PREDICTION OF LIFETIME PRODUCTION ON BASIS OF FIRST LACTATION YIELD AND AGE AT FIRST CALVING FOR SELECTION OF DAIRY CATTLE

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ABSTRACT

This paper evaluates the influence of the first lactation yield and age at first calving on lifetime production and determines the relative importance of them for selection purposes. The data refer to Tharparkar, Sahiwal, and Red Sindhi breeds and one-half Jersey × one-half Thari crossbred cows.

Age at first calving had more influence on the estimation of yield up to a certain age than on certain numbers of lactations, the first lactation yield being of equal importance in both cases. Regression equations to predict total yield up to five lactations, on the basis of the first lactation yield, explained 70% of the variation in Tharparkar and Sahiwal breeds and about 42% in Red Sindhi and crossbred cows. Multiple regression equations to predict yield up to 10 yr of age on the basis of the first-lactation yield and age at first calving explained more than 75% variation in purebred cows and only 40% in crossbred cows. The latter character explained more variation. The partial regression coefficients indicate that an increase of 73 kg of milk in the first lactation yield is equivalent to a reduction of one month in age at first calving in the Tharparkar breed. Similar figures in the Sahiwal, Red Sindhi, and crossbred cows are 57, 92, and 126 kg of milk, respectively.

Profitability in dairying depends upon the efficiency of the animals to convert the animal feeds into milk. A part of the feeds fed to the animals is meant for body maintenance, the rest being utilized for milk secretion. As such, animals are fed according to the milk production and, thus, returns over the feed cost move steadily upwards with increase in level of production. Major emphasis should and is, therefore, laid on production as a criterion of selection of dairy cattle. Therefore, it appears essential to predict the lifetime production of animals at the earliest, on the basis of allied characters for judicious culling of inferior stock which will result in profitable dairying and will improve the herd genetically. Tabler et al. (9) studied various methods of selection of Ayshire cows maintained at the West Virginia Agricultural Experimental Station from 1922 to 1948 and found that individual selection of animals was superior to family selection. Culling one-third of the low-producing animals from 1928 resulted in an increase of 2,802 lb of milk per cow in 1948 by individual selection; whereas, family selection accounted for 2,280 lb only. They also observed that for family selection to be as efficient as individual selection, the genetic relationship between members of the cow families in the herd would have to be about 28%.

The feasibility of predicting the production of milk fat in the first five lactations and up to 7 yr of age was studied by Chapman and Dickerson (1). They concluded that first-lactation yield was highly correlated with 5-lactation yield, as well as with production up to 7 yr of age. Calves with higher age at first calving produced more in later lactations than early calvers. But early calvers produced more up to 7 yr, presumably because of their longer productive lives. Roth (6) found that the yield in 200 days during the first lactation was correlated with production up to 5-6 yr after freshening and this character explained 46% of the total variation. Kliesch and Bankwitz (4) studied two herds of European cattle and reported that 180 days’ production in the first lactation explained 29 and 52% of the variation in estimating the total yield up to the first four lactations. Skjervold (7) reported that yield up to 300 days in the first lactation was highly correlated with total yield of five lactations.

Larson et al. (5) studied the estimation of milk fat production for several periods of life.
on the basis of production up to 305 days in the first lactation and age at first calving in two DHIA herds of the Wisconsin State Department of Public Welfare and found that these characters explained 41% of the total variation in estimating production up to 7 yr. Sundaresan et al. (8) also studied the prediction of milk yield for several periods on the basis of these characters in Red Sindhi breed, various crossbred herds, and Murrah buffaloes at Allahabad Agricultural Institute and Jersey breed at Kansas State College. They found significant correlation between first-lactation yield and 10-yr yield in purebred cows. Highly significant correlations between the yield up to 10 yr and age at first calving were obtained in the Red Sindhi and one-fourth Jersey × three-fourths Red Sindhi; 71% of the total variation was explained by these two characters in estimating the production up to 10 yr in these two breeds.

The customary method of culling animals is based on the first-lactation yield only, as this character is known to be moderately heritable and correlated with the yield up to a fixed number of lactations. As is clear from the study of Chapman and Dickerson (1) and others, early calvers produce more milk up to a fixed age because of their longer productive lives and are, therefore, economical to maintain. Thus, age at maturity is a desirable character to be considered along with the first-lactation yield.

As the cost of upkeep of cattle up to a fixed number of lactations varies a lot from animal to animal, due to the variability in age for the completion of the number of lactations, and is definitely more stable up to a fixed age, it is desirable to predict the yield up to a fixed age.

The present study aims a) at evaluating the effect of 305 days' production in the first lactation, age at first calving, intercalving period, and first two lactations' yield on lifetime production (lifetime production as measured by the yield up to 10 yr of age, as well as up to the completion of five lactations) and b) to determine the relative importance of the first-lactation yield and age at first calving for selection purposes.

**EXPERIMENTAL PROCEDURE**

Data taken for the study refer to three breeds of cattle, viz., Tharparkar, Sahiwal, and Red Sindhi maintained at the National Dairy Research Institute (NDRI), Karnal, and one-half Jersey × one-half Thari crossbred cows maintained at the Southern Regional Station of NDRI, Bangalore. Cows which have either completed 10 yr of age or five lactations were included under study and the following information collected from the history sheets of each cow:

1) Age at first calving;
2) 305 days' yield in the first lactation; or total yield in the first lactation of those cows which milked for less than 305 days. The history sheets of cows which milked for less than 150 days were verified in detail and those found abnormal (suffering from udder diseases, hormonal imbalance, low persistency, Brucellosis, etc.) were excluded from the study.
3) Intercalving period between first and second calving;
4) Yield in the second lactation;
5) Total yield up to the completion of five lactations;
6) Total yield up to 10 yr of age.

Correlation and regression analyses were employed to analyze the data and prediction equations were fitted to predict total yield up to the completion of five lactations, as well as yield up to 10 yr of age.

**TABLE 1(a)**

Averages of first-lactation yield, age at first calving, and five lactations yield with respective standard error

<table>
<thead>
<tr>
<th>Name of breed</th>
<th>No. of animals</th>
<th>Average yield in first lactation in 100's of kg</th>
<th>Standard error</th>
<th>Average age at first calving in months</th>
<th>Standard error</th>
<th>Range in months</th>
<th>Average yield up to 5 lactations in 100's of kg</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tharparkar</td>
<td>48</td>
<td>25.8</td>
<td>0.76</td>
<td>38.8</td>
<td>1.34</td>
<td>27-57</td>
<td>121.1</td>
<td>3.48</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>30</td>
<td>25.2</td>
<td>0.80</td>
<td>40.7</td>
<td>1.40</td>
<td>26-58</td>
<td>134.9</td>
<td>2.61</td>
</tr>
<tr>
<td>Red Sindhi</td>
<td>21</td>
<td>17.9</td>
<td>0.90</td>
<td>42.8</td>
<td>1.36</td>
<td>33-56</td>
<td>99.9</td>
<td>1.93</td>
</tr>
<tr>
<td>Crossbred (1/2 Jersey × 1/2 Thari)</td>
<td>55</td>
<td>23.8</td>
<td>0.66</td>
<td>33.1</td>
<td>0.62</td>
<td>20-47</td>
<td>132.1</td>
<td>2.83</td>
</tr>
</tbody>
</table>
TABLE 1(b)
Averages of first-lactation yield, age at first calving, and yield up to 10 yr of age with respective standard errors

<table>
<thead>
<tr>
<th>Name of breed</th>
<th>No. of animals</th>
<th>Average yield in first lactation in 100's of kg</th>
<th>Standard error</th>
<th>Average age at first calving in months</th>
<th>Standard error</th>
<th>Range of age in 100's of kg</th>
<th>Standard error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tharparkar</td>
<td>40</td>
<td>25.3</td>
<td>0.64</td>
<td>38.6</td>
<td>1.07</td>
<td>27-50</td>
<td>151.4</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>24</td>
<td>24.9</td>
<td>0.89</td>
<td>41.5</td>
<td>1.53</td>
<td>26-58</td>
<td>141.8</td>
</tr>
<tr>
<td>Red Sindhi</td>
<td>16</td>
<td>18.3</td>
<td>1.10</td>
<td>42.8</td>
<td>1.54</td>
<td>33-54</td>
<td>107.3</td>
</tr>
<tr>
<td>Crossbred (½ Jersey × ½ Thari)</td>
<td>44</td>
<td>24.2</td>
<td>0.72</td>
<td>33.4</td>
<td>0.74</td>
<td>21-47</td>
<td>176.6</td>
</tr>
</tbody>
</table>

The extent and nature of data examined to predict the yield up to five lactations as well as up to 10 yr of age are indicated in Tables 1(a) and 1(b).

RESULTS AND DISCUSSION

Relationship between 305 days' production in first lactation, age at first calving, and five lactations yield. This was studied by the method of correlation analysis. It was found that there existed a high degree of relationship between 305 days' production in the first lactation (hereafter called first-lactation yield) and five lactations yield, the correlation coefficients in all the breeds being highly significant (Table 2). Age at first calving had no influence on five lactations yield. Though the correlation coefficients between these two characters were not statistically significant, the negative sign indicates that there is a trend for the yield in five lactations to increase as the age at first calving decreases.

The prediction equations to predict five lactations yield \( y \) on the basis of the first-lactation yield \( x_1 \) were, therefore, fitted and are:

- Tharparkar: \( y = 529.61 + 3.95 x_1 \)
- Sahiwal: \( y = 663.59 + 2.72 x_1 \)
- Red Sindhi: \( y = 746.37 + 1.42 x_1 \)
- Crossbred (½ Jersey × ½ Thari): \( y = 636.85 + 2.87 x_1 \)

(Where \( y \) and \( x_1 \) are both measured in tens of kg.)

These prediction equations were seen to explain a variation of 74, 70, 44, and 42% of the total variation in five lactations yield for the four breeds, respectively.

It was observed that the correlation between age at first calving and age at completion of five lactations were highly significant in Tharparkar, Sahiwal, and crossbred cows and, in the Red Sindhi breed, it was significant only at 5% level. Early calvers are thus seen to complete five lactations quicker than late calvers.

Relationship between first-lactation yield \( x_1 \), age at first calving \( x_2 \), intercalving period \( x_3 \), and yield up to 10 yr of age \( y \). Prediction of lifetime production is not possible, as many of the cows are not kept in the herd.

TABLE 2
Coefficients of correlation between first-lactation yield, age at first calving, and age at completion of five lactations

<table>
<thead>
<tr>
<th>Name of breed</th>
<th>No. of cows</th>
<th>First-lactation yield and five lactations yield</th>
<th>Age at first calving and five lactations yield</th>
<th>Age at first calving and age at completion of five lactations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tharparkar</td>
<td>48</td>
<td>0.801**</td>
<td>-0.116</td>
<td>0.487**</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>30</td>
<td>0.835**</td>
<td>-0.137</td>
<td>0.470**</td>
</tr>
<tr>
<td>Red Sindhi</td>
<td>21</td>
<td>0.661**</td>
<td>-0.168</td>
<td>0.456*</td>
</tr>
<tr>
<td>Crossbred (½ Jersey × ½ Thari)</td>
<td>55</td>
<td>0.639**</td>
<td>-0.143</td>
<td>0.650**</td>
</tr>
</tbody>
</table>

* Significant at 5% level of significance.
** Significant at 1% level of significance.
until their natural death. It is, therefore, necessary to predict the production up to a certain stage which covers a large period of the productive life. Production up to 10 yr of age (hereafter called lifetime production) has been taken as an ideal period, as it covers a major portion of productive life, which is about 6 to 7 yr and, at the same time, most of the cows are expected to complete five lactations during that period.

Correlation coefficients between first-lactation yield and lifetime production were highly significant (Table 3) in all the three pure breeds of cows and in the crossbred cows the same was found to be significant at 5% level. Relationship between age at first calving and lifetime production was also established by very highly significant correlation coefficients. On the other hand, intercalving period between first and second lactations had no influence on lifetime production.

Age at first calving was seen to influence the first lactation yield in Tharparkar and Sahiwal, but the same was not found in Red Sindhi breed and in crossbred animals. Contrary to many of the studies which indicate the independence between the first-lactation yield and age at first calving, highly significant correlations were obtained between these two characters in Tharparkar and Sahiwal breeds.

The intercalving period was seen to be independent of age at first calving, as can be seen from the magnitude of correlation coefficients in the last column of Table 3. This confirms results reported by Skjervold (7).

Lifetime production was, therefore, seen to be more dependent on the first-lactation yield and age at first calving. Table 4 shows the partial and multiple correlation coefficients between these characters.

It is seen that the first-lactation yield and age at first calving are highly related with the lifetime production in all cases, the partial correlation coefficients being highly significant. Highly significant negative partial correlations were obtained between age at first calving and lifetime production. Age at first calving being kept constant, increase in first-lactation yield will increase lifetime production; first-lactation yield being the same, decrease in age at first calving increases lifetime production. Highly significant multiple correlations ($R_{x_1x_2y}$) in all four breeds suggest these two characters provide a sufficient knowledge of lifetime production.

Apparent differences in estimates of the correlation coefficients (Tables 3 and 4) were found between purebred and crossbred cows. These differences may be due to changes in breed composition. Sundaresan et al. (8) also reported that correlation coefficients were of higher magnitude in the purebred cows and cows containing more Red Sindhi blood.

### TABLE 3

Coefficients of correlations between lifetime production ($y$), first-lactation yield ($x_1$), and age at first calving ($x_2$), and intercalving period ($x_3$)

<table>
<thead>
<tr>
<th>Name of breed</th>
<th>No. of cows</th>
<th>Correlation between $x_1$ and $y$</th>
<th>Correlation between $x_2$ and $y$</th>
<th>Correlation between $x_3$ and $y$</th>
<th>Correlation between $x_1$ and $x_2$</th>
<th>Correlation between $x_1$ and $x_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tharparkar</td>
<td>40</td>
<td>0.606**</td>
<td>-0.756**</td>
<td>-0.050</td>
<td>-0.418**</td>
<td>0.104</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>24</td>
<td>0.741**</td>
<td>-0.733**</td>
<td>0.156</td>
<td>-0.418**</td>
<td>-0.137</td>
</tr>
<tr>
<td>Red Sindhi</td>
<td>16</td>
<td>0.610**</td>
<td>-0.728**</td>
<td>-0.057</td>
<td>-0.175</td>
<td>0.186</td>
</tr>
<tr>
<td>Crossbred (1/2 Jersey × 1/2 Thari)</td>
<td>44</td>
<td>0.380*</td>
<td>-0.498**</td>
<td>0.202</td>
<td>0.021</td>
<td>-0.190</td>
</tr>
</tbody>
</table>

* Significant at 5% level of significance.  
** Significant at 1% level of significance.

### TABLE 4

Partial and multiple correlation coefficients between lifetime production ($y$), first-lactation yield ($x_1$), and age at first calving ($x_2$)

<table>
<thead>
<tr>
<th>Name of breed</th>
<th>$r_{y_1}$</th>
<th>$r_{y_2}$</th>
<th>$R_{x_1x_2y}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tharparkar</td>
<td>0.659**</td>
<td>-0.713**</td>
<td>0.864**</td>
</tr>
<tr>
<td>Sahiwal</td>
<td>0.704**</td>
<td>-0.693**</td>
<td>0.876**</td>
</tr>
<tr>
<td>Red Sindhi</td>
<td>0.715**</td>
<td>-0.796**</td>
<td>0.878**</td>
</tr>
<tr>
<td>Crossbred (1/2 Jersey × 1/2 Thari)</td>
<td>0.450**</td>
<td>-0.547**</td>
<td>0.633**</td>
</tr>
</tbody>
</table>

** Significant at 1% level of significance.
the respective standard errors, are presented in Table 5. All the partial regression coefficients were found to be highly significant, indicating the high degree of reliance that can be placed on the prediction equations based on first-lactation yield and age at first calving.

Prediction equations based on these partial regression coefficients were seen to explain 75, 77, 77, and 40% of the total variation in the lifetime production in the four breeds, respectively. The variation explained by these two characters in crossbred cows was very much lower than that of purebred cows. Age at first calving was seen to explain more of the total variation than the first-lactation yield.

The test of linearity showed that all the four prediction equations were linear at 1% level of significance.

The magnitude of the partial regression coefficients indicates that an increase of 73 kg of milk in the first lactation is equivalent to a reduction of one month in age at first calving in the Tharparkar breed. Similar figures in the Sahiwal, Red Sindhi, and crossbred animals are 57, 92, and 126 kg of milk, respectively.

Relationship between first two lactations yield, age at first calving, intercalving period, and lifetime production. Whether the additional knowledge of another lactation yield and intercalving period will increase the accuracy of prediction equation was studied in the Tharparkar breed. The correlation between the total of first two lactations yield \( (x_1) \) and lifetime production \( (y) \) was seen to be 0.645 and between age at first calving \( (x_2) \) and lifetime production 0.756, both correlations being significant at the 1% level. Correlation coefficients obtained (Table 3, Columns 5 and 7) between age at first calving and intercalving period \( (x_2) \) and the lifetime production and intercalving period were not significant. Highly significant correlations were obtained between the first two lactations yield and age at first calving \( (-0.551^{**}) \) and the first two lactations yield and intercalving period \( (0.504^{**}) \).

Prediction equations based on these characters, and taking the first two lactation yields as two separate characters along with the other two characters, were found not to add much additional information to the prediction equation based on first-lactation yield and age at first calving, the variation explained by all the prediction equations being almost the same. This is also supported by low correlation between the second lactation yield and lifetime production (0.0084) and intercalving period and lifetime production.

Results reveal that the first-lactation yield and age at first calving explain a major portion of the variation in lifetime production, in purebred animals. Though the variation explained in the crossbred cows was highly significant, the percentage of variation explained was comparatively less. Studies of Sundaresan et al. (8) also report similar findings.

The present study indicates the high influence of age at first calving on estimation of lifetime production. Chapman and Dickerson (1), Hanson (3), Gethin (2), and Ziegenhagen (10) have reported similar findings.

Total yield up to five lactations was found to be related to the first-lactation yield, and age at first calving had no influence. Studies of other workers in the field (as already mentioned) also indicate the high relationship of yield up to completion of certain lactations and first-lactation yield.

The study thus substantiates that for judicious culling of animals and for improvement of phenotypic characters in the herd it is necessary to consider age at first calving along with first-lactation yield.

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