The data consisting of 2,095 lactation records of 502 Gir cows and 348 daughter-dam pairs spread over a period of 33 years (1936 to 1968) from the Kandivali Cattle Breeding Farm of Bombay Gowrakshak Mandal, Bombay were collected and analysed.

The records on various traits viz., age at first calving, lactation milk yield on 300-days' basis for the first five individual lactations, monthly milk yields of first lactation up to tenth month, cumulative part lactation milk yields of first lactation up to 270-days, life-time milk production based on first three lactations, lactation length, dry period, inter-calving period, service period and gestation period from first to fifth lactation, birth weight, sex-ratio at birth and incidence of abortions, pre-mature births, still-births and twinning were studied. The data were analysed for different environmental effects using least-square technique for non-orthogonal data as recommended by Harvey (1966) and adjusted for effects of factors which were found significant.
The average age at first calving was observed to be 53.60±0.42 months with coefficient of variation of 17.40%. The least square analysis of age at first calving indicated that period effects were highly significant. The heritability estimates of age at first calving were 0.129±0.098 by paternal half-sib intraclass correlation (PHS) and -0.039±0.113 by intra-sire regression of daughters' record on dams' record (ISRDO) methods. The results revealed that within herd genetic variability for age at first calving was fairly low. It could be surmised that improvement in this trait could be brought about not merely through mass selection but more reliance was required to be placed on other methods of selection like pedigree, progeny performance, dam's record and records of collaterals, particularly half-sibs. System of breeding to exploit non-additive gene action could also be adopted.

The average milk yields of first three completed lactations on 300-days' basis were found to be 1228.35±20.44, 1305.37±25.38 and 944.28±32.43 kg with c.v. values of 37.28, 36.48 and 40.08% respectively. The least square analysis of the data on various lactations showed that period effects were found to be highly significant only in case of first lactation milk yield. The season effect was not significant for the milk production of any lactation. The age effect was also not found to be significant on the milk yield of the first three lactations. The average 300-days' milk yield pooled on the
basis of first five lactations was observed to be 1212.63±13.73 kg with coefficient of variation of 40.36%. The least square analysis indicated that the effect of periods and sequence of calving on average lactation milk production pooled on first five lactations were highly significant. The season and age effects were not found to be significant for the milk production based on pooled data. Average lactation milk yield was the highest in second lactation, whereas it was the lowest in the fifth lactation. This indicated that the Gir cows attained maturity after the age of 70 months i.e. during the second lactation. The average life-time milk production based on first three lactations after adjusting the data for period effects was found to be 3478.00±78.25 kg with c.v. of 39.91%.

The heritability estimates of 300-days' completed lactation milk yield records of first three lactations were observed to be 0.455±0.173, 0.392±0.086 and 0.223±0.208 respectively by PHS correlation method. Heritability estimates for the first and second lactation milk yield records by ISRODD method were found to be 0.382±0.124 and 0.297±0.131 respectively. The heritability estimate of average milk yield based on pooled data of first five lactations was 0.204±0.058 by PHS correlation method. The estimated value of heritability of average life-time milk production was 0.273±0.133 by PHS correlation method. Results revealed that first lactation milk yield had a higher estimate of heritability than second and third lactation milk yields, pooled average of first five lactation milk yields and life-time milk production. It could be surmised that
substantial genetic progress in lactation milk yields could be achieved by taking advantage of other bases of selection along with mass selection. The repeatability estimate of 300-days' completed lactation production computed on first three lactation records by PHS correlation method was found to be 0.486+0.036. This high estimate for the trait indicated that the variance from non-additive genetic sources in the Gir herd was of some importance. The selection of animals for faster genetic improvement could be safely based on their performance in first lactation. Estimates of phenotypic, genetic and environmental correlations between age at first calving and 300-days' average milk production of first three lactations were found. The genetic correlations with the milk yield of first lactation was high and negative, whereas the estimates for second and third lactations were found to be high and positive. This showed that adequate variability exists among Gir sires for selection of animals for lowering age at first calving and increasing milk production during first lactation. The estimates of phenotypic, genetic and environmental correlations between 300-days' average milk production of first three lactations were all positive and significant. It could hence be concluded that the milk yield is highly repeatable trait and selection of cows for improving first lactation milk production could also result in genetic progress for more milk production during second and third lactations.

The average monthly part lactation milk yields (kg) from first to tenth month of first lactation were observed to be
108.20±2.21, 161.55±3.19, 156.77±2.87, 150.60±2.66, 147.28±2.17,
143.94±2.28, 136.20±2.95, 129.56±2.81, 115.91±2.74 and 106.88±3.04
respectively. The average cumulative partial lactation milk
yields (kg) for 60, 90, 120, 150, 180, 210, 240 and 270 days of
first lactation were 269.30±5.55, 422.91±7.93, 576.63±10.10,
722.30±12.54, 887.71±14.96, 1061.58±17.03, 1240.72±20.07 and
1307.00±22.81 respectively. The average milk yield was the
maximum in the second month's (30-days') record, whereas it was
the minimum in the tenth month's (30-days') record. The average
milk yield was found to be the highest in first 270-days'
cumulative part lactation record. The least square analysis
of part lactation milk yields indicated that period effects were
highly significant in all monthly and cumulative partial
lactation milk yield records. The effect of seasons was
significant in case of ninth and tenth monthly yields. The age
effect was not found to be significant in case of all partial
lactation records.

The heritability estimates of first to tenth monthly
part lactation yields were found to be 0.373±0.198, 0.414±0.207,
0.349±0.193, 0.369±0.197, 0.484±0.223, 0.456±0.222, 0.326±0.203,
0.309±0.209, 0.236±0.143 and 0.180±0.207 respectively by PHS
correlation method, whereas the estimates obtained by ISROD
method were 0.483±0.113, 0.481±0.111, 0.630±0.103, 0.505±0.121,
0.265±0.140, 0.293±0.122, 0.231±0.138, 0.148±0.159, 0.161±0.168
and 0.218±0.189 respectively. For cumulative partial lactation
yields upto 270 days at an interval of 30 days each commencing
with 60-days' production, the estimates were observed to be
0.669+0.255, 0.617+0.246, 0.595+0.242, 0.624+0.249, 0.617+0.252, 0.517+0.241, 0.701+0.281 and 0.589+0.376 respectively by PHS correlation method, whereas the estimates obtained by ISRDD method were 0.542+0.112, 0.616+0.110, 0.687+0.108, 0.746+0.107, 0.798+0.105, 0.826+0.105, 0.849+0.104 and 0.864+0.105 respectively.

In general the heritability estimates of cumulative partial lactation milk yields were higher and also more consistent than those of monthly consecutive yields.

The estimates of genetic, phenotypic and environmental correlations between 300-days' first lactation milk production and different partial lactation milk yield records of first lactation were found to be positive and high. As was seen in case of 300-days' first lactation milk production, the estimates of genetic, phenotypic and environmental correlations between average life-time milk yield and various part lactation milk yield records both on monthly and cumulative basis were also observed to be high and positive. Except for sixth, seventh and eighth monthly records, all the other part records had high genetic correlations with the average life-time milk production. Results obtained in the present study revealed that various part records of first lactation, the first lactation milk production and average life-time milk production were genetically compatible with respect to genes, their combinations and frequency and thus selection for higher production in any of these part records would also indirectly result in selection for increased production in completed first lactation, as well as, average life-time milk production. The earliest part lactation records that could be
recommended for speedy improvement among Gir cattle were the second and third month's (30-days') milk production records, as well as, 60-days' cumulative milk yield records of the first lactation.

The average records of other traits of first lactation like lactation length, dry period, inter-calving period, service period and gestation length were found to be 342.57±4.64, 167.40±4.40, 510.82±5.56, 225.20±5.39 and 283.93±0.37 days respectively. The respective c.v. values for these traits were 30.36, 51.31, 32.86, 52.13 and 2.81%. The average records of these traits in the same order based on pooled data of first five lactations were observed to be 307.97±2.42, 161.24±2.41, 468.20±2.99, 187.31±2.99 and 283.99±0.40 days with their respective c.v. values of 29.95, 55.64, 23.89, 58.13 and 5.11%. The least square analysis of the data on these traits other than gestation length during first lactation, as well as, on first five records (pooled estimate) revealed significant effect by periods except in case of the dry period. The traits like lactation length, inter-calving period and service period pooled over first five records were significantly affected by the order of parity. The season effect was not significant in case of all of these traits. The gestation length during first calving and on pooled data of first five calvings was not significantly affected by any of the effects studied.

The estimates of heritability for these traits i.e. lactation length, dry period, inter-calving period, service period and gestation length were found to be 0.238±0.127, 0.131±0.103, 0.096±0.095, 0.073±0.091 and 0.031±0.083 during first lactation.
and 0.073±0.044, 0.097±0.051, 0.140±0.060, 0.143±0.061 and 0.069±0.045 on data pooled over first five records respectively by PH5 correlation method. Heritability estimates obtained by ISADD method for the lactation length, dry period, inter-calving period, service period and gestation length during first lactation were observed to be 0.218±0.112, -0.089±0.109, -0.086±0.109, -0.106±0.116 and 0.044±0.186 and for the second record the estimates obtained were 0.222±0.138, 0.056±0.137, 0.182±0.141, 0.090±0.132 and 0.027±0.145 respectively (by ISADD method). From the results, it could be concluded that lactation length was moderately heritable, whereas all other traits studied were lowly heritable. Low estimates of heritability indicate that these traits could mostly be improved with adoption of adequate managemental measures and could not be much affected by selection. Estimates of repeatability for the lactation length, dry period and inter-calving period based on first three lactations were found to be 0.304±0.040, 0.243±0.041 and 0.266±0.041 respectively. It may be deduced that the non-additive genetic variance in lactation length was of importance and selection of Gir cows could be based on their performance in the first lactation for faster genetic progress.

The estimates of genetic, phenotypic and environmental correlations of age at first calving and 300-days' first lactation milk production with other traits viz., lactation length, dry period, inter-calving period and service period of first lactation were obtained. Age at first calving and first lactation milk production were found to have positive and high genetic association
with all the other traits during first lactation. Therefore, it could be concluded that some of the gene pools controlling these traits were common and that selection for reducing age at first calving would also bring about genetic reduction in lactation length, dry period and inter-calving interval during first lactation. The positive and high genetic association of first lactation milk production with the lactation length could be, however, considered in desirable direction from the economic point of view.

The efficiency of selection for various partial lactation records relative to total first lactation milk yield record in improving annual milk production was found high. High value of selection efficiency in earlier monthly parts of lactation was found to be 83.1% for second monthly milk yield. Similarly, the earlier cumulative part lactation milk yields were found to be more efficient for indirect selection for the first lactation in comparison to the direct selection based on total first lactation milk production. First 60-days' and 90-days' milk yields were observed to give fairly high selection efficiencies of 98.9% and 94.5% respectively. For effective selection of the best female breeding stock, as well as, for proving sires at a much earlier stage, it is hence recommended that among the early part records, the second month's milk yield record or first 60-days' milk yield record could be used to advantage.

Accurate estimation of the breeding value of the sires on the basis of minimum number of daughters and early part lactation records could be used to achieve faster genetic
improvement per year in cattle for milk production. It could be
deduced that second, fifth or sixth monthly milk yield records,
as well as, 60-days' cumulative partial lactation milk yield
records based on 10 daughters per sire could be considered
adequate for sire proving with fair degree of accuracy and
efficiency.

Twenty eight selection indexes incorporating various
traits were constructed alongwith their relative efficiency
values. The relative economic weightages of different traits
were computed as partial regression coefficients of the net value
of the animal on each trait separately. The indexes developed
on age at first calving and other economic traits having completed
records were found to be comparatively more efficient than those
involving age at first calving and monthly or cumulative partial
lactation milk yields. The best of the indexes based on economic
traits in different combinations were those which combined first
lactation milk yield and first lactation length with age at first
calving or first lactation length with first lactation milk yield.
The index which was observed to be the best in this series,
involved three traits like age at first calving, first lactation
milk production and first lactation length. The index arrived
at was:

\[ I_2 = -0.7073X_1 + 0.1988X_2 - 0.5093X_4 \]

Where, \( X_1 \) was age at first calving (months), \( X_2 \) was first
lactation milk yield (kg) and \( X_4 \) was first lactation length (days).

This index showed \( \Delta H \) value of 186.62 and \( R_{IH} \) value of 0.4464 and
the expected genetic improvement, due to application of this index
was found to lower the age by 0.96 months (1.78%), increase
lactation milk yield by 81.94 kg (6.67%) and reduce the lactation length by 7.38 days (2.15%). The index showed the highest correlation with the aggregate breeding value of the animal and hence is recommended for adoption.

The incorporation of age at first calving as a trait in an index based on monthly part lactation yields, was adjudged to be the most efficient index. The best index found in this series on the basis of the $R_{IH}$ value was:

$$I_{14} = 0.3308X_1 + 0.0094X_{10}$$

Where, $X_1$ was age at first calving (months) and $X_{10}$ was fourth 30-days' milk yield (kg) of first lactation. This index showed $\Delta H$ value of 72.52 and $R_{IH}$ value of 0.3453 and the expected genetic gain due to the application of this index was found to increase age at first calving and milk yield during the fourth month of first lactation by 0.74 months (1.38%) and 1.35 kg (0.89%) respectively.

On studying the relative efficiency values of various indexes developed on two traits viz., age at first calving and cumulative part lactation milk yield, the following index was found to be the best in this series:

$$I_{28} = -0.5556X_1 + 0.1030X_{24}$$

Where, $X_1$ was age at first calving (months) and $X_{24}$ was first 270-days' cumulative partial lactation milk yield of first lactation. This index showed $\Delta H$ value of 176.96 and $R_{IH}$ value of 0.3013. Selection based on this index could bring about reduction in age at first calving by 0.65 months (1.20%) and an increase in milk yield of 270-days' record by 40.01 kg (3.06%) per generation.
However, considering the relative efficiency of 90-days' cumulative part record in selection for total first lactation milk yield, as well as, high genetic correlation of this part lactation with the first lactation milk production, the index involving age at first calving and cumulative 90-days' part lactation milk yield can also be used with some advantage and developed at an early date. This index was derived as:

\[ I_{22} = -1.5762X_1 + 0.0423X_{18} \]

Where, \( X_1 \) was age at first calving (months) and \( X_{18} \) was first 90-days' cumulative part lactation record (kg). This index showed \( \Delta H \) value of 75.54 and \( R_{IH} \) value of 0.2718 and the expected genetic progress due to the application of this index in selection was found to lower age at first calving by 0.58 months (1.09%) and increase milk yield during first 90-days' period of first lactation by 12.77 kg (3.02%).

The estimates of cases of secondary sex-ratio, twin births, abortions, pre-mature births and still-births in the Gir cows were observed to be 103.75 \( \pm \) 100 (52.85% males), 0.354%, 1.848%, 2.595% and 0.236% respectively on the basis of data on 2,543 calvings. It could be deduced that Gir cows had a higher rate of abortions and pre-mature births over a period of many years. The rate of pre-mature births was found quite high and this showed that better care of the down calvers among Gir cows was necessary. The estimate of average birth weight of Gir calves in the present study was obtained as 23.53 \( \pm \) 0.12 for male and 22.54 \( \pm \) 0.06 for female.