>
<td>.0428</td>
<td>.0037</td>
</tr>
</tbody>
</table>

\(^1\) All variables for the 50-d trial period expressed on a daily basis.

\(*P<.05.\)

\(**P<.01.\)

weight loss must be replaced. Evaluation of gross efficiency on a partial lactation could lead to selecting for the capacity to mobilize body reserve during lactation. Partitioning the energy utilized for lactation apart from that required for body maintenance and BW change to ascertain lactational efficiency has been sought. However, it has not been accomplished experimentally, because all three functions proceed simultaneously in the same animal. Brody (\(^1\)) suggested an indirect statistical approach using multiple regression to partition the energy utilized for lactation, maintenance, and BW change. A considerable volume of experimental data would be required to provide a meaningful partition that would not be overwhelmed by sampling variation. Also, weight change over a short period is not a sensitive measure of anabolism or catabolism (6). For these two groups, the body mass (weight) and weight changes were comparable (Tables 1 and 2, Figure 2). Thus, their impact on the difference in gross efficiency should have been slight.

These results support the premise that selection for yield can give a desired correlated genetic change in gross efficiency of dairy cattle. The paucity of data does not permit a meaningful evaluation as to how the magnitude of the response would compare with expectation.

REFERENCES