GENETIC STUDIES ON GROWTH, PRODUCING ABILITY AND REPRODUCTION TRAITS IN JERSEY CATTLE

BY

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B. V. Sc. & A. H.

DISSERTATION

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PARBHANI

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AFFECTIONATELY DEDICATED

TO

MY BELOVED PARENTS

CANDIDATE'S DECLARATION

I hereby declare that the dissertation or part thereof has not been previously submitted by me for a degree of any University.

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Shri Krishna Udhaorao Methekar has satisfactorily prosecuted his course of research for a period of not less than two semesters and that the dissertation entitled " GENETIC STUDIES ON GROWTH, PRODUCING ABILITY AND REPRODUCTION TRAITS IN JERSEY CATTLE " submitted by him is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that the dissertation or part thereof has not been previously submitted by him for a degree of any University.

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CERTIFICATE II

This is to certify that the dissertation entitled " GENETIC STUDIES ON GROWTH, PRODUCING ABILITY AND REPRODUCTION TRAITS IN JERSEY CATTLE " submitted by Shri Krishna Udhaorao Methekar to the Marathwada Agricultural University in partial fulfilment of the requirement for the degree of Master of Veterinary Science in the subject of Animal Genetics and Breeding has been approved by the student's Advisory Committee after oral examination in collaboration with the external examiner.

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ABBREVIATIONS USED

DMRT	=	Duncan's Multiple Range Test
ADG	=	Average daily gain
g	=	gram
c.v.	=	Coefficient of variation
CI	=	Calving interval
GP	=	Gestation period
SP	=	Service period
BE	=	Breeding efficiency
PA	=	Producing ability

CONTENTS

INTRODUCTION

1. INTRODUCTION

Majority of the cattle are owned by small and marginal farmers who have 30 per cent of the total cultivable land holding. Naturally the cattle breeding in India was of conventional method for centuries.

The wise British businessmen who then became the rulers introduced the crossbreeding in Indian cattle to cater the needs of army personnel for milk.

Consequently, India was freed from British rulers and it took more than 20 years after independence to go in for systematic crossbreeding programme at village level to increase the milk production.

The persistent efforts of scientists to boost milk production were fruitful with breakthroughs in artificial insemination and frozen semen availability from the progeny tested sires which accelerated the work of white revolution.

The white revolution initiated by use of modern techniques preceded for boost in milk production through crossbreeding. Adaptation of the exotic high yielding animals such as Jersey, Holstein Friesian and Brown Swiss under Indian climatic conditions were tried initially by raising such cattle in hilly areas. Thereafter slowly, there was intentional movement of such cattle to different agroclimatic regions of country to make them withstand the heat and resistance against viral and parasitic diseases such as FMD, Thileriasis etc.

It is now an established fact that 50 per cent inheritance of exotic cattle such as Jersey, Holstein Friesian and Brown Swiss is accepted for higher milk yield under Indian climatic conditions. But this does not fulfil the growing demand of our ever growing human population which is more than 84 crores today.

The sole problem of Indian cattle is low productivity which can be enhanced to an appreciable degree by cross-breeding.

The productive summary of animal is dependent on reproductive performance. Genetic evaluation of such traits is of immense use. The exotic breed Jersey simulating the Indian cattle in body size and conformation is outstanding in milk fat percentage. Exploitation of the character is worthwhile.

The idea of raising exotic animals under Indian climatic conditions to exploit 100 per cent genetic potential was thought over. This had given encouraging results in some of the farms located at different agroclimatic conditions.

The latest embryo transfer technology when it will be in vouge would definitely accelerate the white revolution several times. It implies nil inheritance of indigenous cows which would provide only the intrauterine environment for growth of highly potential exotic embryos.

In response to the need of the time, a systematic study of growth and reproduction traits along with producing ability in purebred Jersey cattle is presented in this dissertation.

The attempts are made to study the performance of Jersey cattle with the following objectives:

1 To study the effect of location, period and season on growth and reproduction traits.

2 To study the reproductive performance.

3 To find out genetic and phenotypic correlations amongst all the reproductive traits.

4 To estimate the heritability of birth weight, age at first calving, calving interval, gestation period, service period, breeding efficiency and producing ability.

5 To estimate the producing ability.

6 To estimate the breeding efficiency.

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REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

2.1 Birth weight

Birth weight is the foremost character in prediction of growth rate, early sexual maturity, increased breeding efficiency and milk yield. Birth weight is the first observable metric character in animals. It is an early expression of the phenomenon of growth. Birth weight is reported to be associated with growth rate and other economic characters in dairy animals. Capenko (1967) reported an average birth weight of 19.2 kg in Jersey calves. Roman *et al*. (1970) reported mean birth weight as 24.3 kg in Jersey calves at Florida. Average birth weight over three lactations as reported by Phipps (1974) were 19.2 $\pm$ 1.4 kg for males and 18.3 $\pm$ 1.3 kg for females and observed statistical significance differences for the sexes. Rajgopalan and Dave (1976) reported average birth weight for male and female calves as 20.92 and 18.59 kg respectively. They observed the highly significant differences for parity. Further they reported that the body weight of dam at calving also had significant effect on birth weight. The heritability estimate for birth weight by partial half sib correlation method was 0.1977 $\pm$ 0.4732. Malik *et al*. (1976) reported average birth weight for male 18.62 $\pm$ 0.80 and for female 17.11 $\pm$ 0.58 kg. Sadana and Basu (1981) reported overall least squares mean birth weight as 19.16 ± 0.52 kg with 30.45 per cent c.v. Narasimha Rao (1983) reported the average birth weight of males as 20.4 ± 0.56 kg as against 17.09 ± 1.14 kg in females. Ganpule (1984) reported higher birth weight for male calves as 19.0 kg than female 18.0 kg in Jersey cows. Gopalan Nair et al. (1985) reported average birth weight as 24.44 ± 0.704 kg and heritability estimate as 0.516 by half sib correlation method. Hafey and Pyer (1969) quoted by Gopalan Nair (1985) observed that those animals born with high birth weight and large gestation period were considered as born at relatively higher state of physiological maturity. Sharma et al. (1986) reported that season period and sex influence the birth weight. Zaman et al. (1989) reported least square mean of birth weight as 16.52 ± 1.09 kg. Similar observations were made earlier by Malik et al. (1990), Sharma and Basu (1981) and Das et al. (1983). A summary of some reports on mean values of birth weight is presented in Table 1.

2.2 Growth rate

Growth rate is also another important character. Rajgopalan and Dave (1976) reported the average daily gain as 615 (438-792 g) in males and 522 (412-633 g) in females. Further observed that the sex difference was significant but season of birth had non-significant

Table 1: Mean values of birth weight of Jersey calves

Reference	Average birth weight (kg)
Capenko (1967)	19.20
Roman *et al.* (1970)	24.30
Phipps (1974)	18.30
Rajgopalan and Dave (1976)	18.59
Malik *et al.*(1976)	17.11
Sadana and Basu (1981)	19.16
Narasimha Rao (1983)	17.09
Ganpule (1984)	18.00
Gopalan Nair *et al.* (1985)	24.44
Zaman *et al.* (1989)	16.52

effect. Narasimha Rao (1983) reported daily average gain in weight per quarter from birth to 12 months of age as 583.3, 741.20, 671.1 and 610.0 g for male and 585.5, 700.6, 592.2 and 517.8 g for female. Juneja _et al_. (1989) reported the highest (500.01 ± 65 g) daily gain in weight during 0-3 months of age and the lowest during 3-6 months (281.8 ± 13.1 g).

2.3 Age at first calving

The age at first calving depends upon several factors. Out of these, hereditary factor is mostly responsible in lowering the age at first calving. The age at first calving has a threshold expression. Cow calving at an early age gives more number of calves and more lactations. Age at first calving is related with the economics of lifetime production. McIntyer (1971) reported the average age at first calving as 36.8 months or 1104 days in Jersey cows at Fiji. Dev and Gill (1976) while studying the performance of Jersey cows at Punjab, reported the average age at first calving as 29.0 months. Bala and Nagarcenkar (1978) in west Bengal reported average age at first calving for Jersey as 27.4 ± 0.52 months or 822 ± 15 days. Sadana and Basu (1981) reported average age at first calving 28.49 to 29.57 months in hot Indian climatic conditions.

Arora and Sharma (1983) reported average age at first calving as 835.64 ± 12.78 days in Jersey cattle at Hissar. Polastre *et al*. (1983), while studying on Jersey heifers born during 1951-53, age at first calving averaged 31.6 ±1.2 months. Month of birth had no significant effect on age at first calving. But age at first calving was affected by sire and year of birth ($P < 0.01$). The heritability estimate for age at first calving based on paternal half sib intraclass correlation method was 0.48 ± 0.18. Ganpule (loc cit.) reported average age at first calving as 28.5 months in Jersey heifers at Ranchi (Bihar). Mangurkar *et al*. (1985) reported the age at first calving as 873.8 days. Bhadouria *et al*. (1986) while studying the Jersey cattle at Bilaspur in Madhya Pradesh reported overall age at first calving as 822.14 ± 10.59 days with c.v.of 20.04 per cent. The farm and year had highly significant effect on the age at first calving, while season of calving was found to have non-significant effect. The heritability estimate was 0.131 ± 0.273 for age at first calving. Sadana and Tripathi (1986) studied on 499 Jersey heifers in Haryana. The age at first calving averaged 28.5 ± 0.45 months as against 31.91 ± 0.88 and 30.08 ± 0.58 months for heifers in Kamand and Palampur (Himachal Pradesh). Age at first calving had significant genetic correlation with milk yield. The heritability estimates for age at first calving were 0.25, 0.18 and 0.13 in the three herds, respectively. Roy *et al.* (1987) reported mean age at first calving as 795.31 ± 7.26 days in a study on data from Assam and Madhya Pradesh. The heritability estimate for age at first calving was 0.46 ± 0.20. The genetic correlation of age at first calving with first calving interval was negative and high, with first service period was positive and low. Sanjeet Katoch *et al.* (1989) reported the heritability estimate for age at first calving as 0.50 ± 0.12, in two locations at Himachal Pradesh. Zaman *et al.* (1990) reported the least squares mean age at first calving as 32.05 ± 0.46 months at Barpeta, Assam. Further they reported that the period and season of calving had significant ($P < 0.05$, $P < 0.01$) effect on this trait. The estimate of heritability on adjusted data was 0.11 ± 0.23 for age at first calving. Das *et al.* (1990) reported average age at first calving as 30.28 ± 36.00 months. A summary of some reports on mean values of age at first calving is presented in Table 2.

2.4 Gestation period

Gestation period is one of the important traits in dairy cattle. It is a measure of reproductive efficiency. It contributes the length of calving interval

Table 2: Mean values of age at first calving in purebred Jersey cows

Reference	Average age at first calving in days
Mclntyer (1971)	1104.00
Dev and Gill (1976)	870.00
Bala and Nagarcenkar (1978)	822.00
Sadana and Basu (1981)	854.70
Arora and Sharma (1983)	835.64
Polastre *et al*. (1983)	948.00
Mangurkar *et al*. (1985)	873.80
Bhadouria *et al*. (1986)	822.14
Roy et al. (1987)	795.31
Zaman *et al*. (1990)	961.50
Das *et al*. (1990)	908.40

in association with the service period. Goswami and Datta (1959) reported the mean gestation period as 282.55 $\pm$ 1.41 days. The gestationwise duration of pregnancies varied as 280.87 $\pm$ 2.60, 282.0 $\pm$ 1.75 and 286.33 $\pm$ 3.43 days in first, second and third calving respectively. Under farm conditions of Assam,Das *et al.* (1984) reported the average gestation period as 277.08 $\pm$ 0.39 days. The length of gestation period was found to have significant correlation with the birth weight of calf (r = 0.23). Das *et al.* (1990)[a] reported the mean gestation period as 270.61 $\pm$ 1.05 days. It was significantly affected by the season of calving, lactation order and sex of the calves. The period was larger for cows carrying male calves than for cows carrying the female calves. Das *et al.* (1990)[b] reported the mean gestation period as 272.31 $\pm$ 0.73 days. He further showed that the gestation period and intercalving period were significantly influenced by length of lactation and dry period. A summary of some reports on mean values of gestation period is presented in Table 3.

Table 3: Mean values of gestation period

Reference	Mean gestation period (days)
Goswami and Datta (1959)	282.55
Das *et al.* (1984)	277.08
Das *et al.* (1990)[a]	270.61
Das *et al.* (1990)[b]	272.31

2.5 Service period

The period between the date of calving and the date of consecutive conception is called service period. The calving interval has two components, gestation and service period. Since the variation in the gestation is very little, the calving interval is mostly dependent upon the length of the service period. Regular calving will only decide the optimum service period in cows. Arora and Sharma (1983) reported the service period as 135.20 ± 11.31 days in Jersey cattle at Hissar. Service period for Jersey was 180.3 ± 18.3 days as reported by Sadana and Basu (1983). Arora *et al.* (1983) reported average service period as 135.20 ± 11.33 days and the season of calving had non-significant effect on all the reproductive traits. The period of calving also had non-significant effect on reproductive and productive traits. Duc and Taneja (1984) reported mean service period of 124.13 ± 10.48 days in Jersey cattle at Hissar. Further, they observed significant differences between seasons and highly significant differences between years. They attributed the declining trend to the environmental conditions. Sadana and Tripathi (1986) studied 499 Jersey cows at 3 farms. The average service period was reported 142.0 ± 2.4 days at Hissar, 236.6 ± 9.4 days at Kamand and 193.7 ± 4.9 days at Palampur. Das _et al_. (1987) reported average service period as 145.98 ± 11.48 days. It was significantly affected by season of calving. Cows calving in summer and monsoon, showed larger service period than those calved post monsoon. Das _et al_. (loc.cit. a&b) observed the average least squares means of the trait at two locations as 135.98 ± 11.48 and 140.67 ± 4.73 days. In both the cases, the service period was affected by period of calving, season of calving and the lactation order. A summary of some reports on mean values of service period is presented in Table 4.

Table 4: Mean values of service period

Reference	Average service period (days)
Arora and Sharma (1983)	135.20
Sadana and Basu (1983)	180.30
Arora *et al*. (1983)	135.20
Duc and Taneja (1984)	124.13
Sadana and Tripathi (1986)	142.00
Sadana and Tripathi (1986)	236.60
Sadana and Tripathi (1986)	193.70
Das *et al*. (1987)	145.98

2.6 Calving interval

The period between two consecutive calvings is called as calving interval. It is an important measure of reproductive efficiency of the animal. For profitable milk production the dairy cow must reproduce regularly. An interval of about 12 months is considered satisfactory. Cows, calving every year will produce more milk per day of calving interval than those which do not. Long calving interval reduces the number of calves born in the lifetime, lowering the milk production. Besides this, it increases the generation interval ultimately resulting in decreased annual genetic gains. By reducing the number of calvings the contribution in the terms of improved progeny from a superior cow would also be less. It is, therefore, essential that a cow should not only be higher yielder but should also calve once a year regularly. It is an established fact that genetic gain ΔG over a period is more when generation interval is reduced. Goswami and Datta (1959) reported the average calving interval of 356.08 ± 10.57 days and further stated that calving interval was slightly higher in second lactation (389.0 ± 34.81 days) than the first lactation (345.11 ± 6.72 days). Phipps (1974) reported the calving interval as 448.0 ± 10.1 days in Uganda in imported English Jersey cattle. Dev and Gill (1976) reported a calving interval of 431 days at Punjab for Jersey cattle. Rao and Nagarcenkar (1979) analysed the data from four military and five civil farms at 9 locations for the Jersey cattle, reported calving interval as 14.25 months. Dominguez and Menendez (1980) reported calving interval for Jersey as 404.58 days. Year of calving and season of calving had significant effect on calving interval. The shortest calving interval was observed in cows calved during Oct. to December months. Arora and Sharma (loc.cit.) reported the calving interval of 422.75 ± 10.95 days in Jersey. Palia and Arora (1983) reported that calving interval was shortest in the first lactation and showed deteriorating trend in subsequent lactations. Sadana and Basu (loc.cit.) reported a calving interval of 442.5 ± 18.4 days in Jersey cows. Arora et al. (loc.cit.) reported average calving interval 422.75 ± 10.95 days and further stated that the season of calving had non-significant effect on all the reproductive traits. Ganpule (loc.cit.) reported average calving intervals of 477 and 423 days in first and second calvings respectively . Paired observations showed improvement of 42 days. Ganpule et al. (loc.cit.) reported average calving interval of 422 days in Jersey cattle at Ranchi. Pandyal et al. (1984) reported overall first calving interval as 450.84 ± 12.58 days with 30.56 per cent c.v. The lesser calving interval was obtained for farm II (395.63 days) as compared to farm I (469.24 days). Duc and Taneja (loc.cit.) reported the first calving interval of 406.86 ± 11.00 days. Further, they stated that it was lesser for animals calving in season II (401.35 days) and more for animals calving in season I (465.01 days). Matoch and Tomer (1986) reported first calving interval as 560.89 ± 36.12 days. Sadana and Tripathi (loc.cit.) reported calving interval in three different farms as 411.5 ± 4.9, 530.1 ± 14.3 and 477.2 ± 7.6 days for Hissar, Kamand and Palampur respectively. Mangurkar *et al*. (loc.cit.) reported mean calving interval as 438.08 ± 11.06 days. Juneja *et al*. (loc.cit.) reported first calving interval of 466.7 ± 72.1 days in Jersey cows. A summary of some reports on mean values of calving interval is presented in Table 5.

2.7 Breeding efficiency

Breeding efficiency is a measure of reproductive efficiency. It reduces the generation interval, increases productive life of cow and thus increases net economic output. Productivity of the animal depends on reproductive performance. Wilcox *et al*. (1957) used a formula for calculating breeding efficiency in Friesian herd. Gautam *et al*. (1966) reported 91.90 ± 9.07 per cent breeding efficiency in Hariana cows. He further stated that breeding efficiency had significant negative correlation with age at first calving. Dharmendra Kumar (1981) reported a breeding efficiency of 85.67 per cent in Sahiwal cows at Lucknow. He further found significant negative phenotypic correlation of breeding efficiency with age at first calving and producing ability.

Table 5: Mean values of calving interval in purebred Jersey cows

Reference	Average calving interval (days)
Goswami and Datta (1959)	356.08
Phipps (1974)	448.00
Dev and Gill (1976)	431.00
Dominguez and Menendez (1980)	404.58
Arora and Sharma (1983)	422.75
Sadana and Basu (1983)	442.50
Arora *et al*. (1983)	422.75
Ganpule (1984)	477.00
Pandyal *et al*. (1984)	450.84
Duc and Taneja (1984)	406.86
Matoch and Tomer (1986)	560.89
Sadana and Tripathi (1986)	411.50
Mangurkar *et al*. (1985)	438.08
Juneja *et al*. (1989)	466.70

Deshpande and Sakhare (1984) reported breeding efficiencies of 87.14 and 94.59 per cent in Red Kandhari and Jersey x Red Kandhari, respectively. Further they stated that season, period, order of lactation and grade had significant influence on lactation milk yield, producing ability and breeding efficiency. Phenotypic correlation between breeding efficiency and producing ability was non-significant and positive. Roy and Katpatal (1987) reported highly significant effect of season, year and farm on all measures of breeding efficiency. The lactation-wise heritabilities for breeding efficiency as reported by them were 0.42 ± 0.20 for 1st lactation, 0.20 ± 0.24 for 2nd, 0.70 ± 0.42 for 3rd and 0.49 ± 0.82 for 4th lactation. In Jersey cattle, Das *et al*. (1987) reported the breeding efficiency as 84.85 ± 1.41 per cent. Singh *et al*. (1988) reported average breeding efficiency as 84.57 ± 1.17, 90.37 ± 14.14 and 81.36 ± 2.28 per cent in the Jersey x Sahiwal, Jersey x Rathi and Friesian x Sahiwal crossbreds respectively. A summary of some reports on mean values of breeding efficiency is presented in Table 6.

2.8 Producing ability

It is a character of economic importance. The prediction of producing ability of all cows in herd with different number of records, make it possible to compare

Table 6: Mean values for breeding efficiency

Breed	Mean value per cent	Reference
Hariana	91.90	Gautam *et al*. (1966)
Sahiwal	85.67	Dharmendrakumar (1981)
Red Kandhari	87.14	Deshpande and Sakhare (1984)
Jersey x Red Kandhari	94.59	Deshpande and Sakhare (1984)
Jersey	84.85	Das *et al*. (1987)
Jersey x Sahiwal	84.57	Singh *et al*. (1988)
Jersey x Rathi	90.37	Singh *et al*. (1988)
Friesian x Sahiwal	81.36	Singh *et al*. (1988)

and cull them more accurately on the standard basis (Lush, 1945). Gautam *et al*. (loc.cit.) reported producing ability as 2941.40 ± 566.34 kg in Hariana cows. Producing ability and breeding efficiency were significantly superior in cows calving at an age of 36 months or lesser than 39 months. Producing ability had positive correlation with age at first calving (only when age at first calving was below 39 months). Dharmendra Kumar (loc.cit.) reported producing ability of Sahiwal cows in the range of 709 to 3533 kg. Further he stated that producing ability had significant negative correlation with breeding efficiency. Deshpande and Sakhare (loc.cit.) reported average producing ability of Red Kandhari cow as 563.87 kg and that of Red Kandhari x Jersey cross was 1632.54 kg. A summary of some reports on mean values of producing ability is presented in Table 7

Table 7: Mean values for producing ability

Breed	Mean value(kg)	Reference
Hariana	2941.40	Gautam *et al*. (1966)
Sahiwal	2118.00	Dharmendra Kumar (1981)
Red Kandhari	563.87	Deshpande and Sakhare(1984)
Red Kandhari x Jersey	1632.54	Deshpande and Sakhare (1984)

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MATERIALS AND METHODS

3. MATERIALS AND METHODS

The details of the materials used and methods adopted during the present investigation are given below.

The present study entitled "Genetic studies on growth, producing ability and reproduction traits in Jersey cattle" envisages the evaluation of economic traits of pure bred Jersey cattle pertaining to two Exotic Cattle Breeding Farms in Maharashtra.

3.1 The data

The data taken for present studies on production and reproduction along with growth records were obtained from various sources such as the Central Register maintained at the Farm, history sheets, individual cards maintained at the above mentioned farms.

Records on 1039 lactations for 309 cows, birth weight of 252 calves along with the weights taken at different ages (splitted into different age groups like 0-3, 3-6, 6-9, 9-12, 12-15 and 15-18 months) were collected from Exotic Cattle Breeding Farm, Harsul (Aurangabad) and Exotic Cattle Breeding Farm, Tathwade (Pune). The data from Aurangabad extends over a period of 18 years (1971 to 1989) and that from Pune 10 years (1979 to 1989). These 309 cows represent the progeny of 87 sires while 252 calves represent the progeny of 18 sires, located at two farms at one time or the other.

The two locations where the purebred have performed represent two different environments. The intensity of management and feeding of purebred cows and calves varies from farm to farm.

Assuming the yearly variations follow a cyclic pattern repeatable every, fifth year, the entire duration was divided into four periods of five years each.

Period 1	:	1971-1975
Period 2	:	1976-1980
Period 3	:	1981-1985
Period 4	:	1986-1990

Years were further divided into three seasons of four months each.

Season 1	:	Feb-May
Season 2	:	June-Sept.
Season 3	:	Oct-Jan.

Records of cows completing at least two lactations were included in this study. Abnormal observations due to various causes such as incomplete lactations, abortions, calves born dead or premature birth and ill health of the animal have been deleted from the present investigations.

The economic characters studied were-

1 Birth weight

2 Growth rate during 0-3, 3-6, 6-9, 9-12, 12-15 and 15-18 months of age (calves)

3 Age at first calving

4 Gestation period

5 Service period

6 Calving interval

7 Breeding efficiency (Wilcox)

8 Producing ability

3.2 Methodology used

With disproportionate subclass numbers the different kinds of effects such as locations, periods and seasons of calving can not be separated directly with the ordinary method of analysis of variance. Therefore, the least squares method of analysis (Harvey, 1975) was employed. The principle of this technique is to minimise the error of sum of squares. Sum of squared differences between observed and expected values, called the residual sum of squares.

Mathematical Model

$$Y_{ijkl} = \mu + L_i + P_j + S_k + e_{ijkl}$$

Where,

Yijkl is the record of lth cow calved in Kth season and Pth period, belonging Lth location.

μ is the population mean common to all observations.

Li is the effect of ith location (i = 1,2)

Pj is the effect of jth period (j = 1,2,3,4)

Sk is the effect of Kth season (K = 1,2,3)

eijkl is the random error

0 normally distributed as N (0, σ^2_e)

3.2.1 Least squares analysis of data

The procedure adopted was as follows:

Setting up of normal equations

From the mathematical model a system of normal equations were set up. To estimate the 10 unknown constants, 10 normal equations were formed and these were 1 for μ , 2 for locations, 4 for periods and 3 for seasons. These equations were then set up in the form of matrix imposing the restrictions.

The restrictions that sum of constants estimated in a given set equal to zero was used to get reduced matrix. For obtaining the estimates of constants following restrictions were imposed.

$\sum Li = \sum Pj = \sum Sk = 0$

By imposing these restrictions on the estimates of constants, it is possible to compute the Li, Pj and Sk. The restrictions were imposed in following manner, imposing restrictions for main effects.

Since there were two locations, the nij values in the column corresponding to second location were substracted from nij values of all previous columns. In the row-wise reduction, nij values in the second row were substracted from nij values of all previous rows. The similar procedure was adopted while imposing the restrictions periodwise and seasonwise.

On the right hand side of matrix the column vector of totals with respect to each equation were formed. Thus the first element of this column vector was G.T. and L, P, S ...... respectively.

Reduction of RHM (column sector)

The same procedure adopted in columnwise reduction of nij matrix was followed for reducing RHM. The element was left undisturbed and manipulations were made in coefficients of main effects.

Estimation of constants

The reduced nij matrix is symmetrical about its main diagonal and is of the dimension 7x7, made up of

1 row and column for μ, 1 for location, 3 for periods and 2 for seasons. Similarly reduced RHM is a column vector of 7 rows. Constants were obtained as follows from the inverse of reduced matrix and RHMs of the equations.

Reduced nij Matrix	x	constants	=	Reduced RHM
7 x 7		7 x 1	=	7 x 1

Constants = Reduced nij matrix^{-1} x Reduced RHM

The estimates corresponding to the elements that were suppressed while reduction were carried out, were obtained using following relationship-

$$L_2 = -(L_1)$$

$$P_4 = -(P_1 + P_2 + P_3)$$

$$S_3 = -(S_1 + S_2)$$

Least squares analysis of variance

Computing sum of squares (S.S.)

1) Total uncorrected sum of squares

$\sum_i \sum_j \sum_k \sum_l Y^2_{ijklm}$ was obtained for each character by the usual method.

2) Sum of squares for main effects were estimated using the values of constants obtained and the values of variance covariance matrix.

Total treatments R (μ , L_i, Pj, Sk) was obtained by multiplying the corresponding values of constants and the RHM column vector.

$$\text{Error S.S.} = \sum i \sum j \sum k \sum l$$

$$Y^2 ijkl - R \ (\mu, Li, Pj, Sk)$$

Where,

R is RHM element corresponding to the constants Li, Pj and Sk. Sums of squares due to main effects were obtained by using the following expressions.

$$\text{S.S.for the ith set of main effects} = B_i^1 \ Z_i^{-1} Z \ B_i$$

Where,

B_i is the column vector for the constants for ith set of main effects.

B_i^1 is the transpose of B_i i.e. row vector

Z_i^{-1} is the inverse of the segment of the inverse of the variance covariance matrix corresponding by row and column for ith set of constants.

After obtaining the values of total S.S., error S.S. and main effects S.S., analysis of variance table was set up. The pattern of analysis of variance is shown in Table

Pattern of analysis of variance

Location	$i-1$	$B_i^1 \ Z_i^{-1} B_i$	S.S./d.f.	M.S.L./M.S.E.
Periods	$j-1$	$B_p^1 \ Zp^{-1} B_p$	S.S./d.f.	M.S.P./M.S.E.
Seasons	$k-1$	$B_s^1 \ Z_s^{-1} \ B_x$	S.S./d.f.	M.S.S./M.S.E.
Error residual		$\sum_k \ \sum_j \sum_k \sum_l$	S.S./d.f.	$-R$ (1i Pj Sk)
Total	$n...^{-1}$	$\sum_i \sum_j \sum_k \sum_l Y^2_{ijkl}$	S.S./d.f.	

(309-1) Yijkl

The mean squares were obtained by dividing the sum of squares of each effect by corresponding d.f. The ratio of mean squares for each of the effects and that for the error provided the 'F' value for testing the significance of different effects.

Estimation of least squares means and standard errors

Least squares means were obtained from known values of and least squares constants by using the following expressions.

Least squares mean for Li = μ + Li

Least squares mean for Pj = μ + Pj

Least squares mean for Sk = μ + Sk

Standard errors for least squares mean of main effects were obtained by using values of error mean squares σ^2_e and the elements of variance covariance matrix-

$$S.E. = \sqrt{(C \mu \mu)}$$

$$S.E. (\mu + ai) = \sqrt{(C \mu \mu + Cii + C \mu \cdot i) \sigma^2_e}$$

Where,

C $\mu\mu$ is the element of variance covariance matrix corresponding to μ row and column C_{ii} is the element corresponding to ith effect by row and column, C μ is the element is the μ th row and ith column.

Duncan's multiple range test (DMRT)

After completion of analysis of variance, the significant effects were further analysed to make all pair-wise comparisons using the DMRT as modified by Kramer (1957). The test was performed in the following steps (Harvey, 1966).

1) Least squares mean for a particular effect under study were arranged in a descending manner, largest to the left and smallest to the right.

2) $(\bar{Y}a - \bar{Y}b)$ values were estimated where $\bar{Y}_a$ is equal to least squares mean for treatment a, $\bar{Y}_b$ equal to the least squares mean for treatment b.

3) $$\left[(Ya-Yb) \sqrt{\frac{2}{(Caa + Cbb - 2\ Cab)}} \right]$$

was then estimated where Caa, Cbb are diagonal elements of variance covariance matrix corresponding to a and b respectively, while Cab is the element corresponding to ath row and bth column.

4) The value (σ^2_e Zpn^2) was determined, Zpn^2 from the table given for significant standardized ranges. (Table A-7, Steel and Torrie, 1960) and

$$\sigma e = \sqrt{\text{Error M.S.}}$$

P = number of means is the range chosen and

n^2 = number of degrees of freedom for error

5) If the value $\left[(\bar{Y}a - \bar{Y}_b) \sqrt{\frac{2}{Caa + Cbb - 2\,Cab}} \right]$

was found greater than (σ^2_e Zpn^2) the differences between least squares means 'a' and 'b' was considered significant. Estimation of the values is variance covariance matrix corresponding to the absorbed elements that were suppressed.

For all possible comparisons among least squares means, it was necessary to obtain the diagonal element and off-diagonal element of all the effects including those that were suppressed. These values were estimated from the available values of variance covariance matrix in the following manner.

$$C\,L_1L_2 = \sqrt{\left[(C\mu\mu + CL_2L_2 + 2\,(C\mu\,L_2) \right] \sigma e}$$

Where,

$C\mu\mu$ is the value of variance covariance matrix corresponding to μ row and column using the same technique, values of variance covariance matrix corresponding to other suppressed elements were found out.

Correction of data

Records were corrected for the significant effects for each character using the relationship.

C yijkl = Yijkl − C.F.

Where,

C Yijkl = corrected record

Yijkl = uncorrected record

C.F. = correction factor

Heritabilities, repeatabilities and phenotypic correlations of various traits were estimated from the corrected data for significant effects.

The following generalised model was used to estimate the components of genetic variance and covariance.

$$Yij = \mu + Si + eij$$

Where,

Yij = is the jth observation of ith sire

μ = is the overall mean

Si = is the effect due to its sire common to all its daughters and eij is the random error which is NID $(0, \sigma_e^2)$

Heritability

Heritabilities were estimated by paternal half sib correlation method as outlined by Hazel and Terill (1945). The estimated sire component of variance was used as an estimated of one-fourth of additive genetic variance.

Analysis of variance for estimation of heritabilities

Source	d.f.	M.S.S.	Components
Sires	S-1	MSs	$\bar{K}\ \sigma^2_s + \sigma^2_e$
Errors	N.S.	MSe	σ^2_e

$$\sigma^2_s = \frac{MSs - MSe}{\bar{K}}$$

$\bar{K}$ is the average number of progeny for sire and is estimated by the following formula:

$$\bar{K} = \frac{(\Sigma K)^2 - \Sigma K^2}{K\ (n-1)}$$

$$h^2 = \frac{4\ \sigma^2_s}{\sigma^2_s + \sigma^2_e}$$

The standard errors of heritability was estimated by the method described by Dickerson (1960).

$$\text{S.E. of } h^2 = \frac{\sigma \, \sigma_s}{\sigma^2_s + \sigma^2_e}$$

Where,

$$\sigma_s = \sqrt{\frac{2 \quad (MS)s \; + \; (MS) \; w}{K^2 \cdot \; ns. \; nw}}$$

(MS)s and (MS)w are mean squares for sires and error respectively, with the degree of freedom ns and nw. The K is coefficient of sire component.

Repeatability

Analysis of variance for estimation of repeatability

Source	d.f.	MS	Components
Between cows	n-1	MSs	$\bar{K}\sigma^2_s + \sigma^2_e$
Within cows	N-n	MSe	σ^2_e

$$\sigma^2_s = \frac{MS_s - MS_e}{\bar{K}}$$

$$R = \frac{\sigma^2_s}{\sigma^2_s + \sigma^2_e}$$

Standard error of repeatability was calculated by the **method** described by Cockerham (1948).

S.E.of R =

$$\sqrt{\frac{2(1-R)^2}{K^2(n-1)\ (k-1)n}\left(\left[n(K-1)\left\{1+R\ (K-1)\right\}^2 + (n-1)\left\{1-R\ (K-1)\right\}\right]\right.}$$

Where,

R = repeatability

K = number of records per cent

n = number oc **cows**

Phenotypic correlation

The phenotypic correlations were estimated by the method described by Searle (1961).

$$r\ PiPj = \frac{(Cov.\ (T_i\ T_j)}{C\ V\ (T_i)\ \ V\ (T_j)}$$

Where,

Cov. Ti Tj = total component of covariance of ith and jth character

$V T_i VT_j$ = total components of variance of ith and jth characters respectively

r PiPj = phenotypic correlation between ith and jth characters

Breeding efficiency

Frequent reproduction or birth of many off-springs at one time and or during the life time reveals the genetic variability in an individual and thus allow more efficient chances for selection. The emphasis should be given on higher breeding efficiency in order to produce more milk at lesser cost and more off-spring in lesser time of breeding interval. Breeding efficiency is a measure of reproductive performance which is based on calving interval. Breeding efficiency is calculated by following method breeding efficiency (Wilcox).

It is calculated in percentage by the formula proposed by Wilcox *et al*. (1957).

$$BE\ \% = \frac{365\ (n-1)}{D} \times 100$$

Where,

n = total number of parturitions

D = total number of days from first to last parturition

In this formula the first reproductive cycle as well as cycles after fourth parturitions were excluded because of excessive influence of environment and of suspected bias caused by special managerial practices etc., respectively. From this formula, it will be clear that animals with 100 per cent breeding efficiency will be those whose intercalving period is one year.

Producing ability

Lush (1945) has given the formula for adjusting the records of cows with different number of records to the same basis.

$$\text{Milk producing ability} = H.A. + \frac{nr}{1 + (n-1)\,r.} \times (\bar{Y} - HA)$$

HA = herd average

$\bar{Y}$ = cows average

n = number of lactations

r = repeatability of milk yield

...

RESULTS

4. RESULTS

4.1 Birth weight

Least squares analysis of variance was carried out to estimate the influence of different factors on birth weight in purebred Jersey cattle (Table 8). The location and period had highly significant influence on birth weight. However, the season of calving had no effect.

Table 8: Least squares analysis of variance for birth weight (calves)

Source	d.f.	Mean squares
Season	2	10.351
Location	1	246.149**
Period	1	299.579**
Error	248	6.451

The overall least squares mean birth weight was 19.49 ± 0.19 kg (Table 9).

Duncans Multiple Range Test revealed that the birth weight of calves in all three seasons did not differ significantly. Birth weight in two locations differ significantly, it was found to be higher at Aurangabad than at Pune. Birth weight also differed significantly

Table 9: Least squares means and standard errors for the factors affecting birth weight (Jersey calves)

Source	Code	Number of observations	Mean (kg)	S.E.
<u>Location</u>	μ	253	19.490	0.197
Aurangabad	L_1	161	20.1079[b]	0.202
Pune	L_2	92	18.873[b]	0.197
<u>Period</u>				
1981-84	P_3	75	20.352[c]	0.349
1985-89	P_4	178	18.628[e]	0.197
<u>Season</u>				
Feb-May	S_1	92	19.751[a]	0.291
June-Sept.	S_2	89	19.218[a]	0.297
Oct-Jan.	S_3	72	19.502[a]	0.316

Note: Means connected by the same letters are significantly different.

in two periods, it was higher in 3rd period (1981-84) than in 4th period (1985-1989).

Phenotypic correlations for birth weight were positive and significant with growth during 0-3, 3-6, 6-9 and 12-15 months of age. Phenotypic correlations of birth weightwere negative and significant with growth during 9-12 and 15-18 months of age.

The heritability estimate of birth weight was 0.28 $\pm$ 0.19.

4.2 Growth rate

Least squares analysis of variance was carried out to estimate the influence of different factors on growth rate in purebred Jersey cattle (Table 10). The location, period and season had no significant effect on the growth

Table 10: Least squares analysis of variance for growth during 0-3 months

Source	d.f.	Mean squares
Season	2	0.016
Location	1	0.064
Period	1	0.104
Error	247	0.009

A) Growth rate during 0-3 months

Location, season and period had no significant effect on growth (0-3 months of age).

The overall least squares mean growth rate for 0-3 months was 0.349 ± 0.007 (Table 11).

DMRT revealed that the growth rate for 0-3 months of age in all the three seasons did not differ significantly. Growth rate at Aurangabad was significantly lower than at Pune. The growth rate was higher in 3rd period than in 4th. Significantly differing at both the locations. Phenotypic correlations of growth rate for the period were positive with 3-6, 6-9, 9-2, 12-15 and was significantly positively correlated with 15-18 months.

The heritability estimate of growth rate (0-3 months) was 0.17 ± 0.16.

B) Growth rate during 3-6 months

Least squares analysis of variance was carried out to estimate the influence of different factors on growth rate for 3-6 months period in purebred Jersey cattle (Table 12). Location had significant effect while season and period of calving did not significantly influence the growth for the period.

Table 11: Least squares means and standard errors for the factors affecting growth during 0-3 months in Jersey calves

Source	Code	Number of observations	Mean	S.E.
Location	μ	252	0.349	0.007
Aurangabad	L_1	161	0.312^a	0.007
Pune	L_2	91	0.386^b	0.007
Period				
1981-84	P_3	75	0.390^a	0.013
1985-89	P_4	177	0.309^b	0.007
Season				
Feb-May	S_1	91	0.367^a	0.011
June-Sept.	S_2	89	0.345^a	0.011
Oct-Jan.	S_3	72	0.336^a	0.120

Note: Means connected by the same letters are significantly different.

Table 12: Least squares analysis of variance for growth during 3-6 months (ADG 3-6)

Source	d.f.	Mean squares
Season	2	0.023
Location	1	0.438*
Period	1	0.706
Error	247	0.016

* Significant at $P \angle 0.05$

The overall least squares mean growth rate (3-6 months) was 0.304 ± 0.01 kg (Table 13).

DMRT revealed the significant growth rate in 1st and 3rd season, while in other two seasons it was non-significant. The growth rate in season 3rd was higher than at 1st, It was also significantly affected by two locations. Significant differences were observed in locations, it was higher at Aurangabad. Similarly significant effects were also observed in periods. P_3 was more than P_4.

Phenotypic correlation of growth rate during 3-6 months of age with growth rate during 6-9, 12-15 and

Table 13: Least squares means and standard errors for the factors affecting growth rate during 3-6 months in Jersey calves

Source	Code	Number of observations	Mean	S.E.
<u>Seasons</u>	μ	252	0.304	0.010
Feb-May	S_1	91	0.280^{b}	0.014
June-Sept.	S_2	89	0.307^{ab}	0.015
Oct-Jan.	S_3	72	0.325^{a}	0.015
<u>Location</u>				
Aurangabad	L_1	161	0.328^{a}	0.010
Pune	L_2	91	0.280^{b}	0.010
<u>Period</u>				
1981-84	P_3	75	0.351^{a}	0.017
1985-89	P_4	177	0.257^{b}	0.010

Note: Means connected by the same letters are significantly different.

15-18 months of age was positive but negative during 9-12 months. Genetic correlation of ADG 3-6 was negatively correlated with ADG 9-12, 12-15 while positively with 6-9 months.

The heritability estimate of growth rate for the period was 0.29 ± 0.19.

c) Growth rate during 6-9 months

Least squares analysis of variance was carried out to estimate the influence of different factors on growth rate for 6-9 months in purebred Jersey cattle (Table 14). Location and period had significant effect while season of calving did not show significant effect on growth rate.

Table 14: Least squares analysis of variance for growth rate during 6-9 months

Source	d.f.	Mean squares
Season	2	0.021
Location	1	0.457*
Period	1	0.739**
Error	247	0.014

The overall least squares mean growth rate at 3-6 months was 0.324 ± 0.009 kg (Table 15).

Table 15: Least squares means and standard errors for the factors affecting growth rate during 6-9 months in Jersey calves

Source	Code	Number of observations	Mean	S.E.
<u>Season</u>	μ	252	0.324	0.009
Feb-May	S_1	91	0.313[a]	0.013
June-Sept	S_2	89	0.343[a]	0.014
Oct-Jan.	S_3	72	0.317[a]	0.014
<u>Location</u>				
Aurangabad	L_1	160	0.346[a]	0.009
Pune	L_2	92	0.303[b]	0.009
<u>Period</u>				
1981-84	P_3	75	0.373[a]	0.016
1985-89	P_4	177	0.276[b]	0.009

Note: Means connected by the same letters are significantly different.

DMRT revealed that the growth rate at 6-9 months of age in all the three seasons did not differ significantly. The growth rate was significantly different at two locations, it was higher at Aurangabad than at Pune. It also differed in two periods and was higher in period P_3 (1981-84) than period P_4 (1985-89).

Phenotypic correlations of the growth rate for the period with the others 9-12, 12-15 and 15-18 months of age were positive and significant for growth rate at 9-12 months of age. Genetic correlations of this trait with growth rate at 9-12 and 12-15 months of age were negative.

The heritability estimate of growth rate at 6-9 months of age was 0.009 ± 0.11.

D) Growth rate during 9-12 months

Least squares analysis of variance was carried out to estimate the influence of different factors on growth rate for 9 to 12 months of age in purebred Jersey cattle (Table 16). Location (at P ∠ 0.05) had only significant effect while, period and season of calving did not show significant effect.

The overall least square mean growth rate was 0.377 ± 0.01 kg (Table 17).

Table 16: Least squares analysis of variance for growth rate during 9 to 12 months

Source	d.f.	Mean square
Season	2	0.0399
Location	1	0.1214*
Period	1	0.0323
Error	244	0.0165

DMRT revealed significant difference in season (S_1) and season (S_3). Growth rate in season S_1 being higher than (S_3), yet growth rate in season S_1 and S_2, S_2 and S_3 did not differ significantly. DMRT values for location also differ significantly, growth rate was higher at Pune than at Aurangabad. Period also differ significantly. Growth rate was higher in period P_3 than period P_4.

Phenotypic correlations of growth rate at 9-12 months with growth rate at 12-15 and 15-18 was positive and significant at 12-15 months of age. The genetic correlation of growth rate at 9-12 months of age with 12-15 months age were positive.

The heritability estimate of growth rate during 9-12 months of age was 0.17 $\pm$ 0.16.

Table 17: Least square means and standard errors for the factors affecting growth rate during 9-12 months in Jersey calves

Source	Code	Number of observations	Mean	S.E.
	μ	248	0.377	0.010
<u>Season</u>				
Feb-May	S_1	91	0.403[a]	0.014
June-Sept.	S_2	88	0.376[ab]	0.015
Oct-Jan.	S_3	70	0.353[b]	0.016
<u>Location</u>				
Aurangabad	L_1	159	0.338[a]	0.010
Pune	L_2	90	0.417[b]	0.010
<u>Period</u>				
1981-84	P_3	74	0.409[a]	0.017
1985-89	P_4	175	0.345[b]	0.010

Note: Means connected by the same letters are significantly different.

E) Growth rate during 12-15 months

Least squares analysis of variance was carried out to estimate the influence of different factors on growth rate for 12-15 months of age in purebred Jersey cattle (Table 18). Period of calving had only significant effect on growth. The location and season of calving had non-significant effect on this trait.

Table 18: Least squares analysis of variance for growth rate during 12 to 15 months

Source	d.f.	Mean square
Season	2	0.036
Location	1	0.082
Period	1	0.577**
Error	241	0.012

** Significant at $\angle$ 0.01

The overall least squares mean growth rate for the period was 0.298 $\pm$ 0.008 kg (Table 19).

DMRT revealed higher growth rate in S_3 than S_2, S_3 was higher than season S_2 but no significant difference was observed in S_1 and S_2. There was no effect of location but period 3 (P_3) showed significant difference over P_4.

Table 19: Least squares means and standard errors for the factors affecting growth rate during 12-15 months in Jersey calves

Source	Code	Number of observations	Mean	S.E.
Season	μ	245	0.298	0.008
Feb-May	S_1	90	0.302^a	0.012
June-Sept.	S_2	87	0.278^{ab}	0.013
Oct-Jan.	S_3	69	0.316^a	0.014
Location				
Aurangabad	L_1	158	0.292^a	0.009
Pune	L_2	88	0.304^a	0.008
Period				
1981-84	P_3	74	0.354^a	0.015
1985-89	P_4	172	0.243^b	0.008

Note: Means connected by the same letters are significantly different.

There was positive phenotypic correlation between growth rate at this period and growth rate during 12-15 months of age.

F) Growth rate during 15-18 months

Least squares analysis of variance was carried out to estimate, the influence of different factors on growth rate at 15-18 months of age in purebred Jersey cattles (Table 20).

Table 20: Least squares analysis of variance for growth rate during 15-18 months

Source	d.f.	Mean square
Season	2	0.001
Location	1	0.093
Period	1	0.455**
Error	226	0.015

** Significant at ∠ 0.01

The period of calving had significant effect on growth rate, while location and season of calving had non-significant effect.

The overall growth rate was 0.310 ± 0.01 kg (Table 21).

Table 21: Least squares means and standard errors for the factors affecting growth rate during 15-18 months in Jersey calves

Source	Code	Number of observations	Mean	S.E.
	μ	230	0.310	0.010
Season				
Feb-May	S_1	82	0.305[a]	0.015
June-Sept.	S_2	82	0.309[a]	0.014
Oct-Jan.	S_3	67	0.317[a]	0.015
Location				
Aurangabad	L_1	155	0.310[a]	0.009
Pune	L_2	76	0.311[a]	0.010
Period				
1981-84	P_3	73	0.359[a]	0.017
1985-89	P_4	158	0.262[b]	0.010

Note: Means connected by the same letters are significantly different .

DMRT revealed no significant effect of season and locations. The growth rate during period (P_3) was higher than during period (P_4).

The heritability estimate of growth rate was 0.04 ± 0.10. The heritabilities of birth weight and growth rate during 0-3, 3-6, 6-9, 9-12, 12-15 and 15-18 months of age are presented in Table 22.

Table 22: Heritability estimates of different growth rate along with birth weight in Jersey cows

Trait	Heritability
Birth weight	0.28 ± 0.19
ADG 0-3	0.17 ± 0.16
ADG 3-6	0.29 ± 0.19
ADG 6-9	0.009 ± 0.11
ADG 9-12	0.17 ± 0.16
ADG 12-15	0.01 ± 0.11
ADG 15-18	-0.04 ± 0.10

4.3 Age at first calving

Least squares analysis of variance was carried out to estimate the influence of various factors on age at first calving in purebred Jersey cattle (Table 23).

Table 23: Least squares analysis of variance for age at first calving

Source	d.f.	Mean squares
Location	1	393176.031**
Period	3	360415.416**
Season	2	21373.529
Error	1032	21291.748

** Significant at $P < 0.01$

The location and period had highly significant influence on age at first calving. However, the season of calving had no effect.

The overall least squares mean age at first calving was 861.83 $\pm$ 5.62 days (Table 24).

DMRT revealed that the age at first calving did not differ significantly in two locations. Least squares means for different periods revealed that the

Table 24: Least squares means and standard errors for the factors affecting age at first calving in purebred Jersey cattle

Source	Code	Number of observations	Mean	S.E.
	μ	1039	861.835	5.620
Location				
Aurangabad	L_1	571	861.121[a]	6.229
Pune	L_2	468	862.550[a]	8.904
Period				
1971-75	P_1	102	829.618[c]	15.387
1976-80	P_2	181	808.442[b]	11.756
1981-84	P_3	323	900.145[a]	8.161
1985-89	P_4	433	909.135[a]	5.620
Season				
Feb-May	S_1	362	864.341[a]	8.306
June-Sept.	S_2	377	852.359[a]	8.204
Oct-Jan.	S_3	300	868.806[a]	9.171

Note: Means connected by the same letters are significantly different.

age at first calving was higher in 4th and 3rd period than first and was the lowest in second period (P_2). Age at first calving in the three seasons did not differ significantly.

Age at first calving had highly significant and positive phenotypic correlation with calving interval, gestation period and service period. It had highly significant and negative phenotypic correlation with breeding efficiency and producing ability. Age at first calving had highly significant and positive genetic correlation with calving interval, gestation period and service period while highly significant and negative genetic correlation with breeding efficiency and producing ability.

Heritability estimate of age at first calving was 0.58 ± 0.24.

4.4 Gestation period

Least squares analysis of variance was carried out to estimate the influence of different factors on gestation period in purebred Jersey cattle (Table 25). The period had no significant influence on gestation period. The location and season of calving also had a non-significant effect on gestation period.

The overall least squares mean gestation period was 274.99 ± 0.58 days (Table 26).

Table 25: Least squares analysis of variance for gestation period

Source	d.f.	Mean squares
Location	1	619.557
Period	3	284.755
Season	2	380.886
Error	1032	234.314

The overall least squares mean gestation period was 274.99 ± 0.58 days (Table 26).

DMRT revealed non-significant differences between locations. Gestation period of the purebred Jersey during three different seasons did not differ significantly.

Gestation period had significant and positive phenotypic correlation with producing ability, while negative and significant phenotypic correlation with the breeding efficiency, service period had negative phenotypic correlation. Gestation period had negative and significant genetic correlation with breeding efficiency, negative genetic correlation with producing ability and positive genetic correlation with service

Table 26: Least squares means and standard errors for the factors affecting gestation period in purebred Jersey cattle

Source	Code	Number of observations	Mean	S.E.
	μ	1039	274.996	0.589
<u>Location</u>				
Aurangabad	L_1	571	275.452[a]	0.653
Pune	L_2	468	274.541[a]	0.934
<u>Period</u>				
1971-75	P_1	102	275.132[a]	1.614
1976-80	P_2	181	275.702[a]	1.233
1981-85	P_3	323	275.201[a]	0.856
1986-89	P_4	433	273.950[a]	0.589
<u>Season</u>				
Feb-May	S_1	362	275.328[a]	0.871
June-Sept.	S_2	377	273.895[a]	0.860
Oct.-Jan.	S_3	300	275.766[a]	0.962

Note: Means connected by the same letters are significantly different.

period.

Heritability estimate of gestation period was 0.043 ± 0.059.

Repeatability of gestation period was 0.05 ± 0.048.

4.5 Service period

Least squares analysis of variance was carried out to estimate the influence of different factors on service period in purebred Jersey cattle (Table 27). The location and period had significant influence on service period. Season of calving had a non-significant effect on service period.

Table 27: Least squares analysis of variance for service period

Source	d.f.	Mean squares
Location	1	29801.980*
Period	3	25720.156*
Season	2	3385.324
Error	1032	8621.761

The overall least squares mean service period was 142.80 ± 3.57 days (Table 28).

Table 28: Least squares means and standard errors for factors affecting service period in purebred Jersey cattle

Source	Code	Number of observations	Mean	S.E.
	μ	1039	142.803	3.576
Location				
Aurangabad	L_1	571	134.272[a]	3.964
Pune	L_2	468	151.334[b]	5.666
Period				
1971-75	P_1	102	169.215[a]	9.791
1976-80	P_2	181	135.089[b]	7.481
1981-85	P_3	323	132.139[b]	5.193
1986-89	P_4	433	134.777[bc]	3.576
Season				
Feb-May	S_1	362	142.943[a]	5.285
June-Sept.	S_2	377	145.172[a]	5.220
Oct-Jan.	S_3	300	140.295[a]	5.836

Note: Means connected by the same letters are significantly different.

Significant differences in the two locations were recorded after applying the DMRT. It was higher in Pune compared to Aurangabad. Least square means for different periods revealed a high service period in first period followed by second, fourth and the third, which differ significantly with each other. DMRT revealed that service period in three seasons do not differ significantly service period in second season was higher than first and third.

The service period had highly significant negative phenotypic correlation with breeding efficiency. It had highly significant positive phenotypic correlation with producing ability.

Service period had highly significant negative genetic correlation with breeding efficiency. It had positive genetic correlation with producing ability.

Heritability estimate of service period was 0.14 ± 0.073. Repeatability estimate of service period was 0.16 ± 0.048.

4.6 Calving interval

Least squares analysis of variance was carried out to estimate the influence of various factors on calving interval in purebred Jersey cattle (Table 29). Location and season of calving had a non-significant effect on calving interval. The period had significant influence on calving interval.

Table 29: Least squares analysis of variance for calving interval

Source	d.f.	Mean squares
Location	1	21787.095
Period	3	25443.765*
Season	2	1559.818
Error	1032	8550.233

The overall least squares mean calving interval was 417.79 ± 3.56 days (Table 30).

DMRT revealed that the calving interval at two locations differed significantly, it was high at Pune as compared to Aurangabad. Calving interval also differed significantly in different periods. Least squares means for different periods revealed significant differences. It was highest in first period followed by second, fourth and third. DMRT revealed non-significant differences for calving in different seasons.

Calving interval had highly significant and positive phenotypic correlation with gestation period, service

Table 30: Least squares means and standard errors for the factors affecting calving interval in purebred Jersey cattle

Source	Code	Number of observations	Mean	S.E.
	μ	1039	417.796	3.561
<u>Location</u>				
Aurangabad	L_1	571	409.724[a]	3.947
Pune	L_2	468	425.867[b]	5.642
<u>Period</u>				
1971-75	P_1	102	444.393[a]	9.751
1976-80	P_2	181	410.781[b]	7.450
1981-85	P_3	323	407.341[b]	5.172
1986-89	P_4	433	408.719[b]	3.561
<u>Season</u>				
Feb-May	S_1	362	418.271[a]	5.263
June-Sept.	S_2	377	419.068[a]	5.199
Oct-Jan.	S_3	300	416.048[a]	5.811

Note: Means connected by the same letters are significantly different.

period and producing ability. It had highly significant and negative phenotypic correlation with breeding efficiency. Calving interval had highly significant and positive genetic correlation with gestation period, producing ability, significant positive correlation with service period. Calving interval had highly negative genetic correlation with breeding efficiency.

Heritability estimate for calving interval was 0.168 ± 0.075. Repeatability estimate for calving interval was 0.171 ± 0.048.

4.7 Breeding efficiency

Least squares analysis of variance was carried out to estimate the influence of various factors on breeding efficiency in purebred Jersey calves (Table 31).

Table 31: Least squaresanalysis of variance for breeding efficiency

Source	d.f.	Mean squares
Location	1	132.754
Period	3	677.709*
Season	2	279.131
Error	1032	208.740

The location and season had non-significant effect. The period had significant effect.

The overall least squares mean breeding efficiency was 88.20 $\pm$ 0.55 per cent (Table 32).

Least squares mean for two locations revealed that breeding efficiency was higher at Aurangabad than Pune. The two locations didnot differ significantly. DMRT revealed that the breeding efficiency differed significantly in different periods. It was higher in second, third, fourth period and low in the first period. Breeding efficiency in three seasons did not differ significantly.

Phenotypic correlation of breeding efficiency with producing ability was highly significant and negative. Genetic correlation of breeding efficiency with producing ability was highly significant and negative.

4.8 Producing ability

Least squares analysis of variance was carried out to estimate the influence of various factors on producing ability in purebred Jersey cattle (Table 33). Location and season had significant effect while period had highly significant effect on producing ability.

Table 32: Least squares means and standard errors for the factors affecting breeding efficiency in purebred Jersey cattle

Source	Code	Number of observations	Mean	S.E.
	μ	1039	88.205	0.556
<u>Location</u>				
Aurangabad	L_1	571	89.218[a]	0.616
Pune	L_2	468	87.192[a]	0.881
<u>Period</u>				
1971-75	P_1	102	83.991[a]	1.523
1976-80	P_2	181	89.247[b]	1.164
1981-85	P_3	323	89.865[b]	0.808
1986-89	P_4	433	89.717[b]	0.556
<u>Season</u>				
Feb-May	S_1	362	87.295[a]	0.822
June-Sept.	S_2	377	89.203[a]	0.812
Oct-Jan.	S_3	300	88.117[a]	0.908

Note: Means connected by the same letters are significantly different.

Table 33: Least squares analysis of variance for producing ability

Source	d.f.	Mean square
Location	1	224688.953*
Period	3	714764.833**
Season	2	114464.593*
Error	1032	46980.585

** Significant at $P \angle 0.01$
* Significant at $P \angle 0.05$

The overall least squares mean producing ability was 1796.25 ± 8.34 kg (Table 34).

DMRT revealed that the producing ability in two location was differing significantly. It was higher at Pune than at Aurangabad. Least squares means for different period revealed that the producing ability in period 2 and 1 is highest than period (P_3) and lower at period (P_4) season of calving had significant effect on producing ability, producing ability in three seasons differ significantly. It was highest in season (S_3) while medium in season (S_2) and low in season (S_1).

The heritability estimate for producing ability was 0.683 ± 0.243.

Table 34: Least squares means and standard errors for factors affecting producing ability in purebred Jersey cattle

Source	Code	Number of observations	Mean	S.E.
	μ	1039	1796.25	8.34
Location				
Aurangabad	L_1	571	1753.94^{a}	9.25
Pune	L_2	468	1838.56^{b}	13.22
Period				
1971-75	P_1	102	1863.57^{a}	22.85
1976-80	P_2	181	1839.18^{a}	17.46
1981-85	P_3	323	1786.23^{c}	12.12
1986-89	P_4	433	1696.00^{b}	8.34
Season				
Feb-May	S_1	362	1775.69^{a}	12.33
June-Sept.	S_2	377	1793.34^{ab}	12.18
Oct-Jan.	S_3	300	1819.71^{b}	13.62

Note: Means connected by the same letters are significantly different.

Table 35: Phenotypic correlations among birth weight and growth

Trait	Growth rate during months					
	0–3	3–6	6–9	9–12	12–15	15–18
Birth weight	0.033*	0.046**	0.075	-0.005**	0.034**	-0.017**
Growth rate during (months) 0–3		0.073*	0.101	0.025	0.037	0.031
-do- 3–6			0.109	-0.0002**	0.014**	0.005**
-do- 6–9				0.072	0.037*	0.018
-do- 9–12					0.087*	0.041
-do- 12–15						0.002**
-do- 15–18						

* Significant at $p < 0.05$

** Significant at $P < 0.01$

Table 36: Genetic correlations amongst traits of growth rate and birth weight

Trait		Growth rate during months					
		0–3	3–6	6–9	9–12	12–15	15–18
Birth weight		0.565*	0.955**	-0.683	-0.795**	-3.041**	–
Growth rate during (months)	0–3		-1.416*	0.725	-0.175	-0.597	–
-do-	3–6			0.759	-0.387**	-1.935**	–
-do-	6–9				-0.467	-9.823	–
-do-	9–12						
-do-	12–15						

* Significant at P ∠ 0.05

** Significant at P ∠ 0.01

Table 37: Phenotypic correlations among the traits of reproduction

	CI	GP	SP	BE	PA
Age at first calving	0.006**	0.019**	0.003**	-0.0006**	-0.009**
Calving interval		0.025**	0.414	-0.120**	0.015**
Gestation period			-0.048	-0.004**	0.011**
Service period				-0.120**	0.013**
Breeding efficiency					-0.018**
Producing ability					

** Significant at $\angle$ 0.01

Table 38: Genetic correlations among traits of reproduction

	CI	GP	SP	BE	PA
Age at first calving	0.217**	0.672**	0.169**	-0.241**	0.372**
Calving interval		0.180**	0.998	-1.123**	0.147**
Gestation period			0.090	-0.135**	-0.067
Service period				-1.130**	0.132
Breeding efficiency					-0.467**
Producing ability					

** Significant at ∠ 0.01

Table 39: Repeatability estimates of reproductive traits in purebred Jersey cattle

Trait	Repeatability	S.E.
Calving interval	0.171	0.048
Gestation period	0.050	0.048
Service period	0.165	0.048

Table 40: Heritability estimates of reproductive traits in purebred Jersey cattle

Trait	Heritability	S.E.
Age at first calving	0.580	0.240
Calving interval	0.168	0.075
Gestation period	0.043	0.059
Service period	0.145	0.072
Producing ability	0.683	0.243

DISCUSSION

5. DISCUSSION

It is a recognised fact that the genetic potential of an animal with regards to the expression of economic traits is greatly influenced by environmental conditions. This is evident from the low to moderate heritabilities of most of the economic traits. For optimum expression of genetic potential of animals, scientific feeding, breeding, disease control and sanitation are essential. The reproductive status of the purebred cows needs close monitoring. This high level of environmental manipulation helps cows to express their genetic capability to the optimum extent.

5.1 Means

The data were subjected to least squares analysis. The overall means of different traits are discussed below.

The mean birth weight was 19.49 kg. This estimate is higher than similar estimates reported by Phipps (1974), Rajgopalan and Dave (1976), Malik et al.(1976), Narsimha Rao (1983) and Zaman et al. (1989). However, this estimate of birth weight is lower than the similar estimates reported Gopalan Nair et al. (1985) and Raman et al. (1970). However, these estimates are similar to the estimates reported by Capenko (1967), Sadana and Basu (1981) and Ganpule (1984).

The overall growth rates during 0-3, 3-6, 6-9, 9-12, 12-15 and 15-18 months of age were 349, 304, 324, 377, 298 and 310 g respectively. The present estimate is lower than similar estimates reported by Rajgopalan and Dave (1976), Narsimha Rao (1983) and Juneja et al. (1989).

The overall mean age at first calving was 861.83 ± 5.62 days. The present estimate is higher than similar estimates reported by Bala and Nagarcenkar (1978), Arora and Sharma (1983), Bhadouria et al. (1986) and Roy et al. (1987). However, it is lower than the mean age at first calving reported by Mclntyer (1971), Dev and Gill (1976), Sadana and Basu (1981), Polastre et al. (1983), Ganpule (loc.cit.), Mangurkar et al.(1985), Sadana and Tripathi (1986), Zaman et al. (1990) and Das et al. (1990).

The overall mean gestation period was 274.99 ± 0.58 days. This estimate is lower than similar estimates reported by Goswami and Datta (1959) and Das et al. (1984). However, it is higher than similar estimates reported by Das et al. (1990)a and Das et al. (1990)b.

The mean service period was 142.80 ± 3.57 days. This estimate is higher than similar estimates reported by Arora and Sharma (1983), Arora et al. (1983), Duc and Taneja (1984) and Das et al. (loc.cit. 'a' and'b'). However, this estimate is lower than similar estimates reported by Sadana and Basu (1983), Das et al. (1987). Similar estimate was reported by Sadana and Tripathi (1986).

The mean calving interval was 417.79 ± 3.56 days. The present estimate is higher than similar estimates reported by Goswami and Datta (1959), Dominguez and Menendez (1988), Duc and Taneja (loc.cit.), Sadana and Tripathi (loc.cit.). However, it is lower than the mean calving interval reported by Phipps (1974), Dev and Gill (1976), Rao and Nagarcenkar (1979), Arora and Sharma (loc.cit.), Sadana and Basu (loc.cit.), Arora et al.(loc.cit.), Ganpule (loc.cit.), Pandyal et al. (1984), Matoch and Tomer (1986), Mangurkar et al. (loc. cit.) and Juneja et al. (loc. cit.).

The overall least squares mean breeding efficiency was 88.20 ± 0.55 per cent. This estimate is lower than similar estimates reported by Gautam et al. (1966), Deshpande and Sakhare (1984) for Jersey half breds, Singh et al. (1988) in Jersey x Rathi. However, this estimate is higher than similar estimates reported by Dharmendra Kumar (1981) for Sahiwal cows, Deshpande and Sakhare (1984) for Red Kandhari cows, Das et al. (1987); Singh et al. (1988) for Jersey x Sahiwal, Friesian x Sahiwal.

The overall least squares mean producing ability was 1796.25 ± 8.34 kg. This estimate is higher than the similar estimate reported by Deshpande and Sakhare (1984). However, this estimate is lower than similar estimate reported by Gautam et al. (1966). And was in agreement with similar estimate reported by Dharmendra Kumar (1981).

5.2 Effect of location

Effect of location is the reflection of managemental conditions including feeding, handling of animals, health and sanitation and large number of macro and micro elements of climate determining their effect for the location.

Location had highly significant to significant influence on almost all the traits except gestation period, calving interval and breeding efficiency. The difference in feeding, management and climate conditions might have contributed to the variation in different reproductive traits. Though two exotic Cattle Breeding Farms are located in Maharashtra, they differ in geographical situation and climatic fluctuations leading to variation in performance. Similar findings were reported by Pandyal et al. (1984) and Phipps (1973). Roy and Katpatal (1987) reported that the effects due to farm were highly significant on all measures of breeding efficiency.

5.3 Effects of periods

Period shows the impact of total management as well as climatic factors in different years. Period of calving had highly significant influence on birth weight, growth rate during 6-9; 12-15 and 15-18 months of age, age at first calving, service period, calving interval, breeding efficiency and producing ability. Sharma et al. (1986) reported that period had significant effect on birth weight. Arora et al. (1983) reported non-significant effect of period on reproductive and productive traits. Zaman et al. (1990) reported that the period and season of calving had significant ($P < 0.05$, $P < 0.01$) effect on age at first calving.

Das et al. (1990) reported that service period was significantly affected by period of calving. Deshpande and Sakhare (1984) reported period had significant influence on lactation milk yield, producing ability and breeding efficiency. The traits like birth weight, growth during different quarters of age was maximum in third period (P_3) and minimum in fourth period (P_4). Age at first calving was less in period P_1 and P_2 but was more in period P_3 and P_4.

5.4 Effect of season

Season reflects the responses of animals to different attributes of the climate such as ambient temperature, relative humidity, solar radiation,rainfall etc. Apart from these direct influences, climate influences the productivity indirectly through supply of feeds and fodders.

Season of calving had highly significant influence on producing ability. However, it had non-significant influence on birth weight, growth rate, gestation period, service period, calving interval and breeding efficiency. Arora et al. (1983) reported season of calving had non-significant effect on all the reproductive traits under his study. Bhadouria et al. (1986) reported, season of calving had non-significant effect on age at first calving. Zaman et al. (1990) reported season of calving had significant ($P < 0.05$ and $P < 0.01$) effect on age at first calving. Das et al. (1990) reported that gestation period was significantly affected by season of calving.

5.5 Heritabilities

Heritabilities are estimated in the present study by half sib correlation method from the data corrected for significant effects.

The heritability estimates for different traits were: birth weight 0.28 ± 0.19; growth rate during 0-3 months 0.17 ± 0.16; during 3-6 months 0.29 + 0.19; during 6-9 months 0.009 ± 0.110; during 9-12 months 0.17 ± 0.16, during 12-15 months 0.01 ± 0.11 and during 15-18 months 0.04 ± 0.10; age at first calving 0.58 ± 0.24; gestation period 0.043 ± 0.059, service period 0.14 ± 0.07, calving interval 0.168 ± 0.075 and producing ability 0.68 ± 0.24.

Heritabilities for the reproductive traits like gestation period, service period, calving interval were low; heritability of birth weight was moderate; and heritabilities of age at first calving and producing ability were high.

Low heritability of reproductive traits indicate that there is hardly any scope for improving these traits through selective breeding and hence greater emphasis should be placed on management for improvement in reproduction traits to make these animals more economic. Because of the small magnitude of data the error component in the heritability estimates of some of the traits is high. Therefore, some of these estimates are not valid.

5.6 Repeatabilities

Repeatabilities were estimated from the data corrected for significant effects. Repeatability estimates for gestation period service period, calving interval were 0.05 ± 0.04; 0.16 ± 0.04 and 0.17 ± 0.04 respectively. Repeatability estimate for gestation period, service period and calving interval are low. Low heritabilities and low repeatabilities of these reproduction traits suggest there is hardly any scope for improvement of these traits through selection based on the basis of their first records.

5.7 Correlations

Phenotypic and genetic correlations were estimated amongst all the traits under study.

Phenotypic correlations for birth weight were positive and significant with growth rate during 0-3, 3-6, 6-9 and 12-15 months of age. Phenotypic correlation of birth weight were negative and significant with growth rate during 9-12 and 15-18 months of age.

Phenotypic correlation of age at first calving with calving interval, gestation period, service period is positive and highly significant, and it had highly significant negative phenotypic correlation with breeding efficiency and producing ability. This indicates inherent antagonism amongst these traits. Significant correlation between service period and calving interval indicates that minimizing the service period will reduce the length of calving interval.

Age at first calving had highly significant and positive genetic correlation with calving interval, gestation period and service period while highly significant negative genetic correlation with breeding efficiency and producing ability. But Roy et al.(1987) reported that the genetic correlation of age at first calving with first calving interval was negative and high but with first service period were positive and low.

Gestation period had negative and significant genetic correlation with breeding efficiency, negative genetic correlation with producing ability and positive correlation with service period. Service period had positive genetic correlation with producing ability. Calving interval had highly significant and positive genetic correlation with gestation period, producing ability, significant positive correlation with service period; and had highly negative genetic correlation with breeding efficiency.

However, these genetic correlations are not important and no inference can be drawn on the basis of these correlations because the heritabilities of gestation period, service period and calving interval are low in the present study.

On the basis of these results and discussion it may be concluded that purebred Jersey which has the total exotic inheritance can be reared under Indian climatic conditions with suitable management practices to minimise the adverse effects of ambient temperature and other unfavourable environmental conditions. Managemental efforts must be concentrated to promote early age at first calving, good breeding efficiency and producing ability along with optimum calving interval, while selecting bulls for breeding programmes, high priority should be given to proven bulls with high sire indices to ensure good production among the resulting purebreds.

Heritabilities of reproduction traits are low. This indicates that these traits are largely influenced by environmental factors and can be improved by providing suitable management practices.

As far as breeding efficiency is concerned, the estimate is reasonably good. Of course, there is a further scope for improving breeding efficiency closer to 100 per cent, which is the ideal. The improvement can be brought about by more vigorous involvement of the managerial staff on the farms to spot the cows in heat, inseminate them and also resort to intensive follow-up programme with correct technique.

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SUMMARY

6. SUMMARY

Research investigation on reproductive perfofmance of Jersey cows from Exotic Cattle Breeding Farm, Harsul (Dist. Aurangabad) and Tathwade (Dist. Pune) showed the following results.

The data were subjected to least squares analysis, the means of different traits were calculated, phenotypic and genetic correlations were also calculated and heritabilities were estimated by half sib correlation method from the data corrected for significant effects.

Location had highly significant to significant influence on almost all the traits except gestation period, calving interval and breeding efficiency. Period of calving had highly significant influence on birth weight, growth rate during 6-9, 12-15 and 15-18 months of age; age at first calving, service period, calving interval, breeding efficiency and producing ability. Season of calving had highly significant influence on producing ability. However, it had non-significant influence on birth weight, growth rate, gestation period, service period calving interval and breeding efficiency.

Birth weight (19.49 kg) was observed optimum and normal. But growth rates at different age groups had showed the increasing trend up to 0-3 months of age and then it was steady (up to 6-9 months of age) and

thereafter increase in growth rate at decreasing rate was observed.

The least squaresmean for age at first calving (861.83 ± 5.62 days), gestation period (274.99 ± 0.58 days), service period (142.80 ± 3.57 days) and calving interval (417.79 ± 3.56 days) were observed and showed normal expression of the traits.

The least squares mean for breeding efficiency (88.20 ± 0.55 per cent) and producing ability (1796.25 ± 8.34 kg) were also observed true to the breed.

Heritabilities for the reproductive traits like gestation period, service period and calving interval were low; heritability for birth weight was moderate; and heritabilities of age at first calving and producing ability were high.

Repeatability estimate for gestation period, service period and calving interval were low. The repeatability estimates were higher than the heritability estimates for these traits.

Phenotypic correlations for birth weight were positive and significant with growth rate during 0-3, 3-6, 6-9 and 12-15 months of age. Phenotypic correlation of birth weight with growth rate were negative and significant during 9-12 and 15-18 months of age.

Phenotypic correlations of age at first calving with calving interval,gestation period, service period were positive and highly significant, and it had highly significant negative phenotypic correlation with breeding efficiency and producing ability.

Age at first calving had highly significant and positive genetic correlations with calving interval, gestation period and service period while highly significant negative genetic correlations with breeding efficiency and producing ability.

Gestation period had negative and significant genetic correlation with breeding efficiency, negative genetic correlation with producing ability and positive genetic correlation with service period. Service period had significant positive genetic correlation with producing ability. Calving interval had highly significant and positive genetic correlation with gestation period, producing ability, significant positive correlation with service period and had highly negative genetic correlation with breeding efficiency.

On the basis of encouraging performance of exotic purebreds (Jersey) under Indian climatic conditions, it can be concluded that there is need for accelerating the purebreeding programme for Jersey for the enhancement of milk production through production of Jersey bulls of high merit.

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LITERATURE CITED

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