I certify that this Thesis has been prepared under my supervision by Sri R. L. Singh, a candidate for the Degree of M.Sc. (A.H.) with Animal Genetics and Breeding as major subject, and that it incorporates the results of his independent study.

R. B. Prasad 24.10.63

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PATNA,
D/ ~~23~~ 24.10.'63.

STUDY ON GENETIC AND PHENOTYPIC PARAMETERS OF BACHAUR HERD AT PUSA.

-X-

A THESIS

submitted to the Faculty of Veterinary Science and Animal Husbandry, Magadh University, in partial fulfilment of the requirements for the Degree of Master of Science (Animal Husbandry).

BIHAR VETERINARY COLLEGE
PATNA.
Acc. No. 6164
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AH/164

B y:

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(October, '63)

***

A C K N O W L E D G M E N T S.

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The author is grateful to Dr. H.R.Mishra, M.Sc., Ph.D. (Minn.), U.S.A., Professor of Animal Husbandry, Bihar Veterinary College, Patna, for providing the necessary facilities for this work.

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A word of appreciation is extended to the Manager, Bachaur Cattle Breeding Farm, Pusa, who made available the Farm records for this herd.

The author is also indebted to the Government of Bihar (Animal Husbandry Department) for financing his study during this period.

... AUTHOR.

CONTENTS.

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INTRODUCTION.

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(A) General:- Bachaur cattle is the only recognised breed in Bihar. It has been described in detail by Randhawa (1958) and Fahima (1961).

The typical colour of the cattle of this breed is grey. They are small with compact body, straight back, short neck and muscular shoulder. They have broad forehead, prominant and large eyes, drooping ears, and short tail which often do not reach the hock. The average body measurements are given below:-

Male:

Height	...	55";	Length	...	54";
Girth	...	68";	Weight	...	850 lbs.

Female:

Height	...	52";	Length	...	53";
Girth	...	64";	Weight	...	700 lbs.

The marketting and assembling centres of this breed are cattle fairs in North Bihar. The breeding tracts of Bachaur cattle are Sitamarhi Sub Division of Muzaffarpur, North Champaran, Darbhanga and from Koilpur Pargana to Bhagalpur of Bihar.

The Bachaur breed of cattle is one of the important draft breed of India. Bullocks of this breed are quite good for draft purpose but cows are poor milkers.

Keeping in view a vast tract of land in North Bihar being covered by this breed of cattle and also its low milk producing capacity, Government of Bihar established a breeding Farm for Bachaur cattle at Pusa in Darbhanga District in the year 1948 with three main objectives; firstly, to assess its milk producing capacity under farm condition: secondly, to see whether its milk production can be raised by adopting modern breeding technique: and thirdly, to produce good bullocks for draft purposes for farmers.

To achieve the abovementioned objectives, the technique of selective breeding was adopted. It is known that there are three basic tools available to animal breeders for bringing about genetic improvement in their herd. They are selection, in breeding and cross-breeding. Out of the three tools selection seems to be encompass, directly or indirectly, the rest two i.e. inbreeding and crossbreeding (Prasad, 1962). And for proper utilisation of modern procedures in selection programmes, knowledge of genetic and phenotypic parameters is necessary. The present study is to estimate the genetic and phenotypic parameters of Bachaur herd maintained at the Bachaur Breeding Farm, Pusa.

It is known that milk yield, age at first calving and other economic traits are phenotypic expressions. Phenotype of an economic character is the result of genetic and environmental influences and as such it becomes essential for a breeder to know the percentage

of genetic and environmental variations separately for the particular trait to be improved. Such information can be available by estimating heritability and repeatability coefficients. With this information, a breeder can provide the basis for formulating selection and breeding programme as also predict the degree of expected improvement.

This study includes the estimates of the following genetic and phenotypic parameters of the herd:

PHENOTYPIC PARAMETERS:

(a) Milk yield. (b) Lactation length.
(c) Age at first calving. (d) Calving interval.
(e) No. of services per conception.
(f) Productive life. (g) Sex ratio.
(h) Correlation between age at first calving and first lactation yield.

GENETIC PARAMETERS:

(a) Heritability of milk yield.
(b) Heritability of age at first calving.
(c) Repeatability of milk yield.

<u>Milk yield:-</u> It is the most important economic trait of dairy cattle. The value of a cow is assessed mainly on the quantity of milk she produces. Milk yield is the result of the effects of environment and genetic make up of an individual. Environment includes all the external influences to which a cow has been subjected such as feeding, care, management and climatic conditions.

It also includes some non-tangible factors such as season of calving (Ragab et al, 1954) and weight of heifer at calving (Rajagopalan, 1952) which have been shown to affect first lactation yield.

The causes of genetic variation in milk yield may be due to additive genic action, interallelic and intraallelic interactions or other genetic interactions. According to Waddington (1939), genetic environment thus refers to genetic constitution of an individual.

As the present study aims at the estimates of heritability and repeatability coefficient of first lactation yield along with correlation coefficient between age at first calving and first lactation yield, it would, therefore, be possible for a breeder to formulate a suitable breeding programme for his herd.

Culling of less productive cows at an early stage is essential from economic view point. As milk yield is a repeatable trait, a breeder can predict the most probable producing ability in the next lactation by the estimate of repeatability. Repeatability of milk yield measures the average degree to which a cow will produce in her next lactation as much above or below the average of the herd as she did in the lactation already made.

The correlation coefficient between age at first calving and first lactation yield may also be of considerable help in forecasting the merit of cows with regard to the amount of milk in the first lactation. If it is statistically significant, late calvers would produce more milk in the first lactation period and vice versa.

Lactation length:-

Among the various factors responsible for milk yield of a cow, the lactation length is a major factor. Lactation length varies considerably from one breed to the other in Zebu cattle. Venkayya and Krishnan (1956) found that in Red Sindhi and Gir cows, the correlation coefficient between age at first calving and first lactation length was statistically significant. This indicates that late calvers have a longer first lactation period and consequently may have more total production.

Age at first calving:-

The age at first calving is a character of much economic importance. It affects the life production of the animals, as an early age at first calving would reduce the unproductive period of cows and hence increase their life time production. According to Dickerson and Chapman (1940), Hanson (1941) and Ragab et al (1953 and 1954) age at first calving has got much influence over the first lactation yield. According to Mahadevan (1958), age at first calving is a matter of management practices in temperate zone, whereas in Indian cattle, it is a result of age at first heat period which in turn is a physiological and probably hereditary trait.

Stonaker (1953) has shown that this trait is highly hereditary in the pure bred Red Sindhi herd at Allahabad Agricultural Institute. In other herds and in other breeds of cattle, it may not be the case e.g. Singh (1957) found that heritability of this trait was zero in the Tharparkar herd at Government Cattle Farm, Patna.

As this is an important economic trait, it was necessary to know the heritability coefficient. If the estimate of heritability is not significant, then the selection technique for genetic improvement of the trait will not be effective. The improved feeding and management practices of young female calves would be helpful in reducing the age at first calving to a certain extent which cannot be stable from one generation to another, unless good management practices are regular feature for the herd. Sayer (1936) and Mahadevan (1953) have stated that age at first calving can be further reduced by providing good feeding and management in early life. On the other hand, if the trait is hereditary, selection criteria for genetic improvement will be effective.

By lowering age at first calving, there would be many advantages. Firstly, the productive life of the cow would be enhanced, thereby improving the prospect of cow keeping. Secondly, interval between generations would be shortened, thereby making the progeny testing of sires more successful. And thirdly, it would be helpful for early selection of female stock on the basis of their own performance.

Mahadevan (1958) stated that the herd in which age at first calving of heifers was high, it would not only take a long time to progeny test a bull but it would also increase the number of bulls that have to be kept unemployed until their progeny records become available. But since there is a limit to the number of bulls that a herd-owner could maintain without using them for active service, the end result would be that fewer bulls would be tested each year. This would, in turn, have the undesirable effects of decreasing the intensity of selection between bulls and increasing the rate of inbreeding. In addition to these disadvantages, the period between testing and final proving would be so lengthy that bulls might become too old to be used for service after he is proven.

Calving interval:- It is the period between two consecutive calvings. This period can be divided into two parts: (a) the period between date of calving and conception which is otherwise known as service period and (b) gestation period.

Calving interval plays an important role on breeding efficiency of dairy cattle. There is little variation with the gestation period but variation in the service period exert a pronounced influence on milk yield. Sanders (1927) obtained a correlation of 0.409 between service period and total milk yield in Taurus cattle. Sikka (1931) found correlation of 0.339 and 0.524 in pure bred Sahiwal in India between service period and milk yield, and service period and lactation length respectively. Among Fulani cattle, Lecky (1951) reported correlation of 0.148 and 0.309 between calving interval and total yield, and between calving interval and lactation length respectively.

From economic point of view, high lactation yield with proportionately longer service period and lactation period is not advantageous. The longer service and lactation periods make the calving intervals wider and consequently lower the number of calves that could be obtained in the life time of a cow. Total life time production of milk also tends to be reduced, while generation intervals increase in length and thereby cause a decrease in annual genetic gain. Evidences regarding the optimal length of calving interval for Zebu cattle are very small. Gains and Palfrey (1931), Chapman and Casida (1935) as quoted by Prasad (1958) and Prasad (1962) reported that optimum milk producing efficiency would be obtained in cows calving every 12 months or less.

Variation in gestation period is caused mostly by genetic factors. Other factors causing variation in gestation period are weight and age of dam, sex of calf, birth weight of calf, twin births and sex difference.

Variation in service period is influenced by management as per summary report of breeding work in Nigeria submitted to the F.A.O., Lucknow, Live Stock Conference, 1950. Thus by providing better feeding and management practices, calving interval may be brought to desirable level.

Number of services per conception:-

The knowledge of number of services per conception is necessary to judge the reproductive efficiency of a herd. Regularity in reproduction is an important economic trait. It influences calving interval and milk yield. As the number of services per conception increases, the cow becomes less economical.

GENETIC PARAMETERS:

Heritability:-

It has long been recognised that the phenotype represents a combination of genetic and environmental effects (Dempster and Lerner, 1950). Wright (1920) was one of the first Geneticists to separate the genetic and environmental components of phenotypic variation.

Wright (1921) also devised a statistical method of separating the genetic and environmental portions of the phenotypic variation by means of path coefficients. These methods have been used as a basis in arriving at estimates of degrees of heritability of various traits, (Lush, 1945). Lerner (1950) has defined heritability as "the portion of the total phenotypic variation which is due to additive gene action". In statistical terms, it gives the regression of genetic differences on phenotypic differences.

Heritability is used in both broad and narrow sense. The following formulae make it clear:

$$h^2 = \frac{\sigma^2 H}{\sigma^2 P} = \frac{\sigma^2 G \quad \sigma^2 D \quad \sigma^2 I}{\sigma^2 G \quad \sigma^2 D \quad \sigma^2 I \quad \sigma^2 E \quad \sigma^2 \overline{EH}} \text{ in broad sense.}$$

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where:

h^2 ... Heritability.

P ... Phenotypic deviation.

H ... Hereditary deviation.

G ... Additive genetic deviation.

D ... Dominance deviation.

I ... Epistatic deviation.

E ... Environmental deviation

and $\overline{EH}$ ... Joint effect of heredity and environment.

The heritability in broad sense and narrow sense is the same where there is no dominance or epistatic deviation. Heritability estimates are based on the variation in a particular trait, at a particular time and under particular condition to a particular population.

Since it is a ratio, its value can change with the change in numerator or denominator. As denominator includes numerator, any change in the numerator will bring about change in denominator. The value of heritability varies from zero to one.

The high value of heritability indicates greater genetic variation and lesser environmental variation and vice versa.

As stated by Prasad (1951), heritability estimates are essential in determining the efficiency and choice of different breeding system. If heritability is high for the desired characteristics, the best method will be mass selection with little use for pedigree or relatives. If heritability is low, a better plan would be to make considerable use of pedigree and some use of progeny tests and selection on the basis of family.

Heritability estimates are essential to arrive at optimum weight to be given to several traits in an index in case of selection for more than one trait. Even in other two methods of selection for more than one trait at a time, heritability estimates would aid in properly weighting the various traits. It is also needed for calculation of annual expected genetic gain in next generation.

<u>Repeatability:-</u> It is a measure of overall variation due to heritable causes viz. additive genetic variance, dominance and epistatic deviation. In other words, it may be said that repeatability measure the average degree of variation between cows which are due to the variance mentioned above. Repeatability may be still larger because it also includes the permanent effects of environment. For example, the kinds of feeding to which

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Repeatability may be defined as the regression of future performance or phenotype on past performance.

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Since it is a ratio, its value can change with the change in numerator or denominator. As denominator includes numerator, any change in the numerator will bring about change in denominator. The value of heritability varies from zero to one.

The high value of heritability indicates greater genetic variation and lesser environmental variation and vice versa.

As stated by Prasad (1951), heritability estimates are essential in determining the efficiency and choice of different breeding system. If heritability is high for the desired characteristics, the best method will be mass selection with little use for pedigree or relatives. If heritability is low, a better plan would be to make considerable use of pedigree and some use of progeny tests and selection on the basis of family.

Heritability estimates are essential to arrive at optimum weight to be given to several traits in an index in case of selection for more than one trait. Even in other two methods of selection for more than one trait at a time, heritability estimates would aid in properly weighting the various traits. It is also needed for calculation of annual expected genetic gain in next generation.

Repeatability:- It is a measure of overall variation due to heritable causes viz. additive genetic variance, dominance and epistatic deviation. In other words, it may be said that repeatability measure the average degree of variation between cows which are due to the variance mentioned above. Repeatability may be still larger because it also includes the permanent effects of environment. For example, the kinds of feeding to which calves and young heifers are subjected, do affect their production all through the rest of their lives. These effects would be included in the repeatability but they would not be heritable.

Repeatability may be defined as the regression of future performance or phenotype on past performance.

According to Prasad (1951), symbolically it may be represented as given below:-

$$R = \frac{\sigma^2 Y \quad \sigma^2 C}{\sigma^2 P}$$

where:

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C ... Any environmental effect constant for all the expressions of an individual.

P ... Total phenotypic variance.

This repeatable fraction of total variance is the portion of superiority in selected individuals that may be expected in future performances. A knowledge of repeatability tells us something about how much culling can safely be done.

Repeatability coefficient is estimated only for those traits which are expressed more than once in an individual life e.g. milk yield.

It becomes essential to know the relationship between heritability and repeatability. Since additive genetic deviation, dominance deviation and epistatic deviation remain constant in an individual life, repeatability should be atleast as large as heritability in broad sense.

Using previous notation, relationship between heritability and repeatability may be represented as:

$$\frac{R}{h^2} = \frac{\sigma^2_G \quad \sigma^2_D \quad \sigma^2_I \quad \sigma^2_C}{\sigma^2_G}$$

***

Chapter (I).

REVIEW OF LITERATURE.

Chapter (I).

L I T E R A T U R E   R E V I E W.

Average first lactation yield:-

Milk yield is an economic character of prime importance of a dairy cow. Particularly, average first lactation yield helps much in culling the less productive cows at an early stage. Many workers have studied the average first lactation yield with different breeds of cattle. The results have been presented in table (1).

Table (1).

Note: See page (15)

Table (1).

Table showing average first lactation yield.

AUTHOR.	Year.	Breed or herd.	Genera-tion.	Average (lbs.)	N.	S.D.	S.E.	C.V.
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rajagopalan. ...	1951-52	Sindhi.	-	3389.5	-	-	164.3	0.43
" ...	"	Kangayam.	-	1413.093	-	-	98.40	0.293
Sundaresan et al..	1954	Red Sindhi.	-	2600.0	82	1300.7	-	-
" ...	"	½ Jersey X ½ Red Sindhi.	-	4500.0	30	900.4	-	-
" ...	"	½ Jersey X ½ R.S.	-	3400.0	69	1200.1	-	-
" ...	"	½ Brown Swiss X ½ R.S.	-	4800.0	16	1200.0	-	-
" ...	"	½ B.S. X ½ R.S.	-	3400.0	28	1000.3	-	-
" ...	"	½ Holstein X ½ R.S.	-	6100.0	11	900.8	-	-
" ...	"	Jersey.	-	5700.0	91	1500.9	-	-
Venkayya and Krishnan.	1956	Red Sindhi.	-	3323.0	216	1138	-	34.2
" ...	"	Gir.	-	3149.0	80	942	-	29.9
" ...	"	Ayrshire X Sindhi.	-	4458.0	241	1675	-	37.6

(To be continued)

Table (1) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Venkayya and Krishnan. ...	1957	Red Sindhi.	-	3533.0	64	-	-	38.0
" ...	"	Ayrshire X Sindhi.	-	5157.0	65	-	-	23.5
Amble et al. ...	1958	Sindhi at Hosur.	1st.	3345	46	-	224.0	45.0
" ...	"	-do-	2nd.	3973	67	-	194.0	40.0
" ...	"	Sindhi at Bangalore.	1st.	2451	82	-	165.0	61.0
" ...	"	-do-	2nd.	2570	92	-	145.0	54.0
Singh & Chaudhury.	1961	Sahiwal.	-	3283	118	1542	--	46.9
" ...	"	Tharparkar.	-	3227.7	90	1320	--	40.8
Singh & Desai. ...	"	Hariana at Mathura.	-	2578.9	128	-	-	-
" ...	"	Hariana at Madhurikund.	-	1538.3	119	-	-	-
" ...	"	Hariana at Bharari.	-	2349.7	112	-	-	-
" ...	"	Hariana at Babugarh.	-	1624.5	75	-	-	-
Kohli et al. ...	"	Hariana at Hissor.	-	1491.1	277	-	37.1	41.4

(To be contd.)

Table (1) - Concld.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Batra. ...	1961	Sahiwal at M. F., Lucknow.	-	3740.7	67	938.7	114.7	25.1
" ...	"	Sahiwal at C. G. F., Lucknow.	-	3732.6	67	1364.2	166.8	36.5
" ...	"	Sahiwal at Ambala.	-	3551.2	54	1075.8	146.5	30.3
" ...	"	Sahiwal at M. F., Meerut.	-	3730.6	39	1241.3	198.9	32.7
" ...	"	Overall for all Farms.	-	3724.4	227	1170.5	77.7	31.4
Sharma et al. ...	1951	Hariana.	-	1284.9	133	-	-	-
Kohli, Suri et al.	1961	Hariana.	-	1611.6	-	-	-	-
Ohri et al. ...	"	Rathi.	-	2919.0	27	-	-	-
				Average yield per lactation.			No. of obs.	
Joshi & Phillips.	1953	Kankrej. Chharodi Farm.	-	2665.0			91	
" ...	"	Malvi.	-	2311.0			--	
" ...	"	Bhagnari.	-	2857.0			--	
" ...	"	Krishna Valley.	-	2731.0			--	
" ...	"	Nagori.	-	2800.0			--	
" ...	"	Ongole.	-	2500.0			--	

<u>Average First Lactation Period:-</u> Studies done on average first lactation period are presented in the table (2).

<u>Table (2).</u>

AUTHOR.	Year.	Breed or herd.	Generation.	Average (days)	No. of obs.	S. D. (days)	S. E.	C. V.
1.	2.	3.	4.	5.	6.	7.	8.	9.
Venkayya & Krishnan.	1956	Red Sindhi.	-	305	216	55	-	18.1
"	"	Gir.	-	301	80	44	-	14.6
"	"	Ayrshire X Sindhi.	-	327	241	56	-	17.1
Amble et al.	1958	Red Sindhi at Hosur.	1st.	303	46	-	14	31.0
"	"	-do-	2nd.	335	67	-	9	22.0
"	"	Red Sindhi at Bangalore.	1st	252	82	-	11	40.0
"	"	-do-	2nd	260	92	-	10	38.0
Singh & Chaudhury.	1961	Sahiwal.	-	264.7	118	49.2	-	18.5
"	"	Tharparkar.	-	271.0	90	87.0	-	32.1
Singh & Desai.	"	Hariana at Mathura.	-	318.5	75	-	-	-
"	"	Hariana at Madhurikund.	-	296.3	39	-	-	-
"	"	Hariana at Bharari.	-	342.2	59	-	-	-

(Contd .... 19)

Table (2) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Singh & Desai.	1961	Hariana at Babugarh.	-	272.7	25	-	-	-
B a t r a.	"	Sahiwal at M. F., Lucknow.	-	280.9	67	40.2	4.9	14.3
"	"	Sahiwal at C. G. F., Lucknow.	-	341.5	67	109.3	13.4	32.0
"	"	Sahiwal at M. F., Ambala.	-	280.8	54	47.2	6.4	16.8
"	"	Sahiwal at Meerut.	-	263.9	39	50.2	8.0	19.0
"	"	Overall for all herds.	-	295.8	227	70.5	4.7	23.8
Ohri et al.	"	Rathi.	-	354.5	27	-	-	-
					Average lactation period.		No. of obs.	
Joshi & Phillips.	1953	Kankrej at Chharodi Farm.	-		307.0		91	
"	"	Bhagnari.	-		262.0		128	
"	"	Ongole.	-		303-329		-	
"	"	Rath.	-		About 200		-	

<u>Average age at First Calving:-</u> A review of work done on the average age at first calving is presented in table (3).

Table (3).

Author.	Year.	Breed or herd.	Generation.	Average	No. of obs.	S.D.	S.E.	C.V.
1.	2.	3.	4.	5.	6.	7.	8.	9.
Littlewood.	1933	Ongole.	1st.	Y. 2 M. 7 D. 20	28	-	-	-
"	"	-do-	2nd.	3 - 16	27	-	-	-
"	"	-do-	3rd.	3 2 1	12	-	-	-
"	"	-do-	4th.	3 0 1	2	-	-	-
				Months.				
Kartha.	1934	Sahiwal.	-	36.5	-	-	-	-
"	"	Tharparkar.	-	43.0	-	-	-	-
"	"	Hariana.	-	46.0	-	-	-	-
				Days.				
Rajagopalan.	1951-52	Sindhi.	-	1331.3	81	-	16.9	0.11
"	"	Kangayam.	-	1447.5	31	-	60.211	0.235
				Months.				
Sundaresan et al.	1954.	Red Sindhi.	-	42.0	82	9.1	-	-
"	"	½ Jersey X ½ R. S.	-	29.0	30	6.3	-	-
"	"	½ J. X ½ R.S.	-	36.0	69	7.3	-	-
"	"	½ Brown Swiss X ½ R.S.	-	42.0	16	8.0	-	-

(To be continued)

Table (3) - Contdl.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Sundaresan et al.	1954	½ B.S. X ½ R.S.	-	33.0	28	7.1	-	-
"	"	½ Holstein X ½ R.S.	-	38.0	11	4.1	-	-
"	"	Jersey.	-	30.0	91	4.1	-	-
Mahadevan.	1955	Red Sindhi.	-	47.0	-	-	0.4	-
Venkayya & Krishnan.	1956	-do-	-	42.9	216	8.43	-	19.6
"	"	Gir.	-	47.3	80	6.87	-	14.5
"	"	Ayrshire X Sindhi.	-	35.1	241	7.04	-	20.0
Kohli & Suri.	1957	Hariana.	-	58.83 Days.	-	-	0.20	-
S i n g h.	"	Tharparkar.	-	1461.0	209.	-	14.5	-
Johari & Talapatra.	"	Hariana at Madhurikund.	-	1546	95	-	-	-
"	"	Hariana at Bharari.	-	1683	135	-	-	-
"	"	Hariana at Babugarh.	-	1262	61	-	-	-
"	"	Hariana at Hastinapur.	-	1498	26	-	-	-
"	"	Hariana at Nilgaon.	-	1693	54	-	-	-
"	"	Hariana at Mathura.	-	1544	63	-	-	-

(Contd.)

Table (3) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.
				Months.				
Amble, Krishnan & Srivastava.	1958	Shindhi at Hosur.	1st.	40.3	52	-	0.8	12.0
"	"	-do-	2nd.	40.3	83	-	0.7	14.0
"	"	-do-	3rd.	42.6	89	-	0.8	17.0
"	"	Sindhi at Bangalore.	1st	39.4	102	-	0.6	11.0
"	"	-do-	2nd.	42.1	97	-	0.6	15.0
"	"	-do-	3rd.	44.1	68	-	0.8	14.0
Amble, Krishnan & Soni.	"	Red Sindhi at Hosur.	-	41.7	350	-	0.4	15
"	"	Red Sindhi at Bangalore.	-	41.7	289	-	0.4	13
"	"	Kangayam.	-	44.1	477	-	0.4	20
"	"	G i r.	-	47.0	88	-	0.8	15
"	"	Kankrej.	-	47.4	98	-	0.8	16
"	"	Tharparkar.	-	49.4	422	-	0.4	14
Singh & Desai.	1961	Hariana at Mathura.	-	38.92	79	8.77	1.0	22.21
"	"	Hariana at Madhurikund.	-	50.09	122	9.25	0.84	18.38
"	"	Hariana at Bharari.	-	50.87	130	6.81	0.60	13.31

(Contd.)

Table (3) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.
				Months.				
Singh & Desai.	1961	Hariana at Babugarh.	-	44.09	86	6.69	0.72	14.96
Singh & Chaudhury.	1961	Sahiwal.	-	41.1	118	6.99	-	17.0
"	"	Tharparkar.	-	43.2	90	8.88	-	20.5
Kohli et al.	"	Hariana.	-	59.3	277	-	0.5	15.1
				Days.				
B a t r a.	"	Sahiwal at M.F., Lucknow.	-	1196.8	67	160.1	19.6	13.38
"	"	Sahiwal at M.F., Ambala	-	1144.7	54	125.2	17.1	10.94
"	"	Sahiwal at Meerut.	-	1164.1	39	164.6	26.4	14.26
				Months.				
B e r g e.	1949	Norwegian South & West cattle.	-	24.6	-	-	-	-
Mahadevan.	1953	Black Sinhala cattle.	-	42.4	600	-	0.4	-
Mudgal et al.	1960	Red Sindhi.	-	42.9	-	-	0.72	-
Alim.	"	Kenana herd.	-	38.4	-	-	-	-
Kohli et al.	1961	Hariana.	-	54.3	-	-	0.81	-

(To be concluded)

Table (3) - Concld.

1.	2.	3.	4.	5.	6.	7.	8.	9.
Joshi & Phillips.	1953	Kankrej.	-	Months. 48.47	294	-	-	-
"	"	Malvi at Hyderabad.	-	3 Yrs. 3 Mo.	-	-	-	-
"	"	Bhagnari.	-	42.18 Mos.	28	-	-	-
"	"	Krishna Valley.	-	4 yrs.	-	-	-	-
"	"	Nagori at Nagur Cattle Farm.	-	40.0 Mos.	-	-	-	-
"	"	Ongole.	-	3 to 3½ Yrs.	-	-	-	-

oooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo

<u>Average Calving Interval:-</u> Sanders (1927 a and b), as quoted by Singh (1958), stated that calving interval was directly related to life time milk production which was one of the two main objectives of raising cattle. Many workers have calculated the average calving interval to judge breeding efficiency with different breeds of cattle. The work already done is shown in table (4).

Table (4).

Author.	Year.	Breed or herd.	Sequence of Calving interval.	Generation.	Average.	No. of obs.	S.D.	S.E.	C.V.
1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Dave & Singh.	1934	Sindhi.	-	-	401 days.	-	-	-	-
Kartha. ...	"	Sahiwal.	-	-	408 "	-	-	-	-
" ...	"	Tharparkar.	-	-	399 "	-	-	-	-
" ...	"	Hariana.	-	-	408 "	-	-	-	-
Mahadevan. ...	1953	Black Sinhala	-	-	355 "	600	-	-	-
Stonaker et al.	"	Red Sindhi.	1st.	-	16 months.	69	-	-	-
" ...	"	-do-	2nd.	-	15 "	59	-	-	-
" ...	"	-do-	3rd.	-	14 "	53	-	-	-
" ...	"	-do-	4th.	-	13 "	37	-	-	-
" ...	"	-do-	5th.	-	14 "	28	-	-	-
" ...	"	½ Jersey.	1st	-	13 "	27	-	-	-
" ...	"	-do-	2nd.	-	13 "	26	-	-	-
" ...	"	-do-	3rd.	-	14 "	21	-	-	-
" ...	"	-do-	4th.	-	14 "	12	-	-	-
" ...	"	-do-	5th.	-	15 "	17	-	-	-

(To be continued)

Table (4) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Sundaresan et al.	1954	Red Sindhi.	-	-	16 months.	70	-	-	-
" ...	"	½ Jersey X ½ R.S.	-	-	14 "	29	-	-	-
Mahadevan.	1955	Red Sindhi.	-	-	433 days.	-	-	4	28
Venkayya & Krishnan.	1956	-do-	-	-	416 "	216	111	-	24.1
"	"	Gir.	-	-	465 "	80	124	-	26.8
"	"	Ayrshire X Sindhi.	-	-	397 "	241	85	-	21.3
S i n g h.	1957	Tharparkar.	1st.	-	433 "	1149	-	7.3	-
Singh et al.	1958	Hariana.	-	-	484 "	738	-	4.8	-
Prasad.	"	Tharparkar.	-	-	*131 "	1338	79.8	-	60.7

(*) Mean length of post partum ~~xx xx~~ interval to conception.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Amble, Krishnan & Srivastava.	"	Sindhi at Hosur.	1st.	1st.	519 days.	46	-	19	25
"	"	-do-	1st. ~~2nd~~	2nd.	574 "	56	-	26	34
"	"	-do-	"	3rd.	557 "	68	-	18	27
"	"	-do-	"	4th.	534 "	61	-	25	37

(To be continued)

Table (4) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
					Days.				
Amble, Krishnan & Srivastava.	1958	Sindhi at Bangalore.	1st.	1st.	430	77	-	10	19
"	"	-do-	"	2nd.	445	85	-	11	23
"	"	-do-	"	3rd.	462	58	-	18	31
"	"	-do-	"	4th.	477	17	-	33	28
					Months.				
Amble, Krishnan & Soni.	"	Kangayam.	"	-	16.7	317	-	0.3	28
"	"	Gir.	"	-	15.7	69	-	0.5	27
"	"	Kankrej.	"	-	16.2	73	-	0.4	21
"	"	Tharparkar.	"	-	14.8	376	-	0.2	22
					D a y s.				
Singh & Chaudhuri.	1961	Sahiwal.	"	-	484.4	118	112.20	--	23.4
"	"	Tharparkar.	"	-	480.6	90	108.50	--	22.6
Kohli et al.	"	Hariana.	"	-	630.8	277	-	9.0	23.8
B a t r a.	"	Sahiwala at M. F., Lucknow.	"	-	428.8	66	-	-	-
"	"	-do-	2nd.	-	412.7	53	-	-	-
"	"	-do-	3rd.	-	433.6	37	-	-	-
"	"	-do-	Overall for 3 ~~xxxx~~ C. I.	--	424.5	156	-	-	-

(To be continued).

Table (4) - Contd.

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
B a t r a.	1961.	Sahiwal at C. G. F., Lucknow.	1st.	-	Days. 421.8	52	-	-	-
"	"	-do-	2nd.	-	400.6	52	-	-	-
"	"	-do-	3rd.	-	406.5	35	-	-	-
"	"	-do-	Over-all	-	410.0	139	-	-	-
"	"	-do- at Ambala.	1st.	-	394.4	58	-	-	-
"	"	-do-	2nd.	-	397.6	43	-	-	-
"	"	-do-	3rd.	-	384.5	28	-	-	-
"	"	-do-	Overall.	-	393.3	129	-	-	-
"	"	Sahiwal at Meerut.	1st.	-	392.5	47	-	-	-
"	"	-do-	2nd.	-	420.3	36	-	-	-
"	"	-do-	3rd.	-	411.4	36	-	-	-
"	"	-do-	Overall.	-	409.7	119	-	-	-
Singh & Desai.	1962	Hariana.	-	-	457.9	586	-	4.1	26.2
R i g o r.	1949	Imported Red Sindhi.	-	-	446.09	168	-	-	-

(To be concluded)

Table (4)
(Concld.)

1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
					Days.				
R i g o r.	1949	Alabang born Red Sindhi.	-	-	447.58	75	-	8.21	-
Sharma et al.	1951	Hariana.	-	-	530.8	-	-	5.4	-
Herman et al.	1953	Jersey.	-	-	15.48 Mos.	-	-	-	-
"	"	Holstein.	-	-	14.45 "	-	-	-	-
"	"	Guernsey.	-	-	14.11 "	-	-	-	-
Joshi & Phillips.	"	Kankrej at Chharodi Farm.	-	-	498 Days.	-	-	-	-
"	"	Bhagnari.	-	-	397 "	131	-	-	-
"	"	Nagori.	-	-	460 "	-	-	-	-
"	"	Ongole.	-	-	16 Mos.	-	-	-	-
"	"	Amrit Mahal.	-	-	About 600 days.	-	-	-	-

hhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhhh

Average Number of Services per Conception:-

Breeding efficiency is an important characteristic in raising profitable dairy animals. Besides other factors affecting breeding efficiency, average number of services required for each conception is of great economic importance. Little work has been done in this regard in cattle of tropical region. Studies done on this trait are summarised in The table (5). (See page 31).

Table (5)

Author.		Year.	Breed or herd.	Sequence of conception.	Average.	No. of obs.	S. D.	S. E.	C.V.
1.		2.	3.	4.	5.	6.	7.	8.	9.
Tandon.	...	1959	½ Jersey X ½ Red Sindhi.	-	1.3	412	-	-	
"	...	"	Red Sindhi.	-	2.0	-	-	-	
S i n g h.	...	1961	Tharparkar.	1st.	1.73	207	-	0.07	
"	...	"	-do-	2nd.	1.73	163	-	0.11	
"	...	"	-do-	3rd.	1.89	114	-	0.12	
"	...	"	-do-	4th.	1.74	80	-	0.10	
"	...	"	-do-	5th.	1.78	50	-	0.19	
"	...	"	-do-	6th.	1.68	31	-	0.21	
"	...	"	-do-	7th and after.	1.80	42	-	0.18	
Panasenko.	...	1959	Avlie-Ata	-	1.55	-	-	-	
Boyd et al.	...	1954	Jersey.	-	1.59	225	0.87	-	
"	...	"	Holstein.	-	1.76	208	1.04	-	
"	...	"	Guernsey.	-	1.71	86	0.93	-	

(To be continued)

Table (5) - Concld.

1.		2.	3.	4.	5.	6.	7.	8.	9.
Legates.	...	1954	Ayrshire Herd No.1.	-	1.91	11	-	-	-
"	...	"	Guernsey Herd No.1.		2.02	171			
"	...	"	Holstein Herd No.1.		1.93	158			
"	...	"	Jersey, Herd No.1.		1.70	309			
"	...	"	Holstein, H.No.2.		1.67	24			
"	...	"	" H.No.3.		1.69	191			
"	...	"	" H.No.4.		1.66	32			
"	...	"	" H.No.5.		1.58	125			
"	...	"	" H.No.6.		2.02	63			
"	...	"	" H.No.7.		1.37	27			
"	...	"	" H.No.8.		1.60	20			
"	...	"	" H.No.9.		1.97	107			
"	...	"	Gurnsey, H.No.10		2.31	36			
"	...	"	Jersey, H.No.10		1.88	357			
"	...	"	Ayrshire, H.No.11		1.74	470			
"	...	"	Jersey, H.No.12.		1.79	342			

Average Productive Life:-

Singh and Sinha (1960) reported the average productive life of cows in Tharparkar herd at Patna to be 66.97 ± 4.38 months. They also calculated the average number of calvings of the cows to be 4.86 ± 0.37.

Dickerson and Chapman (1940), as quoted by Singh and Sinha (1960), calculated the average of productive life and number of calvings in one Holstein herd to be 42 months and 3.0 respectively and in the other Holstein herd to be 34 months and 2.8 respectively.

Asker and Ragab (1951), as quoted by Singh and Sinha (1960), calculated the average productive life in terms of lactations to be 3.3 for Egyptian cattle.

Asker et al (1954), as quoted by Singh and Sinha (1960), reported the average productive life in terms of lactations to be 3.5 for Egyptian cattle.

Mahadevan (1953), as quoted by Singh and Sinha (1960), reported the average productive life in terms of lactations to be around 5 for cattle in Ceylon.

Sex Ratio:-

Importance of sex ratio in draft breeds of cattle differs from that of milk cattle. In draft breeds of cattle, greater percentage of male calves is more desirable than female calves and vice versa.

Sex Ratio:-

Joshi and Phillips (1953) observed in Tharparkar herd that sex ratio in calves born was 99.83 males for 100 females.

They also observed in Ongole herd that sex ratio in calves born was 94.5 males for 100 females.

In Kangayam herd, they observed that sex ratio in calves born was 102.75 males for every 100 females.

Correlation between Age at First Calving and First Lactation yield:-

It is known that age at first calving is also a potent non-genetic factor which influences milk yield in the first lactation.

Rajagopalan (1951 - 52) analysed correlation between age at first calving and first lactation yield. The data were obtained for 81 Sindhi cows of the Hosur cattle Farm, Madras and the correlation coefficient was found to be 0.1217 which is not significant.

Correlation coefficient was estimated also for 31 Kangayam cows of the same Farm between the two characters. It was found to be 0.60694 which isstatistícally highly significant.

Sundaresan et al (1954) estimated correlation coefficient between age at first calving and first lactation yield. The result is given in the table at page 35.

Group.	Breeding.	No. of pairs of observation.	'r'
A	Red Sindhi.	82	0.064
B	½ Jersey X ½ R.S.	30	0.300
C	½ Brown Swiss X ½ R.S.	16	0.074
D	¼ J. X ¾ R.S.	69	0.071
E	¼ B.S. X ¾ R.S.	28	0.120
F	½ Holstein X ½ R.S.	11	(-) 0.330
G	Kansas State College Jersey.	91	0.186

The correlation coefficient between these two variables was not significant within any of the groups. It was also noted that in the groups with larger number of cattle the correlation coefficient tended to approach zero, a fact which strengthened the conclusion that the first lactation production is independent of or atleast only weakly associated with age at first calving.

Mahadevan (1955) reported very small effect of age at first calving on yield in the first lactation in Red Sindhix cattle, the regression being negative and not significant.

Venkayya and Krishnan (1956) estimated correlation between age at first calving and first lactation yield in three breeds. The result is given in table at page 36.

Breed.	No. of animals.	Coefficient of correlation.
Red Sindhi.	216	0.44**
G i r.	80	0.34**
Ayrshire X Sindhi.	241	0.19**

(**) Denotes significant at 1% level.

Venkayya and Krishnan (1957) calculated coefficient of correlation to evaluate the effect of age at first calving on first lactation yield (unadjusted). He got the correlation as 0.78 on 64 Red Sindhi cows and 0.41 on 65 Ayrshire X Sindhi cows, which are highly significant.

Asker et al (1958) worked on environmental factors affecting milk production in Egyptian cows. Data on more than 300 cows having 900 lactations were used in this work. Results obtained showed that age at first calving had no significant effect on milk production of the first lactation.

Singh and Sinha (1960) reported that age at first calving was found to influence the milk production in first 150 days lactation period, but had no significant effect on 30 days, 90 days and 300 days milk yield in Tharparkar herd maintained at the Government Cattle Farm, Patna.

Singh and Chaudhury (1961) worked on correlation between age at first calving and first lactation yield in Sahiwal and Tharparkar cows maintained at Ranchi Agricultural College Farm, Kanke. The correlation coefficient between the two traits in Sahiwal and Tharparkar herd were 0.09 and 0.047 respectively and they were statistically mot significant.

Kohli et al (1961) estimated correlation coefficient between age at first calving and first lactation yield in Hariana herd of cattle at Hissar. They obtained the correlation coefficient to be 0.143 which is highly significant at 1% level. The number of records for the first lactation yield was 277.

Ahmad (1961) estimated phenotypic correlation between age at first calving and milk yield in Hariana yerd as 0.183.

Prasad (1962) estimated phenotypic correlation between age at first calving and milk yield in Tharparkar herd to be 0.105.

Heritability of first lactation yield:-

Heritability of first lactation yield is very useful genetic parameter. Many workers studied theheritability of the trait in temperate, tropical and subtropical countries. The work done is presented in ~~tk~~ table (6). (See page 38).

Table (6)

Heritability of First Lactation yield.

Author.	Year.	Breed or herd.	Herita-bility.	~~diff~~ d.f.	Method of analysis.
1.	2.	3.	4.	5.	6.
Johansson.	1950	Swedish Red and White cattle	0.24	-	Intra-sire daughter-dam correlation.
Touchberry.	1951	Holstein.	0.25	186	--
Carnairo.	1953	Brazil Cattle	0.23	--	--
Rognoni & Pasti.	1955	Simmental cattle.	0.22	92	--
Tabler & Touchberry.	1955	American Jersey cattle.	0.25	--	Intra-sire regression of daughter on dam.
Mahadevan.	1955	Red Sindhi.	0.14	90	Regression of daughter on dam.
Amble et al.	1958	Red Sindhi at Hosur.	0.34 ± 0.18	182	Intra-sire regression of daughter on dam.
-do-	1958	Red Sindhi at Bangalore.	0.37 ± 0.14	143	Intra-sire regression of daughter on dam.
Laubscher & Allah.	1958	South African Jersey herd.	0.36 ± 0.08	--	--
Hartmann.	1959	Mariensee/ Mecklen horst Black pied herd.	0.38 ± 0.18	127	--
Johnson & Corley.	1961	Brown Swiss.	0.42	--	Intra-sire regression of daughter on dam.
Mitchel et al.	1961	Holstein - Friesian.	0.20	--	--
Singh & Desai.	1961	Hariana.	0.147 ± 0.043	177	Intra-sire regression of daughter on dam.

(To be continued)

Table (6) - Concld.

1.	2.	3.	4.	5.	6.
Singh & Desai.	1961.	Hariana.	0.198 ± 0.0136	177	Half-sib correlation.
Batra.	1961	Sahiwal.	0.3389 ± 0.2231	226	Half-sib correlation.
Alim.	1962	Butana.	0.278 ± 0.232	--	--
P a n i.	1960	Red Sindhi.	0.4944	64	Intra-sire regression of daughter on dam.
A l i m.	1960	Kenana herd.	0.24 ± 0.25	61	--

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<u>Heritability of age at First Calving:-</u>

Many workers studied the heritability of the trait in temperate, tropical and sub-tropical countries. The results are presented in table (7).

<u>Table (7).</u>

Author. (1)	Year. (2)	Breed or herd. (3)	Herita-bility. (4)	d.f. (5)	Method of analysis. (6)
Larson et al.	1951	D.H.I.A. herd of Wisconsin.	Estimate not available. Indicated to be heritable.	--	Intra-sire regressions of daughter on dam.
Stonaker.	1953	Purebred Red Sindhi.	0.39	90	--

(To be continued)

Table (7) - Concld.

1.	2.	3.	4.	5.	6.
Singh.	1957	Tharparker.	(-)0.361 ± 0.099	139	Intra-sire regression of daughter on dam.
"	"	-do-	(-)0.305 ± 0.083	139	Intra-sire correlation.
"	"	-do-	0.0468 ± 0.086	139	Paternal half-sibs correlation.
Amble et al.	1958	Red Sindhi at Hosur.	(-)0.09 ± 0.17	192	Intra-sire regression of daughter on dam.
"	"	Red Sindhi at Bangalore.	0.16 ± 0.29	134	-do-
Amble, Krishnan & Soni.	"	Kangayam herd at Hosur.	(-)0.08 ± 0.16	281	-do-
"	"	Gir.	(-)1.24 ± 0.58	29	-do-
"	"	Kankrej.	0.66* ± 0.24	41	-do-
"	"	Tharparkar.	0.48** ± 0.16	215	-do-
Singh.	1959	Hariana.	0.3403	--	-do-
"	"	-do-	0.5916	--	Half-sib correlation
Singh & Desai.	1961	-do-	0.34 ± 0.12	243	Intra-sire regression.
"	"	-do-	0.34 ± 0.19	243	Half-sib correlation
"	"	-do-	0.40 ± 0.18	322	-do-
Batra.	"	Sahiwal.	0.50 ± 0.19	159	-do-
Ahmad.	"	Hariana.	0.37	146	Regression of daughter on dam.
Prasad.	1962	Tharparkar.	0.08	-	By dividing additive genetic variance by phonetjpic variance.

(*) Significant at 5% level.

(**) Significant at 1% level.

Repeatability of Milk Yield:-

The success of selecting females in dairy cattle depends upon the accuracy with which the future production records of a cow can be predicted from her present records, i.e. repeatability of the production record. Many workers studied the repeatability of milk yield in different breeds of cattle at different places. The results are presented in the table (8).

Table (8).

Author.	Year.	Breed or herd.	Repeatability	d.f.	Method of analysis.
1.	2.	3.	4.	5.	6.
Sikka.	1933	Sahiwal.	0.502 ± 0.036		
Johansson.	1950	Swedish breed.	0.40		
Carnairo.	1953	Brazil breed.	0.41		
Mahadevan.	1953	Sinhala cattle of Ceylon.	0.46	599	
-do-	1955	Red Sindhi in Ceylon.	0.41	-	Intra-cow correlation.
Rogmoni & Pasti.	1955	Simmental.	0.64	303	
Hartmann.	1958	Schleswig - Holstein.	0.34		
Ambâe et al.	1958	Red Sindhi at Hosur.	0.61		
-do-	"	Red Sindhi at Bangalore.	0.54		

(To be continued)

Table (8) - Concld.

1.	2.	3.	4.	5.	6.
Bauer et al.	1959	Bavarian spotted cattle.	0.24	433	--
Johnson & Corley.	1961	Brown Swiss.	0.47	1759	Intra-class correlation.
Singh & Desai.	1961	Hariana at Mathura.	0.569	59	Intra-sire correlation.
"	"	-do-	0.540	59	Intra-cow correlation.
"	"	Hariana at Madhurikund.	0.472	56	-do-
"	"	-do-	0.369	56	Intra-sire correlation.
"	"	Hariana at Bharari.	0.516	98	-do-
"	"	-do-	0.540	98	Intra-cow correlation.
"	"	Hariana at Babugarh.	0.440	56	-do-
B a t r a.	1961	Sahiwal.	0.4416	--	-do-
A l i m.	1962	Butana in Sudan.	0.415 ± 0.037	--	---
Mahadevan.	1953	Black Sinhala.	0.46	--	---
A l i m.	1960	Kenana herd.	0.43	--	Intra-class correlation.

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Chapter (II).

MATERIALS AND METHODS OF ANALYSIS.

Chapter (II).

M A T E R I A L S   A N D   M E T H O D S   O F   A N A L Y S I S.

Chapter (II).

MATERIALS AND METHODS.

(a) **Sources of data:-** Data used in this study were obtained from the Bachaur cattle Breeding Farm, Pusa. The herd was established in the year 1948. The cows and bulls were purchased from local areas.

The adult animals are given 8 lbs. of dry fodder, 20 lbs. of green fodder and 3½ lbs. of concentrate mixture both for maintenance and production. In addition, animals are also given 2 ounces of salt and 2 ounces of mineral mixture per day.

The composition of concentrate mixture is as follows:-

Groundnut cake.	...	1 seer.
Crushed gram.	...	2 seers.
Wheat bran.	...	1½ "

The dry fodder includes maize straw, joar straw, teosinte straw and hay. The green fodders are berseem, maize, joar, teosinte, napier, maith and cow-pea. Except from December to March, maize and joar are supplied throughout the year. During winter season, berseem and silage are fed to the animals. Animals are

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Cows are housed in pucca byres. In general twice hand-milking per day is practiced. Weaning of calf was never done since the inception of the Farm.

Natural mating was practiced till the year 1954 and since then artificial insemination is in use at the Farm. Heifers have been mated or inseminated at their first heat. Those cows which come in heat within 40 days after giving birth are not inseminated in their first heat.

(b) Preparation of data:-

Heritability of First Lactation Yield:-

The heritability of the first lactation yield was calculated on 34 dam daughter pairs arranged among four sires by intra-sire regression of daughters on dams, intra-sire daughter dam correlation and paternal half-sib correlation methods. The data on the first lactation record was subjected to Bartlett's test for homogenity of variance as described by Snedecor (1957) and it was found to be homogenious at 5% level. The Bartlett's test for it has been shown in the table (9). Analysis of variance was done to test the year effects on the records of all the available year i.e. from 1948 to 1962 except those of 1953, 1955, 1956, 1961 and 1962 since very few records were available for allowed to graze for 5 to 6 hours in morning and 3 to 4 hours in evening. This schedule has continued throughout the existance of this Farm.

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Lactation length upto 305 days had only been considered for the purpose because cases falling beyond this limit were assumed to be abnormal. The data for the first lactation yield was available from the year 1948 to 1962. The lactation yield for the years 1956 and 1962 were not taken into consideration because numbers of lactations in these two years were very few i.e. only 8. It may be noted that the number of dam-daughterx pairs was not sufficient to warrant a reliable estimate for the purpose of application.

<u>Repeatability of First Lactation Yield:-</u>

The repeatability of milk yield was calculated on 117 records of the first three lactations by intra-class correlation method. Lactation length upto 305 days were taken into consideration for analysis. All the cows included in this study belonged to the first generation in addition to one which belonged to second generation.

Average lactation yield:-

The average milk yield for six successive lactations were calculated separately for the first generation only and then overall average was also calculated. Average lactation yields of the second generation excepting first lactation were not calculated because number of observations were very few.

Heritability of age at First Calving:-

The heritability of age at first calving was calculated on 27 dam-daughter pairs arranged among four sires by intra-sire regression of daughters on dams, intra-sire daughter-dam correlation and paternal half-sib correlation methods. The data was subjected to Bartlett's test for homogenity of variance as described by Snedecor (1957) and it was found to be homogenious at 5% level. Bartlett's test has been shown in the table (13). Analysis of variance was done to test the year effect on the records from 1952 to 1961. It was found to be highly significant at 1% level. Again the test was carried out by excluding the records of the years 1954, 1956 and 1957, because of abnormally high average age at first calving in those years. It was found that year effect was insignificant at 1% level. So the computation of heritability and other estimates were carried out by excluding the records of the years 1954, 1956 and 1957. The number of observations and the average age at first calving for each year have been shown in the table (14). Analysis of variance for year effect have been shown in tables (15) and (16).

The highest and lowest number of dam-daughter pairs for a bull were 12 and 4 respectively. The records used in this study were from the cows belonging to 1st, 2nd and 3rd generations.

Average age at First Calving:-

The average age at first calving was calculated for each of the three generations and then overall average was also calculated. The number of records available in the 1st, 2nd and 3rd generations were 80, 60 and 7 respectively.

Phenotypic correlation between age at First Calving and First Lactation Yield:-

The correlation was calculated on 57 records for each trait. The lower and upper limits of age at first calving were 1000 and 1854 days respectively. The lower and upper limits of first lactation yield were 400 and 1502 lbs. respectively.

First lactation length:-

The average first lactation length was calculated for each of the two generations and then overall average was also calculated. The total number of records in the 1st and 2nd generations were 92 and 35 respectively.

Average Calving interval:-

The average 1st calving interval was calculated for 1st and 2nd generation separately. The average of second and third calving intervals were calculated from the records of cows belonging to 1st and 2nd generations both.

The records of second generation were combined with the records of the first generation because of very few number of observations in the second and third calving intervals for 2nd generation. The average of the 4th calving interval was calculated for the first generation only, as no records were available for it in the second generation. The overall average was also calculated.

Average No. of services per conceptions:- The average number of services per conception was calculated for the five successive conceptions separately of the 1st generation and then overall average was also calculated. Calculation for the two successive conceptions separately of the second generation was made and then overall averamge was found out. Calculation for the second, third, fourth and fifth conceptions separately of the foundation stock was made and then overall average was found out.

Average productive life:- The average productive life of the cows was calculated in terms of number of lactations completed for the foundation stock and first generation separately and then overall average was also calculated.

Those cows which either died in the Farm or sent to Gosadan have been taken into consideration for the present study. The number of observation in the foundation stock and first generation were 65 and 12 respectively.

Sex Ratio:-

The records on sex ratio of 1166 calves born alive were used in this study. All the calves born since 1948 to 1962 in the Farm were included for the purpose.

<u>Table (9).</u>

Bartlett's Test of Homogenity.
(First lactation yield)

Year.	Corrected sum of squares. Σx^2	d. f. (n-1)	Reciprocal. $\frac{1}{(n-1)}$	Mean square = s^2 (2) X (4)	Log s^2	(n - 1) Log s^2 (3) X (6)
1.	2.	3.	4.	5.	6.	7.
1948	5641824.125	37	.02702	152442.0878575	5.18197	191.73289
1949	4845372.994	39	.02564	124235.36356616	5.09414	198.67146
1950	5460581.731	51	.019607	107065.625999717	5.02941	256.49991
1951	6918612.383	65	.01538	106408.258450454	5.02548	326.65620
1952	1763302.78	17	.05882	103717.4695196	5.01318	85.22406
1953	1119628.358	6	.16666	186597.26214428	5.26965	31.61790
1954	3202328.808	12	.08333	266850.05957064	5.42509	65.10108
1955	557419.84	5	.2	111483.968	5.0455	25.2275
1956	518462.188	3	.33333	172819.00112604	5.23576	15.70728
1957	1213906.17	11	.0909	110344.070853	5.04152	55.45672
1958	2171041.234	14	.07142	155055.76493228	5.19034	72.66476
1959	2402055.45	19	.05263	126420.1783335	5.10058	96.91102
1960	1878977.237	18	.05555	104377.18551535	5.01719	90.30942
1961	1231087.5	8	.125	153885.9375	5.18494	41.47952
1962	311421.5	3	.33333	103806.128595	5.01318	15.03954
a = 15						
Total...	39236022.298	308	1.658617	--	--	1568.29845

(Continued).

$$\bar{s}^2 = \frac{\Sigma x^2}{\Sigma(n-1)} = 127389.6827 \qquad \text{Log } \bar{s}^2 = 5.10393$$

$$(\text{Log } \bar{s}^2) \times \Sigma(n-1) = 308 \times 5.10393 = 1572.01044$$

$$X^2 = 2.3026 \left((\text{Log } \bar{s}^2) \; \Sigma(n-1) - \Sigma(n-1) \text{ Log } s^2 \right)$$

$$= 2.3026 \left| 1572.01044 - 1568.29845 \right|$$

$$= 2.3026 \, (3.71199)$$

$$= 8.547228174$$

$$\text{Correction factor} = 1 + \frac{1}{3(a-1)} \left| \Sigma \frac{1}{n-1} - \frac{1}{\Sigma(n-1)} \right|$$

$$= 1 + \frac{1}{3(14)} \left| 1.658617 - \frac{1}{308} \right|$$

$$= 1 + .0238 \, (1.658617 - .003246)$$

$$= 1 + .0238 \times 1.655371$$

$$= 1 + .0393978298$$

$$= 1.0393978298$$

$$\text{Corrected } X^2 = \frac{X^2}{\text{Correction factor.}} = \frac{8.547228174}{1.0393978298} = 8.22$$

Tabler X^2 value at 5% level in 14 D. F.
= 23.68

Table (10).

Table showing number of observations for first lactation yield for each year.

Year.	No. of observations.
1948	38
1949	40
1950	52
1951	66
1952	18
1953	7
1954	13
1955	6
1956	4
1957	12
1958	15
1959	20
1960	19
1961	9
1962	4

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Table (11).

Analysis of variance (First Lactation Yield) to test the year effect after deleting five years' records viz. 1953, 1955, 1956, 1961 and 1962.

SOURCES OF VARIATION.	* d. f.	Sum of squares.	Mean squares.	'F' estimated	Tabular 'F' at 1% level.
Between years.	9	7382618.852	820290.9835	6.5**	2.47
Within years. (error)...	283	35498002.912	125434.639		
Total ...	292	42880621.764	-	-	-

(*) Denotes the total number of observations minus one.
(**) Denotes significant at 1% level.

Table (12)

Analysis of variance (First lactation yield) to test the year effect for the records from 1948 to 1951.

SOURCES OF VARIATION.	(*) d. f.	Sum of squares.	Mean squares.	'F' estimated.	Tabler 'F' at 1% level.
Between years. ...	3	791710.807	263903.602	2.21	3.88
Within years. (error) ...	192	22866391.233	119095.7887		
Total. ...	195	23658102.04	-		

(*) Denotes the total number of observations minus one.

...

Table (12)

Analysis of variance (First lactation yield) to test the year effect for the records from 1948 to 1951.

SOURCES OF VARIATION.	(*) d. f.	Sum of squares.	Mean squares.	'F' estimated.	Tabler 'F' at 1% level.
Between years. ...	3	791710.807	263903.602	2.21	3.88
Within years. (error) ...	192	22866391.233	119095.7887		
Total. ...	195	23658102.04	-		

(*) Denotes the total number of observations minus one.

...

Table (13).

Bartlett's test of Homogenity for age at First Calving.

Year.	Corrected sum of squares. Σx^2	d. f. (n-1)	Reciprocal $\frac{1}{(n-1)}$	Mean squares s^2 (2) X (4)	Log s^2	(n-1) Log s^2 (3) X (6)
1952	85287.20	4	.25	21321.80	4.3288162	17.3152464
1953	113456.84	5	.2	22691.368	4.3543099	21.7715495
1954	263769.60	8	.125	32971.20	4.5181557	36.1452456
1955	557459.08	12	.0833	46436.341364	4.666859	56.002308
1956	404635.80	6	.166	67169.5428	4.82716	28.96296
1957	120824.67	11	.0909	10982.962503	4.037842	44.416262
1958	905168.74	14	.07142	64647.1514108	4.810554	67.347756
1959	1347892.00	23	.04347	58592.86524	4.7678514	109.6605822
1960	974982.90	22	.04545	44312.97805	4.6465295	102.223649
1961	887672.93	12	.0833	73943.155069	4.868904	58.426848
1962	1173678.11	18	.055	64552.29605	4.809915	86.57847

* a = 11

Total.	6834827.87	135	1.21511	-	-	628.8508787

(To be concluded)

$$\bar{s}^2 = \frac{\Sigma x^2}{\Sigma(n-1)} = 50628.35459 \qquad \text{Log } \bar{s}^2 = 4.70439$$

$$(\text{Log } \bar{s}^2) \times \Sigma(n-1) = 4.70439 \times 135 = 635.09265$$

$$X^2 = 2.3026 \left\{ (\text{Log } \bar{s}^2) \times \Sigma(n-1) - \Sigma(n-1)\text{Log } s^2 \right\}$$

$$= 2.3026\,(635.09265 - 628.85087)$$

$$= 2.3026\,(6.24178)$$

$$= 14.372322628$$

$$\text{Correction factor} = 1 + \frac{1}{3(a-1)} \left\{ \Sigma\frac{1}{n-1} - \frac{1}{\Sigma(n-1)} \right\}$$

$$= 1 + \frac{1}{3(10)} \left(1.21511 - \frac{1}{135}\right)$$

$$= 1 + \frac{1}{30}\,(1.21511 - .00741)$$

$$= 1 + .033\,(1.2077)$$

$$= 1 + .0398541$$

$$= 1.0398541$$

$$\text{So, corrected } X^2 = \frac{X^2}{\text{Correction factor}}$$

$$= \frac{14.3723226}{1.0398541} = 13.821$$

Tabular value at 5% level at 10 D. F. is 18.307

Table (14).

Table showing the number of observations and average for each year (Age at First Calving).

Year.	No. of obs.	Average age at First Calving (in days).
1952	5	1264.60
1953	6	1219.83
1954	9	1681.22
1955	13	1525.38
1956	7	1667.42
1957	12	1750.66
1958	15	1552.13
1959	24	1373.79
1960	23	1375.30
1961	13	1368.07
1962	19	1346.68

Table (15).

Table showing Analysis of Variance (Age at First Calving) totest the year effect for the records from 1952 to 1961.

SOURCES OF VARIATION.	(*) d. f.	Sum of squares.	Mean squares.	'F' estimated	Tabular 'F' at 1% level.
Between years.	10	3169912.33	316991.23	6.25 **	2.44
Within years (error).	135	6834827.87	50628.35		
Total ...	145	10004740.20	-		

(*) Denotes the total number of observations minus one.

(**) Denotes significant at 1% level.

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Within years (error).	135	6834827.87	50628.35		
Total ...	145	10004740.20	-		

(*) Denotes the total number of observations minus one.

(**) Denotes significant at 1% level.

Table (16)

Analysis of variance (Age at First Calving) to test the year effect after deleting the records for the years 1954, 1956 and 1957.

SOURCES OF VARIATION.	(*) d. f.	Sum of squares.	Mean squares.	'F' estimated	Tabular (F) at 1% level.
Between years.	7	933860.20	133408.60	2.44	2.80
Within years (error) ...	110	6045597.80	54959.98		
Total ...	117	6979458.00			

(*) Denotes the total number of observations minus one.

METHODS OF ANALYSIS.

(1) <u>Heritability:-</u>

Lush (1948) discussed various methods for estimating heritability which are given below:-

(i) Intra-sire regression of offspring on dam.

(ii) Intra-sire daughter-dam correlation.

(iii) Paternal half-sib correlation.

(iv) Isogenic lines.

(v) Regression of offspring on mid-parent.

(vi) Regression of F_3 progenies on F_2 individuals.

(vii) Resemblance of parent and offspring.

(viii) Resemblance between full-sibs.

(ix) Resemblance to grand parents.

All the methods of estimating heritability are based in one way or the other on how closely phenotypic resemblance parallels genetic resemblance. In terms of variance, these may be represented as:

$$\frac{\sigma^2 G}{\sigma^2 P} \quad \text{or} \quad \frac{\sigma^2 H}{\sigma^2 P} \quad \text{if} \quad \sigma^2 EH \quad \text{is zero}$$

where:

$\sigma^2 G$ ... Genic deviation.

$\sigma^2 P$ ... Phenotypic variance.

$\sigma^2 H$ ... Hereditary deviation.

and $\sigma^2 EH$ ... Variation due to joint effect of heredity and environment.

There are mainly three major difficulties in this procedure. Firstly, in knowing and discounting what fraction of phenotypic resemblance comes from correlation between the environmental deviation of these relatives; secondly, in assessing the correlations between epistatic or dominance deviations which may lead to misinterpretation; and thirdly, in estimating correctly the divergence of the random mating system and therefore it may over-estimate or under-estimate the genetic likness between the relatives being studied.

As described by Prasad (1951), the common methods of estimating heretability for animals are those based on intra-sire regression of offspring on dam, intra-sire correlation between dam and offspring and paternal half-sib correlations.

In the present study, the three methods mentioned above have been used for estimating herâtability of first lactation record and age at first calving.

It becomes essential to know the merits and demerits along with applicability with different sets of data of different methods of estimating heritability before attempting to compute it by any one of them.

(i) Intra-sire regression of offspring on dam:-

As quoted by Prasad (1951), Lush (1940) has discussed intra-sire regression in the following manner. Let 'U' and 'V' represent records of offspring and dam respectively. Then the regression coefficient, 'b_{UV}' is found as follows:-

$$b_{UV} = \frac{COV - UV}{S^2 V}$$

when COV and S^2 are estimated co-variance and variance respectively.

COV_{UV} estimates $\frac{1}{2}\sigma^2 G$ and S^2V estimates $\sigma^2 P$

so that $b_{UV} = \dfrac{\frac{1}{2}\sigma^2 G}{\sigma^2 P}$

and $h^2 = 2\ b_{UV}$.

This method serves a more useful purpose for a data where dams are more numerous than sires. This device gives an unbiased estimate of heritability, whether or not selection has been practiced on dams, provided there are no environmental correlations between offspring and dam. This condition is generally achieved when the regression is conducted on a within sire basis. This method also helps in correcting the difference brought about by the mating system because the differences being investigated are only those which exist between females mated to the same sire. The differences existing, if any, between the true means of the groups mated to various sires, are simply left unanalysed.

The intra-sire regression of offspring on dam makes no analysis of the phenotypic differences between the groups of dams mated to the same sire. In case of data from different herds, the environmental differences between those groups are almost always important.

As this method gives an unbiased estimate to the maximum possible extent, it has been used for computing heritability in the present study.

(ii) Intra-sire daughter-dam correlation:- As stated by Prasad (1951), intra-sire correlation method of estimating heritability is used for all practical purposes identical with the regression method provided that there has been no selection among parents. Since the additive genetic portion of the total variance is generally small for traits of quantitative inheritance the correlation procedure is for all practical purposes identical with the regression procedure.

The correlation coefficient is computed by the following formula:-

$$r_{UV} = \frac{COV.\ UV}{\sqrt{S^2U \quad S^2V}}$$

(iii) Paternal half-sib correlation:- In strict sense the present data under study did not permit the use of this method as the degrees of freedom available are not adequate, but the number of sires of which half-sibs have been utilised is sufficient for the purpose.

Paternal half-sib correlation is a method to assess how much smaller the variance is between paternal half-sibs than between non-sibs. The reliability of this method depends considerably upon the number of different sires available.

In random breeding population, the general rule for estimating heritability from the half-sib correlation method is to substract the environmental components and then multiply the remainder by four. This will give the genetic fraction plus a bit of the epistatic fraction.

The statistics need to be multiplied by four because the correlation between their genetic values is expected to be only $\frac{1}{4}$. This multiplication by four magnifies any sampling error which may be in the estimate. It also magnifies any error there may have been in estimating and discounting the environmental components. This is the most serious handicap on the half-sib resemblance method. It does not introduce any systematic bias, but merely allows the estimate to be much too high or much too low. The disadvantage of the half-sib method, as compared with parent offspring or full-sib resemblance in this respect, would be cancelled if there were four times as many degress of freedom in the data available for estimating half-sib correlations as there are for the full-sibs or parent offspring resemblance.

The major advantage of using paternal half-sib correlation to estimate heritability is that this value contains only the additive plus a small fraction of epistatic portion of the hereditary variance. The greater the number of degrees of freedom would be, the more will be the accuracy in the estimate.

(iv) Isogenic lines:- An isogenic line is a group of individuals which have exactly the same genetic composition e.g. clones and sets of identical twins. The variance between members of the same isogenic line is wholly σ^2 E or σ^2 EH.

The heritability can be computed as $\frac{V - B}{V}$ where 'V' represents the variance between unrelated individuals in the population and 'B' represents the variance within isogenic lines.

Clones are not found in the Farm animals except for the special case of identical twins. So, estimation of heritability by this method is not possible in the Farm animals.

(v) Regression of offspring on mid-parent:- Mid-parental method is not possible for the characteristics which the sire does not himself express, e.g. milk yield, butter fat etc. so, the question does not arise of adopting this method for estimating heritability in the present study.

(vi) Regression of F_3 progenies on F_2 individuals:-

It is difficult to get adequate number of F_3 progenies in case of Farm animals. It is only possible with those plants which self-fertilise readily. In the present study as well, this method was not found to be applicable because of very few F_3 progenies.

(vii) Resemblance of parent and offspring:- This method is not feasible because of the traits being sex-limited. So, it was not possible under present study to adopt this method for calculation of heritability.

(viii) Resemblance between full-sibs:- Full sibs are comparatively rare in cattle, sheep and horses, since single births are the rule among them. Further in most herds the males are changed atleast every two or three years. Full-sibs are found in abundance in pigs and chickens. This method could not be used under the present study.

(ix) Resemblance to grand parents:- The number of grand parents are generally not found adequate for estimation of heritability. So, this makes the sampling error large. It was not possible to adopt this method under present study.

(2) REPEATABILITY:-

(1) As described by Prasad (1951), repeatability (R) is defined as the regression of future performance or phenotype on past performance as measured by one expression of the trait and it may logically be estimated by the regression of the second record on the first as was demonstrated by Stewart (1945).

Let (1) and (2) denote the first and second records respectively by the same individual, then the regression coefficient is:

$$b_{21} = \frac{COV\ 12}{S^2_1}$$

COV 12 estimates $\sigma^2 Y + \sigma^2 C$ & S^2_1 estimates $\sigma^2 P$ such that $b_{21} = R$.

The correlation coefficient of the first and the second records is:

$$r_{21} = \frac{COV\ 21}{\sqrt{S^2_2\ S^2_1}}$$

provided there has been no selection, the expectation of S^2_2 and S^2_1 are identical, and thus:

$$r_{21} = \frac{\sigma^2 Y + \sigma^2 C}{\sigma^2 P}$$

which is equivalent to the regression procedure.

(ii) Intra-class correlation:-

According to Prasad (1951), Lush and Mollin (1942), demonstrated methods of intra-class correlation (Snedecor, 1945) which permits the estimation of 'R' on all the records by each individual. To illustrate this method, consider the following analysis of variance where the mean squares are broken up into their expected components of variance (Winsor & Clarke, 1940).

Analysis of variance showing mean square expectation:

Sources of variance.	Mean squares.	M.S.expectation.
Between individuals ...	m_1	$\sigma^2 + K\sigma_i^2$
Between records by the same individual ...	m_2	σ^2

'K' is the number of records per individual, provided the number is equal for all individuals. Otherwise, 'K' is something less than the mean number of records per individual and varies with the type of analysis (Snedecor, 1946). σ^2 is the variance from record to record by the same individual and estimates $\sigma^2 C$. $\sigma^2 i$ is the variance attributable to constant differences between individuals and thus estimates $\sigma^2 Y + \sigma^2 C$.

The intra-class correlation coefficient, r_1 is found such that:

$$r_1 = \frac{m_1 - m_2}{m_1 - (k-1)m_2} = \frac{\sigma^2 1}{\sigma^2 + \sigma^2 1}$$

and substituting $r_1 = \frac{\sigma^2 Y + \sigma^2 C}{\sigma^2 P}$

$$r_1 = R.$$

(3) PHENOTYPIC CORRELATION:-

Correlation coefficient is a measure of how closely two things tend to vary in the same direction. In the present study, phenotypic correlation between age at first calving and first lactation record has been computed by dividing the estimates of phenotypic covariance by the square root of the product of the estimates of phenotypic variances of the two traits. The following formula was used:

$$r\, x_1 x_2 = \frac{\sigma\, x_1 x_2}{\sqrt{\sigma^2 x_1 \;\; \sigma^2 x_2}}$$

where:

x_1 = age at first calving.

and x_2 = First lactation yield.

(4) PHENOTYPIC MEANS, STANDARD ERRORs and COEFFICIENTS OF VARIATIONS:

(i) Averages:-

Averages for different traits were calculated as the arithmetic mean by adopting the following formula:

$$\frac{\Sigma X}{N}$$

where:

X is the value of different observations and

N is the number of observations.

(ii) Standard errors:-

S.E. was calculated by the following formula:

$$\frac{S.\ D.}{\sqrt{n}}$$

where:

S.D. ... Standard deviation

and n ... No. of observations.

(iii) Co-efficient of variation:-

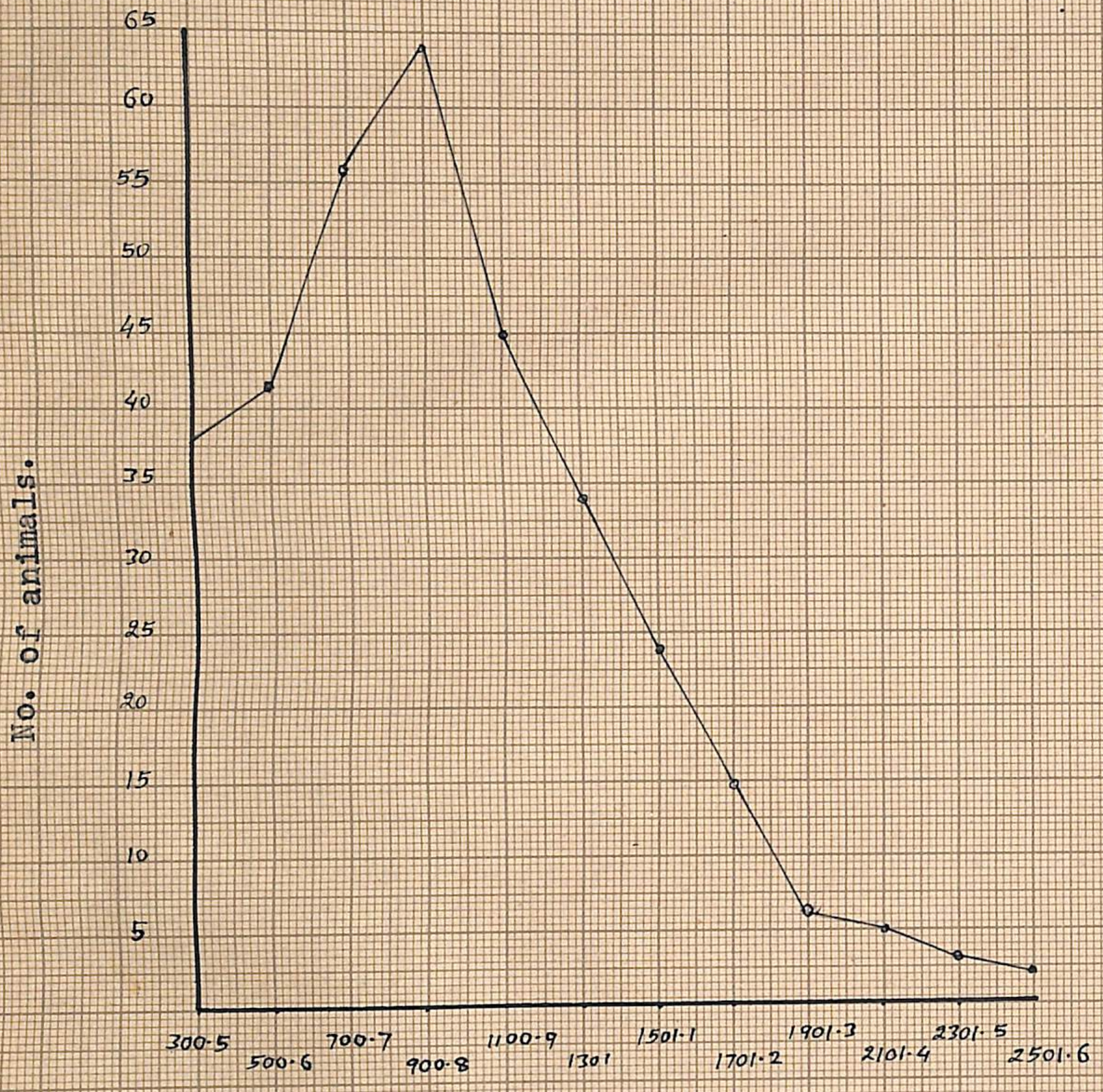
It was calculated by adopting the formula as such:

$$\frac{S.\ D.}{Mean} \times 100.$$

.....

(Figure 1)

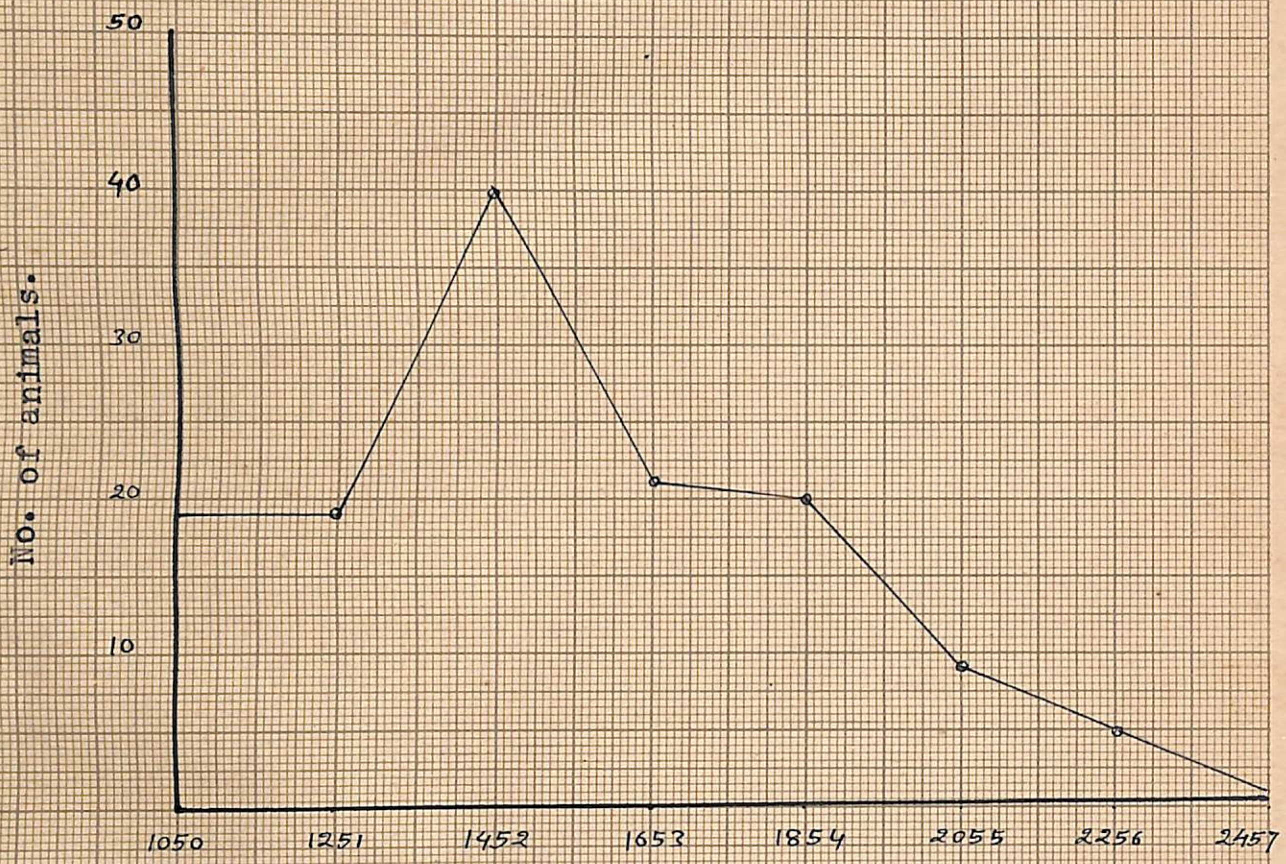
Frequency-polygon showing the First Lactation Yield of 334 Bachaur cows.



Mid-class point of First Lactation Yield (lbs.)

(Figure 2)

Frequency-polygon showing the Age at First Calving of 133 Bachaur cows.



Mid-class point of age at First Calving (days)

Chapter (III).

R E S U L T S.

Chapter (III).

RESULTS.

(A) AVERAGES:-

(i) Milk yield:- The average milk yield of the cows belonging to the foundation stock for six successive lactations are 791.07 ± 27.74, 955.55 ± 36.07, 996.65 ± 50.04, 1075.61 ± 60.00, 1149.61 ± 71.51 and 1143.91 ± 95.04 lbs. with 32.50, 31.35, 37.20, 33.92, 26.37 and 34.23 percent coefficients of variation respectively. The overall average for the six lactations is 952.90 ± 20.15 with 35.51 per cent coefficient of variation. The average mentioned above have been presented in the table (17).

The average milk yield of the cows belonging to the first generation for six successive lactations are 1094.97 ± 30.227, 1208.05 ± 47.55, 1221.57 ± 43.57, 1287.95 ± 67.92, 1321.03 ± 61.28 and 1345.83 ± 70.72 lbs. with 24.845, 30.47, 22.83, 21.41, 18.55 and 18.18 per cent coefficients of variation respectively. The overall average for the six lactations is 1193.04 ± 20.20 with 25.726 per cent coefficient of variation. The averagex mentioned above have been presented in the table (18).

The average yield for the first lactation for the cows belonging to the second generation is 1124.18 $\pm$ 49.028 with 21.806 per cent coefficient of variation.

(ii) Lactation length:-

The average first lactation length for the cows belonging to the foundation stock, first generation and second generation are 247.38 $\pm$ 5.427, 264.25 $\pm$ 4.273 and 258.62 $\pm$ 6.869 days with 19.985, 11.19 and 12.988 per cent coefficient of variation respectively. The overall average is 254.34 $\pm$ 2.486 days with 12.16 per cent coefficient of variation. The results have been ~~xim~~ summarised in the table (19).

(iii) Age at First Calving:-

The average age at first calving for the cows belonging to the 1st, 2nd and 3rd generations are 1501.55 $\pm$ 29.87, 1411.50 $\pm$ 32.65 and 1259.00 $\pm$ 66.928 days with 17.785, 17.907 and 14.034 per cent coefficients of variation respectively. The overall average for the three generations is 1453.24 $\pm$ 21.75 days with 18.14 per cent coefficient of variation. The average have been indicated in the table (20).

(iv) Calving interval:-

The average calving interval of the foundation stock of this herd is 489.64 $\pm$ 11.908, 477.139 $\pm$ 13.757 and 472.88 $\pm$ 17.93 days with 25.73, 25.604 and 27.08 per cent coefficients of variation for the 2nd, 3rd and 4th calving intervals respectively. The overall average is 482.02 ± 8.03 days with 25.909 per cent coefficient of variation. The results have been presented in the table (21).

The average calving interval of the cows belonging to the 1st and 2nd generations are 536.24 ± 10.27 and 521.35 ± 17.87 days with 18.48 and 19.06 per cent coefficients of variation respectively. The average for the 2nd and 3rd calving interval (both for 1st and 2nd generation) are 461.76 ± 10.00 and 446.08 ± 10.796 days with 17.869 and 16.235 per cent coefficients of variation respectively. The average fourth calving interval of the cows belonging to the first generation is 424.46 ± 10.886 days with 14.825 per cent coefficient of variation. The overall average for the cows belonging to the 1st and 2nd generations is 487.79 ± 5.918 with 19.825 per cent coefficient of variation. The results mentioned above have been presented in the table (22).

(v) Number of services per conception:- The average number of services per conception for the cows belonging to the foundation stock are 1.08 ± 0.025, 1.213 ± 0.0596, 1.228 ± 0.0632 and 1.227 ± 0.096 with 28.33, 49.85, 43.078 and 52.322 per cent coefficients of variation for the 2nd, 3rd 4th and 5th conceptions respectively.

The overall average is 1.163 ± 0.0259 with 42.648 per cent coefficient of variation. The results for the foundation stock have been presented in table (23).

The average number of services per conception for five successive conceptions of the cows belonging to the first generation are 1.16 ± 0.049, 1.42 ± 0.049, 1.38 ± 0.103, 1.82 ± 0.219 and 1.56 ± 0.208 with 39.31, 54.08, 53.98, 76.37 and 66.66 per cent coefficient of variation respectively. The overall average is 1.405 ± 0.051 with 61.2 per cent coefficient of variation. The results of the first generation have been presented in the table (24).

The average of two successive conceptions of the cows belonging to the second generation are 1.169 ± 0.0585 and 1.517 ± 0.1539 with 36.44 and 54.58 per cent coefficient of variation. The overall average for the second generation is 1.29 ± 0.068 with 47.8 per cent coefficient of variation. The results have been presented in the table (25).

(vi) Productive life:- The average productive life in terms of number of lactations completed by the cows belonging to the foundation stock and the first generation are 3.83 ± 0.21936 and 2.5 ± 0.5129 with 46.21 and 20.516 per cent coefficient of variation respectively. The overall average is 3.62 ± 0.208 with 50.5 per cent coefficient of variation. The results are given in the table (26).

(vii) Sex ratio:-

Out of 1166 calves born alive, 611 were males and 555 females giving a percentage of 52.4 and 47.6 respectively. In other words, it may be said that sex ratio is 110 males for every 100 females.

(viii) Phenotypic correlation between age at first calving and first lactation yield:

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The correlation coefficient in the present study has been calculated by the following formula:-

$$r = \frac{COV\ XY}{\sqrt{S^2X \quad S^2Y}}$$

The correlation has been estimated to be .130 ± .133.

To see whether the value of 'r' is significant or not, 't' test has been conducted with the formula given below:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

The value of 't' has been calculated to be .972 which is not significant at 5% level for 55 degrees of freedom.

(B) Estimates of Genetic Parameters:-

(i) Heritability of the first lactation yield and age at first calving:

Of the nine methods discussed previously, the following three methods have been used in this study:-

(a) Intra-sire regression of daughters on dams.

(b) Intra-sire daughter-dam correlation.

(c) Paternal half-sib correlation.

(a) Intra-sire regression of daughters on dams:-

According to Krishnan (1956), the value of regression coefficient 'b' ~~ix~~ has been computed by finding out corrected sum of squares for dams and sum of product. These results for both the traits have been presented in the table (27) and table (28).

The following formula was used to estimate the regression coefficient and the standard error:

$$b = \frac{S\,xy}{S\,x^2}$$

Standard error of the regression coefficient:

$$= S_b = \sqrt{\frac{\dfrac{Sy^2 - \dfrac{(S\,xy)^2}{S\,x^2}}{n-2}}{S\,x^2}}$$

For computing standard error of 'b', the results of analysis of co-variance has been used which have been shown in the tables (29) and (30) for both the traits.

Heritability has been estimated by doubling the regression coefficient.

The estimates are .419 ± .354 for first lactation yield and .550 ± .388 for age at first calving as indicated in the table (31).

(b) & (c). Intra-sire daughter-dam correlation and paternal half-sib correlation:

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For these methods, analysis of covariance has been run between the two variables as outlined by Snedecor (1946). The results of analysis of covariance for both the traits are given in the table (29) and (30). The following formulae were used to estimate correlations and their standard errors:

Daughter-dam correlation coefficient $r = \dfrac{S\,xy}{\sqrt{S\,x^2 \;\; S\,y^2}}$

S. E. of the correlation coefficient = $Sr = \dfrac{1 - r^2}{\sqrt{n - 2}}$

Half-sib correlation coefficient = $r_1 = \dfrac{S^2m}{S^2 + S^2m}$

Where:

S^2 ... the mean square of the error term.

S^2m = $\dfrac{\text{m.s. for between sire} - \text{m.s. for error term.}}{\text{Average number in each sire group.}}$

S. E. of half-sib correlation coefficient = S_{r1}

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

Heritability has been estimated by doubling the daughter-dam correlation coefficient and by multiplying by four the half-sib correlation coefficient.

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The estimates by daughter-dam correlation method are:

.407 ± .338 for the first lactation yield and .545 ± .370 for the age at first calving.

Again the estimates by half-sib correlation method are:

.146 ± .706 for the first lactation yield and (-) .423 ± .790 for the age at first calving. The estimates by both methods mentioned above have been given in the table (31).

(ii) Repeatability estimate of milk yield:- Of the two methods discussed previously, the intra-class correlation method has been used for estimating repeatability. Analysis of variance was run for the purpose which has been shown in the table (32).

The calculation of standard error for the correlation coefficient has been estimated by the following formula:-

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

The estimate of repeatability is: .366 ± .142

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Table (17)

Phenotypic Means, Standard Errors and Coefficients of Variations of Milk Yield for the Foundation Stock.

Sequence of Lactation.	Means (lbs.)	Standard errors.	Coefficients of Variations.	N.
1st.	791.07	27.74	32.50	86
2nd.	955.55	36.07	31.35	69
3rd	996.65	50.04	37.20	55
4th.	1075.61	60.00	33.92	37
5th.	1149.61	71.51	26.37	18
6th.	1143.91	95.04	34.23	17
Overall.	952.90	20.15	35.51	282

Table (18)

Phenotypic Means, Standard Errors and Coefficients of Variations of Milk Yield for the First Generation.

Sequence of lactation.	Means (lbs.)	Standard errors.	Coefficients of variation.	N.	Upper limit.	Lower limit.
1st.	1094.97	30.227	24.845	81	1676.5 ~~52~~	521.5
2nd.	1208.05	47.55	30.47	60	1748.0	421.0
3rd.	1221.57	43.57	22.83	41	1741.5	667 .5
4th.	1287.95	67.92	21.41	21	1754.0	817.5
5th.	1321.03	61.28	18.55	16	1754.5	985.5
6th.	1345.83	70.72	18.18	12	1774.5	767.0
Overall.	1193.04	20.20	25.726	231	1774.5	421.0

Table (19)

Phenotypic Means, Standard Errors and Coefficients of Variations of First Lactation Length.

Generations.	Means. (days)	Standard errors.	Coefficients of V.	N.	Lower Limit.	Upper limit.
Foundation stock.	247.38	5.427	19.985	83	200	305
First generation.	264.25	4.273	11.19	48		
Second Generation.	258.62	6.869	12.989	24		
Overall.	254.34	2.486	12.16	155		

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Table (20).

Phenotypic Means, Standard Errors and Coefficients of Variations of Age at First Calving.

First generation.	1501.55	29.87	17.785	80	978	1958
2nd generation.	1411.50	32.65	17.907	60	950	1941
3rd generation.	1259.00	66.928	14.034	7	1030	1430
Overall.	1453.24	21.75	18.14	147	950	1958

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Table (21)

Phenotypic Means, Standard Errors and Co-efficients of Variations of Calving Interval for Foundation Stock.

Sequence of Calving Interval.	Means (days)	S. E.	C. V.	N.
2nd.	489.64	11.908	25.73	112
3rd.	477.139	13.757	25.604	79
4th.	472.88	17.93	27.08	51
Overall.	482.02	8.03	25.909	242

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Table (22).

Phenotypic Means, Standard Errors and Co-efficient of variations of Calving Interval for First and Second Generation.

Particulars of generation and Calving interval.	Means. (days)	S. E.	C. V.	N.	Lower limit.	Upper limit.
First C.I. of first generation.	536.24	10.27	18.48	93	348	735
First C.I. of second generation.	521.35	17.87	19.06	31	350	688
Second C.I. of 1st and 2nd generations.	461.76	10.00	17.869	68	314	652
Third C.I. of first & Second generation.	446.08	10.796	16.235	45	320	584
Fourth C.I. of first generation.	424.46	10.886	14.825	30	351	534
Overall.	487.79	5.918	19.825	267	314	735

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Table (23)

Phenotypic Means, Standard Errors and Co-efficients of Variations of Number of Services per conception for Foundation Stock.

Sequence of conception.	Means.	S.E.	C. V.	N.	Lower limit.	Upper limit.
2nd.	1.08	0.025	28.33	150	1	2
3rd.	1.213	0.0596	49.85	103	1	5
4th.	1.228	0.0632	43.078	70	1	3
5th.	1.227	0.096	52.322	44	1	4
Overall.	1.163	0.0259	42.648	367	1	5

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Table (24)

Phenotypic Means, Standard Errors and coefficients of Variations of No. of Services per Conception for First Generation.

1st.	1.16	0.049	39.31	86	1	3
2nd.	1.42	0.0912	54.08	71	1	4
3rd.	1.38	0.103	53.98	52	1	4
4th.	1.82	0.219	76.37	40	1	6
5th.	1.56	0.208	66.66	25	1	5
Overall.	1.405	0.051	61.20	274	1	6

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Table (25)

Phenotypic Means, Standard Errors and Coefficients of Variations of No. of Services per conception for Second Generation.

1st.	1.169	0.0585	36.44	53	1	3
2nd.	1.517	0.1539	54.58	29	1	4
Overall.	1.29	0.068	47.8	82	1	4

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Table (26)

Phenotypic Means, Standard Errors and Coefficients of Variations of Productive Life.

Generations.	Means.	S. E.	C. V.	N.	Lower limit	Upper limit.
Foundation stock.	3.83	0.2196	46.21	65	1	8
First generation.	2.5	0.5129	20.516	12	1	7
Overall.	3.62	0.208	50.5	77	1	8

Table (32)

Analysis of Variance for Lactation Yield (For calculation of Repeatability)

Sources of Variations.	Degree of freedom.	Sum of squares.	Mean squares.
Between cows.	38	9626975.20	253341.45
Within cows.	78	7225761.25	92637.96
Total ...	116	16852736.45	--

Table (27)

Table showing Sum of Squares for dams and sum of product (First lactation yield) sire-wise for estimation of 'b'

Sl. No.	Sire No.	Daughter-dam pair No.	Total for dams. (lbs)	Total for daughter (lbs.	Sum of squares for dams. Crude.	C. F.	Corrected.	Sum of products. Crude.	C. F.	Corrected.
1.	B.P2.	17	17267.0	20232.5	18845535.5	17538193.47	1307342.03	21152716.25	20550269.26	602446.99
2.	BP.81	7	7024.0	8281.0	7405015.0	7048082.28	356932.72	8259386.75	8309392.0	(-)50005.25
3.	BP.82.	5	4847.0	4615.0	4889850.0	4698681.8	191168.2	4512059.75	4473781.0	38278.75
4.	11.	5	5068.0	5081.5	5851422.0	5136924.8	714497.2	5098427.5	5150608.4	(-)52180.9

Pooled total of corrected S.S. for dams ... 2569940.15

Pooled total correkted sum of product ... 538539.59

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Table (28)

Table showing Sum of Squares for dams and sum of products (Age at First Calving) sire-wise for estimation of 'b'

Sl. No.	Sire No.	Total for dams age at first calving (days)	Total for daughters age at first calving (days)	Dam-daughter pair No.	Sum of squares for dams.			Sum of products.		
					Crude.	C. F.	Corrected.	Crude.	C. F.	Corrected.
1.	BP.81	18079	16200	12	28099633.0	27237520.08	862112.92	24750879.0	24406650.0	344229.0
2.	BP.2.	9306	9551	7	12874438.0	12371662.28	502775.72	12878320.0	12697372.28	180947.72
3.	BP.11.	5973	5776	4	9059023.0	8919182.25	139840.75	8612936.0	8625012.0	(-) 12076.0
4.	BP.82.	4852	5015	4	5946960.0	5885476.0	61484.0	6001208.0	6083195.0	(-)81987.0

Pooled total of corrected sum of squares for dams. ... 1566213.39

Pooled total of corrected sum of products. 431113.72

Table (29)

Analysis of covariance of first lactation yield of dams and their daughters.

SOURCES OF VARIATIONS.	D. F.	Sum of squares for dams. $S x^2$	Sum of product. $S xy$	Sum of squares for daughters. $S y^2$
Total. ...	33	2578574.90	581082.65	3071475.50
Between sires.	3	8634.25	42543.06	358749.81
Within sire (errors).	30	2569940.65	538539.59	2712725.69

Table (30)

Analysis of covariance of age at first calving of dams and their daughters.

Sources of variations.	D. F.	Sum of squares for dams $S x^2$	Sum of product. $S xy$	Sum of squares for daughters. $S y^2$
Total. ...	26	1905828.10	529646.0	1667794.6
Between sires.	3	339614.71	98532.28	73544.13
Within sires (errors)	23	1566213.39	431113.72	1594250.47

Table (31)

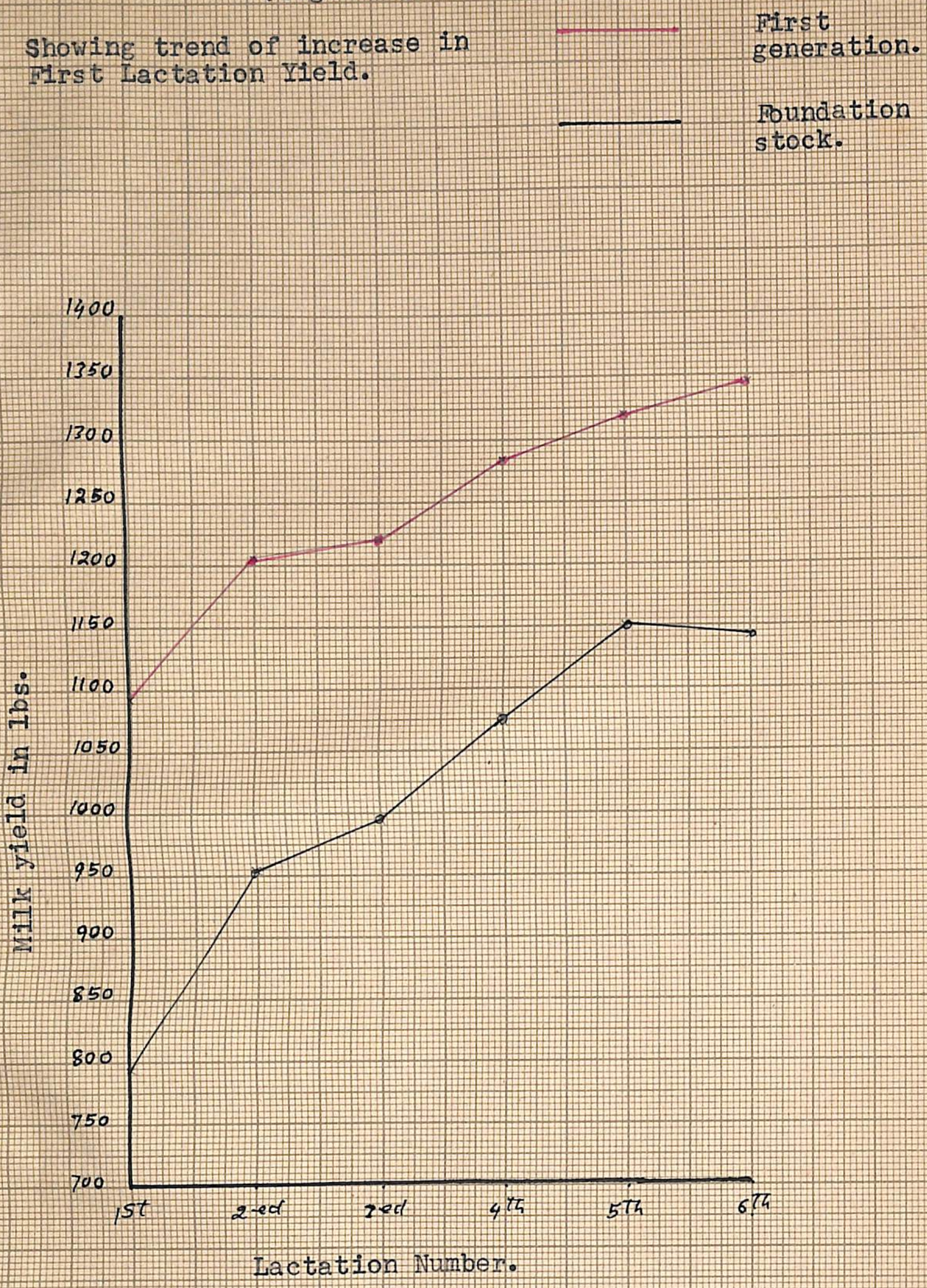
Estimates of Heritability and Standard Errors for First Lactation Yield and age at First Calving.

Characteristics.	METHODS.					
	Intra-sire regression methods.		Intra-sire correlation method.		Paternal half-sib method.	
	Heritability.	Standard error.	Heritability.	Standard error.	Heritability.	Standard error.
First lactation yield. ...	.419	.354	.407	.338	.146	.706
Age at first calving.	.550	.k338	.545	.370	(-).423	.790

-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-X-

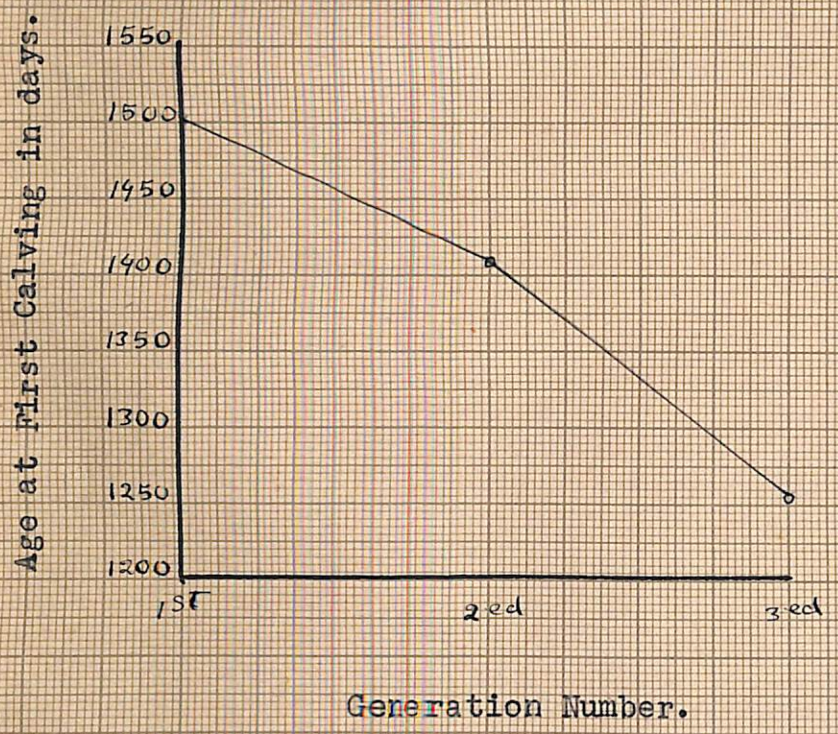
(Figure 3)

Showing trend of increase in First Lactation Yield.



(Figure 4)

Showing trend of decline in Age at First Calving from 1st to 3rd generation.



Chapter (IV)

D I S C U S S I O N.

Chapter (IV).

D I S C U S S I O N.

The average milk yield of the cows belonging to the foundation stock for six successive lactations were 791.07 ± 27.74, 955.55 ± 36.07, 996.65 ± 50.04, 1075.61 ± 60.00, 1149.61 ± 71.51 and 1143.91 ± 95.04 lbs. with 32.50, 31.35, 37.20, 33.92, 26.37 and 34.23 per cent coefficients of variations respectively. The overall average for the six lactations was 952.90 ± 20.15 with 35.51 per cent coefficient of variation. The result on overall basis is much low which is not in agreement with the findings of Joshi and Phillips (1953) on other draft breeds of India viz. Malvi, Bhagnari, Krishna Valley, Nagori and Ongole, who reported the same to be 2311.0, 2857, 2731, 2800 and 2500 lbs. respectively.

The average milk yield of the cows belonging to the first generation for the six successive lactations were 1094.97 ± 30.227, 1208.05 ± 47.55, 1221.57 ± 43.57, 1287.95 ± 67.92, 1321.03 ± 61.28 and 1345.83 ± 70.72 lbs. with 24.845, 30.47, 22.83, 21.41, 18.55 and 18.18 per cent coefficients of variations respectively.

The overall average for the six lactations was 1193.04 ± 20.20 with 25.726 per cent coefficient of variation. The average yield for the first lactation for the cows belonging to the second generation was 1124.18 ± 49.028 with 21.806 per cent coefficient of variation. The results in the first lactation for both the generations are slightly lower than the findings of Sharma et al (1951) on Hariana herd, Rajgopalan (1951-52) on Hariana who reported the same to be 1284.9, 1413.093 and 1491.91 lbs. respectively. No literature on the average first lactation yield of the other draft breeds of India could be available. The result on overall basis for the first generation is also not in agreement with the findings of Joshi and Phillips (1953) on Malvi, Bhagnari, Krishna Valley, Nagori and Ongole who reported the same to be ~~8x~~ 2311, 2857, 2731, 2800 and 2500.0 lbs. respectively.

It will be noticed that milk yield of the herd was raised to 1193 lbs. in the first generation from 953 lbs. ~~df~~ the foundation stock i.e. the yield increased in the first generation by 25.18% over the foundation stock. And the increase in the first lactation yield of second generation cows was 2.7% over the first lactation yield of the first generation.

It may, however, be mentioned here that cows are very poor yielders.

Lactation length:- The average first lactation length for the cows belonging to the foundation stock, first generation and second generation were 247.38 ± 5.427, 264.25 ± 4.273 and 258.62 ± 6.869 days with 19.985, 11.19 and 12.988 per cent coefficients of variation respectively. The overall average was 254.34 ± 2.486 days with 12.16 per cent coefficient of variation. The result in respect to the foundation stock is in agreement with the finding of Amble et al (1958) on Red Sindhi who reported the same to be 252 days. The result for the first generation is in close agreement with the findings of Singh and Chaudhury (1961) on Sahiwal and Tharparkar, Batra (1961) on Sahiwal, Amble et al (1958) on Red Sindhi, Joshi and Phillips (1953) on Bhagnari, and Singh and Desai (1961) on Hariana, who reported the same to be 264.7, 271.0, 263.9, 260.0, 262.0 and 272.7 days respectively. The result for the second generation agrees well with the findings of Amble et al (1958) on Red Sindhi, Singh and Chaudhury (1961) on Sahiwal and Joshi and Phillips (1953) on Bhagnari, who reported the same to be 260.0, 264.7 and 262.0 days respectively.

The result on overall basis is within the limits of the findings mentioned above.

<u>Age at First Calving:-</u> The average age at first calving for the cows belonging to the 1st, 2nd and 3rd generations were 1501.55 $\pm$ 29.87, 1411.50 $\pm$ 32.65 and 1259.00 $\pm$ 66.928 days with 17.785, 17.907 and 14.034 per cent coefficients of variation respectively. The overall average for the three generations was 1453.24 $\pm$ 21.75 days with 18.14 per cent coefficient of variation. The results were in descending order right from the 1st to the 3rd generation. The result for the first generation is in good agreement with the findings of Johari and Talapatra (1957) on Hariana, Amble et al (1958) on Tharparkar and Singh & Desai (1961) on Hariana at Madhurikund and Bharari Farm who reported the same to be 1546.0 days, 49.4 $\pm$ 0.4, 50.09 $\pm$ 0.84 and 50.87 $\pm$ 0.60 months respectively. Similar results as obtained for the second generation in the present study, have been obtained by Amble et al (1958) on Gir and Kankrej herds, Kartha (1934) on Hariana, Mahadevan (1955) on Red Sindhi and Venkayya and Krishnan (1956) on Gir, who reported the same to be 47.0 $\pm$ 0.8, 47.4 $\pm$ 0.8, 46.0, 47.0 $\pm$ 0.4, and 47.3 months respectively. The results obtained by Batra (1961) on Sahiwal herd at Ambala, Meerut, Singh (1957) on Tharparkar and Rajagopalan (1951-52) on Kamgayam are slightly higher than the

second generation who reported the same to be 1144.0 ± 17.1, 1154.1 ± 26.4, 1461.0 ± 14.6 and 1447.5 ± 60.211 days respectively. The results for the third generation is in very close agreement with the findings of Sundaresan et al (1954) on Red Sindhi and ½ Brown Swiss X ½ Red Sindhi, Johanri and Talapatra (1957) on Hariana at Babugarh, Amble, Krishnan and Srivastava (1958) on Sindhi at Hosur and Bangalore, Amble, Krishnan and Soni (1958) on Red Singhi at Hosur and Bangalore, who reported the same to be 42.0 months, 42.0 months, 1262 days, 42.6 months, 42.1 months, 41.7 and 41.7 months respectively. The findings obtained by Singh and Chaudhury (1961) on Tharparkar, Venkayya and Krishnan (1956) on Red Sindhi are slightly higher than the result of the present study who reported the same to be 43.2 and 42.9 months respectively. The result on overall basis is within the limits of the findings mentioned above. It is noticed that there is decrease in age at first calving from the first generation to the second generation by 5.99% and from the 2nd generation to the third generation by 10.77%. Finally, it may be concluded that the economic trait like age at first calving of this herd is almost comparable with the ones for the other breeds in India.

Calving Interval:-

The average calving interval of the foundation stock of this herd were 489.64 ± 11.908, 477.139 ± 13.757, and 472.88 ± 17.93 days with 25.73, 25.604 and 27.08 per cent coefficient of variation for 2nd, third and 4th calving intervals respectively. The overall average was 482.02 ± 8.03 days with 25.909 per cent coefficient of variation. The results are in agreement with Stonaker et al (1953) on Red Sindhi, Singh et al (1958) on Hariana, Venkayya and Krishnan (1956) on Gir, Sundaresan et al (1954) on Red Sindhi, Amble, Krishnan and Srivastava (1958) on Sindhi, Amble, Krishnan and Soni (1958) on Kangayam, Gir and Kankrej, Singh and Chaudhary (1961) on Sahiwal and Tharparkar and Joshi and Phillips (19530 on Ongole. The results in this study were found to be in descending order from the 2nd to the 4th calving interval which agrees with the finding of Stonaker et al (1953, on Red Sindhi. The average of the first calving interval of the cows belonging to the 1st and 2nd generations were 536.24 ± 10.27 and 521.35 ± 19.87 days with 18.48 and 19.06 per cent coefficient of variation respectively. The result of the first generation agrees well with the findings of Amble, Krishnan and Srivastava (1958) on Sindhi, Sharma et al (1951) on Hariana who reported the same to be 534 ± 25 and 530.8 ± 5.4 respectively.

The results of the second generation is in good agreement with the finding of Amble, Krishnan and Srivastava (1958) on Sindhi, who obtained the same as 519 ± 19 days.

The results in this study for second and third calving interval (both for 1st and 2nd generation) were 461.76 ± 10.00 and 446.08 ± 10.796 days with 17.869 and 16.235 per cent coefficients of variation respectively. Similar results have been obtained by Stonaker et al (1955) an Red Sindhi, Sundaresan et al (1954) on Red Sindhi, Venkayya and Krishnan (1956) on Gir, Amble, Krishnan & Srivastava (1958) on Sindhi, Amble, Krishnan and Soni (1958) on Gir, Singh & Desai (1962) on Hariana, Riger (1949) on Red Sindhi and Joshi & Phillips (1953) on Nagori and Ongole.

The result of the fourth calving interval of the cows belonging to the first generation was 424.46 ± 10.886 days with 14.825 per cent coefficient of variation which agrees with the findings of Stonaker et al (1953) on Red Sindhi and ½ Jersey; Venkayya and Krishnan (1956) on Red Sindhi; Singh (1957) on Tharparkar and Batra (1961) on Sahiwal.

The overall average for the cows belonging to the first and second generations was 487.79 ± 5.918 with 19.825 per cent coefficient of variation. It can be concluded that the calving intervals of this herd is almost at par with the other draft and milk breeds of India.

<u>No. of services per conception:-</u> The average number of services per conception for the cows belonging to the foundation stock were 1.08 $\pm$ 0.025, 1.213 $\pm$ 0.0596, 1.228 $\pm$ 0.0632 and 1.227 $\pm$ 0.096 with 28.33, 49.85, 43.078 and 52.322 per cent coefficients of variation for 2nd, 3rd, 4th and 5th conceptions respectively. The overall average was 1.163 $\pm$ 0.0259 with 42.648 per cent coefficient of variation. The results mentioned above are not in agreement with the findings of Singh (1961) on Tharparkar, Tandon (1959) on ½ Jersey X Red Sindhi and Red Sindhi, Boyd et al (1954) on Jersey, Holstein & Guernsey. These findings are much higher than the results in the present study.

The average number of services per conception for five successive conceptions of the cows belonging to the first generation were 1.16 $\pm$ 0.049, 1.42 $\pm$ 0.049, 1.38 $\pm$ 0.103, 1.82 $\pm$ 0.219 and 1.56 $\pm$ 0.208 with 39.31, 54.08, 53.98, 76.37 and 66.66 per cent coefficients of variation respectively. The overall average was 1.405 $\pm$ 0.051 with 61.2 per cent coefficient of variation. The result on overall basis is slightly higher than the finding of Tandon (1959) on ½ Jersey X ½ Red Sindhi and slightly lower than the finding of Boyd et al (1954) on Jersey and Legates (1954) on Holstein in herd number (5) who reported the same to be 1.3, 1.59, and 1.58 respectively.

The average of two successive conceptions of the cows belonging to the second generation were found to be 1.169 $\pm$ 0.0585 and 1.517 $\pm$ 0.1539 with 36.44 and 54.58 per cent coefficients of variation. The overall average was 1.29 $\pm$ 0.068 with 47.8 per cent coefficient of variation. The result on overall basis is in good agreement with the findings of Tandon (1959) on ½ Jersey X ½ Red Sindhi who has reported the same to be 1.3. The result obtained by Singh (1961) on Tharparkar is not in agreement with the result of the present study who reported the same to be about 1.7. It can be concluded that the breeding efficiency in terms of number of services per conception is much better than those of Tharparkar and Red Sindhi among the Indian breeds.

Productive life:-

The average productive life in terms of number of lactations completed by the cows belonging to the foundation stock and first generation were 3.83 $\pm$ 0.2196 and 2.5 $\pm$ 0.5129 with 46.21 and 20.516 per cent coefficients of variation respectively. The overall average was 3.62 $\pm$ 0.208 with 50.5 per cent coefficient of variation. The findings of Asker & Ragab (1951) on Egyptian cattle are slightly lower than the present result on overall basis who reported the same to be 3.3 and 3.5 respectively. Singh & Sinha (1960) reported average number of calvings in Tharparkar herd to be 4.86 $\pm$ 0.37 which is much higher than the present results. The findings of Dickerson and Chapman (1940) on Holstein is also not in agreement with the present result which are 3.0 and 2.8 respectively. In the present study, the result for the first generation is much lower than that of foundation stock which seems to be due to smaller number of observations in the first generation than the foundation stock.

Sex Ratio:-

The sex ratio was 110 males for every 100 females in this study. Proportion of male calves is much higher than the findings of Joshi & Phillips (1953) on Tharparkar, Ongole, and Kangayam herds who reported the same to be 99.83, 94.5 and 102.75 males for every 100 females respectively.

Correlation between age at first calving and first lactation yield:-

The phenotypic correlation between age of first calving and first lactation yield was found to be 0.130 ± 0.133 in the present study which is not significant. Similar results have been obtained by Rajagopalan (1951-52) on Sindhi cattle and Singh and Chaudhury (1961) on Sahiwal herd, who reported the same to be 0.1217 and 0.09 respectively. The present result is not in agreement with the findings of Venkayya and Krishnan (1956) on Red Sindhi, Gir and Ayrshire X Sindhi cattle who reported the same to be 0.44, 0.34 and 0.19 respectively which are highly significant at 1% level.

Heritability estimate of first lactation yield:-

The heritability estimates of the first lactation yield by intra-sire regression of offsprings on dams, intra-sire correlation of daughter and dam and paternal half-sib correlation methods, were found to be .419 ± .354, .407 ± .338 and .146 ± .706 respectively. The results by the intra-sire regression and the daughter-dam correlation methods were of the same order. These results indicate that about 41% of the variation in the first lactation yield is due to genetic variability. In other words, 41 per cent of the selection differential is expected to be recovered in the offspring. Therefore, the results strongly suggest that improvement in increasing first lactation yield in Bachaur herd is possible by selecting individual animals on the basis of their performance. The heritability estimates by intra-sire regression and daughter dam correlation methods in the present study compare favourably with the results obtained by Amble et al (1958) on Red Sindhi herds, Pani (1960) on Red Sindhi, Batra (1961) on Sahiwal, Johnson & Corley (1961) on Brown Swiss, Hartman (1959) on Mariensee / Mecklen horst Black pied herd, and Laubscher & Allah (1958) on South African Jersey herd. The results obtained by different workers have been given in table (6).

The heritability estimate by paternal half-sib correlation method was not in agreement with those obtained by intra-sire regression and intra-sire daughter-dam correlation methods. The heritability estimate by paternal half-sib correlation is much lower than the other two methods. The possible explanation for such differences has been advanced by Lush (1948). He observed that the covariance between half-sibs has to be multiplied by four in order to reach an estimate of heritability. This magnifies any errors that may have been present in estimating and discounting the environmental component. Half-sib correlation method does not introduce any systematic bias, but merely allows the estimate to be too high or too low. The disadvantage of half-sib methods, as compared with parent offspring or full-sibs resemblance in this respect would be cancelled if there were 4 times as many degress of freedom in the data available for estimating half-sib correlations, as there are for the full-sibs or parent offspring resemblance. Similar explanation for the interpretation of the results in the present study also seems to be indicated here. However, it can be concluded that the heritability estimates by intra-sire regression and daughter-dam correlations are more reliable than the half-sib correlations.

Finally, it may be mentioned that the number of daughter-dam pairs was not sufficient to warrant a reliable estimate for the purpose of application.

Heritability estimate of age at First Calving:-

The heritability estimate of the age at first calving were found to be .550 ± .388, .545 ± .370 and (-).423 ± .790 by intra-sire regression of offsprings on dam, intra-sire daughter-dam correlation and paternal half-sib correlation methods respectively. The results by the intra-sire regression and daughter-dam correlation methods are of the same order. The estimates by these two methods give an indication that 55 per cent of the variation in the age at first calving is due to genetic variability. In other words, the high value tells us that more than half of the total phenotypic variance is due to differences in the heredity of the dams. These results also indicate that 55% of the selection differential is expected to be recovered in the offspring. Therefore, the higher estimates of heritability gives a wide scope for genetic improvement of the herd in respect of age at xfirst calving through mass selection. Similar results have been observed by Amble, Krishnan and Soni (1958) on Kankrej and Tharparkar, Singh (1957) on Tharparkar, Singh (1959) on Hariana and Batra (1961) on Sahiwal herd. The results obtained by the different workers have been given in table (7).

The heritability estimate by paternal half-sib correlation was not at all in agreement with those obtained by intra-sire regression of offsprings on dams, and intra-sire daughter-dam correlation methods. The estimate was in minus which may be due to sampling error. However, it is an indicative of zero heritability.

Similar estimates of minus heritability have been obtained by Singh (1957) on Tharparkar, Amble et al (1958) on Red Sindhi at Hosur, and Amble, Krishnan and Soni (1958) on Kangayam and Gir herds.

The estimates in the present study are based on comparatively smaller number of records. So, the conclusion with regard to the presence of genetic variance in respect of age at first calving requires to be confirmed with additional data that would come up in future years. If substanciated, the values would indicate that there is scope of reducing the age at maturiry of Bachaur herd through selection apart from the adoption of measures like feeding or management.

Repeatability estimate of Milk Yield:- The repeatability estimate of milk yield based on three lactations was found to be .366 ± .142 by intra-class correlation method. According to Singh and Besai (1961), the interpretation of the present estimate of repeatability (0.366) is that if a cow's first record expressed as deviation from the contemporary herd average is 10 .0 lbs. of milk, her future life-time production is best estimated as 36.6 lbs. as a deviation from the herd average. Similar estimates of repeatability have been obtained by Singh and Desai (1961) on Hariana, Hartman (1958) on Schleswig - Holstein, Carnairo (1953) on Brazil breed and Johansson (1950) on Swedish breed. Slightly higher results than the present estimate have been obtained by other workers which are mentioned in the table (8).

The estimate in the present study is based on comparatively smaller number of records, so, the conclusion with regard to it needs confirmation with additional data that would come up in future years. If substantiated, the value would indicate that improvement in milk yield by selecting individuals in early lactation periods may be brought about.

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Chapter (V).

S U M M A R Y.

Chapter (V).

S U M M A R Y.

A study on genetic and phenotypic parameters of some of the economic traits in Bachaur herd at Pusa had been made. The data covering the period from April, 1948 to December, 1962 were used for this study.

2. The phenotypic parameters included the following:-

(i) Milk Yield.
(ii) Lactation length.
(iii) Age at first calving.
(iv) Calving interval.
(v) No. of services per conception.
(vi) Productive life.
(vii) Sex ratio.
(viii) Correlation between age at first calving and first lactation yield.

3. The genetic parameters included the following:-

(i) Heritability of first lactation yield.
(ii) Heritability of age at first calving and:
(iii) Repeatability of milk yield.

4. The average milk yield of the cows belonging to the foundation stock for the six successive lactations were 791.07 $\pm$ 27.74, 955.55 $\pm$ 36.07, 996.65 $\pm$ 50.04, 1075.61 $\pm$ 60.00, 1149.61 $\pm$ 71.51 and 1143.91 $\pm$ 95.04 lbs.

with 32.50, 31.35, 37.20, 33.92, 26.37 and 34.23 per cent coefficients of variation respectively. The overall average for the six lactations was 952.90 ± 20.15 with 35.51 per cent coefficient of variation.

The averages ~~of the~~ milk yield of the cows belonging to the first generation for the six successive lactations were 1094.97 ± 30.227, 1208.05 ± 47.55, 1221.57 ± 43.57, 1287.95 ± 67.92, 1321.03 ± 61.28 and 1345.83 ± 70.72 lbs. with 24.845, 30.47, 22.83, 21.41, 18.55 and 18.18 per cent coefficients of variation respectively. The overall average for the six lactations was 1193.04 ± 20.20 with 25.726 per cent coefficient of variation.

The average first lactation yield for the cows belonging to second generation was 1124.18 ± 49.028 lbs. with 21.806 per cent coefficient of variation.

5. The average first lactation length for the cows belonging to the foundation stock, first generation and second generation were 247.38 ± 5.427, 264.25 ± 4.273 and 258.62 ± 6.869 days with 19.985, 11.19 and 12.988 per cent coefficients of variation respectively. The overall average was 254.34 ± 2.486 days with 12.16 per cent coefficient of variation.

6. The average age at first calving for the cows belonging to 1st, 2nd and 3rd generations were 1501.55 ± 29.87, 1411.50 ± 32.65 and 1259.00 ± 66.928 days with 17.785, 17.907 and 14.034 per cent coefficients of

variation respectively. The overall average for the three generations was 1453.24 ± 21.75 days with 18.14 per cent coefficient of variation.

7. The average calving intervals of the foundation stock of this herd were 489.64 ± 11.908, 477.139 ± 13.757, and 472.88 ± 17.93 days with 25.73, 25.604 and 27.08 per cent coefficients of variation for 2nd, 3rd and 4th calving intervals respectively. The overall average was 482.02 ± 8.03 days with 25.909 per cent coefficient of variation.

The average first calving interval of the cows belonging to 1st and 2nd generations were 536.24 ± 10.27 and 521.35 ± 17.87 days with 18.48 and 19.06 per cent coefficients of variation respectively. The average 2nd and 3rd calving intervals (both for 1st and 2nd generation) were 461.76 ± 10.00 and 446.08 ± 10.796 days with 17.869 and 16.235 per cent coefficients of variation respectively. The average of the 4th calving interval of the cows belonging to the first generation was 424.46 ± 10.886 days with 14.825 per cent coefficient of variation.

8. The average number of services per conception for the cows belonging to the foundation stock were 1.08 ± 0.025, 1.213 ± 0.0596, 1.228 ± 0.0632 and 1.227 ± 0.096 with 28.33, 49.85, 43.078 and 52.322 per cent coefficients of variation for 2nd, 3rd, 4th and 4th conceptions respectively. The overall average was 1.163 ± 0.0259 with 42.648 per cent coefficient of variation.

The average number of services per conception for five successive conceptions of the cows belonging to the first generation were 1.16 ± 0.049, 1.42 ± 0.0912, 1.38 ± 0.108, 1.82 ± 0.219 and 1.56 ± 0.208 with 39.31, 54.08, 53.98, 76.37 and 66.66 per cent coefficient of variation respectively. The overall average was 1.405 ± 0.051 with 61.2 per cent coefficient of variation.

The average for the cows belonging to the second generation for two sufccessive conceptions were 1.169 ± 0.0585 and 1.517 ± 0.1539 with 36.44 and 54.58 per cent coefficient of variation. The overall zkaverage was 1.29 ± 0.068 with 47.8 per cent coefficient of variation.

9. The average productive life in terms of number of lactations completed by the cows belonging to the foundation stock and the first generation were 3.83 ± 0.2196 and 2.5 ± 0.5129 with 46.21 and 20.516 per cent coefficient of variation respectively. The overall average was 3.62 ± 0.208 with 50.5 per cent coefficient of variation.

10. The sex ratio was 110 male calves for every 100 female calves in the present study.

11. The phenotypic correlation between age at first calving and first lactation yield was found to be 0.13 ± 0.133 which was not significant statistically.

12. The heritability estimates of the first lactation yield were calculated by intra-sire regression of daughter on dam, intra-sire daughter-dam correlation and paternal half-sib correlation methods and the results were obtained to be .419 ± .354, .407 ± .338 and .146 ± .706 respectively.

13. The heritability estimates of the age at first calving were found to be .550 ± .388, .545 ± .370, and (-).423 ± .790 by intra-sire regression of offsprings on dams, intra-sire daughter-dam correlation and paternal half-sib correlation methods respectively.

14. The repeatability estimate of the milk yield was calculated on the basis of three lactations and it was found to be .366 ± .142 by intra-class correlation method.

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T H E   E N D.