

GENETIC EVALUATION OF LIFE TIME
PRODUCTION AND REPRODUCTION
IN THARPARKAR CATTLE

By Subhash Chander
N.D.R.I., Karnal.

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The genetic parameters or economic characters for a particular breed located at a herd, need not necessarily be the same for same breed located at another place. These estimates change with the managerial practices and the level of production even within breed in a herd.

The economics of dairying revolve around, not only on the milk yield alone but also is associated with breeding efficiency. The primary objective of the cattle breeder is to improve the profitability of the dairy enterprise by increasing their life time milk production. An early age at first calving also reduces the unproductive period of a cow and thus helps in increasing the productivity. It has been felt that early calving might adversely affect the first lactation production and so cautious attempts are made to reduce the age at first calving. It, therefore, becomes essential at this stage to see how age at first calving is related with milk production and the breeding efficiency. It is believed that the breeding efficiency is lowered by postponing the first calving to a later age or by delaying of calvings subsequently as it may disrupt the normal reproductive cycle.

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Genetics Evaluation

Hampshire cattle

"S. S. P. A. M. C."

INTRODUCTION

The genetic parameters of economic characters for a particular breed located at a herd, need not necessarily be the same for same breed located at another place. These estimates change with the managerial practices and the level of production even within breed in a herd.

The economics of dairying revolve around, not only on the milk yield alone but also is associated with breeding efficiency. The primary objective of the cattle breeder is to improve the profitability of the dairy enterprise by increasing their life time milk production. An early age at first calving also reduces the unproductive period of a cow and thus helps in increasing the productivity. It has been felt that early calving might adversely affect the first lactation production and so cautious attempts are made to reduce the age at first calving. It, therefore, becomes essential at this stage to see how age at first calving is related with milk production and the breeding efficiency. It is believed that the breeding efficiency is lowered by postponing the first calving to a later age or by delaying of calvings subsequently as it may disrupt the normal reproductive cycle.

Gethin (1950) argued that early calvings are profitable from the point of more calvings and extra-productive life resulting into more life time milk production. Early calvings tend to reduce the generation interval which might help in higher annual genetic gains.

With the possibility that maximum life time production is associated with optimal age at first calving, early performance and optimal breeding efficiency and bringing simultaneously effective genetic improvement in two or more characteristics, it becomes imperative to investigate the heritability, genetic and phenotypic correlation among different characteristics. These relationships also help in constructing the prediction equations. The expected genetic improvement by selection in a population depends upon the variability and the relationship between the traits for which selection is practiced. Judicious culling of low producing animals is an important phenomenon for livestock improvement in breeding programmes. At which stage an animal should be culled is an important deciding factor in determining the profitability of dairying. The earlier it is known that which animal is likely to be less productive, the higher impact of such culling will enhance the productive and reproductive performance of the herd.

An attempt has been made in the present study to investigate the extent to which life time production and breeding efficiency in the Tharparkar cows regress on the traits expressed during the early life time such as age at first calving, first lactation production and breeding efficiency based on first calving interval.

REVIEW OF LITERATURE

Age at first calving

The importance of age at first calving and its implication in relation to the production traits of the cattle have been discussed by Chapman and Dickerson (1936), Luthmann (1949), Sundaresan et al. (1954), Hargrove et al. (1959), Nagpaul and Bhatnager (1971) and Saller (1971). Variation in age at first calving has generally been attributed to heredity, environment and their interaction. Hogens et al. (1934) reported that age at first calving would differ from herd to herd due to variable management and herd environment.

Seyer (1936) and Mahadevan (1953) were of the opinion that age at first freshening in tropical cattle can be lowered if they are kept on good nutrition and better management in early life.

Sundaresan et al. (1954) concluded that European cattle come in heat early whereas Zebu cattle calve usually at higher age. According to these authors, age at first calving in European cows is a matter of management practices, whereas in Zebu cattle it is a physiological and probably a hereditary trait.

The average age at first calving of the tropical and temperate breeds of cattle as reported by various workers have been summarized in the table.

Average age at first calving in various breeds

Breed	Location	Mean age at first calving (months)	Investigator(s)
<u>Tropical breeds</u>			
Tharparkar	Patna	49.40±0.40	Singh (1957)
	Patna	48.70±0.40	Joshi et al. (1958)
	Ranchi	43.20	Singh and Chaudhury (1961)
	Karnal	38.80	Puri and Sharma (1965)
	Karnal	38.21±7.75(3.0)	Das & Bhatnagar (1967)
	Karnal	38.49±0.29	Nagpaul (1968)
	Karnal	1154.97±8.24(Days)	Reddy and Bhatnagar (1971)
Sahiwal	Ranchi	41.10	Setia and Desai (1964)
U.P. Military Farms		38.40±0.39	— [—] —
	New Delhi	30.40±0.23	Kavikar et al. (1968)
	Karnal	38.08±0.39	Sopal and Bhatnagar (1972)
Red Sindhi	Allahabad	42.00	Saxena (1959)
	Hosur	44.40±0.50	Rajpalan (1952)
	Ceylon	47.04±0.40	Mahadevan (1955)
	Karnal	42.90	Venkayya and Anantakrishnan (1958)
	Hosur	41.70±0.40	Joshi et al. (1958)
Haryana	Jhansi	49.00±0.60	Singh et al. (1956)
	Hissar	50.00±0.20	Kohli and Suri (1957)
U.P. Farms		51.30±2.2	Johri and Talpatra (1957)
	Hissar	59.30±0.05	Kohli et al. (1957)
	Mathura	46.70±0.45	Singh and Desai (1961)
	Hissar	57.41±0.33	Gohil and Sekhon (1966)

contd.

Melvi	Agerpara	51.20	Bhatnagar and Chaudhary (1960)
Kangyan	Hosur	48.20±0.20	RajGopalan (1952)
	Hosur	44.10±0.40	Sabale et al. (1950)
Gir	Bengaluru	47.00±0.80	-50-
Kankrej	Bombay	47.40±0.80	-10-
Egyptian	U.A.R.	42.90±0.60	Bansalny and Saygani (1962)

Temperate breeds

Holstein	Missouri	28.80	Turner (1932)
	Iowa	27.24±0.20	Rogers et al. (1934)
	Nebraska	30.20±0.00	Javia (1953)
	England	33.70	Ridder et al. (1962)
	U.A.R.	35.00	Akbar et al. (1962)
	Pennsylvania	27.03±3.28	White and Nichols (1965)
Jersey	Missouri	27.30	Turner (1932)
	Iowa	25.50±0.3	Rogers et al. (1934)
	Denmark	26.50	Gestergaard (1950)
	Egypt	30.40	Khalishin and ElBassal (1954)
	Ceylon	30.00	Mahadevan (1956)
Ayrshire	Missouri	29.80	Turner (1932)
	Ceylon	40.00	Mahadevan (1956)
Guerney	Missouri	28.50	Turner (1932)
	Iowa	29.50±0.8	Rogers et al. (1934)
Short Horn	Ceylon	41.00±0.0	Mahadevan (1956)
	U.A.R.	37.70±3.6 (S.D.)	El-Metwally and Akbar (1958)
Red & White	Sweden	33.90	Hansen et al. (1941)
Black Pied	Lowland	32.30	Zimmermann (1959)

First lactation production

The First lactation yield in different tropical breeds studied by various workers has been classified in the table given below:

Breed	Location	First Lactation production (kg)	Investigator(s)
Tharparker	Karnal	1638-2524	Sunderasan et al. (1965)
	Karnal	2980	Puri and Sharma (1965)
	Karnal	2160.75±29.20	Das and Bhatnagar (1967)
	Karnal	2168.75±28.21	Reddy and Bhatnagar(1971)
Sahiwal	Ranchi	2218.18	Singh and Choudhary(1961)
	Mathura	1674.38	Singh and Desai (1966)
	Hissar	1632.90±46.29	Gohil and Malik (1967)
	Karnal	2150.18±43.41	Nagarjunkar (1969)
	Colombia	2143.09	Steenakar (1971)
Haryana	Karnal	2236.00±33.48	Copal and Bhatnagar(1972)
	Hissar	1811.61±0.00 (lbs)	Kochi et al. (1961)
	Mathura	1295.90	Dutt and Desai(1961-62)
	Hissar	1650.18±89.34 (lbs)	Gohil and Sakhon (1965)
	Rajasthan	1941.69±51.01 (lbs)	Shashin and Desai (1967)
	Mathura	2223.00 (lbs)	Singh and Desai (1967)
	Pusa	2449.20±47.20 ("")	Singh and Parshad(1967)
Dunneon			
1789.20±74.42 (2) -to-			

Breeding efficiency

Wilcox et al. (1957) reported an average of breeding efficiency in Holstein-Friesian herd to be 87.2 per cent. Meoli et al. (1964) reported average of breeding efficiency as 93, 106 and 90 with 13.8, 15.8 and 13.9 per cent coefficient of variation in Brown Alpine, Dutch Friesian and their crossbreds respectively.

Dutt and Dugal (1965) reported a mean of breeding efficiency in Gangatiri (graded to Haryana cattle) as 63.5 ± 10.6 per cent. Stalinski and Wazyk (1965) reported 88.8 per cent breeding efficiency in Polish Red breed based on 834 observations.

Das and Shethnagar (1967) and Reddy and Shethnagar (1971) reported an average breeding efficiency of 84.2 ± 0.44 and 89.65 ± 0.60 per cent in Tharparker, respectively.

In Egyptian buffaloes average of breeding efficiency was 85.8 per cent (Hafez, 1952) and 74.1 per cent (Youssef and Aaker, 1959), whereas breeding efficiency was calculated to be 78.7 per cent (Singh and Dutt, 1964) and 77.21 ± 1.97 per cent (Gautam et al., 1965) in Murrah buffaloes at military farms.

Life time production

Some arbitrary period is being taken which covers the major period of economic production of a cow for estimating life time production. Cethin (1960), Larson et al. (1951) and

Sundaresan et al. (1984) considered 5, 7 and 10 years of age to predict the life time production, whereas Sukhbir Singh et al. (1963), Daya Singh and Sundaresan (1969), Puri and Sharma (1965), White and Nichols (1963), Mahesh Dutt et al. (1965), Bhasin and Desai (1967), Methur and Roy Choudhury (1971), Copal and Chatnagar (1972) and Saller (1972) considered 6, 8 and 10 years of age as a reliable criteria for the life time production.

The average yield upto 10 years of age has been reported in buffalo to be 9843 ± 228.70 (Singh, 1966). Bhasin and Desai (1967) reported 3532.75 ± 191.48 , 7175.83 ± 377.85 and 8360.98 ± 715.24 lbs of milk yield upto 6, 8 and 10 years of age, respectively in Haryana cattle. Copal and Chatnagar (1972) reported in Sahiwal for first five lactations and yield upto 6, 8 and 10 years of age as 12486 ± 215.90 , 5983 ± 136.53 , 2998 ± 209.47 and 14432 ± 389.76 kg, respectively.

Heritability estimates

Heritability estimate is the fraction of observed phenotypic variance which results from differences in heredity among genes and gene combinations of the individual genotype as a unit (Lush, 1949). Heritability estimates for age at first calving and first lactation production reported by various workers in different tropical and temperate breeds have been tabulated as below:

Breed	Herditability value	Method of Estimation	Author(s)
<u>AGE AT FIRST CALVING (months)</u>			
<u>Tropical breeds</u>			
Tharparkar	-0.38 ± 0.09	Intralinc regression of daughter on dam	Singh (1967)
	0.05 ± 0.09	Paternal halfsib correlation	-do-
	0.48 ± 0.16	Intralinc regression of daughter on dam	Amble et al. (1958)
	0.26 ± 0.18	-do-	Puri and Malik (1963)
	0.79	-do-	Sundaresan (1963)
	0.32 ± 0.16	-do-	Dave Singh and Sundaresan (1966)
	0.21 ± 0.09	-do-	Jha and Bhatnagar (1967)
	0.11 ± 0.09	-do-	Reddy and Bhatnagar (1971)
	0.17 ± 0.08	45/4 Paternal halfsib correlation	Gurnani et al. (1976)
Garhiwal	0.38 ± 0.26	Intralinc regression of daughter on dam	Puri and Malik (1963)
	0.14 ± 0.12	-do-	Gopal and Bhatnagar (1972)
Red Sindhi	0.39 ± 0.16	-do-	Stoneker (1953)
	0.09 ± 0.17	-do-	Amble et al. (1958)
	0.18 ± 0.29	-do-	-do-
	0.44 ± 0.50	-do-	Puri and Malik (1963)
Haryana	0.34 ± 0.12	-do-	Singh and Dass (1961)
	0.34 ± 0.19	Paternal halfsib correlation	-do-
	1.43 ± 0.82	-do-	Chandiramani and Dadlani (1967)
	0.18 ± 0.13	Intralinc regression of daughter on dam	Bhasin and Dass (1967)
	0.44 ± 0.11	-do-	Singh (1967)
	0.30 ± 0.14	-do-	Singh and Parshad (1967)
	0.20 ± 0.30	-do-	-do-

.....contd.

FIRST LACTATION PRODUCTION

The parker	0.22±0.02	Intraline regression of daughter on dam	Kooser (1963)
	0.30±0.16	-do-	Dasy Singh and Sundaresan (1966)
	0.12±0.03	-do-	Reddy and Bhattacharjee (1971)
	0.08±0.07	Paternal halfsib correlation	Gurnani et al. (1976)
Sehival	0.44±0.32	Intraline regression of daughter on dam	Kooser (1963)
	0.37±0.32	Paternal halfsib correlation	-do-
	0.36±0.10	Intraline regression of daughter on dam	Gopal and Bhattacharjee (1972)
	0.14±0.17	Paternal halfsib correlation	Gurnani et al. (1976)
Red Sindhi	0.24±0.09	Intraline regression of daughter on dam	Stoneaker (1953)
	0.34±0.09	-do-	Amble et al. (1958)
	0.37	-do-	-do-
Haryana	0.19±0.04	-do-	Singh and Desai (1961)
	0.20±0.14	Paternal halfsib correlation	-do-
	0.46±0.07	-do-	Kohli et al. (1961)
	0.18±0.09	-do-	Chandiramani and Cadlani (1967)
	0.30±0.13	Intraline regression of daughter on dam	Singh and Paschad (1967)

Temperate breeds

Holstein	0.23	-do-	Touchberry (1951)
	0.30±0.12	-do-	Larson et al. (1951)
	0.58±0.30	-do-	Madden et al. (1955)
	0.28	-do-	Johnson et al. (1956)
	0.41	-do-	Rendel (1957)
	0.18	-do-	Miller and McGilliard (1959)
	0.30	-do-	Borowsky et al. (1959)
	0.27	-do-	Tables and Touchberry (1959)

.....contd.

FIRST LACTATION PRODUCTION

Tharparkar	0.22 ± 0.02	Intrasire regression of daughter on dam	Kooser (1963)
	0.30 ± 0.16	-do-	Daya Singh and Sundaresan (1966)
	0.12 ± 0.03	-do-	Reddy and Bhatnagar (1971)
	0.08 ± 0.07	Paternal halfsib correlation	Gurnani et al. (1976)
Sahiwal	0.44 ± 0.32	Intrasire regression of daughter on dam	Kooser (1963)
	0.37 ± 0.39	Paternal halfsib correlation	-do-
	0.36 ± 0.10	Intrasire regression of daughter on dam	Gopal and Bhatnagar (1972)
	0.14 ± 0.17	Paternal halfsib correlation	Gurnani et al. (1976)
Red Sindhi	0.28 ± 0.10	Intrasire regression of daughter on dam	Stonaker (1953)
	0.34 ± 0.09	-do-	Amble et al. (1958)
Haryana	0.37	-do-	-do-
	0.19 ± 0.04	-do-	Singh and Desai (1961)
	0.20 ± 0.14	Paternal halfsib correlation	-do-
	0.48 ± 0.07	-do-	Kohli et al. (1961)
	0.18 ± 0.09	-do-	Chandiramani and Dadlani (1967)
	0.30 ± 0.13	Intrasire regression of daughter on dam	Singh and Parashad (1967)

Temperate breeds

Holstein	0.25	-do-	Touchberry (1951)
	0.30 ± 0.12	-do-	Larsen et al. (1951)
	0.38 ± 0.20	-do-	Madden et al. (1955)
	0.26	-do-	Johnson et al. (1956)
	0.41	-do-	Randal (1957)
	0.18	-do-	Miller and McGilliard (1959)
	0.30	-do-	Borowsky et al. (1959)
	0.27	-do-	Tabler and Touchberry (1959)

.....contd.

Holstein	0.26±0.02	Intralitter regression of daughter on dam	Specht and McGilliard (1960)
	0.40	-do-	O'Bleness et al. (1960)
	0.24	-do-	Branston et al. (1961)
	0.43±0.02	-do-	Yamada (1961)
	0.43±0.20	-do-	Everett et al. (1966)
Brown Swiss	0.42±0.08	-do-	Johnson and Corley (1961)
	0.22	-do-	-do-
Jersey	0.30	Paternal halfsib corre- lation	Johnson (1954)
	0.28	Intralitter regression of daughter on dam	Johnson and Corley (1961)
Guernsey	0.18	-do-	Miller and McGilliard (1959)
	0.32	Paternal halfsib corre- lation	Everett et al. (1966)

Breeding efficiency

Wilcox et al. (1957) reported the heritability estimate of breeding efficiency to be 0.32 in Holstein Friesian cows.

Evans et al. (1964) estimated the heritability of breeding efficiency to be very low in Holstein Friesian and Reddy and Shetnagar (1971) in Tharparkar.

Senth et al. (1943) found averaged variation to be 63.3 per cent based on services per conception. They believed that breeding efficiency was inherited. Dunbar and Henderson (1958) estimated the heritability of non-returns to first service to be very low (0.004). Pow et al. (1953) obtained the heritability estimate of breeding efficiency as 0.05, 0.07 and 0.07 based on regularity of estrus, interval from first service

to conception and number of services per conception respectively.

Legates (1954) reported heritability estimate of breeding efficiency based on number of services per conception to be 0.026. Smith and Legates (1962) also estimated very low estimates of heritability.

Everett et al. (1966) reported heritability estimates of breeding efficiency being 0.07, 0.04, 0.08 and 0.08 in Holstein herd and 0.07, 0.02, 0.04 and 0.05 in Guernsey herd for the breeding efficiency measures like days open, parturition to first breeding, first breeding to conception and number of services per conception, respectively.

Johnson and Everson (1966) reported that heritability estimates of breeding efficiency on the basis of days from first service to conception and number of services per conception were close to zero.

The heritability estimates of breeding efficiency was found to be very low in Egyptian buffaloes (Yousaf and Askar, 1959) and in Murrah (Singh and Dutt, 1964 and Singh, 1966).

Life time production

The heritability estimate of an average of more than one record is usually higher as the number of records included is increased (Robertson, 1952). This is well illustrated from the results of Johnson and Corley (1961) and Galukanda et al. (1962) and Nagarkar (1964).

However, the heritability estimate of life time production as measured upto 6 years of age was very low in Sahiwal (Gopal and Bhattacharya, 1972).

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PHENOTYPIC AND GENETIC CORRELATIONS

Age at first calving and
first lactation production

Eckles (1913) observed that Holstein heifers which calved for the first time at the age of 20 to 24 months produced less milk than those calved at the age of 30-34 months.

Luthmann (1942) found that heifers calving between 31-36 months for the first time gave more milk than at earlier or later ages.

With the increase in age at first calving among Ayrshire cows, a linear increase in milk yield during first lactation was observed by Pahadován (1951). Positive significant correlation between age at first calving and first lactation yield was observed (Venkayya and Anantakrishnan, 1957; Miller and McGillivray, 1957; Lahouse, 1960; Bhatnagar and Choudhury, 1960; Olisa, 1963 and Horn et al., 1963).

Both the age at first calving and first lactation production were found to be independent traits in Fulani cattle (Robertson, 1950 and Lacky, 1951); in Holstein (Larsen et al., 1951); in Red Sindhi (Sundaresan et al., 1954); in Haryana cattle (Singh and Sinha, 1960; Singh and Choudhury, 1961, Singh and Desai, 1961, Gautam et al., 1966; Sahdev and Sekhon, 1966 and Bhasin and Desai, 1966); in Sahiwal (Gopal and Bhatnagar, 1972 and Gurnani et al., 1976) and in Tharparkar (Reddy and Bhatnagar, 1971 and Gurnani, et al., 1976).

Reddy and Bhatnagar (1971) indicated that the first lactation production was independent of age at first calving.

whereas genetic correlation between these traits was reported to be 0.785 ± 0.19 in Tharparker herd (Dasy Singh and Sundaresan, 1966).

The genetic correlations between age at first calving and first lactation were found to be 0.394 ± 0.396 in Tharparker and -0.307 ± 0.642 in Sahiwal (Gurnani et al., 1976).

Age at first calving and Breeding efficiency

Gautam et al. (1966) classified Haryana cattle into three groups - below 39, 39 to 50 and above 50 months - on the basis of the age at first calving. They observed negative correlation between age at first calving and breeding efficiency based on first calving interval. The correlation between these two traits was, however, significant for the heifers calving between 39 to 50 months of age for the first time. Significant correlation between age at first calving and breeding efficiency in Haryana cattle (Sohlon and Sekhon, 1966) and in Tharparker (Reddy and Bhatnagar, 1971) were observed. On the contrary, non-significant correlation coefficient between these two traits in Egyptian buffaloes (Youssef and Aeker, 1959) and in Murrrah buffaloes (Gautam et al., 1965 and Singh, 1966) were observed.

Reddy and Bhatnagar (1971) observed significant negative genetic correlation (-0.785 ± 0.19) indicating that a large proportion of the same gene is responsible for lower age at first calving causing higher breeding efficiency. Dasy Singh and Sundaresan (1966) reported significant genetic correlation

(0.701 ± 0.193) between age at first calving and first calving interval in Tharparkar cattle. The genetic correlation between age at first calving and first calving interval was 0.424 ± 0.235 in Tharparkar. However, it was negative and more than one in Sahival (Gumani et al., 1978).

First lactation yield and breeding efficiency

High producing Holstein cows did not readily conceive as those producing milk at lower levels (Lewis and Horwad, 1950). Lebon et al. (1966) reported that high yielding cows might be under greater physiological stress than low producers and therefore, exhibit an increased length of reproductive cycle.

Evans et al. (1964) found significant correlation (-0.24) between first lactation yield and breeding efficiency in Holstein cows based on 2297 records of daughters of 56 sires.

The correlation coefficient between 120 days milk production and different measures of breeding efficiency like calving interval, postpartum period, service period and services per conception was observed to be zero in Holstein and Guernsey herds (Everett et al., 1966).

Reddy and Bhatnagar (1971) observed an intrasire correlation coefficient (-0.282 ± 0.02) between first lactation production and breeding efficiency indicated that cows having high first lactation yield tended to have low breeding efficiency. It is possible as infertility in high yielding European cattle is observed because of the heavy drain of calcium and phosphorus

through milk during first lactation (Hewett, 1967). Cows in milk lost approximately 5 per cent body weight during first few months of the lactation bringing a negative relationship between condition of animals and production during the lactation (Lamond, 1961). Thus high production is antagonistic to early conception (Carmen, 1955). Breeding efficiency is likely to be lowered significantly by high productivity.

The probable effects of current gestation on the other hand are also important. The correlation between productive and reproductive efficiency has been attributed to the inhibitory action of gestation on production (Lee et al., 1961). The decreasing effect of early conception on lactation production to early conception on the other side suggest that a dual cause and effect relationship between lactation yield and reproductive efficiency. However, the influence of level of production records like 90 or 120 days yield before gestation period could have an inhibitory influence. This may give a better understanding of the relationship between these two traits.

Everett et al. (1966) estimated genetic correlations of 0.69 ± 0.09 , 0.46 ± 0.13 , -0.03 ± 0.23 , 0.71 ± 0.08 and 1.29 ± 0.16 in Holstein cattle and 0.44 ± 0.15 , 0.51 ± 0.11 , 0.58 ± 0.20 , 0.37 ± 0.15 and 0.34 ± 0.19 in Guernsey between 120 days milk production and different measures of breeding efficiency like days open, calving interval, parturition to first breeding, first breeding to conception and services per conception, respectively.

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Reddy and Bhatnagar (1971) estimated genetic correlation of -0.62 ± 0.24 between first lactation production and breeding efficiency. This indicated that selection for increasing the first lactation yield is likely to lower the breeding efficiency, hence, this genetic antagonism between these traits is not desirable.

Daya Singh and Sundaresan (1965) reported positive and significant (0.775 ± 0.135) genetic correlation between first lactation yield and first calving interval in Tharparker. The genetic correlation between first lactation and first calving interval was 0.897 ± 0.096 in Tharparker and 0.394 ± 0.0 in Sahiwal (Gurmani et al., 1976).

Age at First calving and life time production

Chapman and Dickerson (1936) observed that heifers calving early for the first time produced more milk upto 7 years of age and those possessing higher age at first calving gave more milk in first lactations. Mathur and RayChoudhury (1971) found that early calves produced more milk upto 6, 8 and 10 years of age. The milk yield upto 72 months of age was highly negatively correlated with age at first calving (Soller and Plessis, 1971; Nagpaul and Bhatnagar, 1971; Soller, 1972 and Gopal and Bhatnagar, 1972).

Gethin (1950) studied the age at first calving in relation to subsequent performance and was of the view that the life time production of early calves fell very little that of late calves under favourable conditions.

Larson *et al.* (1951) found that age at first calving accounted for 84 and 41 per cent of variance in 36 and 84 months of production respectively. The life time production upto 10 years of age was calculated to be more in early calves (Sundaresan *et al.*, 1954 and Johri and Talapatra, 1957).

Sidhu (1964) reported that age at first calving was negatively and significantly correlated with first four lactation production. Margrove *et al.* (1969) estimated the optimum age at first calving being 27 months for maximum life time production.

Gopal and Shastri (1972) reported that first five lactation production (305 days) was independent of or at least only weakly associated with age at first calving. However, the correlations between age at first calving and life time milk production as evaluated upto 6, 8 and 10 years of age were negative and highly significant indicating that cows calving at an earlier age produced more milk at a given age as compared to late calves. The simple regression coefficient of milk production upto 6, 8 and 10 years of age on age at first calving (months) were calculated to be -150, -160 and -205 kg respectively.

First lactation yield and Life time production

Larson *et al.* (1951) reported highly significant correlation of first lactation production with total yield upto 72 months of age.

Roth (1952) reported that milk yield in first 200 days of the first lactation accounted for 46 per cent variation

in production during first five or six years after freshening. Klieisch and Bankwitz (1962) reported that 180 days production of first lactation explained a variation of 29 and 52 per cent in estimating the total yield during first four lactations in two herds of European cattle.

Sundaresan et al. (1954) found a significant correlation between first lactation production and yield upto 10 years of age. White and Nichols (1965) concluded that high producing heifers should continue to produce well throughout their life. Early calves produced more milk during life time production (Singh, 1965; Ghosh and Desai, 1967; Margrove et al., 1969; Mathur and RayChoudhury, 1971; Gopal and Bhatnagar, 1972; Koskinska, 1974 and Gill and Allaire, 1976).

Gopal and Bhatnagar (1972) observed variation in the four estimates of life time production (milk produced upto 3 lactations, 6, 8 and 10 years of age) as explained by 305 days first lactation yield being 43, 22, 30 and 16 per cent respectively in Sahiwal cows. They further indicated that the increase of 181, 67 and 68 kg of milk in first lactation was equivalent to reduction of one month of age at first calving for predicting the milk production upto 6, 8 and 10 years of age respectively.

Breeding efficiency and Life time production

No study seems to have been made to establish the relationship between breeding efficiency and life time production. However, non-significant correlation coefficient between breeding

efficiency and producing ability in Haryana cows (Gautam et al., 1966) and in Murrah buffaloes (Gautam et al., 1965) was observed.

Puri and Sharma (1965) observed that life time production was not significantly correlated with the first calving interval.

Bode (1968) reported a decrease in the life time production by 5% with the increase in calving interval by 30 days.

Age at first calving, first lactation yield,
Breeding efficiency and life time production

Sundaresan et al. (1954) reported the multiple regression equation consisting of age at first calving and first lactation milk production for predicting the production upto 7 years of age accounted for 41 per cent of the variance of this estimate. They pointed out that the addition of age at first calving increases only slightly the accuracy of prediction from first lactation production.

Sukhbir Singh et al. (1964) reported that the addition of age at first calving with the production in the first lactation increases the accuracy of prediction equation of milk production in later life.

The prediction equations based on the partial regression coefficients of life time production on age at first calving, first lactation yield were found to explain 73, 77, 77 and 40 per cent of the total variation in the life time production in Tharparkar, Sahiwal, Red Sindhi and Jersey-Tharparkar crossbreds respectively (Puri and Sharma, 1965).

Shasini and Desai (1967) concluded that the existing method of selection based on milk yield in first lactation or in preceding lactation yield alone does not seem to be very efficient for predicting life time production. It needs to be supplemented by age at first calving which has got high economic importance.

Gopal and Shatnagar (1972) observed that the addition of age at first calving to first lactation yield increased the accuracy of prediction from 22 to 51, 30 to 51 and 18 to 40 per cent of the variation for 6, 8 and 10 years of age for life time production, respectively.

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MATERIALS AND METHODS

The data presented in this investigation were taken from available records of the Tharparker herd maintained at the National Dairy Research Institute, Karnal (Haryana). The herd was established in 1923-31. History of this Tharparker herd has been detailed (Kumar, 1956; Sundaresan et al., 1965 and Bhatnagar et al., 1976). The data on 523 cows born to 37 sires constituted the material for this study. Information on the parcentage, age at first calving (months), first 305 days lactation yield (kg), calving intervals (days) and life time milk production (kg) were calculated from the available records. Cows whose date of birth, first lactation yield and first calving interval were not available or milked for less than 150 days and those which were culled or died and of unknown parcentage were excluded from this investigation.

Cows were milked thrice a day since 1923 except in 1941 through 1950, when they were milked four times a day. Milk recorded in pounds has been converted into kilograms.

A true measure of life time production of a cow is seldom obtained, for few cows kept in any herd until their natural death and therefore, an arbitrary period has been taken

which covers the major period of economic production of a cow for estimating the life time production of a cow. The milk produced in first five lactations (305 days) and upto 6, 8 and 10 years of age have been considered as life time production. Breeding efficiency was calculated on the basis of first and other available calving intervals.

The breeding efficiency, a measure of reproductive capacity of a cow, was calculated by the formula (Wilcox et al., 1957):

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

Where, n is the number of calvings and D is total number of days from first to last parturition.

Statistical Analysis of Data

The intra-site mean, variance, standard deviations, standard errors and coefficient of variation (%) were calculated for age at first calving (months), first 305 days lactation yield (kg), breeding efficiency % based on first calving interval ($SE_{\bar{x}}$), total milk produced upto 6, 8 and 10 years of age and total of first five 305 days lactations (kg) as given by Snedecor and Cochran (1967).

Analysis of Variance

Analysis of variance was performed for age at first calving (AFC), first lactation production (FLP), breeding efficiency ($SE_{\bar{x}}$), total yield upto 6, 8 and 10 years of age and the total yield upto first five lactations (305 days) to

see the sire effects using the following model:

One way Analysis of Variance

Model:

$$Y_{ij} = \mu + s_i + e_{ij}$$

$$i = 1, 2, \dots, n_s$$

$$j = 1, 2, \dots, n_i$$

Where, Y_{ij} is an observation of the j^{th} animal in the i^{th} sire.

μ is the mean value of the trait.

s_i is the effect of the i^{th} sire.

e_{ij} is a random error specific to the j^{th} animal under the i^{th} sire.

Assumptions: s_i is a random effect with zero mean and

variance S_s^2 and e_{ij} having zero mean and variance S_e^2 .

Analysis of Variance

Source	d.f.	M.S.	F.
Among sires	S-1	MS(S)	$\frac{MS(S)}{MS(E)}$
Among daughters within sires	N-S	MS(E)	
Total	N-1		

Estimates of heritability

Heritability estimates of age at first calving, first 305 days lactation yield, breeding efficiency based on first intercalving period and breeding efficiency based on all

intercalving periods and life time milk production as measured by milk yield upto 6, 8, 10 years of age and first five lactations (305 days) by intra-sire daughter-dam regression method.

Intra-sire regression of daughter on dam

Lush (1942) reported that the intra-sire regression of daughter on dam method for estimating heritability, includes all of the additive effects of the genes, none of the dominance deviation and something less than half of the effects of the non-linear interactions of the non-allelic genes.

The analytical justification for estimating heritability as twice the intra-sire regression of daughter on dam is as follows:

Model: For Dam $X = G + E$

For daughter $Y = \frac{1}{2}G + \frac{1}{2}G' + E'$

Where, X = Phenotypic value of dam

Y = Phenotypic value of daughter

G = Genotypic value of dam

G' = Genotypic value of sire

E = Non-genetic deviations for the dams

E' = Non-genetic deviations for daughter

Assuming that the covariances between G and G' , G and E , G and E' and E and E' are each zero.

$$\text{Cov. } X, Y = \frac{1}{2}G^2$$

$$V(X) = G_X^2$$

$$b = \frac{\text{Cov. } X, Y}{V(X)} = \frac{\frac{1}{2} h^2}{\sigma_X^2} = \frac{1}{2} h^2$$

$$\text{Therefore } 2b = h^2$$

Regression of daughter on dam is taken as intra-sire wise in order to eliminate the sire effects. The intra-sire regression of daughter on dam must be doubled to estimate the heritability.

If the sires are 1,.....i
dams (X) mated to these sires i are 1,.....j
and daughters (Y) born of these matings are daughter ij
then intra-sire regression of daughter on dam is equal to:

$$b_{YX} = \frac{\sum \sum x_{ij} y_{ij}}{\sum \sum x_{ij}^2}$$

$$h^2 = 2b_{YX}$$

Standard Error

$$\text{Standard error } (h^2) = 2 S.E.(b)$$

$$S.E.(b) = \sqrt{\frac{\sum \sum y_{ij}^2 - (\sum \sum x_{ij} y_{ij})^2}{(n-9-1) \sum \sum x_{ij}^2}}$$

$$S.E.(h^2) = 2 S.E.(b)$$

Phenotypic correlations

The correlation coefficients between different traits were calculated as product moment correlations using the method

described by Snedecor and Cochran (1967). The correlation coefficient was calculated by the formula:

$$r_{XY} = \frac{\sum_{i=1}^n X_i Y_i}{\sqrt{\sum_{i=1}^n X_i^2 \sum_{i=1}^n Y_i^2}}$$

where, X and Y are two traits

X_i^2 = squares of deviations from the mean for X.

Y_i^2 = squares of deviations from the mean for Y.

$X_i Y_i$ = cross products of deviations from the mean of the two traits.

Standard error of the phenotypic correlation was calculated by the formula:

$$SE(r) = \sqrt{\frac{1 - r^2}{n - 2}}$$

Genetic Correlation

Genetic correlations were estimated by the procedure first introduced by Hazel (1943) and which was later on put to application in dairy cattle problems by Touchberry (1951).

Intra-sire phenotypic correlations between one character in daughter and other character in dam were calculated. These were then used to estimate the genetic correlation. The general formula is given by the following equation:

$$r_{GXY} = \frac{r_{X_{dM} Y_M} + r_{Y_{dM} X_M}}{r_{X_{dM} X_M} + r_{Y_{dM} Y_M}}$$

Where, r_{GXY} = Genetic correlation between trait X and trait Y.

$r_{X,Yd}$ = Intra-sire phenotypic correlation between X trait in daughter (X_d) and Y trait in dam (Y_h).

$r_{Yd,Xh}$ = Intra-sire phenotypic correlation between Y trait in daughter (Y_d) and X trait in dam (X_h).

$r_{X,Yh}$ = Intra-sire phenotypic correlation between X trait in dam (X_h) and Y trait in daughter (Y_d).

$r_{Yd,Yh}$ = Intra-sire phenotypic correlation between Y trait in daughter (Y_d) and Y trait in dam (Y_h).

Standard error

The standard error of the estimates of genetic correlation were computed by the formula given by Robertson (1959):

$$SE(r_{GXY}) = \frac{1 - r_{GXY}^2}{\sqrt{\frac{S.E.(h^2_X) \cdot S.E.(h^2_Y)}{h^2(X) + h^2(Y)}}}$$

Where, X and Y are two traits. $S.E.(h^2_X)$ and $S.E.(h^2_Y)$ are the standard errors of heritability estimates of X and Y traits respectively. $h^2(X)$ and $h^2(Y)$ are the heritabilities of the two traits.

Partial Correlation analysis

The partial correlation coefficients between age at first calving, first lactation yield (305 days) and breeding efficiency (95_a) based on first intercalving period with life time milk production (as measured by total yield upto 5, 8 and 10 years of age and upto 9 lactations of 305 days or less) and breeding efficiency based on all intercalving periods separately,

keeping two of these as constant at one time. The partial correlation coefficient was calculated as:

$$r_{12,34} = \frac{r_{12,3} - r_{14,3}r_{24,3}}{\sqrt{1-(r_{14,3})^2} \sqrt{1-(r_{24,3})^2}} \quad (\text{Kempthorne, 1973})$$

Where, $r_{12,34}$ = partial correlation coefficient between trait 1 and 2 keeping 3 and 4 constant,

$r_{12,3}$ = partial correlation coefficient between trait 1 and 2 keeping trait 3 constant.

$r_{14,3}$ = partial correlation coefficient keeping trait 3 constant.

$r_{24,3}$ = partial correlation coefficient 2 and 4 keeping 3 constant

The first order partial correlation coefficients like $r_{12,3}$, $r_{14,3}$, etc. were calculated as:

$$r_{12,3} = \frac{r_{12} - r_{13}r_{23}}{\sqrt{(1-r_{13}^2)(1-r_{23}^2)}}$$

Standard Error

The standard error of partial correlation coefficient was calculated by the formula:

$$SE(r_{12,34}) = \sqrt{\frac{1-(r_{12,34})^2}{n-4}}$$

Multiple regression equations

The multiple regression equations of life time production and breeding efficiency based on available calving

intervals (ΣE_b) on age at first calving, first lactation yield (365 days) and breeding efficiency based on first calving interval (ΣE_a) were estimated. The dependent variables considered were total yield upto 6 years of age, total yield upto 8 years of age, total yield upto 10 years of age, first five lactations yield and breeding efficiency based on all calving intervals (ΣE_b). The following model of multiple regression was used:

Model:

$$Y_{ijk} = a + b_1 X_1 + b_2 X_2 + b_3 X_3$$

Where, Y = the value of life time production upto a particular time.

a = constant

b_1 = partial regression coefficient of Y on age at first calving (X_1).

b_2 = partial regression coefficient of Y on first lactation yield (X_2).

b_3 = partial regression coefficient of Y on breeding efficiency based on first calving interval (X_3).

The coefficients, a , b_1 , b_2 and b_3 were estimated by minimising the quantity $(\hat{y} - y)^2$ representing the residual variation using Uslittle method (Goulden, 1959).

The accuracy of prediction (r^2) of dependent variable based on the independent variables using the multiple

regression method was obtained as:

$$R^2 = \frac{b_1(\sum Yx_1 - \frac{\sum Y \cdot \sum x_1}{n}) + b_2(\sum Yx_2 - \frac{\sum Y \cdot \sum x_2}{n}) + b_3(\sum Yx_3 - \frac{\sum Y \cdot \sum x_3}{n})}{\sum Y^2 - \frac{(\sum Y)^2}{n}}$$

The square root of R^2 was calculated to obtain the multiple correlation coefficient of dependent variable with the independent variables considered in fitting the multiple regression equation.

RESULTS AND DISCUSSION

The mean, standard error and coefficient of variability for age at first calving, first lactation yield (305 days or less), life time production as measured by milk produced in first five lactations (305 days), upto 6, 8 and 10 years of age and breeding efficiency based on first calving interval are presented in table 1.

Table 1. Mean, Standard error and Coefficient of variation of different traits

Traits	n	Mean \pm S.E.	Coefficient of variation(%)
Age at first calving(months)	323	38.02 \pm 0.32	19.00
First 305 days lactation yield (kg)	923	2177.00 \pm 30.43	31.78
Breeding efficiency based on first calving interval(%)	323	85.27 \pm 0.72	19.21
Total yield upto 6 years of age (kg)	331	3805.46 \pm 132.54	41.53
Total yield upto 8 years of age (kg)	196	10812.14 \pm 238.19	33.31
Total yield upto 10 years of age (kg)	108	14453.15 \pm 357.19	25.48
First five lactations yield (305 days) (kg)	167	12144.23 \pm 289.48	30.80

The variability as seen from coefficient of variation among the life time milk production traits was least for the total milk produced upto 10 years of age (25.46%) and maximum for total milk produced upto 5 years of age (41.53%). However, the coefficient of variation was almost similar being 30.80 and 33.31 per cent for first five lactations and milk produced upto 8 years of age respectively. The coefficient of variation for first lactation yield was 31.78 per cent. The reproductive traits in contrast to productive traits had lesser coefficients of variability, the values being 19.03 and 19.21 per cent for age at first calving, and breeding efficiency based on first calving interval respectively.

The maximum life time production for a cow in the first five lactations and upto 5, 8 and 10 years of age were 20,593; 11,614; 17,450 and 22,298 kg respectively.

Highly significant differences between sires for age at first calving and production traits were observed, whereas no effect of sires could be noticed on the breeding efficiency based on first calving interval (Table 2). The breeding efficiency of the cows appeared to be influenced mostly by environmental and managerial practices.

Mean, standard error and coefficient of variation of age at first calving and for production traits (first lactation production, yield in first five lactation, yield upto 5, 8 and 10 years of age) have been tabulated elsewhere, in order of merit to perceive the relative importance of the sires that were used on the farm during entire period (Tables 3 to 8).

Table 2. Analyze of Variance

Source	d.f.	AFC	PLP	GE	Yield upto		Yield upto		Yield upto		Yield upto	
					(HS)	(HS)	(HS)	(HS)	(HS)	(HS)	(HS)	(HS)
Assesg	36	303.85	2269901*	252.85	35	2819515**	25	37744736*	17	41870121*	18	46875725*
alross												
Assesg	492	36.01	346348	246.92	295	315682	165	6273076	87	7707629	143	7800910
daughters												
within sire												

*Significant at 1% level

Table 3. Age at first calving (months) of Tharparkar cows

S.No.	Sire No./Name	n	Mean \pm S.E.	C.V. (%)
1.	Sikandar	9	30.80 \pm 0.63	6.15
2.	Pathan	7	31.14 \pm 1.65	14.03
3.	Alam	19	31.26 \pm 0.92	12.50
4.	Hakim	13	32.00 \pm 0.53	6.00
5.	Leer	8	32.00 \pm 0.89	7.84
6.	Raharaja	26	32.46 \pm 0.60	9.42
7.	Ezaz	12	32.58 \pm 1.51	16.11
8.	Faisal	13	32.69 \pm 1.26	13.97
9.	Cais	22	32.81 \pm 0.67	9.60
10.	RenFurly	34	33.17 \pm 0.42	11.06
11.	619	6	35.50 \pm 1.38	9.55
12.	Narendra	7	35.85 \pm 2.64	19.32
13.	Tikka	39	36.12 \pm 1.25	21.75
14.	Prince	6	36.16 \pm 1.30	8.79
15.	Jung	7	36.85 \pm 2.87	16.07
16.	Maryam	10	37.20 \pm 2.35	21.07
17.	600	6	37.60 \pm 1.48	9.63
18.	Inam	6	39.16 \pm 3.14	19.58
19.	Bringmore	17	39.23 \pm 0.86	9.12
20.	Kulwant	15	39.27 \pm 1.89	18.71

.....contd.

.....contd. (Table 3)

S.No.	Sir No./Name	n	Mean \pm SE	C.V. (%)
21	Dilip	7	39.42 \pm 2.40	15.82
22.	Chandan	13	39.46 \pm 2.34	21.36
23.	Nabha	43	40.19 \pm 0.93	13.17
24.	Balwant	14	40.29 \pm 2.37	22.01
25.	Partap	13	40.59 \pm 1.74	15.43
26.	Latif	11	40.91 \pm 2.09	16.93
27.	357	23	40.95 \pm 0.37	10.23
28.	Rudra	15	42.87 \pm 1.36	17.74
29.	426	19	42.95 \pm 1.02	10.38
30.	Fallopia	13	43.08 \pm 1.54	13.09
31.	Ranjit	25	44.16 \pm 1.77	20.00
32.	Mehash	9	44.25 \pm 2.53	19.10
33.	Kurnol	6	44.33 \pm 1.50	3.23
34.	Azad	10	45.70 \pm 1.78	12.99
35.	E ₁	9	46.52 \pm 2.73	16.84
36.	Xumwell	7	46.82 \pm 1.35	12.52
37.	Raja	6	48.00 \pm 1.03	5.25

Table 4. First 305 days lactation yield (kg) in Tharparkar cows

S.No.	Sire No./Name	n	Mean \pm S.E.	C.V. (%)
1.	Maharaja	26	2784.15 \pm 89.75	16.30
2.	Hakim	13	2756.62 \pm 114.64	15.01
3.	Alam	19	2738.00 \pm 128.04	20.34
4.	Ezaz	12	2707.50 \pm 126.62	16.12
5.	Balwant	14	2637.14 \pm 191.70	27.18
6.	Qais	22	2582.27 \pm 134.37	24.40
7.	Tikka	39	2523.69 \pm 107.27	26.52
8.	Ranpurly	34	2395.47 \pm 122.72	29.86
9.	Jung	7	2389.71 \pm 179.40	19.81
10.	Sikandar	9	2365.66 \pm 200.04	25.36
11.	Kurwall	7	2363.85 \pm 267.48	29.82
12.	Pathan	7	2340.28 \pm 85.14	25.60
13.	Mahash	8	2334.25 \pm 120.71	19.26
14.	Faisal	13	2300.00 \pm 151.06	19.89
15.	Latif	11	2283.45 \pm 205.14	17.46
16.	Maryam	10	2215.50 \pm 215.37	29.38
17.	Azad	10	2175.25 \pm 94.09	32.97
18.	Lear	8	2128.16 \pm 247.52	12.46

....contd.

.....contd. (Table 4)

S.No.	Sire No./Name	n	Mean \pm S.E.	S.V. (%)
19.	Prince	8	2118.26 \pm 247.92	20.37
20.	Ranjit	23	2381.16 \pm 112.87	27.07
21.	Kulwant	15	2073.40 \pm 147.31	27.43
22.	Nabha	43	2033.20 \pm 113.19	36.48
23.	Rudra	15	2009.27 \pm 144.29	27.79
24.	Inam	8	1913.66 \pm 331.56	42.27
25.	426	19	1849.42 \pm 93.08	21.89
26.	619	8	1804.00 \pm 191.45	26.00
27.	Fairhope	13	1768.83 \pm 118.95	28.55
28.	Narendra	7	1750.66 \pm 232.75	35.32
29.	Pastap	13	1701.16 \pm 139.91	20.44
30.	337	23	1645.04 \pm 91.62	28.61
31.	Chandan	13	1617.76 \pm 161.51	35.94
32.	E ₁	8	1594.50 \pm 252.58	30.65
33.	580	8	1582.83 \pm 218.28	33.79
34.	Kurnol	8	1579.16 \pm 201.87	31.19
35.	Raja	8	1578.66 \pm 242.85	37.50
36.	Dalip	7	1573.71 \pm 143.16	23.65
37.	Stringmore	17	1327.82 \pm 153.08	47.50

Table 5. Total milk yield (kg) upto 6 years of age
in Tharparker cows

S. No.	Sire No./Name	n	Mean \pm S.E.	C.V. (%)
1.	Hakim	3	9510.80 \pm 901.31	16.52
2.	Alam	13	8985.76 \pm 431.11	17.27
3.	Sikander	3	8910.33 \pm 783.90	19.32
4.	Ezaz	10	8684.20 \pm 513.87	19.70
5.	Rajahra Ja	17	8392.71 \pm 437.76	21.49
6.	Reinfurly	21	8187.00 \pm 447.59	25.00
7.	Gais	7	8112.03 \pm 782.37	29.46
8.	Faisal	3	7204.03 \pm 373.66	11.56
9.	Leet	3	7148.00 \pm 1049.02	25.29
10.	Pathan	3	7145.66 \pm 2686.63	63.04
11.	Jung	5	7037.00 \pm 1059.03	33.71
12.	Balwant	12	7009.75 \pm 670.93	33.11
13.	Tikka	26	6586.23 \pm 406.04	31.33
14.	619	4	6128.28 \pm 400.83	13.08
15.	Prince	5	5956.40 \pm 919.19	34.41
16.	Dalip	3	5259.00 \pm 396.04	13.02

.....contd.

.....contd. (Table 5)

S.No.	Site No./Name	n	Mean \pm S.E.	C.V. (%)
17.	Inam	3	5187.00 \pm 2344.69	78.20
18.	Nabha	25	5135.88 \pm 412.97	40.21
19.	Latif	8	5132.00 \pm 255.28	12.19
20.	SBG	4	5090.25 \pm 616.40	24.32
21.	Wazir	5	4970.44 \pm 511.89	29.11
22.	Rahash	6	4956.50 \pm 783.90	43.03
23.	Kulwant	11	4791.72 \pm 405.35	23.09
24.	Kuruvall	7	4772.14 \pm 423.84	23.44
25.	Bringsore	13	4743.55 \pm 336.37	43.75
26.	Rudra	7	4726.00 \pm 643.09	38.92
27.	Falshope	12	4540.75 \pm 486.20	37.04
28.	357	16	4362.31 \pm 303.54	23.46
29.	426	19	4278.63 \pm 208.21	21.15
30.	Izad	9	4273.44 \pm 406.46	29.53
31.	Ranjit	10	4184.30 \pm 465.57	35.54
32.	Rarendra	5	3892.80 \pm 525.14	30.08
33.	Kurnel	8	3750.33 \pm 344.01	22.38
34.	Chandan	10	3618.10 \pm 372.26	34.26
35.	Partap	4	3610.25 \pm 846.59	46.89
36.	E ₁	8	2608.75 \pm 498.92	53.80

Table 6. Total milk yield (kg) upto 8 years of age in
Tharparkar cows

S.No.	Sire No./Name	n	Mean \pm S.E.	C.V. (%)
1.	Alam	11	13706.54 \pm 664.72	13.42
2.	Mahatma	9	13564.66 \pm 1077.20	23.82
3.	Banfurly	13	13382.63 \pm 694.70	18.80
4.	Ezaz	7	13190.20 \pm 1056.73	20.09
5.	Jung	4	12940.50 \pm 309.98	4.79
6.	Gale	4	12279.50 \pm 1640.39	26.71
7.	Prince	3	11676.66 \pm 2942.77	43.60
8.	Tikka	22	10654.40 \pm 587.57	25.38
9.	579	3	10490.00 \pm 511.41	4.43
10.	Nabha	11	10303.00 \pm 349.02	27.06
11.	Kulwant	8	10154.75 \pm 456.46	12.67
12.	Maryam	6	9433.33 \pm 1003.11	25.94
13.	Kurwali	7	9029.65 \pm 710.60	20.00
14.	426	12	8770.50 \pm 485.10	19.11
15.	Latif	4	8619.50 \pm 585.85	13.60
16.	Faishep	11	8427.00 \pm 727.32	28.56
17.	Maheesh	5	8225.00 \pm 1353.83	36.87
18.	Kulwant	5	7896.80 \pm 1097.29	31.13
19.	Azad	5	7753.00 \pm 1226.24	33.26
20.	Bringsnote	8	7715.75 \pm 993.42	36.30
21.	357	7	7389.00 \pm 1066.59	38.11
22.	Kurnoi	6	7202.56 \pm 800.39	27.11
23.	Narendra	3	6907.33 \pm 1024.86	26.04
24.	Ranjit	3	6558.33 \pm 1100.35	29.03
25.	Chandan	3	6362.80 \pm 864.50	30.29
26.	Partap	4	6057.00 \pm 876.41	28.93

Table 7. Total milk yield (kg) upto 18 years of age in Tharparker cows

S.No.	Sire No./Name	n	Mean \pm S.E.	C.V. (%)
1.	Maharaja	4	20556.25 \pm 998.85	9.69
2.	Ezaz	5	18672.60 \pm 1350.43	15.12
3.	Jung	4	18073.40 \pm 1071.82	11.85
4.	RainFury	5	17589.50 \pm 1700.19	22.56
5.	Alam	9	17531.25 \pm 945.75	15.21
6.	Prince	3	16534.00 \pm 2969.94	31.23
7.	Nabhe	6	14955.83 \pm 1156.79	18.94
8.	Tikka	14	14575.37 \pm 786.67	20.18
9.	Maheesh	3	13885.67 \pm 1992.07	24.82
10.	Balwant	4	13326.00 \pm 822.65	12.34
11.	426	9	13019.75 \pm 952.93	20.64
12.	Kurwell	7	12887.42 \pm 953.74	19.24
13.	Kulwant	4	12706.75 \pm 1562.62	24.44
14.	Veryam	5	12061.00 \pm 1406.74	26.00
15.	Springmore	6	11975.50 \pm 939.25	19.13
16.	357	3	11911.00 \pm 2067.87	30.03
17.	Falshope	9	11438.55 \pm 477.34	12.49
18.	Kurnel	6	10799.40 \pm 1057.82	23.90

Table 8. Total milk yield in first five (305 days) lactations (kg) in Tharparker cows.

S.No.	Sire No./Name	n	Mean \pm S.E.	C.V. (%)
1.	Kurwell	7	19914.28 \pm 2060.30	26.90
2.	Prince	3	15214.66 \pm 1911.17	21.85
3.	Jung	4	14381.25 \pm 856.65	11.91
4.	Rajendra	11	14055.00 \pm 1108.32	26.05
5.	Banbury	13	13840.69 \pm 632.24	16.43
6.	Ezaz	7	13773.14 \pm 1034.71	19.83
7.	Alas	11	13450.94 \pm 807.60	15.04
8.	Tikka	20	12956.73 \pm 720.33	29.12
9.	Nabha	10	12027.60 \pm 697.53	19.31
10.	Salwant	6	11857.33 \pm 883.53	18.18
11.	Maryam	6	11821.66 \pm 915.97	18.90
12.	Latif	4	11313.25 \pm 1782.47	19.83
13.	428	12	10567.41 \pm 642.81	21.04
14.	Kulwant	4	10435.50 \pm 1305.78	23.03
15.	357	5	10357.60 \pm 447.39	9.68
16.	Barando	3	9228.00 \pm 2797.28	52.84
17.	Falihope	11	9001.91 \pm 607.61	22.34
18.	Kuenol	6	8521.33 \pm 1014.84	29.05
19.	Singapore	8	8431.87 \pm 1213.63	40.59

Heritability Estimates

The heritability estimate of age at first calving, 305 days first lactation yield, breeding efficiency based on first and available calving intervals and life time milk production as measured by yield upto 6, 8, 10 years of age and completion of first five standard lactation yield was calculated by intra-class regression of daughter on dams method. These are presented diagonally in table 9.

Age at first calving

The heritability estimate of age at first calving in this study suggests that only 32 per cent of the total variability in age at first calving is due to genetic sources. This is in agreement with 0.48 ± 0.16 (Amble et al., 1958), 0.32 ± 0.16 (Daya Singh and Sunderesan, 1966) in Tharparkar, 0.39 ± 0.16 (Stonaker, 1953) in Red Sindhi, 0.34 ± 0.12 (Singh and Desai, 1961) in Haryana, 0.38 ± 0.26 (Puri and Malik, 1963) in Sahiwal. This estimate indicates that by subjecting young females to better feeding and management conditions, maturity can be achieved at an earlier age and selection for lower age at first calving can be made.

First lactation production

The heritability estimate of first 305 days lactation yield was 0.402 ± 0.14 which is closer to 0.42 ± 0.16 (Amble et al., 1958), 0.39 ± 0.16 (Daya Singh and Sunderesan, 1966) in Tharparkar; 0.44 ± 0.32 (Koerner, 1963), 0.36 ± 0.10 (Gopal and Shastri, 1972) in Sahiwal and 0.30 ± 0.13 (Singh and Parasad,

rd
old

+0.508

Age at first

+0.156
3)

Breeding effi-
(SE)

+0.464
+0.003
(SE3)

Yield upto 6 y-
age

+0.563
+0.496
3)

Yield upto 8 y-
age

+0.368
3)

First five sta-
lactation yield

+0.051
3)

1967) in Haryana. This estimate indicates that additive genetic effects may be assumed to represent 40 per cent of total phenotypic variance and this magnitude of heritability is large enough to make mass selection for improving first lactation yield.

Life time production

The heritability estimate for the life time milk production evaluated at 8 years of age amongst the life time production traits was higher (0.488 ± 0.137), whereas the heritability estimate for life time production upto 8 years of age was lower (0.195 ± 0.136). The heritability estimates for the total milk produced at 10 years of age and completion of five standard lactations (305 days) were 0.419 ± 0.150 and 0.334 ± 0.051 respectively.

Breeding Efficiency

The heritability estimates of breeding efficiency based on first and all available calving intervals in the present study were 0.561 ± 0.179 and 0.250 ± 0.118 respectively. Erb et al. (1940) observed by analysing the prominent cow family for services per conception, that some families have higher breeding efficiency than the others and assumed that breeding efficiency could be a heritable character. Seath et al. (1943) believed that breeding efficiency was inherited, whereas the heritability estimates of breeding efficiency based on non-returns to first service (Dunbar and Henderson, 1950); on regularity of oestrus, intervals from first service to

conception and number of services per conception (Pou et al., 1953; Legates, 1954; Parsad, 1958; Everett et al., 1966 and Johnson and Everson, 1966), calving to first estrus (Old and Beath, 1953); days open and parturition to first breeding (Everett et al., 1966) were close to zero. Smith and Legates (1962) obtained very low repeatability and heritability of breeding efficiency which were less than 0.10.

However, the present heritability estimate of breeding efficiency based on first calving interval indicates that 56 per cent of the total variability is due to genetic sources and this magnitude of heritability is encouraging. Selection, therefore, based on first breeding efficiency estimate may result in some improvement as there exists high phenotypic and genetic correlation with life time breeding efficiency.

Phenotypic and Genetic correlations

Phenotypic and the genetic correlations of age at first calving, first lactation production, life time production as measured by the total yield during first five lactations, and yield upto 6, 9 and 10 years of age and breeding efficiency based on first and all available calving intervals with their standard errors, among each other have been presented (Table 9). The genetic correlations are above the diagonal values, whereas phenotypic correlations are shown below the diagonal values. The numbers of daughter-dam pairs have also been given.

The genetic correlation of the age at first calving with production (first lactation production and life time production as evaluated by total milk produced during first five

standard lactations and upto 5, 8 and 10 years of age) and reproductive (breeding efficiency based on first and all available calving intervals) traits were negative and significant, showing thereby that with the decrease in age at first calving, the productive and reproductive efficiency increase.

The genetic correlation of age at first calving with life time breeding efficiency and total milk produced in first five lactations was greater than one. The genetic association between these traits indicate that genes causing early age at first calving also increased the productive and reproductive efficiency. On the contrary phenotypic correlation of age at first calving with these traits were generally negative. However, the correlation with first lactation yield and breeding efficiency based on first calving interval were very low. Similar phenotypic correlations have been reported (Larson et al., 1951; Regab et al., 1954; Sundaresan et al., 1954; Mahadevan, 1955; Regini and Pasti, 1955; Singh and Choudhury, 1959; Deyo Singh and Sundaresan, 1966; Ghosh and Dasai, 1967; Copal and Chatnagar, 1972 and Lee, 1976; Gurnani et al., 1975).

Age at first calving and first lactation production appeared to be virtually independent. The age at first calving can be reduced to a level where early maturity would be assured without any untoward effect on the first lactation yields.

Genetic and the phenotypic correlations of first lactation production and life time production traits were positive and significant though the association of first lactation production with breeding efficiency based on first and all

available calving intervals was negative. The animals having high first lactation production tended to have more life time milk production and the lower breeding efficiency. The genetic correlation of first lactation production with life time breeding efficiency was found to be negative and more than unity.

Positive and significant correlations between first lactation and life time production are well supported by Roth (1952), Kliensch and Bankwitz (1952), Sundaresan et al. (1954), Sukhbir Singh et al. (1963), Puri and Sharma (1963), White and Nichols (1965), Rehman Butt et al. (1965), Salles and Plessis (1971), Mathur and RoyChoudhury (1971), Salles (1971) and Gopal and Shatnagar (1972).

Both phenotypic and the genetic correlations between breeding efficiency based on first calving interval and life time breeding efficiency were significant and positive. These suggest that breeding efficiency is an inherited character and an animal with high breeding efficiency tends to repeat the superiority from lactation to lactation.

Animals having high breeding efficiency either based on first or all available calving intervals almost had more production during their life time upto a given age, whereas the breeding efficiency had significant negative relationship with the milk produced during first five standard lactations. Similar observations have been reported (Sawa et al., 1967; Ueda, 1968; Yanchenko and Radionovskii, 1979).

The life time breeding efficiency was positively associated with the life time production upto 6, 8 and 10 years of age. This is probably due to more calvings upto the given age. This fact has been supported by Seda (1968), Sergeev (1970), Vasil'ko (1971) and Yanchenko and Radionovskii (1975).

Genetically breeding efficiency based on first calving interval had negative association with the life time production traits. These genetic correlations were found to be greater than one.

Phenotypic and the genetic correlations amongst the life time production of 6, 8 and 10 years of age were positive and significant indicating their greater association between these traits. It further indicates that there are many sets of genes which are common for genetic part of the variance between these traits.

The total of first five standard lactation yield was found to have positive phenotypic and genetic correlation with her life time milk production at a given age. The phenotypic correlations were highly significant whereas the genetic correlations were greater than one.

Life time milk production in relation to age at first calving

The average life time milk production of all cows for which all the data on first five lactations and upto 6, 8

and 10 years of age were available have been classified according to the range of age at first calving (Table 10).

Table 10. Life time milk production (kg) in different class intervals of age at first calving.

Age groups	No.	Rupees			
		Yield upto 6 years	Yield upto 8 years	Completion 5 lactations	Yield upto 10 years
26-30.5	46	9127.79	14256.65	14017.50	17163.22
30.6-35.5	30	8020.00	12872.60	13798.01	17028.30
35.6-40.5	33	6268.69	10835.70	12435.50	14845.12
40.6-45.5	26	4666.39	8187.00	10240.45	11805.38
45.6-50.5	11	3753.37	7212.00	8709.72	10690.75
50.6 and above	8	3416.75	7131.12	10862.72	10400.72

The animals calving between 26.0 to 30.5 months of age comprising of 11.4 per cent of the population provided more milk in first five lactations and when measured upto 6, 8 and 10 years of age. Cows with higher age at first calving (50.6 months and above) appeared to produce slightly more milk in first five lactations presumably because of their retention on the farm beyond the 10 years of age. With increase in the age at first calving the life time milk production tended to decrease in general (Fig.1) which is in agreement with Sethu (1964); Gopal and Bhattacharya (1969); Nagpaul and Bhattacharya (1971); Deller and Pleonic (1971); Rathur and RoyChoudhury (1971) and Deller (1972).

The frequency of the animals calving between 30.6

and 50.5 months was about the 11.4 per cent of

population calved below 30.6 months of age. The number of heifers calving at an advanced age for the first time also decreased because of selection procedures for higher productive and reproductive efficiency on the farm.

Life time milk production in relation to first lactation yield

The life time milk production per cow as measured by first five lactations and upto 6, 8 and 10 years of age has been classified on the basis of first lactation yield. The results in the table 11 indicate that more than 67 per cent of the animals maintained on the farm produced milk from 2501 to 3500 Kilograms in first lactation of 305 or less days.

Table 11. Life time milk production (kg) classified on the basis of first lactation yield.

First 305 days lactation yield (kg) groups	No.	Means			
		Yield upto 6 years	Yield upto 8 years	5 lactation yield	Yield upto 10 years
Below 1000	6	3489.66	6800.50	7642.83	9712.00
1001-1500	9	3575.00	6890.00	6626.66	10344.88
1501-2000	20	4945.75	8760.60	10117.90	12420.75
2001-2500	34	6101.79	10664.38	12110.90	14679.65
2501-3000	23	7065.52	11732.78	14087.27	15927.09
3001-3500	23	8389.00	12659.68	14743.69	16003.09
3501 and above	3	8393.00	13289.30	15190.00	17070.91

The average life time milk production per cow increased with the increase in first lactation yield revealing that high producing first calves would continue to produce well.

in their later life than those producing less in first lactation. This finding is in agreement with those of Nichols (1965); Mahesh Dutt et al. (1965); Singh (1966); Sasaki and Desai (1967); Copal and Shatnagar (1969); Rathore and RayChoudhury (1971) and Heller (1972). Selection, therefore, on the basis of first lactation for life time production can be an asset. The life time production as affected by the first lactation yield has been presented graphically (Fig.2).

Life time milk production in relation to Breeding efficiency

The average life time milk production as measured by the first five lactations and upto 6, 8 and 10 years of age and average life time breeding efficiency have been grouped on the basis of breeding efficiency based on first calving interval (Table 12). The life time breeding efficiency as affected by breeding efficiency based on first calving interval indicates that the animals having higher breeding efficiency in early life tend to have higher breeding efficiency in their life time. About 52.4 per cent of the animals had the breeding efficiency based on first calving interval between 31 to 100 per cent whereas 12.7 per cent animals had more than 100 per cent efficiency suggesting thereby that cows calved second time within a year which is detrimental for life time productive and reproductive potentiality, if not well cared for, since such animals are subjected to more stress because of heavy load of lactation and pregnancy.

Table 12. Life time milk production (kg) and life time breeding efficiency (%) in different classes of breeding efficiency based on first calving interval.

Breeding efficiency(%) groups	No.	Mean life time production(kg)			Life time breeding efficiency (%)	
		Yield upto 6 years	Yield upto 8 years	5 last- stitions	Yield upto yield 10 years	
Below 60	14	5780.43	10199.64	13777.93	14197.64	71.55
61-70	11	6437.84	9816.00	14304.18	14592.91	80.38
71-80	14	6559.88	10294.00	12503.57	15185.29	82.56
81-90	31	6586.93	10352.81	12119.29	15592.64	84.61
91-100	33	6862.21	11036.38	11869.39	15526.61	87.23
101-110	9	5526.11	9170.78	9747.33	13722.11	93.58
111 and above	8	3918.00	7560.00	7746.17	10449.33	97.60

The average life time production as measured upto 6, 8 and 10 years of age and total yield in first five lactations has been grouped on the basis of life time breeding efficiency in table 13. The life time production as affected by breeding efficiency based on first and all available calving intervals has been presented graphically (figs.3 and 4).

These graphs and tables clearly point out that with the increase in the breeding efficiency upto 95 per cent, the total life time milk production calculated on the basis of age increased but beyond 95 per cent breeding efficiency, there was a fall in life time milk production, most probably the animals with higher breeding efficiency remained in stessa, which

Table 12. Life time milk production (kg) and life time breeding efficiency (%) in different classes of breeding efficiency based on first calving interval.

Breeding efficiency(%) groups	No.	Mean life time production(kg)			Life time breeding efficiency (%)	
		Yield upto 6 years	Yield upto 8 years	5 lactations	Yield upto 10 years	(%)
Below 60	14	5700.43	10199.64	13777.93	14197.64	71.55
61-70	11	6437.84	9816.00	14324.18	14592.91	80.38
71-80	14	5559.86	10294.00	12503.57	13185.28	82.56
81-90	31	6596.93	10352.81	12119.29	15592.64	84.81
91-100	33	6862.21	11036.38	11869.39	15828.61	87.23
101-110	9	5526.11	9170.78	9747.33	13722.11	93.58
111 and above	8	3919.00	7560.00	7740.17	10448.33	97.60

The average life time production as measured upto 6, 8 and 10 years of age and total yield in first five lactations has been grouped on the basis of life time breeding efficiency in table 13. The life time production as affected by breeding efficiency based on first and all available calving intervals has been presented graphically (Figs.3 and 4).

These graphs and tables clearly point out that with the increase in the breeding efficiency upto 95 per cent, the total life time milk production calculated on the basis of age increased but beyond 95 per cent breeding efficiency, there was a fall in life time milk production, most probably the animals with higher breeding efficiency remained in staces, which

resulted in lowering the health status of the animals and consequently the production.

Table 13. Life time milk production in relation to life time breeding efficiency

Breeding efficiency groups	No.	Mean			
		Yield upto 6 years	Yield upto 8 years	5 lactations	Yield upto 10 years
Below 50	6	3860.70	8721.36	14628.56	13052.16
51-70	3	5445.00	9538.43	14242.42	13199.28
71-80	30	5201.23	10740.90	13629.48	13435.88
81-90	42	6308.00	10531.38	12281.93	14682.97
91-100	31	6470.13	10985.55	11381.77	15092.06
101 and above	5	4986.80	8634.80	9069.80	11991.90

Cows calving at shorter intervals or having high breeding efficiency gave more milk upto a given age as compared to the cows having lower breeding efficiency. The trend of milk yield in the first five lactations in different classes of breeding efficiency was different from the other life time production measures. With the increase in breeding efficiency there appeared a fall in life time production represented by a total of five lactations (305 days or less) which is in agreement with Sado (1968) who analysed calving intervals to the first four lactations amongst Hungarian Red Spotted cows reporting that with a decrease in calving interval of 30 days the milk yield decreased by 3 per cent.

Carmen (1959) indicated that when the breeding efficiency was measured by post-partum estrus and days to conception (service period), it was antagonistic to milk production. This might have largely been due to longer time required for conception and the less opportunity for the developing fetus affect the milk production. Florentino (1963) observed the increase in milk yield with the increase in length of calving interval, the increase being greater from 11 to 13 months than from 13 to 21 months.

Goswami and Kumar (1967) reported that first calving interval was longer for high yielding Murrah buffaloes than for low yielders, but the subsequent shorter calving intervals of animals producing higher milk yield indicated that high yielders had more calf crop and so more number of lactations.

Similar reports have been given by Sergeev (1970); Voelke (1971) and Yanchenko and Radionovskii (1975).

Partial Correlation and Regression

The partial correlation and regression coefficients between life time production and life time breeding efficiency with age at first calving, first lactation production and breeding efficiency based on first calving interval have been presented in table 14.

It is seen from the table that age at first calving, first lactation production and breeding efficiency based on first calving interval were highly related with life time

Table 14. Partial correlation and regression coefficients of lifetime production and reproduction on age at first calving, first lactation production and breeding efficiency based on first calving interval.

Traits(y)	Partial correlation coefficients			Partial regression coefficients		
	$r_{yx1 \cdot x2x3}$	$r_{yx2 \cdot x1x3}$	$r_{yx3 \cdot x1x2}$	$b_{yx1 \cdot x2x3}$	$b_{yx2 \cdot x1x3}$	$b_{yx3 \cdot x1x2}$
<u>Milk production up to</u>						
6 years of age	-0.837 \pm 0.079	0.675 \pm 0.059	0.190 \pm 0.030	-237.56 \pm 6.67	0.386 \pm 0.09	3.47 \pm 0.77
8 years of age	-0.614 \pm 0.064	0.507 \pm 0.081	0.207 \pm 0.039	-242.64 \pm 19.14	1.338 \pm 0.18	13.56 \pm 2.20
10 years of age	-0.556 \pm 0.076	0.552 \pm 0.077	0.164 \pm 0.086	-218.38 \pm 14.92	2.441 \pm 1.02	85.43 \pm 5.97
First Five Lactations (305 days)	-0.483 \pm 0.099	0.438 \pm 0.094	0.256 \pm 0.089	-149.01 \pm 15.30	1.007 \pm 0.19	1.01 \pm 0.68
<u>Reproduction</u>						
Life time breeding efficiency(BE_L)	-0.196 \pm 0.091	-0.212 \pm 0.086	0.426 \pm 0.087	-3.643 \pm 0.07	0.015 \pm 0.02	0.270 \pm 0.08
<u>Breeding efficiency based on first calving interval</u>						
x1 = Age at first calving						
x2 = First 305 days lactation production						
x3 = Breeding efficiency based on 1st calving interval						

production and reproduction traits. Partial correlation coefficient being highly significant on keeping two characters as constant. The age at first calving was highly negative correlated with different parameters of life time production and the breeding efficiency based on all calving intervals. Increase in first lactation yield increases life time production and decreases the life time breeding efficiency when the age at first calving and breeding efficiency based on first calving interval were kept constant.

The partial correlation of first breeding efficiency on life time production at a given age and life time breeding efficiency were positive and highly significant whereas the correlation with total yield upto the completion of five lactations was negative and highly significant, keeping both the age at first calving and first lactation production as constant.

It is further pointed out that the life time milk production upto 6 years of age was comparatively more related to first lactation production as compared to the life time milk production upto completion of five lactations and upto 8 and 10 years of age whereas the life time milk production upto 8 years of age was very closely related in contrast to the other measures of life time production under study with the reproductive traits (age at first calving and breeding efficiency based on first calving interval).

No apparent differences in estimates of the partial correlation coefficient between age at first calving and life time production were observed, as tested by 'Z' transformation (Snedecor and Cochran, 1957). However, partial correlation between breeding efficiency (BE_a) and life time production upto 10 years of age differed from the correlation coefficients of BE_a with life time production as evaluated upto completion of five lactations, keeping age at first calving and first lactation yield constant. The level of significance just approached 5% level.

Partial regression coefficients with their respective standard errors have been presented in table 14. The partial regression coefficients for life time milk production were highly significant except breeding efficiency(BE_a) on total milk production during five lactations keeping age at first calving and first lactation yield constant indicating high degree of reliance that can be placed on the prediction equations (Table 15) based on age at first calving, first lactation production and breeding efficiency based on first calving interval.

The reproductive traits (age at first calving and breeding efficiency based on first calving interval) was seen to explain more of the total variation in life time milk production than the first lactation production. Similarly age at first calving was seen affecting life time breeding efficiency more than the breeding efficiency based on first

Table 15. Multiple correlation and regression equations of age at first calving, First 305 days lactation yield and breeding efficiency (βE_a) on life time production and reproduction traits.

Character	Multiple correlation	Multiple regression equation		
		Milk production upto 6 years of age	Milk production upto 8 years of age	Milk production upto 10 years of age
<u>Milk production upto</u>				
6 years of age	0.874	$Y = 18793.16 + 237.56X_1 + 0.385X_2 + 3.47X_3$		
8 years of age	0.508		$Y = 21948.70 + 232.64X_1 + 1.330X_2 + 13.96X_3$	
10 years of age	0.686			$Y = 21342.61 + 210.36X_1 + 2.440X_2 + 85.43X_3$
First Five Lactation(305 days)	0.524			$Y = 15672.20 + 149.09X_1 + 1.007X_2 + 1.01X_3$
<u>Reproduction</u>				
Breeding efficiency (βE_a)	0.302	$Y = 92.78 + 0.443X_1 + 0.015X_2 + 0.27X_3$		
<u>Y = Predicted production</u>				
X_1	= Age at first calving (months)			
X_2	= First 305 days lactation production(kg)			
X_3	= Breeding efficiency (βE_a) based on 1st calving interval (%)			

calving interval. First lactation production was found to have the least effect on life time breeding efficiency.

Prediction Equations

Prediction equations based on partial regression coefficients were found to explain 77, 32, 47 and 27 per cent of the total variation in life time milk yield as evaluated upto 6, 8, 10 years of age and upto completion of five lactations. Highly significant multiple correlation for different measures of the life time milk production suggests that these three characteristics provide a sufficient knowledge of life time production.

The multiple correlation (table 15) of age at first calving, first lactation production and breeding efficiency based on first calving interval were found to explain about 87, 57, 67, 52 and 30 per cent of the total variation of life time production upto 6, 8, 10 years of age and completion of five lactations and life time breeding efficiency respectively.

The test of linearity showed that all the prediction equations for life time milk production and the life time breeding efficiency were linear at 1% level of significance.

Addition of first lactation production and breeding efficiency (DE_g) has increased the accuracy of prediction from 53 to 87, 51 to 86, 48 to 89, 39 to 82 and

calving interval. First lactation production was found to have the least effect on life time breeding efficiency.

Prediction Equations

Prediction equations based on partial regression coefficients were found to explain 77, 32, 47 and 27 per cent of the total variation in life time milk yield as evaluated upto 6, 8, 10 years of age and upto completion of five lactations. Highly significant multiple correlation for different measures of the life time milk production suggests that these three characteristics provide a sufficient knowledge of life time production.

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The test of linearity showed that all the prediction equations for life time milk production and the life time breeding efficiency were linear at 1% level of significance.

Addition of first lactation production and breeding efficiency (ΣE_a) has increased the accuracy of prediction from 53 to 87, 51 to 86, 40 to 69, 39 to 92 and

Table 16. Multiple correlations and percent variance in η^2 .

1 to 30 per cent of the variance for the four estimates of life time milk production (upto 5, 8, 10 years and completion of five lactations) and life time breeding efficiency respectively. Due emphasis should be laid to the first 305 days lactation production and breeding efficiency based on first intercalving period in addition to age at first calving for selecting or replacing the Tharparker cows.

While taking two traits of the three (AFC, FLP and SE_3) at one time (table 16), the difference between the multiple correlation coefficient and the square of each of the simple correlation coefficient, between age at first calving and estimates of life time production and breeding traits indicates the additional consideration of first lactation production (x_2) and breeding efficiency based on first calving interval (x_3) separately, increased accuracy of the prediction of life time production at a given period and life time breeding efficiency. However, additional consideration of age at first calving and first lactation production did not affect the life time breeding efficiency.

S U M M A R Y

Performance records of 523 Tharparkar cows born to 37 sires during the period of 1926-1975 at the National Dairy Research Institute, Karnal constituted the material for this study. Breeding efficiency was calculated using the method described by Gilcox et al. (1957).

Data on age at first calving, first 305 days lactation yield, breeding efficiency based on first calving interval, life time production upto 6, 8, 10 years of age and upto first five lactations (305 days) and life time breeding efficiency were analysed to estimate the heritability of these traits and phenotypic and genetic correlations among themselves.

The influence of age at first calving, first 305 days lactation production and first breeding efficiency on four estimates of life time production (as measured by total milk produced upto 6, 8, 10 years of age and in the 305 days first five lactations) were investigated.

The average of age at first calving (months), first 305 days lactation yield (kg) and breeding efficiency based on first calving interval (%) was 38.03 ± 0.33 , 2177.00 ± 80.43 , 88.27 ± 0.72 and with 19.00, 31.73, 19.21 per cent coefficients of variation for 523 Tharparkar cows respectively.

The life time milk production was 5803.46 ± 132.94 , 10012.14 ± 238.19 , 14453.00 ± 357.19 and 12144.23 ± 289.48 (kg) with 41.53, 33.31, 25.48 and 38.80 per cent coefficient of variation for 331, 196, 106 and 157 Tharparkar cows upto 6, 8, 10 years of age and cumulates (305 days) five lactations respectively.

Highly significant differences between sires for age at first calving, first lactation yield and different measures of life time milk production were observed. However, no effect of sires on the breeding efficiency was observed.

The heritability was estimated by doubling the intrasire regression of daughters on dams. The heritability estimates of age at first calving, first lactation production, breeding efficiency based on first and all calving intervals, life time milk production upto 6, 8, 10 years of age and yield upto five lactations (305 days) were 0.322 ± 0.124 , 0.402 ± 0.142 , 0.561 ± 0.179 , 0.250 ± 0.118 , 0.195 ± 0.136 , 0.488 ± 0.137 , 0.419 ± 0.160 and 0.354 ± 0.051 respectively.

The phenotypic correlations amongst the age at first calving, first lactation production, breeding efficiency based on first and all calving intervals and different measures of life time production were found to be significant except the first lactation production and the first breeding efficiency with age at first calving being negative and non-significant. The age at first calving had a negative relationship with all the traits under study indicating that heifers calving at an earlier age had better life time milk production and reproductive

efficiency. The first lactation production had a significant negative correlation with breeding efficiency based on first and all calving intervals showing thereby that animals which produced more milk in first 305 days lactation were having lower breeding efficiency, other correlations were positive.

The genetic correlations of age at first calving with first lactation production and life time milk production upto 6, 8 and 10 years of age and breeding efficiency based on first calving interval were negative and significant indicating that with the decrease in age at first calving, the productive and reproductive efficiency increased. The genetic trend of age at first calving with life time breeding efficiency was negative. Genetic correlation between breeding efficiency based on first calving interval and life time breeding efficiency was 0.723 ± 0.245 .

The phenotypic and genetic correlation amongst the life time production upto 6, 8 and 10 years of age were positive and significant.

The partial correlation and regression coefficients indicated that the reproductive traits (age at first calving and breeding efficiency based on first calving interval) was seen to explain more of the total variation in life time milk production than the first lactation production. Similarly age at first calving was seen affecting life time breeding efficiency more than the breeding efficiency based on first calving interval. First lactation production was found to have the least effect on life time breeding efficiency.

Frequency of heifers calving between 30.0 to 30.5 months was 51.8 per cent, whereas 11.4 per cent of population calved between 26.0 to 30.5 months. The animals calving within 30.5 months of age had higher life time milk production.

More than 67 per cent of the animals maintained on the farm produced milk ranging from 2501 to 3500 kg in first lactation of 305 or less days. The average life time milk production per cow increased with the increase in first lactation yield.

About 52.4 per cent of the animals had the breeding efficiency based on first calving interval ranging between 81 to 100 per cent, whereas 12.7 per cent animals had more than 100 per cent breeding efficiency meaning thereby that cows calved second time within a year, which is detrimental for life time production and reproductive potentialities if not well cared for. Animals having higher breeding efficiency in early life tend to have higher breeding efficiency in their life time. With the increases in breeding efficiency upto 95 per cent, the total milk production on the basis of given age increased but there was a fall in life time milk production, if breeding efficiency went higher than 95 per cent. More than 95 per cent breeding efficiency might have resulted in the lowering of health of the animal and consequently the production.

Additional information of first lactation production and **first breeding efficiency** to age at first calving increased the accuracy of prediction equation from 53 to 87, 51 to 56, 40 to 69, 39 to 52 and 1 to 30 per cent of the variance for the four estimates of life time production (upto 6, 8, 10 years of age and completion of first five standard lactations) and life time breeding efficiency respectively. However, additional consideration of age at first calving and first lactation production did not improve the life time breeding efficiency.

The prediction equations for the life time production and life time breeding efficiency were found to be:

$$Y_1 = 16793.16 - 257.56X_1 + 0.386X_2 + 3.47X_3$$

$$Y_2 = 21948.70 - 242.64X_1 + 1.330X_2 + 13.96X_3$$

$$Y_3 = 21342.61 - 218.38X_1 + 2.440X_2 + 93.43X_3$$

$$Y_4 = 15672.20 - 149.01X_1 + 1.007X_2 + 1.01X_3$$

$$Y_5 = 99.78 - 0.443X_1 + 1.015X_2 + 0.27X_3$$

Where, Y_1 , Y_2 , Y_3 , Y_4 are the total milk produced during 6, 8, 10 years of age and in first five standard lactation yield and Y_5 is the life time breeding efficiency.

