A STUDY ON
The Estimates Of Some Genetic and Phenotypic Parameters At Different Levels Of Production In The Tharparker Herd
AT
Government Cattle Farm, Rahimy

A THESIS
Submitted in the School of
Veterinary Science & Animal Husbandry
MORADABAD UNIVERSITY
In Partial Fulfillment Of the Requirements for the Degree of
MASTER OF SCIENCE (Animal Husbandry)

Raman Prasad

Office Veterinary College, Faisalabad
December, 1969
A STUDY ON
The Estimates Of Some Genetic And Phenotypic Parameters At Different Levels Of Production In The Tharparkar Herd AT
Government Cattle Farm, Patna

A THESIS
Submitted to the Faculty of Veterinary Science & Animal Husbandry MAGADH UNIVERSITY
In Partial Fulfilment Of The Requirements For The Degree Of MASTER OF SCIENCE (Animal Husbandry)

By Rajendra Brasad Lal
B. V. Sc. & A. H.
Bihar Veterinary College, Patna December, 1970
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Professor & Head,
Department of Animal Husbandry,
Bihar Veterinary College, Patna.

PATNA
Dated, the 30th December, 1970.

I certify that this THESIS has been prepared under my supervision by Shri R.P. Lal, a candidate for the degree of M.Sc. (A.H.), with ANIMAL GENETICS AND BREEDING as major subject, and that it incorporates the results of his independent study.

( H. R. Mishra)
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A word of gratitude is also due to the Manager, Government Cattle Farm, Patna along with his staff for their help in data collection.

PATNA, December, 1970

(R. P. Lal)
INTRODUCTION

With the cracking of Genetic Code, Genetics has now come to a stage where gene-structure has become elaborately defined; its functions better understood and its synthesis undertaken. Genes are even being claimed to be seen under the microscope. All these advances point out to the possibility of direct gene-manipulation in future apart from having other far-reaching consequences on the techniques of selection and breeding of farm animals. But, so far, Genetics of economic characters continues to be investigated primarily through the conventional statistical techniques.

Estimates of Genetic and Phenotypic parameters obtained from different populations speak of their genetic structures on which effective selection and breeding programmes may be framed to bring about genetic improvement in those characters. Information on nature and magnitude of their inheritance, their mutual relationship at the genetic and phenotypic level are abundantly available for livestock population, both exotic and Indian. But such informations at different production levels in various livestock populations are available only to a very limited extent. The nature of inheritance governing a quantitative character being what it is, we are aware of the existence of major genes, minor genes, modifiers, genes for high production, genes for low production and the complicating effects of environment on the phenotypic expression of the economic characters. The conventional statistical techniques
employed to study these characters take into account these phenotypic expressions. Against this background it is logical to expect differences in heritability estimates of economic characters and their relationship at the genetic and phenotypic levels.

It was therefore decided to take of studies on heritability estimates of some economic characters and their correlation at the genetic and phenotypic stage at four different production levels in the Tharparkar herd at the Government Cattle Farm, Patna (including the rate of decline of milk-yield).

The economic characters included in this study are:

1. First lactation yield.
2. First lactation length.
3. Age at maturity.
4. First dry period.
5. First inter-calving period.
6. Rate of decline of milk-yield.

The cows have been divided into four groups, based upon different level of production in first lactation, as follows for the purpose of above studies:

1. Above 4000 lbs.
2. Above 3000 lbs. but below 4000 lbs.
3. Above 2000 lbs. but below 3000 lbs.
The records on the Tharparker cows from 1927 to 1968 are taken for the studies of traits under item 1 to 4 listed in the previous page whereas for item no. 5 (Rate of decline of milk yield) records on milk production were taken from 1946 to 1968.

The idea behind including the rate of decline of milk yield in respect of lactation yields is to assess the part it plays in lowering production specially in low yielders. This was necessitated in view of the fact that a fairly large number of low yielding cows were seen to dry off rather quickly and had sharp decline in the lactation yield. This started affecting not only the production and economics of the herd, but also the data of the Progeny Testing Scheme in progress at this farm.

Under the study of rate of decline, the study on the following parameters was made:

1. Rate of decline of milk yield upto sixth lactation at different level of production.
2. Heritability estimates of rate of decline at different level of production upto third lactation.
3. Monthly peak yield and its heritability estimate upto third lactation at different level of production.
4. Persistency index.

The results obtained are expected to be of use in
the Selection and Breeding Programme of the Tharparkar herd

apart from its value as an information in general.

Based on the available literature on various aspects
of selection for milk production, the following tables
are presented to tabulate her

<table>
<thead>
<tr>
<th>Animal</th>
<th>Date</th>
<th>Breed</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Massage Milk Production</th>
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<tr>
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<td>40 -</td>
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<tr>
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<td>2524</td>
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REVIEW OF LITERATURE

First Lactation Yield.

Under this head the literature on various estimates of parameter for milk yield have been reviewed in tabular form as follows:

1. Average milk yield in different breeds of cattle.
2. Estimates of heritability of milk yield.
3. Estimates of genetic and phenotypic correlation of first lactation yield with first lactation period.
4. The available literature on rate of decline in milk production has been reviewed separately.

For the sake of brevity, the three topics are reviewed in tabular form:

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<tr>
<th>Authors</th>
<th>Year</th>
<th>Breed</th>
<th>No. of records</th>
<th>Stage of lactation</th>
<th>Average (lbs)</th>
<th>C.V%</th>
<th>Remarks</th>
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## Table 1

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## Table 2

(heritability of first lactation yield)

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### TABLE - 3

(Correlation between first lactation yield & 1st lact. length)

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First Lactation Length.

The total production of the cow greatly depends upon the lactation length; higher the lactation length higher is the milk yield (0.94). It is the period right from the date of calving to the last date of milking. Although it has got more variation but keeping the optimum dry period for 60 days the lactation length turns out to be 305 days which is the "Standard Lactation Length". Too long or too short lactation length is undesirable, as it directly affects the milk yield as well as calf crop in the life span of the cow. Prasad (1962) has estimated the economic value of lactation length as Rs. 23.00 per month for the Tharparkar herd at Patna, i.e., for decrease or increase of one month lactation, there will be decrease or increase in the profit amounting to Rs. 22.00. The available literature has been reviewed under the following heads:

1. Average first lactation length of different breeds.
2. Estimate of heritability of first lactation length and the correlation studies have been reviewed under respective heads.

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<td>252.0</td>
<td></td>
<td>+12</td>
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<td>+9</td>
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<td>317.0</td>
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<td>+12</td>
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<td>326.0</td>
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### Table 4

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<tr>
<td>Amble et al</td>
<td>1967</td>
<td>Tharparkar</td>
<td>311.0</td>
<td>-</td>
<td>Overall</td>
<td>+50</td>
</tr>
<tr>
<td>Kavitkar et al</td>
<td>1968</td>
<td>Sahiwal</td>
<td>39</td>
<td>243.2</td>
<td>20.03 (831-1322 lit)</td>
<td>+7.9</td>
</tr>
<tr>
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<td></td>
<td></td>
<td>248</td>
<td>293.4</td>
<td>10.09 (1322-2544 lit)</td>
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<td>172</td>
<td>305.0</td>
<td>0.65 (Above 2544&quot;)</td>
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### Table 5

**Heritability estimate of first lactation length**

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>Estimate</th>
<th>Method</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patel</td>
<td>1957</td>
<td>Sahiwal</td>
<td>0.13</td>
<td>Intra-sire regression</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Kankrej</td>
<td>0.17</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>Amble et al</td>
<td>1958</td>
<td>Re-Sindhi (Bangalore)</td>
<td>0.33</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Re-Sindhi (Kosur)</td>
<td>0.04</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>Singh</td>
<td>1959</td>
<td>Mariana</td>
<td>0.32</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>Batra</td>
<td>1961</td>
<td>Sahiwal</td>
<td>0.37</td>
<td>-do-</td>
<td></td>
</tr>
<tr>
<td>Singh &amp; Desai</td>
<td>1961</td>
<td>Mariana</td>
<td>0.32</td>
<td>Intra-sire regression</td>
<td>-do-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.32</td>
<td>+0.03</td>
<td>Half-sib</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.32</td>
<td>+0.03</td>
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<td></td>
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<td>0.83</td>
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**Contd. Table - 5**

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<tr>
<td></td>
<td>Singh &amp; Prasad 1966</td>
<td>Hariana</td>
<td>0.58</td>
<td>Intra-sire regression</td>
<td></td>
<td>do</td>
</tr>
<tr>
<td></td>
<td>do</td>
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<td></td>
<td>do</td>
<td>do</td>
<td>0.38</td>
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<td>do</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Amble et al 1967</td>
<td>Tharparkar (Patna)</td>
<td>0.29</td>
<td>Intra-sire regression</td>
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</tbody>
</table>

**Age at Maturity**

Age at maturity is such an important trait on which the economics of keeping cow is mainly based. It is rather an entrance from where we expect to get in return from the cow. The period from date of birth till first successful service is known as age at maturity. In our practical life, it becomes difficult to detect the age at first heat or age at maturity. Heat detection is very important in breeding animals. If, by chance, a heifer in heat is not detected and is detected in the second oestrus cycle, i.e., after about one month, then naturally her age at maturity and age at first calving will be increased.

Dealing with the age at maturity Amble et al (1958) point out that delayed maturity and calving interval affect the farm economics adversely.

Johansson (1950) points out that life time production and number of calf crop are higher for early calvers as compared with late calvers.

Tandon (1951) reported that gene for early maturity
are dominant over those of late maturity.

Eckles (1935) reported that restricted feeding delays maturity.

Hartman (1953) reported highest fertility and life time production in cows showing early maturity without any ill effect on their health.

Mahadevan (1953) reported that age at maturity can be lowered down by better feeding and management.

Stettwieser (1952) has shown that early matured heifers gave birth to greater number of calves and produced more milk during their whole productive life as compared to late calvers.

Hawk et al (1954) reported the adverse effect of in-breeding and calf-hood scouring on age at maturity.

Salisbury et al (1961) pointed out significant effect of level of feed intake on age at maturity. Low feed intake group took twice as long time as higher intake group, to attain puberty.

Literature on various estimates of parameter on age at maturity are reviewed in tabular form under the following heads:

1. Average age at maturity in different breeds of cattle.
2. Estimates of heritability of age at maturity.
3. Estimates of phenotypic correlation of age at maturity with first lactation yield and first dry period as well as first inter-calving period.
<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>No. of records</th>
<th>Average</th>
<th>C.V%</th>
<th>Remarks</th>
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</thead>
<tbody>
<tr>
<td>Rajagopalan</td>
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<td>R.Sindhi</td>
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<td>1030.0</td>
<td>30</td>
<td>+35</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1952 Kangayan</td>
<td>1174.0</td>
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<td>+45</td>
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<tr>
<td>Ahuja et al</td>
<td>1961</td>
<td>Hariana</td>
<td>-</td>
<td>909.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luktuke &amp;</td>
<td>1961</td>
<td>-do-</td>
<td>-</td>
<td>1275.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subramaniam</td>
<td></td>
<td></td>
<td>Quadeer</td>
<td>1208.8</td>
<td>21.5</td>
<td>+27.8</td>
</tr>
<tr>
<td>Sharma et al</td>
<td>1968</td>
<td>Hariana</td>
<td>-</td>
<td>29.97</td>
<td>months</td>
<td></td>
</tr>
<tr>
<td>Kavitkar et al</td>
<td>1968</td>
<td>Sahiwal</td>
<td>39</td>
<td>31.92</td>
<td>18.72</td>
<td>0.97</td>
</tr>
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<td></td>
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<td>248</td>
<td>30.40</td>
<td>11.93</td>
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<td>172</td>
<td>30.93</td>
<td>13.05</td>
<td>0.31</td>
</tr>
<tr>
<td>Singh et al</td>
<td>1968</td>
<td>Hariana</td>
<td>610</td>
<td>46.79</td>
<td>18.0</td>
<td>0.35</td>
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### TABLE - 7

(Heritability estimate of age at maturity)

<table>
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<th>No. of records</th>
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<th>Remarks</th>
</tr>
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<tr>
<td>Singh</td>
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<td>Tharparkar</td>
<td>-</td>
<td>0.361</td>
<td>Intra-sire regression</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>0.305</td>
<td>Dd Correlation</td>
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<td></td>
<td></td>
<td></td>
<td>0.468</td>
<td>Half-sib</td>
</tr>
<tr>
<td>Quadeer</td>
<td>1965</td>
<td>Deoni</td>
<td>-</td>
<td>0.362</td>
<td>Intra-sire regression</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>0.570</td>
<td>Correlation method</td>
</tr>
<tr>
<td>Singh et al</td>
<td>1968</td>
<td>Hariana</td>
<td>609</td>
<td>0.760</td>
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### TABLE - 8

(Correlation between age at maturity and 1st lactation yield)

<table>
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<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>Estimate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rajagopalan</td>
<td>1952</td>
<td>Red Sindhi</td>
<td>0.046</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1952</td>
<td>Kangayan</td>
<td>0.316</td>
<td></td>
</tr>
<tr>
<td>Venkayya &amp;</td>
<td>1957</td>
<td>Ayrshire x</td>
<td>0.410</td>
<td>Age at first calving x 1st lactation length</td>
</tr>
<tr>
<td>Anantakrishnan</td>
<td></td>
<td>Red Sindhi</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chandramani</td>
<td>1953</td>
<td>-</td>
<td>-0.07</td>
<td>-do-</td>
</tr>
<tr>
<td>Singh</td>
<td>1959</td>
<td>-</td>
<td>-0.10</td>
<td>-do-</td>
</tr>
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</table>
### Table 8

<table>
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<tr>
<th>Author</th>
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<th>No. of records</th>
<th>Age at 1st calving x first lactation length</th>
</tr>
</thead>
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<tr>
<td>Ahmad</td>
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<td>Hariana</td>
<td></td>
<td>-0.197</td>
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<tr>
<td>Bhatnagar &amp; Chaudhury</td>
<td>1961</td>
<td>Malvi</td>
<td></td>
<td>0.99</td>
</tr>
<tr>
<td>Batra</td>
<td>1961</td>
<td>Sahiwal</td>
<td></td>
<td>0.312</td>
</tr>
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<td>Ahuja et al</td>
<td>1961</td>
<td>Hariana</td>
<td></td>
<td>-do-</td>
</tr>
<tr>
<td>Danasoury &amp; Bayoumi</td>
<td>1962</td>
<td>Sudanese cattle</td>
<td></td>
<td>0.402</td>
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<tr>
<td>Prasad</td>
<td>1962</td>
<td>Tharparkar</td>
<td></td>
<td>0.400</td>
</tr>
<tr>
<td>Chatterjee</td>
<td>1969</td>
<td>-do-</td>
<td></td>
<td>0.077 Genetic</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.133 Phenotypic</td>
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### Table 9

( Correlation between age at maturity & 1st inter-calving period)

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<tbody>
<tr>
<td>Venkayya &amp; Anantakrishnan</td>
<td>1956</td>
<td>Re Sindi</td>
<td>216</td>
<td>0.56</td>
<td>Age at first calving</td>
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<tr>
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<td>Tharparkar</td>
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<td>Batra</td>
<td>1961</td>
<td>Sahiwal</td>
<td>-</td>
<td>0.072</td>
<td>-do-</td>
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<tr>
<td>Singh &amp; Chaudhury</td>
<td>1961</td>
<td>Sahiwal</td>
<td>113</td>
<td>0.120</td>
<td>-do-</td>
</tr>
<tr>
<td>Danasoury &amp; Bayoumi</td>
<td>1962</td>
<td>Sudanese cattle</td>
<td></td>
<td>0.117</td>
<td>-do-</td>
</tr>
<tr>
<td>Prasad</td>
<td>1962</td>
<td>Tharparkar</td>
<td>-</td>
<td>0.043</td>
<td>-do-</td>
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<tr>
<td>Singh</td>
<td>1964</td>
<td>Hariana</td>
<td>-</td>
<td>0.167</td>
<td>-do-</td>
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<tr>
<td>Shukla</td>
<td>1965</td>
<td>Gir</td>
<td>124</td>
<td>0.223</td>
<td>-do-</td>
</tr>
<tr>
<td>Quadeer</td>
<td>1965</td>
<td>Deoni</td>
<td>62</td>
<td>0.140</td>
<td>-do-</td>
</tr>
</tbody>
</table>
Correlation between age at maturity and first dry period:

Askar et al. (1959) found no relationship between age at first calving and first dry period. Damasoury and Bayoumi (1962) obtained a correlation of 0.35 and regression coefficient of 0.293 and 0.117 between age at first calving and first dry period.

Dry Period:

Dry period is one of the important constituents of calving interval. It is directly related to the economy of the cow husbandry. As this period is unproductive component of inter-calving period, care should be taken to maintain this at optimum level.

Puri et al. (1964) reported that if dry period is decreased by 24 days, the cost of milk production will reduce by one paisa per Kg. of milk produced. It is presumed that reduction in dry period will not affect milk yield.

Chaudhury et al. (1964) reported that main cause of low production of milk yield in this country is the large proportion of dry cows than milk cows.

Panse et al. (1964) indicated that the percentage of milk cows in rural and sub-urban area is 30-35%. But in urban areas the percentage of milking cows are over 80% in any of the season.

Carroll (1913) found that for higher production dry period of one month is needed in Utah cows. Side-by-side, he stated that if this period is more than two months, it will
add nothing to subsequent lactation yield.

Gravin (1913) on an analysis of 347 records of an English Herd reported that milk production is reduced in cows having dry period less than 35 days, while those with longer period gained little.

Arnold & Baker (1936) observed that the dry period of 31-60 days is necessary for maximum production.

Dickerson et al (1939) reported that effect of dry period is more pronounced in low producing and poorly managed herd than high yielding and better managed herd.

Leckey (1951) found that high yielders had shorter dry period than poor yielders in Fulani cattle.

Lonka (1946) found that length of dry period had very little effect on milk yield of subsequent lactations.

Shukla (1965) suggested that if dry period is 60 days in Gir cows, the milk yield could be expected to increase by 47400 lbs. in comparison to yield of cows without dry period.

Hammond & Sanders (1923) reported that cows having dry period for 39 days or less were least productive, while those having dry days between 40 and 79 days gave 10.3% more milk and those having 80-119 days dry period gave 14.2% more milk.

Patel (1957) on analysing the records of Kankrej and Sahiwal herds inferred that dry period of less than 80 days is detrimental to efficient production in next lactation in Kankrej cattle. Dry period of 3 to 4 months for Kankrej and 4 to 5 months for Sahiwal animals would be quite useful for optimum production in next lactation.
Bhatnagar & Chaudhury (1961) on an analysis of 65 Malvi cows reported that high negative correlation of -0.81 exists between dry period and subsequent lactation length.

Singh & Desai (1962) suggested that a dry period of 60-90 days be allowed to Mariana cows and it may be more than 90 days with no advantage.

Jha & Biswas (1964) put a range of 30-130 days dry period as optimum for Tharparker herd of Patna.

Literature on various estimates of parameters on dry period have been reviewed in tabular form under the following heads :-

(1) Average, S.E. & C.V. of dry period.
(2) Heritability of the dry period

<table>
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<tr>
<th>Author</th>
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<th>Average (days)</th>
<th>C.V.%</th>
<th>Remarks</th>
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<td>-</td>
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</tr>
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<td>Joshi &amp; Phillips</td>
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<td>Kankrej</td>
<td>-</td>
<td>153-191</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>1953</td>
<td>Thari</td>
<td>-</td>
<td>232.5</td>
<td>15.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1953</td>
<td>Mariana</td>
<td>-</td>
<td>123-157</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
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<td>------</td>
<td>-------</td>
<td>------</td>
<td>------</td>
<td>------</td>
</tr>
<tr>
<td>1</td>
<td>Patel</td>
<td>1956</td>
<td>Gir</td>
<td>-</td>
<td>97.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gir</td>
<td>-</td>
<td>143.0</td>
<td>-</td>
</tr>
<tr>
<td></td>
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<td>Gir</td>
<td>-</td>
<td>211.0</td>
<td>-</td>
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<tr>
<td></td>
<td>Pattabhiraman</td>
<td>1957</td>
<td>Gir</td>
<td>-</td>
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</tr>
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<td></td>
<td>Mahadevan</td>
<td>1958</td>
<td>Gir</td>
<td>-</td>
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<td>-</td>
</tr>
<tr>
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<td>Dave</td>
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<td>Gir</td>
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<td>Gir</td>
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<td>-</td>
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<td></td>
<td>Jha &amp; Biswas</td>
<td>1964</td>
<td>Tharparkar</td>
<td>-</td>
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<td>-</td>
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<tr>
<td></td>
<td>Shukla</td>
<td>1965</td>
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<td>208.6</td>
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<td>Gaolao (Gopuri)</td>
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Calving Interval:

The period between two subsequent calvings is known as calving interval. It includes service period and gestation period or lactation period and dry period. This trait in a way governs the breeding cycle of an animal viz. shorter calving interval which means shorter dry period and service period. If the calving interval is shorter, the expenditure is minimised in breeding operations.

Matson (1929) emphasised relationship between calving interval and succeeding lactation yield that "The optimum calving interval varies directly with the milking capacity and inversely with the age at maturity.

Herin (1952) reported that calving interval is much influenced by management practices.

Johansson et al (1940) reported that by reducing the calving interval to 10 months results in loss of production by 12%.

Johansson (1952) reported that first calving interval should be relatively long because milk yield during first lactation is more persistent (lactation curve is flatter) and heifers are not fully grown at first calving. He observed that highest average milk yield is obtained by a first calving interval of 14 months, a second one of 13 months and successive calving interval of 12 months.

A review of literature on various estimates of parameters of calving interval has been made in tabular form.
on the following items:

(1) Mean, S. E. and C. V. of calving interval in different breeds.

(2) Heritability of calving-interval.

**Table 12**

(Average calving interval of different breeds)

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<th>C. V. %</th>
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### Table 12
(Heritability estimate of calving interval of different breeds)

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Rate of decline of milk production:

Upto first quarter of nineteenth century it was supposed that milk is secreted by the nervous stimulation through the act of milking (Reflex secretion theory).

Later on Gaines and Samann (1927) and Hammond (1935) refuted the above theory by their experiment. They established a ratio between blood flowing through the udder and the volume of the milk secreted (150 : 1 to 560) and put forth the "theory of continuous secretion". It was found that the maximum rate is attained soon after milking and that this is maintained for a period which depends mainly upon the milk yield...
of the cow and her udder capacity. Thereafter the rate of formation declines and if milking is not taken out the secretion will eventually cease after 24-72 hours of the last milking.

A number of measurements of the rate of decline in milk secretion with increasing intervals after milking have been made. The results show some variation due to difference in experimental method, different stage of lactation, udder capacity and milk yield of the cow used.

Fagstaffe, Turner and Brody (1924) found that the rate of secretion in each hour fell to 95% of the production of the previous hour, others found that maximum rate is often maintained for over twelve hours before a serious decline sets in, even with high yielding cows.

In other publications, Turner (1955 a, b, c) put forward that the rate of secretion can be virtually linear for well over 24 hours. Elliott & Brumby (1955) supported the Turner's evidence.

Internal udder pressure:

Tgetgel (1928) found that there was effect of internal udder pressure on the milk secretion. There is gradual increase in the udder pressure between one milking and the next. When the milk ejection is stimulated at milking time, there is very rapid increase in the pressure which may double in the course of a minute.

Korkman (1953) demonstrated that internal udder pressure rises rapidly in the first hour after milk, the rise
being due to hydrostatic pressure of the milk which drains from the secretory tissue to the udder and teat sinuses. After this initial period the rise in pressure is due to the pressure of the milk which is being secreted. At first the increase in the pressure is small but the rate accelerates with increasing interval since milking. There is significant correlation between the increase in pressure and the rate of milk secretion (r = 0.75).

From the records of intramammary pressure which have been collected, it appears that once the pressure reaches 35 mm Hg, milk secretion ceases. So the stoppage of milk secretion at relatively low pressure illustrates the importance of udder structure and conformation. Hammond (1936) points that "whole structure of the cow's udder appears to be designed for the relief of pressure on the secretory alveolar cells."

Frequency of milking and incomplete milking also affect internal udder pressure.

Factors affecting ejection of milk:

1. Manipulation of udder.
2. Washing before milking and
3. Rate of milking.

Aforesaid factors affect the ejection of milk. Dodd & Foot (1953) pointed out that fast milking cows give higher maximum daily yield which decline more slowly over longer lactations. Besides, there are well known physiological and environmental factors that affect lactation yield viz. size, age, pregnancy, season of the year and environmental temperature etc.
The available literature on decline of milk production has been reviewed as follows:

**Table 14**
(Monthly rate of decline of milk yield in lbs./100 lbs.)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>No. of records</th>
<th>Estimate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brody</td>
<td>1927</td>
<td>Holstein</td>
<td>-</td>
<td>0.053</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jersey</td>
<td>-</td>
<td>0.056</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Guernsey</td>
<td>-</td>
<td>0.057</td>
<td></td>
</tr>
<tr>
<td>Kartha</td>
<td>1934</td>
<td>Cross-bred</td>
<td>157</td>
<td>0.092</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pedigree Sahiwal</td>
<td>112</td>
<td>0.074</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ordinary Sahiwal</td>
<td>39</td>
<td>0.110</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indian Buffalo</td>
<td>112-140</td>
<td>0.093</td>
<td></td>
</tr>
<tr>
<td>Murty</td>
<td>1963</td>
<td>Tharparker</td>
<td>-</td>
<td>0.054</td>
<td>First lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-do-</td>
<td>-</td>
<td>0.074</td>
<td>2nd lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-do-</td>
<td>-</td>
<td>0.066</td>
<td>3rd lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-do-</td>
<td>-</td>
<td>0.073</td>
<td>4th lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-do-</td>
<td>-</td>
<td>0.082</td>
<td>5th lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-do-</td>
<td>-</td>
<td>0.076</td>
<td>6th lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-do-</td>
<td>-</td>
<td>0.064</td>
<td>overall</td>
</tr>
<tr>
<td>Scientific</td>
<td>1969-70</td>
<td>Mariana</td>
<td>-</td>
<td>0.061</td>
<td>1st lact.</td>
</tr>
<tr>
<td>report of</td>
<td></td>
<td>Animal genetics section,</td>
<td>0.034</td>
<td>2nd lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>L.R.S. Patna</td>
<td>-</td>
<td>0.058</td>
<td>3rd lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>0.063</td>
<td>4th lact.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-</td>
<td>0.073</td>
<td>5th lact.</td>
</tr>
</tbody>
</table>
### TABLE 15
(Heritability of monthly peak-yield)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>Estimate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sikka</td>
<td>1950</td>
<td>Ayrshire</td>
<td>0.298</td>
<td></td>
</tr>
<tr>
<td>Chief Bureau</td>
<td>1952</td>
<td>Short horn</td>
<td>0.27 - 0.40</td>
<td></td>
</tr>
<tr>
<td>of Animal Industry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural Research</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Admin., U.S.A.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rakes et al</td>
<td>1959</td>
<td>Jersey</td>
<td>0.47</td>
<td></td>
</tr>
<tr>
<td>Batra</td>
<td>1961</td>
<td>Holstein</td>
<td>0.10</td>
<td></td>
</tr>
<tr>
<td>Livestock</td>
<td>1958-67</td>
<td>Sahiwal</td>
<td>0.452 ± 0.113</td>
<td>Intra sire regression.</td>
</tr>
<tr>
<td>Research Station,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U.P. College of</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Veterinary Science &amp;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Animal Husbandry, Mathura.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-do-</td>
<td>1958-67</td>
<td>Hariana</td>
<td>0.45 ± 0.12</td>
<td>Half-sib method.</td>
</tr>
</tbody>
</table>

The literatures on maximum yield are reviewed as below in tabular form.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>Estimate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kartha</td>
<td>1934</td>
<td>Cross-breed</td>
<td>980.9 lbs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pedigree Sahiwal</td>
<td>791.1 lbs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ordinary Sahiwal</td>
<td>492.0 lbs.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indian Buffalo</td>
<td>570.9 lbs.</td>
<td></td>
</tr>
<tr>
<td>Murty</td>
<td>1963</td>
<td>Tharparkar</td>
<td>363.0 lbs. 1st lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>364.0 lbs. 2nd lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>390.0 lbs. 3rd lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>376.0 lbs. 4th lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>385.0 lbs. 5th lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>348.0 lbs. 6th lact.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>361.0 lbs. overall</td>
<td></td>
</tr>
</tbody>
</table>
Rao et al (1970) found maximum milk yield in fifth lactation in Mathura herd and fourth lactation in Babuwarh herd. In all the lactations, the peak-yield reached during the second month of lactation. Maximum persistency was obtained in first lactation.

The literatures on heritability of rate of decline of milk-yield are reviewed below in tabular form.

**TABLE - 16**

(Heritability of rate of decline of milk-yield)

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Breed</th>
<th>Estimate</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sikka</td>
<td>1950</td>
<td>Ayrshire</td>
<td>0.392</td>
<td></td>
</tr>
<tr>
<td>Mahadevan</td>
<td>1951</td>
<td>Ayrshire</td>
<td>0.10 - 0.15</td>
<td>-do-/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(South-West Scotland)</td>
<td></td>
<td>0.242 Repeatability</td>
</tr>
<tr>
<td>Suchenek</td>
<td>1962</td>
<td></td>
<td>0.393</td>
<td>-do-</td>
</tr>
<tr>
<td>Livestock</td>
<td>1958-67</td>
<td>Mariana</td>
<td>0.20 ± 0.17</td>
<td>Half-sib method.</td>
</tr>
</tbody>
</table>

Research Station, U.P. College of Veterinary Science and Animal Husbandry, Mathura.


Rao et al 1970 Murrah Buffalo 0.50 Repeatability

****
***
*
MATERIALS AND METHODS

The data for the present study pertain to a herd of Tharparkar cattle maintained at Government Cattle Farm, Patna. This farm was established in the 1926 with a foundation stock of 52 Tharparkar and 10 Shahabadi cows.

Tharparkar cows were purchased from their native place, i.e., Sindh, and 7 bulls were purchased at the same time from Karnal in the year 1934. Again, during the year 1936 stud bulls numbering 36 were purchased from Karnal. In 1946, the Shahabadi herd was abolished and since then only Tharparkar herd has been maintained.

The farm has been offering facilities for practical training of the students of Bihar Veterinary College, Patna to which it is attached. The farm is also providing materials for research and development.

The cows are fed Berseem, Napier and Paragrass as green fodder which are produced at the farm. Besides, hay is also fed to the cows. For production purpose, 1 lb. concentrate is given for 3 lbs. of milk production. Every mature animal is given 2 lbs. of concentrate mixture daily for general maintenance.

Hand milking is practised in the farm. Upto 1961, cows were allowed natural mating, but since 1961, artificial insemination is in practice.

There are 3 teaser bulls which are let loose in the herd by the attendants, both morning and evening to detect heat in cows.
As regards breeding policy, selective breeding along with progeny testing is practiced for the improvement of the herd. Bulls for the farm use are kept and others are sent to key villages and A.I. Centres for breeding purpose.

In the progeny testing programme, 30 breedable females are allotted per bull randomly to have at least 12 daughters with their first lactations. On availability of the result of progeny test of different sires, only the sons from the best sires alone coming from the highest yielding dams are retained for breeding purpose in future. At present 8th round of mating has finished.

The data for the present study was collected from history sheet and daily milk yield register of the cows of the herd. All the history sheets of the cows from 1923-63 were arranged according to their first lactation yield in descending order. Subsequently, they were grouped into four milk yield groups, viz;

1. 4000 lbs. and above,
2. Above 3000 but below 4000 lbs.
3. Above 2000 but below 3000 lbs.

This division is based purely on their total first lactation yield.

From daily milk yield register from 1946-63, monthly milk yield of each cow was recorded under the four above mentioned groups up to sixth lactation.
In the present study six traits, viz. First lactation yield, First lactation length, Age at maturity, First dry period, First inter-calving period and Monthly rate of decline of milk yield starting from the maximum yield (peak yield) till 11 months i.e., altogether of 12 months including the maximum yield at different four levels of production, have been taken into consideration.

Incomplete records or the records of diseased cows were discarded.

Mean, standard error and co-efficient of variation of the traits were studied after arranging the data into four groups based upon different level of production of first lactation yield. Phenotypic correlation of these traits were studied. The traits under study were as mentioned below :-

1. First lactation yield and first lactation length.
2. Age at maturity and first lactation yield.
3. Age at maturity and first dry period.
4. Age at maturity and first inter-calving period.

Genetic correlation between first lactation yield and first lactation length was studied. The heritability estimate of the following traits were studied:-

1. First lactation yield.
2. First lactation length
3. Age at maturity
4. First dry period
5. First inter-calving period
(6) Monthly peak yield.

(7) Monthly rate of decline of milk yield.

The study was made at different level of production.

Besides, monthly rate of decline of milk yield at different level of production up to sixth lactation was also studied.

First lactation yield:

Data on first lactation yield of 141, 181, 211 and 179 cows coming under different level of production (altogether 712 cows) were used in the present study. The distribution of records for all the herds in general is presented in the table below:

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MID-VALUE</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>550-1000 lbs</td>
<td>775</td>
<td>24</td>
</tr>
<tr>
<td>1001-1450</td>
<td>1225</td>
<td>66</td>
</tr>
<tr>
<td>1451-1900</td>
<td>1675</td>
<td>70</td>
</tr>
<tr>
<td>1901-2350</td>
<td>2125</td>
<td>96</td>
</tr>
<tr>
<td>2351-2800</td>
<td>2575</td>
<td>93</td>
</tr>
<tr>
<td>2801-3250</td>
<td>3025</td>
<td>93</td>
</tr>
<tr>
<td>3251-3700</td>
<td>3475</td>
<td>84</td>
</tr>
<tr>
<td>3701-4150</td>
<td>3925</td>
<td>51</td>
</tr>
<tr>
<td>4151-4600</td>
<td>4375</td>
<td>43</td>
</tr>
<tr>
<td>4601-5050</td>
<td>4825</td>
<td>37</td>
</tr>
<tr>
<td>5051-5500</td>
<td>5275</td>
<td>21</td>
</tr>
<tr>
<td>5501-5950</td>
<td>5725</td>
<td>12</td>
</tr>
<tr>
<td>5951-6400</td>
<td>6175</td>
<td>3</td>
</tr>
<tr>
<td>6401-6850</td>
<td>6625</td>
<td>2</td>
</tr>
<tr>
<td>6851-7300</td>
<td>7075</td>
<td>3</td>
</tr>
<tr>
<td>7301-7750</td>
<td>7525</td>
<td>1</td>
</tr>
<tr>
<td>7751-8200</td>
<td>7975</td>
<td>1</td>
</tr>
</tbody>
</table>

Total = 712
First lactation length:

First lactation length record of 141, 130, 211 and 176 cows, (altogether 703 cows) of respective level of production were considered for the present study. The frequency distribution of the records in general is presented in the table below:

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MID-VALUE</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-50 days</td>
<td>25</td>
<td>1</td>
</tr>
<tr>
<td>51-100</td>
<td>75</td>
<td>4</td>
</tr>
<tr>
<td>101-150</td>
<td>125</td>
<td>30</td>
</tr>
<tr>
<td>151-200</td>
<td>175</td>
<td>55</td>
</tr>
<tr>
<td>201-250</td>
<td>225</td>
<td>95</td>
</tr>
<tr>
<td>251-300</td>
<td>275</td>
<td>135</td>
</tr>
<tr>
<td>301-350</td>
<td>325</td>
<td>135</td>
</tr>
<tr>
<td>351-400</td>
<td>375</td>
<td>106</td>
</tr>
<tr>
<td>401-450</td>
<td>425</td>
<td>48</td>
</tr>
<tr>
<td>451-500</td>
<td>475</td>
<td>23</td>
</tr>
<tr>
<td>501-550</td>
<td>525</td>
<td>8</td>
</tr>
<tr>
<td>551-600</td>
<td>575</td>
<td>8</td>
</tr>
<tr>
<td>601-650</td>
<td>625</td>
<td>1</td>
</tr>
<tr>
<td>651-700</td>
<td>675</td>
<td>2</td>
</tr>
<tr>
<td>701-750</td>
<td>725</td>
<td>16</td>
</tr>
</tbody>
</table>

Total = 703
Age at maturity:

For age at maturity, records on interval in days between date of birth and date of first recorded service as mentioned in the history sheet were taken into consideration for the present study. Age at maturity record of 140, 174, 204 and 175 cows, at different level of production (altogether 693 records) were used for the present study. The table of frequency distribution is given below:

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MID-VALUE</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-600 days</td>
<td>550</td>
<td>1</td>
</tr>
<tr>
<td>601-700</td>
<td>650</td>
<td>0</td>
</tr>
<tr>
<td>701-800</td>
<td>750</td>
<td>6</td>
</tr>
<tr>
<td>801-900</td>
<td>850</td>
<td>36</td>
</tr>
<tr>
<td>901-1000</td>
<td>950</td>
<td>66</td>
</tr>
<tr>
<td>1001-1100</td>
<td>1050</td>
<td>82</td>
</tr>
<tr>
<td>1101-1200</td>
<td>1150</td>
<td>127</td>
</tr>
<tr>
<td>1201-1300</td>
<td>1250</td>
<td>137</td>
</tr>
<tr>
<td>1301-1400</td>
<td>1350</td>
<td>81</td>
</tr>
<tr>
<td>1401-1500</td>
<td>1450</td>
<td>70</td>
</tr>
<tr>
<td>1501-1600</td>
<td>1550</td>
<td>43</td>
</tr>
<tr>
<td>1601-1700</td>
<td>1650</td>
<td>14</td>
</tr>
<tr>
<td>1701-1800</td>
<td>1750</td>
<td>12</td>
</tr>
<tr>
<td>1801-1900</td>
<td>1850</td>
<td>9</td>
</tr>
<tr>
<td>1901-2000</td>
<td>1950</td>
<td>3</td>
</tr>
<tr>
<td>2001-2100</td>
<td>2050</td>
<td>1</td>
</tr>
<tr>
<td>2101-2200</td>
<td>2150</td>
<td>1</td>
</tr>
<tr>
<td>2201-2300</td>
<td>2250</td>
<td>2</td>
</tr>
<tr>
<td>2301-2400</td>
<td>2350</td>
<td>1</td>
</tr>
<tr>
<td>2401-2500</td>
<td>2450</td>
<td>0</td>
</tr>
<tr>
<td>2501-2600</td>
<td>2550</td>
<td>0</td>
</tr>
<tr>
<td>2601-2700</td>
<td>2650</td>
<td>0</td>
</tr>
<tr>
<td>2701-2800</td>
<td>2750</td>
<td>1</td>
</tr>
</tbody>
</table>

Total - 693
**First dry period:**

Data on 635 first dry period records were used for the present study. Out of which 131 records fall under 4000 lbs and above yielders group; 163 under 3000 lbs to 4000 lbs; 195 under 2000 lbs to 3000 lbs; and 146 records under 2000 lbs and below yielders group.

A frequency distribution table of observations on this character is presented as below:

**Table 20**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MID-VALUE</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-50 days</td>
<td>25</td>
<td>109</td>
</tr>
<tr>
<td>51-100</td>
<td>75</td>
<td>109</td>
</tr>
<tr>
<td>101-150</td>
<td>125</td>
<td>121</td>
</tr>
<tr>
<td>151-200</td>
<td>175</td>
<td>105</td>
</tr>
<tr>
<td>201-250</td>
<td>225</td>
<td>71</td>
</tr>
<tr>
<td>251-300</td>
<td>275</td>
<td>45</td>
</tr>
<tr>
<td>301-350</td>
<td>325</td>
<td>17</td>
</tr>
<tr>
<td>351-400</td>
<td>375</td>
<td>18</td>
</tr>
<tr>
<td>401-450</td>
<td>425</td>
<td>10</td>
</tr>
<tr>
<td>451-500</td>
<td>475</td>
<td>7</td>
</tr>
<tr>
<td>501-550</td>
<td>525</td>
<td>3</td>
</tr>
<tr>
<td>551-600</td>
<td>575</td>
<td>3</td>
</tr>
<tr>
<td>601-650</td>
<td>625</td>
<td>2</td>
</tr>
<tr>
<td>651-700</td>
<td>675</td>
<td>2</td>
</tr>
<tr>
<td>701-750</td>
<td>725</td>
<td>4</td>
</tr>
<tr>
<td>751-800</td>
<td>775</td>
<td>0</td>
</tr>
<tr>
<td>801-850</td>
<td>825</td>
<td>1</td>
</tr>
<tr>
<td>851-900</td>
<td>875</td>
<td>1</td>
</tr>
<tr>
<td>901-950</td>
<td>925</td>
<td>0</td>
</tr>
<tr>
<td>951-1000</td>
<td>975</td>
<td>1</td>
</tr>
<tr>
<td>1001-1050</td>
<td>1025</td>
<td>1</td>
</tr>
</tbody>
</table>

**Total:** 635
First inter-calving period.

For first inter-calving period the difference between the date of first calving and second calving were taken into consideration. Out of 655 total records of first inter-calving period 138, 170, 193 and 149 records fall under the respective group as previously mentioned.

The frequency distribution table of records is presented below:

<table>
<thead>
<tr>
<th>GROUP</th>
<th>MID-VALUE</th>
<th>FREQUENCY</th>
</tr>
</thead>
<tbody>
<tr>
<td>301-350 days</td>
<td>325</td>
<td>82</td>
</tr>
<tr>
<td>351-400</td>
<td>375</td>
<td>162</td>
</tr>
<tr>
<td>401-450</td>
<td>425</td>
<td>115</td>
</tr>
<tr>
<td>451-500</td>
<td>475</td>
<td>85</td>
</tr>
<tr>
<td>501-550</td>
<td>525</td>
<td>63</td>
</tr>
<tr>
<td>551-600</td>
<td>575</td>
<td>47</td>
</tr>
<tr>
<td>601-650</td>
<td>625</td>
<td>30</td>
</tr>
<tr>
<td>651-700</td>
<td>675</td>
<td>19</td>
</tr>
<tr>
<td>701-750</td>
<td>725</td>
<td>25</td>
</tr>
<tr>
<td>751-800</td>
<td>775</td>
<td>9</td>
</tr>
<tr>
<td>801-850</td>
<td>825</td>
<td>4</td>
</tr>
<tr>
<td>851-900</td>
<td>875</td>
<td>4</td>
</tr>
<tr>
<td>901-950</td>
<td>925</td>
<td>0</td>
</tr>
<tr>
<td>951-1000</td>
<td>975</td>
<td>2</td>
</tr>
<tr>
<td>1001-1050</td>
<td>1025</td>
<td>2</td>
</tr>
<tr>
<td>1051-1100</td>
<td>1075</td>
<td>3</td>
</tr>
<tr>
<td>1101-1150</td>
<td>1125</td>
<td>1</td>
</tr>
<tr>
<td>1151-1200</td>
<td>1175</td>
<td>1</td>
</tr>
</tbody>
</table>

Total = 655
Monthly rate of decline of milk yield:

For the study of monthly rate of decline of milk yield, monthly milk yield of each cow groupwise and lactation-wise up to sixth lactation were recorded from the daily milk yield register, right from 1946 up to 1968. The milk yield from 1963 onwards was recorded in Kgs. and that was converted into lbs. multiplying the value by 2.2.

The records have been grouped as follows:

**TABLE - 22**

<table>
<thead>
<tr>
<th>LACTATION NO:</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>First</td>
<td>74</td>
</tr>
<tr>
<td>Second</td>
<td>72</td>
</tr>
<tr>
<td>Third</td>
<td>66</td>
</tr>
<tr>
<td>Fourth</td>
<td>54</td>
</tr>
<tr>
<td>Fifth</td>
<td>45</td>
</tr>
<tr>
<td>Sixth</td>
<td>32</td>
</tr>
</tbody>
</table>

**Persistency of milk yield:**

Persistency is the ability to maintain a relatively high level of production throughout the lactation period. Fohrman et al (1954) points out its importance towards the income from operating a milk producing herd.

Persistency is measured as rate of decline in yield
represented by letter 'K'. But there was criticism due to its negative correlation with actual persistency. In order to avoid this, Lennon and Mixner (1958) gave the following formula:

\[
\text{Persistency index (P)} = 100 - (K \times 100)
\]

P is highly correlated with actual persistency and is expressed on a percentage basis.

**Level of production and persistency:**

Ullah (1952) showed an association of higher initial milk yield with lower persistency in Holstein cows.

Kartha (1934b) reported increase in the rate of decline with rise in the level of production among the Zebu, crossbred cows and buffaloes.

Maymon and Malossini (1960) found that cows yielding 375 Kgs. or less in their first month had a higher persistency than more yielding cows in Brown Alpine.

**Method:**

1. **Phenotypic mean, Standard Error and C.V.**
   1. **Average:**

   For average, arithmetic mean of the data was calculated by the following formula:

   \[
   \text{Average} = \frac{X_1}{N}
   \]

   Where \( X_1 \) is the value of a particular observation.

   AND

   \( N \) is the total number of observations.
(b) Standard Error:

Standard Error was calculated by the following formula:

\[ S.E. = \frac{S.D.}{\sqrt{N}} \]

Where \( S.D. \) = Standard deviation
\( N \) = Number of observations

Standard deviation was calculated from the following formula:

\[ S.D. = \sqrt{\frac{\sum X_i^2 - (\sum X_i)^2}{N-1}} \]

Where \( X_i \) = Sum of square of different observations
\( X_i \) = Sum of different observations
\( N \) = Number of observations

(c) Co-efficient of Variation:

It is calculated by the following formula:

\[ CV = \frac{S.D.}{Mean} \times 100 \]

(2) Phenotypic Correlation:

Correlation means tendency of one character to vary in some fixed manner in relation to variation in another character. The intensity of inter-dependence is measured by it. The formula is as follows:

\[ r = \frac{COV_{XY}}{\sqrt{VAF_{x} \times VAF_{y}}} = \frac{COV_{XY}}{S.D_{x} \times S.D_{y}} \]

\( r \) = Phenotypic correlation  
\( y \) = Second character  
\( x \) = First character

The value of \( r \) may vary from 0 to 1.
(3) Genetic Correlation:

Genetic correlation is the ratio between genetic co-variation between two characters under consideration, to the product of their genetic standard deviations. It cannot be obtained directly as we do not know the genotype of the individuals. We estimate it from the co-variation between the character, one from each individual which are closely related. This method was developed by Hazel (1943) and described by Hazel, Marvel and Reinmiller (1943).

So

$$P_{GA \cdot GB} = \frac{\text{Cov. } GA \cdot GB}{\sqrt{\text{Var. of } G \cdot A \cdot \text{Var. of } GB}}$$

Co-variation $GA \cdot GB$ as well as variance of $GA$ and $GB$ are calculated by multiplying sire component of variance and co-variation by four.

**Table 23**

(Analysis of Variance & Co-variation)

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d.f.</th>
<th>$A \cdot B$</th>
<th>$A \cdot E \cdot M \cdot S.$</th>
<th>$B \cdot E \cdot M \cdot S.$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>2</td>
<td>$S_A^2$</td>
<td>$S_A S_B + K S_{AB}^2$</td>
<td>$S_B^2 + K S_{SB}^2$</td>
</tr>
<tr>
<td>Within sire</td>
<td></td>
<td></td>
<td>$S_{AB}^2$</td>
<td>$S_B^2$</td>
</tr>
</tbody>
</table>

$K =$ number of daughter per sire according to Snedecor's formula for disproportionate class number (1967)

$$P_{GA \cdot GB} = \frac{4S_{AB}^2}{\sqrt{4S_A^2 \cdot 4S_{SB}^2}} = \frac{S_{AB}^2}{\sqrt{S_A^2 \cdot S_{SB}^2}}$$
(4) **Heritability:**

The ratio of the genotypic variation to the phenotypic variation is known as heritability and is denoted by

\[ h^2 = \frac{s^2_g}{s^2_p} \]

The genotypic variation comprises of additive genetic variation, dominance deviation and epistatic variation.

\[ s^2_g = s^2_a + s^2_d + s^2_i \]

Various methods of heritability estimation are as given below described by Lush (1948).

1. **Intra-sire regression of offspring on dam.**
2. **Intra-sire daughter-dam correlation.**
3. **Paternal Half-sib correlation.**
4. **Isogenic lines.**
5. **Regression of offspring on mid-parent.**
6. **Resemblance of parent and offspring.**
7. **Resemblance between full sibs.**
8. **Resemblance to grand parents.**
9. **Regression of F1 progenies on F2 individuals.**

Out of all these nine methods, only three methods are common in use (Prasad 1951). They are

1. **Intra-sire regression of offspring on dam.**
2. **Intra-sire correlation between dam and offspring.**
3. **Paternal Half-sib correlation method.**

Out of these three methods, only paternal Half-sib method was used in present study, as the data could not allow
other methods for the estimates of heritability.

(1) Intra-sire regression of offspring on dam:

The formula for estimating intra-sire regression as discussed by Lush (1940) is given below:

\[ b \times y = \frac{\text{Cov.}_{xy}}{\sigma^2_x} \]

Where \( x \) = Dam's record

\( y \) = Daughter's record

Where co-variance and variance are estimated value.

Now this value is half the heritability, the value of \( bxy \) is multiplied by 2.

So \( h^2 = 2bxy \)

This method is applied in the dairy herds where numerous dam-daughter pairs are available for processing. This method gives an unbiased estimate to the maximum possible extent, so this method is reliable one.

(2) Intra-sire correlation between dam and offspring:

This method is identical with the regression method, provided there has been no selection among parents. Since the additive genetic portion of total variance is generally small for the quantitative traits, the quantitative character's inheritance by this method is identical with the regression method:

\[ r \times y = \frac{\text{Cov.}_{xy}}{\sqrt{\sigma^2_x} \cdot \sigma^2_y} \]

Here also \( h^2 = 2r \times Y \)

(3) Paternal Half-sib correlation method:

In this method heritability is obtained by multiplying the intra-class correlation by four. The analysis
of variance table as suggested by Snedecor (1967) is mentioned below.

**TABLE 24**

(analysis of variance for estimating Half-sib correlation and heritability)

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d.f.</th>
<th>E.M.S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Between sire</td>
<td>1</td>
<td>$\delta_e^2 + k\delta_s^2$</td>
</tr>
<tr>
<td>Within sire</td>
<td>$N-s$</td>
<td>$\delta_e^2$</td>
</tr>
</tbody>
</table>

Where $s$ = Number of sire

$N$ = Total number of half-sibs

$$k = \frac{1}{s-1} \left( \frac{N-n_s^2}{N} \right)$$

$n_s$ = Number of daughters of $s$th sire.

Now $\delta_e^2$ and $\delta_s^2$ can be calculated from these values and intra-class correlation can be calculated as intra-class correlation

$$\frac{\delta_s^2}{\delta_e^2}$$

$\delta_e^2$ = $\frac{1}{s}$th of the genetic variance + a small portion of the epistatic variance.

$\delta_s^2$ = $\frac{1}{s}$th of genetic variance; all dominance variance, a major part of epistatic variance and all random environmental variance.

Now $h^2$ can be calculated by multiplying by four, the
intra-class correlation value.

so \( h^2 = 4 \rho \)

The multiplication of intra-class correlation value by four magnifies any sampling error four times. This is the serious limitation of this method. It does not introduce any systemic bias but allows the estimate to be too high or too low. In comparison with full-sib resemblance or parent off-spring resemblance, the limitation may be cancelled if number of half-sibs is four times more than the other methods. This method is strictly valid under random mating system. This method is useful when records of half-sibs are known but records of their dams are not known.

(5) Standard-error \( (h^2) \)

The approximate S.E. of the heritability based on the variance fraction between paternal half-sib group, according to the formula given by Robertson (1959) was estimated as:

\[
S.E. (h^2) = (h^2 + \frac{4}{n}) \sqrt{\frac{2}{N}}
\]

Where \( N \) = Number of sire

\( n \) = Number of daughter per sire

\( h^2 \) = Heritability of the character

(6) Comparative study:

1. 't test': Comparisons were made between
groups averages. (Snedecor, 1967), where

\[ t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \]

\[ t \text{ has } n_1 + n_2 - 2 \text{ degrees of freedom} \]

2. 'F-test': This test was applied to test the difference among means through analysis of variance as detailed below:

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d.f.</th>
<th>S.S.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Between groups</td>
<td></td>
<td>K</td>
<td>S_b^2</td>
<td>A</td>
</tr>
<tr>
<td>Within groups</td>
<td></td>
<td>(n-1)-K</td>
<td>S_w^2</td>
<td>B</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>n-1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. 'Z-test': This test was adopted to test whether all the correlation estimates for the same character are identical or they belong to different populations (Snedecor, 1967) and to combine them into an estimate of population (F). As there was no other suitable method to test heritability of different groups, the (Intra-class correlation) value was taken into consideration. The details of the test are given below:

<table>
<thead>
<tr>
<th>Samples</th>
<th>n</th>
<th>n-2</th>
<th>r</th>
<th>z</th>
<th>(n-3)z</th>
<th>(n-3)z^2</th>
<th>Correlated z</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

n = Number of observations.
Where $N = \text{No. of observations}$.

$r = \text{Correlation estimate}$

$Z = Z \text{ value of } r \text{ from the table}$

$$
\chi^2 = \frac{\sum (N-3)Z^2 - \left[ \sum (N-3)Z \right]^2}{\sum (N-3)}
$$

The value of $\chi^2$ is compared with the tabulated value at $(K-1) \text{ d.f.}$ If it is more than tabulated value

$K = \text{No. of groups.}$

The value is significant otherwise, it is treated as non-significant. In case of non-significance, the average value of weighted $Z$ is calculated and is divided by $n-3$ d.f. and against that value $r$ is estimated. In order to avoid error, the corrected $Z$ is calculated as:

$$
\frac{\rho}{\sum (n-1)} \text{ where } \rho = \text{Average value of correlation co-efficient.}
$$

$n = \text{Number of observations.}$

Fisher advocated the above formula to be deducted from the value of $Z$.

(7) Rate of decline of milk-yield per lb. gain month & maximum initial yield.

Sturtewant (1926) as quoted by Sikka (1950) was the first investigator who put forward the idea that each month's milk production is roughly a constant percentage of the production of the preceding month.

Later on it was proved by Brody, Ragsdale and Turner by their independent work in various breeds. They described the lactation curve by the following formula:

$$
M_t = M_0 e^{-Kt}
$$
Where $M_t$ = Milk production during any month 't'

$M_0$ = Initial rate of milk flow at the time of parturition (Theoretical)

$K$ = Constant measuring relative rate of decline.

$e$ = Base of natural logarithms.

These workers found satisfactory results by fitting this curve in the data.

Gaines and Davidson (1926) also fitted this equation in the milk yield data successfully.

Kartha (1934a) adopted the same method, as by Gaines and Davidson to fit the curves. The equation is applied to the decline portion of the curve.

By method of least square, Kartha (1934a) determined the value of constants and claimed this method efficient one, as least errors possible by this method. Since the equation represented the decline portion of the curve only, it would be more convenient to measure time from maximum yield than from the date of calving.

The whole of the calculation process is represented in the table below.

<table>
<thead>
<tr>
<th>Table - 27</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time in months:</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>$t$</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>Total - $N$</td>
</tr>
</tbody>
</table>
Column shows time in months from maximum, column 2 shows yields in lbs. for the months mentioned in column 1. The log of the yields is maintained in the column 3. Product of column 1 and 3 are placed in column 4. Column 5 is a check on the arithmetic i.e. the summation of column 3 and 4 should equal to the summation of column 5.

Now for the calculation of rate of decline of milk yield $\log Y$ is multiplied by $N-1$ times and from the product two times of $t \times \log Y$ is subtracted. The remaining value is divided by $0.4343 \times \left( N(N-1) / 6 \right)$. In general the formula can be represented as below.

$$\text{Rate of decline} = \frac{(N-1)a-2b}{0.4343 \times N(N-1)/6}$$

Where $N = \text{No. of observations}$

$$a = \text{Total of column No. 3 i.e. } \log Y$$

$$b = \text{Total of column no. 4 i.e. } t+\log Y$$

$$\frac{N(N-1)}{6} \times 0.4343 = \text{Rate of decline per lb. per month.}$$

Maximum yield:
For calculation of maximum yield the process is as follows.

$$3/3 \text{ of the difference i.e. } 3/3 \text{ of } \Sigma \log Y \times (N-1) - 2\Sigma t + \log Y$$

Total of column 3 i.e. $\Sigma \log Y$

Now this sum is divided by No. of observations, that
gives the log of the maximum. The value of maximum yield can
be traced out from the antilog table against this value.

(8) Persistency:
By persistency is meant the degree to which level
of yield is maintained.

Hansson and Johansson (1940) took into their cal-
culation first 100 days period and used the ratio between
the butterfat yield in different periods as a measure of
persistency. The draw back of this method is that first 100
days time of maximum physiological activity of cow includes
a portion of declining segment of lactation curve, and
therefore this method is not sensitive one.

Pontecorvo (1940) used the middle part of lactation
curve for the measure of persistency.

Mahadevan (1951) estimated persistency by using the
following formula :-

\[ P = \frac{A-B}{A} \]

Where \( A \) = Milk yield during the first 180 days
\( B \) = Initial milk yield during the first 10
weeks of lactation.

This method has also got the same drawback as in
the case of Johansson and Hansson.

Ludwick and Peterson (1943) used the sum of the
ratios obtained by comparing production in each of a number
of sub-divisions of the periods with the proceeding one.
Fohrman et al (1954) calculated the persistency based on hypothesis that, if there were perfect persistency, 8.33% of a 360 days milk or butterfat yield would be produced in each of 12 of the 30 days period. The sum of the difference between 8.33% and the percentage of the total milk yield actually produced in each of the 30 days period is taken as a measure of departure from perfect persistency. By this method low value indicate good persistency and high value indicate poor persistency.

Hammond (1957) put forward that the interval from the date of calving to drop to half the maximum as a measure of persistency.

Lennon and Mixner (1958) used the following formula from the rate of decline.

\[ \text{Persistency index} = (P) = 100 - (K \times 100) \]

The formula overcomes the criticism of using \( K \) (rate of decline) as a measure of persistency. The 'P' in the formula is positively correlated with actual persistency and is expressed in percentage.

(9) Heritability of monthly rate of decline:

For this purpose the rate of decline of monthly milk yield of individual record was calculated. Thereafter the analysis was done by Paternal Half-sib method.
RESULTS AND DISCUSSION

First lactation yield:

In the present study, the whole herd has been divided into four groups based upon the first lactation yield of the cows. The groups are as follows:-

(1) Above 4000 lbs.
(2) Above 3000 lbs. but below 4000 lbs.
(3) Above 2000 lbs. but below 3000 lbs. and
(4) Below 2000 lbs. yielding group.

The first lactation yields taken are the normal first lactation records of the cows. All abnormal records were rejected. No correction of the first lactation data has been made. Based on these observations, the following studies have been obtained:-

(1) Distribution of the records pooled over all the groups.
(2) Average, S.E. and C.V. of each group.
(3) Comparison of averages through test of significance.
(4) Heritability and S.E.(h²) group-wise.
(5) Genetic and Phenotypic correlations.
(6) Comparison of heritability and correlation co-efficient among the groups.

In addition, the monthly rate of decline of the milk yield, maximum yield, heritability of rate of decline and peak yield along with Persistency-Index have also been calculated. The details of these studies will be considered separately.
(1) **Distribution of the records:**

Perusal of table 17 will indicate that all the data have been arranged into various groups (17 groups) which are divided at a class-interval of 450 lbs. The maximum number of records fall under the group ranging from 1900 lbs. to 3700 lbs. as it will appear from the frequency polygon in Figure-1 of the first lactation yield. The variability of this character ranges from 627.5 lbs. to 3006.5 lbs. in first lactation.

(2) **Average, S.E. and C.V. of each group:**

For the sake of this study, each group was averaged separately and its Standard-Error and Co-efficient of variation was studied. The average, S.E. and C.V. along with number of observations are presented in Table - 28.

**Table - 28**

(First lactation yield in lbs.)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>AVERAGE</th>
<th>S.E.</th>
<th>C.V%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>141</td>
<td>4322.47</td>
<td>59.31</td>
<td>14.42</td>
</tr>
<tr>
<td>Above 3000 lbs. - below 4000 lbs.</td>
<td>131</td>
<td>3458.89</td>
<td>257.16</td>
<td>5.04</td>
</tr>
<tr>
<td>Above 2000 lbs. - below 3000 lbs.</td>
<td>211</td>
<td>2486.86</td>
<td>20.26</td>
<td>11.83</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>179</td>
<td>1441.93</td>
<td>46.10</td>
<td>42.75</td>
</tr>
</tbody>
</table>

As would appear from the Table 28, the highest yielding group has the average of 4322.47 ± 59.31 lbs. and
FIGURE 1
FREQUENCY POLYGON DISTRIBUTION
OF FIRST LACTATION YIELD RECORDS.

MEAN VALUE IN POUNDS.
the lowest yielding group averages 1441.93 ± 46.10 lbs and the intermediate groups have 3458.89 ± 257.16 lbs and 2486.86 ± 20.26 lbs as their averages. The average of the highest yielding group is higher than those reported by other workers; rather, it seems to compete with the averages of Sahiwal as obtained by Sikka (1931), Bhasin & Desai (1967) in a Red Sindhi and Sahiwal herd and Singh (1963) in a herd of Friesian × Sahiwal. This shows that selected herd of Tharparkar can compete very well with dairy herds, i.e., Sahiwal and Red Sindhi, so far the milk production of first lactation is concerned.

The average of lowest yielding group equals to those of the averages of Kangayan as reported by Rajagopalan (1952) and Amble et al (1960) and averages of Hariana as reported by Sharma et al (1951), Joshi & Phillips (1953) and Singh et al (1968).


In spite of level fixation, the value of Co-efficient of Variation was 14.42%, 5.04%, 11.83% and 42.75% in highest, intermediates and lowest yielding groups respectively. These results agree well with those worked out by Singh & Chaudhury (1961) in the same breed and Kavitkar et al (1968) in Sahiwal breed.
(3) Comparison of groups averages:

The analysis of variance computation as contained in Table 29 indicated significant F value. This showed that group means differed significantly among themselves.

**TABLE - 29**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d. f.</th>
<th>S. S.</th>
<th>M. S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Between groups</td>
<td>3</td>
<td>365832338.53</td>
<td>121944129.51</td>
<td>99.24 **</td>
</tr>
<tr>
<td>Within groups</td>
<td>708</td>
<td>869928551.00</td>
<td>12286693.61</td>
<td></td>
</tr>
</tbody>
</table>

**Total - 711** 123575939.53

** - Significant at 5% level.

When the 'F' value was significant the critical difference between averages in each possible combination of two was calculated and the difference was found to be significant at 5% level. The value of critical difference in each possible combination is shown in the Table - 30.

**TABLE - 30**

(Value of critical difference)

<table>
<thead>
<tr>
<th>Compared groups</th>
<th>Critical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 1 - 2 group</td>
<td>242.90**</td>
</tr>
<tr>
<td>&quot; 1 - 3 &quot;</td>
<td>234.73**</td>
</tr>
<tr>
<td>&quot; 1 - 4 &quot;</td>
<td>243.86**</td>
</tr>
<tr>
<td>&quot; 2 - 4 &quot;</td>
<td>223.89** Highly</td>
</tr>
<tr>
<td>&quot; 2 - 3 &quot;</td>
<td>219.40** significant</td>
</tr>
<tr>
<td>&quot; 3 - 4 &quot;</td>
<td>220.48</td>
</tr>
</tbody>
</table>


(4) **Heritability:**

Heritability of first lactation yield was calculated by Paternal Half-sib correlation Method as the data were most suited to it. The Table - 31 shows the heritability co-efficients of all the groups.

**TABLE - 31**

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>No. of Sires</th>
<th>Heritability + S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>113</td>
<td>12</td>
<td>0.18 ± 0.24</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>127</td>
<td>15</td>
<td>0.00 ± 0.00</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>156</td>
<td>16</td>
<td>0.016 ± 0.14</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>115</td>
<td>13</td>
<td>0.68 ± 0.44</td>
</tr>
</tbody>
</table>

Data on one hundred thirteen Paternal Half-sibs under 12 sires of first group were analysed to provide this co-efficients which turned out to be 0.18 ± 0.24.

Zero heritability was obtained when an analysis of 127 Paternal Half-sib records under 15 sires in the second group was made.

On an analysis of observations on 156 Half-sibs under 16 sire groups, the heritability estimate of the third group came to 0.016 ± 0.14.

The estimate for the lowest yielding group comes to 0.68 ± 0.44 on an analysis of records on 115 Half-sibs under 13 sire groups.
The Analysis of Variance of each group is given under Table 32.

**TABLE 32**

*(Analysis of Variance for Heritability)*

<table>
<thead>
<tr>
<th>A - Above 4000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources of variation</strong></td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B - Above 3000 lbs. and below 4000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources of variation</strong></td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C - Above 2000 lbs. and below 3000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources of variation</strong></td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D - Below 2000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources of variation</strong></td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Heritability</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.18</td>
<td>9.19</td>
</tr>
<tr>
<td>B</td>
<td>0.00</td>
<td>8.36</td>
</tr>
<tr>
<td>C</td>
<td>0.016</td>
<td>9.59</td>
</tr>
<tr>
<td>D</td>
<td>0.63</td>
<td>8.63</td>
</tr>
</tbody>
</table>

Where K = Number of daughters per sire.

Heritability of first lactation yield of first group
which comes to $0.18 \pm 0.24$ is lower than those estimated by Amble et al (1967), Kooner and Sundaresan (1970) by Paternal Half-sib Method in Tharparkear herd. It is lower than the estimates of first lactation yield of other breeds reported by Robertson (1950), Touchberry (1951), Taylor (1955), Amble et al (1956), Kohli et al (1961), Singh & Prasad (1967).

But the result agrees well with the findings of Mahadevan (1951) & (1955), Singh & Desai (1961), Mishra et al (1964), Kooner and Sundaresan (1970) by Intra-Sire regression Method.

The heritability estimate of second group comes to zero. Heritability upto $0.01$ has been calculated by Chandra Shekhar (1951), whereas estimates obtained by others (listed above) are different.

The heritability estimate of third group ($0.016$) is also lower but it agrees with the findings of Chandra Shekhar only (1951); the estimate differs widely with the findings of other workers named above.

The fourth group presents the heritability estimates of $0.68 \pm 0.44$. This estimate is higher than the findings of Robertson (1951), Tyler and Hyatt (1947), Taylor (1955), Amble et al (1958), Singh & Prasad (1967), Kooner and Sundaresan (1970) and Singh & Sundaresan (1969). But heritability coefficient as high as $0.53$ has been reported by Amble et al (1953) in Kangayan cattle.
**Comparison of heritability.**

In order to compare the heritability estimate "Z-test" (Snedecor - 1967) was used. As there is no other direct test to compare the heritability estimates, the value of Intra-class correlation (r) was compared for all the groups. The Table-33 shows these comparisons.

**Table-33**

(Comparison of heritability estimates of all groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n-3</th>
<th>z</th>
<th>Weighted z²</th>
<th>z²</th>
<th>Corrected z²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>113</td>
<td>110</td>
<td>0.045</td>
<td>0.040</td>
<td>4.400</td>
<td>0.176</td>
</tr>
<tr>
<td>2</td>
<td>127</td>
<td>124</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>3</td>
<td>156</td>
<td>153</td>
<td>0.004</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>4</td>
<td>115</td>
<td>112</td>
<td>0.170</td>
<td>0.172</td>
<td>19.264</td>
<td>3.313</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>499</td>
<td>23.664</td>
<td>3.489</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average \( \bar{z} = 0.048 \)

\[
\text{Chi-Square} = \chi^2 = \sum (n-3)z^2 - (\sum (n-3)z)^2 / \chi(n-3)
\]

\[
= 3.489 - (23.664)^2 / 499
\]

\[
= 3.489 - 1.120 = 2.369 \quad (N=8)
\]

Average value of \( \bar{F} = 0.048 \)

Average heritability \( h^2 = 4 \times 0.048 = 0.192 \)

* The value of this was not calculated as the correction factor is very small in comparison to weighted z value.

\[
\bar{z} = \text{Average weighted } z = \frac{\sum (n-3)z}{n-3}
\]
An examination of the table shows that the value of Chi-Square is not significant at 5% level. This clearly indicates that all the estimates belong to same population, so the average estimate was calculated as \( r = 0.043 \) and when this is multiplied by four, the heritability estimate comes to 0.192. This agrees well with the findings of Singh & Desai (1961) in Hariana cows, Mahadevan (1955) in Red-Sindhi and in Ayrshire cows and Kooner and Sundaresan (1970) in Tharparkar cows.

The pooled value of heritability is 0.192. This shows that genetic progress through selection may not be as rapid as could be expected in a herd where sizeable genetic variation exists.

(5) Genetic and Phenotypic correlations:

Genetic and Phenotypic correlations between first lactation yield and first lactation length has been calculated at different levels of production.

Under first group, observations on 113 Paternal Half-sibs under 12 sire group were taken into calculation. The estimate was found to be 0.31 while the Phenotypic correlation between these traits was 0.44 at this level derived from 141 observations.

In the second group, the genetic correlation was 0.133 (from 127 Half-sibs under 15 sires). The Phenotypic correlation was 0.35 from 130 observations.

In the third group, the genetic correlation was
was 0.103 from 156 half-sibs from 16 sires. The phenotypic correlation was 0.154 derived from 211 observations.

In the fourth group, the genetic correlation was 0.24 from 114 half-sibs of 13 sires. The phenotypic correlation was 0.81 from 176 observations. The results of genetic and phenotypic correlations are shown in Table-34 and the analysis of variance is shown under Table-35.

**TABLE - 34**
(Phenotypic correlation between 1st lactation yield and 1st lactation length)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>No. of Sire</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>113</td>
<td>12</td>
<td>0.31</td>
</tr>
<tr>
<td>2</td>
<td>127</td>
<td>15</td>
<td>0.14</td>
</tr>
<tr>
<td>3</td>
<td>156</td>
<td>16</td>
<td>0.103</td>
</tr>
<tr>
<td>4</td>
<td>114</td>
<td>13</td>
<td>0.24</td>
</tr>
</tbody>
</table>

**= Highly significant
* = Significant

**TABLE - 34a**
(Phenotypic correlation between 1st lactation yield and 1st lactation length)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>141</td>
<td>0.442</td>
</tr>
<tr>
<td>Second</td>
<td>130</td>
<td>0.339</td>
</tr>
<tr>
<td>Third</td>
<td>211</td>
<td>0.154</td>
</tr>
<tr>
<td>Fourth</td>
<td>176</td>
<td>0.311</td>
</tr>
</tbody>
</table>
**TABLE 35**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>A. Above 4000 lbs.</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sources of Variation</strong></td>
<td><strong>d. f.</strong></td>
<td><strong>S. S.</strong></td>
<td><strong>M. S.</strong></td>
</tr>
<tr>
<td>Between sire</td>
<td>11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>101</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B. Above 3000 lbs. &amp; below 4000 lbs.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between sire</td>
<td>14</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>112</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C. Above 2000 lbs. &amp; below 3000 lbs.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between sire</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>140</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>D. Below 2000 lbs.</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between sire</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>101</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.31</td>
<td>9.19</td>
</tr>
<tr>
<td>B</td>
<td>0.14</td>
<td>8.36</td>
</tr>
<tr>
<td>C</td>
<td>0.103</td>
<td>9.59</td>
</tr>
<tr>
<td>D</td>
<td>0.24</td>
<td>8.63</td>
</tr>
</tbody>
</table>

Where K = Number of daughters per sire.

The genetic correlation at first level of production agrees well with the findings of Singh and Prasad (1966) in
Harina, Chandiramani and Dadlani (1967) in Harina.

At the second level, it agrees with Kavitkar et al
(1963) in Sahiwal in 2644 litres and above yielding group. The
estimate of third level is also the same.

At fourth level of the lowest yielding group the esti-
mate agrees well with Prasad (1962) in Tharparker.

When all the estimates were compared as shown in the
Table-36, the value of Chi-Square was non-significant, indi-
cating that all the estimates belong to same population. The
average value of $r = 0.187$ agrees with the findings of Prasad

**TABLE - 36**
(Comparison of genetic correlation between first lactation
yield and first lactation length of
different groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>$n-3$</th>
<th>$r$</th>
<th>$z$</th>
<th>Weighted $z$</th>
<th>Weighted Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>113</td>
<td>110</td>
<td>0.31</td>
<td>0.321</td>
<td>35.310</td>
<td>11.234</td>
</tr>
<tr>
<td>2</td>
<td>127</td>
<td>124</td>
<td>0.14</td>
<td>0.141</td>
<td>17.484</td>
<td>2.465</td>
</tr>
<tr>
<td>3</td>
<td>156</td>
<td>153</td>
<td>0.103</td>
<td>0.100</td>
<td>15.100</td>
<td>1.510</td>
</tr>
<tr>
<td>4</td>
<td>114</td>
<td>111</td>
<td>0.24</td>
<td>0.245</td>
<td>27.195</td>
<td>6.662</td>
</tr>
<tr>
<td>Total</td>
<td>498</td>
<td></td>
<td></td>
<td></td>
<td>95.059</td>
<td>21.971</td>
</tr>
</tbody>
</table>

$\bar{z}_n = 0.19$

Chi-Square $= \sum (z^2 = 21.971 - (95.059)^2/498$

$= 21.971 - 18.156 = 3.815 (N.S.)$

$r = 0.187$

N.S. = Non-significant.
The phenotypic correlation at first level is in agreement with Mahadevan (1956) in Sahiwal and (1953) in Black Sinhala, Kavitkar et al (1968) in Sahiwal at 881-1322 litres and 1322-2644 litres of production level.


The estimate of third level is in agreement with Kavitkar et al (1968), at 2644 litres and above yielding group.

**TABLE - 36a**

(Comparison of phenotypic correlation between first lactation yield and first lactation length of different groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n=3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>Weighted z²</th>
<th>Square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>First</td>
<td>141</td>
<td>133</td>
<td>0.442</td>
<td>0.472</td>
<td>65.136</td>
<td>30.744</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>130</td>
<td>177</td>
<td>0.859</td>
<td>1.293</td>
<td>223.861</td>
<td>295.917</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>211</td>
<td>203</td>
<td>0.154</td>
<td>0.151</td>
<td>12.228</td>
<td>1.846</td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>176</td>
<td>173</td>
<td>0.311</td>
<td>1.127</td>
<td>194.971</td>
<td>219.732</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>626</td>
<td></td>
<td>611.196</td>
<td>548.239</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[ \chi^2 = 548.239 - (611.196)^2 / 696 \]

\[ = 548.239 - 536.724 \]

\[ = 11.515 \]

**- Significant at 5% level.**
The comparison of correlation estimates in Table 36a shows that the value of Chi-Square is significant and the correlation estimates differ significantly.

First lactation length:

The total lactation length of individual cows was taken for the study. The study was made altogether on 708 observations. Under this trait the following studies were made:

(1) Distribution of the records pooled over all the groups.
(2) Average, S.E. and Co-efficient of Variation.
(3) Comparison of averages.
(4) Heritability estimate groupwise.
(5) Comparison of heritability estimates.

(1) Distribution of the records:
All the 708 records were distributed into 15 groups at a class interval of 50 days. The range varied from 41 to 708 days. Table - 18, where the distribution has been shown, indicates that maximum number of observations (135) falls under the range of 300-350 days. A graphical representation of the same is shown in Figure - 2.

(2) Average, S.E. and Co-efficient of Variation:
Average was calculated on the basis of the observations falling under the various groups considering first lactation yield. Average, S.E. and C.V. of each group are presented in the Table - 37 at page 73.
### TABLE - 37
(First lactation length in days)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>AVERAGE</th>
<th>S.E.</th>
<th>COV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>141</td>
<td>392.63</td>
<td>6.63</td>
<td>20.05</td>
</tr>
<tr>
<td>Above 3000 lbs.</td>
<td>180</td>
<td>336.83</td>
<td>4.70</td>
<td>13.72</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>211</td>
<td>296.72</td>
<td>3.97</td>
<td>19.47</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>176</td>
<td>213.65</td>
<td>5.09</td>
<td>31.66</td>
</tr>
</tbody>
</table>

The averages of first lactation length groupwise are 392.63 ± 6.63 days, 336.83 ± 4.70 days, 296.72 ± 3.97 days and 213.65 ± 5.09 days of first, second, third and fourth group respectively.

It appears from the results that highest yielding group has got longer lactation length and the lowest yielding group the smallest, whereas the intermediates lie between the two.

The first group has the estimates higher than those quoted by Singh and Chaudhury (1961), Amble et al. (1957) and Kavithkar et al. (1963).

The average of second group is no doubt slightly higher than the results of Venkaya and Anantakrishnan (1956) in Gir and Red Sindhi cows, Amble et al. (1958) in Red Sindhi, Singh (1961); but it is in agreement with the results of Singh and Desai (1961), Joshi and Phillips (1953) in Ongole, Shukla (1965) in Morvi, Kartha (1938) in Deoni breed.

The average of the third group agrees well with Venkaya
and Anantakrishnan (1956), Ambale et al. (1963), Singh and Chaudhury (1961), Kavitkar et al. (1963) in the 3000-5000 lbs. yielding group of Sahiwal and Ambale et al. (1967) in Tharparkar breed and Prasad (1962) in the same breed.

The fourth group average is lower than the estimates calculated by above mentioned workers.

The co-efficient of variation ranges from 18.72 to 31.66% which lies in the range reported by Singh and Chaudhury (1961), Ambale et al. (1963) and Kavitkar et al. (1963).

(3) Comparison of the averages.

The analysis of variance in Table- 38 indicated a significant value of 'F'. This showed that means differed significantly among themselves.

<table>
<thead>
<tr>
<th></th>
<th>Sources of variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Between groups</td>
<td>2742176.30</td>
<td>915055.93</td>
<td>209.25**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within groups</td>
<td>704</td>
<td>3081927.02</td>
<td>4377.73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>707</td>
<td>5830103.62</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**- Significant at 5% level.

Critical difference between the two groups at a time was calculated and all the values were significant at 5% level as shown in the Table - 39 at page 75.
### TABLE - 32
(Value of critical difference)

<table>
<thead>
<tr>
<th>Compared groups</th>
<th>Critical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 1 - 2 group</td>
<td>14.45</td>
</tr>
<tr>
<td>&quot; 1 - 3 &quot;</td>
<td>14.03</td>
</tr>
<tr>
<td>&quot; 1 - 4 &quot;</td>
<td>14.62</td>
</tr>
<tr>
<td>&quot; 2 - 3 &quot;</td>
<td>13.09 <strong>Highly significant</strong></td>
</tr>
<tr>
<td>&quot; 2 - 4 &quot;</td>
<td>13.72</td>
</tr>
<tr>
<td>&quot; 3 - 4 &quot;</td>
<td>13.23</td>
</tr>
</tbody>
</table>

(4) Heritability estimate.

Estimates of heritability co-efficient for the first lactation length was computed by Paternal Half-sib Method. The estimates at different levels are shown in the Table-40

### TABLE - 40
(Heritability estimates of first lactation length)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>No. of Sires</th>
<th>Heritability ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>118</td>
<td>12</td>
<td>0.56 ± 0.39</td>
</tr>
<tr>
<td>Above 3000 lbs.</td>
<td>127</td>
<td>15</td>
<td>-0.332 ± 0.05</td>
</tr>
<tr>
<td>Below 4000 lbs.</td>
<td>156</td>
<td>16</td>
<td>0.192 ± 0.19</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>114</td>
<td>13</td>
<td>0.403 ± 0.33</td>
</tr>
</tbody>
</table>

In the first group 13 half-sibs under 12 sires were analysed and the estimate obtained came to 0.56 ± 0.39. The
estimate of heritability in this study is larger than Ambre et al. (1953) in Red Sindhi, Singh and Desai (1961) in Mariana (Intra-sire) and Batra (1961) in Sahiwal and Ambre et al. (1957) in Tharparkar. But it agrees well with the findings of Singh and Prasad (1966) in Mariana (Intra-sire).

Heritability of second group was estimated from the observations on 127 half-sibs from 15 sires. The heritability estimate came to $-0.332 \pm 0.05$. This estimate is much lower than Shukla (1966) who calculated $-0.082 \pm 0.141$ heritability by Paternal Half-sib Method.

Heritability of the third group was calculated from the data on 156 half-sibs from 16 sires and estimate came to $0.192 \pm 0.19$. This is in agreement with the findings of Patel (1957) in Sahiwal and Kankrej breed. But it is much higher than the values reported by Prasad (1962) in Tharparkar herd and I.C.A.R. team (1957).

The fourth group (i.e., the lowest yielders) had the heritability estimate as $0.408 \pm 0.38$, on an analysis of 114 half-sibs data from 13 sires. This estimate agrees with the findings of Batra (1961) in Sahiwal and Singh and Prasad (1966) in Mariana. The analysis of variance of each group is shown in Table 41.

<table>
<thead>
<tr>
<th>TABLE 41 (Analysis of Variance)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A-Above 4000 lbs.</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>$d$</th>
<th>$e$</th>
<th>$S_e$</th>
<th>$S_e$</th>
<th>$M_e$</th>
<th>$S_e$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>11</td>
<td></td>
<td>191189.41</td>
<td></td>
<td>17280.85</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>101</td>
<td></td>
<td>674954.84</td>
<td></td>
<td>6632.72</td>
<td></td>
</tr>
</tbody>
</table>
Continued Table 41

(Analysis of Variance)

B. Above 3000 lbs. & below 4000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>def.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>14</td>
<td>20173.29</td>
<td>1440.94</td>
</tr>
<tr>
<td>Within sire</td>
<td>112</td>
<td>525166.81</td>
<td>4683.98</td>
</tr>
</tbody>
</table>

C. Above 2000 lbs. & below 3000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>def.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>15</td>
<td>97605.13</td>
<td>6507.01</td>
</tr>
<tr>
<td>Within sire</td>
<td>140</td>
<td>612465.26</td>
<td>4374.75</td>
</tr>
</tbody>
</table>

D. Below 2000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>def.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>12</td>
<td>93402.50</td>
<td>7783.54</td>
</tr>
<tr>
<td>Within sire</td>
<td>101</td>
<td>395929.00</td>
<td>3920.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of k</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.56</td>
<td>9.19</td>
</tr>
<tr>
<td>B</td>
<td>-0.322</td>
<td>8.36</td>
</tr>
<tr>
<td>C</td>
<td>0.192</td>
<td>9.59</td>
</tr>
<tr>
<td>D</td>
<td>0.408</td>
<td>8.60</td>
</tr>
</tbody>
</table>

(5) Comparison of heritability estimates.

Taking the Intra-class correlation value into consideration the comparison was made, under Table - 42.

The Chi-Square value shows a non-significant difference at 5% level indicating that all the estimates represent the same population. The average value of heritability estimate was calculated as 0.156. This estimate agrees with Patel (1961) in Hariana, but is lower than the estimate of
- 78 -

Amlie et al. (1967) in Tharparkar.

**TABLE - 42**

(Comparison of heritability estimate of first lactation length of all groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n-3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>Weighted Square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>First</td>
<td>113</td>
<td>110</td>
<td>0.148</td>
<td>0.151</td>
<td>16.610</td>
<td>2.508</td>
</tr>
<tr>
<td>Second</td>
<td>127</td>
<td>124</td>
<td>-0.080</td>
<td>-0.080</td>
<td>-9.920</td>
<td>0.793</td>
</tr>
<tr>
<td>Third</td>
<td>156</td>
<td>153</td>
<td>0.048</td>
<td>0.050</td>
<td>7.650</td>
<td>0.382</td>
</tr>
<tr>
<td>Fourth</td>
<td>114</td>
<td>111</td>
<td>0.102</td>
<td>0.100</td>
<td>11.100</td>
<td>1.110</td>
</tr>
<tr>
<td>Total</td>
<td>498</td>
<td></td>
<td></td>
<td></td>
<td>19.440</td>
<td>4.793</td>
</tr>
</tbody>
</table>

\[ z_w = 0.039 \]

\[ \chi^2 = \frac{4.793 \times (19.440) \times 2}{498} = 4.793 - 0.753 = 4.035 \text{ (N.S.)} \]

Average \( r = 0.039 \)

Average heritability = \( h^2 = 4 \times 0.039 \)

\[ = 0.156 \text{ (N.S.)} \]

Age at maturity:

The study under this trait was made under the following heads:

1. Distribution of the records.
2. Average, S.E. and Co-efficient of Variation of each group.
3. Comparison of averages.
FIGURE 3
FREQUENCY POLYGON DISTRIBUTION OF AGE AT MATURITY RECORDS

NUMBER OF RECORDS

MEAN VALUE IN DAYS
(4) Heritability estimate of each group.
(5) Comparison of heritability estimates.
(6) Phenotypic correlations.

(1) **Distribution of the records.**

Altogether 693 records were used under this study. All the records were distributed into 23 groups and each group is divided at a class-interval of 100 days. This trait varies from 586 to 2702 days. A frequency polygon graph is shown in Figure 3 and the distribution is shown in Table - 19. Maximum number of records fall under 1200 to 1300 days group.

(2) **Average, S.E. and Co-efficient of Variation.**

Average age at maturity of highest yielding group has been calculated from 140 records. The average of this group comes to $994.53 \pm 63.80$ days. The average for each group is shown separately in the Table - 43.

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>AVERAGE</th>
<th>S.E.</th>
<th>CV%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>140</td>
<td>994.53</td>
<td>63.80</td>
<td>6.43</td>
</tr>
<tr>
<td>Above 3000 lbs below 4000 lbs.</td>
<td>174</td>
<td>1257.60</td>
<td>14.33</td>
<td>11.43</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>204</td>
<td>1242.47</td>
<td>13.74</td>
<td>10.94</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>175</td>
<td>1200.03</td>
<td>17.85</td>
<td>14.67</td>
</tr>
</tbody>
</table>

The average for the second group came to
to 1257.66 ± 14.23 days on the basis of 174 records.

The average of third group was 1242.47 ± 13.74 days from 204 records and the same for the lowest yielding group was 1200.08 ± 17.85 days based on 175 observations. All the averages agree well with the finds of Ahuja et al (1961) in Hariana and Rajagopalan (1962) in Red Sindhi at highest level of production and other groups agree with the findings of Rajagopalan (1952) in Kangayan breed. Luktuke and Subramaniam (1961) in Hariana and Quadeer (1965) in Deoni. The averages (age at first calving) reported by Kavitkar et al (1968) in Sahiwal cows is much lower than that for highest yielding group in this study. Singh et al (1968) in Hariana cows reported 46.79 ± 0.35 months age at first calving. On discarding the gestation period from this, the age at maturity agrees with the averages of the second and the third groups.

Table 43 reveals that highest yielding group has got smaller age at maturity than the other groups. So in this matter it agrees well with the predictions of Hartman (1953), Johansson (1950) and Stettwieser (1952) that generally high producers have got early age at maturity. But this prediction does not fit well with other groups where we get lower age at maturity of lowest yielding groups than the middle groups. This agrees with the views of Mahadevan (1953) that it is the better feeding and managemental practices which affect the age at maturity directly. Moreover the heat detection is a big problem in the farms upon which the age at maturity depends.
If the teaser misses to detect the heat, naturally it will bring an error in the estimate of age at maturity.

The co-efficient of variation of the highest yielding group is 31.35% which is far higher than that reported by other workers while the value of co-efficient of variation in other groups which is 14.93%, 21.54% and 19.67% agrees with the findings of Kavitkar et al (1968) in Sahiwal, Singh et al (1968) in Mariana and Quadeer (1965) in Deoni cows.

(3) Comparison of the averages.

The analysis of variance showed a significant value of 'F' which indicated a significant difference among the averages of different groups as shown in Table - 44.

**Table - 44**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Between groups</td>
<td></td>
<td>15200884.89</td>
<td>5066951.63</td>
<td>252.02**</td>
</tr>
<tr>
<td>Within groups</td>
<td>689</td>
<td>13862190.75</td>
<td>20104.77</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>692</td>
<td>151063045.64</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**- Significant at 5% level.**

**Table - 45**

(Critical difference between averages)

<table>
<thead>
<tr>
<th>Compared groups</th>
<th>Critical difference **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 1-2 group</td>
<td>31.44 **</td>
</tr>
<tr>
<td>&quot; 1-3 &quot;</td>
<td>30.44 **</td>
</tr>
<tr>
<td>&quot; 1-4 &quot;</td>
<td>31.44 **</td>
</tr>
<tr>
<td>&quot; 2-3 &quot;</td>
<td>28.61 (N.S.)</td>
</tr>
<tr>
<td>&quot; 2-4 &quot;</td>
<td>29.59 **</td>
</tr>
<tr>
<td>&quot; 3-4 &quot;</td>
<td>28.61 **</td>
</tr>
</tbody>
</table>
After the 'F' value was found significant, the critical difference between averages of groups in each possible combination was calculated as shown in Table - 45.

All the values mentioned in the comparison are significant at 5% level except between second and third group, where it seems, genetic variation was lesser in magnitude.

(4) Heritability estimates.

Heritability estimate for age at maturity was calculated by Paternal Half-sib Method. The Table - 46 shows the estimates of heritability at different levels of production.

**TABLE - 46**
(Heritability estimates of age at maturity)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>Heritability ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>111</td>
<td>0.452 ± 0.362</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>124</td>
<td>0.013 ± 0.176</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>153</td>
<td>0.220 ± 0.231</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>111</td>
<td>0.452 ± 0.335</td>
</tr>
</tbody>
</table>

The heritability estimate of the first group was found to be 0.452 ± 0.362 from observations on 111 half-sibs under 12 sires.

In the second group records on 124 half-sibs under 15 sires were used for analysis of variance to estimate heritability co-efficient which was estimated to be 0.013 ± 0.176.
The heritability estimate of third group came to 0.280 ± 0.231 from an analysis of records on 153 half-sibs from 16 sires and in the fourth group the estimate came to 0.45 ± 0.355 on an analysis of 111 half-sibs under 13 sire groups. The analysis of variance is presented in Table 47.

### TABLE 47
(Analysis of Variance)

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.452</td>
<td>9.06</td>
</tr>
<tr>
<td>B</td>
<td>0.013</td>
<td>8.36</td>
</tr>
<tr>
<td>C</td>
<td>0.280</td>
<td>9.41</td>
</tr>
<tr>
<td>D</td>
<td>0.452</td>
<td>8.63</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sources of Variations</th>
<th>i</th>
<th>j</th>
<th>k</th>
<th>l</th>
<th>M ± S.e.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>11</td>
<td>823946.40</td>
<td>75449.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>99</td>
<td>3450295.80</td>
<td>34851.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Above 3000 lbs. &amp; below 4000 lbs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between sire</td>
<td>14</td>
<td>844680.15</td>
<td>60334.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>109</td>
<td>6396164.05</td>
<td>58680.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Above 2000 lbs. &amp; below 3000 lbs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between sire</td>
<td>15</td>
<td>1854823.25</td>
<td>123654.99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>137</td>
<td>9873163.60</td>
<td>72066.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Below 2000 lbs.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Between sire</td>
<td>12</td>
<td>1687515.24</td>
<td>140626.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>93</td>
<td>6657595.54</td>
<td>66914.24</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The heritability estimates of all the groups agree with the estimates reported by Singh et al. (1957) in Tharparker herd, except the one which lies in second group.

Although the magnitude of heritability estimates vary to a greater extent, some workers viz. Mahadevan (1953) have suggested to reduce the age at maturity by better feeding and managerial practices.

**Table 48.**

(Comparison of heritability estimates of all groups)

| Group   | No. | : n-3 : r : z : Weighted z : Square z² |
|---------|-----|----------------------------------------|---------------------------------|
| First   | 111 | 108 | 0.113 | 0.110 | 11.880 | 1.307 |
| Second  | 123 | 120 | 0.003 | 0.000 | 0.000 | 0.000 |
| Third   | 153 | 150 | 0.070 | 0.070 | 10.500 | 0.735 |
| Fourth  | 111 | 102 | 0.113 | 0.110 | 11.880 | 1.307 |
| **Total** | **486** | | | | **34.289** | **6.349** |

Average \( \bar{z} = 0.07 \)

Chi-Square = \( \chi^2 = (n-3) z^2 (\Sigma(n-3) z)^2 / (n-3) \)

= \( 3.349 \times (34.289)^2 / 486 \)

= \( 3.349 - 2.415 = 0.934 \) (N.S.)

Average value of \( r = 0.07 \)

Average heritability = \( 4 \times 0.07 = 0.28 \)

Comparison was made among groups Intra-class correlation co-efficients (r) to test if there was a significant difference among the co-efficients. The test materials
are arranged in Table - 42. A perusal of the Table shows that the differences among the co-efficients are non-significant. The average heritability co-efficient calculated comes to 0.28 which is in agreement with the value reported by Singh (1957) in Tharparkar cattle.

(6) Phenotypic Correlations

The phenotypic correlation was studied under the following three heads:

1. Age at maturity and First lactation yield.
2. Age at maturity and First Dry period.
3. Age at maturity and First Intercalving period.

Age at Maturity and First Lactation Yield

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Estimates</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>First</td>
<td>141</td>
<td>0.690</td>
</tr>
<tr>
<td>Second</td>
<td>174</td>
<td>0.328</td>
</tr>
<tr>
<td>Third</td>
<td>205</td>
<td>0.000</td>
</tr>
<tr>
<td>Fourth</td>
<td>175</td>
<td>0.959</td>
</tr>
</tbody>
</table>

The Table-42 shows the results of correlation studies at different levels of production. At the first level the correlation co-efficient is 0.69; at the second level 0.328; at the third level Zero and at the fourth level it is 0.959.

Comparison

All the estimates were compared by z-test.
<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n-3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>(n-3)²</th>
<th>(n-3)z²</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>141</td>
<td>138</td>
<td>0.690</td>
<td>0.348</td>
<td>117.024</td>
<td>98.236</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>174</td>
<td>171</td>
<td>0.323</td>
<td>0.322</td>
<td>56.772</td>
<td>12.848</td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>205</td>
<td>202</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>175</td>
<td>172</td>
<td>-0.960</td>
<td>-1.946</td>
<td>-334.712</td>
<td>651.349</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>699</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Chi-Square = $X^2 = 768.433 - (160.916)^2 / 699$

= 768.433 - 37.912

= 730.521

The Table -50 shows the comparison. The differences among the correlation co-efficients were found significant showing the effect of level of production. At first level it agrees with Rajagopalan (1952) in Kangayam, Retra (1961) in Sahiwal; at second level it comes closer to the estimates reported by Danasoury (1962) in Sudanese cattle, Prasad (1962) in Tharparkar. At the third level, the correlation co-efficient is zero, but comparable estimates could not be traced. Chandiramani (1958) and Singh (1969) have estimated as low as -0.07. However, at the fourth level it is much lower than that obtained by Ahmed (1961) in Haryana.
Age at maturity and first dry period.

Table - 51 shows the results of phenotypic correlation studies.

**TABLE - 51**
(Phenotypic correlation between age at maturity and first dry period).

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>First</td>
<td>123</td>
<td>0.276</td>
</tr>
<tr>
<td>Second</td>
<td>157</td>
<td>0.131</td>
</tr>
<tr>
<td>Third</td>
<td>190</td>
<td>-0.052</td>
</tr>
<tr>
<td>Fourth</td>
<td>141</td>
<td>0.144</td>
</tr>
</tbody>
</table>

At first level, a correlation coefficient of 0.276 was obtained from 123 observations; at second level a correlation of 0.131 was estimated from 157 observations. At the third and fourth level -0.052 and 0.144 values were recorded from 190 and 141 observations respectively.

**TABLE - 52**
(Comparison of phenotypic correlation between age at maturity and first dry period of different groups).

<table>
<thead>
<tr>
<th>Group</th>
<th>No</th>
<th>n-3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>Square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>First</td>
<td>123</td>
<td>125</td>
<td>0.276</td>
<td>0.277</td>
<td>34.625</td>
<td>9.591</td>
</tr>
<tr>
<td>Second</td>
<td>157</td>
<td>154</td>
<td>0.131</td>
<td>0.131</td>
<td>20.174</td>
<td>2.642</td>
</tr>
<tr>
<td>Third</td>
<td>190</td>
<td>187</td>
<td>-0.052</td>
<td>-0.050</td>
<td>-12.950</td>
<td>0.647</td>
</tr>
<tr>
<td>Fourth</td>
<td>141</td>
<td>138</td>
<td>0.144</td>
<td>0.141</td>
<td>19.453</td>
<td>2.743</td>
</tr>
<tr>
<td>Total</td>
<td>604</td>
<td></td>
<td></td>
<td></td>
<td>61.307</td>
<td>15.623</td>
</tr>
</tbody>
</table>
Contd. Table - 52

\[
\text{Chi Square} = \chi^2 = \frac{(61.307)^2}{604} - 15.623 - 6.222 = 9.401^{**}
\]

On z-test the differences among the correlation coefficients were found significant as shown in Table - 52. At the first level, it agrees with the findings of Danasoury and Bayoumi (1962) in Sudanese cattle. At the second and fourth level, it shows closeness to the regression estimate of these workers. At the third level the results were not in agreement with the reports of these workers. Askar et al. (1959) found no relationship between age at first calving and first dry period. Age at maturity and First Inter-calving period.

**TABLE - 53**

(Phenotypic correlation between age at maturity and First Inter-calving period)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>First</td>
<td>134</td>
<td>-0.058</td>
</tr>
<tr>
<td>Second</td>
<td>164</td>
<td>0.600</td>
</tr>
<tr>
<td>Third</td>
<td>192</td>
<td>0.005</td>
</tr>
<tr>
<td>Fourth</td>
<td>144</td>
<td>0.165</td>
</tr>
</tbody>
</table>

As indicated in Table - 53 the phenotypic correlation coefficients at first, second, third and fourth level was found to be -0.058, 0.600, 0.005 and 0.165 from 134, 164, 192 and 144 observations respectively.
TABLE - 54

(Comparison of Phenotypic correlation between age at maturity and First Inter-calving period of different groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.: n-3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>(z^2)</th>
<th>Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>134</td>
<td>131</td>
<td>0.058</td>
<td>-0.060</td>
<td>7.860</td>
<td>0.472</td>
</tr>
<tr>
<td>Second</td>
<td>164</td>
<td>161</td>
<td>0.600</td>
<td>0.693</td>
<td>111.573</td>
<td>77.320</td>
</tr>
<tr>
<td>Third</td>
<td>192</td>
<td>189</td>
<td>0.005</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Fourth</td>
<td>144</td>
<td>141</td>
<td>0.165</td>
<td>0.161</td>
<td>22.701</td>
<td>3.655</td>
</tr>
<tr>
<td>Total</td>
<td>622</td>
<td></td>
<td></td>
<td></td>
<td>125.414</td>
<td>81.447</td>
</tr>
</tbody>
</table>

Chi-Square = \(X^2 = 81.447 - (125.414)^2 / 622\)

= 81.447 - 25.692

= 55.755 *

The differences among the co-efficients were found significant as shown in Table -54. The result at the first level is in contradiction to the findings of Prasad (1962), Singh and Chaudhury (1961) and Shukla (1965). The reason for negative estimate appears to be that in highest yielding group the age at maturity is smaller than other groups and lactation length is also longer and since lactation length is important constituent of the calving interval, there is negative correlation at this level. It agrees with the result of Ananta Krishnan (1956) in Red Sindhi, but is higher than the estimates reported by others. In the third level, it is nearly zero, but in fourth group it agrees with Singh (1964) in Haryana, Singh

First dry period

A study on first dry period has been conducted on the following:

(1) Distribution of the records.
(2) Average, S.E. and Co-efficient of Variation.
(3) Comparison of averages.
(4) Heritability estimation.
(5) Comparison of heritability estimates.

(1) Distribution of the records.

Altogether 635 records have been used under the study. All the records have been distributed into 21 groups which are arranged at a class interval of 50 days. The trait has a variation from 1 to 1026. Maximum number of observations fall under group 100 to 150 days. Table -20 presents the distribution of records and Figure- 4, the frequency polygon of the trait. The larger variation in trait may be due to some abnormal conditions, not mentioned in history sheets.

(2) Average, S.E. and Co-efficient of Variation.

Average of the first dry period of all the four groups have been presented in the Table - 55.

As it appears from the table, the first, second, third and fourth groups have got the averages as 140.83 ±13.79 days from 131 records, 155.25 ± 12.09 days from 163 records, 156.20 ± 7.40 days from 195 records, 226.76 ± 15.35 days from
FIGURE-4

FREQUENCY POLYGON DISTRIBUTION
OF
FIRST DRY PERIOD RECORDS.

NUMBER OF RECORDS

MEAN VALUE IN DAYS
from 146 records respectively.

**TABLE 55**
(First dry period in days)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>AVERAGE</th>
<th>S.E.</th>
<th>C.V%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Above 4000 lbs.</td>
<td>131</td>
<td>140.83</td>
<td>13.79</td>
<td>112.07</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>163</td>
<td>155.25</td>
<td>12.09</td>
<td>99.42</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>195</td>
<td>156.20</td>
<td>7.40</td>
<td>66.17</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>146</td>
<td>226.76</td>
<td>15.35</td>
<td>81.80</td>
</tr>
</tbody>
</table>

The average estimate at first level agrees with Parnerkar (1946) in Gaolao, Patel (1956) in Gir, Pattabhiraman (1957) in Gir.

The estimate of second and third group is in agreement with Joshi and Phillips (1953) in Kankrej and Hariana and Dave (1958) in Gir. But the estimate is shorter than those estimated by Anonymous (1950) in Malvi, Shukla (1965) in Junagarh and Morvi herds.

The average of fourth group is in agreement with the findings of Joshi and Phillips (1953) in Thari, Patel (1956) in other herd of Gir; but this estimate is higher than Pattabhiraman (1957), Shukla (1965), Kavitkar et al (1968) in Sahiwal and Ohri & Singh (1970) in Rathi cattle. The estimate of Gehlon and Singh (1966) in Hariana is even much higher than all the estimates. The highest yielding group's result
nearly agrees with the findings of Jha & Biswas (1964) in Tharparkar. In general higher the production, the lower the dry period as can be seen from the result.

(3) **Comparison of averages:**

Comparative study among the groups has been made and the difference between the means was found significant. The analysis of variance is given in Table - 56.

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d.f.</th>
<th>S.S.</th>
<th>M.S.</th>
<th>F.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Between groups</td>
<td>3</td>
<td>653765.52</td>
<td>217921.84</td>
<td>9.70 **</td>
</tr>
<tr>
<td>Within groups</td>
<td>631</td>
<td>14162002.41</td>
<td>22443.74</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>634</td>
<td>14815767.93</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Critical difference in each possible combination has been calculated and the differences were significant at 5% between groups 1-4, 2-4 and between 3rd and 4th; other differences were non significant. The results are shown in Table - 57.

<table>
<thead>
<tr>
<th>Compared groups</th>
<th>Critical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 1-2 group</td>
<td>34.41 (N.S.)</td>
</tr>
<tr>
<td>1-3</td>
<td>33.08 (N.S.)</td>
</tr>
<tr>
<td>1-4</td>
<td>35.22</td>
</tr>
<tr>
<td>2-3</td>
<td>31.06 (N.S.)</td>
</tr>
<tr>
<td>2-4</td>
<td>33.34</td>
</tr>
<tr>
<td>3-4</td>
<td>32.02</td>
</tr>
</tbody>
</table>
(4) Heritability estimates:

Heritability estimate of each group has been estimated separately. The Table - 58 shows the results.

**Table - 58**

(Heritability estimate of first dry period)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>No. of sires</th>
<th>Heritability ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs</td>
<td>103</td>
<td>12</td>
<td>0.432 ± 0.0360</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs</td>
<td>117</td>
<td>15</td>
<td>-0.560 ± 0.014</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs</td>
<td>145</td>
<td>16</td>
<td>-0.160 ± 0.035</td>
</tr>
<tr>
<td>Below 2000 lbs</td>
<td>97</td>
<td>12</td>
<td>-0.350 ± 0.064</td>
</tr>
</tbody>
</table>

On an analysis of 103 half-sibs records under 12 sires, the heritability estimate of first group came to 0.432 ± 0.0360. This agrees well with the findings of Singh (1964) in Hariana.

On an analysis of 117 half-sibs records under 15 sires, the heritability estimate came to -0.560 ± 0.014 in the second group. In the third group, the value was found to be -0.160 ± 0.035. Heritability was estimated on analysis of 145 half-sibs under 16 sires. In the fourth group, the estimate was -0.350 ± 0.064, from an analysis of 97 half-sibs records from 12 sires. The analysis of variance table of each group is presented under Table - 59 at page 94.
TABLE 52
(Analysis of Variance)

<table>
<thead>
<tr>
<th>A-Above 4000 lbs.</th>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>11</td>
<td>570548.50</td>
<td>51868.04</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>91</td>
<td>2327924.86</td>
<td>25581.59</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B-Above 3000 lbs. &amp; below 4000 lbs.</th>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>14</td>
<td>83651.61</td>
<td>597.51</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>102</td>
<td>2309372.39</td>
<td>22540.90</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C-Above 2000 lbs. &amp; below 3000 lbs.</th>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>15</td>
<td>98990.51</td>
<td>6599.36</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>129</td>
<td>1295740.43</td>
<td>10044.49</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D-Below 2000 lbs.</th>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>11</td>
<td>148094.12</td>
<td>13462.19</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>85</td>
<td>1228333.20</td>
<td>14450.97</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.432</td>
<td>8.40</td>
</tr>
<tr>
<td>B</td>
<td>-0.560</td>
<td>7.71</td>
</tr>
<tr>
<td>C</td>
<td>-0.160</td>
<td>8.91</td>
</tr>
<tr>
<td>D</td>
<td>-0.350</td>
<td>7.84</td>
</tr>
</tbody>
</table>

(5) Comparison of heritability estimates.
The heritability estimates of all the groups were compared taking the value of Intra-class correlation into consideration. The comparison is shown in Table 60 at page 95.
TABLE 60
(Comparison of heritability estimates of all groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n-3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>Weighted square</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>103</td>
<td>100</td>
<td>0.108</td>
<td>0.110</td>
<td>11.000</td>
<td>1.210</td>
</tr>
<tr>
<td>Second</td>
<td>117</td>
<td>114</td>
<td>0.140</td>
<td>0.141</td>
<td>16.074</td>
<td>2.266</td>
</tr>
<tr>
<td>Third</td>
<td>145</td>
<td>142</td>
<td>-0.040</td>
<td>-0.040</td>
<td>-5.680</td>
<td>0.227</td>
</tr>
<tr>
<td>Fourth</td>
<td>97</td>
<td>94</td>
<td>-0.088</td>
<td>-0.090</td>
<td>-8.460</td>
<td>0.761</td>
</tr>
</tbody>
</table>

Total  | 450 |     |      |       | 12.934 | 4.464 |

Average $\bar{z}_w = 0.028$

Chi-Square $= \chi = 4.464 - (12.934)/450$

$= 4.464 - 0.369 = 4.095$ (N.S.)

Average value of $\bar{r} = 0.028$

Average heritability $= 4 \times 0.028 = 0.112$

The value of Chi-Square was found non-significant which clearly indicates that all the values of different groups represent the same population. Hence, the average value of heritability calculated which came to 0.112.

This value agrees well with Mahadevan and Marples (1961) in Nanda cattle, Singh and Desai (1961) in Hariana cattle. The result is slightly higher than that estimated by I.C.A.R. team (1957) and Prasad (1962).
FIGURE 5
FREQUENCY POLYGON DISTRIBUTION OF FIRST INTER-CALVING PERIOD RECORDS.
First Inter-calving period:

For this character the following studies were made:

1. Distribution of the records.
2. Average, S.E. and Co-efficient of Variation.
3. Comparison of averages.
5. Comparison of heritability estimates.

(1) Distribution of the records:

For the study of this trait 655 records have been used including all the groups as a whole. All the records were arranged in 18 groups which vary at an interval of 50 days. The maximum number of records fall in 350-400 days group. The variation in this trait is from 301 days to 1149 days. A very high value of calving-interval may be due to management practices or due to some reproductive diseases which were not mentioned in the history-sheets. Distribution of the records is shown in the Table - 21 and the graphical representation is given in Figure - 5.

(2) Average, S.E. and Co-efficient of Variation:

**Table - 61**

(First Inter-calving period in days)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Average</th>
<th>S.E.</th>
<th>C.V%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>123</td>
<td>531.77</td>
<td>16.25</td>
<td>35.75</td>
</tr>
<tr>
<td>Above 3000 lbs below 4000 lbs.</td>
<td>170</td>
<td>490.82</td>
<td>11.96</td>
<td>22.77</td>
</tr>
<tr>
<td>Above 2000 lbs below 3000 lbs.</td>
<td>198</td>
<td>452.79</td>
<td>2.40</td>
<td>7.45</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>149</td>
<td>444.50</td>
<td>11.10</td>
<td>20.38</td>
</tr>
</tbody>
</table>
On an analysis of 138 records of first group the average calving interval was found as 531.77 ± 16.25 days with 35.75% coefficient of variation.

In the second group the average estimate was 490.82 ± 11.96 days with 32.77% coefficient of variation on an analysis of 170 records.

The average in the third group was found as 452.79 ± 2.40 days with 7.45% coefficient of variation on an analysis of 198 records.

On an analysis of 140 records of fourth group the average was found to be 444.50 ± 11.10 days with 30.38% coefficient of variation.

(3) Comparison of averages.

The average calving interval of first group is significantly different from those of other groups. Same is the case with other groups also in every combination except between third and fourth group, where the difference comes to 8.29 days which is non-significant at 5% level. The Table - 62 shows the analysis of variance for comparison and the Table - 63 shows the value of critical difference whether significant or not.

**TABLE - 62**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d.f.</th>
<th>S.S.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Between groups</td>
<td>3</td>
<td>719741.53</td>
<td>239913.84</td>
<td>11.13</td>
</tr>
<tr>
<td>Within groups</td>
<td>651</td>
<td>14025762.02</td>
<td>21544.94</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>654</td>
<td>14745503.55</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


**TABLE - 63**
(Critical difference)

<table>
<thead>
<tr>
<th>Compared groups</th>
<th>Critical difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between 1-2 group</td>
<td>*** 32.93 **</td>
</tr>
<tr>
<td>&quot; 1-3 &quot;</td>
<td>*** 31.77 **</td>
</tr>
<tr>
<td>&quot; 1-4 &quot;</td>
<td>*** 33.90 **</td>
</tr>
<tr>
<td>&quot; 2-3 &quot;</td>
<td>*** 32.02 **</td>
</tr>
<tr>
<td>&quot; 2-4 &quot;</td>
<td>*** 32.28 **</td>
</tr>
<tr>
<td>&quot; 3-4 &quot;</td>
<td>*** 31.10 (N.S.)</td>
</tr>
</tbody>
</table>

The average of the highest yielding group agrees well with the reports of Joshi and Phillips (1953) in Coelac, Sharma et al (1951) in Haryana, Singh (1964) in Haryana at Dumraon, Joshi (1963) in Deoni cows at Rajendranagar. But it is higher than the estimates of Singh (1957) in Tharparkar, Ambles et al (1958), Prasad (1962) and Singh & Chaudhury (1963) in Tharparkar.

The co-efficient of variation of this group is slightly higher than that reported by Singh (1964), Ambles et al (1960) and Quadeer (1965).

The average of second group is closer to the reports of Singh and Chaudhury (1963), Singh and Sharma (1953) in Haryana, Ambles and Krishnan (1958) in Kangayan and Joshi and Phillips (1953) in Ongole.

The averages of third and fourth group which do not differ significantly, agree with the reports of Ambles et al
Amble et al (1958), Singh (1957) in Tharparker, Dadlani and Chandiramani (1963) in Hariana (Dam and daughter), and Singh and Deasi (1962) in Hariana. But this is higher than the estimate of Prasad (1962) in Tharparker.

(4) **Heritability estimate.**

**TABLE - 64**

(Heritability estimates of first inter-calving period)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>No. of sire</th>
<th>Heritability ± S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>105</td>
<td>12</td>
<td>0.560 ± 0.40</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>121</td>
<td>15</td>
<td>-0.020 ± 0.172</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>147</td>
<td>16</td>
<td>-0.023 ± 0.138</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>99</td>
<td>12</td>
<td>-0.094 ± 0.180</td>
</tr>
</tbody>
</table>

The Table - 64 presents the estimate of heritability at different levels of production.

On an analysis of 105 half-sibs records under 12 sires the estimate of heritability comes to 0.560 ± 0.40. This estimate agrees with Wheat et al (1959) in Hariana, but is higher than the estimates reported by Singh et al (1963) in Hariana, Amble et al (1958) in Red Sindhi and Tharparker, Singh (1958) in the same breed and Ahmad (1961) in Hariana.

The estimated heritability coefficient of the second group was -0.020 ± 0.172 from an analysis of 121 half-sibs records from 15 sires. This agrees well with the
findings of Singh and Desai (1961) in Hariana but is lower than
the estimates of Singh (1958) in Tharparker, Mishra (1960). The
heritability estimate of the third group is in agreement with
second group.

The heritability of fourth group was estimated
as $-0.094 \pm 0.130$ from the analysis of 99 half-sibs records
under 12 sires. This estimate is closer to the estimates of
The analysis of variance table of all the groups are presented
in Table - 65.

| TABLE - 65 |

(Analysis of Variance)

<table>
<thead>
<tr>
<th>A - Above 4000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of variation:</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B - Above 3000 lbs. &amp; below 4000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of variation:</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C - Above 2000 lbs. &amp; below 3000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of variation:</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D - Below 2000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sources of variation:</td>
</tr>
<tr>
<td>df</td>
</tr>
<tr>
<td>-----</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>Between sire</td>
</tr>
<tr>
<td>Within sire</td>
</tr>
</tbody>
</table>
(S) Comparison of heritability estimates.

For comparison of heritability estimates among groups, the Intra-class correlation value was taken into consideration. Table - 66 shows the result.

**Table - 66**

(Comparison of heritability estimates of all groups)

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.560</td>
<td>3.55</td>
</tr>
<tr>
<td>B</td>
<td>-0.020</td>
<td>7.97</td>
</tr>
<tr>
<td>C</td>
<td>-0.023</td>
<td>9.03</td>
</tr>
<tr>
<td>D</td>
<td>-0.094</td>
<td>7.34</td>
</tr>
</tbody>
</table>

![Table](image)

Average \( \bar{z} \) = 0.027

Chi-Square = \( \chi^2 = 2.066 - (12.462)^2 / 460 \)

= 2.066 - 0.337 = 1.729 (N.S)

Average value of \( \bar{r} \) = 0.027

Average heritability = 4 \times 0.027 = 0.108

The result was found non-significant indicating that all the estimates belong to same population. After comparison
average value of Intra-class correlation was calculated and the heritability estimate came to 0.108 representing the whole population and this agrees well with Amble et al (1958) in Kangayan, Askar et al (1953) in Egyptian cattle and Dadlani and Chandiramani (1968) in Hariana cattle.

Lactation Curve.

A lactation curve shows the behaviour of lactation during the whole lactation length. The lactation curve consists of three parts viz. ascending phase of lactation, peak yield and descending phase of lactation. The descending phase of lactation is heritable to some extent (Sikka 1950). Under this head the following studies were made:

1. Monthly rate of decline of milk-yield per pound at different levels of production upto sixth lactation.
2. Observed and calculated peak yield estimation upto sixth lactation.
3. Heritability estimates of rate of decline upto third lactation and comparative studies thereof.
4. Heritability estimates of peak-yield of all the groups upto third lactation and comparative studies thereof.
5. Persistency index.

(1) **Monthly rate of decline of milk-yield.**

**First lactation:**

Monthly rate of decline of milk-yield was calculated
at each level of production from 316 records. On calculation with 74 records of highest yielding group the estimate came to 0.081 lbs. per lbs. per month.

With 77 records of second group the estimate came to 0.109 lbs. per lbs. per month. In third and fourth group the estimate came to 0.110 lbs. per lbs. per month and 0.092 lbs. in the same unit from 85 and 80 records respectively.

TABLE 67
(Monthly rate of decline of milk-yield in lbs./lbs. for different groups).

<table>
<thead>
<tr>
<th>Lactation number</th>
<th>G</th>
<th>F</th>
<th>C</th>
<th>H</th>
<th>D</th>
<th>S</th>
<th>Fourth</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>0.081</td>
<td>0.109</td>
<td>0.110</td>
<td>0.092</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>0.095</td>
<td>0.152</td>
<td>0.089</td>
<td>0.083</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>0.134</td>
<td>0.126</td>
<td>0.087</td>
<td>0.115</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>0.127</td>
<td>0.141</td>
<td>0.127</td>
<td>0.229</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fifth</td>
<td>0.113</td>
<td>0.179</td>
<td>0.113</td>
<td>0.136</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sixth</td>
<td>0.135</td>
<td>0.149</td>
<td>0.159</td>
<td>0.095</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Second lactation:**

On an analysis of 72, 71, 76 and 50 records of first, second, third and fourth level the estimate of rate of decline came to 0.095, 0.152, 0.089 and 0.083 lbs. per lbs. per month respectively.

**Third lactation:**

On an analysis of third lactation records comprising of 66, 62, 56 and 36 observations for all the four groups
respectively ranging from highest to lowest level, the estimates came to 0.134 lbs., 0.126 lbs., 0.087 lbs. and 0.115 lbs. respectively.

Fourth Lactation.
Fifty four, 45, 44 and 25 records from the first, second, third and fourth groups respectively were analysed and the results came to 0.127 lbs., 0.141 lbs., 0.087 lbs. and 0.269 lbs. respectively.

Fifth Lactation.
Monthly rate of decline was found as 0.113 lbs., 0.179 lbs., 0.113 lbs. and 0.136 lbs/month for the first, second, third and fourth group respectively on an analysis of 45, 32, 30 and 15 corresponding records.

Sixth Lactation.
Under sixth lactation, on an analysis of 32, 20, 26 and 7 records of first, second, third and fourth group respectively the value of estimates came to 0.135 lbs., 0.149 lbs., 0.159 lbs. and 0.095 lbs. per month/lbs. respectively. The result of all the lactations under various groups is presented in Table - 67 shown in the beginning of the monthly rate of decline of milk-yield head of lactation curve.

On perusal of Table - 67, it appears that as the sequence of lactation advances, the rate of decline of milk increases and since the animal whose rate of decline is more is least persistent. This agrees with Kartha (1934) in this respect, that as the cow advances in lactation she becomes
less persistent than a first-calver.

The analysis of calculation of rate of decline of milk-yield of each lactation group-wise is shown in Table 68a (a, b, c, d, e and f).

**Table 68a**

(Computation of rate of decline)

**First Lactation**

<table>
<thead>
<tr>
<th>Time in months per month from maximum</th>
<th>Milk yield in lbs.</th>
<th>Logarithm of yields</th>
<th>Product of (t) x log(y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>527.3</td>
<td>2.7220</td>
<td>2.7220</td>
</tr>
<tr>
<td>1</td>
<td>473.5</td>
<td>2.6754</td>
<td>5.3508</td>
</tr>
<tr>
<td>2</td>
<td>429.1</td>
<td>2.6326</td>
<td>7.8978</td>
</tr>
<tr>
<td>3</td>
<td>406.9</td>
<td>2.6095</td>
<td>10.4380</td>
</tr>
<tr>
<td>4</td>
<td>383.8</td>
<td>2.5841</td>
<td>12.9205</td>
</tr>
<tr>
<td>5</td>
<td>353.2</td>
<td>2.5480</td>
<td>15.2880</td>
</tr>
<tr>
<td>6</td>
<td>332.1</td>
<td>2.5212</td>
<td>17.6484</td>
</tr>
<tr>
<td>7</td>
<td>305.5</td>
<td>2.4850</td>
<td>19.8800</td>
</tr>
<tr>
<td>8</td>
<td>280.0</td>
<td>2.4472</td>
<td>22.0248</td>
</tr>
<tr>
<td>9</td>
<td>254.3</td>
<td>2.4053</td>
<td>24.0530</td>
</tr>
<tr>
<td>10</td>
<td>231.4</td>
<td>2.3643</td>
<td>26.0073</td>
</tr>
<tr>
<td>11</td>
<td>203.9</td>
<td>2.3024</td>
<td>27.7228</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>4181.0</td>
<td>30.3040</td>
<td>191.9434</td>
</tr>
</tbody>
</table>

**B. Above 3000 lbs. & Below 4000 lbs.**

<table>
<thead>
<tr>
<th>Time in months per month from maximum</th>
<th>Milk yield in lbs.</th>
<th>Logarithm of yields</th>
<th>Product of (t) x log(y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>459.1</td>
<td>2.6619</td>
<td>2.6619</td>
</tr>
<tr>
<td>1</td>
<td>408.1</td>
<td>2.6054</td>
<td>5.2103</td>
</tr>
<tr>
<td>2</td>
<td>368.8</td>
<td>2.5668</td>
<td>7.7004</td>
</tr>
<tr>
<td>3</td>
<td>328.0</td>
<td>2.5159</td>
<td>10.0536</td>
</tr>
<tr>
<td>4</td>
<td>303.0</td>
<td>2.4814</td>
<td>12.4070</td>
</tr>
<tr>
<td>5</td>
<td>273.8</td>
<td>2.4375</td>
<td>14.6250</td>
</tr>
<tr>
<td>6</td>
<td>243.1</td>
<td>2.3858</td>
<td>16.7006</td>
</tr>
<tr>
<td>7</td>
<td>224.3</td>
<td>2.3358</td>
<td>18.8064</td>
</tr>
<tr>
<td>8</td>
<td>199.6</td>
<td>2.3002</td>
<td>20.7013</td>
</tr>
<tr>
<td>9</td>
<td>161.2</td>
<td>2.2074</td>
<td>22.0740</td>
</tr>
<tr>
<td>10</td>
<td>144.6</td>
<td>2.1599</td>
<td>23.7559</td>
</tr>
<tr>
<td>11</td>
<td>144.3</td>
<td>2.1523</td>
<td>25.3116</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3252.8</td>
<td>28.3323</td>
<td>150.6220</td>
</tr>
</tbody>
</table>
LACTATION CURVE FOR FIRST LACTATION

FIRST GROUP

Monthly yield in lbs.

Number of months after reaching maximum.
LACTATION CURVE FOR FIRST LACTATION

SECOND GROUP

Monthly yield in lbs.

Number of months after reaching maximum.
First Lactation
Below 2000-3000 Lbs.

Lactation Curve for First Lactation

Third Group

Monthly yield in lbs.

Months after reaching maximum.
FIRST LACTATION

2000 LBS. AND BELOW

LACTATION CURVE FOR FIRST LACTATION

FOURTH GROUP

Months after reaching maximum.

Monthly yield in lbs.
<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>408.9</td>
<td>2.6117</td>
<td>2.6117</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>347.5</td>
<td>2.5409</td>
<td>2.5409</td>
<td>5.0818</td>
</tr>
<tr>
<td>2</td>
<td>313.3</td>
<td>2.4959</td>
<td>4.9918</td>
<td>7.4877</td>
</tr>
<tr>
<td>3</td>
<td>289.2</td>
<td>2.4611</td>
<td>7.3833</td>
<td>9.8444</td>
</tr>
<tr>
<td>4</td>
<td>259.2</td>
<td>2.4136</td>
<td>9.6544</td>
<td>12.0580</td>
</tr>
<tr>
<td>5</td>
<td>226.6</td>
<td>2.3553</td>
<td>11.7765</td>
<td>14.1318</td>
</tr>
<tr>
<td>6</td>
<td>196.4</td>
<td>2.3031</td>
<td>13.7586</td>
<td>16.0517</td>
</tr>
<tr>
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<td>161.3</td>
<td>2.2576</td>
<td>15.4532</td>
<td>17.6608</td>
</tr>
<tr>
<td>8</td>
<td>150.3</td>
<td>2.1936</td>
<td>17.4272</td>
<td>19.6056</td>
</tr>
<tr>
<td>9</td>
<td>135.5</td>
<td>2.1341</td>
<td>19.2069</td>
<td>21.3410</td>
</tr>
<tr>
<td>10</td>
<td>121.0</td>
<td>2.0828</td>
<td>20.8280</td>
<td>22.9108</td>
</tr>
<tr>
<td>11</td>
<td>114.4</td>
<td>2.0504</td>
<td>22.6544</td>
<td>25.8048</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>2752.1</strong></td>
<td><strong>27.9249</strong></td>
<td><strong>146.6752</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>283.5</td>
<td>2.4526</td>
<td>2.4526</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>242.1</td>
<td>2.3840</td>
<td>2.3840</td>
<td>4.7680</td>
</tr>
<tr>
<td>2</td>
<td>205.3</td>
<td>2.3124</td>
<td>4.6248</td>
<td>6.9372</td>
</tr>
<tr>
<td>3</td>
<td>175.2</td>
<td>2.2435</td>
<td>6.7305</td>
<td>8.9740</td>
</tr>
<tr>
<td>4</td>
<td>155.1</td>
<td>2.1906</td>
<td>8.7624</td>
<td>10.9530</td>
</tr>
<tr>
<td>5</td>
<td>137.9</td>
<td>2.1346</td>
<td>10.6980</td>
<td>12.8376</td>
</tr>
<tr>
<td>6</td>
<td>116.4</td>
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<td>12.3900</td>
<td>14.4550</td>
</tr>
<tr>
<td>7</td>
<td>103.3</td>
<td>2.0141</td>
<td>14.0987</td>
<td>16.1128</td>
</tr>
<tr>
<td>8</td>
<td>136.7</td>
<td>2.1357</td>
<td>17.0856</td>
<td>19.2213</td>
</tr>
<tr>
<td>9</td>
<td>125.0</td>
<td>1.9234</td>
<td>18.8721</td>
<td>20.9690</td>
</tr>
<tr>
<td>10</td>
<td>105.9</td>
<td>1.7028</td>
<td>20.7722</td>
<td>21.3276</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1971.4</strong></td>
<td><strong>25.9356</strong></td>
<td><strong>137.2123</strong></td>
</tr>
</tbody>
</table>

**TABLE - 68b**

**Second Lactation**

<table>
<thead>
<tr>
<th></th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>502.5</td>
<td>2.7011</td>
<td></td>
<td>2.7011</td>
</tr>
<tr>
<td>1</td>
<td>444.6</td>
<td>2.6480</td>
<td>22.6480</td>
<td>5.2960</td>
</tr>
<tr>
<td>2</td>
<td>397.0</td>
<td>2.5928</td>
<td>5.1976</td>
<td>7.7964</td>
</tr>
<tr>
<td>3</td>
<td>351.3</td>
<td>2.5451</td>
<td>7.6353</td>
<td>10.1804</td>
</tr>
<tr>
<td>4</td>
<td>306.4</td>
<td>2.4963</td>
<td>9.9452</td>
<td>12.4315</td>
</tr>
<tr>
<td>5</td>
<td>280.0</td>
<td>2.4472</td>
<td>12.2360</td>
<td>14.6332</td>
</tr>
<tr>
<td>6</td>
<td>255.3</td>
<td>2.4070</td>
<td>14.4420</td>
<td>16.8390</td>
</tr>
<tr>
<td>7</td>
<td>241.0</td>
<td>2.3820</td>
<td>16.6740</td>
<td>19.0560</td>
</tr>
<tr>
<td>8</td>
<td>212.0</td>
<td>2.3263</td>
<td>18.6104</td>
<td>20.9367</td>
</tr>
<tr>
<td>9</td>
<td>198.1</td>
<td>2.2969</td>
<td>20.6721</td>
<td>22.8690</td>
</tr>
<tr>
<td>10</td>
<td>197.1</td>
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### Table 68a

#### C - above 2000 lbs. & below 3000 lbs.

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#### D - Below 2000 lbs.

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### Table 69b

#### Second Lactation

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LACTATION CURVE FOR SECOND LACTATION

FIRST GROUP.

Monthly yield in lbs.

Months after reaching maximum.
LACTATION CURVE FOR SECOND LACTATION

SECOND GROUP

Monthly yield in lbs.

Number of months after reaching maximum.
LACTATION CURVE FOR SECOND LACTATION

THIRD GROUP

Monthly yield in lbs.

Number of months after reaching maximum.
LACTATION CURVE OF SECOND LACTATION
FOURTH GROUP.

Months after reaching maximum.
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| B- Above 3000 lbs. & below 4000 lbs. |
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| 2 | 353.7 | 2.5487 | 7.5582 | 10.0776 |
| 3 | 320.7 | 2.5194 | 9.7924 | 12.2405 |
| 4 | 280.6 | 2.4481 | 11.6880 | 14.3616 |
| 5 | 247.5 | 2.3936 | 14.2194 | 16.5893 |
| 6 | 224.4 | 2.3599 | 16.1581 | 18.4664 |
| 7 | 203.4 | 2.3083 | 17.6416 | 19.3468 |
| 8 | 160.4 | 2.2052 | 19.5281 | 21.7090 |
| 9 | 148.2 | 2.1709 | 22.4030 | 24.5433 |
| 10 | 173.9 | 2.2403 | 24.0779 | 26.2682 |
| Total | 3175.1 | 22.6841 | 151.0597 | 179.7438 |

| C- Above 2000 lbs. & below 3000 lbs. |
| 0 | 453.5 | 2.6566 | 2.6566 | 2.6566 |
| 1 | 380.3 | 2.5801 | 5.0120 | 7.5130 |
| 2 | 320.7 | 2.5060 | 7.4298 | 9.9064 |
| 3 | 299.6 | 2.4766 | 9.7132 | 12.1415 |
| 4 | 268.1 | 2.4283 | 11.9280 | 14.3136 |
| 5 | 243.0 | 2.3856 | 14.0418 | 16.3821 |
| 6 | 218.9 | 2.3403 | 16.2148 | 18.5312 |
| 7 | 207.2 | 2.3164 | 18.0880 | 20.2490 |
| 8 | 182.4 | 2.2610 | 19.8756 | 22.0840 |
| 9 | 161.6 | 2.2084 | 21.9212 | 24.0128 |
| 10 | 203.3 | 2.2392 | 24.2156 | 26.5632 |
| 11 | 163.8 | 2.2156 | 26.3249 | 28.0070 |
| Total | 3102.6 | 22.5821 | 152.3249 | 181.0070 |
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#### Table - 68d

### Fourth Lactation

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**Total** | **2237.05** | **27.7384** | **144.1160** | 171.9144
### Contd. Table 684

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<tr>
<td>11</td>
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<td>2.0788</td>
<td>22.8658</td>
<td>24.9456</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2739.4</strong></td>
<td><strong>27.8657</strong></td>
<td><strong>146.2229</strong></td>
<td><strong>174.0395</strong></td>
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</tr>
</tbody>
</table>

<p>| | | | | | |</p>
<table>
<thead>
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<tbody>
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<tr>
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<td>2.3069</td>
<td>11.5345</td>
<td>13.8414</td>
<td></td>
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<tr>
<td>6</td>
<td>161.2</td>
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<td>1.9948</td>
<td>21.9428</td>
<td>23.9376</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2442.5</strong></td>
<td><strong>27.1044</strong></td>
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<td><strong>167.6832</strong></td>
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<td>(t+1) X log y</td>
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<td>3</td>
<td>332.90</td>
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<td>7.6273</td>
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<td>4</td>
<td>286.50</td>
<td>2.4572</td>
<td>9.8288</td>
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<td></td>
</tr>
<tr>
<td>5</td>
<td>224.70</td>
<td>2.3516</td>
<td>11.7580</td>
<td>14.1096</td>
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</tr>
<tr>
<td>6</td>
<td>223.40</td>
<td>2.3530</td>
<td>14.1180</td>
<td>16.4710</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>203.40</td>
<td>2.3083</td>
<td>16.1581</td>
<td>18.4664</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>178.10</td>
<td>2.2383</td>
<td>17.9064</td>
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</tr>
<tr>
<td>9</td>
<td>187.70</td>
<td>2.2734</td>
<td>20.4606</td>
<td>22.7340</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>114.80</td>
<td>2.0600</td>
<td>20.6000</td>
<td>22.6000</td>
<td></td>
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<tr>
<td>11</td>
<td>79.20</td>
<td>1.8987</td>
<td>20.8857</td>
<td>22.7844</td>
<td></td>
</tr>
</tbody>
</table>

Total - 3013.31  232413  1463087  1751500

<table>
<thead>
<tr>
<th>B- Above 3000 lbs. &amp; below 4000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
</tbody>
</table>

Total - 2596.5  255795  1307470  1463268

<table>
<thead>
<tr>
<th>C- Above 3000 lbs. &amp; below 3000 lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>t</td>
</tr>
<tr>
<td>----</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
</tbody>
</table>

Total - 2279.5  257815  1373873  1641689
In the first group there is increase in the rate of decline up to fourth lactation, but in fifth lactation there is slight decrease and again in the sixth lactation there is increased rate of decline. The decreased rate of decline in fifth lactation might be due to environmental factors.

In the second group there is increase in the rate of decline up to second lactation, thereafter slight decrease in the third, again rise in the fourth and fifth lactations, but marked increase in sixth lactation.

In the third group there is slight decrease in the second lactation, similar decrease in the third and fourth and thereafter slight increase in fifth lactation and then marked increase in sixth lactation.

In the fourth group there is slight decrease in the rate of decline in second lactation as compared to the first lactation, again increase in third lactation, marked increase...
in fourth and then decrease in fifth and sixth lactations. These fluctuations may be due to environmental factors.

The above results are in agreement with Kartha (1934) Murty (1963) and L.R.S. Patna Report (1970) and Rao et al (1970) that there is slight increase in rate of decline in second lactation and thereafter a lot of fluctuations.

The findings of first lactation are in agreement with Kartha (1934b) but are slightly higher than reported by Murty (1963) in Tharparkar and L.R.S. Patna report (1969-70) in Hariana and Brody (1927).

In the second, third, fourth, fifth and sixth lactations, the estimates are higher than those reported by Brody (1927) and above mentioned workers.

A graphical presentation of the rate of decline is shown in Figure-6 and a composite graph of rate of decline of all the four groups is shown in Figure-7. The decline in the lowest yielding group is sharp as compared to the other groups, which indicates a lower persistency in lowest yielding group in comparison to highest yielders.

(2) Heritability estimate of the rate of decline of milk yield.

For the estimation of heritability of this trait, monthly rate of decline of milk yield of each individual was calculated by the method advised by Kartha (1934). After that it was arranged for the analysis by Half-sib method (Snedecor, 1967).
On an analysis of records of first lactation of different groups the heritability estimate came as shown in the Table - 69.

**Table - 69**

(Heritability estimates of rate of decline of milk yield of first lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>No. of Sires</th>
<th>Heritability ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>51</td>
<td>6</td>
<td>-0.038 ± 0.024</td>
</tr>
<tr>
<td>Above 3000 lbs. - below 4000 lbs.</td>
<td>45</td>
<td>6</td>
<td>-0.480 ± 0.022</td>
</tr>
<tr>
<td>Above 2000 lbs. - below 3000 lbs.</td>
<td>61</td>
<td>8</td>
<td>-0.360 ± 0.150</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>39</td>
<td>5</td>
<td>-0.380 ± 0.160</td>
</tr>
</tbody>
</table>

On analysis of data from 51 half sibs from 6 sires of first group the heritability estimate came as -0.038 ± 0.024.

The heritability estimate of second, third and fourth group was found as -0.480 ± 0.022, -0.360 ± 0.150 and -0.380 ± 0.160 from an analysis of 45, 61 and 39 half-sibs coming from 6, 8 and 5 sires respectively. The analysis of variance is given in Table - 70.

**Table - 70**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>df</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>5</td>
<td>2660219.72</td>
<td>532043.94</td>
</tr>
<tr>
<td>Within sire</td>
<td>45</td>
<td>25939266.32</td>
<td>576421.47</td>
</tr>
</tbody>
</table>
**Contd.** Table 70.

### B - Above 2000 lbs. & below 4000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>5</td>
<td>2897575.11</td>
<td>579515.02</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>39</td>
<td>29173715.69</td>
<td>7430439.09</td>
<td></td>
</tr>
</tbody>
</table>

### C - Above 2000 lbs. & below 3000 lbs.

| Between sire         | 7  | 1334415.10 | 190630.73 |
| Within sire          | 53 | 26106685.59 | 492578.97 |

### D - Below 2000 lbs.

| Between sire         | 4  | 1610505.11 | 402651.23 |
| Within sire          | 34 | 41833371.20 | 1231363.85 |

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.038</td>
<td>8.08</td>
</tr>
<tr>
<td>B</td>
<td>-0.480</td>
<td>8.24</td>
</tr>
<tr>
<td>C</td>
<td>-0.360</td>
<td>7.30</td>
</tr>
<tr>
<td>D</td>
<td>-0.380</td>
<td>7.70</td>
</tr>
</tbody>
</table>

The heritability estimates are in negative direction which may be taken as zero.

**Comparison**

**Table 71**

(Comparison of heritability estimates of rate of decline of milk-yield of first lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>N-3</th>
<th>P</th>
<th>z</th>
<th>Weighted z</th>
<th>Weighted Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>51</td>
<td>48</td>
<td>-0.009</td>
<td>-0.010</td>
<td>-0.480</td>
<td>0.005</td>
</tr>
<tr>
<td>Second</td>
<td>45</td>
<td>42</td>
<td>-0.120</td>
<td>-0.121</td>
<td>-5.082</td>
<td>0.615</td>
</tr>
<tr>
<td>Third</td>
<td>61</td>
<td>58</td>
<td>-0.020</td>
<td>-0.090</td>
<td>-5.220</td>
<td>0.469</td>
</tr>
<tr>
<td>Fourth</td>
<td>39</td>
<td>36</td>
<td>-0.035</td>
<td>-0.090</td>
<td>-3.240</td>
<td>0.291</td>
</tr>
<tr>
<td>Total</td>
<td>184</td>
<td></td>
<td></td>
<td></td>
<td>-14.022</td>
<td>1.380</td>
</tr>
</tbody>
</table>
Contd. Table-71

Chi-Square = $\chi^2 = 1.380 - (-14.022)^2 / 194$

$= 1.380 - 1.068 = 0.312 \ (N.S.)$

$\bar{z}_w = -0.076$

Average $\bar{r} = -0.07$

Average heritability = $-0.07 \times 4 = -0.28$

On comparison the difference among intra-class correlation co-efficients are found to be non-significant and the average value of heritability was estimated as -0.28 which amounts to zero indicating thereby that the trait can’t be improved by selection.

**Second Lactation:**

On an analysis of the second lactation records, the heritability estimate was found as shown in Table - 72.

**TABLE - 72**
(HERITABILITY ESTIMATES OF RATE OF DECLINE OF MILK-YIELD OF SECOND LACTATION)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>N</th>
<th>No. of sires</th>
<th>Heritability ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>62</td>
<td>7</td>
<td>0.260 ± 0.169</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>49</td>
<td>6</td>
<td>-0.520 ± 0.165</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>59</td>
<td>7</td>
<td>-0.268 ± 0.010</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>23</td>
<td>4</td>
<td>0.560 ± 0.510</td>
</tr>
</tbody>
</table>

The table shows that the heritability estimate of first, second, third and fourth group was found as 0.260 ± 0.169, -0.520 ± 0.165, -0.268 ± 0.010 and 0.560 ± 0.510.
from an analysis of 62, 49, 59 and 23 half-sib records from 7, 6, 7 and 4 sires respectively. Limited number of observations may quite possibly bring about greater degree of sampling error in the estimates. The analysis of variance is shown under Table - 73.

**TABLE - 73**

(Analysis of Variance)

### A - Above 4000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>6</td>
<td>8128055.62</td>
<td>8128055.62</td>
</tr>
<tr>
<td>Within sire</td>
<td>55</td>
<td>47655663.22</td>
<td>866466.60</td>
</tr>
</tbody>
</table>

### B - Above 3000 lbs. & Below 4000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>5</td>
<td>18949463.03</td>
<td>378983.20</td>
</tr>
<tr>
<td>Within sire</td>
<td>43</td>
<td>33620126.18</td>
<td>7819633.90</td>
</tr>
</tbody>
</table>

### C - Above 2000 lbs. & Below 3000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>6</td>
<td>2430863.15</td>
<td>405143.86</td>
</tr>
<tr>
<td>Within sire</td>
<td>52</td>
<td>42726499.36</td>
<td>821663.25</td>
</tr>
</tbody>
</table>

### D - Below 2000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>3</td>
<td>13886505.76</td>
<td>4628835.25</td>
</tr>
<tr>
<td>Within sire</td>
<td>19</td>
<td>46305643.20</td>
<td>2441575.05</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.260</td>
<td>8.10</td>
</tr>
<tr>
<td>B</td>
<td>-0.520</td>
<td>7.90</td>
</tr>
<tr>
<td>C</td>
<td>-0.268</td>
<td>8.00</td>
</tr>
<tr>
<td>D</td>
<td>0.560</td>
<td>5.40</td>
</tr>
</tbody>
</table>
**Comparison**

**TABLE - 74**

(Comparison of heritability estimates of rate of decline of milk-yield of second lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th><em>(n-3)</em></th>
<th><em>r</em></th>
<th><em>z</em></th>
<th>Weighted <em>z</em></th>
<th><em>z</em>^2</th>
<th><em>(n-3)</em></th>
<th>*(n-3)*z^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>62</td>
<td>59</td>
<td>0.066</td>
<td>0.060</td>
<td>3.540</td>
<td>0.212</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>49</td>
<td>46</td>
<td>-0.130</td>
<td>-0.131</td>
<td>-6.026</td>
<td>0.789</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third</td>
<td>59</td>
<td>56</td>
<td>-0.067</td>
<td>-0.060</td>
<td>-3.360</td>
<td>0.201</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fourth</td>
<td>23</td>
<td>20</td>
<td>0.140</td>
<td>0.141</td>
<td>2.820</td>
<td>0.397</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>181</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average \( \frac{z}{n} = -0.016 \)

\[
\text{Chi-Square} = \chi^2 = 1.599 - (-3.026)^2 / 181 \\
= 1.599 - 0.050 = 1.549 (N=8) \\
\]

Average \( r = -0.016 \)

Average heritability = 4 x 0.016

= -0.064

On comparison through z-test, the differences in respect of heritability estimates for rate of decline of milk-yield were found to be non-significant. The estimate of heritability for all the groups turned to be -0.064 which can be assumed to be zero.

**Third Lactation**

The heritability estimate of rate of decline of milk-yield for third lactation was calculated as shown in
in the Table - 75.

**TABLE - 75**

(Heritability estimates of rate of decline of milk-yield of third lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Sires</th>
<th>Heritability</th>
<th>S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>53</td>
<td>0.156 ± 0.125</td>
<td></td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>31</td>
<td>0.180 ± 0.217</td>
<td></td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>23</td>
<td>0.720 ± 0.710</td>
<td></td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scanty Records

It appears from the table that the heritability estimate of first group comes to 0.156 ± 0.125 on an analysis of 53 records from 6 sires. The heritability estimate of second group comes to 0.180 ± 0.217 on an analysis of 31 records from 4 sires, whereas for third group it comes to 0.72 ± 0.71 from an analysis of 23 records from 3 sires. The estimate of fourth group could not be obtained due to still lesser number of observations. An analysis of variance of each group is shown under Table - 76. Greater degree of sampling error in the estimate is possible due to limited number of observations.

**TABLE - 76**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d. f.</th>
<th>S. S.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>5</td>
<td>5186524.39</td>
<td>1037304.87</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>47</td>
<td>35205536.63</td>
<td>770330.57</td>
<td></td>
</tr>
</tbody>
</table>
**Continued Table 76**

- **E - Above 3000 lbs. & below 4000 lbs.**

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>3</td>
<td>2402236.22</td>
<td>800755.40</td>
</tr>
<tr>
<td>Within sire</td>
<td>27</td>
<td>15333435.72</td>
<td>586422.54</td>
</tr>
</tbody>
</table>

- **G - Above 2000 lbs. & below 3000 lbs.**

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>2</td>
<td>6076352.20</td>
<td>3038124.40</td>
</tr>
<tr>
<td>Within sire</td>
<td>20</td>
<td>24661660.16</td>
<td>1233083.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.156</td>
<td>8.50</td>
</tr>
<tr>
<td>B</td>
<td>0.180</td>
<td>7.60</td>
</tr>
<tr>
<td>C</td>
<td>0.720</td>
<td>6.35</td>
</tr>
</tbody>
</table>

**Comparison**

**Table 77**

(Comparison of heritability estimates of rate of decline of milk-yield of third lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>No. (n-3)</th>
<th>R</th>
<th>Z</th>
<th>Weighted Z</th>
<th>Weighted Square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>First</td>
<td>53</td>
<td>50</td>
<td>0.039</td>
<td>0.040</td>
<td>2.000</td>
</tr>
<tr>
<td>Second</td>
<td>31</td>
<td>28</td>
<td>0.045</td>
<td>0.045</td>
<td>1.260</td>
</tr>
<tr>
<td>Third</td>
<td>23</td>
<td>20</td>
<td>0.180</td>
<td>0.182</td>
<td>3.640</td>
</tr>
<tr>
<td>Total</td>
<td>98</td>
<td></td>
<td></td>
<td></td>
<td>6.900</td>
</tr>
</tbody>
</table>

Average $\bar{z}_m = 0.07$

Chi-Square $\chi^2 = 0.733 - (6.900)^2 / 98$

$= 0.733 - 0.040 = 0.693 \ (N.S.)$

Average $\bar{r} = 0.07$

Average heritability $= 4 \times 0.07 = 0.28$
On comparison the difference between the Intra-class correlation co-efficient was found to be non-significant and hence the average value (pooled estimate for all the groups) of heritability was obtained. This came to 0.28. The value is in agreement with Sikka (1950) in ayrshire but is higher than that reported by Mahadevan (1951). Since in the third lactation, the animals have produced the maximum yield, the maximum phenotypic expression of the genes may be expected under this lactation. This will apparently have its effect on the heritability estimates obtained.

(4) Monthly Peak-yield.

The monthly peak yield value was calculated for all the four groups upto sixth lactation by the formula suggested by Kartha (1934). The observed value was also calculated and the estimates were found as shown below in Table - 78.

**TABLE - 78**

(Average value of monthly peak-yield)

<table>
<thead>
<tr>
<th>Lactation:</th>
<th>G</th>
<th>R</th>
<th>Q</th>
<th>U</th>
<th>P</th>
<th>S</th>
</tr>
</thead>
<tbody>
<tr>
<td>number: 1</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>First</td>
<td>527.3</td>
<td>523.4</td>
<td>459.0</td>
<td>461.0</td>
<td>408.9</td>
<td>391.6</td>
</tr>
<tr>
<td>Second</td>
<td>502.5</td>
<td>474.1</td>
<td>471.3</td>
<td>478.8</td>
<td>456.0</td>
<td>380.6</td>
</tr>
<tr>
<td>Third</td>
<td>520.3</td>
<td>524.0</td>
<td>484.5</td>
<td>492.3</td>
<td>453.5</td>
<td>397.1</td>
</tr>
<tr>
<td>Fourth</td>
<td>493.2</td>
<td>491.9</td>
<td>484.6</td>
<td>450.8</td>
<td>476.6</td>
<td>352.3</td>
</tr>
<tr>
<td>Fifth</td>
<td>462.9</td>
<td>444.8</td>
<td>483.3</td>
<td>483.4</td>
<td>432.4</td>
<td>391.5</td>
</tr>
<tr>
<td>Sixth</td>
<td>457.5</td>
<td>475.5</td>
<td>434.8</td>
<td>447.2</td>
<td>403.1</td>
<td>410.2</td>
</tr>
</tbody>
</table>

A - Observed value in lbs.
B - Calculated value in lbs.
Heritability of monthly peak-yield.

Under the heritability estimate of peak-yield, the study was made with first, second and third lactation records under four groups. The Table - 79 shown represents the results of all the groups of first lactation.

**Table - 79**
(Heritability estimates of monthly peak-yield of first lactation)

<table>
<thead>
<tr>
<th>GROUP</th>
<th>No. of sires</th>
<th>Heritability ± S.E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>63</td>
<td>7</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>46</td>
<td>6</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>67</td>
<td>8</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>44</td>
<td>5</td>
</tr>
</tbody>
</table>

**First lactation.**

On an analysis of 63, 46, 67 and 44 half-sibs records from 7, 6, 8 and 5 sires of first, second, third and fourth group respectively the heritability estimate came to -0.148±0.173, 0.56 ± 0.59, 0.148 ± 0.320 and 0.56 ± 0.642 respectively. The values are less reliable as the standard error is very high.

**Comparison.**

On comparison a non-significant value was obtained in respect of Intra-class correlation value as shown in Table - 30. An average value of heritability was therefore calculated as 0.04 which is quite lower. The value is too
low as compared to that of Rakes et al (1959) in Holstein.

**TABLE - 80**

(Comparison of heritability estimates of monthly peak-yield of first lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n-3</th>
<th>r</th>
<th>z</th>
<th>Weighted z</th>
<th>Weighted z²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>63</td>
<td>60</td>
<td>-0.037</td>
<td>-0.037</td>
<td>-2.220</td>
<td>0.032</td>
</tr>
<tr>
<td>2</td>
<td>46</td>
<td>43</td>
<td>0.140</td>
<td>0.141</td>
<td>6.063</td>
<td>0.855</td>
</tr>
<tr>
<td>3</td>
<td>67</td>
<td>64</td>
<td>0.037</td>
<td>0.037</td>
<td>2.363</td>
<td>0.087</td>
</tr>
<tr>
<td>4</td>
<td>44</td>
<td>41</td>
<td>0.140</td>
<td>0.141</td>
<td>5.781</td>
<td>0.315</td>
</tr>
<tr>
<td>Total</td>
<td>208</td>
<td></td>
<td></td>
<td></td>
<td>10.992</td>
<td>1.839</td>
</tr>
</tbody>
</table>

**average \( \bar{z} = 0.052 \)**

\[
\text{Chi-Square} = \chi^2 = 1.839 - \left( \frac{10.992^2}{208} \right) = 1.839 - 0.580 = 1.259 (NS)
\]

**average \( \bar{r} = 0.05 \)**

**average heritability = 4 \times 0.05 = 0.20**

The analysis of variance of all the groups for heritability estimation is shown in Table - 81.

**TABLE - 81**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>A-above 4000 lbs</th>
<th>Sources of variation</th>
<th>df</th>
<th>( n-1 )</th>
<th>( S^2 )</th>
<th>( M^2 )</th>
<th>( M^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Between sire</td>
<td>6</td>
<td>6</td>
<td>34622.91</td>
<td>14103.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>56</td>
<td>55</td>
<td>1137996.87</td>
<td>20321.36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Sources of Variation

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>5</td>
<td>11409.39</td>
<td>2281.906</td>
</tr>
<tr>
<td>Within sire</td>
<td>40</td>
<td>394000.04</td>
<td>98501.54</td>
</tr>
</tbody>
</table>

### C. Above 2000 lbs. & below 3000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>7</td>
<td>50001.43</td>
<td>7143.056</td>
</tr>
<tr>
<td>Within sire</td>
<td>59</td>
<td>321058.49</td>
<td>5441.66</td>
</tr>
</tbody>
</table>

### D. Below 2000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>4</td>
<td>923168.49</td>
<td>23292.12</td>
</tr>
<tr>
<td>Within sire</td>
<td>39</td>
<td>373452.07</td>
<td>9703.99</td>
</tr>
</tbody>
</table>

### Group Estimates

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.143</td>
<td>8.5</td>
</tr>
<tr>
<td>B</td>
<td>0.560</td>
<td>7.5</td>
</tr>
<tr>
<td>C</td>
<td>0.148</td>
<td>8.1</td>
</tr>
<tr>
<td>D</td>
<td>0.560</td>
<td>8.6</td>
</tr>
</tbody>
</table>

### Second Lactation

**Table 2**

(Heritability estimates of monthly peak-yield of second lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>R</th>
<th>O</th>
<th>U</th>
<th>P</th>
<th>Sires: Heritability ± S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>64</td>
<td>7</td>
<td>0.720 ± 0.636</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>61</td>
<td>6</td>
<td>1.280 ± 1.114</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>60</td>
<td>7</td>
<td>0.064 ± 0.298</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td>25</td>
<td>4</td>
<td>0.036 ± 0.543</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Beyond the range.*

On an analysis of 64, 61, 60, and 25 records from
from 7, 6, 7 and 4 sires and the heritability estimates came to 0.720 ± 0.636, 1.220 ± 1.114, 0.084 ± 0.298 and 0.036 ± 0.543 for the first, second, third and fourth groups respectively.

The value at first level is higher than that estimated by Rakes et al (1959) and Batra (1961). At the second level the value is beyond the range and this may be due to sampling fluctuations. At the third and fourth level the estimates are lower than those of Rakes et al (1959) in Holstein. The result of low yielding group shows a lower estimate of heritability. The estimates are less reliable as their standard error is very high.

The analysis of variance of heritability estimates is as shown in Table 83.

**Table 83**

(Analysis of Variance)

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>A. f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Between sire</td>
<td>6</td>
<td>347453.21</td>
<td>57908.86</td>
</tr>
<tr>
<td>Within sire</td>
<td>57</td>
<td>1149926.17</td>
<td>20063.84</td>
</tr>
</tbody>
</table>

A- Above 4000 lbs.

B- Above 2000 lbs. & below 4000 lbs.

| Between sire         | 5     | 239664.23 | 57932.84 |
| Within sire          | 45    | 537315.92 | 14951.46 |

C- Above 2000 lbs. & below 3000 lbs.

| Between sire         | 6     | 39640.66  | 6606.77  |
| Within sire          | 53    | 303602.97 | 5822.69  |
### Contd. Table - 83

#### D-Below 2000 lbs.

<table>
<thead>
<tr>
<th>Sources of Variation</th>
<th>d.f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between sire</td>
<td>3</td>
<td>17709.25</td>
<td>5903.08</td>
</tr>
<tr>
<td>Within sire</td>
<td>21</td>
<td>237475.58</td>
<td>11308.36</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.720</td>
<td>8.2</td>
</tr>
<tr>
<td>B</td>
<td>1.230</td>
<td>8.0</td>
</tr>
<tr>
<td>C</td>
<td>0.064</td>
<td>8.0</td>
</tr>
<tr>
<td>D</td>
<td>0.036</td>
<td>5.4</td>
</tr>
</tbody>
</table>

#### Comparison

<table>
<thead>
<tr>
<th>TABLE - 84</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Comparison of heritability estimates of monthly peak yield of second lactation)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Group : No. : n-3 :</th>
<th>r</th>
<th>z</th>
<th>Weighted z : Weighted Square : (n-3)z^2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>First</td>
<td>64</td>
<td>61</td>
<td>0.180</td>
</tr>
<tr>
<td>Second</td>
<td>51</td>
<td>48</td>
<td>0.320</td>
</tr>
<tr>
<td>Third</td>
<td>60</td>
<td>57</td>
<td>0.064</td>
</tr>
<tr>
<td>Fourth</td>
<td>25</td>
<td>22</td>
<td>-0.009</td>
</tr>
<tr>
<td>Total</td>
<td>188</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{average } \bar{z}_w = 0.16
\]

\[
\text{Chi-Square } = \chi^2 = 7.537 - \left( \frac{30.223^2}{188} \right)
\]

\[
\text{average } \bar{r} = 0.159
\]

\[
\text{average heritability } = 4 \times 0.159 = 0.636
\]
The comparison showed a non-significant difference among the Intra-class correlation co-efficient, therefore, an average value was estimated as 0.636 which is higher than that of Batra (1961) and L.R.S. report of Mathura (1952-57). The higher value might be due to sampling fluctuations because of lesser number of observations.

Third Lactation.

**TABLE - 35**

( Heritability estimates of monthly peak-yield of third lactation).

<table>
<thead>
<tr>
<th>Group</th>
<th>No. of Sires</th>
<th>Heritability ± S. E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Above 4000 lbs.</td>
<td>54</td>
<td>0.360 ± 0.062</td>
</tr>
<tr>
<td>Above 3000 lbs. below 4000 lbs.</td>
<td>36</td>
<td>0.210 ± 0.0438</td>
</tr>
<tr>
<td>Above 2000 lbs. below 3000 lbs.</td>
<td>23</td>
<td>0.800 ± 1.136</td>
</tr>
<tr>
<td>Below 2000 lbs.</td>
<td></td>
<td>Scanty Records</td>
</tr>
</tbody>
</table>

The heritability estimate of first group came to 0.360 ± 0.062 from an analysis of 54 half-sib records from 6 sires. On an analysis of 36 and 23 half-sib records of second and third group under 5 and 3 sires respectively, the heritability estimate came to 0.210 ± 0.0438 and 0.800 ± 1.136 respectively. No attempt was made to estimate heritability estimate of fourth group as the number of observations were considered to be quite meagre. Analysis
of variance is given in Table - 86.

**TABLE - 86**

(analysis of Variance)

### A - Above 4000 lbs.

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d. f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Between sire</td>
<td>5</td>
<td>29156.03</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>48</td>
<td>1221306.07</td>
<td></td>
</tr>
</tbody>
</table>

### B - Above 3000 lbs. & Below 4000 lbs.

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d. f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Between sire</td>
<td>4</td>
<td>122552.98</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>31</td>
<td>697010.02</td>
<td></td>
</tr>
</tbody>
</table>

### C - Above 2000 lbs. & Below 3000 lbs.

<table>
<thead>
<tr>
<th>Sources of variation</th>
<th>d. f.</th>
<th>S. S.</th>
<th>M. S.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>88542.38</td>
<td></td>
</tr>
<tr>
<td>Within sire</td>
<td>20</td>
<td>271662.51</td>
<td></td>
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<table>
<thead>
<tr>
<th>Group</th>
<th>Estimate</th>
<th>Value of K</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-0.360</td>
<td>3.50</td>
</tr>
<tr>
<td>B</td>
<td>0.210</td>
<td>7.60</td>
</tr>
<tr>
<td>C</td>
<td>0.300</td>
<td>6.35</td>
</tr>
</tbody>
</table>

The estimates obtained for the first level are contradictory to that reported by Rakes et al (1959) but at second level it agrees with that of Sikka (1950) in Ayrshire and Chief Bureau of Animal Industry, Agricultural Research Admn. U. S. A. (1952) whereas at third level the value is much higher in comparison to that of Batra (1961). This may be due to sampling error in the estimate.
Comparison

**TABLE 87**
(Comparison of heritability estimates of monthly peak-yield of third lactation)

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>n-3</th>
<th>F</th>
<th>(z)</th>
<th>Weighted (z)</th>
<th>Weighted Square</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>First</td>
<td>54</td>
<td>51</td>
<td>-0.090</td>
<td>-0.090</td>
<td>-4.590</td>
<td>0.413</td>
</tr>
<tr>
<td>Second</td>
<td>36</td>
<td>33</td>
<td>0.053</td>
<td>0.050</td>
<td>1.650</td>
<td>0.082</td>
</tr>
<tr>
<td>Third</td>
<td>23</td>
<td>20</td>
<td>0.200</td>
<td>0.203</td>
<td>4.060</td>
<td>0.324</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>104</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>1.120</strong></td>
<td><strong>1.319</strong></td>
</tr>
</tbody>
</table>

Average \(\bar{z}\) = 0.010

Chi-Square = \(\chi^2 = 1.319 - (1.120)^2 / 104\)

= 1.319 - 0.012

= 1.307 (N.S.)

Average \(\bar{F}\) = 0.010

Average heritability = 4 x 0.010 = 0.040

On comparison a non-significant value was obtained in respect of Intra-class correlation coefficient as shown in the above table. An average was, therefore, calculated as 0.04 which is quite lower. The value is too low as compared to that of Rakes et al (1959) in Holstein and L.R.S. report Mathura (1958-67).

**Persistency - Index**

The persistency index upto third lactations under four different groups was calculated. The results are shown
On perusal of the results it seems that cows in first lactation are more persistent than in second under first and second group. But in the third and fourth group they are more persistent in second lactation. Thereafter there is decrease in the persistency-index. It agrees with Kartha (1934) that first calvers are more persistent than late calvers. In the second and the third group the highest persistency in second lactation might be due to their undeveloped maturity. However, the differences have not been tested statistically for significance or otherwise.
SUMMARY

A Genetic study on (1) First lactation yield, (2) First lactation length, (3) Age at maturity, (4) First dry period, (5) First Inter-calving period and (6) Lactation curve has been made at four different levels of production viz., above 4000 lbs., above 3000 lbs. & below 4000 lbs., above 2000 lbs. & below 3000 lbs., below 2000 lbs. yielding groups, which were designated as first, second, third and fourth group respectively, based upon first lactation yield of Tharparkar herd at Government Cattle Farm, Patna.

The history sheets from 1927-1968 have been taken for analysis, but the data for lactation curve study have been taken for the period 1946-1968 only. The results obtained have been briefly summarised below:

(1) First lactation yield.

The average first lactation yield for the first group was 4882.47 ± 59.31 lbs. with 14.42 percent co-efficient of variation. For the second, third and fourth group, it was 3458.89 ± 257.16, 2486.86 ± 20.26 and 1441.93 ± 46.10 lbs. with 5.04, 11.83 and 42.75 percent co-efficient of variation respectively. The differences among the groups averages were found significant.

The genetic correlation between first lactation yield and first lactation length was found to be 0.31, 0.14, 0.103 and 0.24 at first, second, third and fourth level of
SUMMARY

A Genetic study on (1) First lactation yield, (2) First lactation length, (3) Age at maturity, (4) First dry period, (5) First Inter-calving period and (6) Lactation curve has been made at four different levels of production viz., above 4000 lbs., above 3000 lbs. & below 4000 lbs., above 2000 lbs. & below 3000 lbs., below 2000 lbs. yielding groups, which were designated as first, second, third and fourth group respectively, based upon first lactation yield of Tharparkar herd at Government Cattle Farm, Patna.

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The genetic correlation between first lactation yield and first lactation length was found to be 0.31, 0.14, 0.103 and 0.24 at first, second, third and fourth level of
production respectively. These values were found to differ non-significantly. The average value was obtained as 0.187.

The phenotypic correlation between first lactation yield and first lactation length was studied. The estimates were found to differ significantly.

The heritability estimate of the first lactation yield for each group was obtained and differences among these values were found non-significant. The pooled heritability estimate was found to be 0.192.

(2) **First lactation length.**

The average first lactation length was estimated as 392.63 ± 6.63, 336.83 ± 4.70, 296.72 ± 3.97 and 213.65 ± 5.09 days for first, second, third and fourth group respectively with 20.05, 18.72, 19.47 and 31.66 percent co-efficient of variation.

The heritability estimate of each group was calculated and the differences among the estimates non-significant. The pooled heritability estimate was found to be 0.156.

(3) **Age at maturity.**

The average for age at maturity was 994.53 ± 68.80, 1257.66 ± 14.23, 1242.47 ± 18.74 and 1200.08 ± 17.85 days for first, second, third and fourth group respectively with 81.85,
and 14.93, 21.54, 19.67 percent co-efficient of variation in the same order.

The phenotypic correlation between age at maturity and first lactation yield was found as 0.69, 0.328, zero and -0.959 at first, second, third and fourth level of production. These values differed significantly.

Phenotypic correlation between age at maturity and first dry period was estimated as 0.276, 0.131, -0.052 and 0.144 for the first, second, third and fourth group respectively. These values differed significantly.

The phenotypic correlation estimate between age at maturity and first Inter-calving period was found as -0.058, 0.600, 0.005 and 0.165 for first, second, third and fourth group respectively. These values differed significantly. So, these correlation studies showed that level of production has got significant effect on phenotypic correlation estimates.

The heritability estimate for each group was estimated. The differences among the estimates were found non-significant and hence a pooled heritability estimate calculated was found to be 0.28.

(4) First dry period.

The average first dry period was estimated as 140.83 ± 13.79, 155.25 ± 12.09, 156.20 ± 7.40, and 226.76 ± 15.35 days for the first, second, third and fourth group with 112.07, 99.42, 66.17 and 81.80 percent co-efficient of variation.
respectively.

The heritability estimate for each group was estimated. The differences among the Intra-class correlation value being non-significant, the average value of heritability was obtained as 0.112.

(5) First inter-calving period.

Average first inter-calving period was calculated as 531.77 ± 16.25, 490.82 ± 11.96, 452.79 ± 2.40 and 444.50 ± 11.10 days with 35.75, 32.77, 7.45 and 30.38 percent co-efficient of variation respectively.

The heritability estimate of each group was estimated. The values were found to differ non-significantly, hence the pooled heritability estimate was obtained as 0.108.

(6) Monthly rate of decline of milk yield.

The monthly rate of decline of milk-yield for the first, second, third and fourth group was studied upto sixth lactation. It showed an increase in the rate of decline in second lactation as compared with first and a sharp decline was observed in the lowest yielding group.

The heritability of rate of decline of milk-yield was calculated which showed a negative value in first and second lactation but a pooled mean value of 0.28 was found in third lactation.
Monthly peak-yield and maximum milk-yield values (observed and expected) were calculated.

The heritability estimate of peak-yield showed a pooled estimate as 0.20, 0.636, 0.04 for the first, second and third lactation respectively. Persistency indices for different lactations were also calculated. Peak-yield was observed in the third lactation generally.

(7) Heritability estimates of rate of decline.

In general, the heritability estimates were not found to differ significantly at different levels of production. The heritability estimates for rate of decline, though based on limited number of observations, by and large, showed negative values (which may be taken as zero) indicating thereby that this trait is conditioned by the environmental factors alone. The low yielders were found to have sharp rate of decline. This indicates that sharp decline in milk-yield is mainly responsible for low yield.

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<th>Year</th>
<th>Reference</th>
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<td>Year</td>
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