STUDY ON

GENETIC TREND OF THARPARKAR HERD AT GOVERNMENT CATTLE FARM, PATNA WITH SPECIAL REFERENCE TO PRODUCTION AND REPRODUCTION

THESIS
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RAJENDRA AGRICULTURAL UNIVERSITY, BIHAR
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BY
Satyendra Prasad Singh

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

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Pusa (Samastipur), 1981

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C E R T I F I C A T E

This is to certify that the thesis entitled "STUDY ON GENETIC TREND OF THARPARKAR HERD AT GOVERNMENT CATTLE FARM, PATNA WITH SPECIAL REFERENCE TO PRODUCTION AND REPRODUCTION" submitted in partial fulfilment of the requirements for the Degree of Master of Veterinary Science (Animal Breeding and Genetics) of the Faculty of Postgraduate studies, Rajendra Agricultural University, Bihar, is the record of bonafide research carried out by Dr. Satyendra Prasad Singh under my supervision and guidance. No part of the thesis has been submitted for any other Degree or Diploma.

It is further certified that such help or information received during the course of this investigation and preparation of the thesis have been duly acknowledged.

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C E R T I F I C A T E

We, the undersigned, members of the Advisory Committee of Dr. Satyendra Prasad Singh, a candidate for the Degree of Master of Veterinary Science with Major in Animal Breeding and Genetics, have gone through the manuscript of the thesis and agree that the thesis entitled "STUDY ON GENETIC TREND OF THARPARKAR HERD AT GOVERNMENT CATTLE FARM, PATNA WITH SPECIAL REFERENCE TO PRODUCTION AND REPRODUCTION" may be submitted by Dr. Satyendra Prasad Singh in partial fulfilment of the requirements for the Degree.

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(S.P. SINGH)

C O N T E N T S

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INTRODUCTION

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The entire Indo-gangetic expanse is a rich and fertile agricultural belt with high potentiality for improved animal husbandry practices. Tharparkar cattle which originally hails from sindh area of Indus belt has maintained its identity in different agro-climatic conditions and high thermal stress zones of the Indian sub-continent. Tharparkar, a well known Zebu cattle for its milk production and draught potentiality, seems to suit the Indian farming community immensely as they are able to get both milch cows and humped draught bullocks which are so much vitally needed for the country's agricultural operations.

In a sub-tropical country like India with its varied agro-climatic conditions, the different economic traits in cattle do not find same threshold values in different regions. Secondly, germ plasm potentiality of this breed under the existing thermal stress in the country has not been fully studied and since only a few works have been done with inconclusive presentation, the present studies assume considerable importance.

Indian cattle, specially Tharparkar suffer from late sexual maturity resulting in delayed age at first calving and long calving intervals. Early maturity has been found to be of

great economic value, as increase in the age of sexual maturity of a cow by a single day pushes up the expenditure to a back-breaking level (Desai and Kumar, 1963). Early sexual maturity not only reduces the unproductive period of cows but also increases the life time production.

From the economic stand point the milk yield per unit time is more important than lactational performance and since breeding efficiency is highly correlated with performance per unit time, the present study has combined both production and reproduction traits with following objectives :

To estimate the Genetic variability as well as milk producing ability ;

to estimate the production efficiency of certain economic traits ;

to study the reproductive performance and to study inheritance of certain economic traits.

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REVIEW OF LITERATURE

Age at first calving :

Delayed maturity coupled with long calving interval is a major cause of uneconomic dairying in India (Amble et al., 1958). They further observed that age at first calving reduced the generation interval which facilitated the process of progeny testing.

Johansson (1950) reported that the life time production and number of calvings in case of early calvers were more than those in late calvers.

Late maturity is the breed characteristic in tropical cattle (Lecky, 1951). Stonaker (1953) observed this trait to be highly heritable in Red Sindhi cows.

According to Mahadevan (1958) the age at first calving could be greatly reduced by improved managemental practices. The average age at first calving in Zebu cattle was reported to be higher in comparison to their crosses with exotic ones.

Tandon (1951) and Nagpaul and Acharya (1970) found non-significant influence of month of calving on age at first

calving in Sahiwal herd, whereas significant effect of month of calving was reported in Hariana cows by Acharya (1966) and Dhillon et al. (1970). Year of calving was observed to have significant influence on age at first calving in Hariana cows.

Sundaresan et al. (1965), Guha et al. (1968) and Nagpal and Acharya (1970) reported significant variation among periods, years within period for age at first calving in Tharparkar cows indicating thereby non-genetic influence on the trait.

Koul (1968) in a study of various genetic and non-genetic factors in Sahiwal and crosses with Friesians observed significant effects of grades, farms, periods, seasons and breeds on age at first calving. Significant effects of farms, years of calving, weight of dam at calving was observed by Nagpal and Acharya (1971) but effect of season of calving was found to be non-significant.

Singh et al. (1964), [illegible] and Gill (1969) noticed non-significant effect of age at first calving on first lactation yield in Hariana cows.

Based on 727 records of Tharparkar cows during the period 1937-1961, Das and Bhatnagar (1967) showed that age at first calving ranged between 24-72 months. The mean age at first calving was found by them to be 38.4 ± 7.75 months and seasonal variation in the trait was reported to be 46 per cent. only 21 per cent was observed to be due to heredity. More than 52 per

cent of the heifers were noticed to have calved between 30 to 40 months of age.

Nagpaul and Bhatnagar (1971) reported that 13 per cent of heifers calved at the age below 30 months. It was also apparent that cows calving at 25 to 30 months age had an opportunity to produce milk for longer periods as compared to late calvers. The age at first calving as reported in different breeds of Zebu are presented in table given below :

Table 1. Showing age at first calving in different Zebu breeds.

Breeds	No. of observation	Mean + S.E. (months)	C.V.	Reference
1	2	3	4	5
Tharparkar	209	1461.0+14.5 (days)	-	Singh (1957)
	350	48.70+0.48	-	Amble et al. (1958)
	90	43.20+1.26	-	Singh and Choudhary (1961)
	48	38.80+1.34	-	Puri and Sharma (1965)
	185	42.0	-	Sundaresan et al. (1965)
	596	38.49+0.30	19.0	Nagpaul and Bhatnagar (1971)
	742	38.80+0.27	-	Reddy and Bhatnagar (1971)
	396	1498.77+7.7 (days)	10.2	Prasad and Prasad (1972)
	63	41.1+0.70	13.5	Dutt et al. (1974)
	30	1075+16.7 (days)	-	Basu et al. (1979)
	523	38.02+0.32	19.0	Gupta and Bhatnagar (1979)
Sahiwal	27 (overall)	1070.8+23.1 (days)	-	Basu et al. (1979)
	522	1112 (days)	17.0	Kumar and Narain (1979)

Table 1 Cont'd.

Breeds	No. of observation	Mean ± S.E. (months)	C.V.	Reference
1	2	3	4	5
Red Sindhi	58	1117±18.6 (days)	-	Basu et al. (1979)
	123	41.5± 50	13.37	Malhotra and Singh (1980)
Hariana	533	50.0±0.5	-	Kumar and Bhat (1979)
	-	1316.96±10.77 (days)	14.60	Mishra et al. (1980)

Lactation yield :

The value of cow is generally measured in terms of milk yield. The findings of different workers in the different Indian breeds of cattle are summarised in Table 2.

Breed	No.of observation	Mean first lactation yield ±S.E. (kg.)	C.V.	Reference
1	2	3	4	5
Tharparkar	48	2580.00	-	Puri and Sharma (1965)
	37	1995-2211	-	Sundaresan et al. (1965)
	229 (overall)	2227.0±73.0	-	Amble et al. (1967)
	727	2160.75±28.20	-	Das and Bhatnagar (1967)
	596	2146.62±22.4	-	Nagpaul and Bhatnagar(1971)
	742	2166.75±28.21	-	Reddy and Bhatnagar(1971)
	1529	2414.36±20.50 (lbs.)	32.2	Prasad and Prasad (1972)

Table 2 Cont'd.

Breed	No. of observation	Mean first lactation yield ± S.E. (kg.)	C.V.	Reference
1	2	3	4	5
	-	1301.9±58.6	32.9	Sharma et al. (1972)
	102 (overall)	912.55±47.71	52.75	Johar and Taylor (1973)
	63	1301.06±53.6	41.7	Dutt et al. (1974)
	31	1414.87±189.77	-	Basu et al. (1979)
Sahiwal	65	1160.00	-	Sen et al. (1953)
	115	1489.00	-	Singh and Chaudhary (1961)
	112	2218.00	-	Sundaresan et al. (1965)
	118	1772.00±83.00	-	Amble and Jain (1966)
	162	1674.38	-	Singh and Desai (1966)
	51	1632.90±48.29	-	Gehlon and Malik (1967)
	104	1618.00±38.00	-	Khanna and Bhat (1971)
	456	1596 ± 21	-	Nagpal and Acharya (1971)
	398	2336.00±33.46	-	Gopal and Bhatnagar (1972)
	655	1610.00±19.00	-	Mishra (1973)
	443	1617.00	-	Kumar and Narain (1979)
	44	1602.5±180.83	-	Basu et al. (1979)
Hariana	-	1491±37.1 lbs.	-	Kohli et al. (1961)
	565	708.93±13.08	-	Singh et al. (1968)
	105 (overall)	1136.65±48.16	-	Johar and Taylor (1973)
	Overall	921.92±24.51	-	Mishra et al. (1980)
Red Sindhi	-	3389.5±164.3 lbs.	0.43	Raj Gopalan (1952)
	-	2500.57±126.8 lbs.	-	L.R.S., Patna (1959-60)

Table 2 Cont'd.

Breed	No.of observation	Mean first lactation yield ±S.E. (kg.)	C.V.	Reference
1	2	3	4	5
	32	3314.0 lbs	-	I.C.A.R. (1962)
	-	2897.0±207.0 lbs.	-	Bhasin and Desai (1967)
	31	1159.3	-	Raj Kumar (1969)
	9	1450.09±261.73	-	Basu et al. (1979)
	219	1534.9±32	28.1	D'souza et al. (1979)
	123	1391.55±40	44.20	Malhotra and Singh (1980)

Mishra and Biswas (1963) observed that the daughters born to cows aged between 11-12 years were found to produce more milk in the first lactation (4027 ± 32.61 lbs) as compared to the females of other age groups. They also reported significant environmental influence from year to year on milk production. They further reported that daughters served by bulls of age groups between 0-4 years were found to produce more milk in the first lactation (5418.92 ± 664.83 lbs).

In Tharparkar cattle, Singh et al. (1962), Sandhu (1968) reported significant effect of season of calving on milk yield.

Sundaresan et al. (1965) observed that short span changes in milk production was essentially a reflection of changes in the feeding and management practices in Tharparkar herd at

N.D.R.I. Karnal.

Nagpaul (1968) reported significant effect of order of lactation on average milk production in Tharparkar cows and obtained maximum average production in third lactation (2709.47 ± 698.8 kg).

Dutt et al. (1974) found that cows with early maturity were superior in respect of production trait like milk yield.

Nagpaul and Bhatnagar (1972) found that order of lactation and month of calving on lactation yield accounted for 0.5 per cent and 49 per cent of total variation in lactation yield respectively.

Tharparkar cows calving in winter were reported to give 52 kg more milk than those calving in other seasons (Basu and Gupta, 1974).

Mishra et al. (1979) in his studies in Hariana, Tharparkar, Sahiwal with their Friesian crosses reported that seasons of calving had no significant effect on lactation yield in any breed group.

Das and Balaine (1980) reported that season of calving significantly affected milk yield in Hariana cows. The cows calving during the spring season produced significantly more milk and were followed by those of autumn and summer in descending order. They further observed that sequence of lactation had

significant effect on lactation milk yield. The result showed that milk production increased from first to third lactation and thereafter yield declined as lactation numbers increased.

Singh et al. (1980) reported that season of calving had significant effect on first 100 days milk yield and total first lactation yield in Tharparkar cows maintained at Government Cattle Farm, Patna. They further observed that milk yield of cows calving in winter and summer was significantly more than those calving in rainy season. The difference in milk yield between winter and summer calvers was however non-significant.

Lactation length :

Sandhu et al. (1973) studied the various genetic and non-genetic factors on lactation length. Effect due to farms were reported to be significant while that due to seasons of calving and breeds of sires were non-significant. The following table indicated the observations of different workers on lactation length in Indian breeds of cattle.

Table 3. Lactation length in different Zebu breeds of cattle.

Breed	No.of obser-vation	Mean first lactation length ± S.E. (days)	C.V.	Reference
1	2	3	4	5
Tharparkar	-	314.6±7.82	41.6	Singh (1961)
	-	271.0	32.1	Singh and Chaudhary (1961)

Table 3 Cont'd.

Breed	No. of observation	Mean first lactation length ± S.E. (days)	C.V.	Reference
1	2	3	4	5
	1602	278.8±1.2	17.5	Prasad (1962)
	-	282.0± 16	-	Amble et al. (1967)
	596	271 ± 4	-	Nagpaul (1968)
	-	254.0	-	Nagarcenkar (1969)
	-	268.0	-	Nagpaul and Bhatnagar (1971)
	1529	278.88±1.2	-	Prasad and Prasad (1972)
	-	318.0±10.1	25.5	Sharma et al. (1972)
	-	299.0±5.2	26.5	Dutt et al. (1974)
	331	283.84±12.06	-	Ram et al. (1979)
Hariana	-	331.4	27.45	Singh and Desai (1961)
	-	316.6	25.63	Singh and Desai (1961)
	203	255.71±5.75	-	Gehlon and Sekhon (1966)
	Overall	272.05±4.28	-	Mishra et al. (1980)
Red Sindhi	46	303±14.0	31.0	Amble et al. (1958)
	-	332.5	-	L.R.S. Patna (1959-60)
	-	254.82±10.25	-	Bhasin and Desai (1967)
	31	268.8	-	Raj Kumar (1969)
	-	284.1±3.3	17.7	D'Souza et al. (1979)
	123	287±6.89	26.65	Malhotra and Singh (1980)
Sahiwal	-	247.0	-	Sen et al. (1953)
	-	299±4.8	-	Singh and Dutt (1963)

Table 3 Cont'd.

Breed	No. of observation	Mean first lactation length ± S.E. (days)	C.V.	Reference
1	2	3	4	5
	-	296.0	-	Batra and Desai (1964)
	-	274.0	-	Sandhu (1968)
	-	278.0	-	Mishra (1973)
	-	321 ± 9	-	Johar and Taylor (1973)
	-	300 ± 4	-	Gurbachan (1975)
	442	292.0	30	Kumar and Narain (1979)

Singh et al. (1962) observed non-significant effect of season of calving on lactation length in Tharparkar cattle.

Rehfeld et al. (1976) observed that in Zebu the year of calving and parity had significant effects on lactation length.

Mishra et al. (1979) in his studies on Hariana, Sahiwal, Red Sindhi and their Friesian crosses reported non-significant effect of seasons of calving on lactation length.

Ram et al. (1979) concluded that parity had significant effect on lactation length in Tharparkar cattle.

Das and Balaine (1980) found significant effect of season of calving on lactation length in Hariana cows.

Dry period :

Dry period is one of the important segments in life time production of a cow. As this period is unproductive component of intercalving period, both genetic and non-genetic steps could be taken to maintain this at optimum level. Reports of different workers on this trait are as summarised in Table 4.

Table 4. Showing dry periods in different Zebu cattle.

Breed	No.of observation	Mean first dry period (± S.E.(days)	C.V.	Reference
1	2	3	4	5
Tharparkar	651	140.3±0.83	-	Jha and Biswas (1964)
	-	188.2	-	Nagarcenkar (1969)
	-	147.0	-	Nagpaul and Bhatnagar (1971)
	-	147.3 ± 8	67.8	Das et al. (1971)
	300	133.22±10.45	-	Pandey et al. (1978)
	28	160.4±40.6	-	Basu et al. (1979)
Red Sindhi	5	57.60±69.8	-	Basu et al. (1979)
	219	159±10.4	54.9	D'Souza et al. (1979)
Sahiwal	41	142.76±32.6	-	Basu et al. (1979)

Singh and Desai (1962) reported that a dry period of 60-90 days were found to be normal in Haryana and that more than 90 days dry period had no advantages.

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

Nagpaul and Bhatnagar (1972) observed that cows having dry period less than 30 days produced significantly less milk and recorded nearly 54.4 per cent of the observations within 30-60 days. Variation in lactation yield due to preceeding dry period was nine per cent.

Shri Ram et al. (1976) in their studies in Tharparkar herd reported that dry period and milk yield are two independent traits; thus the former could be reduced to optimum level of 60 days without affecting milk production at Chandenwell (Rajasthan).

Sharma et al. (1979) found no significant effect of sires and periods on dry period in Tharparkar cattle.

Buragohain and Sharma (1980) reported non-significant influence of seasons of calving on subsequent length of dry period in different genetic groups.

Calving interval :

Calving interval has important and dominant role in the optimisation of breeding efficiency. However, there are large variation not only between and within breeds but also due to several other reasons. The variation were indicated as given in Table 5.

Table 5. Calving interval in different Zebu cattle.

Breed	No. of observation	Mean calving interval ± S.E. (days)	C.V.	Reference
1	2	3	4	5
Tharparkar	-	433 ± 7.3	-	Singh (1957)
	-	454.6	-	Singh and Sinha (1960)
	-	480.6	-	Singh and Chaudhary (1961)
	111	476.0	-	Sundaresan et al. (1965)
	-	429.6±8.8	-	Johar and Taylor (1970)
	-	430.0	-	Nagpaul and Bhatnagar(1971)
	-	433.0	-	Nagpaul and Bhatnagar(1972)
	1529	407.55±3.1	-	Prasad and Prasad (1972)
	-	482.0±12.6	20.9	Sharma et al. (1972)
	-	456 ± 7.5	23.0	Dutt et al. (1974)
	29	410.46±34.62	-	Basu et al. (1979)
	302	426.15±12.15	-	Ram et al. (1979)
Red Sindhi	5	350.22±56.39	-	Basu et al. (1979)
	123	447±9.01	22.37	Malhotra and Singh (1980)
Sahiwal	-	484.4	-	Singh and Chaudhary (1961)
	42	393.20±26.05	-	Basu et al. (1979)
	390	451.0	24.0	Kumar and Narain (1979)
Hariana	-	438.88±7.43	-	Johar and Taylor (1970)
Malvi	-	518.40±12.57	-	-do-

Long calving interval means less number of calves and

less milk production, resulting in increased gestation length and less annual genetic gain (Mahadevan, 1958).

Johar and Taylor (1972) found that cows giving birth to male calves tended to have slightly longer calving intervals than those producing female ones, though the difference was not significant.

Gill and Balaine (1979) reported that in Hariana cows a significant portion of variability in calving interval was determined by years and months of calving. The shorter calving interval was observed in cows calving in October. The calving interval of cows calving from July to January was observed to be 48 days less than those calving in other months.

In Tharparkar cattle, significant effect of seasons and parity on calving interval was observed by Ram et al.(1979).

Das et al. (1979) also corroborated the significant effect of months and years of calving on calving interval in Brahaman cattle.

Non-significant effects of sires and periods on calving interval in Tharparkar cattle were noted by Sharma et al. (1979).

First lactation milking average :

Singh and Chaudhary (1961) reported that cows having first calving age between 30 to 39 months in Sahiwal exhibited the highest milking average of 11.4 to 13.5 kg whereas in Tharparkar cows having age at first calving between 36 to 45 months, milking average was found to be 5.55 to 6.90 kg.

Nagarcenkar (1966) reported the milking average for Tharparkar herd at N.D.R.I. Karnal to be 4.75 ± 0.61 kg.

Raut and Singh (1971) found the milking average for first lactation in Hariana cows to be 2.61 ± 0.25 kg.

Sharma et al. (1972) observed milking average in Tharparkar cattle to be 4.0 ± 1.0 whereas Dutt et al. (1974) recorded it to be 4.0 ± 0.10 kg in the same breed group at Bhararí Farm.

Milking average in Sahiwal cows were found to be 5.66 kg by Kumar and Narain (1979).

Malhotra and Singh (1980) observed milking average in Red Sindhi cows to be 4.67 kg at Bangalore.

First lactation overall milking average :

Singh and Chaudhary (1961) reported that cows having 30 to 39 months of age at first calving showed overall milking

average to be 6.55 to 6.90 kg in Sahiwal cows, whereas for Tharparkar cows having 36 to 45 months of age at first calving the overall milking average was found by them to be 5.2 to 8.81 kg.

In Tharparkar cows, overall average was observed to be 2.7 ± 0.1 kg by Sharma et al. (1972).

Malhotra and Singh (1980) obtained the overall milking average in Red Sindhi cows to be 3.20 ± 0.13 kg whereas Kumar and Narain (1979) obtained it as 3.96 kg.

Breeding efficiency :

Wilcox et al. (1957) reported an average breeding efficiency in Holstein Friesian herd to be 87.2 per cent.

Gautam et al. (1966) observed breeding efficiency to be 77.21 ± 1.97 in Hariana cattle as against 84.2 ± 0.44 in Tharparkar ones by Das and Bhatnagar (1967).

Based on first calving interval, Reddy and Bhatnagar (1971) calculated the average breeding efficiency to be 85.65 ± 0.60 in Tharparkar cows at N.D.R.I. Karnal.

Dutt et al. (1974) reported 81.4 per cent breeding efficiency in Tharparkar cows at Bharari Farm.

Gupta and Bhatnagar (1979) reported 85.27 ± 0.27 per cent breeding efficiency in Tharparkar cattle. They further observed that cows having higher breeding efficiency had more

production during life time to a given age.

Effect of sires on breeding efficiency :

Singh (1966) observed that sires had non-significant effects on breeding efficiency.

Prakaystha and Mazumdar (1979) reported that the influence of sire on breeding efficiency was highly significant.

Heritability :

The heritability assumes considerable importance in improvement of different economic traits. The utilization and thereby maximization of productivity are heavily dependent upon the proper breeding methodology, the consequences of which are varied with certain long term responses too.

The different workers have observed heritabilities to be different even within farms as indicated in the table given below :

Table 6. Heritability estimate for age at first calving in different Zebu cattle.

Breed	Heritability estimates with S.E.	Method	Reference
Tharparkar	-0.36±0.09	ISR	Singh (1957)
	0.05±0.00	PHC	Singh (1957)

Table 6 Cont'd.

Breed	Heritability estimates with S.E.	Method	Reference
	0.48±0.16	ISR	Amble et al. (1958)
	0.26±0.18	ISR	Puri and Malik (1963)
	0.21±0.09	ISR	Das and Bhatnagar (1967)
	0.11±0.09	ISR	Reddy and Bhatnagar (1971)
	0.08	ISR	Prasad and Prasad (1972)
	0.174±0.096	PHC	Gurnani et al. (1976)
Hariana	0.44±0.11	ISR	Singh (1957)
	0.30±0.14	ISR	Singh and Prasad (1966)
	0.20±0.30	ISR	Singh and Prasad (1968)
	0.34±0.12	ISR	Singh and Desai (1967)
	0.044±0.11	ISR	Balaine (1971)
	0.54±0.15	PHC	Balaine (1971)
	0.30±0.02	PHC	Kumar and Bhat (1979)
	0.402±0.22	PHC	Mishra et al. (1980)
Red Sindhi	0.39±0.16	ISR	Stonaker (1953)
	0.09±0.17	ISR	Amble et al. (1958)
	0.16±0.29	ISR	-do-
	0.44±0.50	ISR	Puri and Malik (1963)
Sahiwal	0.16±0.29	ISR	Amble et al. (1958)
	0.38±0.26	ISR	Puri and Malik (1963)
	0.50±0.19	-	Batra and Desai (1964)
	0.19±0.14	PHC	Kaul (1968)
	0.46±0.19	-	Nagpal and Acharya (1970)
	0.37±0.19	-	Mishra (1973)

Table 6 Cont'd.

Breed	Heritability estimates with S.E.	Method	Reference
	0.144±0.139	-	Gurnani et al. (1976)
	0.14±0.12	ISR	Gopal and Bhatnagar (1972)
	0.75±0.21	PHC	Singh (1977)

Heritability estimate of lactation yield :

Table 7. Heritability estimates of lactation yield in certain Zebu cattle.

Breed	Heritability estimates with S.E.	Method	Reference
Tharparkar	0.22±0.02	ISR	Kooner (1963)
1st lact.	0.017	ISR	Mishra et al. (1964)
2nd lact.	0.37		
3rd lact.	0.16		
	0.22±0.11	ISR	Kooner and Sundaresan (1970)
	0.12±0.05	ISR	Reddy and Bhatnagar(1971)
	0.05	-	Prasad and Prasad (1972)
	0.15±0.43	PHC	Mishra (1973)
	0.580±0.262	ISR	Mishra et al.(1973)
	0.08±0.07	PHC	Gurnani et al.(1976)
	0.15±0.43	PHC	Mishra et al. (1979)
Sahiwal	0.44±0.32	ISR	Kooner (1963)
	0.44±0.11	ISR	Kooner and Sundaresan (1970)

Table 8 Cont'd.

Breed	Heritability estimates with S.E.	Method	Reference
	0.26±0.10	-	Gill and Balaine (1971)
	0.03±0.07	-	Tomar et al. (1972)
	0.24±0.28	-	Mishra et al. (1979)
	0.189±0.17	PHC	Mishra et al. (1980)
Sahiwal	0.45±0.14	-	Mishra (1973)
Red Sindhi	0.34±0.21	-	Mishra et al. (1979)

Heritability estimates of dry period :

Heritability estimate of dry period in Tharparkar cows was reported to be 0.08 by I.C.A.R. Team (1957).

Prasad (1962) obtained low heritability estimates of dry period in Tharparkar cows by paternal half sib correlation method and found it to be 0.09 indicating large environmental influence on this trait.

Pandey et al. (1978) reported heritability estimates of dry period to be 0.058±0.1106 by intra-sire regression of daughter on dam. Heritability estimates of 2nd and 3rd dry periods were observed by them to be -0.1306 ± 0.1050 and -0.0933± 0.1610 on the basis of 259 and 148 records respectively. This suggested that the dry period was amenable to improvement by

Table 6 Cont'd.

Breed	Heritability estimates with S.E.	Method	Reference
	0.144±0.139	-	Gurnani et al. (1976)
	0.14±0.12	ISR	Gopal and Bhatnagar (1972)
	0.75±0.21	PHC	Singh (1977)

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2nd lact.	0.37		
3rd lact.	0.16		
	0.22±0.11	ISR	Kooner and Sundaresan (1970)
	0.12±0.05	ISR	Reddy and Bhatnagar(1971)
	0.05	-	Prasad and Prasad (1972)
	0.15±0.43	PHC	Mishra (1973)
	0.580±0.262	ISR	Mishra et al.(1973)
	0.08±0.07	PHC	Gurnani et al.(1976)
	0.15±0.43	PHC	Mishra et al. (1979)
Sahiwal	0.44±0.32	ISR	Kooner (1963)
	0.44±0.11	ISR	Kooner and Sundaresan (1970)

Table 7 Cont'd.

Breed	Heritability estimates with S.E.	Method	Reference
	0.144±0.170	PHC	Gurnani et al. (1976)
	0.48±0.18	PHC	Mishra et al. (1979)
Hariana	0.219±0.18	ISR	Johar and Taylor (1973)
	0.48±0.15	PHC	Mishra et al. (1979)
	0.38±1.98	PHC	Mishra et al. (1980)
Red Sindhi	0.36±0.28	PHC	Mishra et al. (1979)
Gir	0.02±0.12	PHC	Mishra et al. (1979)

Table 8. Heritability estimates of lactation length in certain Zebu cattle.

Breed	Heritability estimates with S.E.	Method	Reference
Tharparkar	0.29	ISR	Amble et al. (1967)
	0.09	ISR	Prasad and Prasad (1972)
1st lact.	0.39±0.18	-	Bhat et al. (1980)
2nd lact.	0.43±0.21	-	-do-
3rd lact.	0.24±0.18	-	-do-
4th lact.	0.08±0.16	-	-do-
Hariana	0.32±0.03	ISR	Singh and Desai (1961)
	0.83±0.29	PHC	-do-
	0.58±0.14	ISR	Singh and Prasad (1966)
	0.44±0.25	DDC	-do-
	0.38±0.18	PHC	-do-

Table 8 Cont'd.

Breed	Heritability estimates with S.E.	Method	Reference
	0.26±0.10	-	Gill and Balaine (1971)
	0.03±0.07	-	Tomar et al. (1972)
	0.24±0.28	-	Mishra et al. (1979)
	0.189±0.17	PHC	Mishra et al. (1980)
Sahiwal	0.45±0.14	-	Mishra (1973)
Red Sindhi	0.34±0.21	-	Mishra et al. (1979)

Heritability estimates of dry period :

Heritability estimate of dry period in Tharparkar cows was reported to be 0.08 by I.C.A.R. Team (1957).

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Pandey et al. (1978) reported heritability estimates of dry period to be 0.058±0.1106 by intra-sire regression of daughter on dam. Heritability estimates of 2nd and 3rd dry periods were observed by them to be -0.1306 ± 0.1050 and -0.0933± 0.1610 on the basis of 259 and 148 records respectively. This suggested that the dry period was amenable to improvement by

environmental and managemental factors mostly and not much by breeding methods.

Heritability estimates of calving interval :

Amble et al. (1958) reported heritability estimates of calving interval in Tharparkar cows to be -0.37 ± 4.8, whereas Prasad and Prasad (1972) obtained it to be 0.01.

Moulik et al. (1972) estimated heritability of first calving interval on the basis of 45 and 498 records in case of Sahiwal and Tharparkar cattle as -0.454 ± 0.172 and 0.22 ± 0.138 respectively.

Kumar and Bhat (1979) obtained heritability estimates in Hariana cows as 0.0006 ± 0.14 by intra-sire regression of daughters on dam indicating thereby large environmental influence on this trait.

Genetic and phenotypic correlation :

Maximization of genetic progress in economic traits is the sole object of the dairy cattle breeders. For this, it is essential to have an idea about the genetic and phenotypic association among those traits and the extent to which genetic variation exists in them. On the basis of these decisions appropriate selection and mating procedure are taken. The literature has been reveiwed on these association between several economic traits as

given below.

Singh (1957) observed positive but low phenotypic correlation (0.025) in limited studies between age at first calving and first calving interval in Tharparkar cows.

Singh and Chaudhary (1961) observed positive and non-significant phenotypic correlation co-efficient between age at first calving and first lactation yield (0.09 and 0.047) in Sahiwal and Tharparkar cows respectively. The correlation between age at first calving and first lactation length was found by them to be 0.19 and 0.08 for Sahiwal and Tharparkar cows respectively. There was significant phenotypic correlation between age at first calving and first calving interval (0.12 and 0.04) in Sahiwal and Tharparkar cows respectively.

Daya Singh and Sundaresan (1966) reported positive and significant (0.775 $\pm$ 0.135) genetic correlation between first lactation yield and first calving interval in Tharparkar cows.

The genetic correlation between first lactation length and first calving interval was found by them to be 0.897 $\pm$ 0.096 in Tharparkar and 0.394 $\pm$ 0.00 in Sahiwal cows.

Kavitkar *et al.* (1968) observed positive but significant phenotypic correlation (0.20) between age at first calving and first lactation yield in high yielding Sahiwal cows, though they observed non-significant correlation for moderate and low yielders.

Singh et al. (1969) reported that age at first calving was genetically associated with first lactation milk yield in Hariana cattle.

Nagpaul and Acharya (1970) obtained high value of phenotypic and genotypic correlations between age at first calving and first lactation yield in Sahiwal cattle.

Reddy and Bhatnagar (1971) indicated that first lactation yield was independent of age at first calving whereas genetic correlation between these traits were reported to be 0.765±0.15 and 0.42 ± 0.62 in Tharparkar and Sahiwal cows respectively (Naidu and Desai, 1970).

Balaine (1971) observed genetic correlation between age at first calving and first lactation yield in Hariana cows to be -0.33 ± 0.52 while Dutt and Tomar (1972) calculated it to be -0.54 ± 0.32 in same breed.

Non-significant, negative phenotypic correlation between age at first calving and first lactation yield -0.0587 ± 0.04 was obtained by Nagpaul and Bhatnagar (1971) in Tharparkar herd of N.D.R.I. Karnal.

Dutt and Tomar (1972) reported high but negative genetic correlation -0.89 ± 0.15 between age at first calving and first lactation length in Hariana cows.

Dutt et al. (1974) reported positive but non-significant phenotypic correlation between age at first calving

and first lactation yield 0.1332 in Tharparkar herd. They also observed negative and non-significant correlation between age at first calving and first lactation length(-0.0889). But, age at first calving and calving interval exhibited significant negative correlation (-0.2698). The phenotypic correlation between lactation yield and lactation yield and lactation length was positive and significant (0.7616). The lactation yield and calving interval showed highly significant positive phenotypic correlation (0.3282) whereas lactation length and calving interval showed non-significant positive relationship (0.3976).

Gurnani et al. (1976) observed negative but non-significant phenotypic correlationship between age at first calving and first lactation yield in Tharparkar herd of N.D.R.I. Karnal (-0.021). They also observed positive and non-significant phenotypic correlation between age at first calving and first calving interval (0.069). The non-significant phenotypic positive correlation between first lactation yield and first calving interval was found by them to be 0.264. They further reported that the positive genetic correlation between age at first calving and first lactation yield was 0.394. The high positive genetic correlation between age at first calving and first calving interval was found by them to be 0.424. They further observed higher and positive genetic correlation between first lactation yield and first calving interval (0.897). While in Sahiwal cows they observed positive phenotypic correlation between age at first calving and first lactation yield, age at

first calving and first calving interval, first lactation length and first calving interval (0.066, 0.148, 0.130) respectively. The genetic correlation between age at first calving and first lactation yield, age at first calving and first calving interval were found to be negative but low (-0.387, -1 respectively) whereas genetic correlation between first lactation yield and calving interval was reported to be positive (0.394).

Chander (1977) observed genetic correlation between age at first calving and first lactation yield to be -0.202 ± 0.103 in Tharparkar cows. Whereas Gupta and Bhatnagar (1979) observed the genetic and phenotypic correlation between the two traits as mentioned above to be -0.202 and 0.041 respectively in Tharparkar cows.

D'Souza et al. (1979) observed negative but non-significant correlation between age at first calving and lactation yield to be -0.052 in Red Sindhi cows whereas age at first calving and lactation length, age at first calving and calving interval revealed positive phenotypic correlation of 0.018 and 0.100 respectively. Phenotypic correlation between lactation yield and lactation length was found to be as high as 0.67. Positive phenotypic correlation were observed to be 0.073 and 0.368 between lactation yield and first calving interval, lactation length and calving interval respectively.

Negative phenotypic correlationship -0.147 between age at first calving and calving interval was recorded in Hariana cows

by Kumar and Bhat (1979). They further observed that genetic correlation between age at first calving and calving interval to be positive and high (2.150).

Basu et al. (1980) observed negative phenotypic correlation between age at first calving and 305 days milk yield in Sahiwal cows (-0.14) while in Tharparkar cows it was positive and significant (0.36). They further observed that the age at first calving was negatively correlated with lactation length in Sahiwal and Tharparkar cows (-0.37, -0.03 respectively). The value of correlation turned out to be highly significant in Sahiwal whereas it was non-significant in Tharparkar cows. The correlation coefficient between age at first calving and calving interval was found to be negative -0.39 but highly significant in Sahiwal cows whereas non-significant positive phenotypic correlation was recorded in case of Tharparkar herd (0.13). They also observed highly significant positive phenotypic correlation between lactation length and 305 days milk yield in Sahiwal and Tharparkar cows (0.89 and 0.91 respectively). The calving interval found to have positive and highly significant correlation with lactation length in Tharparkar cows (0.61). The correlationship between lactation length and 305 days milk yield in Sahiwal was observed to be positive and significant (0.31) and significant positive (0.18) between lactation length and calving interval. They further observed that in Tharparkar cows the correlationship between lactation length and calving interval was positive and highly significant.

Expected producing ability :

Gautam et al. (1966) observed that cows ranged between 36 to 39 months of age group had higher milk producing ability (3016 lbs) in Hariana cows.

Dutt et al. (1974) reported that the average lactation yield (1301.6 ± 53.6 kg) and producing ability (1325.09±37.21 kg) with coefficient of variation as 41.7 and 22.3 per cent.

Table 8A. Repeatability estimates of lactation yield in certain Zebu cattle.

Breed	No. of observation.	Method	Repeatability estimate	Reference
Red Sindhi at Hosur	921	Intraclass correlation	0.61	Amble et al. (1958)
Red Sindhi at Banglore	958	-do-	0.54	Amble et al. (1958)
Bachaur		-do-	0.366	Singh (1963)
Tharparkar		-do-	0.49	Kooner (1963)
Sahiwal		-do-	0.49	Kooner (1963)
Red Sindhi		-do-	0.37	Kooner (1963)
Tharparkar		-do-	0.94	Singh (1963)
Sahiwal		-do-	0.52	Singh (1963)

***

MATERIAL AND METHODS

Brief history of the herd :

The Tharparkar herd at Government Cattle Farm, Patna was established in 1927 with the foundation stock of 52 Tharparkar cows purchased from Sindh. Seven Tharparkar bulls were purchased and brought from Government Cattle Farm, Karnal for breeding purpose. In 1936, again 36 Tharparkar bulls were purchased from Karnal. Besides these, the bulls of this breed were also brought from different Government Cattle Farms for herd improvement, the last being in the year 1968 from Suratgarh.

The objectives for establishing Tharparkar herd under the existing climatic conditions of the State were :

I. to study the performance of the breed ;

II. to grade-up Sahabadi cows ;

III. and to provide practical instructional facilities to the students of Bihar Veterinary College, Patna.

Breeding policy :

Since its inception, the farm resorted to selective breeding for maintaining pure breeding herd. From 1960-61 progeny

testing programme was launched to preserve tand propagate superior germ plasm of this breed. The bulls under this programme were sent to the field for grading up local cattle after completion of first round of service.

Location and climatic condition :

The Government Cattle Farm, Patna established on the right side of river Ganges is nearest to the heart of the state capital of Bihar. The farm is situated 53 meters above the mean sea level; the latitude and longitude being 25°, 37'N and 85° 10'E respectively. The highest summer temperature and the lowest winter temperature were recorded to be 43.2°C and 7°C respectively. The average annual rainfall was about 1109.8 mm. and most of these were received during July to September. The winter rainfall was also recorded but with much less intensity. The mean mateorological observations recorded at Patna during 1930-1961 were as given in Table 9.

Table 9. Average temperature, humidity and rainfall at Patna.

Month	Mean air temperature				Mean relative humidity (%)	Mean monthly rainfall (mm)
	Daily maximum (°C)	Daily minimum (°C)	Highest in the month (°C)	Lowest in the month (°C)		
January	23.6	11.0	27.1	7.0	71	21.1
February	26.3	13.4	31.0	8.5	62	20.2

Table 9 Cont'd.

Month	Mean air temperature				Mean relative humidity (%)	Mean monthly rainfall (mm)
	Daily maximum (°C)	Daily minimum (°C)	Highest in the month (°C)	Lowest in the month (°C)		
March	32.9	18.6	37.9	13.5	45	6.7
April	37.6	23.3	41.5	19.1	41	8.2
May	38.9	26.0	43.2	21.9	56	28.3
June	36.7	27.1	42.2	23.4	71	139.0
July	32.9	26.7	36.5	24.4	81	265.8
August	32.1	26.6	35.0	24.1	83	307.1
September	32.3	26.3	35.3	23.4	80	242.5
October	31.9	23.0	34.4	18.7	70	62.8
November	28.9	16.1	31.5	11.8	62	5.7
December	24.9	11.7	27.7	8.2	67	2.4

Managemental practices :

Weaning of calves was practiced at this farm since its inception. The milking was done twice a day except in a few cases of heavy yielders where thrice a day milking was practised. The calves removed at the birth from their dams were fed colostrum

for five days and whole milk upto 30 days. Calves between age group of 1-4 months were fed with separated and whole milk and from 4 months to 6 months only separated milk. Concentrates, mineral and roughages were made available from first month onward according to their body weight and growth requirement as per nutritional standards. For adult cows green fodders, other roughages and concentrates were fed according to the laid down nutritional standards at the farm. Standard culling procedures were adopted all along the years for the removal of unproductive, diseased and defective animals.

All the animals were maintained under high level of sanitary conditions with adequate veterinary aids including inoculation, vaccination and drenching etc.

Recording of observations :

Reproductive and breeding records under this investigation comprised of age at first calving, lactation yield, lactation length, dry period, calving interval, milking average, probable producing ability, breeding efficiency of Tharparkar cows of the Government Cattle Farm, Patna extended over the period from 1950 to 1971.

Traits under study :

Observations regarding the productive and reproductive

traits were collected from history sheets maintained at the farm on the traits given below :

(i) Age at first calving.
(ii) Lactation yield.
(iii) Lactation length.
(iv) Dry period.
(v) Calving interval.
(vi) Milking average.
(vii) Overall average.
(viii) Probable producing ability.
(ix) Breeding efficiency.

Classification of data :

The data recorded were classified according to the season and period of calving. The seasons were classified into four groups, i.e., (i) Winter (November to January), (ii) Spring (February to April), (iii) Summer (May to July),(iv) Rainy (August to October). Data upto fourth lactation were recorded and analysed as per technical programme.

Methods of statistical analysis :

Different tests of significance and other statistical methods were applied as per Snedecor and Cochran (1965), Panse and Sukhatme (1967), Becker (1975).

Heritabilities estimates :

Heritabilities for productive and reproductive traits were estimated by paternal half sib correlation (unbalanced design) using variance components from the analysis of variance (Becker, 1975). The model used for estimating the heritability was :

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

Where Y_{ij} observation of $_j$th individual of $_i$th sire.

μ = population mean

s_i = effect of $_i$th sire

e_{ij} = uncontrolled environmental and genetic deviation attributable to individuals within sire groups. All effects were random, normal and independent with expectation equal to zero.

The standard errors of h^2 were calculated as per Swiger et al. (1964) : -

$$SE(h^2) = 4\sqrt{\frac{2(N-1)\,(1-t)^2\left[1+(\bar{k}-1)t\right]^2}{\bar{k}^2(N-S)\,(S-1)}}$$

Where, t = intraclass correlation
N = total number of progeny
$\bar{K}$ = weighted number of daughters under each sire

The analysis of variance between and within sire group was done in the usual way. Such analysis of variance giving the expected value of mean sum of squares in terms of σ_s^2 (between sire components of variance) is given in Table 10.

equating mean sum of squares with its expected values and solving for σ_s^2 we get

$$\sigma_s^2 = \frac{\text{Between sire} - \text{within sire}}{k} = \frac{B' - W'}{k}$$

$$\text{where } k = \frac{\sum_{i=1}^{S} n_i - \sum_{i=1}^{S} n_i^2 / N}{S-1}$$

This gives t, the intraclass correlation as :

TABLE - 10

ANOVA

S.V.	df	SS	MS	E(MSS)
Between sire	(S-1)	$B = \sum_{i=1}^{S} \frac{[a_i Q_i + (n_i - a_i) Q_i']^2}{n_i} - \frac{[\sum_{i=1}^{S} a_i Q_i + (n_i - a_i) Q_i']^2}{\sum_{i=1}^{S} n_i}$	$\frac{B}{S-1} = B'$	$\sigma_o^2 + k\sigma_s^2$
Within sire	$(n_i - S)$	$W = \sum_{i=1}^{S} [a_i Q_i^2 + (n_i - a_i) Q_i'^2] - \sum_{i=1}^{S} \frac{[a_i Q_i + (n_i - a_i) Q_i]}{n_i}$	$\frac{W}{n_i - S} = W'$	σ_o^2
Total.	$\sum_{i=1}^{S} n_i - 1$	$\sum_{i=1}^{S} [a_i Q_i^2 + (n_i - a_i) Q_i'^2] - \frac{[\sum_{i=1}^{S} a_i Q_i + (n_i - s_i) Q_i']^2}{\sum_{i=1}^{S} n_i}$		

$$\frac{\frac{B'-W'}{k}}{\frac{B'-W'}{k}+W'} = \frac{\frac{(B'-W')}{k}}{\frac{(B'-W')+kW'}{k}}$$

$$= \frac{B'-W'}{B'-W'+kW'} = \frac{B'-W'}{B'+W'(k-1)}$$

Now $h_q^2 = \frac{t}{r}$, where, r is the genetic relationship among half sibs in which r takes the value of 0.25.

As such

$$h_q^2 = \frac{B'-W'}{0.25\,[B'+W'(k-1)]}$$

The S.E. of h^2 as given by Becker (1975)

$$SE(h_q^2) = \frac{1+(k-1)t \quad (1-t)}{0.25\sqrt{1/2k(k-1)\ (S-1)}}$$

(2) Heritability for productive and reproductive traits were estimated by Intra-sire regression of daughter on dam (unbalanced design) using variance, covariance components from analysis of variance.

"The reference population was the population from which

the parents were derived. The symbol X would denote the observation on the dam (parent) and Z for the observation of daughter records. It was assumed that population was not inbred and was randomly mated" (Becker, 1975).

Computational formula

The sum of squares for between Dams with in Sires were calculated for X, Z and XZ. The design given below gives required estimates for $SS_{D(XX)}$, $SCP_{D(XZ)}$, $SS_{D(ZZ)}$ (Becker, 1975).

Sources	df	Sum of products		
		Dams (XX)	Dam X Daughter (XZ)	Daughter (ZZ)
Between sires	S-1		Not needed	
Between dams within sires	D-S	$SS_{D(XX)}$	$SCP_{D(XZ)}$	$SS_{D(ZZ)}$
Total	D-1			

Where S = number of sires
D = number of dams

a. Analysis of variance for dams records

Source	Sum of squares	Symbol
Sires	$\sum_i \frac{X_{i.}^2}{n_i}$ - C.T.(not needed)	
Dams/sires	$\sum_i \sum_j X_{ij}^2 - \frac{X_{i.}^2}{n_i}$	$SS_{D(XX)}$

where n_i is the number of dams mated to the $_i$th sire.

b. The $SS_{D(ZZ)}$ was obtained in the same way using the mean of each dam progeny, Z.

c. The sum of cross products, $SCP_{D(XZ)}$ was obtained in a similar manner.

Analysis of co-variance

Source	Sum of cross products	Symbol
Sires	$\sum_i \frac{X_{i.} Z_{i.}}{n_i}$	
Dams/sires	$\sum_i \sum_j X_{ij} Z_{ij} - \frac{X_{i.} Z_{i.}}{n_i}$	$SCP_{D(XZ)}$

$$Cov_{D(XZ)} = \frac{SCP_{D(XZ)}}{D - S} \text{ or } MCP$$

d. Regression is obtained

$$b = \frac{SCP_{D(XZ)}}{SS_{D(XX)}}$$

$$h^2 = 2b$$

e. The standard error of h^2

$$Sb^2 = \frac{SS_{D(ZZ)} - \frac{(SCP_{D(XZ)})^2}{SS_{D(XX)}}}{(D-S-1)}$$

$$S.E.(b) = \sqrt{\frac{Sb^2}{SS_{D(XX)}}}$$

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

Repeatability :

The analysis of variance for the measures of repeatability were conducted as per Becker (1975).

Analysis of variance

Source	df	Sum of squares	Mean squares
Correction term (C.T.)	1	$\frac{Y^2_{..}}{m.}$	-
Between individuals	N-1	$\sum_k \frac{Y^2_{k.}}{m_k} - C.T.$	SS_w $(N-1)=MS_w$

Measurements/ individuals	N(M-1)	$\sum_k \sum_m Y^2_{km} - \frac{Y^2_{k.}}{m_k}$	SS_e	$N(M-1) = MS_e$

Where, m_k is the number of measurements on the $_k$th individual and $m_. =$ total number of measurements.

In the analysis of variance each $Y^2_{k.}$ was divided by m_k or the number of measurements taken on the $_k$th individual. The degree of freedom for MS_e are the total number of measurements minus number of individuals.

Estimating σ^2_e, σ^2_w and R

$$\hat{\sigma}^2_e = MS_e$$

$$\hat{\sigma}^2_w = \frac{MS_w - MS_e}{k_1}, \text{ where } k_1 = \frac{1}{N-1}\left[m_. - \frac{m_k^2}{m_.}\right]$$

$$R = \frac{\hat{\sigma}^2_w}{\hat{\sigma}^2_w + \hat{\sigma}^2_e} = \text{Repeatability.}$$

S.E. of R.

This is an approximate method of standard error. Normality of repeatability and unequal number per group is assumed. (Swiger et al., 1964)

$$SE(R) = \sqrt{\frac{2(m-1)(1-R)^2\left\{1+(k_1-1)R\right\}^2}{k_1^2(m_.-N)(N-1)}}$$

Genetic and phenotypic correlation :

The genetic and phenotypic correlations of different traits under study were calculated as per Becker (1975).

The genetic and phenotypic correlations between two traits were obtained by method similar to those used to estimate the genetic variance, X_1 X_2 X_3 and X_4 and Y_1 Y_2 Y_3 and Y_4 were symbols used for age at first calving, first lactation yield, first lactation length and first calving interval for dams and daughters respectively. It was assumed that the inbreeding of the reference population was zero. The out lines of analysis of covariance are as given below :

Analysis of covariance

Source	df	MCP	EMCP
Between sires	S-1	MCP_s	$Cov_e + k\ Cov_s$
Progeny within sires	N-S	MCP_e	Cov_e

The components of variance were calculated as given below :

$$Cov_e = MCP_e$$

$$Cov_s = \frac{MCP_s - MCP_e}{k}$$

Genetic correlation (r_g)

The (r_g) genetic correlations of different traits was calculated as follows :

$$r_g = \frac{Cov_{s(XY)}}{\sqrt{6^2_{s(X)} \; 6^2_{s(Y)}}}$$

Where, X and Y represents two characters in the same individual.

$Cov_{s(XY)}$ covariance between two traits X and Y

$6^2_{s(X)}$ and $6^2_{s(Y)}$ = variances due to X and y

Standard error (SE) of genetic correlation (r_g)

Standard error of genetic correlation (r_g) was calculated as per Robertson (1959).

$$S.E.\ (r_g) = \frac{1-r_g^2}{\sqrt{2}} \sqrt{\frac{SE(h_x^2) \cdot SE(h_y^2)}{h_x^2 \cdot h_y^2}}$$

Where, h_x^2 and h_y^2 were the heritabilities of X and Y traits.

Phenotypic correlation (r_p)

Phenotypic correlation co-efficient was estimated after Becker (1975) :

$$r_p = \frac{Cov_{e(XY)} + Cov_{s(XY)}}{\sqrt{(\sigma^2_{e(X)}+\sigma^2_{s(X)})(\sigma^2_{e(Y)}+\sigma^2_{s(Y)})}}$$

Where, X and Y were two traits under consideration and σ^2_e and σ^2_s were same as in estimation of h^2.

Standard error (SE) of phenotypic correlation

Standard error of phenotypic correlation was estimated as given by Panse and Sukatme (1967).

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

Where, $r_{p(XY)}$ = Phenotypic correlation coefficient between X and Y in the same individual.

n-2 = degree of freedom.

Milking average

The milking average was calculated on the first lactation records with the method given below :

$$\text{Milking average} = \frac{\text{Total lactation yield (kg)}}{\text{Lactation length in days}}$$

Similarly the overall average was calculated as

$$\text{Overall average} = \frac{\text{Total lactation yield (kg)}}{\text{Lactation length (days)} + \text{Dry period (days)}}$$

Expected producing ability

Expected producing ability on the basis of records of first lactation was worked out according to formula described by Lush (1945) which runs as follows :

$$\text{EPA} = \text{the herd average} + \frac{nr}{1+(n-1)r} \left(\text{cows average} - \text{the herd average}\right)$$

Where, 'n' is the number of lactation

Where, 'r' is the repeatability of milk yield.

Breeding efficiency

Breeding efficiency of individual cow was calculated as per formula given by Wilcox et al. (1957).

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

Where, D = number of days from first to last parturition

n = total number of parturitions.

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*

RESULTS AND DISCUSSION

Age at first calving :

The average age at first calving in Tharparkar herd worked out to be 1543.91 ± 12.011 days (Table 11). The present finding was similar in magnitude to that of Singh (1957), Amble et al. (1958) and Prasad and Prasad (1972) but Singh and Chaudhary (1961), Puri and Sharma (1965), Sundaresan et al. (1965), Nagpaul and Bhatnagar (1971), Reddy and Bhatnagar (1971), Dutt et al. (1974), Basu et al. (1979) and Gupta and Bhatnagar (1979) reported lower age at first calving in different Tharparkar herds of cattle in India. The difference in age at first calving of the present work and those of earlier reports might be clearly identified as due to lower volume of data. This might be due to the managemental practices and due to the different periods and farms under study by different workers.

The co-efficient of variation for age at first calving was found to be 13.064 per cent which was in consonance with the findings of Dutt et al. (1974) but higher values were reported by Nagpaul and Bhatnagar (1971) and Gupta and Bhatnagar (1979). Although co-efficient of variation for age at first calving for the Tharparkar herd at Patna (13.064 %) was slightly higher than the reported estimate of 10.2 per cent for the same herd by

TABLE 11.

Average values of age at first calving, milk yield in 305 days, total milk yield, lactation length, dry period and calving interal.

order of lacta-tion	Milk yield in 305 days (kg)		Total milk yield (kg)		Lactation length (days)		Dry period (days)		Calving interval (days)		Age at first calving (days)	
	Average	C.V.	Average	C.V.	Average	C.V.	Average	C.V.	Average	C.V.	Average	C.V.
1	1161.83 ± 25.283 (282)	36.540	1267.23 ± 31.630 (282)	41.910	301.74 ± 5.533 (282)	1.183	172.76 ± 9.456 (260)	88.258	468.70 ±10.073 (260)	34.653	1543.91 ± 12.011 (282)	13.064
2	1206.38 ± 23.534 (260)	31.456	1282.85 ± 32.306 (260)	40.607	286.50 ± 4.604 (260)	25.914	149.91 ± 8.020 (211)	77.709	439.73 ± 4.992 (211)	16.489	-	-
3	1249.80 ± 29.565 (211)	18.360	1288.09 ± 38.564 (211)	43.488	283.51 ± 3.849 (211)	19.721	195.83 ±41.049 (18)	88.230	444.16 ±36.726 (18)	35.080	-	-
4	1201.71 ±118.743 (18)	41.922	1238.35 ±123.035 (18)	42.151	265.33 ±14.430 (18)	23.074	-	-	-	-	-	-

Figures in parentheses indicate number of observations.

Prasad and Prasad (1972), this difference of 2.864 per cent can not be recommend as significant. This difference might be due to sampling error. Age at first calving is mostly a matter of management. So the variation on higher side suggested that the trait might be improved by selection.

The present data were further subjected to statistical analysis for a clear genetic picture of age at first calving and to know the contribution of sires. The perusal of Table - 15 indicated that sire component of variance was statistically significant. Similar results were reported by Srivastava (1970).

Seasonwise average age at first calving had been incorporated in Table - 13. The average age at first calving was worked out to be 1490.01 ± 27.64, 1588.32 ± 33.26, 1643.86 ± 13.61 and 1590.59 ± 33.64 days with 14.05, 14.20, 16.14 and 12.86 per cent co-efficient of variation in winter, spring, summer and rainy seasons respectively. The age at first calving was recorded to be the highest for the calves born during summer and lowest for those born during the winter. Similar reports had been published by Das and Bhatnagar (1967). Scrutiny of the Table - 14 revealed that season had significant (P 0.01) influence on age at first calving but Kaul (1968) and Nagpal and Acharya (1971) reported non-significant effect of seasons of calving on age at first calving. This difference might be mainly due to meteorological factors.

Lactation yield :

The average milk yield in 305 days of lactation in Tharparkar herd was found to be 1161.83 ± 25.283, 1206.38 ± 23.534, 1249.80 ± 29.565 and 1201.71 ± 118.743 kg with 36.540, 31.456, 18.360 and 41.922 per cent co-efficient of variation from first to fourth sequences respectively (Table 11). The mean total lactation yield in the same herd were observed to be 1267.23 ± 31.630, 1282.85 ± 32.306, 1288.09 ± 38.564 and 1238.35 ± 123.035 kg with co-efficient of variation of 41.910, 40.607, 43.488 and 42.151 per cent from the first to the fourth lactation sequences respectively (Table 11). Prasad and Prasad (1972), Sharma et al. (1972), Dutt et al. (1974) reported overall average for first lactation yield to be 1300, 1301.9 and 1301.06 kg respectively. But Puri and Sharma (1965), Sundaresan et al. (1965), Das and Bhatnagar (1967), Nagpaul and Bhatnagar (1971), Reddy and Bhatnagar (1971) reported overall milk yield ranging from 2160 to 2580 kg in Tharparkar herds. In the present study in both cases (305 days milk yield and total milk yield) the highest milk yield was recorded in the third lactation. Nagpaul (1968), Das and Balaine (1980) also reported maximum average production in third lactation. Sikka (1931) pointed out that Indian cows does her best performance roughly at third lactation and maintained it during the fourth lactation. The peculiarity about attainment of maximum production at comparatively earlier age (as measured in lactation numbers) in the Indian cattle under study can be explained by fact that the Indian cows calved about a year later

(in some cases more) than European cattle and total period covered by their fourth lactation equal in length to fifth lactation or more of European cattle. This indicates that age of maximum production is more or less the same for both the classes of animals.

It was evident from Table - 12 that parity had non-significant influence on total lactation yield but Nagpaul (1968), Nagpaul and Bhatnagar (1972) and Das and Balaine (1980) reported significant effect of parity on milk yield.

First lactation yield was further classified according to season of calving and seasonwise means had been tabulated along with standard errors and co-efficients of variation (Table 13). Average milk yield for the winter, the spring, the summer and the rainy seasons were found to be 1383.61 ± 40.18, 1391.79 ± 42.58, 1376.65 ± 54.30, 1329.18 ± 53.84 kg with 41.78, 43.70, 40.84, 45.47 per cent co-efficients of variation respectively.

The analysis of variance revealed non-significant effect of seasons of calving on first lactation yield (Table 14). But on the basis of average production during different seasons, it could be said that cows calving during spring had produced more compared to those calving during the rainy season. But, Das and Balaine (1980) with Hariana cattle at Hissar reported significant effect of seasons of calving on milk yield. Similar was the finding of Singh et al. (1980), but Singh (1962), Sandhu (1964), Sundaresan et al. (1965), Das and Bhatnagar (1967), Mishra et al. (1979) reported non-significant effect of seasons of

TABLE 12.

Effect of sequences on lactation yield, lactation length, dry period and calving interval in Tharparkar herd at Patna.

Sources of variation	Lactation yield		Lactation length		Dry period		Calving interval	
	df	M.S.	df	M.S.	df	M.S.	df	M.S.
Among sequence	3	457101.396	3	20491.228*	2	40029.279	2	50005.685*
Error	767	337083.474	767	5985.495	486	19314.562	486	17179.102
Total	770		770		488		488	

* $P < 0.05$

calving on first lactation yield suggesting that short span changes in milk production were essentially a reflection of changes in feeding and managemental practices.

Table - 15 revealed that the first lactation yield was not significantly affected by sires. Similar findings were reported by Rahman (1979) in Tharparkar herd.

Lactation length :

The mean lactation length from first to fourth calvings were observed to be 301.74 ± 5.533, 286.50 ± 4.604, 283.51 ±3.849, 265.33 ± 14.430 days respectively (Table 11). Similar estimates of lactation length had been reported by Singh (1961), Singh and Chaudhary (1961), Prasad (1962), Amble et al. (1967), Nagpaul (1968), Nagpaul and Bhatnagar (1971), Prasad and Prasad (1972), Dutt et al. (1974), Ram et al. (1979).

The co-efficient of variation of the trait from the first to fourth lactation lengths were found to be 1.183, 25.914, 19.721 and 23.074 per cent respectively (Table 11). In the present estimate lower co-efficient of variation in the first and higher in the second lactation length were obtained. But higher estimates were obtained by Singh (1961), Singh and Chaudhary (1961).

Analysis of variance indicated that lactation sequences had significant influence on lactation lengths ($P < 0.05$) (Table 12).

TABLE 13.

Calving seasonwise mean with standard error and C.V. of different economic traits of Tharparkar herd at Patna.

Seasons	Age at first calving (days) Mean±SE	C.V.	First lactation yield (kg) Mean±SE	C.V.	First lactation length (days) Mean ± SE	C.V.	First dry period (days) Mean±SE	C.V.	First calving interval(days) Mean±SE	C.V.
Winter	1459.01 ± 27.64 (55)	14.05	1383.61 ± 40.18 (207)	41.78	335.11 ± 7.14 (207)	30.66	186.66 ±12.14 (166)	83.84	477.18 ±12.19 (166)	32.92
Spring	1588.32 ± 33.26 (46)	14.20	1391.79 ± 42.58 (204)	43.70	341.72 ± 7.61 (204)	31.82	206.62 ±10.88 (207)	75.83	535.41 ±13.41 (207)	36.06
Summer	1643.86 ± 13.61 (38)	16.14	1376.65 ± 54.30 (107)	40.84	338.32 ±10.81 (107)	32.13	166.80 ±15.46 (87)	86.47	491.35 ±14.69 (87)	27.90
Rainy	1590.59 ±33.64 (37)	12.86	1329.18 ± 53.84 (126)	45.47	318.36 ± 9.58 (126)	33.79	170.23 ±14.59 (73)	73.27	463.68 ±12.94 (73)	23.84

Figures in parentheses indicate number of observations.

Rehfeld et al. (1976) and Ram, et al. (1979) in their studies with Zebu cattle observed significant influence of parity on lactation length.

The mean first lactation length for the cows calving in winter, spring, summer and rainy seasons were found to be 335.11 ± 7.14, 341.72 ± 7.61, 338.32 ± 10.81, 318.36 ± 9.58 days respectively (Table 13). In winter, spring, summer and rainy seasons the co-efficients of variation of the trait were recorded to be 30.66, 31.82, 32.13 and 33.79 respectively (Table 13). The present finding showed that cows calving during the spring were found to have higher lactation lengths in comparison to other ones. Singh et al. (1962) reported similar results in the same herd. But Buragohain and Sharma (1980) observed maximum lactation length in winter season. This variation might be attributed to differences in breed groups and agro-climatic conditions under which the herds were maintained.

The season of calving had non-significant influence on first lactation length (Table 14). Results obtained by Singh et al. (1962) in Tharparkar cattle were consonance with those of the present ones. This was further supported by Mishra et al. (1979). They observed non-significant effect of season on lactation lengths in Hariana, Sahiwal, Red Sindhi and their Friesian crosses. However, Das and Balaine (1980) in Hariana cows reported significant influence of season of calving on lactation length.

The non-significant influence of sires on the first

TABLE 14.

Effect of season of calving on age at first calving, first lactation yield, first lactation length, first dry period and first calving interval in Tharparkar herd at Patna.

Sources of variation	Age at first calving		First lactation yield		First lactation length		First dry period		First calving interval	
	df	M.S.	df	M.S.	df	M.S.	df	M.S.	df	M.S.
Between seasons	3	299885.78**	3	113472.98	3	15027.27	3	44587.8	3	149601.55
Within seasons	172	50434.71	640	165912.7	640	11369.95	529	58794.02	529	279092.02

** $P < 0.01$

lactation length in the present study was in consonance with those of Srivastava (1970) and Sandhu et al (1973) (Table 15).

Dry period :

The mean dry periods from first to third sequences in Tharparkar herd at Patna were found to be 172.76 ± 9.456, 149.91 ± 8.020, 195.83 ± 41.049 days respectively (Table 11). The present findings had close proximity with those of Nagarcenkar (1969) and Basu et al. (1979) in Tharparkar herd (188.2 and 160.4 days respectively) but the estimate of dry period was found to differ from those of Jha and Biswas (1964), Nagpaul and Bhatnagar (1971), Das et al. (1971). The average first dry period was higher than the second one but lower than the third ones. The increase of first dry period might help in better development of physiological complex leading to improvement in milk production in subsequent lactation.

The co-efficients of variation for dry period from first to third sequences were observed to be 88.258, 77.709 and 88.230 per cent respectively (Table 11). The findings indicated that trait was highly variable, with highest in first and the lowest in second calvings respectively. This seemed to agree closely with those of Das et al. (1971) in Tharparkar herd of N.D.R.I., Karnal.

The study under reference revealed non-significant influence of lactation sequences on dry period (Table 12), but

significant effect of lactation sequences on dry periods were observed by Shukla (1965) in Gir cattle, Srivastava (1970) in Red Sindhi herd. The nature of variation might be due to inclusion of less data in the present study.

The seasonwise mean first dry periods in winter, spring, summer and rainy season were found to be 186.66 ± 12.14, 206.62 ± 10.88, 166.80 ± 15.46 and 170.23 ± 14.59 days with co-efficient of variation 83.84, 75.83, 86.47 and 73.27 per cent respectively (Table 13). High variability in the trait was indicated in the present estimate, the highest dry period being found in cows calving during the spring and lowest in those calving in summer. But, Buragohain and Sharma (1980) observed the minimum dry period in post-monsoon and the maximum in summer season in Hariana cows. This variation might be due to the differences in genetic make-up of the breed of cattle under study.

The present study revealed non-significant influence of season of calving on first dry period (Table 14) which was in consonance with the reports of Buragohain and Sharma (1980) for the Red Sindhi, Hariana and their crosses.

Calving interval :

The mean calving intervals from first to third calvings were found to be 466.70 ± 10.073, 439.73 ± 4.992 and 444.16 ± 36.726 days respectively (Table 11). The highest calving interval was observed in the first and the lowest in the

second. The present estimate was found to be in close agreement with those of Singh and Sinha (1960), Dutt et al. (1974). But slight higher estimates were reported by Singh and Chaudhary (1961), Sundaresan et al. (1965), Sharma et al. (1972). The differences might be due to persistency of first calvers and deliberate delay in first post-partum service, the first calving interval being generally found to be longer than the subsequent ones.

The co-efficients of variation for the trait from first to third calving intervals were found to be 34.653, 16.489 and 35.080 per cent respectively. The estimates were found to be higher than those reported by Sharma et al. (1972), Dutt et al. (1974) in Tharparkar herd. Significant influence of calving sequences on calving interval was observed in the present study (Table 12). Ram, et al. (1979) also reported similar results.

The seasonwise mean first calving interval in the winter, [illegible] spring, [illegible] summer and [illegible] rainy season were observed to be 477.18 ± 12.19, 535.41 ± 13.41, 491.35 ± 14.69 and 463.68 ± 12.94 days along with 32.92, 36.06, 27.90 and 23.84 per cent co-efficients of variation respectively (Table 13). The highest value was observed during the spring season as against the lowest in the rainy season. The increase or decrease of inter-calving period in different seasons might be due to early heat or delayed heat after calving caused by environmental factors like climatic, nutritional etc. In the present study, season of calving was not found to influence the calving interval significantly (Table 14).

TABLE 15.

Influence of sires on age at first calving, first lactation yield, first lactation length, first calving interval and breeding efficiency in Tharparkar herd at Patna.

Sources of variation	Age at first calving		First lactation yield	First lactation length	First calving interval	Breeding efficiency	
	df	M.S.	M.S.	M.S.	M.S.	df	M.S.
Between sires	37	74971.02*	522478.75	17901.82	40763.53	19	1665.03**
Progeny within sires	165	49709.83	376963.26	15208.90	29311.45	84	248.40

* $P < 0.05$

** $P < 0.01$

But Ram, et al. (1979) reported significant effect of season of calving on calving interval. This might be explained by environmental variations. The study under reference revealed non-significant effect of sires on calving interval (Table 15). Sharma et al. (1979) also found similar values in Tharparkar cows but with Red Sindhi cows Srivastava (1979) reported to the contrary.

First lactation milking average :

The milking average for first lactation yield in Tharparkar herd at Patna was found to be 4.05 ± 0.09 kg with 33.33 per cent co-efficient of variation (Table 16). The values of milking average in different Tharparkar herds in literature were found to range from 4.0 kg (Sharma et al., 1972) to 6.90 kg (Singh and Chaudhary, 1961). This might be due to the effect of breeds, agroclimatic conditions, differential managemental practices in different farms and also due to different lactation sequences studied by them.

Overall average :

The overall milking average for the first lactation yield in Tharparkar herd was observed to be 2.63 ± 0.10 kg with 59.69 per cent co-efficient of variation (Table 16). In different Tharparkar herd maintained in the country, the overall milking average was found to vary from as low as 2.7 kg (Sharma

et al., 1977) to as high as 8.81 kg (Singh and Chaudhary, 1961). This seemed to agree closely with those of the present study which indicated high co-efficient of variation. But slightly higher estimates were observed by Kumar and Narain (1979) in Sahiwal and Malhotra and Singh (1980) in Red Sindhi herd. These deviations might be due to breed differences and different managemental practices.

TABLE 16.

Mean, S.E. and co-efficient of variation for milking average, overall average and breeding efficiency in Tharparkar herd at Patna.

Trait	Number of observation	Mean ± S.E.	C.V.
First lactation milking average.	203	4.05 ± 0.09	33.33
First lactation overall milking average.	203	2.63 ± 0.10	59.69
Breeding efficiency.	104	67.58 ± 2.21	33.39

Breeding efficiency :

Cows calving yearly are economical to keep (Gaines and Palfrey, 1931). To achieve such an objective, measures requires to be taken for increasing the breeding efficiency of cow. Different methods have been proposed to increase the breeding efficiency in form of average conception rate, service period, calving interval etc. One of the recent technique

proposed to know the breeding efficiency is the method of Wilcox et al. (1957).

By applying the formula of Wilcox et al. (1957) breeding efficiency, in the present study, was estimated to be 67.58 ± 2.21 with 33.39 per cent co-efficient of variation. Slightly higher estimates were obtained by Gautum et al. (1966) in Hariana cows, Das and Bhatnagar (1967), Reddy and Bhatnagar (1971), Dutt et al. (1974) and Gupta and Bhatnagar (1979) in Tharparkar cows kept at different Livestock Farms in India. As breeding efficiency in cow is purely a matter of management it depends upon decrease or increase of inter-calving period, delay in heat after calving. These might be the probable causes of difference in the present estimate and the works of early workers.

Highly significant difference in breeding efficiency between sires were observed in the present study (Table 15). Daspurakaystha and Mazumdar (1979), however, found no significant effect of sire on this trait.

H E R I T A B I L I T Y

Age at first calving :

Heritability estimate of age at first calving were calculated by intra sire regression of daughter on dam and paternal half-sib correlation method. The estimate obtained by

intra sire regression and paternal half-sib method were found to be 0.26 ± 0.10 and 0.78 ± 0.664 respectively (Table 17).

TABLE 17.

Heritability estimate of age at first calving.

Method	h^2 ± S.E.
ISR	0.26 ± 0.10
PHC	0.78 ± 0.664

Puri and Malik (1963) obtained similar results by intra sire regression methods whereas Das and Bhatnagar (1967) observed slight lower estimate by same method. But, low estimate of heritability were reported by Reddy and Bhatnagar (1971), Prasad and Prasad (1972) by intra sire regresson methods though heritability estimate for age at first calving by paternal half-sib correlation method were reported by Balaine (1971) to be 0.54 ± 0.15 in Hariana cows. Singh (1977) found it to be 0.75 ± 0.21 in Sahiwal cows by same methods. The estimate obtained by paternal half-sib method is high in magnitude (0.78). This may be due to magnification of error four times, if any in sire component of variance. Any how, these estimates require to be confirmed on more number of data. But on the basis of present finding it could be concluded that age at first calving is heritable in Tharparkar herd. The age at first calving in Tharparkar herd, Patna may be reduced by selection.

TABLE 18.

Analysis of Variance for estimating half-sib correlation and heritability of age at first calving.

Source of variation	df	S. S.	M. S.	S.M.S.
Between sire	37	3395971.213	91783.006	7952.181
Within sire	244	8017192.390	32857.346	32857.346
Total	281			

$$K = 7.41$$

$$t = \frac{7952.181}{40809.527}$$

$$h^2 = 0.78 \pm 0.664$$

Lactation yield :

Heritability for milk production in different lactation both for 305 days and total milk yield obtained by paternal half-sib correlation method is summerised in Table 19.

TABLE 19.

Trait	No. of observation	$h^2 \pm$ S.E.	
		Milk yield in 305 days	Total milk yield
First lactation	282	0.657 ± 0.2445	0.5399 ± 0.218
Second lactation	260	0.518 ± 0.2252	0.445 ± 0.2159
Third lactation	211	0.605 ± 0.2651	0.326 ± 0.2322

The heritability estimate of first lactation production in 305 days milk and total milk yield were 0.657 ± 0.2315 and 0.5399 ± 0.218 respectively. The present finding was similar in magnitude to those of Singh and Sundaresan (1969), Bhat et al. (1980) in Tharparkar cows. The values reported by them mostly range from 0.30 to as high as 0.63. The present estimate appear to be within reasonable limits. The heritability for later lactations i.e. second and third were slight lower on the basis of 305 days as compared to first lactation production. This reflect that the milk yield in different lactations were in different character genetically. Freeman (1960) reported decrease in heritability with increase in lactation order in Friesian cattle their conclusion was based on the argument that with the increased in lactation order, there is also increase in non-genetic variability reducing thereby the heritability of traits.

Heritability estimate on the basis of total milk yield were found to be 0.5399 ± 0.218, 0445 ± 0.2159 and 0.326± 0.2322 for first, second and third total lactation production respectively. Literature available on this trait has been reported by other workers in indegeneous as well as exotic breeds of cattle with which present estimates appear to be within reasonable limits. Pertaining among these are, 0.30 to 0.26 (Johnson, 1957) for Holstein and Jersey herd, 0.25

(Touchberry, 1951) in Holstein Friesian, 0.22, 0.44 (Kooner, 1963) for Tharparkar and Sahiwal, 0.2, -0.37 and 0.16 (Mishra et al., 1964) for first to third lactation record in Tharparkar cows, 0.22, 0.44 (Kooner and Sundaresan, 1970) for Tharparkar and Sahiwal cows, 0.12 (Reddy and Bhatnagar, 1971), 0.15 (Mishra, 1973), 0.580 (Mishra et al., 1973) for Tharparkar, 0.219 (Johar and Taylor, 1973) in Hariana cows, 0.08, 0.144 (Gurnani et al., 1976) for Tharparkar and Sahiwal, 0.15, 0.48, 0.48 and 0.36 (Mishra et al., 1979) in Tharparkar, Sahiwal, Hariana and Red Sindhi cows, 0.38 (Mishra et al., 1980) for Hariana cows.

In the present study the heritability of total milk yield had declining trend as lactation progressed. This may be due to higher environmental variation with increase in lactation length. Since estimate were not significantly different from each other, no definite conclusion to this effect could be drawn. Therefore, heritability estimates require to be confirmed on large volume of data. Its values varies with its numerator or denominator or both due to environmental variations, great fluctuation from time to time within the same herd of same breed are noticed. Further, it is also known that heritability estimate do not depend mainly on variation in breeding and managemental condition of the herd but also to some extent on the errors appraisal of the trait in the question. Any how on the basis of the present work the selective breeding might prove effective in improving the milk yield of the herd.

TABLE 20.

Analysis of variance for estimating heritability for first 305 days lactation yield.

Source of variation	df	S. S.	M. S.	E.M.S.
Between sire	37	13750300.643	371629.7471	29743.313
Within sire	244	36900558.253	151231.7961	151231.7961
Total:	281			

$K = 7.41$

$$t = \frac{29743.3132}{180975.1091}$$

$h^2 = 0.657 \pm 0.2315$

TABLE 21.

Analysis of variance for estimating heritability for second 305 days lactation yield.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	37	9382503.418	253581.173	18716.519
Within sire	222	27915911.331	125747.348	125747.348
Total:	259			

$K = 6.83$

$$t = \frac{18716.519}{144463.867}$$

$h^2 = 0.518 \pm 0.2252$

TABLE 22.

Analysis of variance for estimating heritability for third 305 days lactation yield.

Source of variation	df	S. S.	M. S.	E.M.S.
Between sire	36	11389273.512	316368.709	28032.607
Within sire	174	27342969.285	157143.502	157143.502
Total.	210			

$$K = 5.68$$

$$t = \frac{28032.607}{185176.109}$$

$$h^2 = 0.605 \pm 0.2651$$

TABLE 23.

Analysis of variance for estimating heritability for first total lactation yield.

Source of variation	df	S.S.	M. S.	E.M.S.
Between sire	37	19534276.637	527953.4226	38208.5083
Within sire	244	59738123.579	244828.3753	244828.3753

$$K = 7.41$$

$$t = \frac{38208.5083}{283036.8836}$$

$$h^2 = 0.5399 \pm 0.218$$

TABLE 24.

Analysis of variance for estimating heritability for second total lactation yield.

Source of variation	df	S.S.	M. S.	E.M.S.
Between sire	37	16593257.543	448466.420	30251.600
Within sire	222	53690253.573	241847.989	241847.989
Total:	259			

$$K = 6.83$$

$$t = \frac{30251.600}{272099.589}$$

$$h^2 = 0.445 \pm 0.2159$$

TABLE 25.

Analysis of variance for estimating heritability of third total lactation yield.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	36	15661849.670	435051.380	25764.266
Within sire	174	50235600.707	288710.349	288710.349
Total.	210			

$$K = 5.68$$

$$t = \frac{25764.266}{314474.615}$$

$$h^2 = 0.326 \pm 0.2322$$

Lactation length :

The heritability estimate for lactation length in different order of lactation was obtained by paternal half-sib correlation method. The results obtained by this method have been incorporated in Table 26.

TABLE 26.

Trait	No. of observation	$h^2 \pm$ S.E.
First lactation length	282	0.862 ± 0.252
Second lactation length	260	0.061 ± 0.157
Third lactation length	211	0.406 ± 0.242

In the present study, the heritability estimate were found to be 0.862 ± 0.252, 0.061 ± 0.157 and 0.406 ± 0.242 respectively for first, second and third lactation length. The genetic variability of this trait in Tharparkar herd at Patna, was observed to be higher in first order of lactation, but heritability estimate for subsequent lactation length varied from zero to 41 per cent. The estimates from present work however were within limits of similar findings on different Indian breeds of cattle viz. 0.32 to 0.83 (Singh and Desai, 1961), 0.26 (Gill and Balaine, 1971), 0.38 to 0.58 (Singh and Prasad, 1966) for Hariana cows, 0.29 (Amble et al., 1967), 0.09 (Prasad and Prasad, 1972) in Tharparkar cows, 0.03 (Tomar et al., 1972) in Hariana

cows, 0.45 (Mishra, 1973) for Sahiwal, 0.24 to 0.34 (Mishra et al., 1979) for Hariana and Red Sindhi cows, 0.189 (Mishra et al.,1980) in Hariana cows and 0.39, 0.43, 0.24 and 0.08 (Bhat et al.,1980) for first, second,third and fourth lactation length in Tharparkar cows. The heritability of first lactation length is higher in magnitude. Magnification of error four times in sire components of variance and lower number of data might be the probable cause for it. Lush (1945) has pointed out that for reliable estimate of heritability it needs several hundred pair of records. The accuracy of heritability estimate using sire components depends largely on the number of sires. In face of these remarks there is every need for the confirmation of the present obtained estimates on larger number of data that would gather in the course of breeding. Secondly heritability of this trait with increase in lactation order in Tharparkar cattle have shown decreasing trend 0.061 ± 0.157 in second lactation and 0.406 ± 0.242 in third lactation which are not significant estimates in the face of standard error. This is due to increase in the effect of non-genetic causes of variation in later lactation.

TABLE 27.

Analysis of variance for estimating half-sib correlation and heritability of first lactation length.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	37	765021.122	20676.247	1871.725
Within sire	244	1660850.495	6806.764	6806.764
Total	281			

$$K = 7.41$$

$$t = \frac{1871.725}{8678.489}$$

$$h^2 = 0.862 \pm 0.252$$

TABLE 28.

Analysis of variance for estimating half-sib correlation and heritability of second lactation length.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	37	222212.027	6005.730	84.276
Within sire	222	1205486.970	5430.121	5430.121
Total	259			

$$K = 6.83$$

$$t = \frac{84.276}{5514.397}$$

$$h^2 = 0.061 \pm 0.157$$

TABLE 29.

Analysis of variance for estimating half-sib correlation and heritability of third lactation length.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	36	223841.741	6195.60	426.544
Within sire	174	656472.740	3772.83	3772.83
Total	210			

$$K = 5.68$$

$$t = \frac{426.544}{4199.374}$$

$$h^2 = 0.406 \pm 0.242$$

Dry period :

The heritability estimate of dry period in Tharparkar herd at Patna was obtained by paternal half-sib correlation method. The results obtained by these method is summerised in Table 30.

TABLE 30.

Traits	Number of observation	$h^2 \pm$ S.E.
First dry period	260	0.423 ± 0.213
Second dry period	211	0.424 ± 0.244

The estimates obtained by former method were found to be 0.423 ± 0.213 and 0.424 ± 0.244 for first and second dry period respectively. The heritability estimates of this trait in the present study was observed to be higher in magnitude than the estimates reported by 0.06 (ICAR team, 1957), 0.321 (Singh and Desai, 1961), 0.09 (Prasad and Prasad, 1962), for Tharparkar and Hariana cows, but the present estimates were similar in magnitude to those of 0.43 reported by Lal (1970) in Tharparkar cows whereas Pandey et al. (1978) observed 0.058 ± 0.1106, -0.1306 ± 0.1050 and -0.0933 ± 0.1610 for first to third dry period in Tharparkar cows of N.D.R.I., Karnal. The variation in higher side (0.42) might be due to inclusion of four time error in sire components of variance in genetic parameter. Therefore these

require further confirmation on larger volume of data for conclusive results. Moreover these estimates are not significantly conclusive on face of standard error. Therefore, the present findings suggest that by providing better environmental condition and sexual health, improvement in dry period can be effected. Mahadevan (1958) has suggested that there is hardly any evidence to show that longer dry period represents genetic trait peculiar to Zebu cattle. On the contrary, evidence are there that improved managemental condition can be instrumental in shortening the dry period in tropical herd.

TABLE 31.

Analysis of variance for estimating half-sib correlation and heritability of first dry period.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	37	1395074.156	37704.706	2469.352
Within sire	222	4626264.058	20839.027	20839.027
Total	259			

$$K = 6.83$$

$$t = \frac{2469.352}{23308.379}$$

$$h^2 = 0.423 \pm 0.213$$

TABLE 32.

Analysis of variance for estimating half-sib correlation and heritability of second dry period.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	36	732966.302	20360.175	1442.601
Within sire	174	2116918.988	12166.201	12166.201
Total	210			

$$K = 5.68$$

$$t = \frac{1442.601}{13608.802}$$

$$h^2 = 0.424 \pm 0.244$$

Calving interval :

Heritability estimate of calving interval was obtained by paternal half-sib correlation method. The results obtained have been summerised in Table 33.

TABLE 33.

Traits	Number of observation	$h^2 \pm$ S.E.
First calving interval	260	0.121 ± 0.168
Second calving interval	211	-0.394 ± 0.293

The heritability estimates for first and second calving interval in Tharparkar herd was found to be 0.121 ± 0.168 and -0.394 ± 0.293. moreover the estimate are not significantly conclusive in face of standard error. The genetic variability observed in the present study was similar in magnitude to those reported by various workers in different breeds of Indian cattle -0.37 (Amble et al., 1958), 0.01 (Prasad and Prasad, 1972), -0.454 and 0.22 (Moulik et al., 1972) for Sahiwal and Tharparkar cows, 0.0006 ± 0.14 (Kumar and Bhat, 1979) in Hariana cows with high standard error. In the present work also calving interval may not be taken as heritable trait but on the basis of present finding it may be concluded that good feeding and managemental practices is the most important factors in shortening the calving interval. Secondly it was found that this character is non-heritable character and having practically no relation with subsequent lactation yield, so improvement in this character could be brought about by giving higher plan of nutrition to growing heifers and then controlling the service period so as to get the cow conceived within 3 to 4 months of calving. This object can not be achieved by selecting cows on calving interval basis due to its non-genetic variability which makes first calving interval less reliable for predicting their future performance.

TABLE 34.

Analysis of variance for estimating half-sib correlation and heritability of first calving interval.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	37	1155850.496	31239.202	803.709
Within sire	222	5716470.501	25749.867	25749.867
Total	259			

$$K = 6.83$$

$$t = \frac{803.709}{26553.576}$$

$$h^2 = 0.121 \pm 0.168$$

TABLE 35.

Analysis of variance for estimating half-sib correlation and heritability of second calving interval.

Source of variation	df	S.S.	M.S.	E.M.S.
Between sire	36	101723.276	2825.64	-516.645
Within sire	174	1002272.862	5760.188	5760.188
Total	210			

$$K = 5.68$$

$$t = \frac{-516.645}{5243.543}$$

$$h^2 = -0.394 \pm 0.293$$

Genetic and phenotypic correlation between reproduction and production traits :

The phenotypic correlation of age at first calving with first lactation yield in the present case was found to be (0.07 ± 0.07) low, positive and non-significant (Table 36). Similar findings were obtained by Singh and Chaudhary (1961), Dutt et al. (1974) and Singh (1979). But non-significant negative phenotypic correlations were obtained by Nagpaul and Bhatnagar (1971), Gurnani et al. (1976) in Tharparkar cows. A positive but significant phenotypic correlation (0.36) was reported by Basu et al. (1980).

Positive and highly significant genetic correlation between age at first calving and first lactation yield was observed to be 0.69 ± 0.06 in the present study. Findings of Naidu and Desai (1970) and Gurnani et al. (1976) were similar to the present result (0.765 and 0.394 respectively), though negative genetic correlation between the traits under reference was observed by Chander (1977) in Tharparkar cows (-0.202 ± 0.103).

Low positive but non-significant phenotypic correlation between age at first calving and first lactation length was found in the present study (0.12 ± 0.06). Findings of Singh and Chaudhary (1961) found it to be 0.08 where D'Souza et al.(1979) and Gupta and Bhatnagar (1979) observed it to be -0.052 and 0.041

TABLE 36.

Phenotypic and genetic correlations between age at first calving, first lactation yield, first lactation length and first calving interval in Tharparkar herd at Patna.

	Age at first calving	First lactation yield	First lactation length	First calving interval
Age at first calving		0.07 ± 0.07 (203)	0.12 ± 0.06 (203)	>1 (203)
First lactation yield.	0.69 ± 0.06** (203)		0.74 ± 0.03** (203)	-0.18 ± 0.07* (203)
First lactation length.	>-1 (203)	>-1 (203)		0.30 ± 0.06** (203)
First calving interval	>-1	>1	>1	

Phenotypic correlations above and genetic correlation below the diagonal.

** significant $P < 0.01$ * significant $P < 0.05$

Figures in parentheses indicate number of observations.

respectively. Negative phenotypic correlation (-0.03) between the trait mentioned above was observed by Basu *et al.* (1980).

The present study revealed that the genetic correlatim between age at first calving and first lactation length was found to be negative and more than unity. The probable causes for this unity might be due to sampling error. The findings of Gupta and Bhatnagar (1977) between two traits mentioned above to be -0.202 whereas Dutt and Tomar (1972) calculated it to be -0.89 ± 0.15 between age at first calving and first lactation length in Hariana cows.

The phenotypic correlation between age at first calving and first calving interval was found to be positive and more than unity. The probable causes already explain above but findings of Singh (1957), Singh and Chaudhary (1961) observed to be 0.025 and 0.04 respectively. But negative phenotypic correlation were also reported by Dutt *et al.* (1974), Kumar and Bhat (1979) though Gurnani *et al.* (1976) and Basu *et al.* (1980) found non-significant but positive correlation.

The present study revealed negative genetic correlation between age at first calving and first calving interval. The value obtained in the present estimate was more than unity. Gurnani *et al.* (1976), Kumar and Bhat (1979) observed high positive genetic correlation between age at first calving and first calving interval it to be 0.424 and 2.150.

The present study revealed positive and significant phenotypic correlationship between first lactation yield and first lactation length (0.74 ± 0.03) in Tharparkar herd at Patna. The finding was in agreement with those of Dutt et al. (1974) in Tharparkar. Positive but significant phenotypic correlation between first 305 days lactation yield and first lactation length in Tharparkar (0.91) and Sahiwal (0.89) cows were reported by Basu et al. (1980).

Negative genetic correlation of first lactation length with first lactation yield was obtained in the present case. The value was found to be more than unity. The negative correlation might be due to strong rigid selection applied to the milk yield trait only without considering lactation length. It had double advantages first it increases the lactation production with decreases lactation length resulting shorter length of calving interval. But Singh (1979) reported low, but positive genetic correlation between the traits under reference in case of Tharparkar, Red Sindhi and Sahiwal cows.

Negative and significant phenotypic correlation between first lactation yield and first calving interval was observed in the present study (-0.16 ± 0.07) though highly significant positive phenotypic correlation was observed by Dutt et al.(1974), D'Souza et al. (1979) however, found low but positive phenotypic correlation between first lactation yield and first calving interval in Red Sindhi cows (0.073) whereas Basu et al. (1980)

EXPECTED PRODUCING ABILITY.

Repeatability :

The amount of milk that a cow produces in one lactation usually differs from the amount produced in other lactations. This differences in yield of same cow may be due to temporary environmental circumstances such as variation in the amount and quality of feed and changes in managemental practices. Animals also vary in growth and physiological development. Size is a factor in milk production. These variation tended to be cancelled when the average of all records of a cow is used. Permanent changes of a environmental nature may also occur. The growth of a cow with increasing age and development of udder by recurrent period of pregnancy and lactation, damage to the body by serious illness or loss of quarter represent changes of more permanent nature. The degree to which a cow tends to produce the same amount of milk from lactation to lactation is defined as repeatability of traits. The repeatability is measured by average co-efficient of correlation between records of the same cow. Hence repeatability is used to predict the probable producing ability when average of more than one lactation is used.

Estimate of repeatability can be calculated as the correlation between repeated results either in usual correlation analysis or in an intraclass correlation by an analysis of variance. By combining repeatability and heritability an estimate can be made of predicting breeding value of an animal. Heritability of average of n record (h_n^2) is higher than the (h^2) single records. However, averages have decreased variance, the possible selection differential

is decreased by $1+(n-1)r$ /n where several records are used. Averaging records has advantage of better precison in estimating breeding value but has the disadvantage of lengthening the generation interval because of time required for the accumulation of data before selection can begin.

In the present study the analysis of variance were conducted as per Beeker (1975) for repeatability estimate (Table 37).

TABLE 37.

Analysis of variance for estimating repeatability of milk yield.

Source of variation	df	S.S.	M.S.	E.M.S.
Between individual	104	110488525.540	1062389.66	214972.307
Measurement within individual	275	78743400.574	286339.638	286339.638
Total	379			

$$K = 3.61$$

$$R = \frac{214972.307}{501311.945}$$

$$= 0.428$$

The results obtained in the present study were found to be 0.428 ± 0.0546 for milk yield. The estimate obtained from the present work were similar in magnitude to those reported by 0.366 (Singh, 1963) for Bachaur cows, 0.49, 0.49 and 0.37 (Kooner, 1963) for Tharparkar, Sahiwal and Red Sindhi cow respectively whereas Singh (1963) in same year found values to be 0.94 ± 0.06 and 0.52 ± 0.06 for Tharparkar and Sahiwal cow respectively, but slight higher estimates were also reported by Amble et al.(1958) in Red Sindhi cow.

The best estimate of real producing ability for a trait such as milk yield is expressed as follows (Lush, 1945).

$$\text{the herd average} + \frac{nr}{1+(n-1)r} \times \text{cows average} - \text{the herd average}$$

The estimate of most probable producing ability of cows in the herd on different number of records make it possible to compare and cull them more accurately on a standard basis. The results obtained according to this method is given in the Table 38.

TABLE 38.

Trait	No. of observation	Most probable producing ability (kg) Mean ± S.E.	C.V.
First lactation	105	1235.88 ± 13.530	11.217
Second lactation	105	1237.69 ± 18.992	15.723
Third lactation	81	1253.92 ± 23.111	16.588

The results were found to be quite close to the actual first, second and third lactation production thereby indicating the scope for bringing about improvement on milk production. Dutt et al. (1974) found it to be 1325.09 ± 37.21 kg with 22.3 per cent coefficient of variation for next lactation in Tharparkar cows at Bhareri farm. Gautum et al.(1966) reported that efficiency of Hariana cows for higher milk producing ability were superior when age at first calving was below 39 months (3016 lbs). The ability of cows were reported to decreased significantly with increasing age at first calving past 39 months, though age at first calving of 51 months did not seemed to show any appreciable impact on milk producing ability. If the cow had one record it indicate what she will produce milk in future lactation, but if the repeatability i.e. r

is small the estimate can not be taken as very much reliable. the increasing number of records reliability of estimates might be increases. Thus less and less use of herd average is needed. The use of many records or many observations is most useful and most needed for the trait which repeatability is low.

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S U M M A R Y

The present investigation was undertaken to evaluate the genetic and non-genetic performance of certain productive and reproductive traits in Tharparkar cattle stationed at Government Cattle Farm, Patna for the period 1950-1971.

Depending upon the existing climatic conditions the year was divided into four seasons under the present study i.e. winter (November to January), spring (February to April), summer (May to July), rainy (August to October). Productive and reproductive traits taken into consideration for studies were : age at first calving, lactation yield, lactation length, dry period, calving interval, first lactation milking average, first lactation overall average, breeding efficiency and probable producing ability.

Statistical models were used to estimate the different productive and reproductive traits and factors influencing them. Different statistical tests of significants and methods were utilised in the present studies.

The average age at first calving for the Tharparkar herd at the Government Cattle Farm, Patna was found to be 1543.91 ± 12.011 days with 13.064 per cent co-efficient of variation. The mean age at first calving in winter, spring, summer and rainy season was observed to be 1459.01 ± 27.64, 1588.32 ± 33.26, 1643.86 ± 13.61 and 1590.59 ± 33.64 with 14.05, 14.20, 16.14 and 12.86 per cent co-efficient of variation res

respectively on the basis of calving season, season of calving and sire both were found to have significant effects on age at first calving.

The mean 305 days milk yield was observed to be 1161.83 ± 25.283, 1206.38 ± 23.534, 1249.80 ± 29.656 and 1201.71 ± 118.743 kg with 36.540, 31.456, 18.460 and 41.922 per cent co-efficient of variation respectively from the first to fourth lactation. whereas total lactation yield in same herd from the first to fourth sequences were observed to be 1267.23 ± 31.630, 1282.85 ± 32.306, 1288.09 ± 38.564 and 1238.35 ± 123.035 kg with co-efficient of variation of 41.910, 40.607, 43.488 and 42.151 respectively. Sequence of lactation did not significantly influence the total lactation yield. The mean first lactation yield seasonwise - winter, spring, summer, rainy was found to be 1383.61 ± 40.18, 1391.79 ± 42.58, 1376.65 ± 54.30, 1329.18 ± 53.84 kg with 41.78, 43.70, 40.84, 45.47 per cent co-efficient of variation respectively. Season of calving was not found to affect the lactation yield significantly. Non-significant sire affect on first lactation yield was however observed in the herd.

From first to fourth calving average lactation length were observed to be 301.74 ± 5.533, 286.50 ± 4.604, 283.51 ± 3.849, 265.33 ± 14.430 days with 1.183, 25.914, 19.721 and 23.074 per cent co-efficient of variation respectively. Lactation sequence had significant effect on lactation length. For the cows calving in winter, spring, summer and rainy season mean lactation lengths were found to be

335.11 ± 7.14, 341.72 ± 7.61, 338.32 ± 10.81, 318.36 ± 9.58 days with 30.66, 31.82, 32.13 and 33.79 per cent co-efficient of variation respectively. Sire and season of calving did not seem to have any significant effect on lactation length.

From first to fourth sequences the mean dry period in Tharparkar herd were found to be 172.76 ± 9.456, 149.91 ± 8.020, 195.83 ± 41.049 days along with 88.258, 77.709 and 88.230 per cent co-efficient of variation respectively. Lactation sequences were not found to have significant effect on dry period. The mean first dry period in winter, spring, summer and rainy seasons were found to be 186.66 ± 12.14, 206.62 ± 10.88, 166.80 ± 15.46 and 170.23 ± 14.59 days with 83.84, 75.83, 86.47 and 73.27 per cent co-efficient of variation respectively. Season of calving also did not seem to have any significant influence on first dry period.

From first to fourth calving mean calving interval were found to be 468.70 ± 10.073, 439.73 ± 4.992 and 444.16± 36.726 days along with 34.653, 16.489 and 35.080 per cent co-efficient of variation respectively. Calving sequences were noted to have significant effect on calving intervals. The mean calving intervals in the winter, spring, summer and rainy seasons were observed to be 477.18 ± 12.19, 535.41 ± 13.41, 491.35 ± 14.69 and 463.68 ± 12.94 days along with 32.92, 36.06, 27.90 and 23.84 per cent co-efficient of variation respectively. Non-significant effects of season of calving and sires both on calving interval.

First lactation milking average was found to be 4.05 ± 0.09 kg with 33.33 per cent co-efficient of variation, whereas overall average for first lactation yield was recorded to be 2.63 ± 0.10 with 59.69 per cent co-efficient of variation.

The breeding efficiency in the herd was observed to be 67.58 ± 2.21 with 33.39 per cent co-efficient of variation.

The heritability estimates of age at first calving by intra sire regression of daughter on dam and paternal half-sib method were found to be 0.26 ± 0.10 and 0.78 ± 0.664 respectively.

Heritability of 305 days milk yield and total milk yield was obtained to be 0.657 ± 0.2315, 0.518 ± 0.2252 and 0.605 ± 0.2651 and 0.5399 ± 0.218, 0.445 ± 0.2159, 0.326 ± 0.2322 for first, second and third lactation respectively.

From first to third lactation length the heritability estimates were found to be 0.862 ± 0.252, 0.061 ± 0.157 and 0.406 ± 0.242 respectively.

Heritability estimate of first and second dry period were found to be 0.423 ± 0.213 and 0.424 ± 0.244 respectively.

Heritability estimate of first and second calving interval were observed to be 0.121 ± 0.168 and -0.394 ± 0.293

High genetic correlation (0.69 ± 0.06) was observed between age at first calving and first lactation yield in Tharparkar herd at Government Cattle Farm, Patna.

Non-significant but positive phenotypic correlation between age at first calving and first lactation yield was (0.12 ± 0.06) evident in the present studies.

Positive but significant phenotypic correlation between age at first calving and first calving interval (>1) was obtained in the present studies.

The positive but significant phenotypic correlation between lactation yield and lactation length (0.74 ± 0.03) was observed whereas genetic correlation between the traits was found to be negative, high (-> 1) and more than unity.

Though the phenotypic correlation between lactation yield and calving interval was found to be negative and significant (-0.18 ± 0.07), the genetic correlation turned out to be highly significant and positive (>1).

Significant phenotypic correlation between lactation length and calving interval was observed in present study with Tharparkar herd at Government Cattle Farm, Patna (0.30±0.06).

The probable producing ability of cow turned out to be 1235.88 ± 13.530, 1237.69 ± 18.992 and 1253.92 ± 23.111 kg on the basis of first, second and third lactation respectively.

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