LIFETIME PRODUCTION AND BREEDING EFFICIENCY OF RATHI COWS

राठी गायों की जीवनकालीन उत्पादन एवं प्रजनन क्षमता

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THESIS

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This is to certify that **MR. ARVIND KUMAR PANWAR** has successfully completed the **COMPREHENSIVE EXAMINATION** held on May 29, 1995 as required under the regulations for the degree of **MASTER OF VETERINARY SCIENCE.**

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This is to certify that the thesis entitled **"LIFETIME PRODUCTION AND BREEDING EFFICIENCY OF RATHI COWS"**, submitted by **MR. ARVIND KUMAR PANWAR** to the Rajasthan Agricultural University, Bikaner in partial fulfilment of the requirements for the degree of **MASTER OF VETERINARY SCIENCE** in the subject of **ANIMAL BREEDING AND GENETICS** has been approved by the Student's Advisory Committee after getting the satisfactory report of the external examiner and conducting oral examination of the same.

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ARVIND KUMAR PANWAR

LIST OF CONTENTS

Contd. ...

... Contd.

Contd. ....

... Contd.

LIST OF TABLES

Contd. ...

... Contd.

Contd. ...

... Contd.

LIST OF FIGURES

LIST OF ABBREVIATIONS USED

Abbreviation	Meaning
LTMY	Lifetime milk yield
MYPDLL	Milk yield per day of lactating life
MYPDL	Milk yield per day of productive life upto temination of lactation
MYPDCI	Milk yield per day of productive life upto start of next lactation
BE	Breeding efficiency
SD	Standard deviation
CV	Coefficient of variation
AFC	Age at first calving
CI	Calving interval

INTRODUCTION

1. INTRODUCTION

The economy of India is primarily based on agriculture with a substantial contribution to livestock wealth. Only cattle population contributes nearly 15 per cent of gross national income. Out of the total geographical area hardly 45 per cent is cultivated and of this nearly 50 per cent is in arid or semi-arid region, where rainfall is scanty and sources of irrigation are limited. As most of the area of Rajasthan is arid and semi-arid, hence the people of this area are mainly dependent upon animal husbandry than agriculture. About 80 per cent of work force in India is engaged in agriculture but crop production generates employment for only 90-120 days per year as studied by Pitchai (1990). Milk production provides supplementary employment and income especially for the poorer households. So farmers of this area are mainly dependent upon the milch cattle for there livelihood. Therefore, milk assumes a major role in economy of farmers of this area.

India possess largest number of cattle in this world, comprising one sixth of the total world's cattle population i.e., 191 million (1990) but in milk production India stood third producing 58.6 million tons (Singhal, 1994) and per caput availability was 187 gms by the end of 1993 (Singhal, 1994). Out of the total cattle population of India, Rajasthan possess 115.96 lakhs cattle producing 4586 thousand tons milk (Rajasthan livestock census, 1992). Though the cattle population is much larger but the cows producing only 45 per cent of the total milk yield of the country with an average production of 190 kg per annum. This production is very less as compare to other agriculturally well advance countries.

Since the time immemorial Rathi, Tharparkar and Sahiwal breeds of cattle have been reared for milk production by nomadics. Among the milch breeds of cattle Rathi and Tharparkar have been found suitable for North-Western arid region of Rajasthan. By virtue of its good milk production potential and adaptability in the desert and drought prone area, the Rathi cows has drawn attention of breeder for exploitation of its production potential. The production of Rathi cows has been found comparable with various milch breeds like Gir, Tharparkar, Sahiwal and Red Sindhi (Basu, 1979).

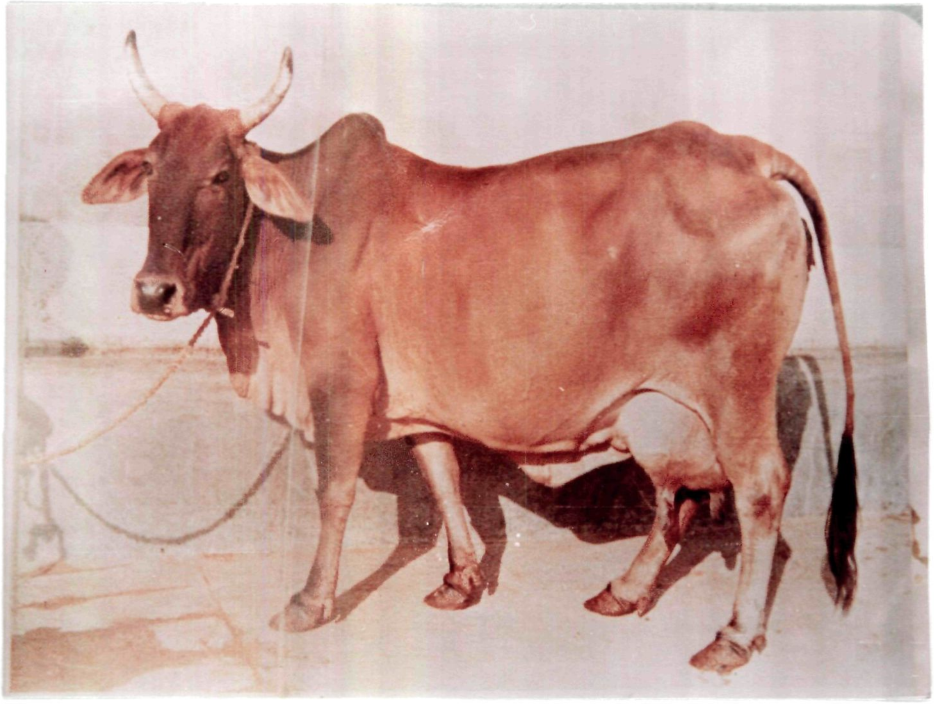
On the basis of average performance studied by various authors (Ohri and Singh, 1970; Gahlot, 1972; Saraswat, 1980; Chaudhry et al., 1983; Saraswat et al., 1983; Tiwari et al., 1983; Gahlot, 1986; LRS, Bikaner Annual Report, 1987-1988; Joshi, 1989; LRS, Bikaner Annual Report, 1992-1993 and Gahlot, 1994) on Rathi cows revealed that the Rathi animals are lighter (male 385.5 kg and female 326.6 kg adult body weight), having total lactation yield (1500-2200 litres), three hundred days lactation yield (1500-1900 litres), peak yield (6.5-10 litres), longer lactation length (11 months), dry period (5 months), milk yield per day of lactation length (5.0-6.75 litres), number of services per conception (1.3-1.8 services), age at first service (1100-1200 days), age at first calving (1450-1550 days), calving interval (450-550 days), service period (150-180 days) and gestation period (275-278 days).

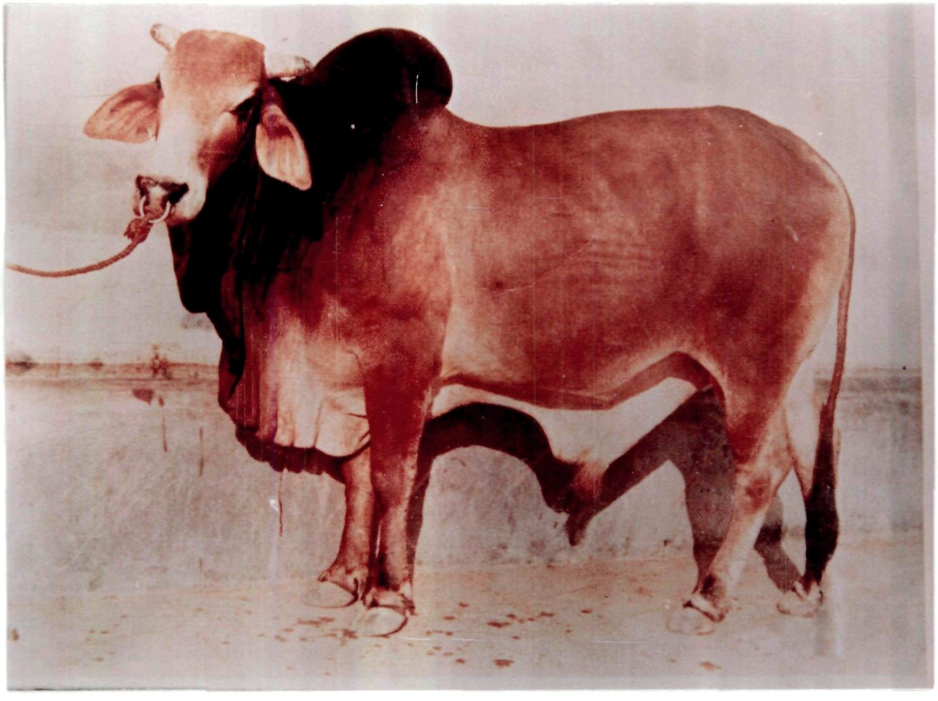
Rathi cattle take their name from a pastoral tribe called Raths, who were Mohammadans of Rajput extraction and lead a nomadic life. These nomads own large herds of cattle and maintain them on free grazing in the arid tract of the vast desert lands of North-Western Rajasthan. Rathi cattles are a mixture of Sahiwal, Red-Sindhi and non-descript cattle, apparently with a preponderance of Sahiwal inheritance (Powlett, 1935 and Ohri and Singh, 1970). They are white or red coloured with a gray markings on heads and are medium sized with broad and flat heads, straight face, large and wide eyes, short and pendulous ears, small horns which emerged laterally and fine skin. The adult Rathi females weighs 326.6 kg gives an expression of milch animal, while males weighs 385.5 kg.

The ultimate goal of an animal breeder is to acquire maximum returns per unit of inputs incurred during lifetime of a cow. But the economics of dairy enterprises is based not only on lifetime milk production but also on efficient reproductive performance of dairy animal. Profitable milk production and faster improvement of dairy cattle can be brought about by high degree of reproductive efficiency. Failure to maintain this high degree of reproductive efficiency is a major economic loss to dairy industry. These losses occurs in terms of decrease lifetime milk production, number of calvings and value of valuable animals. Thus lifetime milk production efficiency and breeding efficiency are the key factors for economic dairying (Kumar, 1979 and Sodakar et al., 1986).

A RATHI PUREBRED COW (Top)

A RATHI PUREBRED BULL (Bottom)





The lifetime milk production efficiency is the returns obtained through milk production during the productive life of an animal and not only in one lactation (Reddy and Nagarcenkar, 1988). It can be measured by lifetime milk yield (LTMY), milk yield per day of lactating life (MYPDLL), milk yield per day of productive life upto termination of lactation (MYPDL) and milk yield per day of productive life upto start of next lactation (MYPDCI).

In overall lifetime productivity, the reproductive efficiency is measured in terms of breeding efficiency (BE) plays the most important role. The breeding efficiency is the number of young ones produced per female per time unit (Sharma, 1978). It can be measured upto various stages of life by number of calvings and sum of calving intervals.

No information on breeding efficiency of Rathi cows could be noticed in the lifetime reviewed and the present investigation is been effort to fill this informative gap. Therefore, the present work has been carried out on lifetime or longevity traits and breeding efficiency upto various stages of life on two different herds of Rathi cattle.

For the practical purpose identification of lifetime production efficiency traits and breeding efficiency, the effect of non genetic factors on these are also necessary. The heredity and environment are the two fundamental factors contributing to the variability in the traits. The environment may some times superimpose itself on the genotype reaching to contribution of environmental advantages as genetic superiority. Hence, study of effect of environmental influences become essential to account for their contribution.

By keeping these points in view the present investigation was proposed under the following specific objectives :

(i) To evaluate the Rathi cattle for lifetime production and breeding efficiency.

(ii) To estimate the non-genetic factors affecting the lifetime production and breeding efficiency of Rathi cows.

(iii) To estimate association among lifetime production efficiency traits and breeding efficiency.

(iv) To device the suitable selection criteria for maximizing the lifetime production efficiency.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

Efficiency of performance is the principle criterion in deciding economic viability of a system which in turns emphasises the maximization of returns incurred during lifetime. The lifetime profits are solely depends on lifetime milk production and breeding efficiency.

The main objective of dairy breeder is maximization of milk production and reproductive performance by providing optimum environment and selection of superior genotypes and ultimately the focus of attention is on the maximization of returns, which means production from efficient utilization of available genetic potential requires the particular breeding and management practices leading to maximization of returns. (Gill and Allaire, 1976; Sadana and Basu, 1982; Balaine et al., 1981; Bourden, 1988). For breeding with such an objective one has to consider efficiency of production and returns obtained. Lifetime production, longevity and returns obtained (profitability) are often loosely regarded as being synonyms (Burnside et al., 1984). The lifetime production is a function of production per lactation, length of productive life, dry period and calving interval etc.

Although longevity indirectly reflects the production potential of an individual but in reality it is the length of productive life and is helpful in determining lifetime returns. In Third International Symposium on Cattle Breeding, Oschika (1986) emphasized on combining longevity with high performance potential in breeding bulls and dams. Later on Goddard (1987) proposed to analyse and draw the conclusion from characters like milk yield per day instead of milk yield per lactation, lactation length, calving interval, longevity and age at first calving on lifetime production efficiency. After one year Bourden (1988) identified two major challenges in cattle breeding for an ultimate bovine nirvana, firstly as identification of optimal genotype for different production environments and secondly, there conservation and multiplication in that specific environment. Further review cited for present investigation has been divided into

a) Lifetime production efficiency and

b) Breeding efficiency.

2.1. LIFETIME PRODUCTION EFFICIENCY

Generally production efficiency of dairy cow could be measured in terms of total lactation milk yield, milk yield per day of herd life, milk yield per day of productive life, milk yield per kg of feed consumed, milk yield per day of body weight, milk yield per unit of input and so on. Milk yield per kg of feed consumed and milk yield per kg of body weight are of importance to physiologists and nutritionists, where as milk yield per unit of time and/or per unit of investment are of prime importance to a breeder.

From a breeders view point except total lactation yield all other traits are composite traits (Sadana and Basu, 1982; Goddard, 1987). The composite traits are also termed as generated traits or ratio traits, which are not a simple linear function of their individual component traits but are the result of a multiplication derivative function and therefore, may not have a simple biological interpretation. These traits are indices of efficiency of production, combining growth, reproduction, longevity and production.

Lactation milk yield, milk yield per day of lactation, total lactation yield in first and subsequent parities, cumulative milk yields, milk yield per day of calving interval, lifetime milk yield, longevity, herd life, milk yield per day of herd life, productive life and lactating life in relation to their averages, variability and association among them have been reviewed under following sub headings

1. Averages and factors affecting lifetime production efficiency.
2. Association among lifetime production efficiency traits.

2.1.1. AVERAGES AND FACTORS AFFECTING LIFETIME PRODUCTION EFFICIENCY

The literature cited reveals consideration of some arbitrary periods as the criterion for lifetime production either in terms of lactations or in terms of production upto certain age, such that they give due consideration to cover greater period of economic production of a cow. Gethin (1950), Larson et al., (1951) and Sundaresan et al.,(1954) considered upto five, seven and ten years of age to predict the lifetime milk production. While production upto six, eight and ten years of age were found reliable criterion for prediction of lifetime production by various workers. (Singh *et al.*, 1964; Puri and Sharma, 1965; Dutt *et al.*, 1965; Bhasin and Desai, 1967; Mathur and Raychaudhary, 1971; Beller, 1971; Gopal and Bhatnagar, 1972; Chandra, 1977; Gupta and Bhatnagar, 1979; Choudhary, 1980).

Gaalaas and Plowman (1963) reported that the cows producing higher milk yield in first lactation had some what longer productive life in Holstein herds. Similar results were obtained by White and Nicholas (1965) in Holstein cows and Murdia and Tripathi (1991) in Jersey cows.

Bhasin and Desai (1967) estimated the production upto six, eight and ten years to be 3532±191.48, 7175.83±377.85 and 8360.98±715.24 lbs, respectively in Hariana cattle and observed that early calvers produced more milk.

Hargrove *et al.* (1969) evaluated a relationship between first lactation and lifetime milk production and reported lifetime production to be 20854 kg in a minimum of 52 months of productive age in Holstein cattle.

Gopal and Bhatnagar (1972) observed the production upto five lactations and six, eight and ten years of age to be 12486±215.9, 5983±136.53, 9998±209.47 and 14432±365.76 kg, respectively in Sahiwal cattle. The corresponding estimates for Tharparkar cattle were reported to be 12144.23±289.48, 5805.46±132.54, 10012.14±238.19 and 14453.15±357.19 kg, respectively (Chandra, 1977).

Ram *et al*. (1976) conducted a study on 165, 146 and 296 Sahiwal purebreds, crossbreds (Brown Swiss x Tharparkar, Brown Swiss x Sahiwal) and Murrah buffaloes, respectively at National Dairy Research Institute, Karnal during 1974 to 1975. They reported herd average to be 9.36, 5.96 and 4.23 litres for crossbreds, purebreds and Murrah buffaloes, respectively. They also reported wet average to be 11.71, 7.65 and 6.43 kg per day in respective genetic groups.

Dhillon and Jain (1977) estimated milk yield per day of lactation in Sahiwal cattle with 0, 25, 50, 62.5 and 75 percent inheritance of Holstein Friesian. The estimates were 4.52±0.36, 5.11±0.36, 6.40±0.36, 6.58±0.36 and 5.98±0.49 kg per day of lactation, respectively. They also observed significant genetic group and periodic difference but no effect of month of calving on milk yield per day of lactation.

Chowdhary and Barhat (1979) studied the effect of crossbreeding and certain environmental factors on lactation yield and yield per day of lactation of Holstein Friesian x Hariana crosses maintained in semi-arid region of Rajasthan. They observed that period, season, parity and various grades had significant effect on both lactation yield and yield per day of lactation.

Studies on lifetime production considering 523 records of Tharparkar cows by Gupta and Bhatnagar (1979) revealed that total milk yield upto six, eight and ten years of age and first five lactations cumulative milk yield were 5805.16±132.54, 10012.14±238.19, 14453.15±357.19 and 12144.23±289.48 kg, respectively.

Similarly corresponding age lifetime production and upto four lactation total milk yield in Rathi and Rathi x Red Dane cattle were reported by Chaudhary (1980) as 1535.10±112.46, 3429.84±213.38, 5421.91±225.53 and 6327.43±275.99 litres, respectively in Rathi cows and 4036.45±188.03, 7292.04±342.92, 9817.70±665.34 and 8592.82±279.96 litres, respectively in cross bred cows. Bhatia (1980) reported lifetime milk yield to be 6404±4617 (SD) kg in Sahiwal cattle.

Honnette et al. (1980) studied the records of 34675 Holstein cows calving between 10th Jan to 10th June 1966 and reported first lactation milk yield as 7130±1469 (SD) kg, lifetime milk production as 17688±13459 (SD) kg and herd life as 1010±668(SD) days.

Reddy and Basu (1980) estimated means for herd life, lifetime milk yield and milk yield per day of life in crossbred cattle of seven military farms in India as 1413±9.43 days, 14168±968.4 kg and 7.24±3.37 kg, respectively.

Reddy et al. (1980) compared production efficiency of crossbreds and indigenous cows in and around Bangalore city and reported that lactation length of native compared with crossbreds was 242 Vs 292 days and calving interval as 420 Vs 370 days giving an average yield per day of calving interval as 2.08 Vs 8.03 kg. They also reported that indigenous cows produced only 30 per cent of the milk than that produced by crossbreds.

Choudoba *et al*. (1981) in Polish Red and White Lowland breeds observed that highest profit could be obtained from the cows calving first time with in 28 months of age, yielding on an average above 4540 kg of milk in first lactation and having a production life of 6 lactations. The most uneconomical animals were those which calved first after 31 months of age producing less than 3340 kg of milk in first lactation and having a production life of 2 lactation.

Norman *et al*. (1981) reported number of lactations (lifetime), total days in milk, days of productive life and lifetime milk yield as 337±1.80 (SD), 942±545 days, 1172±719 days and 13813±9449 kg in Jersey cattle.

Patel *et al*. (1982) evaluated age at disposal and productive life of Kankrej cows and observed that average age at disposal was 7.28±0.18 and 9.10±0.674 years for Anand and Chharodi farms, respectively. Corresponding averages for productive life were 3.45±0.57 and 4.58±0.48 years, in respective farms. These observations suggested a significant effect of management practices and the climate on decision for selection or culling of a cow besides its production potential.

Panda and Sadhu (1982) evaluated lifetime performance of Holstein-Friesian x Hariana, Holstein-Friesian x Desi Bengal, Jersey x Hariana and Jersey x Desi Bengal crossbreds and estimates obtained by them were 13332.79±174.45, 11159.21±94.65, 10848.77±128.79 and 9976.19±119.96 kg, respectively.

In Friesian x Sahiwal crosses milk yield per day of age at second calving was 1.302±0.035 kg as reported by Deshpande and Bonde (1983).Periods and farms significantly affected this character and non-significant effect of season was observed.

Average milk yield per day of calving interval for three Jersey farms at Hissar, Kamand and Palampur was 5.09, 3.10 and 4.03 kg, respectively as reported by Sadana (1984). He also reported a highly significant effect of period of calving on milk yield per day of lactating life and a significant effect of season of calving on this trait. Similar observations on Jersey cattle were made by Kothekar (1981) and Ganpule and Sane (1984).

Reddy and Basu (1985) observed factors affecting profit functions and production traits in Holstein x Sahiwal in 7 farms during 1950 to 1977 and reported that farm had a significant effect on age at first calving, first lactation milk yield, daily milk yield in first lactation, herd life, lifetime milk yield and milk yield per day of lifetime. The period significantly affected all these traits except daily milk yield in first lactation.

Performance traits of F1 Jersey x Kankrej and F1 Holstein x Kankrej crossbreds was studied by Patel et al. (1987) and observed that the average age at first calving was 830.87±12.16 and 891.23±16.56 days, 300 days lactation milk yield was 2659.57±70.24 and 3517.39±100.17 kg,lactation length was 325.52±13.90 and 361.12±8.65 days, dry period was 74.70±4.47 and

78.70±4.80 days, peak yield was 13.81±0.36 and 17.08±0.44 kg and average daily milk yield was 8.39±0.25 and 10.60±0.35 kg, respectively.

Prasad and Manglik (1987) observed the average lifetime milk yield in Sahiwal, Danish-Red, Jersey, Jersey x Sahiwal, Danish Red x Sahiwal, Holstein-Friesian x Sahiwal and Sahiwal cows with 75 per cent Jersey inheritance to be 5932.12, 11317.73, 5867.31, 8287.35, 8612.34, 9952.71 and 6732.51 litres, respectively.

Singh et al. (1987) estimated average cumulative milk yield in first three lactations in various grades (1/8 to 7/8 Friesian inheritance) of Friesian x Zebu cows to be 6928.4±1348.9 kg. They reported that cumulative milk yield in the first three lactations was significantly affected by grade and herd but period of years, season of birth and age at first calving had no significant effect. Cumulative milk yield was highest in the halfbreds (8640.8 kg) and did not differ significantly from cows having higher Friesian inheritance.

Prasad et al. (1987) reported average age at first calving, herd life, first lactation milk yield, herd life milk production and average yield per day of herd life to be 1124.89±18.46 days, 1210.08±21.68 days, 2909.25±72.39 litres, 8377.72±118.55 litres and 6.63±0.13 litres, respectively in crossbred cows.

Deshpande et al. (1988) evaluated on the basis of least-squares analysis of variance for milk yield per day of second calving, that the influence of farm and period was highly significant. Influence of month of calving was observed to be significant where as the effect of grade was not significant in Friesian x Sahiwal crossbreds.

Dhumal *et al*. (1988) reported least-squares means of milk yield per day of calving interval to be 2.35±0.16 and 1.49±0.4 kg, respectively in Red Kandhari cows and 6.29±0.21 and 4.19±0.22 kg in crossbreds.

Khattab and Ashnawy (1988) analysed 1620 lactation records from 1969 to 1979 to study the relationship of the days open and days dry with milk production in Friesian cows in Egypt. They reported that 305-day milk yield averaged 3045±27 kg, lactation milk yield averaged 3423±46 kg and days open 171±4 days. They also reported that milk yield was significantly affected by days open, dry period, season and year of calving and farm.

Markushin (1988) noticed that from the economic stand point it is best to milk most cows for seven to eight lactations, although very high producing cows should be used for longer.

Ponce De Leon and Gomez (1988) analysed data on 1254 Holstein Friesian cows in Cuba and reported that average calving interval was 462±4 days, average age at first calving was 30.5±0.2 months, length of useful life 45.0±0.9 months and age at culling 75.6±0.9 months. They also reported that all traits were significantly affected by herd and year of first calving where as season of first calving significantly affected length of useful life.

Reddy and Nagarcenkar (1988 a) studied the records of five farms of Sahiwal cattle on the basis of production performance and reported that herd life, productive life and milk yield per day of productive life to be 3220 days, 1971 days and 3.47 kg, respectively. They also estimated lifetime milk production considering production upto 3,5 and 7 lactations and the averages obtained were 5244, 8928 and 12921 kg, respectively. It was observed that the period of calving significantly affected the herd life, productive life and lifetime milk yield whereas season of calving had no significant effect on any of the above mentioned traits including milk yield per day of herd life. Reddy and Nagarcenkar (1988 b) also studied the average of milk yield per day of calving interval in first lactation to be 3.92 kg and seven lactations pooled average to be 4.50 kg in Sahiwal cows maintained at five Government farms.

Singh et al. (1988) studied milk production on data from 38 Sahiwal and 108 Jersey x Sahiwal cows and reported that average first lactation yield was 1519.25 and 2631.77 kg, respectively,upto second lactation milk yield average was 3479.74 and 5073.88 kg,respectively, mean milk yield of second calving interval was 3.98 and 6.52 kg, respectively, average herd life yield was 8165.93 and 13266.27 kg, respectively, mean milk yield per day of lifetime was 3.68 and 6.02 kg, respectively and mean herd life (five calving interval) was 2145.89 and 2032.75 days, respectively in Sahiwal and Sahiwal x Jersey cows.

Singh and Tomar (1988) estimated lifetime production and productive life of Karan-Fries cattle developed at National Dairy Research Institute, Karnal as 9538.5±294.5 kg and 3.58±0.11 lactations, respectively.

Ulmek (1988) investigated effect of age at first calving on lifetime milk yield on relatively small number (80) of Red Sindhi cows and estimated average lifetime milk yield to be 5216.04, 6321.16, 5769.52, 6289.12 and 5708.23 litres in cows calving for the first time at < 30, 30-36, 36-42, 42-48 and > 48 months of age, respectively.

Patel and Trivedi (1989) estimated the production profiles of Jersey x Kankrej F1 halfbreds and reported first lactation milk yield and milk yield per day of calving interval to be 2681.1 and 7.01 kg, respectively whereas average of the first four lactation milk yield and milk yield per day of calving interval was 2798.3 and 7.22 kg, respectively.

The data pertaining to 222, 125, 103 records, respectively for first, second and third lactations of Kankrej cows studied by Bhambure and Dave (1989) and reported that the average effect of period of calving, season of calving and age at first calving on 300 days milk yield in each of the first three lactations were non-significant.

Gahlot (1990) evaluated the Tharparkar cattle as a milch breed for arid zone of Rajasthan on the basis of production efficiency traits. He noticed that the average lifetime milk yield from first to upto seven parity ranged from 2010.40±725.52

to 15095.00±2172 kg, milk yield per day of herd life upto termination of lactation from 1.1767±0.3949 to 3.8405±0.5370 kg, milk yield per day of herd life upto start of next lactation from 1.1244±0.3872 to 3.7378±0.5393 kg and milk yield per day of lactating life from 5.6067±1.3748 to 6.9556±0.771 kg, respectively. He also noticed that season and period of calving had no significant effect on efficiency traits at any level of lifetime,however, sire affected significantly most of the efficiency traits upto fourth parity except the lifetime milk yield. This trait shows significant sire effect in second and fourth parity but not in third parity. In subsequent parities the influence of sire was reduced as non-significant.

Gandhi and Gurnani (1990) reported average lifetime milk yield in five herds of Sahiwal cows at the age of five years (2555.67±25.02 kg), eight years (7384.85±117.93 kg) and ten years (10793.84±135.83 kg) and the productive life (1872.98±36.64 days). He also reported that lifetime milk yield was significantly affected by season and period.

Jadhav et al. (1990) analysed data on the first six lactations of 570 cows, calving over a period of 29 years and reported that cows aged 761-820 days at first calving had the highest lifetime milk yield, milk yield per day of productive life and herd life but those aged greater than 1240 days had the lowest yields.

Katoch et al. (1990) investigated the effect of various non-genetic factors on lifetime production traits on records of 756 Jersey cows from three Government farms and one

Institutional farm located in Himachal Pradesh. They reported the least-square mean values for lifetime milk yield, average daily milk yield for lifetime lactation, lifetime lactation period to be 6044.22±66.06 kg, 6.25±0.05 kg and 1067.63±9.86 days, respectively. They also reported that farm had a significant effect on all above mentioned traits but season had a significant effect on average daily lifetime milking and lactation period.

Singh and Tomar (1990) analysed lactation records for 517 Karan-Fries cows sired by 34 bulls and born between 1972 to 1980 and reported that average milk yield per day of lactation was 9.93±0.15 kg and average milk yield per day of herd life was 8.76±0.13 kg and also reported that milk yield per day of lactation did not differ significantly among seasons.

Roy and Tripathi (1990) studied the factors affecting lifetime performance in 2131 Sahiwal and Tharparkar crossbreds having 25 to 75 per cent Holstein inheritance. They reported average herd life, productive life (from first calving to the end of last lactation), total milk yield and number of lactations to be 2725±26 days, 1543±26 days, 12475±237 kg and 3.99±0.07 lactations, respectively. Cows having 37.5 to 50 per cent Holstein inheritance had the highest values for herd life (2970±62 days), productive life (1789±61 days),total milk yield (15909±560 kg) and number of lactations (4.68±0.15 lactations).

Sahota and Gill (1990) analysed the data obtained from 197 Sahiwal and 543 Holstein x Sahiwal cows with percentage of Holstein inheritance ranging from 25 to 75 per cent, observed that the length of herd life was shortest for Sahiwal (3202 days) and longest (3460 days) for 25 per cent Holstein crosses. Among the crossbreds the highest lifetime milk yield was from halfbreds (13660 kg) followed by 5/8 Holstein crosses (13150). Cows with 75 per cent Holstein inheritance produced significantly less milk than halfbreds and 5/8 crossbreds. Further,they found that Sahiwal had the minimum (8646 kg) and halfbreds had maximum (13660 kg) average lifetime milk yield. They also observed a similar trend for average milk yield per day of productive life.

Jadhav et al. (1991) studied lifetime milk yield in 260 Holstein x Sahiwal cows for 8 lactations of cows with 25, 37.5, 50, 62.5, 75 and 87.5 per cent Holstein inheritance and reported that number of days in lactation averaged was 2526±44, 2372±46, 2500±36, 2440±27, 2363±40 and 2309±84, respectively, milk yield was 21403±1014, 22371±1069, 31140±824, 27999±624, 26317±906 and 28501±1948 kg, respectively.

Murdia and Tripathi (1991) analysed lactation and calving records for 1065 Jersey cows for a period from 1971 to 1987 and estimated first lactation milk yield, first lactation length, milk yield per day of first lactation length and milk yield per day of first calving interval in Jersey cattle as 2873.06±13.7 kg, 349.93±3.33 days, 8.28±0.06 kg and 6.55±0.6 kg, respectively. They reported that effect of farm on all the traits under study except lactation length was highly significant. The age at first calving had highly significant effect on first lactation milk yield, milk yield per day of first lactation and per day of calving interval.

Bagherwal and Khan (1991) analysed the data from 193 purebred Jersey cows at Government cattle breeding farm, Bhadhada, Bhopal and reported cumulative milk yield to be 4526.49±81.73, 6940.58±130.12 and 9413.72±159.03 kg for first two, first three and first four lactations respectively,CV being 17.78, 15.34 and 14.92 per cent, respectively. They also reported that cumulative milk yield for first two lactations was significantly affected by age at first calving but not by season of first calving whereas effects on first three and first four lactations cumulative milk yield was not significant.

In Jersey cows Deshpande et al. (1992) reported average milk yield per day of lactation to be 5.92±0.05 kg, milk yield per day of age at second calving 1.41±0.01 kg and milk yield per day of calving interval 4.67±0.05 kg. Cows calving in October to January had significantly higher values for the first two traits than those calved in other season.

Gandhi and Gurnani (1992) evaluated milk yield per day of lactation length, per day of first calving interval, per day of age at first calving, per day of second lactation length, per day of second calving interval, average milk yield per day of first and second lactation length and average milk yield per day of first and second calving interval for Sahiwal cattle as 5.90±0.08, 3.96±0.04, 1.09±0.01, 6.51±0.06, 4.43±0.05, 6.29±0.05 and 4.20±0.04 kg, respectively. They also reported significant effect of farms on all these traits of production efficiency except for milk yield per day of second lactation length and average milk yield per day of first and second lactation. The milk yield per day of first lactation length was the only trait affected significantly by period of calving.

Saini _et al_. (1992) analysed the factor affecting production efficiency traits in Red Sindhi cows and observed that age at first calving, milk yield per day of lactation length, milk yield per day of calving interval and milk yield per day of lifetime period of first lactation were significantly affected by period of calving but milk yield per day of dry period was not affected.

Singh (1992) reported significant effect of parity, period and season on milk yield per day per lactation length and milk yield per day per calving interval in Sahiwal cows maintained on five different herds.

Dhumal _et al_. (1993) reported average milk yield per day of lactation length and milk yield per day of calving interval as 2.17±0.07 kg and 1.34±0.05 kg, respectively in Deoni cows.

Gupta (1993) studied 178 lactation records in Rathi purebreds and 225 lactation records in Red Dane x Rathi crossbreds cows calving during 1977 to 1991 at LRS,Bikaner farm for production efficiency traits. He evaluated that lifetime milk yield upto termination of lactation from first upto fifth parity ranged from 1840.75±541.76 to 9505.68±2367.09 litres, in Rathi cows and 2772.64±890.96 to 13759.59±2464.83 litres in crossbred cows, milk yield per day of productive life upto termination of lactation from 5.08±0.95 to 4.32±0.83 in Rathi cows and 6.11±1.20 to 6.07±0.81 litres in crossbred cows, milk yield per day of productive life upto start of next lactation from 3.48±0.88 to 3.96±0.78 litres in Rathi cows and 5.02±1.41 to 5.54±0.84 litres in crossbred cows and milk yield per day of lactating life from 5.08±0.95 to 6.11±0.75 litres in Rathi cows and 6.11±1.20 to 7.08±0.82 litres in crossbred cows. He also noticed that effect of genetic group was highly significant on all traits except that MYPDLL upto fourth parity on which the effect was less prominent. The effect of period and season of first calving was not significant on any of the production efficiency traits except MYPDCI at second parity.

Rao (1993) estimated productive life as 5.7 and 6.3 years, herd life as 7.9 and 9.4 years and number of lactations as 4.35 and 4.45 lactation, respectively under farm and village condition in Jersey x Desi cross.

Ulmek and Patel (1993) estimated milk yield per day of age at first calving (MY/AFC) as 1.10±0.04 kg, milk yield per day of first calving interval (MY/FCI) as 4.20±0.14 kg, milk yield per day of first lactation length (MY/ FLL) as 5.54±0.12 kg, milk yield per day of first two calving intervals (MY/F2CI) as 4.25±0.13 kg and first two lactation milk yields (F2LMY) as 3988±124 kg, in Gir cattle. They also reported that period of calving had significant effect on MY/AFC, MY/FLL, MY/F2CI and F2LMY but season of calving affects significantly to only F2LMY.

Jairath (1994) studied lifetime performance traits for Canadian Holsteins and reported milk yield upto 2, 3 and 4 lactations, lifetime milk yield to be 9396.28±4818.86 (SD), 12269.8±7705.88 (SD), 13965.4±9986.81 (SD) and 15237.5±12494.4 (SD) kg, respectively whereas productive life was 833.63±620.91 (SD) days. They also reported significant effect of age at first calving on all these lifetime traits.

Lifetime milk yield and productive life for crossbred of Sahiwal, Brown Swiss and Ayrshire cattle were 7992±108 kg and 1045±100 days, respectively as reported by Thorpe et al (1994). Similarly Fuerst and Salkner (1994) observed lifetime milk yield and productive life to 18678±13463 (SD) kg and 1680±1030 (SD) days in crossbreds and purebreds dairy cattle.

2.1.2. Association among lifetime production efficiency traits

Relationship between first lactation and lifetime traits for Holstein cows was investigated by Hargrove et al. (1969) and observed correlation (0.48) between first lactation milk yield and lifetime production on a with in herd-year of first calving basis and correlation (0.43) between first lactation milk yield and productive life. The corresponding genetic correlations were obtained as 0.85 and 0.76, respectively. The genetic correlation between measures of lifetime production namely lifetime milk yield, length of productive life and number of lactations were found to be 0.95 and above.

One thousand four hundred milk production records in first five lactations of 456 Sahiwal cows sired by 68 bulls was investigated by Acharya and Nagpal (1971) and reported that the first lactation production had high genetic and phenotypic corrections with lifetime production (0.94±0.02 and 0.74±0.04 respectively).

Beller (1971) observed in Slovakian Pied cows that total milk production at 72 months of age was highly significantly ($p < 0.01$) correlated (0.534) with milk yield in first lactation and significantly ($p < 0.05$) correlated (0.313) with age at first calving.

Gupta and Bhatnagar (1979) observed phenotypic correlations of age at first calving with lifetime production upto 6, 8 and 10 years of age and yield in first lactation as −0.708±0.048, −0.625±0.054, −0.634±0.119 and 0.623±0.082, respectively for Tharparkar cattle. The corresponding genetic correlation were observed to be −0.937±0.045, −0.498±0.106, 0.532±0.261 and < −1.0, respectively. The phenotypic correlations of first lactation yield with 6, 8 and 10 years of age and yield in five lactation were observed to be 0.633±0.05, 0.657±0.62, 0.499±0.089 and 0.443±0.08, respectively. The corresponding genetic correlations among these traits were 0.9192±0.053, 0.354±0.211, 0.583±0.180 and 0.642±0.166, respectively.

The phenotypic correlation of lifetime milk yield with first lactation milk yield in Sahiwal cattle was observed by Bhatia (1980) as 0.431±0.029. The estimate was statistically significant at 1 per cent level of significance.

Norman *et al.* (1981) reported phenotypic correlation among number of lactations, total days in milk, days of productive life, lifetime actual milk yield and lifetime value of product ranging between 0.95 to 0.99, while working on lifetime performance and profitability of Jersey cows.

Panda and Sadhu (1982) estimated the phenotypic correlations between age at first calving and lifetime milk production in Hariana x Holstein, Holstein x Non-Descript, Jersey x Hariana and Jersey x Non-Descript as 0.3039±0.0196, 0.2305±0.0195, 0.3212±0.092 and 0.4136±0.889, respectively. Further they reported the correlation between first lactation milk yield and lifetime milk production in above crosses as 0.7689±0.0616, 0.5762±0.0769, 0.6532±0.0753 and 0.6924±0.779, respectively.

DeLorenzo and Everett (1982) estimated correlation between milk yield and stayability upto 48 and 72 months as 0.27 and 0.35, respectively, which indicates that milk yield and stayability are positively correlated traits.

Pape *et al.* (1982) established genetic and phenotypic correlations between first lactation performance traits and lifetime performance as 0.62 to 0.89 and 0.27 to 0.56, respectively in Angeler cows. This indicates that it was possible to select for lifetime performance on the basis of first lactation. Similarly, first lactation milk yield was reported to have large phenotypic and genetic correlation with longevity by

El-Barbary (1983) in Egyptian native cows. He also suggested that this trait may be used for improving both first lactation milk yield and longevity.

Likewise Deshpande and Bonde (1983) observed phenotypic and genetic correlation between milk yield per day of age at second calving and total milk yield in Friesian x Sahiwal crosses as 0.819±0.016 and 0.997±0.001, respectively. Phenotypic correlation between milk yield per day of age at second calving with lactation yield, dry period, service period and calving interval were reported as 0.808±0.034, 0.024±0.034 and 0.15±0.034, respectively by Deshpande et al. (1988).

In Red Kandhari cows and its crosses significant correlation of milk yield per day of lactation, per day of calving interval with lactation length, dry period, service period and calving interval was reported by Dhumal et al. (1988).

The phenotypic correlations between milk yield upto 5 years of age and age at first calving, first lactation 305 days milk yield and lactation yield were reported by Gandhi and Gurnani (1988) as -0.649, 0.488 and 0.264, respectively. These estimates were highly significant.

Hayes et al. (1990 a) reported the phenotypic correlation of lifetime milk yield with herd life (0.95) and productive life (0.97) in Holstein cows. Similarly,Hayes et al (1990 b) obtained phenotypic correlation between milk yield per day of herd life and milk yield per day of productive life as 0.70 in Holstein cows. Likewise Hayes et al. (1990 c) observed phenotypic correlation of first lactation milk yield with lifetime milk yield (0.40), herd life (0.31) and productive life (0.24) in Holstein cows.

Gahlot (1990) reported that phenotypic correlations among production efficiency traits were positive, high in magnitude and highly significant for all the production efficiency traits at all the stages of lifetime performance in Tharparkar cows. The estimates of correlation coefficient for LTMY with MYPDL upto termination of lactation, MYPDCI upto start of next lactation and MYPDLL upto termination of lactation were 0.92, 0.93 and 0.79 upto first parity; 0.91, 0.92 and 0.80 upto second parity; 0.90, 0.90 and 0.79 upto third parity; 0.88, 0.88 and 0.75 upto fourth parity; 0.87, 0.87 and 0.76 upto fifth parity; 0.89, 0.89 and 0.77 upto sixth parity and 0.85, 0.84 and 0.76 upto seventh parity, respectively. The phenotypic correlation coefficient of MYPDL with MYPDCI and MYPDLL were 0.99 and 0.76 upto first parity; 0.99 and 0.84 upto second parity; 0.99 and 0.83 upto third, fourth, fifth, sixth parity and 0.91 and 0.77 upto seventh parity, respectively. Similarly, phenotypic correlation coefficient between MYPDCI and MYPDLL upto respective parities were 0.74, 0.83, 0.82, 0.82, 0.82, 0.82 and 0.77.

Dhumal *et al.* (1993) noticed phenotypic correlation of lactation yield with milk yield per day of lactation length and milk yield per day of calving interval in Deoni cattle and reported that these were high in magnitude and significantly and positively correlated.

Gupta (1993) studied phenotypic correlation among lifetime production traits in Rathi and Rathi x Red Dane (R x RD) cattle upto different parities and observed that correlation between production efficiency traits at all the stages of lifetime performance. The estimates of phenotypic correlation coefficient of LTMY with MYPDL, MYPDCI and MYPDLL were 0.61, 0.83 and 0.61 for Rathi cows and 0.63, 0.72 and 0.63 for R x RD upto first parity; 0.75, 0.78 and 0.66 in Rathi cows and 0.71, 0.67 and 0.69 in R x RD cows upto second parity; 0.80, 0.78 and 0.72 in Rathi cows and 0.77, 0.76 and 0.70 in R x RD cows upto third parity; 0.73, 0.74 and 0.57 in Rathi cows and 0.71, 0.71 and 0.63 in R x RD cows upto fourth parity and 0.78, 0.82 and 0.64 in Rathi cows and 0.69, 0.69 and 0.55 in R x RD cows upto fifth parity, respectively. The phenotypic correlation coefficient of MYPDL with MYPDCI and MYPDLL were 0.62 and 1.0 in Rathi cows and 0.81 and 1.0 in R x RD cows upto first parity; 0.92 and 0.73 in Rathi cows and 0.90 and 0.89 in R x RD cows upto second parity; 0.93 and 0.83 in Rathi cows and 0.98 and 0.89 in R x RD cows upto third parity; 0.96 and 0.79 in Rathi cows and 0.98 and 0.86 in R x RD cows upto fourth parity and 0.96 and 0.76 in Rathi cows and 0.97 and 0.70 in R x RD cows upto fifth parity, respectively. Likewise the phenotypic correlation coefficient of MYPDCI with MYPDLL upto respective parities were 0.62, 0.71, 0.80, 0.72 and 0.65 for Rathi cows and 0.81, 0.78, 0.85, 0.81 and 0.59 for R x RD cows.

Ulmek and Patel (1993) obtained phenotypic correlation among milk yield per day of first calving interval,milk yield per day of age at first calving and milk yield per day of first lactation length and reported that estimates of these traits were positive and significant.

Jairath et al. (1994) obtained highly significant and high magnitude phenotypic correlation of lifetime milk yield with yield of two lactations (0.91), yield of three lactations (0.96) and yield of four lactations (0.99) in Canadian Holsteins.

2.2. BREEDING EFFICIENCY

The economy of breeder is not only dependent on milk production but also on the breeding efficiency of an animal. The breeding efficiency of a dairy cow could be measured by number of calvings during lifetime and sum of calving intervals. Hence breeding efficiency of animal is depends on number of calving, calving interval, age at first calving and dry period etc.

Breeding efficiency upto various calving was mainly dependent upon

1. Number of calvings during the life of an animal and
2. Sum of calving intervals during the life.

This indicates efficiency of reproduction of an animal which in turn reflects the production.

Averages of breeding efficiency, their variability and association with the age at first calving, calving interval, dry period, service period, LTMY, MYPDCI, lactation milk yield and yield at different years were reviewed under the following sub headings.

2.2.1. Averages and factors affecting Breeding Efficiency.

2.2.2. Association of Breeding Efficiency with production efficiency traits.

2.2.1. Averages and factors affecting breeding efficiency

Kenneth et al. (1951) using length of service period as criterion for breeding efficiency, measured the interval between first service to conception and the interval from calving to first service in terms of days in Ayrshire breed and reported the breeding efficiency 77 to 89 per cent in 19 families.

Herman et al. (1953) estimated reproductive efficiency in 790 exotic cows (Jersey, Holstein and Guernsey) and determined the calving interval and the percentage of the cows calving in 12 months. They observed these values to be 15.48 months and 77.51 percent, 14.45 months and 83.04 percent, and 14.11 months and 85.05 percent for the respective breeds. Overall reproductive efficiency was reported as 80.86 percent.

In Black Pied cows Detkens and Malik (1954) observed that cows which calved more than five times required on an average less number of service per conception than the heifers and conceived more readily.

In Red Sindhi cows Venkayya and Ananta-Krishnan (1957) observed that the order of lactation had little effect on length of service period. Larger service period benefits milk yield in current lactation but also results in unduly long calving interval, which in turn affect the useful life of a cow in terms of number of lactations. It impairs the reproductive efficiency of cows, while Joher and Taylor (1967) and Bhasin and Desai (1967) reported the average calving interval to be 437±11.7 and 429±15.65 days, respectively in Red Sindhi cows. Singh and Desai (1971) found breeding efficiency to be 92.9 percent.

Gehlon and Malik (1967), Joher and Taylor (1967) and Bhasin and Desai (1967) reported the average intercalving period in Sahiwal cows to be 439.3±0.8, 416.11±5.36 and 478.82±15.87 days, respectively.

Gautam _et al_. (1966) estimated the breeding efficiency in Hariana cows to be maximum 90.81 percent at 36 to 39 months of age at first calving. They also reported that according to age at first calving (less than 39, 39 to 50 and 51 months and above) the highest values of calving were at 39 months.

Bhasin and Desai (1967) reported the average intercalving period in Hariana cows to be 418.58±21.76 days. Singh _et al_. (1968) while studying the reproductive efficiency reported the age of puberty, number of services per conception, first service period and first calving interval to be 46.8±0.35 months, 2.0±0.07, 305.2±6.4 days and 607.0±6.9 days, respectively in Hariana cattle.

Bhasin (1969) observed 68.62 percent average breeding efficiency in Mewati cattle. Gupta (1969) reported 84.10 percent breeding efficiency in Jersey x Red Sindhi cows.

Sharma (1978) estimated the overall breeding efficiency in Hariana cattle to be 78.84 percent with an average age of first calving to be 48.69 months and calving interval 508.81 days. He also classified the breeding efficiency in different class intervals and observed as 50- 64 percent (age at first calving 53.5 months and calving interval 677.25 days), 64-78 percent (AFC 48.7 months and CI 560.65 days), 78-92 percent (AFC 47.7 months and CI 460.20 days) and 92-106 percent (AFC 41.9 months and CI 368.13 days). It indicates that as age at first calving decreases the calving interval also decreases but the breeding efficiency increases.

Daspurakayastha and Mazumder (1979) estimated the average breeding efficiency and calving interval to be 71.48±1.0790 and 34.61±0.34 months, respectively in Holstein x Hariana F1 cows. He also reported that breeding efficiency was maximum for cows that dropped their first calf between 25-28 months of age and there after it was in descending order.

Lahiri et al. (1981) studied breeding efficiency of Hariana herd upto first three lactation and reported that average value of breeding efficiency were 75.78±0.97 per cent and 78.30±0.93 per cent for the second and third consecutive calvings.

Mondal and Choudhury (1987) noticed breeding efficiency of Non-Descript, Hariana, Hariana x Non-Descript and Jersey x Hariana cows upto different parities under the range less than 70, 70-100 and greater than 100 per cent and observed that 21, 69 and 10 per cent cows stood under this range. The Hariana x Non-Descript cows had maximum breeding efficiency at second parity (78-90 %), Hariana x Non-Descript at fourth parity (92-199 %), Jersey x Hariana at fifth parity (85 %). Age at first calving, season and period of calving, parity, first lactation milk yield and first lactation length significantly affect the breeding efficiency in all breed types except for Jersey x Hariana, the breeding efficiency of which was only affected by season and age at first calving.

Gupta and Bhatnagar (1979) reported the average breeding efficiency of Tharparkar cows to be 85.27±0.72.

Patro and Rao (1983) worked on inheritance of age at first calving, calving interval and breeding efficiency in different lactation of Red Sindhi cows and estimated that average age at first calving was 1338.66±15.67, average calving interval were 496.91±10.14, 453.25±9.16 and 456.75±11.43, respectively for first, second and third parity and breeding efficiency were 79.12±1.57 and 80.96±1.41 for second and third parity. Breeding efficiency in Red Sindhi cows observed by Rigor and Nelmida (1959) to be lower than Patro and Rao estimates.

Breeding efficiency of Jersey cows in first four parities were analysed by Ray and Katpatal (1987) and the average estimates were 92.09±0.81, 86.15±1.11, 84.46±1.36 and 87.13±2.19 per cent for the respective parities. The breeding efficiency of four parities were significantly affected by farm and year in first and second parity where as season in third and fourth parity.

The study involved 157 cows from the F1 and F2 (F1 X F1) generation by Dhanger and Patel (1991) for breeding efficiency and he observed the breeding efficiency was similar in two groups. Methekar et al. (1992) analysed 1040 records on Jersey cows for productive and breeding efficiency and noticed that average breeding efficiency of Jersey cows was 88.2±0.55 per cent.

The effect of various factors on breeding efficiency estimates based five calving intervals was studied by Singh et al. (1980) in Sahiwal cows. The average breeding efficiency estimated to be 88.9 per cent and at various calving upto five calvings as 89.3±13.59, 87.4±13.69, 88.7±13.59 and 90.0±13.58, respectively for second, third, fourth and fifth calving. The effect of farms and periods were significant on the breeding efficiency based on five calving intervals. Similarly, Kumar (1981) estimated breeding efficiency (85.67±0.82 %) in Sahiwal cows. He also estimated AFC (40.25±0.81 months) and producing ability (709 to 3533 kg) and concluded that first calving at 37.23 months and producing ability between 1500-2000 kg giving breeding efficiency 88 per cent would be the optimum combination.

Matharu and Gill (1981) evaluated different grades of Holstein-Friesian X Sahiwal crosses (1/4, 1/2, 5/8 and 3/4 inheritance) on the basis of lifetime production and reproduction efficiency and reported that 1/2 and 5/8th Friesian grades were superior than the other grades in all the traits representing production, reproductive efficiency and longevity. Similarly, Deshpande and Ingole (1986) estimated the different grades (1/2, 5/8 and 3/4 Friesian inheritance) of Friesian X Sahiwal cows and reported that breeding efficiency of different grades was 90.35, 80.08 and 83.88 per cent, respectively.

Data from 1964-79 on Friesian X Sahiwal cows at two farms were analysed by Sodakar et al. (1988) and breeding efficiency measured by using three formulae (i) Number of calving intervals from first to last calving (BE was 69.34±2.27 %), (ii) Number of calving intervals, age at first calving, sum of calving intervals and desired calving interval (BE was 78.29±1.34 %) and (iii) Number of calving intervals, age at first calving, desired calving interval and desired age at first calving (BE was 75.13±1.54 %). Season, genetic group and farm did not significantly affect breeding efficiency but it was affected by period of birth.

Reddy et al. (1988) studied 149 Holstein-Friesian X Ongale cows for breeding efficiency, milk yield and age at first calving. He reported that cows with a milk yield of ≤ 2000, 2001-2500, 2501-3000, 3001-3500 or ≥ 3501 kg, breeding efficiency average 89.55, 89.48, 86.29,82.93 and 81.63 per cent, respectively and age at first calving 975.62,994.48, 998.84, 938.88 and 875.90 days. Cows calving first at ≤ 900, 901-1080, 1081-1170 or ≥ 1171 days of age had on an average milk yield of 2528.08,2341.31, 2254.32 and 2190.64 kg, respectively and breeding efficiency averaged 86.83, 85.30, 88.88 and 85.54 per cent.

Reproductive records for 1978-88 of an unspecified number of Malwi Zebu cattle were analysed by Qureshi and Barwe (1990) and observed that average age at first calving was 46.85±0.53 months, average calving interval was 13.88±0.49 months and breeding efficiency was 72.6 per cent (Wilcox formula).

Shelke et al. (1992) analysed Red Kandhari and Jersey X Red Kandhari cows for breeding efficiency and observed that breeding efficiency was 74.8 per cent and 89 per cent for respective breeds.

2.2.2. Association of Breeding efficiency with production efficiency traits

Dutt and Saksena (1966) studied the correlation of breeding efficiency with age at first calving in Hariana cattle and reported it to be non-significant. However, Singh and Desai (1971) observed negative and significant correlation between these traits and similar findings were also obtained by Reddy and Bhatnagar (1971) in Tharparkar herd.

Positive and significant phenotypic correlation (0.666) was observed between breeding efficiency and age at first calving (30-40 months), whereas positive and non-significant

(0.007) between BE and AFC (20-30 months) by Dasparkayastha and Mazumdar (1979) in Holstein X Hariana cows.

In Hariana cows Sharma (1978) studied phenotypic correlation of BE with AFC (-0.069), first dry period (-0.536), first calving interval (-0.666), service period (-0.683) and first lactation milk yield (-0.204) and reported BE had negative and highly significant correlation with first dry period, first calving interval and service period whereas negative and non-significant with AFC and first lactation milk yield.

In Sahiwal cows, factors affecting breeding efficiency were studied by Singh <u>et al</u>. (1980) and they reported that BE was phenotypically negatively correlated with AFC (-0.04), first service period (-0.44), first dry period (-0.36), first calving interval (-0.47), first lactation length (-0.23) and first lactation yield (-0.21) whereas positively correlated with milk yield per day of calving interval (0.05). He found all the association significant except with AFC and milk yield per day of calving interval.

Similarly, Gandhi and Gurnani (1990) observed that BE was negatively correlated phenotypically with AFC (-0.14), first lactation milk yield (-0.33), first lactation length (-0.32) and first calving interval (-0.68).

Negative and significant phenotypic correlation was obtained by Qureshi and Barwe (1990) between BE and AFC (-0.385) and BE and CI (-0.708).

Breeding efficiency was significantly and negatively correlated with AFC (-0.31) and producing ability (-0.45) as reported by Kumar (1981).

Gupta and Bhatnagar (1979) reported phenotypic correlation of BE with AFC, first lactation yield, 6, 8 and 10 years of age and five lactation yield to be -0.080, -0.355, 0.181, 0.245, 0.294 and -0.300, respectively in Tharparkar cows.

Lahiri _et al_. (1981) observed negative correlation of persistency of milk yield with BE of first two calvings (-0.0119) and with BE of first three calvings (-0.0116) in Hariana herd.

Correlation between milk yield and BE was -0.06 observed by Reddy _et al_. (1988) in Friesian X Ongole cows. Similar observations were obtained in Holstein cross cows by Purakayastha (1980). Methekar (1992) also observed negative and highly significant genetic correlation between BE and producing ability.

MATERIAL AND METHODS

3. MATERIAL AND METHODS

3.1. EXPERIMENTAL MATERIAL

For the present investigation, data generated over 20 years (1974 to 1993) on two units of Rathi cattle viz., (i) Livestock Research Station of Department of Animal Breeding and Genetics, College of Veterinary and Animal Science, Bikaner and (ii) Livestock Research Station, Nohar (Hanumangarh), were utilized. Both the units are located in arid region of North-Western Rajasthan under the administrative control of Rajasthan Agricultural University, Bikaner.

The first unit is situated 300 meters away from the Ganganagar-Jaipur Highway in Veterinary College Campus of Bikaner city at 28°3' N latitude, 73°5' E longitude and 234.84 meters altitude from the mean sea level.

The second unit is situated on Ganganagar-Hissar Highway at 29°15.6' N latitude and 74°45.7' E longitude from the mean sea level.

3.1.1. History of breeding stock and breeding policy

3.1.1.1. The foundation stock of 21 Rathi cows was established in 1959 at unit one, which was further strenghtened with addition of more Rathi cows in subsequent years till 1986 from nomadic cattle breeder of Rathi tract.

Initially main objective was to establish Rathi herd of excellent genetic material and therefore, the selective breeding within the native was under taken by acquiring the Rathi cows of high production potential from nomadic breeders. But later on in 1968 cross breeding along with selective inbreeding was also started with the exotic inheritance of Red-Dane bulls. Then from 1978 onwards pure breeding of Rathi cows and its cross breeding with Red-Dane bulls is carried on simultaneously till today.

3.1.1.2. The unit second was formerly known as Cattle Breeding Farm connected with the Department of Animal Husbandry, Government of Rajasthan. But in the year 1983 it was transferred to University with 121 Rathi cows to improve the well known prized Rathi milch breed of cattle on scientific lines.

Since the transfer of the farm to the university, efforts has been made to improve the Rathi cattle germ plasm of the area by distribution of quality germ plasm. To achieve the production of the superior germ plasm, selective breeding has been initiated in a close herd.

3.1.2. Feeding

All the animals of the two units are managed almost under uniform conditions that animals are stall fed except rainy season. At both the units the standard feeding schedule based on age, production level, stage of pregnancy and other physiological conditions were followed.

For all the animals roughages consisted chaffed common dry grasses of this tract mostly consisting of Lasiurus sindicus (sewan), Cenchrus ciliaris, Cenchrus bifilorus, Dicanthum annulatum and chaffed wheat staw.

The seasonal green fodder in the form of Andropogan sorghum (Jawar), Pennesetum typhoid (Bajra), Trifolium alexandrium (Barseam), Medicago sativa (Rijka), Avina sativa (Jai) etc., are fed to the animals of unit second throughout the year due to availability of water of Indira Gandhi Canal in this tract, where as at unit first it is not available except for very short time and in meagre quantity.

The concentrate ration (containing 15% DCP and 70% TDN) was fed to milking animals at the rate of 0.5kg per litre of milk produced over and above maintenance ration.

3.1.3. Housing and management

Housing and management is almost uniform on both the units. Animals are housed under free barn housing system with adequate shades against sun, rain and extreme winter etc. For achieving efficient management and care, herds were divided into different groups according to age and reared in separate barns. The isolation of sick animals was practiced for specialized care and prevention of communicable diseases. The young calves were kept in pucca calf pans.

Cows were milked twice a day and calves were allowed to suckle their dams till cows were dry on both the units. Each calf received approximately 450 litres of milk during the 300 days of lactation period.

3.1.4. Health care

On both the units adequate prevention measures were taken against the prevalent diseases in the area. All animals were regularly vaccinated against black quarter, haemorrhagic septicemia, foot and mouth disease and anthrax during rainy and summer season. The routine programme of deworming and treatment of sick animals was also practiced.

3.2. DATA

The data for present investigation pertained to 628 normal lactation records for a period of 20 years (1974 to 1993) of Rathi cows maintained on two units. Out of which 183 records belongs to unit first i.e., Livestock Research Station, Bikaner while 445 records belongs to unit second i.e., Livestock Research Station, Nohar (Hanumangarh).

The lactations following abortions, premature births, death of calf at birth, short records associated with problems of let down of milk or termination due to disease conditions were excluded from the present study. Paritywise informations were recorded on date of calving, date of drying and lactation yield of each cow.

3.2.1. Lifetime performance traits

Lifetime performance traits are the traits which are obtained through the production of animal during the whole life and not only in one lactation.

From the dates of different events, lactation length (period between date of calving and date of drying), dry period (period between date of drying and date of next calving) and calving interval (period between subsequent calvings) were computed for each parity (upto sixth and higher parities).

Different efficiency traits included in this study were generated as follows:

3.2.1.1. Lifetime milk yield upto termination of ith lactation (LTMYi):

This was calculated by summing of lactation yield of i lactation as

$$LTMYi = \Sigma\ MYi$$

Where,

i = 1,2,3,...,6 and higher parities and

Σ MYi = sum of milk yield of i lactation.

3.2.1.2. Milk yield per day of lactating life upto termination of ith lactation (MYPDLLi) :

This was calculated by dividing the LTMYi by sum of lactation length of i lactations as :

$$MYPDLLi = \frac{LTMYi}{\Sigma LLi}$$

where,

i = 1,2,3,...,6 and higher parities and

ΣLLi = sum of lactation length of i lactations.

3.2.1.3. Milk yield per day of productive life upto termination of ith lactation (MYPDLi) :

This was calculated by dividing the LTMYi by sum of calving intervals of previous calvings and lactation length of ith lactation as :

$$MYPDLi = \frac{LTMYi}{(ECI_{i-1} + LLi)}$$

where,

i = 1,2,3,...,6 and higher parities;

ECIi-1 = sum of calving intervals of previous calvings and

LLi = lactation length of ith lactation.

3.2.1.4. Milk yield per day of productive life upto start of next lactation (MYPDCIi) :

This was calculated by dividing LTMYi by sum of i calving intervals as :

$$MYPDCIi = \frac{LTMYi}{ECIi}$$

where,

i = 1,2,3,...,6 and higher parities and

ECIi = sum of i calving intervals.

3.2.2. Breeding efficiency (BE)

Breeding efficiency is the number of young ones produced per female per time unit.

The breeding efficiency of a cow has been measured by different workers through

(i) service period,

(ii) number of service per conception,

(iii) calving interval and

(iv) age at first calving and calving interval.

In the present study number of calvings and calving interval was taken as a measure of breeding efficiency. The formula used for this was proposed by Wilcox *et al*. (1957) as :

$$BEi = \frac{365\ (Ni-1)}{\Sigma CIi} \times 100$$

where,

$i = 1,2,3,...,6$ and higher calvings;

BEi = breeding efficiency upto ith calving;

Ni = number of calvings upto ith calvings and

ΣCIi = sum of calving intervals upto i calvings.

3.2.3. CLASSIFICATION OF DATA

The data were identified by parity and date of calving. To estimate the effect of non-genetic factors, the data were classified according to herd or unit (i.e., LRS,Bikaner and LRS,Nohar), season of first calving and period of first calving as under :

3.2.3.1. Period of first calving

The total duration of 20 year performance records were sub-divided into four periods. The period first consisted of records of those animals which were calved for first time during 1974 to 1980. The second period included records of animals calving first time between 1981 to 1985. The third period considering the records of animals calved first time between 1986 to 1990. Fourth period included records of animals calved first time during 1991 to 1993.

Period of first calving	years
first	1974 to 1980
second	1981 to 1985
third	1986 to 1990
fourth	1991 to 1993

3.2.3.2. Season of first calving

In order to study the effect of climatic changes viz.,temperature, humidity, rainfall etc., each year was further divided into four seasons on the basis of variation in temperature throughout the year by season of first calving. The specific seasons were as follows :

Season of first calving	month of year
Comfort	1st March to 15th April and
	1st October to 31st October
Hot-Dry	16th April to 15th July
Hot-Humid	16th July to 30th September
Winter	1st November to 29th February

3.2.3.3. Frequency distribution of records

Frequency distribution of observations according to parity and season of first calving upto various parities is given below :

Upto parity	Season	<-------------Period------------>				Total
		P1	P2	P3	P4	
First	S1	17	05	08	08	38
	S2	13	12	15	12	52
	S3	03	07	02	07	19
	S4	04	15	36	08	63
	TOTAL	37	39	61	35	172
Second	S1	14	09	05	02	30
	S2	14	09	11	02	36
	S3	03	08	02	03	16
	S4	03	18	28	05	54
	TOTAL	34	44	46	12	136
Third	S1	07	10	04	-	21
	S2	13	10	07	-	30
	S3	03	06	01	-	10
	S4	04	12	19	-	35
	TOTAL	27	38	31	-	96
Fourth	S1	08	06	-	-	14
	S2	12	06	05	-	23
	S3	03	04	01	-	08
	S4	04	14	15	-	33
	TOTAL	27	30	21	-	78
Fifth	S1	07	07	-	-	13
	S2	10	04	01	-	15
	S3	02	01	-	-	03
	S4	03	10	09	-	22
	TOTAL	22	22	10	-	54

Upto parity	Season	<------------Period-----------> P1	P2	P3	P4	Total
Sixth	S1	03	10	-	-	13
	S2	28	07	-	-	35
	S3	09	01	-	-	10
	S4	12	17	05	-	34
	TOTAL	52	35	05	-	92

3.3. STATISTICAL METHODS

To study the effect of non genetic factor, it is not possible to use the conventional method of analysis of data for test of significance of various factors in animal breeding because of some non-orthogonality of data due to unequal sub class frequencies. Therefore, it is logical to chose a simultaneous consideration of all the effects with a linear mathematical model and fitting the constants for their effects, so the procedure least-squares was employed. The least-squares analysis was carried out by using LSMLMW PC-2 Version package designed by Harvey (1990). The mathematical model used for statistical analysis is given below :

3.3.1. MATHEMATICAL MODEL

$$Y_{ijkl} = \mu + H_i + S_j + P_k + e_{ijkl}$$

where,

Y_{ijkl} is the observation on lth animal of ith farm calved in jth season and kth period;

μ is the over all mean assuming equal subclass number;

H_i is the fixed effect of ith farm (i = 1,2);

S_j is the fixed effect of jth season (i = 1,2,3,4);

P_k is the fixed effect of kth period (i = 1,2,3,4) and

e_{ijkl} is the residual random error under the standard assumption which make the analysis valid, i.e., NID (O,σ2).

The analysis of variance under this model will be as follows :

Source	d.f.	S.S.	EMS
Herd (H)	H-1	R(μ,H,S,P)-R(μ,S,P)	σe^2 + $k3k^2H$
Season (S)	S-1	R(μ,H,S,P)-R(μ,H,P)	σe^2 + $k2k^2S$
Period (P)	P-1	R(μ,H,S,P)-R(μ,H,S)	σe^2 + $k1k^2P$
Residuals	N-H-S-P+2	Y'Y-R(μ,H,S,P)	σe^2

The sub class mean comparisons for significant main effects were made using Duncan's multiple range test.

3.3.2. ESTIMATION OF ASSOCIATION AMONG LIFETIME PRODUCTION EFFICIENCY TRAITS AND BREEDING EFFICIENCY

The phenotypic correlation among lifetime production efficiency traits and breeding efficiency will be estimated by using variances and covariances of respective traits.

RESULTS AND DISCUSSION

4. RESULTS AND DISCUSSION

The ultimate goal of a breeder is to acquire maximum returns by per unit of inputs, which inturn not only depends on production efficiency of an animal but also on reproductive efficiency. Thus the present investigation was intended to estimate the production and breeding efficiency of Rathi cows maintained at two different farms.

The results from the present investigation have been presented in table 1 to 23 and discussed objective wise after giving general overview of Rathi studied in terms of averages, standard deviations and coefficients of variation of different traits, for the pooled as well as separately for each farm. To present and discuss the outcomes simultaneously and systematically this section has been divided into following sub headings -

4.1 General overview of the performance of the farms.

4.2 Effect of non-genetic factors.

4.3 Association among different efficiency traits.

4.4 Suggested selection criteria for improvement in the farm.

Under each of the sub-heading performance of overall group (pooled over two farms of Rathi cattle), Rathi cattle of Bikaner farm and Rathi cattle of Nohar (Hanumangarh) farm have been discussed sequentially.

4.1. GENERAL OVERVIEW OF THE PERFORMANCE OF THE FARM

Means with respective standard deviations and coefficients of variation of different traits for 172 lifetime performance records upto first parity, 136 records upto second parity, 96 records upto third parity, 78 records upto fourth parity, 54 records upto fifth parity and 92 records upto sixth and higher parities are illustrated in tables 1 to 5. Increase in number upto sixth parity is because, that in higher parities the number of records were very less, hence these higher parities were considered in parity sixth.

4.1.1. Averages and variation in production efficiency traits :

The estimates of means, SD and CV for various traits viz., LTMY, MYPDLL, MYPDL and MYPDCI upto different parities for overall, Bikaner farm and Nohar farm are given in table 1 to 4. Graphically, Bikaner farm and Nohar farm means of these traits have been illustrated in figure 1 and figure 2, respectively, whereas coefficients of variation of corresponding farm with respect to these traits have been shown in figure 3 and 4, respectively.

4.1.1.1. Lifetime milk yield (LTMYi) :

Table 1 showed that the average lifetime milk yield (LTMYi) for overall group was 1866.95 litres in 313.26 days upto first parity, 3469.86 litres in 545.38 days upto second parity, 5154.13 litres in 785.10 days upto third parity, 6826.82 litres in 995.61 days upto fourth parity, 8652.13 litres in

Table 1 : Mean, S.D. and C.V. (%) for lifetime milk yield and lactation length upto termination of ith lactation (LTMYi) and lactation length (LLi)

Upto Parity	Parameters	LRS, Bikaner		LRS, Nohar		Over all	
		LTMY	LL	LTMY	LL	LTMY	LL
First	N	55	55	117	117	172	172
	Mean	1622.16	325.73	1982.03	308.86	1866.95	313.26
	S.D.	514.97	69.42	441.65	62.00	494.37	68.71
	C.V.	31.74	21.31	22.28	20.07	26.48	21.93
Second	N	43	43	93	93	136	136
	Mean	3204.51	561.23	3592.54	539.10	3469.86	545.38
	S.D.	1082.36	178.47	1027.49	136.99	1056.76	151.87
	C.V.	35.77	31.80	28.60	25.41	30.45	27.75
Third	N	30	30	66	66	96	96
	Mean	4827.43	829.42	5252.63	768.49	5119.13	785.10
	S.D.	1291.61	247.11	1447.85	180.20	1411.59	203.62
	C.V.	26.75	29.79	27.56	23.44	27.32	25.93
Fourth	N	19	19	59	59	78	78
	Mean	6510.57	1054.82	6928.66	977.16	6826.82	995.61
	S.D.	1944.13	288.05	1673.49	225.75	1739.46	249.54
	C.V.	26.21	27.30	24.15	23.10	25.47	25.06
Fifth	N	15	15	39	39	54	54
	Mean	8203.93	1313.04	8824.51	1220.82	8652.13	1243.83
	S.D.	2020.90	348.01	1844.66	261.01	1896.64	298.25
	C.V.	26.63	24.21	20.90	21.37	21.92	23.97
Sixth	N	21	21	71	71	92	92
and	Mean	9504.71	1511.17	12652.81	1742.85	11934.22	1695.61
higher	S.D.	2347.00	399.56	3890.55	448.03	3823.48	461.91
	C.V.	24.69	26.40	30.74	25.70	32.03	27.23

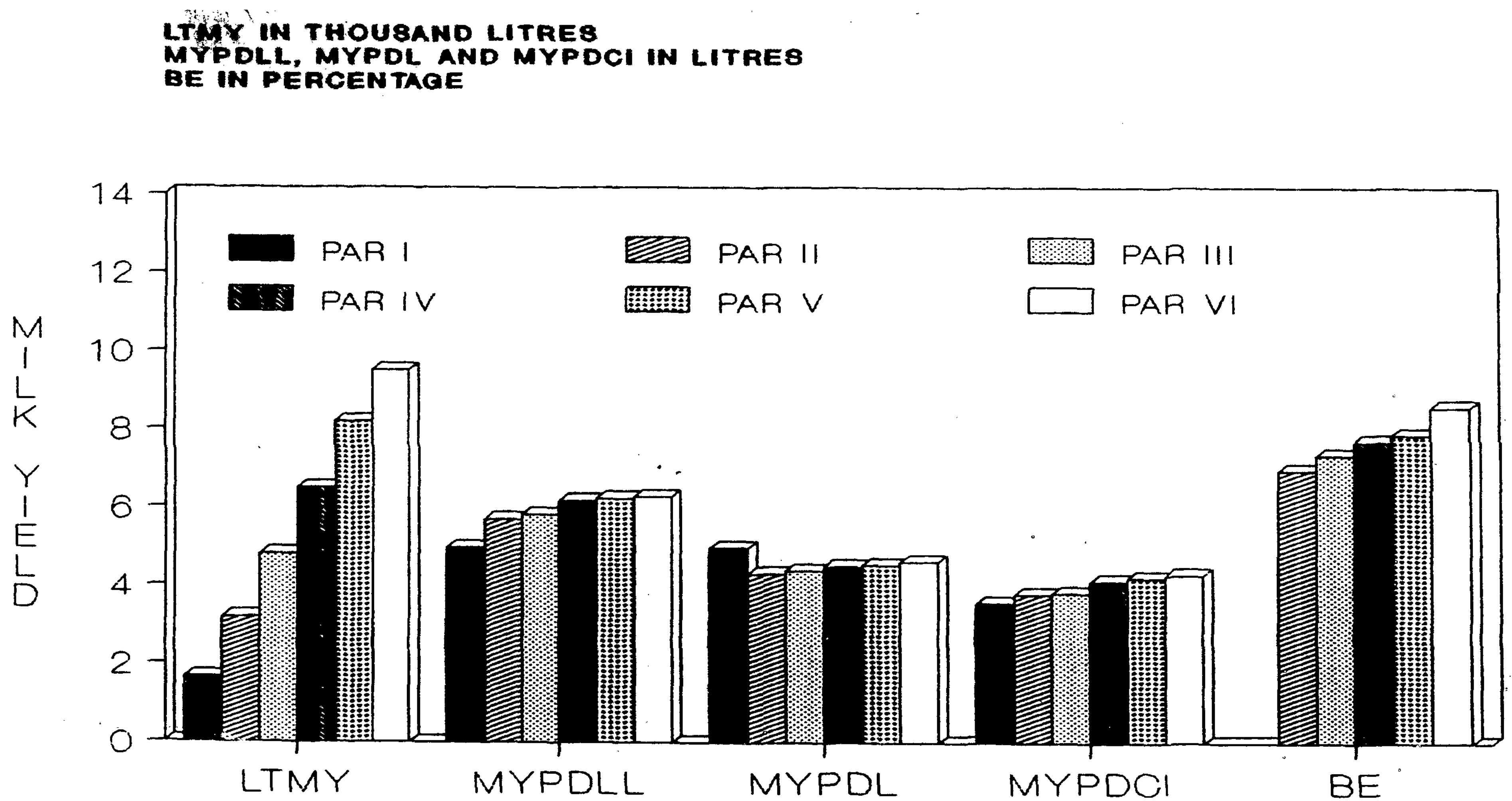


FIGURE 1 : AVERAGES FOR PRODUCTION AND BREEDING EFFICIENCY TRAITS OF BIKANER FARM

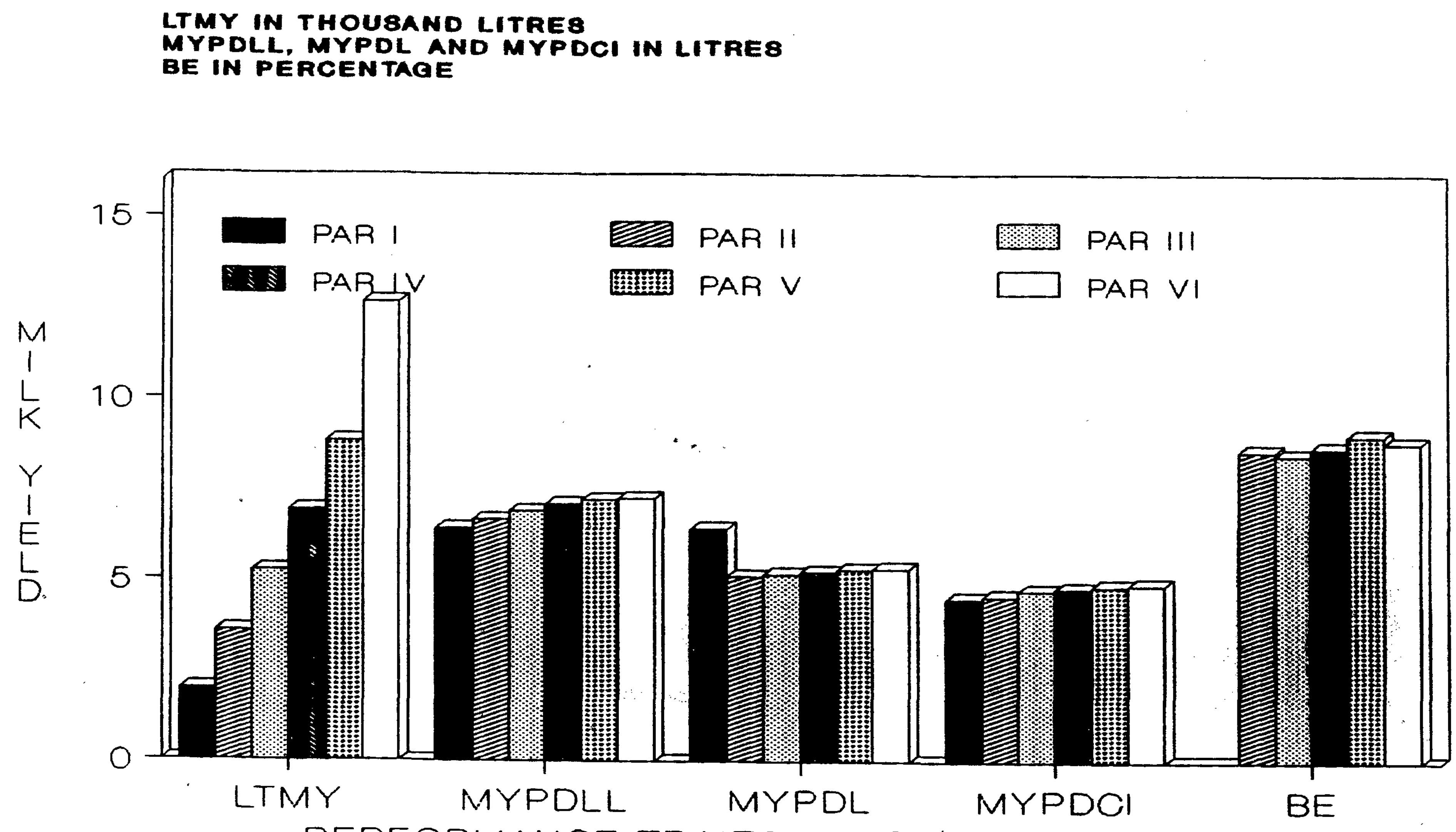


FIGURE 2 : AVERAGES FOR PRODUCTION AND BREEDING EFFICIENCY OF NOHAR FARM

1243.83 days upto fifth parity and 11934.22 litres in 1695.61 days upto sixth and higher parities. The lifetime milk yield for Bikaner farm was 1622.16 litres in 325.73 days upto first parity, 3204.51 litres in 561.23 days upto second parity, 4827.43 litres in 829.42 days upto third parity, 6510.57 litres in 1054.82 days upto fourth parity, 8203.93 litres in 1313.04 days upto fifth parity and 9504.71 litres in 1511.17 days upto sixth and higher parities, whereas for Nohar farm these averages were 1982.03 litres in 308.86 days upto first parity, 3592.54 litres in 539.10 days upto second parity, 5302.63 litres in 768.49 days upto third parity, 6928.66 litres in 977.16 days upto fourth parity, 8824.51 litres in 1220.82 days upto fifth parity and 12652.81 litres in 1742.85 days upto sixth and higher parities.

The increase in LTMY upto various parities for Bikaner farm and Nohar farm had shown in figure 1 and figure 2, respectively. This increase was 1582.35 litres (232.12 days) due to second parity, 1622.92 litres (239.72 days) due to third parity, 1683.14 litres (210.59 days) due to fourth parity, 1693.36 litres (258.22 days) due to fifth parity and 1300.78 litres (451.78 days) due to sixth and higher parities for overall group. For Bikaner farm, there was an average addition of 1582.35 litres (225.50 days) due to second parity, 1622.92 litres (268.19 days) due to third parity, 1683.14 litres (225.40 days) due to fourth parity, 1693.36 litres (259.21 days) due to fifth parity and 1300.78 litres (198.13 days) due to sixth and higher parities in LTMY whereas for Nohar farm the increase in LTMY was 1610.51 litres (230.24 days) due to second parity, 1660.51 litres (229.39

days) due to third parity, 1676.03 litres (208.67 days) due to fourth parity, 1895.85 litres (243.66 days) due to fifth parity and 3828.30 litres (522.03 days) due to sixth and higher parities.

The increase in milk yield was regular upto fifth parity in Rathi cows except at second parity where it was decreased, which might be due to decreased lactation length as compare to the Lactation length of first parity. This occurred in both the farms as well as in overall group.

Gupta (1993) observed lifetime milk yield of Rathi cattle upto five parities to be 1840.75, 3804.16, 5827.72 and 9505.68 litres upto respective parities and increase in LTMY was 1963.41 litres due to second parity, 2023.36 litres due to third parity, 2029.50 litres due to fourth parity and 1648.46 litres due to fifth parity which were slightly higher than the estimates obtained for respective parities under present study.

Chaudhary (1980) reported lifetime production upto four lactation in Rathi cows to be 6327.43±275.99 litres. This estimate was slightly lower then the estimates observed in the present study.

In Sahiwal cows lifetime production upto 3, 5 and 7 lactations were 5244, 8923 and 12971 litres, respectively as reported by Reddy and Nagarcenkar (1988 a) which are lower than the Rathi cattle.

Gahlot (1990) estimated the lifetime milk yield of Tharparkar cattle as 2010.40, 3936.80, 6266.47, 8630.21, 10955.00, 13129.56 and 15097.67 litres upto first, second, third, fourth, fifth, sixth and seventh parities, respectively and estimates were marginally higher than the corresponding estimates of present study.

On comparing the lifetime production of Rathi cattle with the literature of other milch cattle like Tharparkar, Sahiwal etc. of this tract it can be concluded that milk production of Rathi cows are comparable with other breed of milch cattle.

Table 1 further revealed that the standard deviation of lifetime milk yield increased gradually from 494.37 litres upto first parity to 3823.48 litres upto sixth and higher parities in overall group. Increase in SD for Bikaner farm was from 514.97 litres upto first parity to 2347.00 litres upto sixth and higher parities, whereas for Nohar farm it was 441.65 litres upto first parity to 3890.55 litres upto sixth and higher parities. The increase in SD for all the groups for sixth and higher parities might be due to increase number of observations, as higher parities were also considered in sixth parity due to less number of observation available in higher parities. The increasing trend in SD at higher stage of lifetime performance might be a reflection of increase in mean value.

The trend of variatiqn in LTMY expressed in terms of coefficient of variation shown in figure 3 and 4 for Bikaner

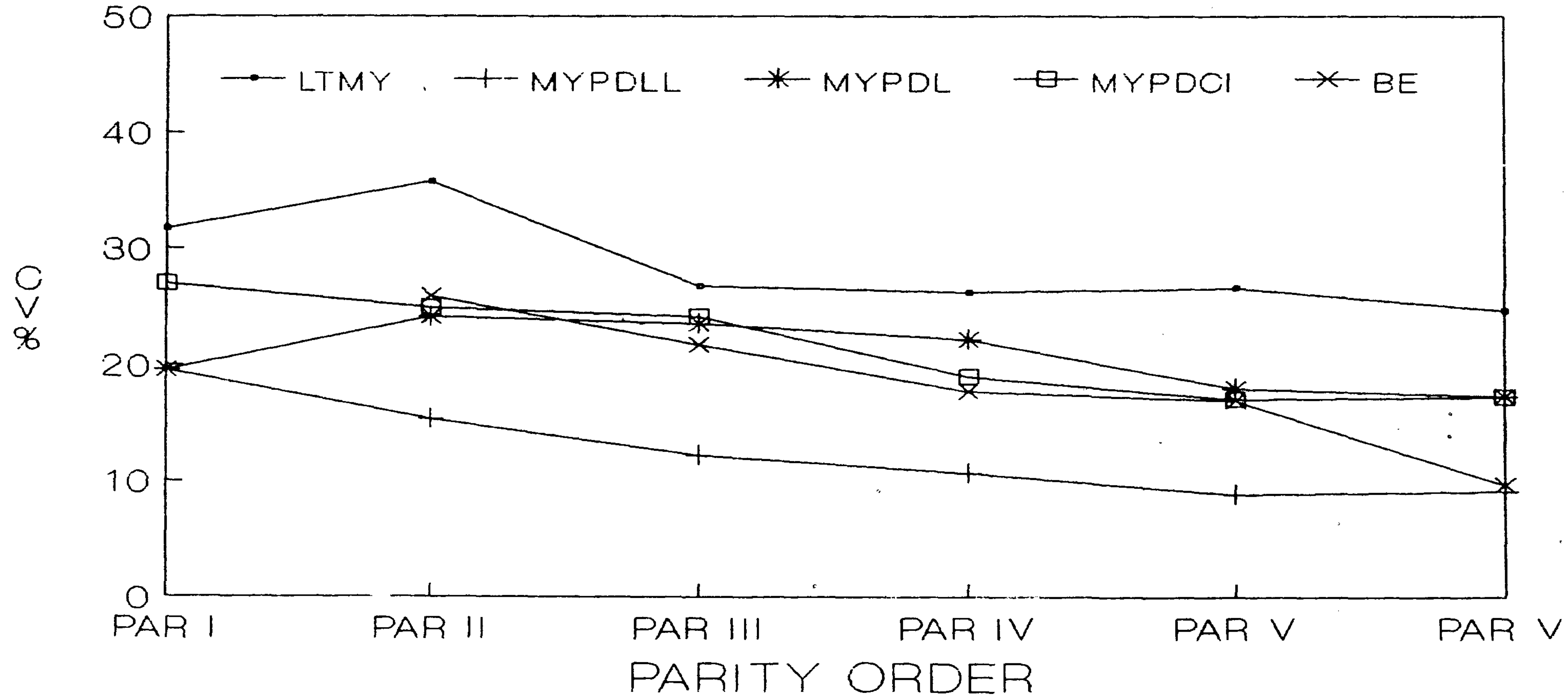


FIGURE 3 : COEFFICIENTS OF VARIATION FOR PRODUCTION AND BREEDING EFFICIENCY TRAITS OF BIKANER FARM

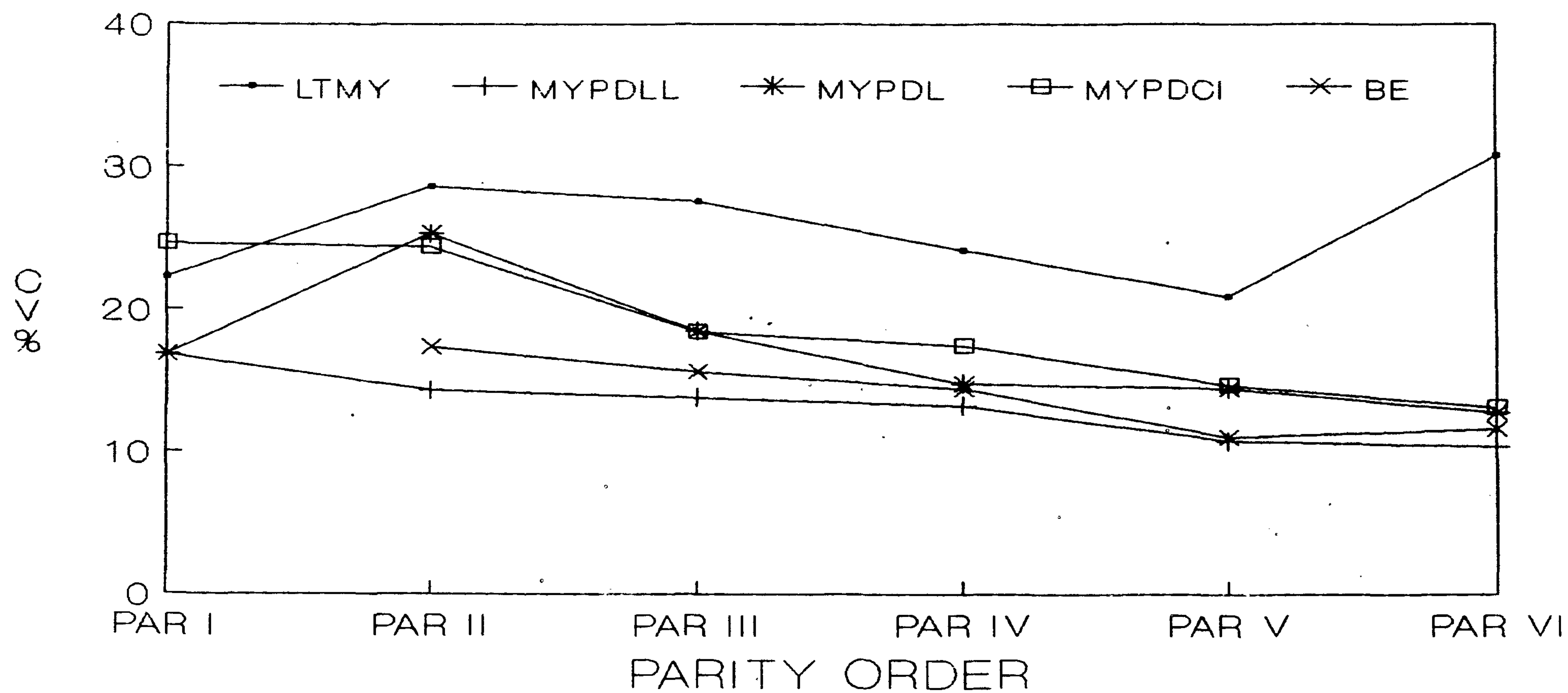


FIGURE 4 : COEFFICIENTS OF VARIATION FOR PRODUCTION AND BREEDING EFFICIENCY TRAITS OF NOHAR FARM

farm and 2, respectively. The coefficient of variation regularly decreased from 26.48 per cent upto first parity to 21.92 per cent upto fifth parity except at upto second parity (30.45 %) and at upto sixth and higher parities (30.03 %) in overall group of Rathi cows. Similar trend in CV was observed in individual farm separately. The decrease in CV ranged from 31.74 per cent upto first parity to 24.69 upto sixth and higher parities, where as values for CV upto second parity was 35.77 per cent for Bikaner farm and the values of CV for Nohar farm were decreasing from 22.28 per cent upto first parity to 20.90 per cent upto fifth parity but for upto second parity and upto sixth and higher parities these estimates were 28.60 per cent and 30.74 per cent, respectively.

The increase in CV upto second parity might be due to marginal higher increase in SD and shorter lactation length, and at upto sixth and higher parities was because of consideration of higher parities in sixth parity, variation in cumulative yield occurred. But in fact the estimates of CV were decreasing for higher stages of life.

Decreasing trend for lifetime production upto various parities for CV in Rathi cows was also observed by Gupta (1993) and in Tharparkar cows by Gahlot (1990).

Johanson and Rendel (1968) stated that, as age of animal increases, production of cows also increases but at a decline rate until the full development of body is achieved i.e., upto 6-8 years of age. After this the production capacity decreases at an increasing rate as the ageing of body proceeds. In growing Swidish-Fresian farms, they observed that animals growing faster reached their maximum capacity earlier than slower growing animals but they also aged rapidly. In Rathi cattle a almost constant rate of increasing in LTMY might be associated with the maturation of cows physiologically as well as physically.

Decrease in coefficient of variation with addition of subsequent parities can be explained through following hypothesis -

(i) The primiparous cows experienced physiological changes arising from the reproduction and lactation stress, due to change in feeding and management and other stimuli because of milking, suckling, mixing with older animals and other environmental changes for the first time.

(ii) There is sequential culling of the poor producer after completion of each successive lactation and therefore, the stock which is completing higher lactation, is more uniform than those completing lower lactations.

(iii) Animals which stay longer in the farm shows less variability due to homogeneity among animals at genetic level and due to this adaptability of multiparous animals to the environment is increased leading to more homogeneity at environmental level also.

(iv) The variation between individual is due to genetic causes and environmental differences. As the lifetime performance is cumulative and there by positive and negative effects due to parities are cancelled out or reduced increasingly with the addition of each parity leading to reduction in overall variability between lifetime records.

4.1.1.2. Milk yield per day of lactating life upto termination of ith lactation (MYPDLLi) :

It was revealed that milk yield per day of lactating life increased with the increasing number of lactation or parities as shown in table number 2. The average estimates of MYPDLL for overall group ranged from 5.9576 litres upto first parity to 7.0383 litres upto sixth and higher parities. Similar trend of increase in MYPDLL was observed in Bikaner farm and Nohar farm, where it ranged from 4.9800 litres for first parity to 6.2826 litres upto sixth and higher parities for Bikaner farm and 6.4171 litres for first parity to 7.2598 litres upto sixth and higher parities for Nohar farm.

The increase in MYPDLL upto various parities for Bikaner farm and Nohar farm has been shown in figure 1 and 2, respectively. This increase in MYPDLL for overall group was 0.41 litres from first to second parity, 0.20 litres from second to third parity, 0.30 litres from third to fourth parity, 0.09 litres from fourth to fifth parity and 0.08 litres from fifth to sixth and higher parities. Increase in MYPDLL for Bikaner farm was 0.72 litres from first to second parity, 0.12 litres from second to third parity, 0.35 litres from third to fourth parity, 0.07 litres from fourth to fifth parity and 0.04 litres from

Table 2 : Mean, S.D. and C.V. (%) for milk yield per day of lactating life upto termination of ith lactation (MYPDLLi)

Upto Parity	Parameters	LRS, Bikaner	LRS, Nohar	Over all
First	N	55	117	172
	Mean	4.9800	6.4171	5.9576
	S.D.	0.9749	1.0810	1.2429
	C.V.	19.5763	16.8560	20.8624
Second	N	43	93	136
	Mean	5.7097	6.6639	6.3622
	S.D.	0.8752	0.9541	1.2987
	C.V.	15.3283	14.3174	20.4112
Third	N	30	66	96
	Mean	5.8202	6.9034	6.5649
	S.D.	0.7082	0.8825	0.9392
	C.V.	12.1683	12.7835	14.3063
Fourth	N	19	59	78
	Mean	6.1722	7.0906	6.8669
	S.D.	0.6576	0.9362	0.9585
	C.V.	10.6542	13.2045	13.9582
Fifth	N	15	39	54
	Mean	6.2480	7.2283	6.9560
	S.D.	0.5514	0.7771	0.8424
	C.V.	8.8252	10.7507	12.1104
Sixth and higher	N	21	71	92
	Mean	6.2896	7.2598	7.0383
	S.D.	0.5739	0.7531	0.8389
	C.V.	9.1245	10.3735	11.9190

fifth to sixth and higher parities, while the increase in MYPDLL for Nohar farm was 0.25 litres from first to second parity, 0.24 litres from second to third parity, 0.19 litres from third to fourth parity, 0.13 litres from fourth to fifty parity and 0.03 litres from fifth to sixth and higher parities. It reveals that the increase in MYPDLL was higher in initial parities than the higher stages.

Gupta (1993) estimated a similar trend in increase of MYPDLL upto five parities in Rathi cows and the estimates reported by him for respective parities were slightly lower than the estimates obtained in present study.

Similarly increasing trend in MYPDLL upto various parities in Tharparkar cows was observed by Gahlot (1990) and estimates reported by him were slightly higher than the estimates obtained under present investigation for Rathi cows.

The average milk yield per day of first lactation length (5.90±0.08 kg) and average milk yield per day of first and second lactation length (6.29±0.05 kg) was estimated by Gandhi and Gurnani (1990) in Sahiwal cows. The estimates obtained by him were slightly higher for respective parities than the estimates observed under present investigation.

The average milk yield per day of lactation length for Red Sindhi was estimated as 4.55 kg by Saini et al. (1992) which was slightly lesser than the estimates of the present study.

The standard deviation of milk yield per day of lactating life upto various parities in overall group was ranging from 0.8389 litres upto sixth and higher parities to 1.2429 litres upto first parity. The SD for MYPDLL for Bikaner farm was ranging between 0.5739 litres upto sixth and higher parities to 0.9749 litres upto first parity, whereas its range was 0.7531 litres upto sixth and higher parities to 1.0810 litres upto first parity for Bikaner farm. It reveals that SD for MYPDLL gradually decreases as the parities or lactation number increases.

The coefficients of variation in different groups showed (figure 3 and 4) decreasing trend in higher stages of lifetime in overall group as well as in Bikaner farm and Nohar farm. In general, the decreasing trend of CV for MYPDLL upto different parities of lifetime reveals that variability reduced in higher stages of lifetime production performance.

4.1.1.3. Milk yield per day of productive life upto termination of ith lactation (MYPDLi) :

Means, SD and CV of MYPDL upto various stages of lifetime are illustrated in table 3. Graphically, means of this trait has been shown in figure 1 and 2 where as CV in figure 3 and 4 for Bikaner farm and 2, respectively. The average estimates of MYPDL upto various parities for overall group were 5.9576, 4.8560, 4.9252, 5.0507, 5.0877 and 5.1616 litres, upto first, second, third, fourth, fifth and sixth and higher parities, respectively. The estimates of MYPDLL were 4.9800, 4.3298,

Table 3 : Mean, S.D. and C.V. (%) for milk yield per day of productive life upto termination of ith lactation (MYPDLi)

Upto Parity	Parameters	LRS, Bikaner	LRS, Nohar	Over all
First	N	55	117	172
	Mean	4.9800	6.4171	5.9576
	S.D.	0.9749	1.0810	1.2429
	C.V.	19.5763	16.8560	20.8624
Second	N	43	93	136
	Mean	4.3298	5.1046	4.8560
	S.D.	1.0459	1.2912	1.2659
	C.V.	24.1558	25.2948	26.0689
Third	N	30	66	96
	Mean	4.3946	5.1671	4.9257
	S.D.	1.0343	0.9526	1.0378
	C.V.	23.5359	18.4358	21.0690
Fourth	N	19	59	78
	Mean	4.5083	5.2253	5.0507
	S.D.	0.9994	0.7715	0.8819
	C.V.	22.1680	14.7647	17.4609
Fifth	N	15	39	54
	Mean	4.5409	5.2981	5.0877
	S.D.	0.8155	0.7649	0.8440
	C.V.	17.9567	14.4372	16.5890
Sixth and higher	N	21	71	92
	Mean	4.6298	5.3189	5.1616
	S.D.	0.8004	0.6783	0.8007
	C.V.	17.2880	12.7526	15.5126

4.3946, 4.5083, 4.5409 and 4.6298 litres for Bikaner farm and 6.4171, 5.1046, 5.1671, 5.2253, 5.2981 and 5.3189 litres for Nohar farm upto respective parities. There was a continuous increase in MYPDL for all the stages of life (i.e.,from upto second parity to upto sixth and higher parities) for Bikaner farm, Nohar farm and overall group (figure 1 and 2) except from first to upto second parity, where it was declining which might be because of that estimates upto first parity were not having or including dry period, while it was considered for first time in second parity and onwards, which creates decline in MYPDL upto second parity. As the preceding dry period for the first parity was not existing the value of MYPDLL1 and MYPDL1 were coinciding.

Gahlot (1990) estimated the milk yield per day of farm life upto termination of ith lactation for Tharparkar cows. He reported continuous increasing trend upto seventh parity for this trait with a declining rate of increase as the order of parity increased. The increase in MYPDL for Tharparkar cattle were higher than the increase in MYPDL estimates of the present study of Rathi cows.

The coefficients of variation was observed to be increased initially upto second parity (26.06 %) from first parity (20.86 %) and then declines regularly and was minimum at upto sixth and higher parities (17.28 %) for overall group. Similar trend of variation in CV was observed in Bikaner farm and farm 2 where the estimates of CV increase from 19.57 per cent upto first parity to 24.15 per cent upto second parity and than continuously decreased and was minimum at upto sixth and higher parities (17.28 %) for Bikaner farm where as for Nohar farm its value increases from 16.85 per cent upto first parity to 25.29 per cent upto second parity and second parity onwards it declines regularly and the values were minimum at upto sixth and higher parities i.e., 12.75 per cent.

The SD for MYPDL also shows the same trend as observed for CV. The values for SD, were 1.2429 litres at upto first parity, increased to 1.2659 litres upto second parity and than declines regularly upto sixth and higher parity i.e., 0.8007 litres for overall group. Similarly, the estimates of SD for Bikaner farm were 0.9749 litres upto first parity, increased to 1.0459 litres upto second parity than gradually declines upto sixth and higher parities i.e.,0.8004 litres, whereas the values of SD for Nohar farm were 1.0810 litres upto first parity, increased to 1.2912 litres upto second parity than decreases continuously upto sixth and higher parities i.e., 0.6783 litres.

It also revealed that SD and CV decreases as the subsequent parities were added for MYPDL.

4.1.1.4. Milk yield per day of productive life upto start of next lactation (MYPDCIi) :

Means, SD and CV for milk yield per day of productive life upto start of next lactation has been illustrated in table number 4. Graphically means of this trait wage shown in figure 1 and 2 and CV in figure 3 and 4 for Bikaner farm and 2, respectively.

Table 4 : Mean, S.D. and C.V. (%) for milk yield per day of productive life upto start of next lactation (MYPDCIi)

Upto Parity	Parameters	LRS, Bikaner	LRS, Nohar	Over all
First	N	55	117	172
	Mean	3.5612	4.4856	4.1900
	S.D.	0.9613	1.1046	1.1430
	C.V.	26.9937	24.6254	27.2792
Second	N	43	93	136
	Mean	3.7966	4.5509	4.3124
	S.D.	0.9463	1.1091	1.0758
	C.V.	24.9249	24.3729	24.9496
Third	N	30	66	96
	Mean	3.8256	4.7134	4.4360
	S.D.	0.9239	0.8682	0.9733
	C.V.	24.1504	18.4198	21.9409
Fourth	N	19	59	78
	Mean	4.1216	4.7680	4.6105
	S.D.	0.7809	0.8301	0.8600
	C.V.	18.9435	17.4177	18.6500
Fifth	N	15	39	54
	Mean	4.2182	4.8433	4.7159
	S.D.	0.7352	0.7109	0.7644
	C.V.	17.0272	14.6780	16.2089
Sixth	N	21	71	92
and	Mean	4.2968	4.8725	4.7411
higher	S.D.	0.7413	0.6387	0.7237
	C.V.	172523	13.1082	15.2643

Averages of MYPDCI for overall group were 4.1900, 4.3124, 4.4360, 4.6105, 4.7159 and 4.7411 litres upto first, second, third, fourth, fifth and sixth and higher parities, respectively. Similar trend of increasing order of MYPDCI was observed for Bikaner farm and Nohar farm where it ranges between 3.5612 litres upto first parity to 4.2968 litres upto sixth and higher parities for Bikaner farm, and for Nohar farm it ranges between 4.4856 litres upto first parity to 4.8725 litres upto sixth and higher parities.

Means of MYPDCIi has shown continuous increasing trend in higher stage of lifetime but at a declining rate of increase with addition of each parity for Bikaner farm, Nohar farm and overall group.

Gahlot (1990) obtained similar trend of increase in milk yield per day of herdlife upto start of next lactation in Tharparkar cattle.

The estimates of milk yield per day of first calving interval (3.96±0.04 kg) and average milk yield per day of first and second calving interval (4.20±0.04 kg) in Sahiwal cattle reported by Gandhi and Gurnani (1992) were lesser than MYPDCI1 and MYPDCI2 observed in present study for Rathi cows. Thus Rathi cows had better performance than Sahiwal pure bred cows.

The observed value of MYPDCI1 for Rathi cows was less than that reported by Saini et al. (1992) for Red Sindhi.

The standard deviation of means for MYPDCI ranges from 0.7237 litres upto sixth and higher parities to 1.1430 litres upto first parity for overall group of Rathi cows. The estimates of SD for MYPDCI for Bikaner farm was maximum (0.9613 litres) at upto first parity and minimum (0.7413 litres) at upto sixth and higher parities where as for Nohar farm it was maximum (1.1046 litres) upto first parity and minimum (0.6387 litres) upto sixth and higher parities. MYPDCIi also showed a decreasing trend of SD for higher parity as similar to MYPDLi.

The coefficients of variation for MYPDCIi showed the decreasing trend with addition of subsequent parities. The values of CV were maximum (27.27 %) at upto first parity and minimum (15.26 %) at upto sixth and higher parities for overall group of Rathi cows. Likewise these estimates were maximum (26.99 % and 24.62 per cent for Bikaner farm and Nohar farm, respectively) at upto first parity and minimum (17.25 % and 13.10 % for Bikaner farm and Nohar farm, respectively) upto sixth and higher parities.

It was concluded that MYPDCI was a better estimate of daily milk yield as comparedto MYPDL and MYPDLL because it accounts for productive and unproductive part of the parity. Whereas MYPDL consider the dry period of the previous lactation while MYPDLL neither include dry period of previous lactation nor of present lactation.

4.1.2. Averages and variation in breeding efficiency upto ith calving (BEi)

The estimates of mean, SD and CV for breeding efficiency upto various stages of life was given in table 5 and graphically, for Bikaner farm and Nohar farm means of BE has been illustrated in figure 1 and 2, respectively, where as CV of corresponding farm has been illustrated in figure 3 and 4.

The estimate of BE upto first parity or calving could not be estimated by the formula proposed by Wilcox et al. (1957). The average BE upto various calvings for overall group was 80.57, 81.07, 84.25, 86.85 and 87.45 per cent for upto second, third, fourth, fifth and sixth and higher calvings. respectively. The estimates of BE for Bikaner farm were 69.60, 73.51, 77.07, 78.78 and 85.80 per cent upto second, third, fourth, fifth and sixth and higher calvings and for Nohar farm these estimates were 85.65, 84.51, 86.56, 89.95 and 87.94 per cent upto second, third, fourth, fifth and sixth and higher calvings, respectively.

Trend of increase in BE was shown in figure 1 and 2 for Bikaner farm and 2, respectively. It reveals that BE for overall group was gradually increased upto sixth and higher parities. Similar increasing trend was observed on Bikaner farm where as for Nohar farm BE was almost equal upto second, third and fourth calving i.e., about 85 per cent than it increased in upto fifth calving and marginally decreased upto sixth and higher calvings.

Table 5 : Mean, S.D. and C.V. (%) for breeding efficiency upto ith calving (BEi)

Upto Parity	Parameters	LRS, Bikaner	LRS, Nohar	Over all
Second	N	43	93	136
	Mean	69.6017	85.6548	80.5792
	S.D.	18.0357	14.8361	17.5309
	C.V.	25.9127	17.3208	21.7549
Third	N	30	66	96
	Mean	73.5109	84.5126	81.0746
	S.D.	15.9639	13.1826	14.9324
	C.V.	21.7166	15.5983	18.4180
Fourth	N	19	59	78
	Mean	77.0784	86.5623	84.2521
	S.D.	13.6241	12.4571	13.3060
	C.V.	17.6756	14.3909	15.7937
Fifth	N	15	39	54
	Mean	78.7890	89.9536	86.8523
	S.D.	13.3458	9.9441	11.9760
	C.V.	16.9386	11.0546	13.7889
Sixth and higher	N	21	71	92
	Mean	85.8063	87.9402	87.4531
	S.D.	8.2617	10.2172	9.8037
	C.V.	9.6283	11.6183	11.2102

Patro and Rao (1983) estimated BE in Red Sindhi cows upto third calving as 79.12±1.57 and 80.96±1.41 per cent for second and third calvings, respectively. These estimates were lower than the estimates obtained under present investigation.

Lahiri _et al_. (1981) studied BE of Hariana cattle upto first three lactation and reported that average value of BE were 75.78±0.97 and 78.30±0.93 per cent for the second and third calvings, respectively.

Patro and Rao (1983) and Lahiri _et al_. (1981) observed increasing trend of BE in Red Sindhi and Hariana cows, respectively and similar trend was obtained in the present investigation of Rathi cows.

Singh _et al_. (1980) estimated the BE of Sahiwal cows based on five calving interval and observed that average BE upto five calvings were 89.3±13.59, 87.4±13.69, 88.7±13.59 and 90.0±13.58, for second, third, fourth and fifth calvings, respectively. The trend was slightly different that BE was decreased upto third calving than increased upto fifth calvings. The estimates obtained by Singh _et al_. revealed that Sahiwal cows having higher estimates of BE upto five calvings than the Rathi cows as obtained under present investigation.

On the basis of the results obtained by the literature and present study it was concluded that Rathi cows have better BE than Red Sindhi and Hariana cows but were less efficient than Sahiwal cows.

Table 5 further revealed that the SD of BE decreased with the addition of higher order of calving. It ranges from maximum (17.53 %) upto second calving to minimum (9.80 %) upto sixth and higher calvings for over group of Rathi cows. This range for Bikaner farm was 18.03 per cent upto second calving to 8.26 per cent upto sixth and higher calvings. Similarly for Nohar farm its range was 14.83 per cent upto second calving to 10.21 per cent upto sixth and higher calving which was marginally higher than fifth calving i.e., 9.94 per cent.

The coefficient of variation was also gradually decreased, as the calving number increased. It was maximum 21.75 per cent at upto second calving and minimum 11.21 per cent at upto sixth and higher calvings for overall group. Similarly,for Bikaner farm it was maximum 25.91 per cent at upto second calving and minimum 9.62 per cent at upto sixth and higher calvings and for Nohar farm it was maximum 17.32 per cent at upto second calving and minimum 11.61 per cent at upto sixth and higher calvings which was slightly higher than upto fifth calving (11.05 %).

It reveals that variation for calving decreased as the number of calving increased and hence the breeding efficiency also increased.

4.2. EFFECT OF NON-GENETIC FACTORS

Along with genetic make up of an individual, environmental stimuli causes variation in production. Animals of good genetic potential may not develop to the limit of their inherited capacity under poor management and malnutrition. Thus, consideration of environment in animal breeding is as important as the heredity. To study the effects of non-genetic factors on lifetime production traits and breeding efficiency, period and season of first calving and farm were considered as fixed effects.

4.2.1. Effect of Non-genetic factors on lifetime production efficiency traits

Least-square analysis of variance for lifetime production efficiency traits for various stages of life are given in tables 6 to 11 and least-squares means are illustrated in tables 12 to 17.

4.2.1.1. Effect of farm :

Least-squares analysis of variance revealed that all the lifetime production efficiency traits viz., LTMY, MYPDLL, MYPDL and MYPDCI were significant ($P < 0.01$) by farm upto first parity (Table 6).

It also indicates that LTMY was non-significantly affected by farm where as MYPDL was affected significantly ($P < 0.05$) and MYPDLL and MYPDCI were highly significantly affected ($P < 0.01$) by farm upto second parity (Table 7).

For lifetime production efficiency traits farm had non-significant effect on LTMY but had highly significant effect on MTPDLL, MYPDL and MYPDCI ($P < 0.01$) upto third and fourth parity (Tables 8 and 9).

Table 6 : Least-squares analysis of variance of lifetime production effeciency traits and breeding efficiency upto first parity

Source of variation	Herd	Season of first calving	Period of first calving	Residuals
Degrees of Freedom	1	3	3	164
Mean squares				
LTMY	3479706.50**	211027.61	231567.84	218386.35
MYPDLL	41.3668**	1.6289	7.7977**	0.9846
MYPDL	41.3668**	1.6289	7.7977**	0.9846
MYPDCI	11.2958**	0.6521	5.1476**	1.0577
BE	NE	NE	NE	NE

** significant at $p < 0.01$
* significant at $p < 0.05$

Table 7 : Least-squares analysis of variance of lifetime production effeciency traits and breeding efficiency upto second parity

Source of variation	Herd	Season of first calving	Period of first calving	Residuals
Degrees of Freedom	1	3	3	128
Mean squares				
LTMY	3729410.52	723269.34	1000688.37	1107486.73
MYPDLL	9.8479**	1.9392	3.4707	1.4159
MYPDL	7.4726*	3.1858	5.9796**	1.3394
MYPDCI	7.3457**	1.6835	1.4151	1.0059
BE	1387.7314*	449.7341	683.8400*	231.7494

** significant at $p < 0.01$
* significant at $p < 0.05$

Table 8 : Least-squares analysis of variance of lifetime production effeciency traits and breeding efficiency upto third parity

Source of variation	Herd	Season of first calving	Period of first calving	Residuals
Degrees of Freedom	1	3	2	89
Mean squares				
LTMY	2986849.39	3892121.40	3751730.87	1886990.39
MYPDLL	16.8693**	0.8434	3.5870**	0.5641
MYPDL	7.9688**	0.7999	3.6993*	0.9027
MYPDCI	11.2062**	0.4765	2.6158*	0.7558
BE	624.2080	499.1050	116.8636	184.8026

** significant at $p < 0.01$
* significant at $p < 0.05$

Table 9 : Least-squares analysis of variance of lifetime production effeciency traits and breeding efficiency upto fourth parity

Source of variation	Herd	Season of first calving	Period of first calving	Residuals
Degrees of Freedom	1	3	2	71
Mean squares				
LTMY	4022636.52	3886025.45	2658798.99	3049108.43
MYPDLL	7.8013**	0.8736	0.8725	0.7547
MYPDL	6.9546**	1.0386	0.1411	0.6915
MYPDCI	6.4648**	1.6494	0.2540	0.6407
BE	70.4075	103.6310	578.6783	145.7303

** significant at $p < 0.01$
* significant at $p < 0.05$

Table 10 : Least-squares analysis of variance of lifetime production effeciency traits and breeding efficiency upto fifth parity

Source of variation	Herd	Season of first calving	Period of first calving	Residuals
Degrees of Freedom	1	3	2	47
Mean squares				
LTMY	10931198.48	5329727.08	2148286.08	3504471.20
MYPDLL	5.5293**	0.8597	0.3604	0.4698
MYPDL	3.8079*	0.2324	0.0875	0.6409
MYPDCI	1.4354	0.0752	0.1342	0.5689
BE	4.4994	389.2928**	364.1487	85.4797

** significant at $p < 0.01$
* significant at $p < 0.05$

Table 11 : Least-squares analysis of variance of lifetime production effeciency traits and breeding efficiency upto sixth and higher parities.

Source of variation	Herd	Season of first calving	Period of first calving	Residuals
Degrees of Freedom	1	3	2	85
Mean squares				
LTMY	171476560.23**	107493517.07**	15740223.52	9711594.93
MYPDLL	11.0410**	1.3460	1.8421*	0.4073
MYPDL	4.3165**	1.3051	1.7032	0.4935
MYPDCI	4.1146**	1.2774*	0.6336	0.4091
BE	42.1605	374.9326**	707.6255**	65.5962

** significant at $p < 0.01$
* significant at $p < 0.05$

Table 12 : Least-square means, S.E. and subclass number for various lifetime production efficiency traits and breeding efficiency upto first parity.

Class or Subclass	Parameters	LTMY	MYPDLL	MYPDL	MYPDCI
Over all μ	Mean	1798.87	5.7305	5.7305	4.0222
	S.E.	41.2354	0.0875	0.0875	0.0907
	N	172	172	172	172
Herd					
Bikaner	Mean	1619.88a	5.1134a	5.1134a	3.6997a
	S.E.	68.8144	0.1461	0.1461	0.1514
	N	55	55	55	55
Nohar	Mean	1977.87b	6.3477b	6.3477b	4.3447b
	S.E.	51.8312	0.1100	0.1100	0.1140
	N	117	117	117	117
Season of first calving					
Comfort	Mean	1920.71a	6.0277a	6.0277a	4.1684a
	S.E.	78.4490	0.1665	0.1665	0.1726
	N	38	38	38	38
Hot-Dry	Mean	1784.02a	5.6417a	5.6417a	3.9227a
	S.E.	66.5755	0.1413	0.1413	0.1465
	N	52	52	52	52
Hot-Humid	Mean	1733.42a	5.7288a	5.7288a	3.8909a
	S.E.	109.2770	0.2320	0.2320	0.2405
	N	19	19	19	19
Winter	Mean	1757.35a	5.5239a	5.5239a	4.1068a
	S.E.	70.1121	0.1488	0.1488	0.1543
	N	63	63	63	63
Period of first calving					
P-1 (1974-80)	Mean	1674.38a	4.9896a	4.9896a	3.4396a
	S.E.	82.2434	0.1746	0.1746	0.1810
	N	37	37	37	37
P-2 (1981-85)	Mean	1821.13a	5.8656b	5.8656b	4.0630b
	S.E.	77.5873	0.1647	0.1647	0.1707
	N	39	39	39	39
P-3 (1986-90)	Mean	1828.67a	6.0421b	6.0421b	4.2780b
	S.E.	79.9141	0.1590	0.1590	0.1648
	N	61	61	61	61
P-4 (1991-93)	Mean	1871.31a	6.0249b	6.0249b	4.3082b
	S.E.	80.6009	0.1711	0.1711	0.1773
	N	35	35	35	35

Note : Figures with different letter within a class differ significantly ($P < 0.05$)

Table 13 : Least-square means, S.E. and subclass number for various lifetime production efficiency traits and breeding efficiency upto second parity.

Class or Subclass	Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
Over all	Mean	3383.56	6.3000	4.7632	4.2353	78.1557
μ	S.E.	117.5010	0.1328	0.1292	0.1120	1.7000
	N	136	136	136	136	136
Herd						
Bikaner	Mean	3160.12a	5.9369a	4.4469a	3.9217a	73.8456a
	S.E.	196.0105	0.2216	0.2155	0.1868	2.8354
	N	43	43	43	43	43
Nohar	Mean	3607.00a	6.6631b	5.0795b	5.5489b	82.4659b
	S.E.	137.3075	0.1552	0.1510	0.1308	1.9862
	N	93	93	93	93	93
Season of first calving						
Comfort	Mean	3522.91a	6.5203a	5.0962a	4.4281a	76.2344a
	S.E.	208.7147	0.2359	0.2295	0.1989	3.0192
	N	30	30	30	30	30
Hot-Dry	Mean	3256.88a	5.9669a	4.3672a	3.8992a	79.0166a
	S.E.	196.1339	0.2217	0.2156	0.1869	2.8372
	N	36	36	36	36	36
Hot-Humid	Mean	3540.31a	6.3048a	5.0188a	4.3658a	73.8680a
	S.E.	273.3253	0.3090	0.3005	0.2604	3.9538
	N	16	16	16	16	16
Winter	Mean	3214.14a	6.4081a	4.5707a	4.2482a	83.5040a
	S.E.	183.4556	0.2074	0.2017	0.1748	2.6538
	N	54	54	54	54	54
Period of first calving						
P-1	Mean	3433.62a	5.7562a	4.4209a	3.9256a	70.7477a
(1974-80)	S.E.	193.1713	0.2184	0.2124	0.1840	2.7943
	N	34	34	34	34	34
P-2	Mean	3323.66a	6.2121a	4.5672a	4.1706a	76.9681ab
(1981-85)	S.E.	163.2909	0.1846	0.1795	0.1556	2.3621
	N	44	44	44	44	44
P-3	Mean	3630.64a	6.4338a	5.3860b	4.4478a	81.7297b
(1986-90)	S.E.	195.1010	0.2206	0.2145	0.1859	2.8222
	N	46	46	46	46	46
P-4	Mean	3146.33a	6.7980a	4.6788ab	4.3972a	83.1775b
(1991-93)	S.E.	313.5230	0.3545	0.3447	0.2987	4.5353
	N	12	12	12	12	12

Note : Figures with different letter within a class differ significantly ($P < 0.05$)

Table 14 : Least-square means, S.E. and subclass number for various lifetime production efficiency traits and breeding efficiency upto third parity.

Class or Subclass	Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
Over all	Mean	5275.71	6.4003	6.8314	4.2921	78.2415
μ	S.E.	169.5053	0.0926	0.1172	0.1072	1.6774
	N	96	96	96	96	96
Herd						
Bikaner	Mean	5057.71a	5.8826a	4.4756a	3.8702a	75.0925a
	S.E.	279.0558	0.1525	0.1930	0.1766	2.7615
	N	30	30	30	30	30
Nohar	Mean	5493.51a	6.9179b	5.1873b	4.7141b	81.3906a
	S.E.	198.8661	0.1087	0.1375	0.1258	1.9680
	N	66	66	66	66	63
Season of first calving						
Comfort	Mean	5307.26a	6.6520a	5.0426a	4.4865a	75.8832a
	S.E.	305.1015	0.1668	0.2110	0.1931	3.0193
	N	21	21	21	21	21
Hot-Dry	Mean	4846.76a	6.2973a	4.6941a	4.2296a	78.5702a
	S.E.	265.9189	0.1454	0.1839	0.1683	2.6315
	N	30	30	30	30	30
Hot-Humid	Mean	6028.65a	6.4669a	4.9672a	4.3243a	73.2327a
	S.E.	446.5727	0.2441	0.3088	0.2826	4.4193
	N	10	10	10	10	10
Winter	Mean	4920.17a	6.1848a	4.6216a	4.1282a	85.2801a
	S.E.	271.2501	0.1483	0.1876	0.1716	2.6843
	N	35	35	35	35	35
Period of first calving						
P-1 (1974-80)	Mean	5260.90a	5.9936a	4.4173a	3.9346a	76.4700a
	S.E.	279.5687	0.1528	0.1933	0.1769	2.7666
	N	27	27	27	27	27
P-2 (1981-85)	Mean	4925.39a	6.4320ab	4.8669ab	4.3491ab	77.5165a
	S.E.	228.5303	0.1249	0.1580	0.1446	2.2615
	N	38	38	38	38	38
P-3 (1986-90)	Mean	5640.84a	6.7751b	5.2102b	4.5924b	80.7381a
	S.E.	308.5204	0.1686	0.2133	0.1952	3.0531
	N	31	31	31	31	31

Note : Figures with different letter within a class differ significantly ($P < 0.05$)

Table 15 : Least-square means, S.E. and subclass number for various lifetime production efficiency traits and breeding efficiency upto fourth parity.

Class or Subclass	Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
Over all	Mean	6883.81	6.6370	4.8221	4.4046	83.8322
μ	S.E.	270.2596	0.1344	0.1287	0.1238	1.8683
	N	78	78	78	78	78
Herd						
Bikaner	Mean	6565.70a	6.1940a	4.4038a	4.0013a	82.5014a
	S.E.	471.7327	0.2347	0.2246	0.2162	3.2612
	N	19	19	19	19	19
Nohar	Mean	7201.91a	7.0800b	5.2404b	4.8079b	85.1631a
	S.E.	277.4003	0.1380	0.1321	0.1271	1.9177
	N	59	59	59	59	59
Season of first calving						
Comfort	Mean	7530.64a	6.8124a	5.1600a	4.8653a	79.7486a
	S.E.	497.4531	0.2474	0.2369	0.2280	3.4390
	N	14	14	14	14	14
Hot-Dry	Mean	6640.44a	6.3950a	4.6108a	4.1265a	83.4687a
	S.E.	433.3901	0.2156	0.2063	0.1986	2.9961
	N	23	23	23	23	23
Hot-Humid	Mean	7043.84a	6.5192a	4.5818a	4.1318a	86.7080a
	S.E.	645.7731	0.3212	0.3075	0.2960	4.4644
	N	08	08	08	08	08
Winter	Mean	6320.31a	6.8215a	4.9358a	4.4948a	85.4036a
	S.E.	362.3436	0.1802	0.1725	0.1660	2.5050
	N	33	33	33	33	33
Period of first calving						
P-1	Mean	8689.02a	6.6024a	4.8461a	4.4099a	77.4999a
(1974-80)	S.E.	357.2597	0.1774	0.1701	0.1637	2.4698
	N	27	27	27	27	27
P-2	Mean	6645.60a	6.4576a	4.7390a	4.2991a	84.7411a
(1981-85)	S.E.	372.4138	0.1852	0.1773	0.1707	2.5746
	N	30	30	30	30	30
P-3	Mean	7316.81a	6.8511a	4.8811a	4.5049a	89.2557a
(1986-90)	S.E.	506.6008	0.2520	0.2412	0.2322	3.5023
	N	21	21	21	21	21

Note : Figures with different letter within a class differ significantly ($P < 0.05$)

Table 16 : Least-square means, S.E. and subclass number for various lifetime production efficiency traits and breeding efficiency upto fifth parity.

Class or Subclass	Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
Over all	Mean	8510.14	6.7140	4.9037	4.6158	86.9235
μ	S.E.	442.3241	0.1619	0.1891	0.1782	2.1845
	N	54	54	54	54	54
Herd						
Bikaner	Mean	7870.53a	6.2591a	4.5228a	4.3841a	86.5131a
	S.E.	702.9896	0.2574	0.3006	0.2832	3.4719
	N	15	15	15	15	15
Nohar	Mean	9149.75a	7.1689b	5.2778b	4.8476a	87.3339a
	S.E.	399.2712	0.1416	0.1707	0.1608	1.9719
	N	39	39	39	39	39
Season of first calving						
Comfort	Mean	8955.08a	6.9113a	5.0834a	4.6684a	78.3463a
	S.E.	562.3677	0.2059	0.2405	0.2265	2.7774
	N	14	14	14	14	14
Hot-Dry	Mean	7593.15a	6.3735a	4.7611a	4.5215a	89.7090b
	S.E.	605.8176	0.2218	0.2590	0.2440	2.9920
	N	15	15	15	15	15
Hot-Humid	Mean	9367.49a	6.6433a	4.7760a	4.5812a	87.8874ab
	S.E.	1209.5575	0.4428	0.5173	0.4873	5.9737
	N	03	03	03	03	03
Winter	Mean	8124.84a	6.9277a	4.9807a	4.6923a	91.7513b
	S.E.	482.8971	0.1768	0.2065	0.1945	2.3849
	N	22	22	22	22	22
Period of first calving						
P-1 (1974-80)	Mean	9012.93a	6.5697a	4.7989a	4.4895a	80.5474a
	S.E.	453.3492	0.1659	0.1938	0.1826	2.2389
	N	22	22	22	22	22
P-2 (1981-85)	Mean	8486.24a	6.8588a	4.9341a	4.6542a	89.5912a
	S.E.	558.2227	0.2043	0.2387	0.2249	2.7569
	N	22	22	22	22	22
P-3 (1986-90)	Mean	8031.25a	6.7134a	4.9679a	4.7038a	90.6318a
	S.E.	829.2464	0.3036	0.3546	0.3341	4.0954
	N	10	10	10	10	10

Note : Figures with different letter within a class differ significantly ($P < 0.05$)

Table 17 : Least-square means, S.E. and subclass number for various lifetime production efficiency traits and breeding efficiency upto sixth and higher parities

Class or Subclass	Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
Over all	Mean	11026.63	6.9263	5.3630	4.7968	89.4619
μ	S.E.	687.3610	0.1407	0.1549	0.1410	1.7804
	N	92	92	92	92	92
Herd						
Bikaner	Mean	9164.09a	6.4537a	5.0675a	4.5083a	90.3855a
	S.E.	988.9133	0.2025	0.2229	0.2029	2.5701
	N	21	21	21	21	21
Nohar	Mean	12889.17b	7.3990b	5.6585b	5.0853b	88.5584a
	S.E.	599.9343	0.1228	0.1352	0.1231	1.5591
	N	71	71	71	71	71
Season of first calving						
Comfort	Mean	11081.97a	7.1038a	5.4692a	5.0689a	83.6723a
	S.E.	1018.60	0.2086	0.2292	0.2090	2.6472
	N	13	13	13	13	13
Hot-Dry	Mean	8153.90b	6.5521a	5.0883a	4.4849b	93.0362b
	S.E.	930.3830	0.1905	0.2097	0.1909	2.4179
	N	35	35	35	35	35
Hot-Humid	Mean	14301.48a	7.0842a	5.7214a	4.9825ab	87.4167ab
	S.E.	1298.0816	0.2658	0.2926	0.2664	3.3736
	N	10	10	10	10	10
Winter	Mean	10569.15ab	6.9649a	5.1730a	4.6509ab	93.7225b
	S.E.	651.5733	0.1334	0.1468	0.1337	1.6933
	N	34	34	34	34	34
Period of first calving						
P-1 (1974-80)	Mean	12235.95a	6.6519a	4.9460a	5.5670a	81.7925a
	S.E.	506.9473	0.1038	0.1142	0.1040	1.3175
	N	52	52	52	52	52
P-2 (1981-85)	Mean	11568.60a	7.1750b	5.2761a	4.8546a	91.2050b
	S.E.	726.9009	0.1488	0.1638	0.1492	1.8891
	N	35	35	35	35	35
P-3 (1986-90)	Mean	9277.33a	6.9522ab	5.8665a	4.9688a	95.4883b
	S.E.	1605.4645	0.3288	0.3619	0.3295	4.1724
	N	05	05	05	05	05

Note : Figures with different letter within a class differ significantly ($P < 0.05$)

Upto fifth parity LTMY and MYPDCI were affected non-significantly by farm where as MYPDL was significantly (P <0.05) and MYPDLL highly significantly affected (P <0.01) by farm (Table 10).

The affect of farm was found highly significant (P <0.01) on LTMY, MYPDLL, MYPDL and MYPDCI upto sixth and higher parities (Table 11).

The significant difference between two farms stated that the feeding regimes at two farms might be different and due to this difference between the lifetime production efficiency traits of the two farms was observed.

These tables revealed that animals of Nohar farm were having better production than the animals of Bikaner farm throughout the lifetime, which might be due to availability of green fodder throughout the year.

Deshpande et al. (1988) evaluated on the basis of least-squares analysis of variance of milk yield per day of second calving that the influence of farms had highly significant effect in Friesian X Sahiwal crossbreds.

The least-squares means for lifetime milk yield, average daily milk yield for lifetime lactation, lifetime lactation period in Jersey cows was investigated by Kathoch et al. (1990) and reported that farm had a significant effect on all these traits.

Gandhi and Gurnani (1992) evaluated milk yield per day of lactation length, per day of first calving interval, per day of age at first calving interval, per day of second lactation length, per day of second calving interval, average milk yield per day of first and second lactation length and average milk yield per day of first and second calving interval for Sahiwal cattle and reported that farm had significant effect on all these production efficiency traits except for milk yield per day of second lactation length and average milk yield per day of first and second lactation where it effect non-significantly.

4.2.1.2. Effect of season and period of first calving

The effect of season of first calving was observed non-significant for all the lifetime production efficiency traits upto various stages of lifetime except at parity sixth and higher where MYPDCI ($P < 0.05$) and LTMY ($P < 0.01$) was observed significant. This might be due to availablitye in Hot-Dry season and the significant difference was observed of this season with other seasons. (Table 12-17).

The effect of period of first calving was observed non-significant for LTMY and significant ($P < 0.05$) for MYPDCI, MYPDLL and MYPDL upto first parity. This might be because of the animals born first time during the period 1974-1980 had improper nutrition might be due to drought or other managemental condition which decreases milk yield and increased lactation length as well as dry period and calving interval and significant difference of this period was observed with other three periods (Table 12).

The effect of period was observed non-significant for LTMY, MYPDLL and MYPDCI but observed significant (P <0.01) for MYPDL upto second parity. This might be because of plenty availability of nutrition through out lactation of these animals who calved first time in period-3 which may be due to good rainfall and better managemental conditions and decreased the dry period and increased lactation yield, hence creates significant difference in MYPDL of period-3 (1986-90) with other three seasons.

The effect of period was obtained non-significant for LTMY but significant for MYPDLL and MYPDCI (P <0.05) and MYPDLL (P < 0.01) upto third parity. This might be because of drought or other managemental condition through out lifetime for animal calving in period-1 (1974-80). The malnutrition in these animals might had created significant difference in period-1 (1974-1980) with rest of the periods.

The effect of period was noticed non-significant for all the lifetime production efficiency traits upto fourth and upto fifth parity.

The effect of period for LTMY, MYPDL and MYPDCI was observed nonsignificant but for MYPDL and MYPDLL significant (P <0.05). This might be due to the animals calved first time in period-1 (1974-80) got poor nutritional and managemental condition and which ultimately creates significant difference in MYPDLL of period-1 with other two periods.

Similar results were obtained by Bagherwal and Khan (1991). They reported a non-significant effect of period and season of first calving on first four lactation yields except of a significant effect of period on first lactation yield.

Singh et al. (1987) reported a non-significant effect of period and season of birth on cumulative yield in first three lactations of crossbred cows. Similar conclusions were drawn by Bhambure and Dave (1989) on milk yield.

Gahlot (1990) reported non-significant effect of period and season of first calving on lifetime milk yield, milk yield per day of herd life upto termination of ith lactation, milk yield per day of herd life upto start of next lactation and milk yield per day of lactating life from first to upto seventh parity for Tharparkar cattle. Similar results were obtained for Rathi cattle upto five parities by Gupta (1993).

Gandhi and Gurnani (1992) observed non-significant effect of period and season of calving on some production efficiency traits of Sahiwal cattle. However, significant effect of period on milk yield per day of first lactation and that of season on milk yield per day of second lactation and average milk yield per day of first and second lactation were reported by them.

A non-significant effect of season of calving was also reported by Reddy and Nagarcenkar (1988) on lifetime milk yield upto 3, 5 and 7 lactations and on milk yield per day of lactation length, milk yield per day of calving interval, milk yield per day of dry period and milk yield per day of life time.

On the contrary, significant effect of period and season of calving were reported on milk yield per day of age at second calving by Deshpande et al. (1988), and on first lactation milk yield, milk yields per day of first lactation length and first calving interval by Murdia and Tripathi (1991).

4.2.2 Effect of non-genetic factors on breeding efficiency upto various stages of life

Least-squares analysis of variance for breeding efficiency upto various stages of life are given in table 6-11 and least-squares means are tabulated in table 12-17.

4.2.2.1. Effect of farm :

Effect of farm on breeding efficiency was observed significant upto second parity ($p < 0.01$) upto third parity ($P < 0.05$) and non-significant upto fourth, fifth and sixth and higher parities. This significant difference might be due to different feeding regimes at two farms.

4.2.2.2. Effect of season and period of first calving on breeding efficiency :

The effect of season was noticed non-significant on BE upto second, third and fourth parity, after that for fifty parity and sixth and higher parities it was observed significant ($P < 0.01$). This significant difference in different season was observed due to Season-1 (Comfort) in both fifth and sixth and higher parities which might be because that the animals calved during Comfort season might be conceived in the months of rains and due to lack of availability of fodder in prior months of rainy season the calving interval increased, which inturn decreases the BE and creates significant difference with other seasons.

The effect of period was observed non-significant on BE upto third, fourth and fifth parity while significant (P <0.05) at upto second parity and highly significant (P <0.01) at upto sixth and higher parities.

This significant difference in both the parities was due to period-1 (1974-80), means the animals calved first time in this period. Due to drought and poor managemental conditions in this period the calving interval of animal calved during this period increased which inturn decreases the BE and significant difference creates with other periods of the same parities.

The effect of various factors on breeding efficiency estimates based on five calving interval was studied by Singh et al. (1980) and reported that effect of farms and periods were significant on the breeding efficiency based on five calving interval.

Mondal and Choudhuri (1987) observed breeding efficiency of Non-Descript, Hariana, Hariana X Non-Descript and Jersey X Hariana upto different parities and reported that season and period of calving significantly effect the breeding efficiency in all breed types except for Jersey X Hariana, the breeding efficiency of which was only affected by season of calving.

Breeding efficiency of Jersey cows in first four parities were analysed by Ray and Kotpatal (1987) and observed that breeding efficiency of four parities were significantly affected by farm and year in first and second parity where as season in third and fourth parity.

Friesian X Sahiwal cows at two farms were analysed for breeding efficiency by Sodakar et al. (1988) and reported that season and farm did not significantly affect the breeding efficiency but it was affected by period of birth.

4.3. PHENOTYPIC ASSOCIATION AMONG DIFFERENT LIFETIME PRODUCTION EFFICIENCY TRAITS AND BREEDING EFFICIENCY

The phenotypic correlation is association between phenotypic values of different traits measured on the same animal. It is a joint function of genotype and environment and interaction if any, between the two, but their relative contribution may vary.

4.3.1. Phenotypic association among different lifetime production efficiency traits

The phenotypic correlations among different lifetime production efficiency traits have been illustrated in tables 18 to 23 upto various parities.

4.3.1.1. Association of LTMY with MYPDLL, MYPDL and MYPDCI :

Estimates of phenotypic correlation coefficients of lifetime milk yield (LTMY) with milk yield per day of lactating life (MYPDLL), milk yield per day of productive life

Table 18 : Association among different lifetime production traits and breeding effeciency upto first parity

Parameters	LTMY	MYPDLL	MYPDL	MYPDCI
LRS, Bikaner	No. 55			
LTMY	1.0000			
MYPDLL	0.6943	1.0000		
MYPDL	0.6943	1.0000	1.0000	
MYPDCI	0.7750	0.6235	0.6235	1.0000
LRS, Nohar	No. 117			
LTMY	1.0000			
MYPDLL	0.5502	1.0000		
MYPDL	0.5502	1.0000	1.0000	
MYPDCI	0.7670	0.6482	0.6482	1.0000
Over all	No. 172			
LTMY	1.0000			
MYPDLL	0.5952	1.0000		
MYPDL	0.5952	1.0000	1.0000	
MYPDCI	0.7632	0.6586	0.6586	1.0000

All correlation coefficients are significant at $P<0.01$
No. =Number of observations

Table 19 : Association among different lifetime production traits and breeding effeciency upto second parity

Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
LRS, Bikaner	No. 43				
LTMY	1.0000				
MYPDLL	0.7251	1.0000			
MYPDL	0.8032	0.8706	1.0000		
MYPDCI	0.7588	0.7043	0.9226	1.0000	
BE	-0.3112	0.1897 NS	0.0273 NS	0.0835 NS	1.0000
LRS, Nohar	No. 93				
LTMY	1.0000				
MYPDLL	0.6409	1.0000			
MYPDL	0.8042	0.7477	1.0000		
MYPDCI	0.8019	0.8135	0.8230	1.0000	
BE	-0.4815	0.0314 NS	0.0632 NS	0.0520 NS	1.0000
Over all	No. 136				
LTMY	1.0000				
MYPDLL	0.6246	1.0000			
MYPDL	0.7531	0.7260	1.0000		
MYPDCI	0.6421	0.8036	0.8545	1.0000	
BE	-0.2124	0.0249 NS	0.0129 NS	0.0865 NS	1.0000

NS indicates non-significant correlation while all other were significant at $p<0.01$

No. =Number of observations

Table 20 : Association among different lifetime production traits and breeding effeciency upto third parity

Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
LRS, Bikaner	No. 30				
LTMY	1.0000				
MYPDLL	0.7568	1.0000			
MYPDL	0.7815	0.7648	1.0000		
MYPDCI	0.6735	0.7714	0.8778	1.0000	
BE	-0.3032 NS	0.0921 NS	0.1417 NS	0.0453 NS	1.0000
LRS, Nohar	No. 66				
LTMY	1.0000				
MYPDLL	0.7140	1.0000			
MYPDL	0.7783	0.7463	1.0000		
MYPDCI	0.7137	0.7432	0.9166	1.0000	
BE	-0.1810 NS	0.0638 NS	0.1224 NS	0.1252 NS	1.0000
Over all	No. 96				
LTMY	1.0000				
MYPDLL	0.7666	1.0000			
MYPDL	0.8020	0.7525	1.0000		
MYPDCI	0.7448	0.7578	0.9003	1.0000	
BE	-0.2418 NS	0.0901 NS	0.0695 NS	0.0928 NS	1.0000

NS indicates non-significant correlation while all other were significant at $p<0.01$

No. =Number of observations

Table 21 : Association among different lifetime production traits and breeding effeciency upto fourth parity

Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
LRS, Bikaner	No. 19				
LTMY	1.0000				
MYPDLL	0.6822	1.0000			
MYPDL	0.8112	0.7040	1.0000		
MYPDCI	0.8039	0.6713	0.7081	1.0000	
BE	-0.5918	0.3877 NS	0.0802 NS	0.2630 NS	1.0000
LRS, Nohar	No.59				
LTMY	1.0000				
MYPDLL	0.6851	1.0000			
MYPDL	0.7609	0.7243	1.0000		
MYPDCI	0.7918	0.7634	0.9180	1.0000	
BE	-0.3241	0.0409 NS	0.0198 NS	0.0569 NS	1.0000
Over all	No.78				
LTMY	1.0000				
MYPDLL	0.7314	1.0000			
MYPDL	0.7023	0.6962	1.0000		
MYPDCI	0.7408	0.7442	0.8440	1.0000	
BE	-0.2617	0.1118 NS	0.1984 NS	0.0902 NS	1.0000

NS indicates non-significant correlation while all other were significant at $p<0.01$
No. =Number of observations

Table 22 : Association among different lifetime production traits and breeding effeciency upto fifth parity

Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
LRS, Bikaner	No. 15				
LTMY	1.0000				
MYPDLL	0.8151	1.0000			
MYPDL	0.8026	0.8081	1.0000		
MYPDCI	0.7914	0.8804	0.8895	1.0000	
BE	-0.5497	0.2179 NS	0.1255 NS	0.1475 NS	1.0000
LRS, Nohar	No. 39				
LTMY	1.0000				
MYPDLL	0.6347	1.0000			
MYPDL	0.7052	0.6496	1.0000		
MYPDCI	0.7133	0.6713	0.9149	1.0000	
BE	-0.3231	0.1556 NS	0.2263 NS	0.3164 NS	1.0000
Over all	No. 54				
LTMY	1.0000				
MYPDLL	0.7674	1.0000			
MYPDL	0.7039	0.6036	1.0000		
MYPDCI	0.7252	0.6525	0.9122	1.0000	
BE	-0.3518	0.2007 NS	0.1942 NS	0.2410 NS	1.0000

NS indicates non-significant correlation while all other were significant at $p<0.01$

No. =Number of observations

Table 23 : Association among different lifetime production traits and breeding effeciency upto sixth and higher parities

Parameters	LTMY	MYPDLL	MYPDL	MYPDCI	BE
LRS, Bikaner	No. 21				
LTMY	1.0000				
MYPDLL	0.7055	1.0000			
MYPDL	0.7981	0.8822	1.0000		
MYPDCI	0.7932	0.8849	0.8734	1.0000	
BE	-0.4287	NS 0.2124	NS 0.1206	NS 0.1718	1.0000
LRS, Nohar	No. 71				
LTMY	1.0000				
MYPDLL	0.7052	1.0000			
MYPDL	0.6523	0.6486	1.0000		
MYPDCI	0.6915	0.7793	0.7707	1.0000	
BE	-0.2967	NS 0.1391	NS 0.0960	NS 0.1592	1.0000
Over all	No. 92				
LTMY	1.0000				
MYPDLL	0.6956	1.0000			
MYPDL	0.8200	0.6846	1.0000		
MYPDCI	0.8084	0.6635	0.8138	1.0000	
BE	-0.3129	NS 0.1018	NS 0.1492	NS 0.0983	1.0000

NS indicates non-significant correlation while all other were significant at $p<0.01$

No. =Number of observations

upto termination of ith lactation (MYPDL) and milk yield per day of productive life upto start of next lactation (MYPDCI) were 0.5952, 0.5952 and 0.7632 upto first parity; 0.6246, 0.7531 and 0.6421 upto second parity; 0.7666, 0.8020 and 0.7448 upto third parity; 0.7314, 0.7023 and 0.7408 upto fourth parity; 0.7674, 0.7039 and 0.7252 upto fifth parity and 0.6956, 0.8200 and 0.8084 upto sixth and higher parities, respectively for overall group of Rathi cows. These estimates for Rathi cows of Bikaner farm were 0.6943, 0.6943 and 0.7750 upto first parity; 0.7251, 0.8032 and 0.7588 upto second parity; 0.7568, 0.7815 and 0.6734 upto third parity; 0.6822, 0.8112 and 0.8039 upto fourth parity; 0.8151, 0.8026 and 0.7914 upto fifth parity and 0.7055, 0.7981 and 0.7932 upto sixth and higher parities, respectively whereas for Rathi cows of Nohar farm, these estimates were 0.5502, 0.5502 and 0.7670 for first parity; 0.6409, 0.8042 and 0.8019 upto second parity; 0.7140, 0.7783 and 0.7137 upto third parity; 0.6851, 0.7609 and 0.7918 upto fourth parity; 0.6347, 0.7052 and 0.7133 upto fifth parity and 0.7052, 0.6523 and 0.6915 upto sixth and higher parities, respectively.

These estimates were high in magnitude, positive and statistically significant ($p < 0.01$) at all the stages of lifetime indicating that higher performers were also higher producers.

Gupta (1993) obtained similar results upto various parities in Rathi cattle. He also obtained high magnitude, positive and highly significant phenotypic correlation of LTMY with MYPDLL, MYPDL and MYPDCI and concluded that higher performers were efficient producers too.

Similarly, high magnitude, positive and highly significant phenotypic correlation of LTMY with MYPDLL, MYPDL and MYPDCI were noticed by Gahlot (1990) in Tharparkar cows.

Gill and Allaire (1976) estimated the phenotypic correlation of lifetime milk yield with milk yield per day of life and herd life as 0.63 and 0.97, respectively in dairy cattle.

Dhumal et al. (1993) also noticed phenotypic correlation of lactation yield with milk yield per day of lactation length and milk yield per day of calving interval and reported that these were high in magnitude, positive and significantly correlated.

4.3.1.2. Association of MYPDLL with MYPDL and MYPDCI :

The estimates of phenotypic correlation coefficients of milk yield per day lactating life (MYPDLL) with milk yield per day of productive life upto termination of ith lactation (MYPDL), milk yield per day of productive life upto start of next lactation (MYPDCI) were 1.0000 and 0.6586 upto first parity; 0.7260 and 0.8036 upto second parity; 0.7525 and 0.7578 upto third parity; 0.6942 and 0.7442 upto fourth parity; 0.6036 and 0.6525 upto fifth parity and 0.6846 and 0.6635 upto sixth and higher parities, respectively for overall group of Rathi cows. These estimates for Rathi cows of Bikaner farm were 1.0000 and 0.6235 upto first parity; 0.8706 and 0.7043 upto second parity; 0.7648 and 0.7714 upto third parity; 0.7040 and 0.6713 upto fourth parity; 0.8081 and 0.8804 upto fifth parity and 0.8822 and 0.8849 upto sixth and higher parities, respectively, whereas for Nohar farm i.e., Nohar, these estimates were 1.0000 and 0.6482 upto first parity; 0.7477 and 0.8135 upto second parity; 0.7463 and 0.7432 upto third parity; 0.7243 and 0.7634 upto fourth parity; 0.6496 and 0.6713 upto fifth parity and 0.6486 and 0.7793 upto sixth and higher parities, respectively.

These correlations were very high, positive and statistically significant ($P < 0.01$) at all the stages of lifetime.

Similar association among MYPDLL with MYPDL and MYPDCI were reported by Gupta (1993) in Rathi cows and Gahlot (1990) in Tharparkar cows.

Ulmek and Patel (1993) obtained positive and significant phenotypic correlation among milk yield per day of first calving interval and milk yield per day of first lactation length.

4.3.1.3. Association of MYPDL with MYPDCI :

The estimates of phenotypic correlation coefficients between milk yield per day of productive life upto termination of ith lactation (MYPDL) and milk yield per day of productive life upto start of next lactation (MYPDCI) were 0.6586 upto first parity; 0.8545 upto second parity; 0.9003 upto third parity; 0.8440 upto fourth parity; 0.9122 upto fifth parity; and 0.8138 upto sixth and higher parities for overall group of Rathi cows. The corresponding correlation coefficients for Rathi cows of Bikaner farm were 0.6235, 0.9226, 0.8778, 0.7081, 0.8895 and 0.8734 upto first, second, third, fourth, fifth and sixth and higher parities, respectively, while for Rathi cows of Nohar farm the corresponding correlations were 0.6482, 0.8230, 0.9166, 0.9180, 0.9149 and 0.7707 upto respective parities. These estimates were high in magnitude, positive and statistically significant ($P < 0.01$).

The positive and high magnitude correlations between production efficiency traits like MYPDLL and MYPDCI, which are composite traits represented a ratio of lifetime production to the productive life time upto various stages of productive life suggesting that any of the production efficiency traits is sufficient for selection of animals for improvement in production efficiency. In terms of merit,however, MYPDCI might be better measure of production efficiency as it considers both productive and unproductive part of productive life whereas MYPDL does not consider the dry period of current lactation and it takes in account only the productive part of current lactation.

Similar results were obtained by Gahlot (1990) on Tharparkar cows for association between MYPDL and MYPDCI upto various stages of life. He also concluded that the traits considering productive as well as unproductive portion of lifetime was better one then those which consider only productive life or did not account the dry period of the current lactation. Similarly, Gupta (1993) also observed same results in Rathi cattle upto various stages of life.

4.3.2. Phenotypic association among breeding efficiency and different lifetime production efficiency traits

The phenotypic correlation between BE and different lifetime production efficiency traits are illustrated in tables 18 to 23.

The estimates of phenotypic correlation coefficients of BE with LTMY, MYPDLL, MYPDL and MYPDCI were -0.2124, 0.0249, 0.0219 and 0.0865 upto second parity; -0.2418, 0.0901, 0.0695 and 0.0928 upto third parity; -0.2617, 0.1118, 0.1984 and 0.0902 upto fourth parity; -0.3518, 0.2007, 0.1942 and 0.2410 upto fifth parity and -0.3129, 0.1018, 0.1492 and 0.0983 upto sixth and higher parities, respectively for overall group of Rathi cows. The values of these estimates for Rathi cows of Bikaner farm were -0.3112, 0.1897, 0.0273 and 0.0835 upto second parity; -0.3032, 0.0921, 0.1417 and 0.0453 upto third parity; -0.5918, 0.3877, 0.0802 and 0.2630 upto fourth parity; -0.5497, 0.2179, 0.1255 and 0.1475 upto fifth parity and -0.4287, 0.2127, 0.1206 and 0.1718 upto sixth and higher parities, respectively, while for Rathi cows of Nohar farm, these estimates were -0.4815, 0.0314, 0.0632 and 0.0520 upto second parity; -0.1810, 0.0638, 0.1224 and 0.1252 upto third parity; -0.3241, 0.0409, 0.0198 and 0.0569 upto fourth parity; -0.3231, 0.1556, 0.2263 and 0.3164 upto fifth parity and -0.2967, 0.1391, 0.0960 and 0.1592 upto sixth and higher parities, respectively.

These estimates indicates that BE was negatively and significantly correlated with LTMY upto all the stages of life except upto third parity where it was non-significant for Bikaner farm, Nohar farm and overall group of Rathi cows.

It is also indicated that BE was positive and non-significantly correlated phenotypically with MTPDLL, MYPDL and MYPDCI upto all the stages of life for Bikaner farm, Nohar farm and overall group of Rathi cows.

On review cited for correlation of BE with lifetime production efficiency traits, only few references could be obtained on association of these traits and for correlation of BE with MYPDLL and MYPDCI non of the review could be obtained.

Gupta and Bhatnagar (1979) observed the negative relationship between breeding efficiency and five lactation milk yield. Negative and significant correlation between breeding efficiency and producing ability was observed by Kumar (1981).

Purakayastha (1980) reported the non-significant correlation between breeding efficiency and milk yield. Reddy et al. (1988) obtained negative correlation between breeding efficiency and milk yield (-0.06).

Negative phenotypic correlation was observed by Gandhi and Gurnani (1990) of breeding efficiency with first lactation milk yield (-0.33), first lactation length (-0.32) and first calving interval (-0.068). Qureshi and Barwe (1990) also reported significant negative correlation (-0.780) between breeding efficiency and calving interval.

No information could be collected under the review cited for correlation coefficient between lifetime milk production traits and breeding efficiency upto various stages of life.

4.4. SUGGESTED SELECTION CRITERIA FOR IMPROVEMENT IN THE FARM

Although for the sound breeding strategies and selection programmes reliable estimates of genetic parameters, viz. heritabilities, genetic correlations and breeding value of sires and cows is necessary but based on the observations made and conclusions drawn from this investigation following suggestions are given for further improvement in the farm.

The production performance of an animal is greatly influenced by environmental fluctuations and probably the nutritional regimes over the year. Observations on phenotypic scale upto different parities indicated a great fluctuation even in the farm condition and such effect are more pronounced at farmers level where the management control on the cattle grazing ranges and pastures are not practical due to poor economic status of dairy cattle breeder in native area of Rathi cattle i.e., arid and semi-arid region of North-Western Rajasthan.

It may be concluded that among the lifetime production efficiency traits the correlation is highly significant and positive indicating that selection on LTMY would be sufficient to bring improvement in other traits also.

The selection on LTMY upto first lactation would also be effective in improving lifetime production efficiency at later stages of life.

Among all the production efficiency measures, MYPDCI could be a best measure of choice as it accounts for productive and unproductive efficiency together.

SUMMARY

5. SUMMARY

The present study was under taken on 628 normal lactation records of Rathi cows generated from 1974 to 1993 at two units viz., Livestock Research Station, Bikaner (F-1) pertained 183 records and Livestock Research Station, Nohar (F-2) pertained 445 records. Out of 628 records, 172 for first parity (F1-55, F2-117), 136 for second parity (F1-43, F2-93), 96 for third parity (F11-30, F2-66), 76 for fourth parity (F1-19, F2-59), 54 for fifth parity (F1-15, F2-39) and 92 for sixth and above parities (F1-21, F2-71). The objectives of the study were to evaluate Rathi cows for lifetime production and breeding efficiency, estimate the non-genetic factors affecting the lifetime production and breeding efficiency, estimate association among lifetime production efficiency traits and breeding efficiency and to device the suitable selection criteria for maximizing the lifetime production. The lifetime measures for production and breeding efficiency evaluation were from production upto first parity to production upto sixth and above parities. The lifetime efficiencies were studied interms of lifetime milk yield upto termination of ith lactation (LTMYi), milk yield per day of lactating life upto termination of ith lactation (MYPDLLi), milk yield per day of productive life upto termination of ith lactation (MYPDLi), milk yield per day of productive life upto start of i+1th lactation (MYPDCIi) and breeding efficiency upto ith calving (BEi).

The total duration of twenty years of performance was sub-divided into four periods viz., first (1974-1980), second (1981-1985), third (1986-1990)and fourth (1991-1993). Each year was further divided into four seasons on the basis of temperature variation throughout the year viz., Comfort (1st March to 15th April and 1st October to 30th October), Hot-Dry (16th April to 15th July), Hot-Humid (16th July to 30th September) and Winter (1st November to 29th February).

The mean±SD of LTMY for overall herd was 1866.95±494.37, 3469.86±1056.76, 5119.13±1411.59, 6826.82±1739.46, 8652.13±1896.64 and 11934.22±3823.48 litres upto first, second, third, fourth, fifth and sixth and above parities, respectively. For Rathi cows of Bikaner farm LTMY was 1622.16±514.97, 3204.51±1082.36, 4827.43±1291.61, 6510.57±1944.13, 8203.93±2020.90 and 9504.71±2347.00 litres and for Nohar farm it was 1982.03±441.65, 3592.54±1027.49, 5252.63±1447.85, 6928.66±1673.49, 8824.51±1844.66 and 12652.81±3890.55 litres upto respective parities. The high increase in milk yield upto sixth and higher parities as compared to fifth parity at Nohar farm might be due to consideration of higher parities in the sixth parity and this was a average estimate of cumulative milk yield of sixth and higher parities.

The CV for LTMY was decreased from 30.45 per cent upto second parity to 21.92 per cent upto fifth parity for overall group, whereas CV declined from 35.77 per cent upto second parity to 24.69 per cent upto sixth and above parities for

Bikaner farm, while for Nohar farm it was decreased from 28.60 per cent upto second parity to 20.90 per cent upto fifth parity. The CV upto second parity increased in Bikaner farm , Nohar farm and overall group. Similarly, CV increased in sixth and above parities in Nohar farm and overall group.

The mean±SD of MYPDLL for overall group of Rathi cows was 5.9576±1.2429, 6.3622±1.2987, 6.5649±0.9392, 6.8669±0.9585, 6.9560±0.8424 and 7.0383±0.8389 litres, respectively upto first, second, third, fourth, fifth and sixth and above parities. It was 4.9800±0.9749, 5.7097±0.8752, 5.8202±0.7082, 6.1722±0.6576, 6.2480±0.5514 and 6.2896±0.5739 litres for Rathi cows of Bikaner farm and 6.4171±1.0810, 6.6639±0.9541, 6.9034±0.8825, 7.0906±0.9362, 7.2283±0.7771 and7.2598±0.7531 litres for Rathi cows of Nohar farm upto respective stages of lifetime. The CV continuously declined from upto first parity to upto sixth and above parities in Bikaner farm, Nohar farm and overall group. The range of CV was 20.86 to 11.91 per cent for overall group, 19.57 to 9.12 per cent for Bikaner farm and 16.85 to 10.37 per cent for Nohar farm, respectively from first parity to upto sixth and above parities. The means of Rathi cows of Nohar farm were higher than the means of Rathi cows of Bikaner farm.

The mean±SD of MYPDL for overall herd was 5.9576±1.2429, 4.8560±1.2659, 4.9257±1.0378, 5.0507±0.8819, 5.0877±0.8440 and 5.1616±0.8007 litres, respectively upto first, second, third, fourth, fifth and sixth and above parities. It was 4.9800±0.9749, 4.3298±1.0459, 4.3946±1.0343, 4.5083±0.9994, 4.5409±0.8155 and 4.6298±0.8004 litres for Rathi cows of Bikaner farm and 6.4171±1.0810, 5.1046±1.2912, 5.1671±0.9526, 5.2253±0.7715, 5.2981±0.7649 and 5.3189±0.6783 litres for Rathi cows of Nohar farm upto respective parities. The means of Nohar herd were higher than the means of Bikaner herd for all the stages of life.

The CV of MYPDL wase decreased continuously from upto second parity to upto sixth and above parities for all the groups of Rathi cows. The range of CV for overall group was 26.06 to 15.551 per cent, for Bikaner farm 24.15 to 17.28 per cent and for Nohar farm 25.29 to 12.75 per cent, respectively upto second parity to upto sixth and above parities, while in all the groups CV increased upto second parity.

The mean±SD of MYPDCI for overall group was 4.1900±1.1430, 4.3124±1.0758, 4.4360±0.9733, 4.6105±0.8600, 4.7159±0.7644 and 4.7411±0.7237 litres, respectively upto first, second, third, fourth, fifth and sixth and above parities. These were 3.5612±0.9613, 3.7966±0.9463, 3.8256±0.9239, 4.1216±0.7809, 4.2182±0.7352 and 4.2968±0.7413 litres for BIkaner farm and 4.4856±1.1046, 4.5509±1.1091, 4.7134±0.8682, 4.7680±0.8301, 4.8433±0.7109 and 4.8725±0.6387 litres for Nohar farm upto respective parities. The MYPDCI means of Rathi cows of Nohar farm were higher than the BIkaner farm for all the stages of life. The CV was continuously decreased from upto first parity to upto sixth and above parties for all the groups of Rathi cows. The range of CV was 27.27 per cent upto first parity to 15.26 per cent upto sixth and above parities for overall group of Rathi cows. Similarly, its range was 26.99 to 17.25 per cent for Bikaner farm and 24.26 to 13.10 per cent for Nohar farm respectively upto first parity to upto sixth and above parities.

The mean±SD of BE for overall herd was 80.57±17.5309, 81.07±14.9324, 84.25±13.3066, 86.85±11.9760 and 97.45±9.8037 per cent, respectively upto second, third, fourth, fifth and sixth and above parities. For Bikaner farm these estimates were 69.60±18.0357, 73.51±15.9639, 77.07±13.6241, 78.78±13.3458 and 85.80±8.2617 per cent and for Nohar farm 85.65±14.8361, 84.51±13.1826, 86.56±12.4511, 89.95±9.9441 and 87.94±10.2172 per cent upto respective parities. The means of the two farm showed that the breeding efficiency of Rathi cows of Nohar farm was better than Bikaner farm. The CV of BE declined from upto second parity to upto sixth and above parities for all the groups of Rathi cows. The range of CV was maximum (21.75 per cent) upto second parity to minimum (11.21 per cent) upto sixth and above parities for overall group. Similarly, its range was maximum (25.91 per cent) to minimum (9.62 per cent) for Bikaner farm and maximum (17.32 per cent) to minimum (11.61 per cent) for Nohar farm upto respective parities.

The least-squares analysis of variance revealed that effect of farm was significant ($P < 0.01$) for LTMY upto first parity and for upto sixth and above parities but for rest of the parities its effect was observed non-significant. While its effect on MYPDLL, MYPDL and MYPDCI was observed significant

(P <0.01) for all the stages of life except upto MYPDL2 and MYPDL5 where it was significant (P <0.05) and for MYPDCI5 it was non-significant. The effect of season of first calving was observed non-significant for all the lifetime production efficiency traits at all the stages of life except upto sixth and above parities where it was observed highly significant (P <0.01) for LTMY and significant (P <0.05) for MYPDCI. The effect of period of first calving was observed highly significant (P <0.01) for MYPDLL1, MYPDL1, MYPDCI1, MYPDL2 and MYPDLL3, but significant (P <0.05) for MYPDL3, MYPDCI3, and MYPDLL6 while for remaining lifetime production efficiency traits upto various parities it was observed non-significant.

The effect of farm on breeding efficiency was observed non-significant upto various parities except upto parity second where it was significant (P <0.05). The effect of season and period was observed non-significant for BE upto various parities except to BE5 and BE6 for seasons (P <0.01) and BE2 (P <0.05) and BE6 (P <0.01) for periods where it was observed significant.

The estimates of phenotypic correlation coefficients of LTMY with MYPDLL, MYPDL and MYPDCI were 0.5952, 0.5952 and 0.7632; 0.6246, 0.7531 and 0.6421; 0.7666, 0.8020 and 0.7448; 0.7314, 0.7023 and 0.7408; 0.7674, 0.7039 and 0.7252; and 0.6956, 0.8200 and 0.8084 upto first, second, third, fourth, fifth and sixth and above parities, respectively for overall farm of Rathi cows. These estimates of Rathi cows of Bikaner farm were

0.6943, 0.6943 and0.7750; 0.7251, 0.8032 and 0.7588; 0.7568, 0.7815 and 0.6734; 0.6822, 0.8112 and 0.8039; 0.8151, 0.8026 and 0.7914; and 0.7055, 0.7981 and 0.7932 and of Rathi cows of Nohar farm were 0.5502, 0.5502 and 0.7670; 0.6409, 0.8042 and 0.8019; 0.7140, 0.7783 and 0.7137; 0.6851, 0.7609 and 0.7918; 0.6347, 0.7052 and 0.7153; and 0.7052, 0.6523 and 0.6915 upto respective parities in that order.

The estimates of phenotypic association of MYPDLL with MYPDL and MYPDCI were 1.0000 and 0.6586; 0.7260 and 0.8036; 0.7525 and 0.7578; 0.6942 and 0.7442; 0.6036 and 0.6525; and 0.6846 and 0.6635 of overall group of Rathi cows, 1.0000 and 0.6235; 0.8706 and 0.7043; 0.7648 and 0.7714; 0.7040 and 0.6713; 0.8081 and 0.8804; and 0.8822 and 0.8849 for Rathi cows of Bikaner farm and 1.0000 and 0.6482; 0.7477 and 0.8135; 0.7463 and 0.7432; 0.7243 and0.7634; 0.6496 and 0.6713; and 0.6486 and 0.7793 for Rathi cows of Nohar farm from first to upto sixth and above parities respectively in that order.

The phenotypic association upto respective parities between MYPDL and MYPDCI were 0.6586, 0.8545, 0.9003, 0.8440, 0.9122 and 0.8138 for overall group of Rathi cows; 0.6235, 0.9226, 0.8778, 0.7081, 0.8895 and 0.8734 for Rathi cows of Bikaner farm; and 0.6482, 0.8230, 0.9166, 0.9180, 0.9149 and 0.7707 for Rathi cows of Nohar farm.

The phenotypic association between lifetime production efficiency traits were high in magnitude, positive and statistically highly significant ($P < 0.01$) for all the lifetime production efficiency traits for all the stages of life.

The phenotypic association of BE with LTMY, MYPDLL, MYPDL and MYPDCI were -0.2124, 0.0249, 0.0219 and 0.0865; -0.2418, 0.0901, 0.0695 and 0.0928; -0.2617, 0.1118, 0.1984 and 0.0902; -0.3518, 0.2007, 0.1942 and 0.2410; and -0.3129, 0.1018, 0.1492 and 0.0983 for overall group of Rathi cows, -0.3112, 0.1897, 0.0273 and 0.0835; -0.3032, 0.0921, 0.1417 and 0.0453; -0.5918, 0.3877, 0.0802 and 0.2630; -0.5497, 0.2179, 0.1255 and 0.1475; and -0.4287, 0.2127, 0.1206 and 0.1718 for Rathi cows of Bikaner farm and -0.4815, 0.0314, 0.0632 and 0.0520; -0.1810, 0.0638, 0.1224 and 0.1252; -0.3241, 0.0409, 0.0198 and 0.0569; -0.3231, 0.1556, 0.2263 and 0.3164; and -0.2967, 0.1391, 0.0960 and 0.1592 for Rathi cows of Nohar farm, respectively upto second parity to sixth and above parities in that order.

These estimates showed that BE was negatively and significantly ($P < 0.01$) correlated with LTMY for all the stages of life except upto third parity where it was negative and non-significant, while association of BE with MYPDLL, MYPDL and MYPDCI were positive and non-significant for all the stages of life.

After observing the estimates obtained it may concluded that cows at Nohar farm had better production and breeding efficiency than those at Bikaner farm. This could be attributed to availability of green fodder throughout the year at Nohar farm.

It may be concluded that among the lifetime production efficiency traits the correlation is highly significant and positive indicating that selection on LTMY would be sufficient to bring improvement in other traits also.

The selection on LTMY upto first lactation would also be effective in improving lifetime production efficiency at later stages of life.

Among all the production efficiency measures, MYPDCI could be a best measure of choice as it accounts for productive and unproductive efficiency together.

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6. LITERATURE CITED

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LIFETIME PRODUCTION AND BREEDING EFFICIENCY OF RATHI COWS

M.V.Sc. Thesis
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ABSTRACT

The performance records of 628 lactation of Rathi cows maintained at Bikaner and Nohar stations, calved during 1974 to 1993 were analysed for lifetime milk yield upto termination of ith lactation (LTMYi), milk yield per day of lactating life upto termination of ith lactation (MYPDLLi), milk yield per day of productive life upto termination of ith lactation (MYPDLi), milk yield per day of productive life upto start of i+1th lactation (MYPDCIi) and breeding efficiency upto ith calving (BEi) upto first, second, third, fourth, fifth, and sixth and above parities. The total duration of twenty years of performance was sub-divided into four periods (1974-1980, 1981-1985, 1986-1990 and 1991-1993) and each year was further divided into four seasons (Comfort, Hot-Dry, Hot-Humid and Winter).

The mean±SD of LTMY ranged from 1622.16±514.97 litres upto firs parity to 9504.71±2347.00 litres upto sixth and higher parities for Bikaner farm and from 1982.03±441.65 litres upto first parity to 12652.81±3890.50 litres upto sixth and higher parities for Nohar farm. The mean±SD of MYPDLL ranged from 4.98±0.97 litres upto first parity to 6.28±0.57 litres upto sixth and higher parities for Bikaner farm and 6.41±1.08 litres upto first parity to 7.25±0.75 litres upto sixth and higher parities for Nohar farm.

The mean±SD of MYPDL was 4.98±0.97 litres upto first parity, after that it ranged from 4.32±1.04 litres upto second parity to 4.62±0.80 litres upto sixth and higher parities for Bikaner farm and it was 6.41±1.08 litres upto first parity, than it ranged from 5.10±1.29litres upto second parity to 5.31±0.67 litres upto sixth and higher parities for Nohar farm. The mean±SD of MYPDCI was ranging from 3.56±0.96 litres upto first parity to 4.29±0.74 litres upto sixth and higher parities for Bikaner farm and from 4.48±1.10 litres upto first parity to 4.87±0.63 litres upto sixth and higher parities for farm.

The mean±SD of BE ranged from 69.90±18.03 percent upto second parity to 85.80±8.26 percent upto sixth and higher parities for Bikaner farm and from 85.65±14.83 percent upto second parity to 87.94±10.21 percent upto sixth and higher parities for Nohar farm.

The least-squares analysis of variance revealed that effect of farm was significant (P <0.01) for LTMY upto first parity and for upto sixth and above parities but for rest of the parities its effect was observed non-significant. While its effect on MYPDLL, MYPDL and MYPDCI was observed significant (P <0.01) for all the stages of life except upto MYPDL2 and MYPDL5 where it was significant (P <0.05) and for MYPDCI5 it was non-significant. The effect of season of first calving was observed non-significant for all the lifetime production efficiency traits at all the stages of life except upto sixth and above parities where it was observed highly significant (P <0.01) for LTMY and significant (P <0.05) for MYPDCI. The effect of period of first calving was observed highly significant (P <0.01) for MYPDLL1, MYPDL1, MYPDCI1, MYPDL2 and MYPDLL3, but significant (P <0.05) for MYPDL3, MYPDCI3, and MYPDLL6 while for remaining lifetime production efficiency traits upto various parities it was observed non-significant.

The effect of farm on breeding efficiency was observed non-significant upto various parities except upto parity second where it was significant (P <0.05). The effect of season and period was observed non-significant for BE upto various parities except to BE5 and BE6 for seasons (P <0.01) and BE2 (P <0.05) and BE6 (P <0.01) for periods where it was observed significant.

The correlation coefficients among lifetime production efficiency traits were positive, high in magnitude and highly significant (p <0.01) for all the stages of life. The correlation coefficients of BE with LTMY were significant (p <0.05) and negative for all the stages of life except upto third parity, where it was negative and non-significant, while BE was non-significant and positively correlated with MYPDLL, MYPDL and MYPDCI for all the stages of life in both the farm.

On the basis of results of analysis, it was concluded that among the lifetime production efficiency traits the correlation coefficient is highly significant and positive indicating that selection on LTMY would sufficient to bring improvement in other traits also.

The selection on LTMY upto first lactation would also be effective in improving lifetime production efficiency at later stages of life.

Among all the production efficiency measures, MYPDCI could be a best measure of choice as it accounts for productive and reproductive efficiency together.

राठी गायों की जीवन कालीन उत्पादन एवं प्रजनन क्षमता

स्नातकोत्तर शोध प्रबन्ध
पशु प्रजनन एवं आनुवांशिकी विभाग
पशु चिकित्सा एवं पशु विज्ञान महाविद्यालय
राजस्थान कृषि विश्वविद्यालय
बीकानेर - 334001

प्रस्तुतकर्ता : अरविन्द कुमार पंवार

अनुक्षेपण

बीकानेर एवं नोहर प्रक्षेत्र पर पोषित राठी गायों, जो कि 1974 से 1993 के बीच ब्याई गयी, के 628 स्त्रवणों के निष्पादन आंकड़ों का जीवन कालीन दुग्ध उत्पादन (जीदुउ), दुग्ध उत्पादन प्रति स्त्रवण कालिक दिन (दुउप्रसदि), दुग्ध उत्पादन प्रति उत्पादन कालिक दिन (दुउप्रउदि), अगले दुग्ध स्त्रवण के प्रारम्भ तक प्रति उत्पादन कालिक दिन दुग्ध उत्पादन (अदुप्राप्रउदिदुउ) और प्रजनन क्षमता प्रति ब्यात कालिक दिन (प्रक्षप्रब्कादि) के लिए मूल्यांकन किया गया । 20 वर्षों के निष्पादन की पूर्ण अवधि को चार कालों (1974-1980, 1981-1985, 1986-1990 एवं 1991-1993) में अर्न्तविभक्त किया था और प्रत्येक वर्ष को आगे चार ऋतुओ (अनुकूल, उष्ण-शुष्क, उष्ण-आक्लिन्न एवं सर्दी) में विभक्त किया गया था ।

बीकानेर प्रक्षेत्र की गायों का औसत एवं मानक विचलन का सर्वव्यापी जीदुउ परिसर 1622.16 ± 514.97 लीटर प्रथम ब्यांत तक से 9504.71 ± 2347.00 लीटर छठे एवं ऊंचे ब्यांत तक और नोहर प्रक्षेत्र की गायों के लिए 1982.03 ± 441.65 लीटर प्रथम ब्यांत तक से 12652.81 ± 3890.50 लीटर छठे एवं ऊंचे ब्यांत तक था । दुउप्रउदि के लिए औसत ± मानक विचलन का परिसर बीकानेर प्रक्षेत्र के लिए 4.98 ± 0.97 लीटर प्रथम ब्यांत तक से 6.28 ± 0.57 लीटर छठे एवं ऊंचे ब्यांत तक और नोहर प्रक्षेत्र के लिए 6.41 ± 1.08 लीटर प्रथम ब्यांत तक से 7.25 ± 0.75 लीटर छटे एवं ऊंचे ब्यांत तक था ।

दुउप्रउदि के लिए औसत ± मानक विचलन बीकानेर प्रक्षेत्र 4.98 ± 0.97 लीटर प्रथम ब्यांत तक था तत्पश्चात् इसका परिसर 4.32 ± 1.04 लीटर द्वितीय ब्यांत तक से 4.62 ± 0.80 लीटर छठे व ऊंचे ब्यांतों तक था और नोहर प्रक्षेत्र के लिए 6.41 ± 1.08 लीटर प्रथम ब्यांत तक तत्पश्चात् इसका परिसर 5.10 ± 1.29 लीटर द्वितीय ब्यांत तक से 5.31 ± 0.67 लीटर छठे व ऊंचे ब्यांतों तक था ।

अदुप्राप उदिदुअ का बीकानेर प्रक्षेत्र के लिए परिसर 3.56 ± 0.96 लीटर प्रथम ब्यांत तक से 4.29 ± 0.74 लीटर छठे व ऊंचे ब्यांतों तक था और नोहर प्रक्षेत्र के लिए 4.48 ± 1.10 लीटर प्रथम ब्यांत तक से 4.87 ± 1.10 लीटर प्रथम ब्यांत तक से 4.87 ± 0.63 लीटर छठे व ऊंचे ब्यांतों तक था ।

प्रक्षप्रब्कादि के लिए औसत ± मानक विचलन का परिसर बीकानेर प्रक्षेत्र के लिए 69.90 ± 18.03 प्रतिशत द्वितीय ब्यांत तक से 85.50 ± 8.26 प्रतिशत छठे व ऊंचे ब्यांतों तक और नोहर प्रक्षेत्र के लिए 85.64 ± 14.83 प्रतिशत द्वितीय ब्यांत तक से 87.94 ± 10.21 प्रतिशत छठे व ऊंचे ब्यांतों तक था ।

न्यूनतम वर्ग विश्लेषण से प्रकट हुआ कि प्रक्षेत्र समूह का प्रभाव जीदुउ पर प्रथम और छठी व ऊंची ब्यांत पर अत्यधिक अर्थपूर्ण था किन्तु बाकि ब्यांतों के लिए अर्थपूर्ण नहीं पाया गया । जबकि इसका प्रथम दुउप्रस्त्रदि, दुउप्रउदि एवं अदुप्राप उदिदुअ के लिए दुउप्रउदि 2 एवं दुउप्रउदि 5 को छोड़कर जहां पर इसका प्रभाव अर्थपूर्ण पाया गया, जीवन के सभी स्तरों पर अत्यधिक अर्थपूर्ण पाया गया एवं अदुप्रापउदिदुअ पर इसका प्रभाव अर्थपूर्ण नहीं पाया गया ।

छठी व ऊंची ब्यांतों को छोड़कर, जीवन के सभी स्तरों पर उत्पादन क्षमता गुणों पर प्रथम ब्यांत की ऋतु का प्रभाव अर्थपूर्ण नहीं था । प्रथम ब्यांत के काल का प्रभाव दुउप्रस्त्रदि 1, दुउप्रउदि 1, अदुप्रापउदिदुअ 1, दुउप्रउदि 2, दुउप्रस्त्रदि 3 के लिए अत्यधिक अर्थपूर्ण एवं दुउप्रउदि 3, अदुप्रापउदिदुउ 3, दुउप्रस्त्रदि 6, व दुउप्रउदि 6 पर अर्थपूर्ण पाया गया जबकि शेष जीवन कालीन उत्पादन क्षमता गुणों पर विभिन्न ब्यांतों तक यह अर्थपूर्ण नहीं पाया गया ।

द्वितीय ब्यांत के अलावा जीवन काल के विभिन्न ब्यांतों तक प्रक्षप्रब्कादि पर प्रक्षेत्र का प्रभाव अर्थपूर्ण नहीं था । जीवनकाल के विभिन्न ब्यांतों तक प्रक्षप्रब्कादि पर प्रथम ब्यांत के ऋतु का प्रभाव, प्रक्षप्रब्कादि 5 एवं प्रक्षपब्कादि 6 को छोड़कर और प्रथम ब्यांत के काल का प्रभाव प्रक्षप्रब्कादि 6 को छोड़कर, अर्थपूर्ण नहीं पाया गया ।

जीवन के सभी स्तरों के लिए जीवन कालीन उत्पादन क्षमता गुणों के मध्य सहसम्बन्ध गुणांक अत्यधिक अर्थपूर्ण एवं धन दिशा में था । प्रक्षप्रब्कादि का जीदुउ के साथ जीवन के सभी स्तरों के लिए सहसम्बन्ध गुणांक, तृतीय प्रक्षप्रब्कादि को छोड़कर, अत्यधिक अर्थपूर्ण एवं ऋण दिशा में था जबकि दुउप्रस्त्रदि, दुउप्रउदि एवं अदुप्रापउदिदुउ के साथ यह धन दिशा में तथा अर्थपूर्ण नहीं था ।

मूल्यांकन के परिणामों के आधार पर यह निष्कर्ष निकाला गया कि जीवन कालीन उत्पादन क्षमता गुणों में सुधार लाने के लिए जीदुउ के लिए चयन ही पर्याप्त रहेगा, चूंकि इनमें परस्पर अत्यधिक अर्थपूर्ण तथा धन सहसम्बन्ध था ।

जीवन कालीन उत्पादन क्षमता के पिछले स्तरों में सुधार के लिए प्रथम ब्यांत के जीदुउ पर चयन ही प्रभावशाली रहेगा ।

सभी उत्पादन क्षमता के परस्पर मापन में अदुप्रापउदिदुअ मापन का चुनाव श्रेष्ठ हो सकता है, चूंकि यह उत्पादन एवं प्रजनन की साथ-साथ गणना करता है ।