GENETIC EVALUATION OF HARIANA CATTLE FOR SELECTIVE VALUE

By

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CERTIFICATE - 1

This is to certify that this thesis entitled, "**Genetic Evaluation of Hariana Cattle for Selective Value**", submitted for the degree of **Doctor of Philosophy** in **Animal Breeding** of the Chaudhary Charan Singh Haryana Agricultural University, is a bonafide research work carried out by **Arun Kumar** under my supervision and that no part of this thesis has been submitted for any other degree.

The Assistance and help received during the course of investigation have been fully acknowledged.

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(Arun Kumar)

Dedicated to my
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for
showing their love & affection to
educate my father
who made me
what I am today

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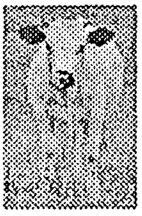
List of Abbreviation

AFC	Age at first calving
ARI	Annual replacement index
BLUP	Best Linear Unbiased prediction
BS	Brown Swiss
BV	Breeding value
CGR	Coefficient of gene replication
d.f.	Degree of freedom
Ex	Expected herd life
FLMY	First lactation milk yield
h^2	Heritability
HF	Holestein Friesian
KF	Karan Fries
KS	Karan Swiss
MDF	Military Dairy Farm
MS	Mean square
PHL	Productive herdlife
PHS	Paternal half sib
S/C	Service per conception
SE	Standard error
SV	Selective value
TP	Tharparkar

CHAPTER 1

INTRODUCTION



Said Lord Krishna to Arjuna

"O Arjun, ! the cow are the most sacred and highest, are the best in the world, for without curd and ghee, no yajna can be performed in the world. O Arjun ! the cows help us through their milk, ghee, curd,...... their hide, skin and bones, hair and horns. O Partha ! I see no other wealth to be superior to the wealth of the cows. Cows in fact are the root of the wealth..............."

भगवान श्रीकृष्ण ने अर्जुन से कहा

"हे अर्जुन ! इस संसार में गाय श्रेष्ठ,पवित्र, पावन एवं उत्तम है। इनके दूध एवं घी के बिना संसार में कोई यज्ञ संपादित नहीं होता है। हे पार्थ! गाय का दूध, घी-दही, मूत्र, चमड़ी, बाल और हड्डियाँ हमारा उपकार करती हैं। हे अच्युत! इस संसार में गाय के समान और कोई धन मैं नहीं देखता। गाय वास्तव में सम्पत्ति का मूल है।"

INTRODUCTION

The cattle are reared over a large area of the world. India ranks second in the world to have 14 percent of the total world and about half of the total cattle population of Asia. The cattle population in India was 201 million in 1990 which increased to 276.69 million in 1998 including 10 million crossbreeds. However, the milch cows are only 50.7million (Chatterjee and Acharya, 1992 Dairy India). It is a matter of proud that India has become first for (1997 provisional) annual milk production in the world, producing about 78 million tonnes. Inspite of this, it is very much shocking that per capita availability of milk per day in India is only around 200 gm per day, which is still less than the minimum recommended requirement of about 240 gm (Tomar, O.S. 1998 IDA Conference).

India ranked second for dairy cow population in the world but ranks fifth in cow milk production. According to N.C.A. the overall average annual milk yield per Zebu cow is only of 157 kg. However, the milk production per lactation in organised herds has been reported to be 800 kg for descript cow and 1800 to 2400 kg for crossbreds (Chatterjee and Acharya, 1987 Dairy India). This is due to the fact that about 80 to 85 percent of the cattle population in the country is non-descript and the large majority of the descriptive belong to draft and dual purpose breeds.

The above population and production statistics shows a wide gap. This is mainly due to the poor genetic potential of Zebu cows, unsound breeding policy, lack of adequate nutrition and poor managemental practices. Providing balanced ration and good management brings temporary improvement whereas the improvement in genetic potential through sound breeding policy is permanent.. Therefore, it necessitate to improve the genetic potential of dairy herds for permanent improvement to have rapid economic growth and desirable social change through appropriate breeding plans involving suitable selection and mating system.

The selection is an essential tool of genetic improvement even in a crossbreeding programme. The degree of selection known as selection intensity, determines the rate of genetic improvement in further generation. With high intensity of selection the selection differential is large which brings higher genetic gain. Therefore, efforts should be made to increase the selection differential. The selection differential is large in a herd of large size because of high intensity of selection. It is thus important to increase the herd size by increasing the number of off springs in future generation to take advantage of culling. There are two ways to increase the size of herd viz., firstly to reduce the selection intensity so as to allow more number of females to produce the progeny generation and, secondly to have more number of heifer replacements per year in off-spring generation by improving the fertility status, health cover and viability. Low intensity of selection by allowing more number of adult females to reproduce results in small selection differential. This in turn results in low genetic gain. To get more number of female calves by increasing fertility status and to reduce the mortality at prenatal and postnatal stages is the best way to increase the herd size (number of female replacement available each year/generation in the herd) for genetic improvement.

Moreover, the selective value of an individual is also important in dairy farming. The proportionate contribution of the living progeny (female in case of dairy animals) to the next generation is known as the selective value/adaptive value/fitness of an individual. This is associated with lifetime calf production. An individual is better fit to have better selective value if it produces more surviving offspring than others in the same environment. The selective value of an individual depends upon its reproductive and survival efficiency in a given environment. There is differential reproduction of different individuals in the herd. Some are capable to produce their progeny while others are not, and some others produce their progeny for a longer period than others. Consequently, the number of surviving progeny per individual (number of progeny produced and reached to breeding age) differ and thereby contribution of different individuals to the next generation also differ. Therefore, it is essential to know the number of female calves being produced and reached to breeding age from each adult female during its lifetime.

A higher replacement rate and higher selective value can be obtained through regular breeding of adult females, low rate of abnormal births, low male births, and low mortality of female calves from birth to their age at first calving. Poor fertility, poor health, low survival rate and higher frequency of male calves cause the genetic death of some cows in dairy herd and thus they failed to replace themselves. About 3-5 pregnancies are required to produce one heifer to reach the milking herd because of prenatal and postnatal calf losses upto the age at first calving (Tomar and Verma 1988a,b; Lathwal, 1989; Rawal, 1991 and Tomar and Ram, 1992). They also observed that the Coefficient of gene replication (CGR) was less than one, which indicated that all the adult females could not replace themselves.

Besides the milk production which directly affect the economy of the herd, the calf production (mainly the females) is also an important factor which affects the economy as well as rate of genetic gain. The female calves are the pillars for the viability of dairy farming to provide replacement for old and inferior adults. To make the dairy enterprises a remunerative industry at least 20 percent of the herd should be replaced by farm raised heifers every year. The efforts to bring genetic improvement in milk production of dairy animals will prove futile if the female progeny from better parents are not available in the herd. The Hariana breed of cattle has wide genetic variability with respect to traits of economic importance (Bhattacharya, 1985) which can be genetically exploited by increasing the replacement rate in a year/generation as well as to increase the selective value of high producing adult females. The information on the aspect of selective value and replacement rate are vital for planning and monitoring the breeding programme for increased profitability from dairy farming. Such information are hardly available on Hariana cattle. It is, therefore, imperative to determine the genetic variability in selective value and its components so as to know the possibility of genetic improvement in these components. Keeping this in view, the present study was designed with the following objectives.

1. To estimate the coefficient of gene replication to know the genetic contribution to future generation.(Selective value).

2. To estimate the replacement rate and its components.

3. To estimate the genetic parameters of replacement rate and its components.

4. To establish the relationship of selective value and its components with breeding value for milk production.

5. To develop strategies for the improvement of Hariana breed of cattle.

CHAPTER 2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Scanty information are available on the selective value and its components in dairy animals throughout the world and no such report in the literature for Hariana cattle. The selective value indicates the genetic contribution to the future generation by a female and it is the function of total calves produced by each adult female in its lifetime minus the loss of female calves in terms of the abnormal births, male calves born and loss of female calves due to death and culling from birth to age at first calving. The various published reports on the relevant aspects have been scanned and given here as under in the following order:

2.1. GENETIC CONTRIBUTION TO FUTURE GENERATION (SELECTIVE VALUE AND ITS COMPONENTS

2.2. REPLACEMENT RATE AND ITS COMPONENTS (DEMOGRAPHIC ANALYSIS)

2.3. GENETIC ANALYSIS

2.4. SIRE EVALUATION AND RANK CORRELATION AMONG DIFFERENT TRAITS

The information available in the literature have been reviewed mainly on Zebu cattle but the reports on exotic cattle, crossbred cattle and buffaloes have also been reviewed on those aspects where the information are lacking on Zebu cattle in order to elucidate the importance of the subject.

2.1. GENETIC CONTRIBUTION OF COWS TO FUTURE GENERATION (SELECTIVE VALUE AND ITS COMPONENTS).

The life history of adult females can be analysed as the productive life in terms of the total number of lactations or total calves produced and the number of years spent in the herd after first calving, total number of alive female calves produced, total number of daughters replaced in the herd and its genetic contribution to future generations.

The proportionate contribution of an individual in terms of the living progeny to the next generation is a function of the life time calf production and termed as the selective value of an animal. In dairy animals the number of live female calves born and reached to the milking herd from each adult cow is important because it is the female which replaces the old and unproductive cows from the herd. The available reports showed that some of the cows failed to replace themselves while others left one or more replacement daughters in the herd. The genetic contribution to the future generation or selective value of an animals depends upon the total calvings, total females calves born and survived upto the milking age.

2.1.1. Productive herd life

The average productive herd life in terms of the number of years a cow stayed in the herd after first calving and number of lactations initiated/completed or calves born during its stay in the herd for different breeds have been reviewed in Table 1.

Kohli and Suri (1957) reported that Hariana cows had 6.4 years productive herd life (PHL). Whereas the report of Singh *et al.* (1964) indicated the average PHL of 4.94 years.

The average PHL has been reported to be 5.30 ± 0.2 and 5.87 years by Matharu and Gill (1981) and Singh *et al.* (1988) for Sahiwal cows, 4.8 years by Nair (1976) for Red Sindhi, 7.7± 0.2 years by Basu *et al.* (1983) for Tharparkar cows and 2.9 years by Singh and Tomar (1989) for Karan Fries cattle.

Period effect

Significant effect of period on PHL was reported by Basu *et al.* (1983) for Tharparkar cows, Hegde and Bhatnagar (1985), Reddy and Basu (1985) and Mukherjee (1993) for Brown Swiss Zebu crossbred cows, Tanida *et al.* (1988) for Hereford and Angus breed, and Singh and Tomar (1989) for Karan Fries cattle.

Age at first calving and PHL

The age at first calving has been reported to have no effect on PHL by Camacho *et al.* (1985) for Brahman cows and Sahota and Gill (1990) for crossbred cattle in India.

Significant effect of AFC on PHL has been reported by Dentine *et al.* (1987), Durocq *et al* (1988), Rogers *et al.* (1991) for exotic cattle and Mukherjee (1993) for crossbreds. They reported that lower AFC was associated with longer PHL.

First lactation milk yield and PHL

Sahota and Gill (1990) reported that milk yield per day of first lactation length had no effect on PHL of crossbred cattle.

Durocq *et al.* (1988), Rogers *et al.* (1991) for exotic cattle and Mukherjee (1993) for crossbreds reported that first lactation milk production had significant effect on PHL in a way that high yielders had longer PHL which may be due to voluntary culling of low producers.

2.1.2. Number of calves produced during life time

The reports available in the literature on life time calf production have been given in Table 2 for average number of calves produced and in Table 3 for the frequency distribution of cows according to the number of calves they produced.

Kohli and Suri (1957) reported that on an average each Hariana cow produced 4.67 ± 0.11 calves during its stay in the herd.

The number of calves produced by Sahiwal cow has been reported to be 3.48 by Sharma and Singh (1974) and 3.73 ± 0.09 by Rawal and Tomar (1994) and 4.32 by Matharu and Gill (1981).

The study conducted on Tharparkar cows at NDRI, Karnal indicated that on an average each cow produced 3.47, 3.68±0.18 and 3.84± 0.77 calves

Table 1: Productive herd life of different breeds of cattle

Breeds	No. of cows	Productive herd life: Years	Productive herd life: Lactations or calves	Reference
Zebu breeds:				
Hariana	100	4.94	-	Singh *et al.* (1964)
"	1917	6.40	4.67±0.11	Kohli & Suri (1957)
Zebu	-	-	4.30	Katpatal (1977)
Red Sindhi	164	-	3.55±2.18	Sharma & Singh (1974)
"	483	-	3.32±0.12	Tomar *et al.* (1985)
"	88	4.8	-	Nair (1976)
Sahiwal	371	-	3.48±2.49	Sharma & Singh (1974)
"	744	-	3.73±0.09	Rawal & Tomar (1994a)
"	189	5.30±0.2	4.32	Matharu & Gill (1981)
"	38	5.87	-	Singh *et al.* (1988)
Tharparkar	837	-	3.47±2.84	Sharma & Singh (1974)
"	1368	-	3.84±0.77	Rawal (1991)
"	958	7.7±0.2	3.68±0.18	Basu *et al.* (1983)
Exotic breeds:				
Jersey	854	-	3.40	Fosgate (1965)
"	-	2.91	-	Rogers *et al.* (1991)
"	83838	3.30	3.50	Nieuwhof *et al.* (1989)
HF	1861	3.60	3.48	Hargrove *et al.* (1969)
"	933	3.92	3.68	Gill & Allaire (1976)
"	615	4.18	3.73	Evans *et al.* 1964)
"	4819	-	3.44±1.36	White & Nichols (1965)
"	55813	3.20	3.40	Nieuwhof *et al.* (1989)
BS	19936	3.30	3.40	"
Ayrshire	20127	3.10	3.30	"
Guernsey	84506	2.90	3.10	"
Angus	1586	4.49±0.09	3.78±0.09	Schons *et al.* (1985)
"	836	4.49±0.13	3.66±0.11	Tanida *et al.* (1988)
Hereford	1452	4.21±0.06	3.46±0.06	"
Beef breed	4660	4.80	-	Greer *et al.* (1980)

contd....

Breeds	No. of cows	Productive herd life		Reference
		Years	Lactations or calves	
Crossbreds:				
BS x Zebu F_1	210	4.4±0.15	4.1±0.14	Hegde & Bhatnagar (1985)
F_2	63	3.1±0.30	2.8±0.28	
F_3	14	3.7±0.59	3.5±0.55	
Misc	254	3.7±0.17	3.4±0.18	
3/4	52	3.7±0.32	3.4±0.18	
Karan Swiss	1399	3.2±0.11	3.3±0.10	Mukherjee & Tomar (1996)
HF x TP	634	2.9±0.08	-	Singh & Tomar (1989)
Jer x RS	230	7.57±0.16	4.22±0.14	Thakur *et al.* (1992)
Jer x Sahiwal	108	5.5	-	Singh *et al.* (1988)
Exotic- 1/4		-	2.5	Katpatal (1977)
1/2		-	7.9	
5/8		-	5.2	
3/4		-	4.4	
7/8		-	3.4	
Hol x Sahi 1/4	201	6.2±0.19	5.17±0.02	Matharu & Gill (1981)
1/2	130	6.2±0.20	5.22±0.2	
5/8	107	6.5±0.15	5.33±0.1	
3/4	76	6.0±0.20	4.78±0.2	
Hol. crosses 1/4	367	4.40±0.16	4.48±0.15	Roy & Tritpathi (1990)
3/8	251	3.65±0.18	4.02±0.18	
1/2	321	4.90±0.17	5.19±0.16	
5/8	454	4.42±0.14	4.74±0.14	
3/4	4509	3.72±0.13	4.01±0.12	

during its stay in the herd as reported by Sharma and Singh (1974), Basu *et al.* (1983) and Rawal (1991), respectively.

Regarding the frequency distribution of cows according to the total number of calves produced during their lifetime, Kohli and Suri (1957) reported that 8.8% of the Hariana cows produced only one calf, about one tenth of the cows produced only one calf, 11.0 to 13% cows produced two to seven calves and one – tenth produced seven or more calves.

Lathwal *et al.* (1992) working on Red Sindhi cattle reported that 29 percent of cows produced only one calf, 22 percent had two calves and maximum number of calves produced were 14 by only one cow, whereas only 2 percent of the cows produced 10 or more calves during their lifetime. Rawal (1991) working for Tharparkar cattle and Rawal and Tomar (1994a) for Sahiwal cattle reported that 22.4 and 22.2 percent cows produced only one calf, 21.1 and 21.4 percent produced two calves and 5.3 and 4.0% produced ten or more calves with maximum number of calves being produced as 15 and 14 by only 0.1 percent of the total Tharparkar and Sahiwal cows, respectively.

Mukherjee and Tomar (1996) reported that 32.1 percent of Karan Swiss cows produced only one calf, 29.2 percent had two calves and 5.5 percent cows had 10 or more calves with maximum number of calves produced were 14 by 0.3 percent cows. They further reported that total calves produced were significantly affected by period, AFC and FLMY.

2.1.3. Number of alive calves born

The data presented in Table 2 indicated that on an average the total number of alive calves produced by each cow during lifetime in the herd were 3.68±0.07 for Tharparkar cows (Rawal, 1991), 3.16±0.11 for Red Sindhi cows (Tomar *et al.* 1995), 4.07±0.14 for Jersey and Jersey x Red Sindhi F_1 cows (Thakur *et al.* 1992), 3.14±0.10 for Brown Swiss crossbred cows (Mukherjee and Tomar, 1996) and 3.61 ± 0.10 for Sahiwal cows (Rawal and Tomar, 1994a).

Table 2: Average values of life time calf production traits and coefficient of gene replication (CGR) in different breeds

Breeds	No.	No. of alive calves	No. of female calves	Total replacement daughter	C.G.R.	Reference
Red Sindhi	448	3.12±0.10	1.59±0.07	0.94	0.47±0.02	Tomar *et al.* (1995)
Sahiwal	744	3.61±0.09	1.80±0.05	1.26±0.04	0.63±0.02	Rawal & Tomar (1994a)
Tharparkar	1368	3.68±0.07	1.75±0.04	1.16±0.03	0.58±0.02	Rawal *et al.* (1993)
Angus	1586	-	-	1.10±0.83	0.48±0.08	Schons *et al.* (1985)
JR x RS	230	4.07±0.14	2.37±0.09	1.49±0.06	-	Thakur *et al.* (1992)
Karan Swiss	1399	3.14±0.10	1.47±0.068	0.77±0.047	0.39±0.023	Mukherjee & Tomar (1996)
Murrah	152	4.15±0.21	1.91±0.12	-	-	Tomar & Basu (1981)
Murrah	936	3.40±0.08	1.61±0.05	0.75±0.03	-	Tomar & Ram (1992)
"	936	-	-	-	0.37±0.02	Tomar & Ram (1991)

The frequency distribution of cows according to the total number of alive calves produced by cows of different Zebu breeds have been reviewed in Table 3. Rawal (1991) observed that 1.4% Tharparkar cows did not produce any alive calf, 23% produced only one and 20.7% had 2 alive calves whereas only 5% had 10 or more alive calves. The corresponding figures were 0.6, 30.4, 21.5 and 2% respectively for Red Sindhi cows as reported by Tomar *et al.* (1995) whereas in case of Sahiwal cows the corresponding percentage of cows were 1.2, 22.5, 21.4 and 3.3 according to Rawal and Tomar (1994a).

Mukherjee and Tomar (1996) reported that 2.8% Brown Swiss crossbred cows failed to produce any alive calves, 33.2% produced one, 27.1% had two alive calves and 5.4 had ten or more alive calves.

2.1.4. Number of female calves born

The average number of female calves produced by each cow during its stay in the herd has been reported to be 1.75± 0.04 by Rawal (1991) for Tharparkar herd, 1.53±0.07 by Tomar *et al.* (1995) for Red Sindhi herd, 2.37±0.01 by Thakur *et al.* (1992) for Jersey and Jersey x Red Sindhi herd, 1.6 ± 0.05 by Rawal and Tomar (1994a) for Sahiwal herd and 1.47±0.06 by Mukherjee and Tomar (1996) for Karan swiss (Table 2).

The contribution of individual cow in term of number of female calves produced during its lifetime is presented in Table 3. Rawal (1991) reported that about one-fifth (22.1%) of the total Tharparkar cows did not produce any female calf during their lifetime, about one third (31.6%) produced only one female calf and 20.7% produced two female calves whereas 3.3% cows produced 6 or more female calves, Almost similar values have been reported by Rawal and Tomar (1994a) for Sahiwal cows and Tomar *et al.* (1995) for Red Sindhi cows.

Mukherjee and Tomar (1996) worked out the individual contribution of Brown Swiss-Zebu crossbred cows and observed that about one–third (30.5%) of total cows failed to produce any female calf, another one-third (36.5%) produced only one female calf, 16.4% produced two and 4.3% of the

Table 3: Frequency distribution of cows (%) according to total calves born, total female calves born and replacement daughters during lifetime for different breeds

No. of calves born

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	*Ref.
							Total calves born								
-	8.8	13.9	12.9	13.2	12.2	13.1	13.1	7.1	1.8	0.4	0.31				1
-	15	12	27	6	26	86									2.1
-	10	15	14	5	21	66									2.2
-	4	13	8	5	65										2.3
-	28.9	12.2	8.6	9.1	5.7	5.7	3.3	1.8	0.6	1.2	-	-	0.2	-	3
-	22.2	14.9	9.3	8.3	7.1	5.7	4.4	2.7	3.0	0.4	0.1	0.4	0.1	-	4
-	22.4	14.8	9.1	7.9	6.5	4.6	4.7	3.4	2.1	1.9	1.0	0.2	-	0.1	5
-	11.2	26.3	17.1	5.2	7.9	5.9	4.6	3.9	5.2	-	1.3	-	-	-	6
0.3	20.8	20.4	15.2	6.8	7.2	4.9	3.8	1.9	1.4	0.6	0.1	0.1	-	-	7
-	22.3	23.4	14.5	9.4	6.4	3.2	0.3	1.3	0.5	0.5	0.3	-	-	-	8
-	32.1	29.2	12.7	8.0	3.6	2.6	2.1	2.1	1.7	1.8	1.5	1.5	0.4	0.3	9
							Female calves born								
24.4	36.0	10.7	5.4	3.3	1.0	0.2	0.2								3
19.1	33.9	11.7	7.5	3.9	1.8	0.7	0.5								4
22.1	31.6	12.1	7.0	3.1	1.8	1.0	0.4	0.1	0.05						5
13.8	35.5	12.5	7.9	5.2	2.6										6
20.9	36.4	11.1	6.5	2.5	1.2	0.2	0.2								7
30.5	36.5	16.4	7.1	3.8	2.1	1.8	1.1	0.6	0.07						9

This should be explained in review?

Contd……/-

Contd…../-

Replacement daughters										
42.4	36.0	13.4	5.3	1.6	0.6	0.4			99.7	3
33.9	32.4	18.4	7.9	4.6	2.0	0.7	-	0.1		4
39.6	30.0	15.6	7.9	4.2	2.2	0.4	0.1	0.1		5
51.4	31.4	10.9	4.2	1.7	0.1	0.1	-	0.1	100%	7
54.8	29.9	8.0	4.2	1.8	0.8	0.2	0.07			9

*** Reference**

1. Khohli & Suri (1957)	Hariana
2. Agarwal (1968)	2.1. Red Sindhi ; 2.2. ¼ Jersey; 2.3. ½ Jersey
3. Lathwal (1989)	Red Sindhi
4. Rawal and Tomar (1994a)	Sahiwal
5. Rawal (1991)	Tharparkar
6. Tomar & Basu (1981)	Murrah
7. Ram (1988)	Murrah
8. Basu & Ghai (1980)	Murrah
9. Mukherjee & Tomar (1996)	Karan Swiss

total cows produced 6 or more female calves during their life time. They observed significant effect of period, FLMY and AFC on total number of female calves born.

2.1.5. Number of female calves reached to milking herd

Schons *et al.* (1985) reported that, on an average, Angus cows left 1.1 ± 0.23 replacement heifers and concluded that each cow was more than replacing herself, resulting in an overall increase in the herd size.

Similarly, replacement of more than one daughters have been reported for Tharparkar cows (1.16 ± 0.03), Sahiwal cows (1.26 ± 0.04), Jersy and Jersey x Red Sindhi crossbred cows (1.49 ± 0.06) as reported by Rawal (1991), Rawal and Tomar (1994a) and Thakur *et al.* (1992), respectively.

The average number of female daughters left by each cow was less than one as reported by Tomar *et al.* (1995) for Red Sindhi cows (0.92±0.06) and by Mukherjee and Tomar (1996) for Brown Swiss-Zebu crossbred cows (0.77 ± 0.04) and they thus the cows did not replace themselves.

The data presented in Table 3 on the contribution of individual cows indicated that 42.2% of total Red Sindhi cows did not have any replacement daughter in the herd and 36% left only one replacement daughter that reached the milking herd (Tomar *et al.* 1995). The reports of Rawal (1991) on Tharparkar, and Rawal and Tomar (1994a) on Sahiwal cows showed that 39.6 and 33.9% of the total cows did not replace themselves whereas about one-third (29.8 and 32.4) left only one daughter and 15.6 and 18.4% left two daughters.

More than one-half of total corssbred cows (54.8%) did not replace themselves, 30.0% left only one replacement and 8.0% left two replacement daughters as reported by Mukherjee and Tomar (1996). They also reported that the effect of period and FLMY was highly significant whereas AFC did not affect this trait.

2.1.6. Coefficient of gene replication (CGR)

Schons *et al.* (1985) first defined the term of coefficient of gene replication as the additive genetic relationship between the adult female and each of her female progeny selected as replacement of herself. They found that the average CGR was 0.486 ± 0.086 which was somewhat less than one gene replication (0.5) that could contribute again to the next generation.

Rawal (1991) reported the average CGR in Sahiwal herd of 736 cows as 0.63 ±0.02 with 105% coefficient of variation which indicated that each cow, on an average, was more than once replicating her genes. However, about one-third of total cows did not replicate their genes and hence had no genetic contribution to future generation. The value of CGR among rest of two-third cows ranged from 0.5 in one-third to 3.0 in only 0.7% of the total cows except one cow which had the CGR value as 4.0. The average CGR was found to be 1.39 for 33.7% the total cows and hence each of one-third of the total cows in the herd was replicating her genes about three times to future generation.

Mukherjee (1993) reported the value of CGR as 0.39 ± 0.023 for the crossbred herd at NDRI, Karnal. This indicated that it was less than one gene replication (0.5) that could materially contribute again to the future generation. The frequency distribution of the cows according to CGR values showed that about 55 percent of the total cows had zero CGR and hence genetically dead which indicated that these cows had no genetic contribution to future generation.

Rawal *et al.* (1993) worked out the CGR in a herd of 1366 Tharparkar cows as 0.58 ± 0.02 which was little higher than one time gene replication. About 40% of the total cows had no genetic contribution to next generation for replicating their genes in the population (CGR = 0) whereas the CGR value among rest of the cows ranged from 0.5 in 29% cows to 4.0 in only 0.1% (one cow) and the average CGR was found to be 1.41 for 26.3 % of the total cows indicating that each of about one-fourth of the total cows in the herd replicated their genes about three times to the future generation.

Tomar *et al.* (1995) working on Red Sindhi herd reported less than one CGR (0.47). They further observed that 42% of the total cows had no genetic contribution to future generation and the CGR values among rest of the cows ranged from 0.5 in 34.8 percent cows to 3.0 in only 0.4 percent (2 cows). The average CGR was 1.21 for 23.1 percent of the total cows indicating that each of about one-fourth of the total cows in the herd was more than twice replicating her genes to future generation.

Tomar and Ram (91) observed the CGR as 0.37 ±0.016 which was less than one gene replication and hence each buffalo did not contribute genetically to the future generation.

2.2. REPLACEMENT RATE AND ITS COMPONENTS (DEMOGRAPHIC ANALYSIS)

The demographic analysis of a population involves total births, sex ratio among normal births, mortality rates, age structure of the population, growth rate, longevity and life history production. The reports available in literature have been reviewed in terms of the number of services required for conception, prenatal calf losses, sex-ratio, female calf losses through death and culling of female calves from birth to age at first calving, heifer replacement that become available in a particular year, replacement index and age structure of the herd

2.2.1. Number of services per conception (S/C)

In this study the fertility is defined in terms of the number of inseminations/services required per conception (S/C), which is in reality important factor to affect the calf production and regular breeding of dairy animals and hence affects the total life time milk production as well as the total calf crop in life time of an animal. The literature indicate that the dairy cows require different number of services for conception in relation to various non-genetic factors. The average number of services required for conception for different breeds among different years, season and in different parity alongwith the significance of differences reported by various workers have been presented in Table 4 and have been reviewed as under:

Table 4: Average number of services per conception for different breeds

Breed	No.	Average services per conception	Effect of Year	Effect of Season	Effect of Parity	Reference
Hariana	376	1.7	-	-	S	Tomar & Arora (1971)
"	1061	1.77	-	-	-	Kohli *et al.* (1961)
"	126	1.85±0.09	-	-	S	Singh *et al.* (1964)
"	1950	2.0	N	N	-	Grewal *et al.* (1974)
"	688	2.00±0.07	-	-	-	Singh *et al.* (1968)
"	99	2.00±0.2	-	-	-	Tomar & Arora (1971a)
"	160	2.18±0.11	-	-	N	Singh & Singh (1970)
"	Heifer	2.70±0.1	-	-	-	Kumar & Bhat (1979)
	Cows	2.1 to 2.6		-	N	
Red Sindhi	27	1.73±0.43	-	-	-	Basu *et al* (1979)
"	334	2.40±0.1	-	-	N	Sharma & Bhatnagar (1975)
Sahiwal	79	2.01±0.4	-	-	-	Basu *et al* (1979)
"	79	2.10±0.36	-	-	N	Bhatnagar *et al.* (1979)
"	108	2.61±0.05	S	N	-	Singh *et al.* (1990)
"	967	2.70±0.1	-	-	N	Sharma & Bhatnagar (1975)
Desi		2.2	-	N	-	Pachlag *et al.* (1982) 91 not in bibligo
Tharparkar	57	1.54±0.41	-	-	-	Basu *et al.* (1979)
"	1048	2.40±0.1	-	-	N	Sharma & Bhatnagar (1975)
Bachur		1.29±0.06	-	-	S	Singh & Parsad (1969)
"	86	1.44±0.09	-	-	N	Singh *et al.* (1964)

N = Nonsignificnat, S = Significant

Effect of year

Grewal *et al.* (1974) and Tomar *et al.* (1976a) working on Hariana cows found that year had no effect on S/C. Basu *et al.* (1979) observed that year variations were not significant on S/C in Sahiwal, Red Sindhi and Tharparkar cows. On the contrary, Basu and Ghai (1980) for crossbred cows and Singh *et al.* (1990) for Sahiwal reported significant effect of year on S/C.

Seasonal variation

Kohli *et al.* (1961) working on Hariana cows at GLF Hissar reported that variations in S/.C among months were not significant. Kale (1963) for Sahiwal cows reported that S/C was lowest during January to April (1.8, 1.8, 1.6 and 1.9 respectively) July (1. 9) and October (1.5) and maximum in November (3.6).

Grewal *et al.* (174) for Hariana cows and Pachlag *et al.* (1982) for Deshi cows, reported that season did not influence the S/C.

Bhatnagar *et al.* (1979) reported significant differences in S./C in Sahiwal cows among months. The cows calved in July took more S/C (2.30) while those calving in December required minimum S/C (1.26).

Basu *et al.* (1979) observed significant effect of month of calving on S/C for 3 Zebu breeds at Karnal, cows calving in November (1.05 S/C) requires less S/C than calving in August (3.8 S/C).

Parity effect

Singh (1961) for Tharparkar and Singh and Singh (1970) for Hariana cows, reported that parity of calving had no significant effect on S/C. Non-significant effect of parity of calving on S/C was reported by Sharma and Bhatnagar (1975) and Basu *et al.* (1979) for Sahiwal , Red Sindhi and Tharparkar cows, Kumar and Bhat (1979) in Hariana cows, Bhatnagar *et al.* (1979) for Sahiwal cows and Chaudhri *et al.* (1984) for Hariana cows.

Singh *et al.* (1964) reported that parity of lactation had significant effect on S/C in Hariana and Bachur cows, the heifer took lesser number of services for conception (1.36±0.09 and 1.16±0.06) than in second (2.4 ±0.19 and 1.90 ±0.02)third and more calving (1.82 ±0.18 and 1.71±0.29).

Singh and Parsad (1969) reported that the average of two successive conceptions of the Bachur cows were 1.16 ± 0.058 and 1.51 ± 0.15 with an overall average of 1.29± 0.06 services for conception.

Tomar and Arora (1971b) working on Hariana cows observed that heifer calvings significantly took more number of services for conception (2.0) than subsequent calvings

2.2.2. Abnormal births

The average values of incidence of prenatal calf losses or abnormal births (abortions, still births, pre-mature births, dystocia etc.) in dairy cattle reported by various workers have been given in Table 5.

The reports showed that the average pre-natal calf losses ranged from 4.66 to 11.1 percent in Red Sindhi, 3.5 to 9.0 percent in Sahiwal, 3.1 to 10.3 percent in Tharparkar, 1.1 to 9.8 percent in Hariana and 3.4 to 10.9 percent in Gir breed of cattle.

Year of birth

Tomar *et al.* (1975), Tomar and Verma (1981 and 1988a) studied the incidence of abnormal calvings in Sahiwal, Red Sindhi and Tharparkar cows respectively and observed that year of birth had no effect on the trait.

Non-significant effect of year of calving has also been reported by Negi and Luktuke(1982) in Holstein x Sahiwal crossbreds and Singh and Jain (1997) for native and crossbred cattle..

Significant effect of year of birth on prenatal calf losses were reported by Sharma and Jain (1984) where as the incidence of still births were not

Sharma and Jain (1984) reported higher per-natal calf losses in monsoon and winter season than in Summer in Zebu (RS, Sahiwal and Tharparkar) and crossbred cows.

Significantly higher incidence of abnormal calvings have been observed during summer and lower during winter season by Negi and Luktuke (1982) in Zebu crossbred cattle, Chatterjee *et al.* (1985) in exotic, Zebu and crossbred cattle, Arun *et al.* (1995) in Holstein x Sahiwal crosses and Mukherjee (1993) for Karan Swiss cattle.

Higher incidence of abortion during summer (4.2%) and winter (31.6%) than in monsoon season (10.5 to 15.7%) were reported by Ramalingam *et al.* (1990) in Jersey crossbred.

Parity of calving

No effect of parity order on the incidence of abnormal calvings have been reported by Prabhu and Chatterjee (1970) for Sahiwal, Red Sindhi, Gir, Tharparkar and Hariana cattle, Tomar and Verma (1981), Reddy and Sampath (1981), Sharma and Jain (1983) and Lathwal *et al.* (1993) for Red Sindhi, Sharma and Jain (1983) and Rawal and Tomar (1996a) for Sahiwal, Sharma and Jain (1983), Tomar and Verma (1988a) and Rawal and Tomar (1996c) for Tharparkar, Shukla *et al.* (1980) for Gir, Reddy and Sampath (1981) for Gir and Ongole,

Similarly no effect of parity was observed by Reddy and Sampath (1981) for Tharparkar cows mated to Jersey sires and RS/Sahiwal cows mated to Ayrshire bulls, Tomar and Verma (1988a) for Tharparkar cows mated to Holstein sires, Reddy and Sampath (1981) for Jersey x Tharparkar cows, Sharma and Jain (1984) for HJT and HBT crossbreds and Ramalingham *et al.* (1990) in Jersey crossbreds.

Significantly higher incidence occurred in younger cows as reported by Sharda and Lohia (1966) in Hariana cows, Tomar *et al.* (1975) for Sahiwal, Chaterjee *et al.* (1985) for Holstein x Sahiwal crosses and Singh and Jain (1997) for native and crossbred cattle.

Table 5. Percent incidence of prenatal calf losses (abnormal birth) in different breeds of cattle

Breed	No.	Average	Effect of			Reference
			Y	S	P	
Hariana	259	1.1	-	-	-	Tomar & Singh (1973)
"		3.6	-	N	N	Prabhu & Chatterjee (1970)
"		4.2	-	N	S	Sharda & Lohia (1966)
"		9.3	-	-	-	Luktuke & Chaudhary (1965)
"		9.8	-	-	-	Halder & Sen (1970)
Sahiwal	3245	3.5	S	N	N	Rawal & Tomar (1996a)
"		4.1	-	N	N	Prabhu & Chatterjee (1970)
"		4.3	-	-	-	Kaikini *et al.* (1976)
"	184	5.9	-	-	-	Bhosreker (1973)
"	782	8.3	N	N	S	Tomar *et al.* (1975)
"	1876	8.8	-	S	N	Sharma & Jain (1983)
"		9.0	-	-	-	Amble & Jain (1967)
"	1752	4.6	-	-	N	Reddy & Sampath (1981)
"		4.7	N	N	N	Tomar & Verma (1981)
"	1604	4.7	S	S	N	Lathwal *et al.* (1993)
"	2701	5.2	-	N	N	Prabhu & Chatterjee (1970)
"	53	5.9	-	-	-	Bhosreker (1973)
"	1036	11.1	-	S	N	Sharma & Jain (1983)
Tharparkar		3.1	-	N	N	Prabhu & Chatterjee (1970)
"	1576	4.4	N	N	N	Tomar & Verma (1988a)
"	4774	4.4	S	N	N	Rawal & Tomar (1996c)
"	277	7.9	-	-	-	Bhosreker (1973)
"		10.3	-	S	N	Sharma & Jain (1983)
Gir		3.4	-	N	N	Shukla *et al.* (1980)
"		4.6	-	-	N	Reddy & Sampath (1981)
"		10.9	-	N	-	Prabhu & Chatterjee (1970)
Ongole		4.6	-	-	N	Reddy & Sampath (1981)
"		6.4	-	-	-	Prabhu & Chatterjee (1970)
Native cattle		4.4	-	S	S	Chatterjee *et al.* (1985)
Kankrej	1465	4.9	-	-	-	Prabhu & Chatterjee (1970)
Kangayam	607	4.9	-	-	-	"
Amritmahal	388	6.2	-	-	-	"
Halliker	356	2.8	-	-	-	"
Bagusi	243	5.7	-	-	-	"
Hol x Hariana	178	2.2	-	-	-	Tomar & Singh (1973)
BS x Hariana	118	3.4	-	-	-	"
RD x Hariana	55	3.6	-	-	-	"
Hol x Sahiwal	240	8.4	-	N	S	Tomar *et al.* (1975)
"	1523	9.5	N	S	-	Negi & Luktuke (1982)
BS x Tharp	189	10.6	S	S	-	Sharma & Jain (1984)
HF x Tharp	299	5.3	-	-	-	"
Sindhi crosses	1127	3.3	-	N	N	Prabhu & Chaterjee (1970)
Sahiwal crosses	428	11.9				"
Gir crosses	84	8.3				"
Karan Swiss	2611	8.1				Sharma & Jain (1984)
"	1098	6.4	S	S	S	Mukherjee (1993)
Karan Fries	505	17.1				"

Y = Year, S= Season, P = Parity order
N = Nonsignificnat, S = Significant

It should be bold

Significantly higher incidence of abnormal calvings in older cows of later lactations have been reported by Arun *et al.* (1995) in Holstein x Sahiwal crosses and Mukherjee (1993) in Karan Swiss cattle.

2.2.3. Sex ratio (%, Male births)

The sex ratio at birth is generally expressed as the percentage of male birth to the total normal births and it is normally expected to be 50:50 as the male sex is determined by the Y chromosome. The probability to fertilize the ovum by the sperm carrying either X or Y chromosome is equal. Therefore, the sex ratio should not deviate significantly from normal expectation of 50:50. However, there may be some genetic and environmental factors which may favour or hamper the penetration of either X or Y chromosome in fertilizing the ovum. In support of this theory, there are also reports available in literature indicating that the sex ratio at birth deviates significantly due to various genetic and environmental factors. The average sex ratio in different breeds/crosses of cattle reported by various workers in relation to different environmental factors have been reviewed (Table 6). The important environmental factors studied by various workers have been the year, season and parity of calving.

Year/period of calving

The year of calving was not a significant source of variation in sex ratio as reported by Singh and Singh (1968), Tomar and Arora (`1970) and Rao *et al.* (1970) for Hariana, Kale *et al.* (1982) for Red Sindhi, Tomar *et al.* (1976), Sethi and Rao (1981) and Rawal and Tomar (1995) for Sahiwal, Tomar and Verma (1989a) and Rawal and Tomar (1996c) for Tharparkar, Singh and Parekh (1982) in crossbred calves born to Gir cows mated to HF, BS and Jersey bulls, Rao *et al.* (1969) in Ongole cattle, Singh *et al.* (1983) and Shukla and Parekh (1988) in Gir.

Patel *et al.* (1988) in Jersey x Kankrej and Holstein x Kankrej, Tomar and Verma (1988b) for crossbred cows mated to HF and ¾ HF bulls, *Singh et al. (1991) in crossbred cattle, Mukherjee (1993) for Karan Swiss* also reported no effect of year of calving on sex ratio.

Table 6: Average sex ratio (% male births) among normal birth for different breeds of cattle

Breed	Location	No.	Average	Effect of			Reference
				Y	S	P	
Hariana	Mathura	622	47.6	-	S	N	Singh & Singh (1968)
"	Haringhata	3271	50.7	-	N	-	Goswami *et al.* (1963)
"	Hisar	1147	52.3	N	S	N	Tomar & Arora (1970)
"	Izatnagar	1962	54.0	-	-	N	Rao *et al.* (1970)
Sahiwal	Karnal	3131	51.3	N	N	N	Rawal & Tomar (1995)
"	"		51.7	-	-	-	Pandit *et al.* (1989)
"	MDF		53.5	N	N	N	Tomar *et al.* (1976)
Red Sindhi	Karnal	1364	51.6	S	N	N	Lathwal *et al.* (1993)
"	"		55.2	N	N	N	Kale *et al.* (1982)
Tharparkar			50.5	-	-	-	Kulkarnai (1980)
"	Karnal		51.3	N	N	N	Rawal & Tomar (1996c)
"			51.4	N	N	N	Tomar & Verma (1981)
"	Mhow		52.0	N	N	S	Tomar & Verma (1988a)
Gir			50.0	N	-	N	Shukla & Parekh (1988)
"	Indore	549	50.4	N	N	N	Singh *et al.* 1983
Kankrej			51.0	-	-	-	Tripathi *et al.* (1973)
Ongole	Chintaladeve	570	51.6	-	-	N	Rao *et al.* (1969)
Vachur	Bihar		55.0	-	-	-	Singh & Prasad (1969)
Hol x Hariana	Hisar	175	54.8	-	-	-	Tomar & Singh (1973)
BS x Hariana	"	115	50.8	-	-	-	"
RD x Hariana	"	155	50.9				"
Hol. x Hariana	"		49.8	-	-	-	Singh & Balaine (1973)
BS x Hariana	"		51.6				"
Jer. x Haryana	"		52.2				"
Hol x Hariana	Izatnagar	535	53.3	-	-	-	Kaushik & Singhal (1982)
BS x Hariana	"	364	51.6				"
Jer. x Haryana	"	331	54.7				"
HF x TP	Karnal	308	58.1	S	S	S	Tomar & Verma (1988a)
BS x TP	"	178	53.4	-	-	-	"
Jer x TP	"	213	56.8	-	-	-	"
Jer x Kankrej	Anand	449	48.0	N	N	-	Patel *et al.* (1988)
Hol x Sahiwal	MDF	197	50.2	S	N	N	Arun *et al.* 1992)
3/8		252	51.9				"
1/2		150	55.3				"
5/8		490	53.5				"
3/4		410	48.0				"
7/8		89	52.8				"

N = Nonsignificnat, S = Significant

Y S P ?
give full form

Tomar and Verma (1988a) reported that the percent male births among years did not differ significantly but the sex ratio was significantly higher during certain years in Tharparkar (TP) cows mated to TP, HF, BS and Jersey sires.

Significant effect of year of calving on sex ratio was reported by Lathwal *et al.* (1993) in Red Sindhi cows. The sex ratio varied significantly among years from 44.3 to 67.7 percent.

Arun *et al.* (1992) reported that the male births varied significantly from 37.9 to 58.5 percent during different years in Holstein x Sahiwal crossbred cows. Singh and Jain (1997) also reported the significant effect of period of calving on sex ratio in native and crossbred cattle.

Season of birth

Bhattacharya *et al.* (1956) analysed 22866 calving records of 6132 cows in 41 farms comprising 13 breeds and 4 types of grade cattle and reported that there were no significant differences in sex ratio of calves born in different months.

Tomar and Mittal (1960) observed non-significant effect of month of calving on sex ratio in Hariana cattle, though the sex ratio was higher in March (63.4%) while lowest in November (36.6%).

Goswami *et al.* (1963) also reported that the sex ratio did not differ significantly among months of calving in Hariana cattle. Non-significant effect of month or season of calving on sex ratio had been reported by Mukherjee (1973) in Hariana cattle, Tomar *et al.* (1976) and Rawal and Tomar (1995) in Sahiwal cows, Kale *et al.* (1982) and Lathwal *et al.* (1993) in Red Sindhi, Singh *et al.* (1983) in Gir cows and Rawal and Tomar (1996c) in Tharparkar cows.

Non significant effect of season on sex ratio have also been reported by Singh and Parekh (1982) among F_1 and ¾ calves from Gir and half bred cows, Shukla and Parekh (1988) in Gir and their crosses, Patel *et al.* (1988)

for F_1 and F_2 Jersey x Kankrej and Friesian x Kankrej crossbreds, Tomar and Verma (1988b) for Holstein x Tharparkar crossbreds, Singh *et al.* (1991) in crossbred cattle, Arun *et al.* (1992) in Holstein x Sahiwal crosses, Mukherjee (1993) in Karan Swiss cattle and Singh and Jain (1997) for native and crossbred cattle.

Significant effect of season of calving on sex ratio was reported by Tomar and Arora (1970) in Hariana cows, being significantly higher among summer born calves while Singh and Singh (1968) reported significantly lower sex ratio in Hariana cattle during summer (38.2).

The sex ratio was found to be significantly higher during winter born calves followed by those born during summer and rainy season in Sahiwal cows mated to Holstein and Brown Swiss (Sethi and Rao, 1981).

Significantly higher sex ratio during summer and autumn seasons than during winter and rainy seasons among purebred Tharparkar and crossbred F_1 calves has been reported by Tomar and Verma (1988a)

Parity of calving

No significant differences between parity orders in sex ratio of calves born to any of 13 Zebu breeds and 4 types of grade cattle in India had been reported by Bhattacharya *et al.* (1956).

The order of calving has also not been found to be a significant source of variation in sex ratio by Goswami *et al.* (1963), Singh and Singh (1968) and Tomar and Arora (1970) in Hariana cattle, Rao *et al.* (1969) in Ongole cattle, Tomar *et al.* (1976b), Sethi and Rao (1981) and Rawal and Tomar (1995) in Sahiwal cattle, Singh *et al.* (1983) and Shukla and Parekh (1988) for Gir cattle, Kale *et al.* (1982) and Lathwal *et al.* (1993) for Red Sindhi cattle, Rawal and Tomar (1996c) in Tharparkar cattle.

Singh *et al.* (1991), Arun *et al.* (1992), Mukherjee (1993) in crossbreds and Singh and Jain (1997) for native and crossbred cattle also reported that parity order had no effect on sex ratio.

Tomar and Verma (1988a) observed that sex ratio was significantly affected by parity order, being higher in first (56.1%) and fifth (61.0%) parities but the percentage of male birth did not differ significantly among parity orders in Tharparkar cattle.

Tomar and Verma (1988b) reported significantly lower sex ratio (45.5 and 44.2%) for second and third calvings but the percentage of male calves among parity orders did not differ significantly in crossbred cows having 50% and 75% exotic inheritance.

2.2.4 Post-calving losses of female calves from birth to age at first calving (AFC)

(I) Mortality

The average mortality rates from birth to AFC in different breeds have been reviewed in Table 7. The average mortality rates ranged between 8.2 to 16.3 percent in Red Sindhi female calves, between 12.1 to 16.4 percent in Sahiwal, except 28.0 percent in one report that is based on small sample size, between 18.8 to 23.0 percent in Tharparkar, 23.6 percent in Hariana and 17.0 percent in indigenous female calves from birth to age at first calving.

Most of the reports available in literature on mortality rate covered the calf mortality upto first 6 or 12 months of age. The reports on mortality in female calves from birth to age of first calving have been reviewed here.

Age of calf

Most of the reports on calf mortality have indicated that age of the calf is an important factor. About half of the total mortality occurred in first months of life and mortality rate decreased with the increase in age (Singh and Singh, 1973; Tomar, 1973; Patil and Gupta, 1980; Rao and Nagarcenkar, 1982 and Mukherjee and Tomar, 1997).

Year of birth

Lathwal *et al.* (1993) not observe any effect of year on the mortality rate of Red Sindhi female calves upto AFC.

Rawal and Tomar (1994b) and Tomar and Rawal (1996) have reported that mortality rates in female calves from birth to AFC ranged significantly over different periods of calving from 15.0 to 32.9 percent and 8.9 to 22.0 percent in Sahiwal and Tharparkar cattle, respectively.

Significant effect of year on mortality rates have been reported by Lemka *et al.* (1973) in Hariana, and Reddy and Nagacenker (1989a) in Sahiwal calves.

Significant effect on mortality of female calves have also been reported by Chaudhary *et al.* (1984) in crossbreds, Tomar and Verma (1988b) in Tharparkar and crossbred calves, Singh and Jain (1997) for native and crossbred cattle and Mukherjee and Tomar (1997) for Karan Swiss.

Season of birth

Negligible effect of season on mortality rates of female calves from birth to age at first calving (AFC) was reported by Lemka *et al.* (1973) in Hariana, Desi and Bos Taurus, Reddy and Nagercenkar (1989a) and Rawal and Tomar (1994b) in Sahiwal, Tomar and Rawal (1996) in Tharparkar and *Lathwal et al. (1993) in Red Sindhi,*

Similar results of no effect of season were observed by Tomar and Verma (1988b) for crossbred, Singh and Jain (1997) for native and crossbred and Mukherjee and Tomar (1997) for Karan Swiss

Significantly lower mortality among Holstein and Jersey crossbred female calves born during rainy (5.8%) and summer (8.1%) seasons than those born during winter (13.8%) were reported by Chaudhary *et al.* (1984).

Significant effect of season of birth on mortality rate was observed by Tomar and Verma (1988a) in Tharparkar and Crossbred F_1 female calves from birth to AFC. The incidence was low among calves born during rainy season (8.4%) than born in other seasons (16.0 to 17.4%)

Parity of calving

The effect of dam's parity was non-significant on pre-calving losses in female calves as reported by Rawal and Tomar (1994b) for Sahiwal and Tomar and Rawal (1996) for Tharparkar.

Tomar and Verma (1988a) for Tharparkar and Holstein x Tharparkar F_1, Tomar Verma (1988b) for crossbreds, Mukherjee and Tomar (1997) for Karan Swiss also observed non-significant effect of dam parity on female calf mortality.

However, significant effect of dam's parity on mortality rate was reported by Lathwal *et al.* (1993a) for Red Sindhi female calves. The mortality rates were low among calves from older dams of Seventh and eighth parity (4.0 and 8.8%) and from cows of third parity (5.6%), whereas high mortality was observed among those which born from dams of second (20.2%) and fourth (20.9%) parity.

Singh and Jain (1997) have also reported significant effect of parity order on mortality of native and crossbred female calves from birth to AFC.

Birth weight of calves

Lathwal (1989) and Mukherjee (1993) did not observe any effect of birth weight on mortality upto age at first calving in the female calves of Red Sindhi and crossbred, respectively,

Significant differences in mortality rates of calves due to the birth weight of female calves have been reported by Rawal (1991) in Sahiwal and Tharparkar breeds. He observed high mortality among calves having birth weight below 19 kg in Tharparkar breed and below 17 kg in Sahiwal breed.

Tomar (1984) had also reported that Murrah buffalo female calves having the birth weight beyond normal range had significantly high mortality.

Table 7: Average incidence (%) of death and culling in female calves from birth to AFC for different breeds

Breed	No.	Period	Death	Culling	Total losses	Replacement rate	References
Hariana	2578	1952-66	23.6	22.8	46.4	53.6	Lemka *et al.* (1973)
Sahiwal	648	-	14.1	2.01	16.1	-	Singh *et al.* (1987)
"	848	1951-76	12.1	12.3	24.4	-	Reddy & Nagarcenkar (1989a)
"	1064	1951-78	14.0	13.2	27.3	-	"
"	1400	-	16.4	13.5	29.9	-	"
"	1180	1949-87	15.4	15.1	30.5	69.5	Rawal & Tomar (1994b)
"	61	1934-55	28.0	15.0	43.0	-	Amble & Jain (1967)
Red Sindhi	724	1921-52	8.2	14.1	22.3	77.7	Amble *et al.* (1958)
"	472	1951-76	12.1	13.0	25.1	-	Singh *et al.* (1987)
"	643	1948-83	13.5	28.7	42.2	57.8	Lathwal *et al.* (1993)
"	674		16.3	33.9	50.2	42.8	Amble *et al.* (1958)
Tharparkar	388	1966-78	23.0	8.5	31.5	68.5	Tomar & Verma (1988a)
"	1151	1951-76	18.8	13.6	32.4	-	Singh *et al.* (1987)
"	2222	1923-81	21.1	14.9	36.0	64.0	Tomar & Rawal (1996)
Deshi	509	-	17.0	26.9	51.1	48.9	Lemka *et al.* (1973)
Local	227	-	32.1	11.2	43.3	56.7	Singh & Jain (1997)
< 50% exotic	130	-	48.6	8.9	57.5	42.5	"
> 50% exotic	293	-	43.4	11.6	55.0	45.0	"
Karan Swiss	2008	-	20.7	27.1	47.8	52.2	Mukherjee & Tomar (1997)
BS x TP	83		6.0	15.7	21.7	78.3	Tomar & Verma (1988a)
BS x Sahi.	84		-	-	-	89.3	Taneja & Bhatnagar (1983)
Jersey	854	1948-63	-	-	-	67.0	Fosgate (1965)
"	-	-	-	-	-	69.0	Moore & Richardson (1976)
Holstein	1806	1972-82	-	-	-	77.8	Loyd & Hargrove (1991)
Bostaurus	221	1952-66	27.0	-	49.0	51.0	Lemka *et al.* (1973)
Jersey crosses	1468	1966-70	16.7	2.0	18.7	80.3	Chaudhary *et al.* (1984)
Murrah	1646	1958-87	24.3	22.7	47.0	53.0	Tomar & Ram (1993)

Ram (1988) reported significant effect of birth weight on mortality for Murrah buffalo calves, the rate being high in calves having birth weight less than 22 kg and more than 41 kg.

(II) Culling

The female calves are culled from the herd before they reach sexual maturity for a number of reasons like poor growth rate, abnormal phenotype, late maturity, reproductive problems and as a policy decision.

The average culling rates in female calves based on total female calves born in different herds and breeds reported by various workers have been reviewed in Table 7. In general, 15-20 percent of the total female calves born alive were culled upto their age at first calving.

Lemka *et al.* (1973) reported that pre-calving losses due to culling of female calves were found to be 22.8 and 26.9 percent in Hariana and Desi breeds of cattle.

Singh (1979) reported culling rate between 0 to 6 months and between 7 months to AFC as 1.8 and 12.6 percent in Red Sindhi; 1.4 and 12.1 percent in Sahiwal; 1.6 and 14.4 percent in Tharparkar and 0.25 and 4.5 percent in Brown Swiss crossbred female calves.

Lathwal *et al.* (1993) observed 28.7 percent culling rate in Red Sindhi female calves from birth to AFC at Karnal. Low culling rates from birth to AFC have been reported by Rawal and Tomar (1994b) for Sahiwal (15.1%) and Tomar and Rawal (1996) for Tharparkar (15%). Singh and Jain (1997) observed only 10.6% culling rates in native and crossbred female calves upto AFC.

Year of birth

The year was not a significant source of variation in culling rates of Karan Swiss heifers, whereas significant differences over years for culling rates in Karan Fries heifers were reported by Kulkarni and Sethi (1990).

Highly significant differences among years for culling rates of female calves from birth to age at first calving have been reported by Reddy and Nagarcenkar (1989a) and Rawal and Tomar (1994b) in Sahiwal calves, Lathwal *et al.* (1993) in Red Sindhi calves, Tomar and Rawal (1996) in Tharparkar,

Tomar and Verma (`1988a, b) in Tharparkar and crossbred calves, Mukherjee and Tomar (1997) in Karan Swiss and Singh and Jain (1997) in native and crossbred also observed that year had significant effect on culling rates.

Tomar and Ram (1993) reported that the culling rates varied significantly among years from 7.8 to 42.1 percent for Murrah buffalo female calves.

Season of birth

The culling rates were not affected by season of birth as reported by Tomar and Verma (1888a) for Tharparkar and Holstein x Tharparkar F_1 female calves, Lathwal *et al.* (1993) for Red Sindhi, Rawal and Tomar (1994b) for Sahiwal.

Mukherjee and Tomar (1997) for Karan Swiss, Singh and Jain (1997) for native and crossbreds and Tomar and Ram (1993) for Murrah buffaloes also reported no effect of season on culling rate.

Reddy and Nagarcenkar (1989a) for Sahiwal and Tomar and Rawal (1996) for Tharparkar calves also reported significant effect of season on culling rates, being highest in winter and lowest in rainy season.

Significant effect of season of birth was reported by Tomar and Verma (1988b) for crossbred calves, the culling rates being significantly higher in calves born during autumn season (35.9%) than in winter, summer and rainy season (17.8 to 22.8%).

Parity of dam

The parity order did not influence the culling rates as reported by Tomar and Verma (1988a,b) for Tharparkar and crossbreds and Lathwal *et al.* (1993) for Red Sindhi calves.

Significant effect of dam's parity of lactation on culling rates was reported by Rawal and Tomar (1994b) for Sahiwal, Tomar and Rawal (1996) for Tharparkar calves, Mukherjee and Tomar (1997) for Karan Swiss and Singh and Jain (1997) for native and crossbreds. They all found that the culling of calves was low from older dams above seventh parity.

Birth weight of calves

The culling rates were not found to be affected by birth weight of female calves according to the reports of Lathwal (1989) for Red Sindhi calves, Rawal (1991) for Sahiwal and Tharparkar calves and Ram (1988) for Murrah buffalo female calves.

Significant effect of birth weight of Karan Swiss female calves on culling was reported by Mukherjee (1993), however, the calves having birth weight between 24 to 29 kg had low culling rates than those exceeding this limit on both the sides.

2.2.5. Replacement rate

The replacement rate is more a function of the death and culling of female calves from birth to age at first calving, in addition to the incidence of abnormal births and male births. These are the components of the replacement rate and hence any variation in any of these components due to any factor will influence the replacement rate.

The replacement rates observed by different workers for different breeds have been given in Table 7. The replacement rates have been reported to be 67 percent by Fosgote (1965) and 69 percent by Moore and Richardson (1976) in Jersey, about 72 percent in Holstein, Brown Swiss, Ayrshire and their two breed crosses, and 64 percent in three breed crosses by McDowell and McDaniel (1968).

Low replacement rate of 51 percent was reported by Lemka *et al.* (1973) in exotic cattle. Vaccaro (1990) observed 44 percent replacement rate in imported exotic cattle and 61 percent in the local born cattle.

Among Zebu breeds, the replacement rates varied from 42.8 to 69.5 percent (Table 7).

According to the reports of Chaudhary *et al.* (1984), Singh *et al.* (1987), Taneja and Bhatnagar (1983) and Tomar and Verma (1988a) the replacement rate was higher (about 80%) in exotic-Zebu crossbreds than in Zebu cattle.

Tomar and Ram (1993) reported that only 53 percent of the total Murrah buffalo female calves born reached to the milking herd.

Year of birth

Tomar and Verma (1988b) reported that year of birth had no effect on the percentage of female calves born that reached to the milking herd in crossberd calves.

Significant effect of year of birth have been reported by Tomar and Verma (1988a), Rawal (1991), Lathwal *et al.* (1993), Tomar and Rawal (1994) for Zebu cattle, Mukherjee and Tomar (1997) for crossbred and Singh and Jain (1997) for native and crossbred and Tomar and Ram (1993) for buffaloes on replacement rate based on female calves as well as total calves basis.

Season of birth

No effect of season of birth on the replacement rate either on female calf basis or total calf basis was observed by Rawal (1991) for Tharparkar, Tomar and Rawal (1994) for Sahiwal and Singh and Jain (1997) for native and crossbreds, Tomar and Verma (1988b) and Mukherjee and Tomar (1997) for crossbreds.

The replacement rate was significantly higher among calves born during rainy season than in other seasons (Tomar and Verma, 1988a).

Significantly lower replacement rate of female calves of Red Sindhi breed born during summer season (55.8%) than born in other seasons (59.5 to 61.3%) was reported by Lathwal *et al.* (1993). However the replacement rate based on total calf basis was not affected by the season of birth.

Winter born Murrah buffalo calves had significantly low replacement rate (47.1%) on female calf basis than in other seasons (51.7 to 56.5%) whereas the season did not influence the replacement rate based on total calf basis (21.0 to 25.1%) in calves born during different seasons as reported by Tomar and Ram (1993).

Parity of dam

Tomar and Verma (1988 a,b) in Tharparkar and crossbred calves, Rawal (1991) for Tharparkar cattle and Tomar and Ram (1993) in Murrah buffaloes reported that dam's parity of lactation had no effect on the replacement rate either based on female calf basis or total calf basis.

Mukherjee and Tomar (1997) reported that replacement rate based on female calves born was not different among the calves born to dams of different parity order but on the basis of total calves born it was significantly affected by parity order.

Significant effect of dam's parity was reported by Lathwal *et al.* (1993) in Red Sindhi and Tomar and Rawal (1994) for Sahiwal on replacement rate based on female calf basis, being significantly higher for the calves from older cows beyond fifth parity, whereas the replacement rate based on total calf basis was not affected by dam's parity. Singh and Jain (1997) reported that replacement rates on both the basis were significantly higher among the calves born to older cows.

2.2.6. Age / lactation specific demographic parameters

Five important age specific demographic parameters have been reported in literature which are survival rate, survivorship or stayability, age distribution in terms of the proportion of cows lost and present in the herd of each age group, and the expected herd life in years at different ages. These parameters have been studied either in terms of age or in terms of lactation by different workers. The various reports on these parameters have been reviewed in Table 8.

(1) Survival rate

The report of Greer *et al.* (1980) on Hereford cattle and of Schons *et al.* (1985) on Angus cattle indicated that the survival rate was near 0.80 upto the age of 8 years after which it started declining.

Ahmed *et al.* (1992) working on Nili Ravi buffaloes reported the survival rate as 0.90 upto 4 years of age with a decreasing trend along age, being more than 0.70 upto 10 years of age, nearly 0.68 between 11-13 years and 0.58 during 14 years of age.

Mukherjee (1993) reported that survival rate was maximum during second year of age (0.92) which decreased to 0.69 by 4 years of age and thereafter it remained more or less constant upto 13 years of age.

Camacho *et al.* (1985) observed that 85±7.7 percent Brahmin cows remained in the herd after first calving. Nieuwhof *et al.* (1989) studied the survival rate in cows of 5 milch breeds in different parity of lactation and observed that the survival rate was maximum (0.78) in the second lactation after which it started declining.

Tomar *et al.* (1994) reported that the probability of survival of Sahiwal cows was 0.78 in first lactation, 0.74 or more upto 5th lactation and then decreased.

Lathwal *et al.* (1995) observed the survival rate of Red Sindhi cows to be nearly 0.7 among the cows belonging to parity one through six and then decreased. Tomar *et al.* (1996) observed the survival rate in Tharparkar cows as 0.78 after first parity and then decreased along parity.

(2) Survivorship or stayability

Sharma and Singh (1974) observed a sharp decline in the probability of *an animal to remain in the herd (1.0 to 0.49) from 3.5 to 7 years after which* the reduction in the probability was steady in Zebu breeds.

Greer *et al.* (1980) and Schons *et al.* (1985) observed a declining trend in survivorship with increasing age. Similarly a decreasing trend with increasing age or parity of lactation has also been reported by Agarwal (1968) and Ahmed *et al.* (1992). Tanida *et al.* (1988) reported that age specific survivorship decreased more rapidly with age in Angus herd than in Hereford herd.

Tomar *et al.* (1994), Lathwal *et al.* (1995) and Tomar *et al.* (1996) for Sahiwal, Red Sindhi and Tharparkar cows respectively considered the survivorship as unity in first lactation and observed that survivorship decreased along parity order being less than 0.10 after eighth parity.

(3) Expected herd life

The expected herd life for Angus, Hereford and Shorthorn breed of cattle was estimated by Krehbiel *et al.* (1962) at birth, at 5 and 10 year of age to be 3.9, 2.9 and 1.9 years, respectively.

Greer *et al.* (1980) reported the expected herd life at one year of age as 3.82 years and there was a decrease in expected herd life with advancing age.

A constant expected herd life between 4 to 5 years for the cows upto 6 years of age and after that a decline was noted in Angus and Hereford cows by Schons *et al.* (1985).

A declining trend in expected herd life with advancing age in Nili Ravi buffaloes was reported by Ahmed *et al.* (1992). He reported the expected

Table 8. Age or lactation specific demographic parameters in dairy herds of different breeds

Year/ Lact.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	References
1. Survival rate (Px)																	
Year	-	-	0.807	0.847	0.840	0.825	0.839	0.824	0.801	0.723	0.525	0.0					1
Lact.	-	-	0.78	0.57	0.40	0.27	0.17	0.10	0.05								2
Year	-	-	1.0	0.902	0.908	0.852	0.839	0.797	0.774	0.752	0.728	0.689	0.695	0.699	0.577	0.0	3
Year	0.52	0.96	0.84	0.82	0.85	0.84	0.96	0.83	0.84	0.78	0.86	0.81	0.76	0.68	0.65	0.0	4
Lact.	-	0.778	0.725	0.736	0.777	0.742	0.702	0.664	0.602	0.600	0.267	0.625	0.0	0.0			11
Lact.	-	0.711	0.688	0.750	0.763	0.675	0.693	0.549	0.543	0.527	0.700	0.147	1.0	1.0			12
Year	-	0.777	0.922	0.808	0.689	0.542	0.612	0.688	0.617	0.804	0.686	0.792	0.658	0.64	0.50	0.375	13
Lact.	-	0.775	0.727	0.737	0.780	0.757	0.735	0.745	0.652	0.608	0.616	0.427	0.0	0.0			14
2. Survivorship or stability (Lx)																	
Year	-	-	-	1.0	0.947	0.795	0.639	0.490	0.390	0.305	0.258	0.203	0.15	0.102	0.76	0.04	5
Lact.	-	0.945	0.721	0.533	0.398	0.289	0.212	0.150	0.101	0.068	0.038	0.019	0.006	0.002			5
Year	-	-	1.0	0.807	0.687	0.574	0.474	0.398	0.328	0.268	0.190	0.99					1
Year	1.0	0.52	0.50	0.43	0.35	0.30	0.25	0.22	0.18	0.15	0.11	0.10	0.08	0.06	0.04	0.03	4
Lact.	-	0.88	0.835	0.828	0.799	0.759	0.704	0.68	0.596	0.522	0.371	0.0					6
Year						0.873	0.744	0.624	0.497	0.385	0.290	0.211	0.145	0.098	0.068	0.039	3
Lact. (1)	-	-	0.85	0.71	0.59	0.32	0.26										7
(2)	-	-	0.90	0.55	0.40	0.26	0.21										7
(3)	-	-	0.96	0.91	0.78	0.70	0.65										7
Lact.	-	1.0	0.773	0.546	0.415	0.322	0.239	0.168	0.111	0.067	0.040	0.011	0.006				11
Lact.	-	1.0	0.710	0.488	0.366	0.279	0.188	0.128	0.072	0.039	0.020	0.014	0.002	0.002	0.002	-	12
Year	1.0	0.777	0.716	0.579	0.398	0.216	0.132	0.091	0.056	0.045	0.031	0.024	0.016	0.010	0.005	0.002	13
Lact.	-	1.00	0.775	0.564	0.416	0.324	0.245	0.180	0.134	0.088	0.053	0.033	0.014	0			14

contd..../-

contd.../-

Year/ Lact.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	References
3. Expected herd life (Ex) in years																	
Year	-	3.82	3.73	3.41	3.05	2.69	2.21	1.68	1.10	0.53							1
Lact.	3.09	-	-	-	-	2.9	-	-	-	-	1.9						10
Year	4.09	5.73	4.99	4.79	4.72	4.53	4.49	4.12	3.7	3.34	3.29	2.55	2.12	1.67	1.18	0.43	4
Year	-	-	-	4.64	-	-	3.18	-	-	2.24	-	-	1.50	-	-	0.30	3
Lact.	-	2.72	2.50	2.45	2.32	1.99	1.70	1.43	1.12	0.86	0.43	0.63					11
Lact.	-	2.38	2.34	2.41	2.22	1.90	1.49	1.16	1.12	1.06	1.00	0.44	2.0	1.0			12
Year	-	3.1	2.99	2.24	1.80	1.58	1.91	2.12	2.09	2.39	1.97	1.87	1.37	1.08	0.68	0.37	13
Lact.	-	2.82	2.65	2.63	2.57	2.31	2.04	1.78	1.39	1.14	0.87	0.42	0.00				14
4. Age distribution of cows culled of each age (q_x)																	
Year			0.193	0.123	0.109	0.099	0.076	0.07	0.065	0.043	0.09	0.099					1
Year				0.049	0.078	0.127	0.121	0.128	0.122	0.096	0.079	0.067	0.047	0.029	0.029	0.038	3
Lact. (1)	0.049	0.144	0.149	0.140	0.167	0.08	0.076	0.063	0.117								8
(2)	0.12	0.195	0.195	0.170	0.065	0.07	0.090	0.050	0.045								8
Year	-	-	0.212	0.171	0.145	0.121	0.100	0.84	0.069	0.056	0.04	0.0					1
Lact.	-	0.31	0.23	0.17	0.12	0.08	0.05	0.03	0.01								2
Lact.	-	0.15	0.098	0.17	0.227			0.354									9
Years	-	-	0.007	0.098	0.159	0.162	0.138	0.116	0.092	0.071	0.054	0.039	0.027	0.018	0.013	0.006	3
Lact.	-	0.222	0.213	0.149	0.092	0.083	0.071	0.056	0.044	0.027	0.029	0.004	0.006				11
Lact.	-	0.289	0.222	0.122	0.087	0.090	0.058	0.058	0.033	0.018	0.006	0.012	0.00	0.00	0.002		12
Years	-	0.223	0.061	0.137	0.181	0.182	0.084	0.041	0.035	0.011	0.014	0.007	0.008	0.06	0.005	0.003	13
Lact.	-	0.224	0.221	0.148	0.092	0.078	0.065	0.046	0.046	0.034	0.020	0.019	0.014				14
5. Age distribution of cows present in herd (p_x)																	
Year	-	-	0.211	0.171	0.144	0.121	0.100	0.084	0.069	0.055	0.040						1
Lact.	-	0.31	0.23	0.17	0.11	0.08	0.05	0.03	0.02								2
Lact	-	0.267	0.209	0.151	0.111	0.086	0.064	0.045	0.029	0.018	0.010	0.026	0.003				11
Lact	-	0.302	0.214	0.147	0.110	0.083	0.057	0.038	0.022	0.012	0.006	0.004	0.001	0.001			12
Years	-	0.250	0.230	0.186	0.129	0.069	0.042	0.029	0.018	0.014	0.010	0.007	0.005	0.003	0.001		13
Lact	-	0.261	0.202	0.147	0.109	0.085	0.064	0.047	0.035	0.023	0.014	0.008	0.003				14

contd.

Year/ Lact.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Reference
							6. Reproductive value (Vx)										
Year	1.0	1.88	2.02	2.02	2.04	1.94	1.90	1.72	1.56	1.44	1.36	1.13	1.06	0.88	0.61	0.46	4
Year			1.57	1.31	1.23	1.40	1.45	1.43	1.60	1.43	1.40	1.14	1.01	0.82	0.65	0.46	13
Lact.		1.86	1.77	1.75	1.82	1.52	1.47	1.25	1.14	1.05	0.85	0.67	0.44				14

1. Greer *et al.* (1980),
2. Nieuwhof *et al.* (1989)
3. Ahmed *et al.* (1992)
4. Schons *et al.* (1985)
5. Sharma & Singh (1974)
6. Ochoa *et al.* (1991)
7. Agarwal (1968)
8. Amble *et al.* (1958)
9. Gadzhiev *et al.* (1991)
10. Krehbiel *et al.* (1962)
11. Tomar *et al.* (1994)
12. Lathwal *et al.* (1995)
13. Mukherjee (1993)
14. Tomar *et al.* (1996)

herd life at 3, 6, 9, 12 and 15 years of age as 4.64, 3.18, 2.24, 1.50 and 0.30 years.

The expected herd life was estimated by Tomar *et al.* (1994) for Sahiwal, Lathwal *et al.* (1995) for Red Sindhi and Tomar *et al.* (1996) for Tharparkar cows during first lactaiton to be 2.72, 2.38 and 2.92 more lactations respectively with a decreasing trend along increase in lactation number.

(4) Age distribution of cows left the herd

The proportion of Red Sindhi cows at Bangalore and Hosur farm which left the herd in different lactations was studied by Amble *et al.* (1958). They reported that 5% and 12% of the total cows at two farms left the herd before completing first lactation whereas 14.4 and 19.5 percent of the total cows left after completing first lactaion. Around 15 percent of the total cows at Bangalore left the herd in each lactation from 1 through 4 lactation and thereafter the proportion of cows culled decreased along lactations. A decreasing trend was observed in Hosur herd after third lactation. The proportion of cows culled was reported by Greer *et al.* (1980) to be 0.193 at 2 years of age which decreased to 0.123 at 3 years and it remained around *0.07 after 5 years of age till 11 years.*

The report of Ahmed *et al.* (1992) indicated that the proportion of Nili-Ravi buffaloes being culled increased from 0.049 at age 3 years to 0.127 at 5 years and it remained constant upto 8 years after which a decline was observed.

Mukherjee (1993) reported that the proportion of crossbred female calves being lost from the herd due to their death and culling was found to be 0.223 upto one year of age whereas during the second year of age the rate of loss was only 6.1 percent. About three fourth of the total females were lost from the herd (78.4%) till they attained the age of 5 years.

Tomar *et al.* (1994), Lathwal *et al.* (1995) and Tomar *et al.* (1996) studied the lactation specific distribution of Sahiwal, Red Sindhi and

Tharparkar cows which left the herd. They reported that about one-fourth of the total cows left the herd after first lactation based on several years of culling and replacement of the culled cows and hence this figure can be used to estimate the number of replacement heifers required to maintain the herd size. They have further observed that the proportion of cows left the herd after second lactation was nearly the same as that in the first lactation and thereafter it decreased appreciably.

(5) Herd structure for cows present in the herd

Regarding the constitution of herd of cows belonging to different lactations, the reports of Greer *et al.* (1980), Nieuwhof *et al.* (1989) and Gadzhiev *et al.* (1991) have indicated that the herds were mostly constituted of younger cows belonging to first 4 parities or upto the age of 5-6 years.

Ahmed *et al.* (1992) observed that about 56 percent of the total buffaloes present in the herd were in the age group of 4 to 7 years.

Mukherjee (1993) observed that about one-half of the total herd (48.5%) comprised the females below 2 years of age (heifers) and 31.5 percent belonged to the age group of 2 to 4 years. Only 2.8% of the total females were of the age group of more than 9 years.

The reports of Tomar *et al.* (1994) on Sahiwal, Lathwal *et al.* (1995) on Red Sindhi and Tomar *et al.* (1996) on Tharparkar cows have shown that about one-fourth of the total cows in the herd belonged to first parity and that about two-third of the total cows belonged to first through third parity. Thus the herd contained mostly the younger cows.

(6) Mean rate of loss

The mean rate of loss for all age groups was reported as 0.25 per female per year by Chaughley (1966) for Himalayan Thar. The average probability of loss per lactation per cow have been reported as 0.268 by Tomar *et al.* (1994) for Sahiwal herd, 0.302 by Lathwal *et al.* (1995) for Red Sindhi cows and 0.26 by Tomar *et al.* (1996) for Tharparkar cows.

Table 9: Overall lifetable statistics for different breeds

Breed	Mean age of cows (Lact. or year)		Life expectancy at first lactation (Lact.)	Mean rate of loss per cow per lact. (Proportion	Reproductive rate (female calves per cow)	Generation interval (Years)	References
	Present in herd	Lost from herd					
Hereford	4.78	5.7	-	-	-	-	Greer et al. (1980)
Angus	-	-	-	-	1.26	5.62	Schons et al. (1985
Karan Swiss	3.56	2.35	2.60	0.32	1.12	-	Mukherjee (1993)
Sahiwal	3.52	3.69	3.22	0.27	1.78	-	Tomar et al. (1994)
Red Sindhi	3.05	2.96	2.81	0.30	1.60	-	Lathwal et al. (1995)
Tharparkar	3.81	3.43	3.32	0.26	1.79	-	Tomar et al. (1996)
Himalaya Thar	-	-	3.05	0.25	-	-	Caughley (1966)
Nili Ravi Buffalo	6.58	7.92	-	-	-	-	Ahmed et al. (1992)

(7) Mean age of cows present and left the herd

Greer *et al.* (1980) reported the mean age of cows being lost from the herd and present in the herd as 5.7 and 4.8 years respectively.

Ahmed *et al.* (1992) found the average age of cows culled and those which were present in the herd as 7.92 and 6.58 years, respectively in a herd of a Nili-Ravi buffalo.

Tomar *et al.* (1994) for Sahiwal cows, Lathwal *et al.* (1995) for Red Sindhi cows and Tomar *et al.* (1996) for Tharparkar cows observed that the average number of lactations completed by cows which left the herd were 3.69, 2.96 and 3.43 respectively, whereas for those which were present in the herd were 3.52, 3.05 and 3.81 for the three breeds, respectively.

(8) Life expectancy

Chaughley (1966) reported that the mean life expectancy at birth was 3.5 years for Himalayan Thar. The mean lactation expectancy at first lactation was observed as 3.2 lactations by Tomar *et al.* (1994) for Sahiwal herd, 2.8 lactations by Lathwal *et al.* (1995) for Red Sindhi herd and 3.32 lactations by Tomar *et al.* (1996) for Tharparkar herd.

2.2.7. Herd replacement

The herd replacement in any year (annual replacement index) depends on the number of heifer calvings which replace the number of adult females leaving the herd due to their death and culling.

(1) Mortality and culling of adult cows

The average incidence of mortality and culling of adult cows of different breeds during different lactations reported in literature have been given in Table 10. Whereas average loss per lactation and per year have been given in Table 11.

Lemka *et al.* (1973) found that annual loss of adult females due to death and culling was 18 percent for Hariana, 17 percent for desi cows and

Table 10: Average incidence of mortality and culling (%) in adult cows during different lactations for different breeds

Breed	Total cows	Lactations 1	2	3	4	5	6	7	8	9	10	11	12	13	14	Ref.
								Mortality								
RS	483	1.5	0.9	3.3	3.4	4.4	6.5	4.8	5.7	5.2	-	28.5	-	-	100.0	1
TP	1368	1.7	2.6	1.6	2.1	2.2	3.8	1.6	4.8	6.6	5.4	8.8	15.7	-	-	2
Sahi.	744	3.2	2.4	3.1	3.5	3.6	3.9	6.4	7.2	10.0	3.2	25.0	-	-	-	3
KS	1399	2.6	3.2	3.4	5.5	3.8	4.8	3.6	6.6	2.8	6.1	7.1	11.8	-	-	4
Mur.	733	2.3	2.3	4.4	1.0	3.7	5.9	4.6	15.0	4.5	-	-	-	-	-	5(1)
"	364	0.5	0.8	1.7	1.6	1.3	2.2	1.0	0.0	7.0	-	-	-	-	-	5(2)
Surti	909	5.5	3.7	3.9	5.8	11.7	14.7	8.1	15.8	-	-	-	-	-	-	6
								Culling								
RS	483	27.5	30.3	21.6	20.3	28.1	25.2	38.7	40.0	42.1	30.0	57.0	-	-	-	1
TP	1368	20.7	24.6	24.6	19.8	22.1	22.6	23.8	29.9	32.5	32.8	48.8	84.2	-	-	2
Sahi.	744	18.9	25.1	23.3	18.7	22.1	25.8	27.2	32.5	30.0	70.0	12.5	100.0	-	-	3
KS	1399	29.0	39.4	29.0	25.3	17.6	14.1	14.9	15.4	19.8	25.6	30.3	88.2	-	-	4
Mur.	733	23.6	23.5	28.0	27.3	16.9	26.5	27.7	30.0	36.5	57.1	75.0	-	100.0	-	5(1)
"	364	2.8	6.3	25.9	37.2	24.1	33.6	37.9	38.4	50.0	55.5	75.0	100.0	-	-	5(2)
Surti	909	17.7	25.0	29.5	29.5	36.1	33.3	49.0	63.1	75.0	100.0	-	-	-	-	6

1. Lathwal (1989) RS = Red Sindhi
2. Rawal & Tomar (1998) TP = Tharparkar
3. Rawal *et al*. (1994) Sahi = Sahiwal
4. Mukherjee (1993) KS = Karan Swiss
5. Ram & Tomar (1993) Mur = Murrah (1) Farm born (2) Purchase
6. Kulkarni (1995) Surti

21 percent for exotic cattle. Sharma and Singh (1974) observed that out of 1372 cows of Sahiwal, Tharparkar and Red Sindhi breeds, 13.1 percent left the herd due to their death.

The average mortality for Hariana, Sahiwal, Tharparkar and Karan Swiss cows have been reported as 9.8, 7.2, 5.0 and 1.2 percent, respectively by Chikara and Balaine (1977).

Reddy and Nagarcenkar (1989b) reported annual mortality in Sahiwal cows as 2.1, 2.1, 1.6, 4.2 and 2.9 percent at Karnal, Durg, Hissar, Meerut and Gangeria farm respectively and the culling rates as 14.9, 9.4, 9.8, 11.6 and 8.9 percent.

Lathwal (1989) reported the mortality and culling of Red Sindhi cows as 9.3 and 90.7 % out of total losses but 2.8 % death and 21.6% culling occurred in each lactation with significant differences among lactations for both mortality and culling rates. The annual mortality rates were 3.9 percent in foundation stock and 1.82 percent in farm born cows while the annual culling rate was 20.7 percent for both foundation cows and farm born cows. The effect of years was significant only for culling rates.

Mukherjee (1993) observed that out of total losses 11.2 percent of the crossbred cows died and the rest 88.8 percent were culled from the herd. He further observed that total losses were less in cows of middle age i.e. during 5-9 lactations. Out of the total losses of 32.5 percent per lactation the mortality accounted for 3.6 percent and the culling for 28.8 percent. It was further observed that the annual loss of cows averaged 24.4 percent due to death and culling each year.

Rawal *et al.* (1994) working on Sahiwal cattle at NDRI, Karnal reported that out of the total losses about 13% of the cows were died and 87% were culled during the entire period of 39 years. The annual mortality and culling rates averaged 2.5 and 16.8% respectively amounting to significant loss of 19.3% per year. The mortality and culling per lactation averaged 3.6 and 23.2% respectively amounting to 26.7% per lactaion and lation had highly significant effect on both the traits..

Table 11: Loss of adult cows through death and culling

Breed	No. of cows			Loss / lactation (%)			Loss / year (%)			Ref.
	Total	Died	Culled	Death	Culling	Total loss	Death	Culling	Total loss	
RS	483	45 (9.3)	438 (90.7)	2.8**	27.6*	30.4*	1.8	20.7**	22.5*	1
TP	1368	132 (9.7)	1236 (90.3)	2.5**	23.5**	26.0**	1.9*	17.8**	19.7**	2
Sahi.	744	100 (13.4)	644 (86.6)	3.6**	23.2**	26.8**	2.5*	16.8**	19.3**	3
KS	1428	160 (11.2)	1268 (88.8)	3.6**	28.8**	32.5**	2.7**	21.7**	24.4**	4
Mur.	586	65 (11.1)	521 (88.9)	3.1*	25.0**	28.1**	2.1**	17.0**	19.1**	5(1)
"	350	26 (7.4)	324 (92.6)	1.3**	16.3**	17.6**	1.2**	15.3**	16.5**	5(2)
Surti	909	165 (18.1)	744 (81.9)	5.7**	25.7**	31.4	3.0**	13.5**	16.5**	6

*P < 0.05 **P < 0.01

1. Lathwal (1989) RS = Red Sindhi
2. Rawal & Tomar (1998) TP = Tharparkar
3. Rawal *et al.* (1994) Sahi = Sahiwal
4. Mukherjee (1993) KS = Karan Swiss
6. Ram & Tomar (1993) Mur = Murrah (1) Farm born (2) Purchase
6. Kulkarni (1995) Surti

Rawal and Tomar (1998) reported the annual mortality and culling rates in Tharparkar cows as 1.9 and 17.78% respectively and about one-fourth of the total cows left the herd in each lactation due to death (2.5%) and culling (23.5%). The mortality and culling rates varied significantly among years and lactations. They further reported that 9.7 percent cows died when they were in the herd and rest 90.3 were culled from the herd.

(2) Annual replacement index

Lathwal (1989) worked out the annual replacement index varying between 0.6 to 1.31 in different periods with an overall value of 0.84 which indicated a reduction in herd size for Red Sindhi herd over a period of 37 years from 1950 to 1986.

Mukherjee (1993) analysed the data for crossbred cattle maintained at Karnal and reported the overall annual replacement index as little more than one (1.07). This indicated that heifer calvings were nearly equal to that of the number of adult cows left the herd in any year and hence the herd size remained constant.

Rawal *et al.* (1994) worked out the replacement index in a herd of Sahiwal cattle at NDRI Karnal and found it to be nearly one which indicated that the herd size remained constant over a period of 39 years (1952-19990). However, the annual replacement index was found to vary significantly among years.

Rawal and Tomar (1998) reported the overall replacement index to be 0.92 for Tharparkar cattle at NDRI, Karnal for 64 years (1923-86) which fluctuated significantly among years.

2.3. GENETIC ANALYSIS

The genetic variability present in terms of the sire differences, heritability estimates and repeatability estimates for replacement rate and selective value and its components have been reviewed

2.3.1. Selective value and its components

Selective value of an adult female is determined by the productive herd life of a cow in terms of calf production traits i.e., total calves born, total alive calve born, total female calves born and total replacement daughter per cow.

(1) Productive herd life

Effect of sire

The heritability estimates for productive herd life reported by various workers for different breeds have been given in Table 12.

Camacho *et al.* (1985) reported that the length of useful life was not significantly affected by sire in Brahman herd.

Singh and Tomar (1989) also reported that the effect of sire was highly significant on the trait indicating that the progeny of certain sires had longer life than of the other or vice versa.

Tomar and Basu (1981) reported highly significant effect of sires on herd life in Murrah buffaloes which varied from 1.35 to 9.5 years among the daughters of different sires. They concluded that sire selection can be effective for improving herd life.

Heritability

The heritability estimates of herd life (Table 12) that these were low for exotic breeds where as the estimates were medium in Hariana, high in Tharparkar, low to medium in Sahiwal breed and in crossbreds.

(2) Calf production traits

Effect of sire

Rawal and Tomar (1994) reported that the effect of sire was not significant for life time calf production trait in Sahiwal herd.

Table 12. Heritability estimates of productive herd life in different breeds

Breed	Method	Heritability	Reference
Hariana	DD	0.33±0.11	Singh *et al.* (1964)
Tharparkar	PHS	0.69±0.10	Basu *et al.* (1983)
Sahiwal	PHS	0.005±0.10	Reddy & Nagarcenkar (1989c)
Karan Fries	PHS	0.49±0.16	Singh & Tomar (1989)
Karan Swiss	PHS	0.118±0.07	Mukherjee (1993)
HF x Sahiwal			
$\geq$ 50% exotic		0.27±0.04	Reddy (1979)
< 50% exotic		0.21±0.08	"
Jersey	-	0.03	Rogess *et al.* (1991)
Hereford	PHS	0.26±0.08	Tanida *et al.* (1988)
"	DD	0.16±0.08	"
Holstein	PHS	0.37±0.14	Evans *et al.* (1964)
"	*ISRD*	0.0	"
"	PHS	0.14±0.17	White & Nichols (1965)
"	DD	0.15	Hargrove *et al.* (1969)

Rawal (1991) reported that the effect of sire was highly significant on total number of calves, total alive calves born, total female calves born, and significant effect on total number of female calves born in Tharparkar breed of cattle,

Lathwal *et al.* (1992) reported highly significant effect of sire on the percentage of Red Sindhi cows which failed to produce female calf and to replace themselves.

Mukherjee and Tomar (1996) observed significant effect of sire on total calves born and total alive calves born whereas the sire had no effect on total female calves born and the number reached to milking herd for Brown Swiss crosses.

Tomar and Basu (1981) analysed the different calf production traits of Murrah buffaloes and observed that sire effect was significant on number of total calves, number of alive calves and number of female calves born. The total number of calves born by the daughters of different sires varied from 1.86±0.4 to 8.86±0.6 whereas the number of female calves born varied form 0.71±0.18 to 3.86±0.74.

Tomar and Ram (1992) had also reported highly significant effect of sire on total number of calves born, total alive calves, total female calves and total female calves reached to the milking herd from each female.

Heritability

The literature reviewed (Table 13) indicated that in exotic breeds, the heritability estimates of total number of lactations were low.

Basu *et al.* (1983) reported that the heritability for number of lactations completed by each cow in Tahrparkar the herd was high (0.67±0.13).

Rawal (1991) reported medium heritability for the total number of calves born (0.277), total alive calves (0.243), total female calves born (0.376) and the number reached to milking herd (0.171) by each cow of Tharparkar breed.

Table 13: Heritability estimates of life time calf production traits in different breeds

Breed	Total calves or no. of lactations	No. of alive calves	No. of . female calves		Reference
			Born	Reaching milking herd	
Tharparkar	0.67±0.13	-	-	-	Basu *et al.* (1983)
"	0.28	0.24	0.37	0.17	Rawal (1991)
Sahiwal	0.02	-0.20	0.02	-0.07	Rawal & Tomar (1994a)
Holstein	0.13±0.17	-	-	-	White & Nichols (1965)
"	0.14	-	-	-	Hargrove *et al.* (1969)
Hereford	0.22±0.08	-	-	-	Tanida *et al.* (1988)
Angus	0.03±0.14	-	-	-	"
Hol. x Sahiwal $\geq$ 50%	0.15±0.05	-	-	-	Reddy (1979)
Karan Swiss	0.206±0.09	0.177±0.08	0.043±0.06	0.036±0.06	Mukherjee & Tomar (1996)
Murrah buffalo	0.50	0.44	0.39	> 1	Tomar & Ram (1992)

Rawal and Tomar (1994a) observed that the heritability estimate for all the life time calf production in Sahiwal herd was close to zero.

Mukherjee and Tomar (1996) reported that the heritability estimates were 0.206±0.09 for total number of calves born and 0.177±0.08 for total alive calves born whereas, the heritability estimates were close to zero or low (0.043±0.06 and 0.036±0.06) for total number of female calves born and number of calves reached to milking herd.

Tomar and Ram (1992) reported medium heritability for total number of calves, total alive calves, total female calves born and number of calves reached to milking herd from each buffalo of Murrah breed.

2.3.2. Replacement rate and its components

(1) Abnormal calving

Effect of sire

Effect of sire on the incidence of abnormal calves born of Tharparkar, half breed and ¾ bred cows was reported non significant (Tomar and Verma, 1988a, b). Lathwal and Arun (1993) also observed that the rate of abnormal calvings was not affected by sire of the calf in Red Sindhi cows.

Singnificant effect of sire was reported by Tomar *et al.* (1975) on this trait in Sahiwal cows bred to Sahiwal and Holstein sires. Abnormal births recorded for the progeny of Sahiwal and Holestein bulls were 64 and 50 percent, respectively. Sharma and Jain (1983) also observed significant sire effect on abortions and pre-natal mortality but not on still births in Zebu and crossbred cattle.

Rawal and Tomar (1996 a & c) working on Sahiwal and Tharparkar cattle observed significant sire effect on the rate of abnormal calvings. They further reported no incidence of abnormal births among the pregnancies settled from 48 percent Sahiwal sires and 42 percent Tharparkar sires indicating that about 50-60 percent of the total bulls used for breeding were responsible for the abnormal births ranging from 0.1 to 25.0 percent abnormal births among the progeny of different sires.

Arun *et al.* (1991) reported significant difference among sires and grand sires of Sahiwal breed for incidence of abnormal parturitions while the Holstein sires had no effect. No abnormal birth occurred among the pregnancies from 29.4 percent Sahiwal and 21.7 percent HF sires used for breeding.

Mukherjee (1993) found that sire had significant effect on abortion ranging from 2.94 to 20 percent among the progeny of different sires in Karan Swiss cattle.

In Murrah buffaloes, Ram and Tomar (1992) reported that sire of calf had significant effect on the incidence of abnormal births. There had been no abnormal births among the pregnancies of 39 percent of the bulls. The abnormal births ranged from 0.1 to 18.0 percent among the progeny of rest of the 61.0 percent sires. Significant differences in abnormal births among the daughters of different sires have also been reported by Tomar and Basu (1981) in Murrah buffaloes.

Heritability

The heritability estimates of abnormal births presented in Table 14 indicated very little additive genetic variability in the trait in all the breeds.

Lindhe (1967) reported considerable sire differences in the trait with medium heritability (0.43) of still born progeny in Swedish breed of cattle.

Repeatability

Low repeatability estimates of abnormal births have been reported by Rawal and Tomar (1996a) in Sahiwal (0.025) and Rawal and Tomar (1996b) in Tharparkar (0.032) cattle and Arun *et al.* (1991) in crossbred cattle ranging from 0.065 to 0.28 among different grades.

Mukherjee (1993) found very low repeatability for abortions (0.038) and for still birth (-0.02) in Karan Swiss cattle.

Tomar (1984) reported very low estimate of repeatability in Murrah buffaloes at two farms (0.049 and 0.10). Similarly low estimate of the repeatability of abnormal births in Murrah buffaloes (0.049) was reported by Ram and Tomar (1992).

(2) Sex ratio

Effect of sire

The sex ratio did not differ significantly among the progeny of different sires as reported by Goswami *et al.* (1963), Tomar and Arora (1970) in Hariana, Tomar *et al.* (1976) and Sethi and Rao (1981) in Sahiwal, Lathwal and Arun (1993) in Red Sindhi, Tomar and Verma (1988a) in Tharparkar, Singh *et al.* (1983), Tomar and Verma (1988b) in crossbred cattle and Mukherjee (1993) in Karan Swiss.

Significant effect of sire of the calf on the sex ratio was reported by Powell *et al.* (1975) in exotic cattle. Rawal and Tomar (1995) observed that in a Sahiwal herd the sex ratio was highly significantly affected by sire of the calf. The sex ratio ranged between 40 to 70 % among the pregnancies of about two third of total sires. There were about 7 percent of the total sires in the herd, the sex ratio was about 75 percent while the sex ratio was below 20 percent for the progenies of about 5 percent of total sires.

Rawal and Tomar (1996c) found that the effect of sire of the calf on sex ratio in Tharparkar herd was highly significant to the extend that the sex ratio was zero percent among the pregnancies of 1 out of 79 sires and there were 6 sires whose pregnancies consisted of about 75 percent male calves whereas the sex ratio was below 40 percent among the pregnancies settled from 9 out of 79 bulls.

Arun *et al.* (1993b) observed significant sire differences in sex ratio for Sahiwal breed varying from 16.7 to 100 percent while among the progeny of

Holstein sires the differences were not significant though the sex ratio among the progeny of different sires ranged from 22.2 to 68.0 percent.

Tomar and Tripathi (1988) reported that the effect of sire on sex ratio was significant in one of the two herd of Murrah buffaloes.

Heritability

The estimates of heritability of sex ratio have been reported to be very low by Arun *et al.* (1993a) for Sahiwal (0.062) and HF sires (0.0176), Mukherjee (1993) for Karan Swiss cattle, Rawal and Tomar (1995) for Sahiwal cattle (0.0954) and Rawal and Tomar (1996b) for Tharparkar cattle (0.0674).

Tomar and Tripathi (1988) reported low to medium heritability of sex ratio estimated in two herds of Murrah buffaloes (0.124 and 0.434).

Ram and Tomar (1992) observed medium heritability of sex ratio (0.206) in Murrah buffaloes.

Repeatability

The repeatability estimates of sex ratio were reported were low by Tomar and Tripathi (1988) in two herds of buffaloes (-0.064 & 0.045), Sethi and Rao (1981) in Sahiwal cattle (0.034), Arun *et al.* (1993a) for crossbred cattle (-0.035), Rawal and Tomar (1995) for Sahiwal (0.084) and Rawal and Tomar (1996c) for Tharparkar (0.0157). All these reports have indicated that sex of the calf in future gestation can not be predicted based on the sex of the calf in previous gestation.

Stonaker and Knapp (1974) and Elbarbery (1983) found a tendency of calves of the same sex to be born in successive calving i.e. more female calves will likely to be born following a female calf.

(3) Mortality rate

Effect of sire

Tomar and Verma (1988a) for Karan Fries, Tomar and Verma (1988b) for Tharparkar cattle and Lathwal and Arun (1993) for Red Sindhi observed no effect of sire on the female calf mortality from birth to AFC.

Significant effect of sire on female calf mortality from birth to age at first calving has been reported by Chaudhary *et al.* (1984) in crossbred cattle.

Rawal and Tomar (1994) observed that sire had highly significant effect on female calf mortality of Sahiwal breed. There was no mortality of female calves from birth to age at first calving among the progeny of 19.2 percent of the total sires, the maximum mortality was 50 percent among the progeny of one Sahiwal sire.

Tomar and Rawal (1996) reported that sire of calf had highly significant effect on the mortality of Tharparkar female calves from birth to AFC. There was no mortality among the female calves from 12.7 percent sires, whereas the mortality was below 10 percent among the progenies of 7.6 percent sires, between 40-50 percent among the progenies of 12.6 percent sires and for one sire 63.1 percent female progeny died before breeding age.

Mukherjee and Tomar (1997) observed highly significant effect of sire on female calf mortality rate in Karan Swiss. They reported that there was no mortality from birth to age at first calving among the female progeny of 3 out of 48 sires. The average mortality ranged from 5.1 to 40.0 percent among the female calves born to rest of the 45 sires. The mortality was below 20 percent among the progeny of 54.1 percent of the total sires, between 20 to 30 percent among the progeny of 27 percent sires and between 30 to 40 percent among the progeny of rest of the 12.4 percent sires.

Ram and Tomar (1992) observed highly significant effect of sire on female calf mortality from birth to age at first calving in Murrah buffaloes. No mortality was recorded among the progeny of 10.7 per cent of the total sires.

Among the progeny of 18 percent of the total sires, mortality was more than 40 percent, whereas the mortality was observed as high as 63.1 percent among the progeny of one sire .

Heritability

Low estimates of heritability of mortality rate have been reported by most of the workers (Table 14).

Medium heritability estimates have been reported by Singh(1979) in Sahiwal, Tharparkar, Red Sindhi and crossbred cattle.

(4) Culling rate

Effect of sire

The sire effect was not significant on the culling of female calves from birth to AFC for Tharparkar and its half bred female calves (Tomar and Verma 1988a) and Karan Fries cattle (Tomar and Verma 1988b).

Lathwal and Arun (1993) reported that the effect of sires on culling percentage of female calves from birth to age at first calving in Red Sindhi cattle was highly significant, the culling percentage ranged form 2.5 to 69.2 percent among the progeny of different sires.

Highly significant differences for the culling percentage from birth to age at first calving among the female calves from different sires in Sahiwal cattle were observed by Rawal and Tomar (1994), none of the female calf born to 25 percent sires was culled whereas the culling percentage was as high as 42.8 percent among the female progeny of one sire. More than 30 percent of the female calves were culled for 6.4 percent of the total Sahiwal sires.

Tomar and Rawal (1996) observed highly significant differences in culling rates of female calves from different sires. There were about one-fourth of the total Tharparkar sires whose none of the female calf was culled from the herd till breeding age. The culling rates observed were 10 percent among the female calves of 31.6 percent sires, between 20 to 40 percent among the female calves of 20.2 percent sires and about two third of the female calves from one sire were culled before their reproductive age.

Mukherjee and Tomar (1997) also reported highly significant effect of sire on culling of Karan Swiss female calves. They reported that there was only one out of 48 sires whose none of the female progeny was culled from the herd till they attain reproductive age. The average culling rates varied from 8.0 to 50.7 percent among the progeny of rest 47 sires. Among the progeny of 27 percent of the total sires, the culling rates were below 20 percent and 20 to 30.9 percent for the female progenies of 31.3 percent sires. There were 27.1 and 12.5 percent of the total sires among whose progenies the culling rates were between 30 to 40 percent and exceeded to 40 percent, respectively.

Ram and Tomar (1992) reported highly significant effect of sire on the culling percentage of female calves from birth to age at first calving for Murrah buffalo.

Heritability

Very low estimate of heritability for culling (0.065±0.025) was reported by Schwenger *et al.* (1989) in exotic cattle.

Lathwal and Arun (1993) observed medium (0.347) heritability of culling in Red Sindhi female calves from birth to age at first calving..

The heritability of culling rates of female calves from birth to AFC was reported as 0.1706 for Sahiwal (Rawal and Tomar, 1994a), 0.2123 for Tharparkar (Tomar and Rawal, 1996) and 0.115 for Karan Swiss cattle (Mukherjee and Tomar, 1997).

Ram and Tomar (1992) also reported low heritability estimates of culling of female calves from birth to age at first calving.

(5) Replacement rate

Effect of sire

Tomar & Verma (1988a) reported no effect of sire of the calf on the percentage of female calves reaching to the milking herd.

Lathwal and Arun (1993) reported highly significant effect of sire on replacement rate in Red Sindhi cattle based on female calves and total calves born. The percentage of female calves reaching to milking herd ranged from 30.7 to 92.8 percent on female calf basis and from 16.0 to 53.2 percent on total calf basis among progeny of different sires.

Highly significant differences in replacement rates among the progeny of different sires have been reported by Rawal and Tomar (1992) for Sahiwal and Rawal (1991) for Tharparkar breed based on total births as well as based on female births. The replacement rate ranged from 25 to 97 percent based on female calves born and from 7.7 to 70.0 percent based on total births among the progeny of different sires in Sahiwal breed. The corresponding figures were 28.5 to 95.6 and as 9.9 to 54.5 percent among the progeny of different sires for Tharparkar breed.

Mukherjee and Tomar (1997) also observed highly significant effect of sire on replacement rate on both the basis. They reported that the replacement rate (percentage of female calves reaching milking herd) ranged from 24.6 to 87.5 percent on total calves born basis. The replacement rate (female calf basis) were between 20 to 40 percent among the progenies of 18.7 percent of the total sires and more than 70 percent for the progenies of 18.8 percent total sires. On total calf basis, the replacement rates were below 20 percent for the progenies of 27 percent of the total sires and above 35 percent for the progenies of 12.4 percent of total sires. Thus it may be concluded that the replacement rate was higher among the progenies of certain sires and this information can be utilized to improve the replacement rate.

Table 14: Heritability estimates of replacement rate and its components in dairy herds of different breeds

Breed	Abnormal calving	Sex ratio	Mortality	Culling	Replacement Rate	Reference
Red Sindhi	-	-	0.18±0.11	-	-	Singh (1979)
Sahiwal	-	-	0.38±0.12	-	-	"
"	-	0.05	-	-	-	Sethi & Rao (1981)
"	-	-	0.116	0.17	-	Rawal & Tomar (1994a)
"	-	-	-	-	0.28 (0.06)	Rawal & Tomar (1992)
"		0.095	-	-	-	Rawal & Tomar (1995)
"	0.10	-	-	-	-	Rawal & Tomar (1996a)
Tharparkar	-	-	0.31±0.09	-	-	Singh (1979)
"	-	-	-	-	0.11(0.031)	Rawal (1991)
"	0.16	0.067	-	-	-	Rawal & Tomar (1996c)
"	-	-	0.088	0.21	-	Rawal & Tomar (1996b)
Red Sindhi	0.042	0.016	0.001	0.347	0.23(0.10)	Lathwal & Arun (1993)
Crossbreds	-	0	0.003 to 1.0	-	-	Parekh & Singh (1987)
"	0.07	-	-	-	-	Arun *et al.* (1991b)
"	-	0.06	-	-	-	Arun *et al.* (1993a)
Karan Swiss	0.056	0.002	-	-	-	Mukherjee (1993b)
"	-	-	0.137	0.115	0.225(0.064)	Mukherjee & Tomar (1997)
Exotic	0.05	-	-	-	-	Erb *et al.* (1959)
"	0.43	-	-	-	-	Lindhe (1967)
"	-	0.017	-	-	-	Powell *et al.* (1975)
"	-	-	-	0.065±0.025	-	Schwenger *et al.* (1989)
Murrah	-	-	-0.006±0.11	-	-	Singh *et al.* (1980)
"	-0.05	-	0.095±0.06	-	-	Tomar (1984)
"	-	0.124±0.124	-	-	-	Tomar & Tripathi (1988)
"	0.42	0.206	0.206	0.172	0.124(0.01)	Ram & Tomar (1992)

Figures in parenthesis are the heritability estimate of replacement rate based on total calves born.

Ram and Tomar (1992) observed highly significant effect of sire on the replacement rate in Murrah bufrfaloes. The percentage of female reaching to age at first calving from different sires varied from 31.5 to 100 percent based on female calves born and 14.9 to 43.7 percent based on total calvings.

Heritability

Rawal (1991) reported low heritability of replacement rate in Tharparkar cattle (0.11) based on female calf basis and 0.031 on total calf basis). Rawal and Tomar (1992) reported the heritability estimates as 0.28 and 0.060 for replacement rates in Sahiwal herd on both the basis.

Lathwal and Arun (1993) observed heritability of replacement rate on female calf basis as 0.235 and on total calf basis as 0.103 in Red Sindhi herd.

Mukherjee and Tomar (1997) found the heritability for replacement rate as 0.225 for female calf basis and 0.064 for total calf basis.

Tomar and Ram (1992) reported low heritability estimates for the traits on female calf basis (0.124) as well as on total calf basis (0.011).

2.4. SIRE EVALUATION FOR SELECTIVE VALUE AND ITS COMPONENTS AND THEIR RELATIONSHIP WITH MILK PRODUCTION

Most of the work on sire evaluation has been done on production traits. The author has not come across any work, except Mukherjee (1993), on ranking of sires for selective value. However, very limited information are available regarding sire evaluation for some reproductive traits and daughter's survivability.

Westell *et al.* (1982) evaluated the Canadian Holstein Friesian sires for disposal reasons of their daughters in different lactations. The correlations between sire ranking for same disposal reason in different lactations were positive and ranged from 0.21 to 0.82 for all the disposal reasons.

Martinez *et al.* (1983) studied the genetic relationship between calf livability, calving difficulty and feasibility of sire evaluation for livability and calving difficulty was 0.66. The correlation coefficient between sires transmitting ability for calf livability and for calving difficulty was 0.4.

Erf *et al.* (1990) evaluated the sires for calf mortality based on 7513 calving records of Brown Swiss cattle considering the calf mortality as three traits viz, death at birth, death at 2nd day and death from 1st to 7th day. Sire ranked almost identically (0.99) for death at birth and death through 2nd day and both the traits had the same positive association of 0.55 with death from 1st to 7th day.

Mukherjee (1993) evaluated sires evaluation by estimating the transmitting ability for abnormal birth, female calf losses upto AFC and for selective value (proportion of daughters reached upto AFC). He found negative and low rank correlation for ranking of sires for abnormal birth with female culled upto AFC (-0.08), with female mortality upto AFC (-0.20) and with selective value (-0.2) which were all non-significant. This showed that selection of sire for reduced abnormal birth will not bring any improvement in these traits. There was also a negative and very low rank correlation between the estimates of sires for mortality and culling rates among the daughters of the sires and hence these two traits were not associated. There was a moderately and positive correlation of ranking of sires between selective value and female culled (0.69) and between selective value and female mortality (0.58). This suggested that direct selection of sire for low mortality and culling rates may bring some improvement in selective value. He further reported that the rank correlation between selective value and 305 day first lactation milk was 0.30 which means rank for sires adaptive value also improve the milk yield where as very low positive rank correlation between selective value and first lactation total milk yield (0.04) indicated that there was no correlation between selective value and first lactation total yield. The rank correlation between selective value and AFC was low but positive (0.19).

CHAPTER 3

MATERIAL & METHODS

MATERIAL AND METHOD

3.1. SOURCE OF DATA

The relevant data for the present investigation were collected from the history and pedigree sheets on 735 Hariana cows born from 1970 to 1989 and maintained at Government Livestock Farm, Hisar.

3.2 HISTORY AND BREEDING POLICY OF HERD

Hariana is a well defined dual purpose breed and has been maintained since long at a number of farms. The Government Livestock Farm located at Hisar is one of the oldest farm maintaining a herd of Hariana breed, which was established in the year 1945 under the scheme "To Supplement Livestock Investigations". The initial stock consisted of 80 cows, 150 heifers and 12 bulls. Six of these bull came from farm bred stock and rest six were purchased from the open market. The criterion of selection was on the basis of breed confirmation without much stress on performance records. Upto 1949, there was no culling of male stock. Later on, it was decided to retain only those males for replacement whose dam yielded at least 907 kg of milk in 300 days, but limited to one third of total number of males in each sire family. The retained males had to confirm to the draught type. The families where the dam's performance had not reached 907 kg, a minimum of 3 males of the best performing dams with the best conformity to draught type within a family were retained and the rest were culled. Before 1952-53, females were not culled. Planned selection programme was initiated during 1952-54 in Hariana females with selection criteria of 363 kg of milk in first lactation of 300 days. In order to ensure random selection, all the heifers except those not conforming to breed characteristics were retained atleast till the completion of their first lactation and, thereafter , the low producers were culled. Besides production levels, breed characteristics, poor growth rate, late maturity, reproductive problem and conformation were also considered for culling. Selected females were divided into groups and assigned to progeny tested bulls. Care was taken to avoid mating between close relatives.

3.3. HERD MANAGEMENT AND FEEDING

All the animals were maintained in open enclosures throughout the year. In severe winter they were moved into roofed enclosures. The milch, dry, young and male breeding stock were managed separately. Male and female calves were housed separately after six months of age. Upto 1952, milch and dry cows were let out for grazing on natural pastures. After 1952, only dry cows were let out for grazing except for rainy season. The cows were milked twice daily at 3.30 AM and 3.30 PM. Weaning was not practised. Test day recording was done once in a week.

In general, group feeding system was followed category wise except feeding of advanced pregnant cows and breeding bulls which were kept in individual pens. The feeding schedule for various categories of animals is given in Table 3.1. Antibiotics and feed supplements were given according to the dosage prescribed by the manufacturers. Rations fed to lactating animals were computed on the basis of milk production, live weight and stage of pregnancy. The green fodder consisted of maize and jowar during the month of June to October and berseem, oats and rape mixture from November to March. The dry fodder consisted of jowar karbi, bajra karbi and wheat bhoosa.

Adequate veterinary care was provided round the clock. Animal sheds were sprayed regularly with insecticides and pesticides to control ticks, lice, mosquitoes and flies.

TABLE 3.1. FEEDING SCHEDULE OF DIFFERENT CATEGORIES OF CATTLE

Category of animals	Concentrate* (kg)	Dry fodder (kg)	Green fodder/head/day (adjusted against dry fodder) (kg)
Birth to 3 month	-	-	*ad lib*
3 to 9 months	0.5-1.0	1-3	*ad lib*
Young growing stock	1.0	4	6
Heifers	1.5	6	16
Milch cows	2.5	8	20
Pregnant dry cows	1.5	8	20
Non-pregnant dry cows	1.5	7	16
Breeding bulls	3.0	10	20

*Mineral mixture was supplied in the form of mineral bricks to all categories of animals. Two per cent common salt and 1% mineral mixture were added to the concentrate feed. The concentrate mixture containing 20% D.C.P. and 75% T.D.N. for growing stock and 16% D.C.P. and 75% T.D.N. for lactating animals.

The periodic testing of the herd against Brucellosis, Tuberculosis, and Johne's disease was carried out every year. The animals found positive on the initial testing were segregated from healthy herd. On subsequent testing if they found positive, they were sent to Gosadan. Prophylactic vaccinations were carried out against Black Quarter, Rinderpest, Foot and Mouth Disease and Haemorrhagic septicaemia. Regular deworming of calves as carried out monthly upto age of 9 months.

Identification of calves was done by tattoo marks. Hot iron branding was done at the age of 1 year. Records of pedigree and performance of each animal were maintained regularly.

3.4. DATA RECORDING AND COLLECTION

The records/information on cows and calves for the present investigation were collected from history sheets, birth records and disposal records on different traits viz., production, reproduction, calving and disposal through death and culling at different ages. These were as under:

Cow's records

i. Cow number, its sire and dam number

ii. Date of birth of each cow

iii. Date of service and service sire number for different gestations.

iv. No. of services required for conception

v. Date of calving in all the lactations

vi. Lactation number

vii. First lactation milk yield

viii. Mode of disposal (death or culling) of each cow alongwith date

Calf's recrods

i. Calf number, its sire and dam number

ii. Date of birth

iii. Type (normal and abnormal) and sex of calf

iv. Birth weight of the calf

v. Mode of disposal (death or culling) of female calf from birth to age at first calving along with date.

vi. Date of first calving, if survived.

3.5. *CALCULATION OF CERTAIN PARAMETERS*

The breeding data collected were used to calculate certain other parameters viz., productive herd life, longevity, coefficient of gene replication and lactation specific demographic parameters.

3.5.1. Productive herd life

It was calculated as the number of days from the date of first calving to the date of disposal of the cow from the herd and expressed in years.

3.5.2. Longevity

It was taken as the time interval in years from date of birth to the date of disposal of cows from herd either due to culling or death.

3.5.3. Selective value of each cow (Life time calf production)

The selective value of an animal ~~is~~ was defined as the proportionate contribution of the living female progeny to the next generation. This is the function of the life time calf production and the number of female calves reached to the milking herd from each cow which depends on total calvings, total female calves produced and survived to the milking age. Therefore, the total number of calves, total alive calves, total female calves born and the total number of female calves reach~~ed~~ing ~~to~~ the milking herd from each cow were counted.

3.5.4. Coefficient of gene replication (CGR)

The term CGR was coined by Schons *et al.* (1985) on the basis of the life time female replacements. They defined the CGR as, the additive genetic relationship between adult female and its female descendents reached to milking herd and have become as the replacement heifers. These relationships were considered to be the proportion of a cow's genes that were replicated and given further opportunity to make genetic contribution to the future generation. These relationship were added over each cow's life time female descendents that reached to the milking herd to become the parents of next generation. They have assigned the value *to one female replacement as 0.5 and termed it as the CGR.*

3.5.5. Replacement rate

The replacement rate was taken as the percentage of female calves reach~~ed~~ing to the milking herd to that of the total female calves born as well as to that of the total calves born in any year (Tomer and Verma, 1988 a,b). Replacement rate is more a function of the death and culling of female calves from birth to age at first calving, in addition to the loss of female calves through abnormal birth and male births.

3.5.6. Lactation specific demographic parameters

The following lactation-specific parameters (i-vi) were calculated after Schons *et al* (1985):

(i) **Loss rate(Q_X)**: It is the probability (assuming survival to lactation x,) of dying or culling before lactation x+1. Thus $Q_X = \frac{d_x}{n_X}$

Where,

d_X is the number of animals died and culled during lactation x

n_X is the number of animals present in the herd at the beginning of lactation x

(ii) **Survival rate (P_X)**: This is the complement of Q_X. It is the probability (assuming survival to lactation x) of surviving or remaining in the herd up to lactation x+1 and estimated as

$P_X = L_{X+1}/L_X = 1\text{-}Q_x$

Thus it is the probability of an animal being present to lactation x in the herd to the next lactation of x+1.

(iii) **Stayability** : (L_x) : This is the probability at first lactation of a cow present in the herd to lactation x and estimated as number present at lactation x divided by the number alive at first lactation. The survivorship at first lactation was taken as unity and hence $L_0 = 1.0$. The $L_x = \frac{n_x}{n_0}$. This *can also be estimated as* $L_x = P_X L_{X-1}$

Where n_X = No. surviving at lactation x

n_0 N_0 = No. ofcows at first lactation

(iv) **Expected herd life (Ex)**: This is the number of additional years that an animal of lactation x is expected to remain in the herd Ex more years and it was estimated as the sum of probability of an animal of a given lactation remaining in the herd (Px) through each succeeding lactation upto the last lactation. Thus

$E_X = P_X + P_X P_{X+1} + P_X P_{X+1} P_{X+2} + \ldots P_X P_{X+1}. P_{X+n}$ (Ahmed *et al*, 1992).

$= \left[\sum_{x}^{n} L_{X+1}\right] / L_{X+0.5}$ (Schons *et al*., 1985)

(v) Birth rate (M_X): This is the probability of a cow of lactation x producing a live female calf. Thus

$$M_X = \frac{\text{No. of female calves produced by a cow of lactation x}}{\text{No. of cows in lactation x}}$$

(vi) Reproductve value (V_X): This is the relative contribution of a cow of lactation x to future generation and estimated as :

$$V_X = \left[\sum_{x}^{n} L_x M_x\right] / L_X$$

(vii) Lactation – specific herd structure

The procedure given by Greer *et al.* (1980) was used to estimate the following two parameters indicating the herd structure or age distribution of cows being lost from the herd and being present in the herd of different lactations.

(a) Age-specific loss (q_X): It is the probability of cows being lost that are of each lactation and estimated as :

$$q_x = Q_x L_{X-1} \text{ such that } \sum_{X=1}^{N} q_x = 1.0$$

Where $Q_X = \frac{d_x}{n_X}$

(b) Age – specific distribution of cows (p_x): This is the probability of cows remaining in the herd that are of each lactation and estimated as:

$$p_x = \frac{Lx}{\sum_{x=1}^{n} Lx}, \text{ such that } \sum_{x=1}^{n} p_x = 1.0$$

3.5.7. Over all life table statistics

The following six life table statistics have been estimated after the procedure given by Caughley (1966), Greer *et al.* (1980) and Schons *et al.* (1985):

Greer *et al* (1980) calculated the following two life time parameters as:

i) **Mean age of cows being lost (death and culling):** This parameter was obtained by multiplying each lactation (x) by proportion of cows lost from the herd (q_x) and adding the products i.e. $\Sigma\, x\, q_x$

ii) **Mean age of cows present in the herd:** They obtained this parameter by multiplying each lactation (x) by proportion of total cows present in the herd (P_x) and adding the product i.e. $\Sigma\, x\, p_x$

Caughley (1966) estimated the following two parameters as:

iii) **Mean rate of loss per female per lactation ($\bar{q}_x$):** It is the average probability of a female animal being lost from the herd each lactation . This parameter is calculated as:

$$\bar{q}_x = 1/\Sigma\, L_x \text{ per female per year.}$$

iv) **Average life expectancy at birth:** This is the sum of survivorship at each lactation minus 0.5. Thus it was calculated as :

$$\sum_{i=1}^{n} L_x - 0.5$$

Schons *et al.* (1985) calculated the following two parameters as:

v) **Net reproductive rate:** It was defined as expected number of daughters produced by each animal entering the population or finite rate of population increase per generation. This was estimated as:

$$\sum_{x=0}^{n} (L_x)\,(M_x)$$

vi) **Generation interval (t):** This is the mean interval between birth of a parent and birth of its offspring and estimated as:

$$t = \left[\sum_{x=1}^{n} L_x M_x X\right] / R_0$$

3.5.8. Annual replacement index (ARI)

The procedure of Ram and Tomar (1993) was used to calculated the annual replacement index as :

$$ARI = \frac{\text{No. of heifer calvings in a year}}{\text{No. of cows left the herd}}$$

3.6. CLASSIFICATION OF DATA

The data were spread over a period of 26 years (1970-1996), were divided into following periods:

Periods No.	Year of birth	Year of calving
1	1970-1975	1973-1975
2.	1976-1980	1976-1980
3.	1981-1985	1981-1985
4	1986-1989	1986-1990
5.		1991-1996

The year of calving was divided into four seasons depending upon the temperature, relative humidity and rainfall.

Months	Seasons	Code
December to March	Winter	1
April to June	Summer	2
July to September	Rainy	3
October to November	Autumn	4

The first lactation milk yield groups and age at first calving groups of cows were made based on ½ σ of trait as

Sr. No.	FLMY group (kg)	AFC group (Days)
1.	< 550 kg	< 1100 days
2.	550-749	1100-1299
3.	750-949	1300-1499
4.	950-1149	1500-1699
5.	1150-1349	>1700
6.	1350-1549	
7.	> 1550	

σ = 400 kg σ = 400 days

To study the effect of birth weight of female calves on their mortality, culling and survival in the herd upto the age at first calving, the birth weight groups were made taking a class interval of 2 kg and in all six groups. The first group was made for the female calves having birth weight of 17 kg and less, second group of calves having 18-19 kg and so on, and last group was for those with birth weight of 26 kg or more.

The data were also classified into sire progeny groups for the lifetime calf production traits and for the replacement rate and its components. The data were available on 660 cows of 44 sires for the life time calf production, whereas on 3556 calves of 108 sires for the incidence of abnormal births, sex ratio, mortality, culling and replacement rate.

The adult cows were arranged and a frequency distribution of cows was made according to their life time calf production traits, PHL, longevity etc.

3.7. STATISTICAL ANALYSIS OF DATA

The statistical analysis was conducted to study the effect of genetic and non genetic factors on selective value based on life time calf production and the replacement rate and its components (incidence of abnormal births, frequency of male births (sex ratio), mortality and culling of female calves and survival of female calves upto their age at first calving).

3.7.1. Effect of genetic and non-genetic factors

(1) Replacement rate and its components

The replacement rate and its components viz., incidence of abnormal births, sex ratio, mortality, culling and survival rate upto age at first calving were expressed as proportions or percentage which did not follow normal distribution. So the data were transformed in arcsine (Senedecor and Cochran, 1967). Therefore, resort had to be made for transformation of data into angles. The phenotypic value of an animal expressing the trait was coded as one whereas the value zero was assigned to the animal which did not express the trait. The frequency distribution of two groups of animals viz., having the value 1 and 0 were worked out under different cells developed according to the period, season and parity of calving. These were then used to estimate the proportion of animals expressing the trait. The proportion under each cell, developed according to the period, season and parity of calving, was transformed into angles where

$Q = Sin^{-1}\sqrt{p}$ and p is the proportion of animals for a trait.

The transformation of data was done to make the data amenable to least squares analysis and to make the variance independent of mean. The least squares analysis without interaction (Harvey, 1966) on transformed data was conducted using the following model:

P_i

$Y_{ijkl} = \mu + p_i + S_j + L_k + e_{ijkl}$

Where,

μ is the overall mean

P_i is the effect of ith period of calving (i = 1,2,....5)

S_j is the effect of jth season of calving (j = 1,..., 4)

L_k is the effect of kth parity of lactation (k = 1, ..11)

e_{ijkl} is the random error specific to particular observation.

(2) Selective value and its components

The least squares analysis of variance was conducted to study the effect of period of first calving, age at first calving, and milk production of first lactation on productive herd life, longevity, selective value and its components and CGR by using the following mathematical model:

P_i

$Y_{ijkl} = \mu + p_i + A_j + M_k + e_{ijkl}$

Where,

μ is the overall mean

P_i is the effect of ith period of calving (i = 1,2, ...5)

A_j is the effect of jth AFC group (j = 1,2, ...5)

M_k is the effect of Kth FLMY group (k = 1,2, ...7)

e_{ijkl} is the random error specific to particular observation.

3.7.2. Estimation of genetic parameters

1. Heritability

The heritability estimates of life time calf production traits viz., total calves born, total alive calves born, total female calves born and total female calves reaching milking herd from each cow, longevity, herd life, replacement rate and its components viz., abnormal births, sex ratio, mortality and culling of female calves from birth to AFC and replacement rate to AFC were worked out by the paternal half sib correlation method.

The following model was used:

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

Where,

Yij = observation (total number of life time) calf production trait of jth daughter from ith sire or the observation (Component traits of replacement rate) on jth calf from ith sire.

μ= is the over all mean

S_i = is the effect of ith sire

e_{ij} = is the random error

The expected mean squares (EMS) for between sire component of variance (σ^2_s) and within sire component of variance (σ^2_W) were obtained as under

Source of variation	D.F.	S.S.	M.S.	E.M.S.
Between Sire	S-I	SS_S	MS_S	$\sigma^2_W + k\sigma^2_s$
Within Sire	N-S	SS_W	MS_W	σ^2_W

$$\sigma^2_S = \frac{MS_S - MS_W}{K}$$

where,

K = Av. No. of progenies per sire

$$= \frac{N - \sum n_i^2 / N}{S - 1}$$

S = No. of sire

N = Total number of observations

n_i = number of observation for ith sire

The heritability (h^2) was estimated as :

$$h^2 = 4t$$

$$\text{Where, } t = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_w^2}$$

The standard error of heritability was estimated by using the formula suggested by Swiger *et al.* (1964)

$$S.E.(h^2) = 4\sqrt{\frac{2(N-1)(1-t)^2\left[1+(K-1)t\right]}{K^2(N-S)(S-1)}}$$

(2) Repeatability

The abnormal calving and the birth of male calves (sex ratio) are the repeatable characters. The repeatability of these two traits were worked out by two methods as:

(i) Regression of second record on the first

The cows were divided into two groups. The group one was of the cows which had abnormal births and the second group of those which had normal births in the first gestation. The incidence of abnormal calving among these two groups of cows was worked out based on second gestation. The difference in the incidence of abnormal calving in second gestation between two groups of cows was taken as the repeatability.

Likewise the cows were divided in two group for the incidence of male births and female births in the first gestation. The percentage of male births in second gestation was estimated in the two groups of cows. The difference in sex ratio in the second gestation between the two groups of cows was taken as the repeatability of sex ratio. Thus , repeatability (t) was taken as.

t = difference in two groups of cows for the trait in second gestation.

(ii) Intraclass correlation method

The repeatability was estimated based on all lactation records from intra-cow variability using the following model.

$$Y_{ij} = u + C_i + e_{ij}$$

where,

Y_{ij} is the observation of jth lactation record of ith cow

C_i is the effect of ith cow

eij is the random error

The expected mean squares for the between cow component (σ^2_S) and for the within cow component (σ^2_W) were obtained as under:

Sources of Variation	D.F.	S.S.	M.S.	E.M.S
Between cows	C-1	SS_b	MS_b/c-1	$\sigma^2_W + K\,\sigma^2_b$
Within cows	N-C	SS_W	MS_W/N-C	σ^2_W

$$(\sigma^2_B) = \frac{MS_b - MS_W}{K}$$

Where,

K is the aveage number of records per cow

Repeatability

$$(t) = \frac{\sigma^2_B}{\sigma^2_B + \sigma^2_W}$$

The sum of squares were estimated after Robertson and Lerner (1949) as :

$$\text{Total sum of squares} = \sum a_i - \frac{\left(\sum a_i\right)^2}{\sum n_i}$$

$$\text{Between cow S.S} = \sum \frac{a_i^2}{n_i} - \frac{\left(\sum a_i\right)^2}{\sum n_i}$$

$$\text{Error S.S} = \sum a_i - \sum \frac{a_i^2}{n_i}$$

Where,

a_i No. of records of ith cow expressing the trait

n_i total records of ith cow

3.7.3. Estimation of breeding value of sires

The sires used were ranked for abnormal calving, sex ratio, female calves culled, died and retained upt to AFC. The breeding value of sire for AFC and FLMY were also estimated based on the following two sire indices

$I_1 = \overline{D}$, this is simple daughters average method

$$I_2 = \frac{2\, n_i\, h^2}{4 + (n_i - 1)h^2}(S_i) + \mu$$

Where,

S_i is sire constant for ith sire

n_i is the number of observations for ith sire

h^2 is the heritability of the trait.

μ is the population mean

3.7.4. Rank correlation

Rank correlation between two methods for both traits as well as among the rank of the sires for different traits viz., selective value and its components, AFC and FLMY were calculated by using the following formula:

$$\text{Rank correlation (.r)} = 1 - \frac{6\Sigma d_i^{\,2}}{N(N^2-1)}$$

Where,

N = Total no. of sires

Σd_i^2 = Square of differences between two ranks for a sire and summed overall the sires.

The estimated value of rank correlation was tested for its significance by comparing with the table value at (N-2) degree of freedom.

CHAPTER 4

RESULTS & DISCUSSION

RESULTS AND DISCUSSION

The results of this present investigation have been presented and discussed objective-wise. The important findings on zebu, crossbred and exotic breeds of cattle/buffaloes have been cited to compare the results of this investigation in case of non availability of information on the relevant aspect.

4.1. GENETIC CONTRIBUTION TO FUTURE GENERATION

The whole life time contribution from adult females have been studied in terms of the longevity, the productive herd life expressing it as the number of years after first calving and total number of lactations or total calves produced in the herd, total number of female calves produced, total number of replacement daughters left in the herd by each cow and finally the genetic contribution to future generation in terms of coefficient of gene replication (CGR).

4.1.1. Productive herd life and longevity

The average values of longevity and productive herd life in relation to periods of birth, FLMY group and AFC group have been given in Table 15, the analysis of variance to show the effect of these non-genetic factors in Table 16 and frequency distribution of cows according to their AFC, PHL and longevity have been given in Table 17.

The average life span (longevity) of Hariana cow in this herd was found to be 9.12±0.19 years out of which 5.38 ±0.18 years was the productive herd life during which she calved 5.2±0.16 times. The present estimate fall within the range reported by Singh *et al.* (1964) and Kohli and Suri (1957) for Hariana cattle, Matharu and Gill (1981), Singh *et al.*, (1988) for Sahiwal cattle and Basu *et al.* (1983) for Tharparkar.

The cows born in the first period had the longest life span of 11.86±0.31 years out of which 7.06±0.34 years was the productive herd life. It was found that in last period both longevity and PHL were the shortest (7.06±0.34 and 3.25±0.33 years). Longevity and PHL had decreasing trend in later periods. Statistically the effect of period was found to be highly significant on both the traits (Table 16). Significant effect of period has also been reported by Basu *et al.* (1983) for Tharparkar cows, Hegde and Bhatnagar (1985), Reddy and Basu (1985), Singh and Tomar (1989) and Mukherjee (1993) for crossbred cows and Tanida *et al.* (1988) for beef cows.

Maximum longevity and PHL of 11.63±0.40 and 7.75±0.39 years was observed for the cows which had highest milk production in the first lactation. The longevity and PHL increased with increase in first lactation milk production. Longevity varied from 5.75±0.33 to 11.63±0.40 years, whereas PHL ranged from 2.42±0.32 to 7.75±0.39 years in different FLMY groups. The statistical analysis of the data (Table 15) indicated that FLMY had highly significant effect on both the traits. Lower milk production in the first lactation was the main cause to cull the cows from the herd, so higher milk production in the first lactation was associated with longevity and longer productive herd life. Dentine *et al.* (1987), Ducrorq *et al.* (1988) and Rogers *et al.* (1991) and Mukherjee (1993) observed similar effect and reported that higher milk production in the first lactation was associated with longer life span and PHL. However, Sahato and Gill (1990) reported that milk yield per day of first lactation length had no effect on PHL of crossbred cattle.

It was observed that the longevity increased as the age at first calving increased but for PHL there was a decreasing trend alongwith increase in age at first calving. Longevity was shortest (8.95±0.69 years) whereas PHL was longest (6.21±0.68) years for the cows which attained their age at first calving in early age (below 1100 days). The cows with maximum age at first calving beyond 1700 days had the shortest herd life of 4.85±0.36 years, whereas longevity was the highest 9.67±0.36. Analysis of variance indicated that AFC had highly significant effect on both longevity and PHL. The highest PHL at lower age at first calving means that animal started production at early stage of life and highest AFC caused the PHL to be low and highest longevity, because animal took more time for production. Similar results have also been reported by Dentine *et al.* (1987), Durocq *et al* (1988), Rogers *et al.* (1988) and Mukherjee (1993) mentioning that lower AFC was associated with longer

Table 15: Average longevity and productive herd life of Hariana breed

Effect	No. of cows	Longevity (Years)	Productive herd life	
			Years	Lactations
Overall	**660**	**9.12 ± 0.19**	**5.38 ± 0.18**	**5.2 ± 0.16**
Periods of birth				
1970-75	119	11.86 ± 0.31	7.99 ± 0.30	7.5 ± 0.27
1976-80	193	9.31 ± 0.26	5.49 ± 0.25	5.4 ± 0.23
1981-85	239	8.25 ± 0.24	4.46 ± 0.24	4.3 ± 0.22
1986-89	109	7.06 ± 0.34	3.25 ± 0.33	3.2 ± 0.29
FLMY groups				
< 550 kg	108	5.75 ± 0.33	2.42 ± 0.32	2.1 ± 0.28
550-749	141	7.61 ± 0.29	3.78 ± 0.28	3.2 ± 0.25
750-949	101	7.84 ± 0.33	4.01 ± 0.32	3.9 ± 0.28
950-1149	110	9.51 ± 0.31	5.68 ± 0.31	5.4 ± 0.27
1150-1349	79	10.34 ± 0.36	6.52 ± 0.35	6.1 ± 0.32
1350-1549	58	11.09 ± 0.48	7.34 ± 0.41	6.8 ± 0.36
> 1550	63	11.63 ± 0.40	7.75 ± 0.39	6.7 ± 0.35
AFC groups				
< 1100 days	18	8.95 ± 0.69	6.21 ± 0.68	5.8 ± 0.62
1100-1299	121	8.01 ± 0.29	4.92 ± 0.29	4.5 ± 0.26
1300-1499	288	9.41 ± 0.19	5.56 ± 0.18	5.4 ± 0.16
1500-1699	166	9.57 ± 0.23	5.15 ± 0.22	4.9 ± 0.21
> 1700	67	9.67 ± 0.36	4.85 ± 0.36	4.6 ± 0.32

Table 16: Analysis of variance (m.s. values) for longevity and productive herd life

Sources of variation	D.F.	Longevity	PHL (years)	PHL (Lactation)
Period	3	432.569**	427.449**	333.634**
FLMY	6	344.079**	337.417**	210.769**
AFC	4	43.527**	22.072*	15.488*
Error	646	8.551	8.309	6.759

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

Table 17: Frequency distribution of cows according to their AFC, PHL and longevity (years)

Traits	Years																		
	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19
AFC			2.7	51.8	42.4	3.1													
			(18)	(342)	(280)	(20)													
PHL	20.3	15.1	11.4	6.8	5.6	4.6	5.7	4.5	5.6	6.8	4.3	4.6	2.2	1.6	0.1	0.1			
	(134)	(100)	(75)	(45)	(37)	(31)	(38)	(30)	(37)	(45)	(29)	(31)	(15)	(11)	(1)	(1)			
Longevity				7.5	14.6	12.4	10.7	7.4	6.5	5.1	4.3	5.4	6.2	4.8	5.9	4.0	2.5	1.5	0.4
				(50)	(97)	(82)	(71)	(49)	(43)	(34)	(29)	(36)	(41)	(32)	(39)	(27)	(17)	(10)	(3)

Figures within parentheses are the number of cows.

PHL. On the contrary, Camacho *et al.* (1988) and Sahota and Gill (1990) reported that AFC had no effect on PHL.

Table 17 showed that most of the females (about 94 %) reached their AFC between 3 to 5 years, only very few (2.7 %) females attained their AFC below 3 years and only 3.1 percent female had longer AFC between 5 to 6 years. From the frequency distribution of cows it was observed that on an average, 20.3 percent of the total females had one or less than one year of PHL and 15.1 percent cows had 1 to 2 years of productive herd life. The percentage of cows completing 3, 4 through 13 years of productive life were 11.4, 6.8, 5.6, 4.6, 5.7, 4.5, 5.6, 6.8, 4.3, 4.6 and 2.2 percent where as only about less than two percent of the total cows had productive life of more than 13 years. It was found that only a very few (0.4 %) females have attained the highest longevity (18-19 years) and about 50 percent of the total cows left the herd completing 7 years of longevity. The percentage of cows completing 3 through 16 years of longevity were 7.5, 14.6, 12.4, 16.7, 7.4, 6.5, 5.1, 4.3, 5.4, 6.2, 4.8, 5.9, 4.0 percent and only 4.5 percent of the total cows had longevity of more than 16 years.

4.1.2. Number of calves produced during life time

The average number of total calves produced, total alive calves, total female calves born and total female calves survived upto the age of first calving (or reached milking herd) by each cow in relation to different non-genetic factors have been given in Table 18, the results regarding analysis of variance have been given in Table 19 and the frequency distribution of cows (%) according to their life time calf production have been presented in Table 20.

The average number of total calves produced by each Hariana cow during its life time in the herd was found to be 5.2±0.16. These estimates are more than reported by Kohli and Suri (1957), Katpatal (1977), Sharma and Singh (1974), Tomar *et al.* (1995), Basu *et al.* (1983), Rawal (1991), Rawal and Tomar (1994a) for Indian breeds, Fosgate (1965), Hargrove *et al.* (1969), Gill and Allaire (1976), Nieuwhof *et al.* (1989), Tanida *et al.* (1988) and Schons *et al.* (1985) for exotic breeds, Hegde and Bhatnagar (1985), Singh and Tomar (1983) and Thakur *et al.* (1992) for crossbred cows. However the number of calves produced similar to the present results have been reported by Matharu and Gill (1981) and Roy and Tripathi (1990).

The total number of calves born by each cow of first period were more than those produced by cows in later periods and there was a declining trend in later periods. The variation in total calf production among periods was found to be highly significant. This corroborated with the findings of Mukherjee and Tomar (1996).

It was observed that lesser number of total calves were produced by those cows which had longer age at first calving whereas, the cows which had shorter age at first calving produced more total calves in the herd. The effect of AFC on the trait was significant. Mukherjee and Tomar (1996) also reported similar results.

There was an increasing trend for the total calves born with the increase in first lactation milk production, higher milk producing cows produced more number of calves compared to low milk producers. Total number of calves produced varied from 2.1±0.28 by low milk producers (550kg) to 6.8±0.36 calves by high milk producers (more than 1550 kg FLMY). The effects of FLMY was highly significant on the traits. The significant effect of FLMY on total calves born has also been reported by Mukherjee and Tomar (1996) for crossbred cattle.

Further it was evident that the highest number of total calves produced were 14 by only 0.3 percent of the total cows and about 50 percent cows left the herd after producing 3 or less calves in their life time. 21.2 percent of the cows left the herd after giving only one calf and 18.7 percent after producing two calves in their whole life time. The percentage of cows producing 3 through 9 calves were 9.6, 6.5, 5.9, 6.2, 7.8 and 6.0 respectively and 11.3 per cent cows produced 10 or more calves. The percentage of cows which left the herd after giving birth to 10 or more calves have been reported to be 0.7 for Hariana (Kohli and Suri (1957), 2.0 for Red Singh (Lathwal *et al.*, 1992), 4.0 for Sahiwal (Rawal and Tomar, 1994a) and 5.3 for Tharparkar breed (Rawal, 1991), whereas the percentage of cows which left the herd after producing one calf were 8.8 for Hariana, 28.9 for Red Sindhi, 22.2 for Sahiwal and 22.4 for Tharparkar as reported by these workers.

4.1.3. Number of alive calves born

It was observed that each cow produced on an average 4.9 ±0.15 alive calves. This value is more than reported by Kohli and Suri (1957), Kathpatal (1977), Sharma and Singh (1974), Tomar *et al.* (1995), Rawal (1991) and Rawal and Tomar (1994a) for Zebu breeds, Fosgate (1965), Hargrove *et al.* (1969), Gill and Allaire (1976), Tanida *et al.* (1988) and Schons *et al.* (1985) for exotic breeds, and Hegde and Bhatnagar (1985), Singh and Tomar (1989) and Thakur *et al.* (1992) for crossbred cows. Almost similar number of alive calves produced have been reported by Matharu and Gill (1981) and Roy and Tripathi (1990).

It was further observed that the total number of alive calves born by each cow of first period were more than those produced by cows in later periods and there was declining trend in later periods. Analysis of variance indicated highly significant effect of period on this trait. Mukherjee and Tomar (1996) also reported the similar findings.

From the results it is evident that lesser number of total alive calves were produced by those cows which had longer age at first calving whereas the cows which had shorter age at first calving produced more alive calves in the herd. It was also observed that there was an increasing trend for the total alive calves born with the increase in FLMY, high milk producer cows produced more alive calves than low milk producers. It was also observed that total alive calves production were affected significantly by FLMY and AFC of the cows. This is in agreement with the findings of Mukherjee and Tomar (1996) for crossbred cattle.

The frequency distribution of cows according to the total number of alive calves produced in their life time indicated that 1.2 percent of the total cows left the herd without producing any alive calf. Rawal (1991), Lathwal *et al.* (1992) and Rawal and Tomar (1994a) reported that 0.6 to 1.4 percent total cows did not produce any alive calf.

Table 18: Average values of life-time calf production traits in relation to non-genetic factors

Effect	No. of cows	No. of alive calves born	No. of female calves born	No. of female calves survived upto AFC (Selective value)	C.G.R.
Overall	**660**	**4.9 ± 0.15**	**2.38 ± 0.15**	**1.2 ± 0.21**	**0.6 ± 0.11**
Periods of births					
1970-75	119	7.2 ± 0.26	3.6 ± 0.15	1.9 ± 0.11	0.95 ± 0.05
1976-80	193	5.1 ± 0.22	2.4 ± 0.13	1.3 ± 0.10	0.65 ± 0.05
1981-85	239	4.0 ± 0.21	1.8 ± 0.12	0.7 ± 0.36	0.35 ± 0.18
1986-89	109	3.0 ± 0.28	1.6 ± 0.17	0.7 ± 0.13	0.34 ± 0.06
FLMY groups					
< 550 kg	108	1.9 ± 0.27	1.1 ± 0.16	0.5 ± 0.13	0.25 ± 0.06
550-749	141	3.0 ± 0.24	1.8 ± 0.14	0.8 ± 0.11	0.40 ± 0.05
750-949	101	3.5 ± 0.28	1.8 ± 0.16	0.7 ± 0.12	0.35 ± 0.06
950-1149	110	5.1 ± 0.26	2.6 ± 0.16	1.0 ± 0.12	0.50 ± 0.06
1150-1349	79	5.7 ± 0.31	2.8 ± 0.18	1.5 ± 0.14	0.75 ± 0.07
1350-1549	58	6.5 ± 0.35	3.2 ± 0.21	2.2 ± 0.16	1.10 ± 0.08
> 1550	63	6.3 ± 0.35	2.9 ± 0.20	1.8 ± 0.15	0.90 ± 0.07
AFC groups					
< 1100 days	18	5.4 ± 0.59	2.6 ± 0.36	1.3 ± 0.27	0.65 ± 0.13
1100-1299	121	4.3 ± 0.25	2.3 ± 0.15	1.1 ± 0.11	0.55 ± 0.05
1300-1499	288	5.2 ± 0.15	2.5 ± 0.35	1.4 ± 0.42	0.70 ± 0.20
1500-1699	166	4.7 ± 0.19	2.3 ± 0.11	1.2 ± 0.39	0.60 ± 0.19
> 1700	67	4.4 ± 0.31	2.1 ± 0.19	1.0 ± 0.15	0.50 ± 0.07

Table 19: Analysis of variance to test the effect of non-genetic factors on life time calf production traits (m.s. values)

Source of variation	D.F.	Alive calves born	Female calves born	Selective value	C.G.R.
Period	3	328.807**	82.783**	41.121**	10.561**
FLMY	6	207.548**	41.387**	26.888**	6.332**
AFC	4	16.351*	3.489	2.556	0.612
Error	646	6.213	2.276	1.289	0.321

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

Table 20: **Frequency distribution of cows (%) according to their life time calf production traits**

Life time calf production	Value of the trait														
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Total calves born	-	21.2 (138)	18.7 (124)	9.6 (64)	6.5 (43)	6.7 (45)	5.9 (39)	6.2 (41)	7.8 (52)	6.0 (40)	4.1 (27)	4.0 (26)	2.2 (15)	0.7 (5)	0.3 (2)
2. Normal calves born	1.2 (8)	21.9 (144)	18.5 (122)	10.5 (69)	5.8 (38)	6.5 (43)	6.3 (42)	5.3 (35)	6.6 (44)	5.8 (38)	4.9 (32)	3.6 (24)	1.0 (7)	0.9 (6)	1.2 (8)
3. No. of female calves born	19.3 (127)	25.3 (167)	17.4 (115)	14.3 (94)	11.9 (78)	6.8 (45)	3.4 (22)	0.9 (6)	0.7 (5)	0.1 (1)					
4. Female reached milking herd	49.3 (326)	21.4 (141)	12.9 (85)	8.7 (57)	5.5 (36)	1.9 (13)	0.15 (1)	0.15 (1)							
5. Abnormal calvings	83.8 (547)	15.0 (99)	1.8 (12)	0.3 (2)											

Figures in parentheses indicate number of cows.

4.1.4 Number of female calves born

It was observed that, on an average, each cow during its life time in the herd produced 2.38±0.15 female calves. This estimate is higher than reported by Tomar *et al.* (1995) for Red Sindhi, Rawal (1991) for Tharparkar, Rawal and Tomar (1994a) for Sahiwal, Mukherjee and Tomar (1996) for crossbred, Schons *et al.* (1985) for exotic cattle, Tomar and Basu (1981), Tomar and Ram (1992) for Murrah buffalo herd. The similar number of female calves produced by a crossbred cow were reported by Thakur *et al.* (1992).

There was a decreasing trend for the number of female calves produced in later periods. The cows in the first period produced more number of female calves (3.6±0.15). Mukherjee and Tomar (1996) also observed significant effect of period on the trait.

There was a positive association between FLMY and the total number of female calves produced. The cows which had milk production above 1350 kg during first lactation harvested the maximum female calves and the cows which had less than 550 kg FLMY produced less number of female calves (1.1±1.6) in the herd. Statistical analysis of the data (Table19) had shown highly significant effect of FLMY on total number of female calves produced by each cow in the herd. Similar to the present results were reported by Mukherjee and Tomar (1996).

Statistically the AFC did not affect significantly the total number of female calves produced but the cows which had their AFC below 1100 days produced more number of female calves (2.6±0.36) as compared to those which had AFC more than 1700 days (2.1±0.19). This is in contrary to those reported by Mukherjee and Tomar (1996) who found significant effect ($P>0.05$) of AFC on total number of female calves produced by each cow.

From the frequency distribution of cows according to the total number of female calves produced, it was observed that 19.3 per cent of the total cows in the herd could not produce any female calf, 25.3 per cent cows left the herd after producing only one female calf. The percentage of cows produced 2 through 5 female calves were 17.4, 14.3, 11.9 and 6.8 per cent. Only 5 per cent of total cows produced more than 5 females calves while a maximum number of 9 female calves were produced by only one cow.

The percentage of cows which could not produce any female calf have been reported as 23.6 for Red Sindhi cows (Lathwal *et al.* 1992), 19.1 for Sahiwal (Rawal and Tomar, 1994) and 22.1 for Tharparkar cows (Rawal, 1991) in the herd. They also reported that about one third of the total cows produced only one female calf and about one fifth produced only two female calves with the maximum number of female calves produced as 8, 7 and 10 respectively by only few cow (<0.5%).

4.1.5. Number of female calve reached milking herd (selective value)

The average number of female calves reaching to the milking herd from each cow was found to be 1.2±0.21. Almost similar results have been reported by Schons *et al.* (1985) for Angus breed, Rawal (1991) for Tharparkar cattle, Rawal and Tomar (1994a) for Sahiwal, whereas Thakur *et al.* (1992) for crossbred cattle reported more number of female reaching to the milking herd. Les than one heifer replacement per cow was left as reported by Tomar *et al.* (1995) for Red Sindhi cows and Mukherjee and Tomar (1996) for Karan Swiss cows.

The cows in the first period of study left on an average 1.9±0.11 replacement daughters and it was 0.7±0.13 in the last period of the study. The number of replacement daughters decreased in subsequent periods. Statistical analysis of the data had shown that the effect of period on the total female reached to the milking herd by each cow was highly significant. This is in agreement with the findings of Mukherjee and Tomar (1996).

There was a positive association among FLMY and number of heifer replacements. The lower milk producer (<550kg) left lesser number of replacement daughter (0.5±0.13) as compared to the higher milk producers (>1350kg) which left about 2 replacement daughters. Results indicated highly significant effect of FLMY on this trait. The findings of Mukherjee and Tomar (1996) supported the present results.

Effect of AFC was not significant on the female survived upto age at first calving (Table 19). Similar result were also observed by Mukherjee and Tomar (1996) for crossbred.

Further it was observed that about fifty percent (49.3%) of the total cows left the herd without giving any replacement heifer whereas 21.4 percent of the total cows left only one, 12.9 and 8.7 percent left two and three replacements and rest 7.5 percent of the total cows left four or more replacement daughters with maximum of 7 replacement daughters left by only one cow (0.1%). The percentage of cows which id not leave any replacement daughters, was 42.4 for Red Sindhi (Tomar *et al.* 1995), 33.9 for Sahiwal (Rawal and Tomar, 1994a), 39.6 percent for Tharparkar cows (Rawal 1991) and 54.8 percent for Karan Swiss (Mukherjee and Tomar (1996). Ram (1988) reported that about one half of total Murrah buffaloes (51.4%) could not replace themselves, 31.4 per cent left only one replacement daughter. They also reported that the maximum number of 6 to 8 replacement daughters were left by only 0.1 percent of the total cows.

4.1.6 Coefficient of gene replication (CGR)

Coefficient of gene replication for this herd was found to be on an average 0.6±0.11 and it indicated that this value is more than the one time gene replication (0.5). The CGR value higher than one have been reported by Rawal (1991) for Sahiwal (0.63±0.02) and Rawal *et al.* (1993) for Tharparkar cows (0.58±0.02) whereas, Schons *et al.* (1985) for Angus breed, Mukherjee (1993) for Karan Swiss, Tomar *et al.* (1995) for Red Sindhi and Tomar and Ram (1991) for Murrah buffalo observed CGR values lesser than one time gene replication (0.5).

The highest CGR value (0.95±0.05) was found only in first period and there was a decreasing trend in subsequent periods. It was less than one time gene replication (0.5) in the III (0.35±0.18) and IV (0.34±0.06) period of the study and it indicated that females were not replacing themselves in the herd in later periods. Statistical analysis of the data indicated that the period had highly significant effect on CGR. Present findings are in conformity to those of Mukherjee (1993).

The CGR of this herd had positive association with FLMY. The cows which produced about 1150 kg or more milk in the first lactation have the CGR value more than one time gene replication (0.5) and hence they had their full genetic contribution to future generation. Statistically the effect of FLMY was highly significant on the CGR whereas the AFC did not affect this trait. Mukherjee (1993) observed that FLMY and AFC had highly significant effect on the CGR.

4.2. REPLACEMENT RATE AND ITS COMPONENTS

The average values of replacement rate and its different components in relation to non genetic factors have been presented in Tables .

4.2.1 Number of services per conception (S/C)

The average number of services required per conception, average incidence of repeat breeders and problem cows in relation to different non-genetic factors have been given in Table 21 and 23 and the result regarding analysis of variance to show the effect of non genetic factors on S/C, conception rate at first service, repeat breeders and problem cows have been given in Table 22.

The results indicated that a cow in this herd, on an average required 1.86±0.18 service to conceive. This value is almost similar reported by Kohli *et al.* (1961), Singh *et al.* (1964), Tomar and Arora (1971b) for Hariana breed, and Basu *et al.* (1979) for Red Sindhi, whereas higher value have been reported by Singh *et al.* (1968), Singh and Singh (1970), Tomar and Arora (1971a), Grewal *et al.* (1974) Kumar and Bhat (1979) for Hariana breed, Sharma and Bhatnagar (1975), for Tharparkar Red Sindhi and Sahiwal, Singh *et al.* (1990) for Sahiwal and Arun (1997) for crossbred.

The average service per conception varied from 1.65±0.01 to 2.05±0.24 in different lactations and it was less at heifer stage than in older cows. Statistical analysis of the data showed that the differences in S/C among different lactation were significant. This supported the findings of Singh *et al.* (1964), Singh and Parsad (1969) and Tomar and Arora (1971b) where as non-significant of effect of lactation on S/C was reported by Singh (1961), Singh and Singh (1970), Kumar and Bhat (1979),

Table 21: Average number of services required per conception, repeat breeders and problem cows in relation to non-genetic factors

Effects	No.	S/C±S.E.	Incidence of			
			Repeat Breeders		Problem Cows	
			%	No.	%	No.
Overall (μ)	**3672**	**1.86±0.18**	**10.8**	**(397)**	**0.8**	**(30)**
Lactations						
1	738	1.65±0.02	7.8	(58)	0.9	(7)
2	594	1.85±0.04	11.6	(69)	0.3	(2)
3	472	1.97±0.05	12.0	(57)	1.6	(8)
4	405	1.86±0.05	11.3	(46)	0.7	(3)
5	360	1.82±0.05	10.5	(38)	0.5	(2)
6	309	1.87±0.06	10.3	(32)	0.6	(2)
7	261	1.87±0.06	11.5	(30)	0.3	(1)
8	209	2.03±0.08	12.9	(27)	0.9	(2)
9	144	1.97±0.09	11.8	(17)	0.6	(1)
10	90	1.88±0.11	11.1	(10)	1.1	(1)
11	56	1.82±0.09	10.7	(6)	0.0	(0)
12	34	2.05±0.24	20.5	(7)	2.9	(1)
Periods						
1970-75	52	2.02±0.25	11.5	(6)	7.6	(4)
1976-80	426	1.89±0.05	12.6	(54)	0.7	(3)
1981-85	919	1.84±0.03	11.3	(104)	0.7	(7)
1986-90	1087	1.78±0.03	9.6	(105)	0.9	(10)
1991-95	1072	1.84±0.04	10.7	(115)	0.4	(5)
1996-98	116	2.13±0.10	11.2	(13)	0.8	(1)
Seasons						
Winter	1788	1.75±0.02	9.6	(172)	0.5	(9)
Summer	931	1.85±0.03	10.3	(96)	0.7	(7)
Rainy	562	2.05±0.04	14.0	(79)	1.0	(6)
Autumn	391	1.97±0.08	12.8	(5.0)	2.0	(8)

Table 22: Analysis of variance (M.S. Values) to show the effect of non-genetic factor on average services per conception, repeat breeder and problem cows

Source of variation	D.F.	Service per conception (S/C)	Conception rate at first service	Repeat Breeder	Problem Cows
Lactation	11	3.068*	0.9194**	0.1113	0.0067
Period	5	3.0169*	1.0684**	0.0645	0.0521**
Season	4	15.496**	2.9545**	0.3412**	0.0238**
Error	3651	1.5903	0.2415	0.0968	0.0081

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

Table 23: Frequency distribution of cows (%) conceived at subsequent services in relation to non-genetic factors

Effects	Service (insemination) per conception								Total cows
	1	2	3	4	5	6	7	8	
μ	54.4 (1997)	24.7 (907)	10.1 (371)	5.8 (213)	3.8 (140)	0.4 (14)	0.2 (9)	0.5 (21)	3672
Lactation									
1	63.9 (472)	21.6 (160)	6.5 (48)	3.8 (28)	3.1 (23)	-	-	0.9 (7)	738
2	52.8 (314)	25.7 (153)	9.7 (58)	7.2 (43)	3.7 (22)	0.4 (2)	0.6 (1)	0.6 (1)	594
3	49.2 (232)	27.5 (130)	11.2 (53)	6.1 (29)	3.6 (17)	0.6 (3)	0.4 (2)	1.2 (6)	472
4	53.3 (216)	25.4 (103)	9.9 (40)	6.4 (26)	3.9 (16)	0.2 (1)	-	0.7 (3)	405
5	56.1 (202)	22.2 (80)	11.1 (40)	6.1 (22)	3.3 (12)	0.6 (2)	0.5 (2)	- -	360
6	53.4 (165)	23.9 (74)	12.2 (38)	5.1 (16)	3.9 (12)	0.6 (2)	0.3 (1)	0.3 (1)	309
7	52.5 (137)	24.1 (63)	11.5 (30)	6.5 (17)	4.2 (11)	0.4 (1)	-	0.3 (1)	261
8	45.9 (96)	26.8 (56)	14.3 (30)	6.2 (13)	5.2 (11)	0.5 (1)	0.4 (1)	0.4 (1)	209
9	45.8 (66)	31.9 (46)	9.7 (14)	6.2 (9)	3.5 (5)	1.4 (2)	0.6 (1)	-	144
10	54.4 (49)	25.5 (23)	10.0 (9)	4.4 (4)	5.5 (5)	-	1.1 (1)	-	90
11	55.3 (31)	23.2 (13)	10.7 (6)	5.3 (3)	5.3 (3)	-	-	-	56
12	47.0 (16)	17.6 (6)	14.7 (5)	8.8 (3)	8.8 (3)	-	-	0.9 (1)	34
Period									
1970-75	61.5 (32)	19.2 (10)	7.7 (4)	-	3.8 (2)	0 (0)	1.9 (1)	5.7 (3)	52
1976-80	54.2 (231)	23.5 (100)	9.6 (41)	6.6 (28)	4.5 (19)	0.9 (4)	0 (0)	0.7 (3)	426
1981-85	55.4 (509)	23.2 (213)	10.1 (93)	6.7 (62)	3.5 (32)	0.3 (3)	0.4 (4)	0.3 (3)	919
1986-90	56.7 (610)	23.7 (258)	9.9 (108)	5.0 (55)	3.5 (38)	0.1 (2)	0.2 (3)	0.6 (7)	1087
1991-95	52.9 (568)	26.5 (284)	9.8 (105)	5.8 (62)	4.1 (44)	0.3 (4)	0.1 (1)	0.3 (4)	1072
1996-98	35.3 (41)	36.2 (42)	17.2 (20)	5.2 (6)	4.3 (5)	0.8 (1)	0 (0)	0.8 (1)	116
Season									
Winter	58.6 (1048)	23.3 (418)	8.4 (150)	4.9 (89)	3.8 (68)	0.3 (6)	0.1 (2)	0.3 (7)	1788
Summer	53.0 (494)	25.8 (240)	10.8 (101)	5.5 (51)	3.9 (36)	0.2 (2)	0.2 (2)	0.5 (5)	931
Rainy	44.7 (251)	28.1 (158)	13.1 (74)	8.5 (48)	3.7 (21)	0.7 (4)	0.5 (3)	0.5 (3)	562
Autumn	52.2 (204)	23.3 (91)	11.8 (46)	6.4 (25)	3.8 (15)	0.5 (2)	0.5 (2)	0.1 (6)	391

Sharma and Bhatnagar (1975), Basu *et al.* (1979), Bhatnagar *et al.* (1979), Chaudhary *et al.* (1984) and Arun (1997).

The average S/C ranged from 1.78±0.03 to 2.13±0.10 among different years in this herd. Statistical analysis of the data indicated that variation in S/C among years were significant. This supported the findings of Basu and Ghai (1980), Singh *et al.* (1990) and Arun (1997), whereas non-significant effect were reported by Agarwal (1974), Grewal *et al.* (1974) and Singhal *et al.* (1981).

Services per conception ranged from 1.75±0.02 to 2.05±0.04 among different seasons. Statistical analysis of the data indicated that the variation in S/C among seasons was highly significant. Present results are in conformity those of Bhatnagar *et al.* (1979), Basu *et al.* (1979), Singh *et al.* (1964), Grewal *et al.* (1974), Panda (1972), Dutt *et al.* (1980), Raja and Rao (1983) and Chaudhary *et al.* (1984). On the contrary, Kohli *et al.* (1961), Pachlag *et al.* (1982), Tomar *et al.* (1972) and Arun (1997) reported that S/C did not differ significantly among seasons.

From the results it was observed that 54.4 percent of the total cows in this herd conceived with first service and rest of them required more than one service for conception (Table 23). Almost similar values of conception rate with first service were reported by Tomar and Arora (1971b) for Hariana cows (54.2%), Bhatnagar and Sharma (1985) for Karan Swiss cows (50.0%) and Arun (1997) for crossbred (54%). It was further observed that the conception rate with subsequent services decreased. It was found that 54.4, 24.7, 10.1 5.8, and 3.8 percent of the total cows in the herd were conceived with first through five services respectively and only 1.3 percent of the total cows required more than 5 services to conceive.

On an average, 10.8 percent of the total cows in this herd required more than 3 services (repeat breeders) for conception. Lower incidence of repeat breeding was observed in first calf heifers (7.8%) in comparison to subsequent parity. This supported the findings of Arun (1997) for crossbred cattle. The high incidence of repeat breeding among older cows may be due to the reason that older cows were exposed to the risk of retention of placenta and metritis which leads to decrease in fertility rate (Roberts, 1971; Pandit *et al.*, 1989; Tomar and Tripath, 1986b).

The effect of year on the incidence of repeat breeding was also found to be highly significant. The incidence of repeat breeding ranged from 9.6 to 12.6% among different years and was similar to those reported by Tomar and Tripathi (1986b).

The frequency of cows required more than 6 services for conception (Problem cows) was found to be 0.8% in this herd.

4.2.2. Abnormal births

The average incidence of abnormal births among total births according to period, season and parities are presented in Table 24 and the ANOVA to test the effect of non-genetic factors on the abnormal birth and sex ratio are given in Table 25.

It was observed that on an average the incidence of abnormal birth was found to be 4.5% among 3556 total births in this herd. Almost similar incidence of abnormal birth have been reported by Sharda and Lohia (1966) for Hariana cattle, Reddy and Sampath (1981), Tomar and Verma (1981), *Lathwal et al. (1993) for Red Sindhi, Tomar and Verma (1988a) and Rawal* and Tomar (1996c) for Tharparkar, Reddy and Sampath (1981) for Gir and Ongole. On the other hand, higher estimates were observed by Luktuke and Chaudhary (1965) and Halder and Sen (1970) for Hariana cow, Sharma and Jain (1983) for Red Sindhi, Amble and Jain (1967), Tomar *et al.* (1975) and Sharma and Jain (1983) for Sahiwal cows, Bhosrekar (1973), Sharma and Jain (1983) and Parbhu and Chatterjee (1970) for Tharparkar, whereas lower incidence were reported by Tomar and Singh (1973) for Hariana cows, Rawal and Tomar (1996a) and Parbhu and Chatterjee (1970) for Sahiwal cows and Shukla *et al.* (1980) for Gir.

The rate of abnormal births was lowest in the second period (2.5%) and highest in the last period (6.4%). The analysis of variance revealed non significant effect of period on abnormal births. This was in agreement with the reports of Tomar *et al.* (1975), Tomar and Verma (1981 and 1988a) in Sahiwal, Red Sindhi and Tharparkar cows respectively, Negi and Luktuke

(1982) for crossbred cattle and Singh and Jain (1997) for native and crossbred cattle. However, significant effect of period of calving has been reported by Lathwal *et al.* (1993) for Red Sindhi, Rawal and Tomar (1996a,c) for Sahiwal and Tharparkar cow, Arun *et al* (1995) and Mukherjee (1993) for crossbred cattle.

The incidence of abnormal births was less among calves born during summer and winter (3.7 and 4.2%) than those born during rainy and autumn season (5.1 and 7.3%). Non-significant effect of season of birth on the abnormal calving was observed. Similar results were reported by Prabhu and Chatterjee (1970) for Hariana, Red Sindhi, Sahiwal and Tharparkar, Sharda and Lohia (1966) for Hariana cow, Tomar *et al.* (1975) and Rawal and Tomar (1996a,c) for Sahiwal and Tharparkar cows, Tomar and Verma (1981) for Red Sindhi, Tomar and Verma (1988a,b) for Tharparkar and crossbred, Shukla *et al.* (1980), Reddy and Sampath (1981) and Singh and Jain (1997) for crossbred cattle. On the contrary, significant effect of season of calving was reported by Pandey and Desai (1973), Sharma and Jain for Red Sindhi, Sahiwal and Tharparkar, Lathwal *et al.* (1993) for Red Sindhi, Negi and Luktuke (1982), Mukherjee (1993), Arun *et al.*(1993b) for crossbred cattle.

The incidence of abnormal birth varied from 2.7 to 9.1 percent among the cows of different parity. Results revealed non-significant effect of parity on this trait. Present results are in conformity to those of Prabhu and Chatterjee (1970), Tomar *et al.* (1975), Shukla *et al.* (1980), Reddy and Sampath (1981), Tomar and Verma (1981), Sharma and Jain (1983), Tomar and Verma (1988a, b), Lathwal *et al.* (1993), Rawal and Toamr (1996a,c). However, significant effect of parity order was reported by Tomar *et al.* (1975), Sharda and Lohia (1966), Negi and Luktuke (1982), Chatterjee *et al.* (1985), Arun *et al.* (1993b), Mukherjee *et al.* (1993) and Singh and Jain (1997).

4.2.3. Sex ratio (% male births)

Average sex ratio according to periods season and parity are presented in Table 24 and analysis of variance in Table 25.

Average sex ratio for this herd was observed to be 51.4 percent. Similar to the present results were observed by the Tomar and Arora (1970), Rao *et al.* (1970), Goswami *et al.* (1963) for Hariana, Rawal and Tomar (1995), Pandit *et al.* (1989) for Sahiwal, Tomar and Verma (1988a and 1981), Kulkarani (1980) and Rawal and Tomar (1996c) for Tharparkar, Tripathi *et al.* (1973) for Kankrej, Rao *et al.* (1969) for Ongole, whereas, higher values of sex ratio have been observed by Tomar *et al.* (1976) for Sahiwal, Kale *et al.* (1982) for Red Sindhi, Rao *et al.* (1970) for Hariana, Tomar and Verma (1988a), Arun *et al.* (1992) and Pandit *et al.* (1989) for crossbred cattle.

The sex ratio was highest among the calves born during last period (53.3%) and lowest in the first period (42%). However, the frequency of male births among different periods did not differ significantly. The period of calving was not a significant source of variation in sex ratio as reported by Rao *et al.* (1970), Tomar and Arora (1970), Tomar *et al.* (1976), Sethi and Rao (1981), Kale *et al.* (1982), Singh *et al.* (1983), Shukla and Parekh (1988), Tomar and Verma (1988a) and Rawal and Tomar (1995 and 1996c). On the contrary, significant effect of period on sex ratio had been reported by Lathwal *et al.* (1993) in Red Sindhi, Arun *et al.* (1992) for crossbred cows and Singh and Jain (1997) for native and crossbreds.

The season of birth had no effect on the sex ratio in this herd (Table 25). These results are in agreement to the reports of Tomar *et al.* (1976), Kale *et al.* (1982), Singh *et al.* (1983), Lathwal (1993) and Rawal and Tomar (1995 and 1996c) for calves born to Zebu breeds, Patel *et al.* (1988), Tomar and Verma (1988b), Arun *et al.* (1992) for crossbred cows and Singh and Jain (1997) for native and crossbreds. On the other hand, significant effect of season on the sex ratio was reported by Singh and Singh (1968), Tomar and Arora (1970), Kulkarni (1980), Sethi and Rao (1981) and Tomar and Verma (1988a) for zebu breeds.

The sex ratio varied from 48.6 to 58.6 percent among different parity of calving. However, parity of calving did not affect the sex ratio. This is in agreements of the findings of Tomar and Arora (1970), Tomar *et al.* (1976), Sethi and Rao (1981), Singh *et al.* (1983), Kale *et al.* (1982), Singh *et al.* (1991), Rawal and Tomar (1995 and 1996c), Arun *et al.* (1992), Lathwal *et al.*

Table 24: Average incidence (%) of abnormal births and sex ratio in relation to non-genetic factors

Effects	Total births	Abnormal births %		Normal births Sex ratio (Male births)		Female births	Total
Overall	**3556**	**4.5**	**(163)**	**51.4**	**(1745)**	**1648**	**3393**
Periods							
1973-75	52	3.8	(2)	42.0	(21)	29	50
1976-80	426	2.5	(11)	49.9	(207)	208	415
1981-85	919	3.1	(28)	51.6	(460)	431	891
1986-90	1087	4.8	(53)	50.6	(523)	511	1034
1991-96	1072	6.4	(69)	53.3	(534)	469	1003
Season							
Winter	1734	4.2	(74)	51.1	(848)	812	1660
Summer	898	3.7	(34)	51.5	(445)	419	864
Rainy	539	5.1	(27)	52.3	(271)	241	512
Autumn	385	7.3	(28)	50.8	(181)	176	357
Parity							
1	737	4.1	(30)	48.6	(343)	364	707
2	593	4.2	(25)	51.8	(294)	274	568
3	471	4.9	(23)	49.4	(221)	227	448
4	402	4.5	(18)	51.8	(199)	185	384
5	348	4.3	(15)	51.9	(173)	160	333
6	293	5.2	(15)	52.2	(145)	133	278
7	240	5.8	(14)	54.8	(124)	102	226
8	192	2.7	(5)	53.1	(99)	88	187
9	123	4.1	(5)	58.5	(69)	49	118
10	80	7.5	(6)	50.0	(37)	37	74
≥ 11	77	9.1	(7)	58.6	(41)	29	70

Figures in parentheses are number of observations.

Table 25: Analysis of variance (m.s. value) to test the effect of non-genetic factors on abnormal births and sex ratio

Source of variance	D.F.	Abnormal birth	Sex ratio
Period	4	0.1919	0.2378
Season	3	0.1208	0.0515
Parity	10	0.0383	0.2101
Error		0.435 (3538)	0.2493 (3375)

Figures in parentheses are the error degrees of freedom.

(1993), Mukherjee (1993) and Singh and Jain (1997). On the contrary, Singh and Singh (1968), Kulkarni (1980), Tomar and Verma (1988a,b) and Sangle and Kulkarni (1979) reported that sex ratio differed significantly among parities.

4.2.4. Post calving losses of female calves from birth to AFC

The female calves born alive are lost from the herd either due to their death or culling for certain reasons before they joins the milking herd. The average mortality and culling rates among the total female calves born in different periods, season of birth and dam's parity, have been given in Table 26 and the analysis of variance in Table 27.

I. Mortality

The average mortality rate among the female calves from birth to age at first calving was observed to be 21.1 percent. Almost similar mortality rates have been reported by Lemka *et al.* (1973), Tomar and Verma (1988a) and Tomar and Rawal (1996) for female calves born to Zebu breeds, whereas higher mortility rates were reported by Amble and Jain (1967) and Singh and Jain (1997) for cattle and lower estimates were reported by Amble *et al.* (1958), Singh *et al.* (1987), Reddy and Nagarcenkar (1989a), Chaudhary *et al.* (1984), Lathwal *et al.* (1993) and Rawal and Tomar (1994a).

From the results it was observed that mortality among female calves varied significantly from 12.8 to 26.9 percent in different periods being maximum in last period and minimum in III and I periods. Significant effect of year on mortality has also been reported by Lemka *et al.* (1973), Tomar and Verma (1988a), Reddy and Nagarcenkar (1989a), Rawal and Tomar (1994b), Tomar and Rawal (1996) for zebu cattle, Chaudhary *et al.* (1984), Tomar and Verma (1988b) for crossbred cattle and Singh and Jain (1997) for native and crossbred cattle, whereas Lathwal *et al.* (1993) could not observe any effect of year on female calf mortality.

It was also observed that the mortality rates were higher among calves born during winter (22.7%) and summer season (21.9%) than among those born during autumn (18.2%) and rainy season (19.1%). However, the differences among season were statistically non-significant. No effect of season on mortality was also observed by Lemka *et al.* (1973), Reddy and Nagarcenkar (1989), Rawal and Tomar (1994b), Lathwal *et al.* (1993), Tomar and Rawal (1996) for zebu cattle, Tomar and Verma (1988b) and Mukherjee and Tomar (1996) for crossbred and Singh and Jain (1997) for native and crossbred. On the contrary, Chaudhary *et al.* (1984) and Tomar and Verma (1988a) reported that mortality rates differed significantly due to season of birth.

The mortality of female calves was little higher (24.3%) from first calvers (heifers) as compared to the female calves produced by older cow. Parity had no significant effect on the female calf mortality from birth to age at first calving (Table 27). This supported the findings of Tomar and Verma (1988a,b), Rawal and Tomar (1994b) and Tomar and Rawal (1996) for cattle. On the contrary, significant effect of parity was reported by Lathwal (1993) and Singh and Jain (1997).

Regarding the effect of birth weight on mortality (Table 28) it was observed that mortality was high in calves having birth weight equal or less than 17 kg (33.3%) and it was low for those which had birth weight more than 26kg (5.5%). However, effect of birth weight group did not affect mortality (Table 29). Lathwal (1991), Mukherjee (1993) and Singh and Jain (1997) also could not observe the effect of birth weight on mortality of female calves. On the other hand, significant effect was reported by Rawal (1991) for Sahiwal and Tharparkar breeds and Tomar (1984) and Ram (1988) for Murrah female calves.

Age specific mortality

Age specific mortality among female calve upto the age at first calving have been given in Table 30 and their ANOVA in Table 31.

The female calf mortality from birth to AFC at different ages viz. 0-1 month, 1-3 month, 3-6 month, 6-12 month and 12-AFC were observed to be 7.0, 0.8, 1.2, 5.8 and 9.9 percent. Results revealed that 33.5 percent of the total mortality occurred during first month of life and it decreased along with the age. Similar results have been reported by Singh and Singh (1973), Tomar (1973), Patil and Gupta (1980), Rao and Nagarcenkar (1982)and Mukherjee (1993).

Period of birth was found to have highly significant effect on mortality in two age groups viz. 1-3 months and 12 m-AFC. Variation in mortality in different years have also been reported by Sharma and Jain (1976), Chaudhary *et al.* (1984) and Reddy and Nagarcenkar (1989a).

Season of birth had no effect on female calf mortality at any age which is similar to those reported by Shrivastava and Agarwal (1973), Sharma and Jain (1976), Rao and Nagarcenkar (1982) and Parekh and Singh (1981). On the contrary, Tomar (1973), Jain and Sharma (1982), Chaudhary *et al.* (1984) and Reddy and Nagarcenkar (1989a) reported significant differences in mortality rate among season of birth.

The parity of dam had no effect on calf mortality at any age. Mukherjee (1993) also failed to observe any effect of dam's parity on calf mortality.

II. Culling

It was observed that on an average 30.6 percent of the total female calves born were culled before they reached the milking herd. This estimates is in close agreement with the reports of Lathwal *et al.* (1993) for Red Sindhi female calves. The culling rate lower than the present study have been reported by Amble and Jain (1967), Chaudhary *et al.* (1984), Singh *et al.* (1987), Tomar and Verma (1988a), Reddy and Nagarcenkar (1989a), Rawal and Tomar (1994b), Rawal and Tomar (1996) and Singh and Jain (1997), whereas Amble *et al.* (1958) reported higher culling rate (33.9%) than the present study.

The culling rates were very high during first two periods (51.7% and 35.1%) compared to later periods of the study. Analysis of variance indicated that period had significant ($P<0.05$) effect on culling rate. Tomar and Verma (1988a,b), Reddy and Nagarcenkar (1989a), Lathwal *et al.* (1993), Rawal and Tomar (1994b), Tomar and Rawal (1996), Mukherjee and Tomar (1997) and Singh and Jain (1997), while Kulkarni and Sethi (1990) could not find any effect of year on culling rates.

Table 26: Average incidence (%) of female calf mortality, culling and number of female reached to milking herd in relation to non-genetic factors

Effect	No. of female calves born	Female calves					Replacement rate	
		Died		Culled		Reached to milking herd		
		%	No.	%	No.	No.	% (F)	% (T)
Overall	**1648**	**21.1**	**347**	**30.6**	**504**	**797**	**48.4**	**22.5**
Periods								
1973-75	29	13.7	4	51.7	15	10	34.5	19.3
1976-80	208	23.1	48	35.1	73	87	41.8	20.5
1981-85	431	12.8	55	27.2	117	259	60.1	28.2
1986-90	511	22.4	114	29.9	153	244	47.8	22.4
1991-96	469	26.9	126	31.2	146	197	42.1	18.4
Season								
Winter	812	22.7	177	34.4	279	356	43.9	20.6
Summer	419	21.9	92	27.7	116	211	50.4	23.5
Rainy	241	19.1	46	25.3	61	134	55.7	24.9
Autumn	176	18.2	32	27.3	48	96	54.6	25.1
Parity								
1	364	24.7	90	42.1	153	121	33.3	16.5
2	274	19.4	53	38.1	104	117	42.8	19.4
3	227	21.2	48	34.4	78	101	44.5	21.5
4	185	20.0	37	22.8	42	106	57.3	26.4
5	160	18.2	29	25.0	40	91	56.9	26.2
6	133	23.1	31	23.6	23	79	59.4	27.1
7	102	22.6	23	15.7	16	63	61.8	26.3
8	88	20.5	18	20.5	18	52	59.1	27.1
9	49	10.2	5	34.7	17	27	55.1	22.1
10	37	19.1	7	21.6	8	22	59.5	27.5
≥11	29	20.7	6	17.2	5	18	62.1	23.4

F = Replacement rate on female calf basis.
T = Replacement rate on total calf basis.

Table: 27 Analysis of variance to test the effect of non-genetic factors on mortality, culling and replacement rate (m.s. value)

Source of variation	D.F.	Mortality	Culling	Replacement rate	
				F	T
Period	4	1.2166**	0.5660*	2.3232**	1.2568**
Season	3	0.1058	0.7909**	1.2539**	0.4292**
Parity	10	0.1416	1.4644**	1.7864**	0.5829**
Error	1630	0.1643	0.2021	0.2342	0.1724 (3538)

Figures in parentheses are the error degree of freedom

** - P< 0.01

* - P < 0.05

F - Replacement rate on female calf basis

T - Replacement rate on total calf basis

Table 28: Average incidence of mortality, culling and replacement rate in different birth weight groups

Birth weight (kg)	Total female born (No.)	Female calves					
		Mortality		Culled		Reached milking/ Replacement rate	
		No.	%	No.	%	No.	%
Total	**1334**	**251**	**18.81**	**383**	**28.72**	**700**	**52.48**
<17.0	21	7	33.3	4	19.0	10	47.6
18-19	95	17	17.8	42	44.2	36	37.9
20-21	774	152	19.6	238	30.7	384	49.6
22-23	333	62	18.6	84	25.2	187	56.1
24-25	75	11	14.6	12	16.0	52	69.3
>26.0	36	2	5.5	3	8.3	31	86.1

Table 29: Analysis of variance for birth weight effect on mortality, culling and replacement rate (m.s. value)

Source of variance	D.F.	Mortality	Culling	Replacement rate
Birth weight	5	0.2532	1.1822**	1.8718**
Error	1328	0.1534	0.2024	0.2434

** P< 0.01

Table 30: Age specific mortality and culling rates in female calves at different ages in different period, season and parity

Effects	0-1 month No. exp.	0-1 month Died	0-1 month Culled	1-3 months No. exp.	1-3 months Died	1-3 months Culled	3-6 months No. exp.	3-6 months Died	3-6 months Culled	6-12 months No. exp.	6-12 months Died	6-12 months Culled	12 Months – AFC No. exp.	12 Months – AFC Died	12 Months – AFC Culled
Overall	1648	7.0 (116)	2.5 (42)	1490	0.8 (12)	2.0 (30)	1448	1.2 (8)	2.7 (40)	1390	5.8 (81)	6.9 (96)	1213	9.9 (120)	24.4 (296)
Periods															
1	29	13.3 (3)	- -	26	- -	3.8 (1)	25	4.0 (1)	- -	24	- -	- (3)	21	1.4 (3)	33.3 (7)
2	208	5.7 (12)	- -	196	3.1 (6)	3.1 (6)	184	3.3 (6)	1.6 (3)	175	4.0 (7)	10.8 (19)	149	8.7 (13)	30.2 (45)
3	431	5.1 (22)	4.2 (8)	401	0.2 (1)	1.5 (6)	394	1.1 (4)	2.0 (8)	382	3.4 (13)	8.3 (32)	337	5.9 (20)	21.4 (72)
4	511	9.3 (48)	2.5 (13)	450	- -	2.0 (9)	441	0.6 (3)	3.2 (14)	424	8.7 (37)	8.2 (35)	352	9.1 (32)	24.4 (86)
5	469	6.6 (31)	4.5 (21)	417	1.2 (5)	1.9 (8)	404	0.9 (4)	3.7 (15)	385	6.2 (24)	1.8 (7)	354	14.5 (52)	24.3 (86)
Season															
1	812	8.4 (66)	2.8 (23)	723	1.4 (8)	2.4 (17)	698	1.2 (8)	3.1 (22)	668	6.9 (46)	9.7 (65)	557	10.2 (57)	28.1 (157)
2	419	5.9 (25)	2.6 (11)	383	0.5 (2)	1.1 (4)	377	1.6 (6)	2.1 (8)	363	6.3 (23)	4.7 (17)	323	9.9 (32)	22.6 (73)
3	241	6.6 (16)	1.6 (4)	221	- -	2.3 (5)	216	1.4 (3)	3.7 (8)	205	2.9 (6)	5.4 (11)	188	10.6 (20)	19.2 (36)
4	176	5.1 (9)	2.2 (4)	163	1.2 (2)	2.4 (4)	157	0.6 (1)	4.7 (2)	154	3.8 (6)	1.9 (3)	145	7.6 (11)	20.7 (30)
Parity															
1	364	9.6 (35)	3.3 (12)	317	1.9 (6)	3.8 (12)	299	1.6 (5)	- (14)	280	8.6 (24)	12.1 (34)	222	9.9 (22)	39.6 (88)
2	274	8.1 (22)	2.5 (7)	245	0.8 (2)	3.3 (8)	235	1.7 (4)	3.4 (8)	223	5.8 (13)	9.8 (22)	188	8.5 (16)	30.3 (57)
3	227	7.9 (18)	2.6 (6)	203	- -	1.9 (4)	199	1.0 (2)	3.0 (6)	191	5.7 (11)	8.4 (16)	164	10.3 (17)	26.8 (44)
4	185	6.4 (12)	2.1 (4)	169	0.6 (1)	- -	168	1.2 (2)	1.8 (3)	163	7.9 (13)	4.3 (7)	143	7.6 (11)	18.2 (26)
5	160	5.0 (8)	1.3 (2)	150	1.3 (2)	- -	148	2.0 (3)	1.4 (2)	143	2.8 (4)	6.9 (10)	129	9.3 (12)	20.2 (26)
6	133	3.7 (5)	1.5 (2)	126	- -	1.6 (2)	124	0.8 (1)	1.6 (2)	121	4.9 (6)	- -	115	15.6 (18)	17.4 (20)
7	102	5.9 (6)	0.9 (1)	95	- -	2.1 (2)	93	- -	2.2 (2)	91	6.6 (6)	2.1 (2)	83	10.8 (9)	10.5 (9)
8	88	4.5 (4)	4.5 (4)	80	- -	- -	80	1.2 (1)	2.3 -	79	1.3 (1)	1.3 (1)	77	9.1 (7)	14.3 (11)
9	49	8.1 (4)	- -	45	- -	2.2 (1)	44	- -	- (1)	43	- -	4.6 (2)	41	7.3 (3)	26.8 (11)
10	37	5.4 (2)	5.4 (2)	33	3.0 (1)	3.1 (1)	31	- -	3.2 (1)	30	6.6 (2)	3.3 (1)	27	3.7 (1)	14.8 (4)
≥11	29	- -	6.9 (2)	27	- -	- -	27	- -	3.7 (1)	26	3.8 (1)	3.8 (1)	24	- -	- -

Table 31: Analysis of variance to test the effect of different non-genetic factors on mortality rate of female calves in different age-group

Source of variation	D.F.	0-1m	1-3m	3-6m	6-12m	12m-AFC
Period	4	0.1295	0.0373**	0.0186	0.1817	0.3564**
Season	3	0.0709	0.0089	0.0038	0.1047	0.0313
Parity	10	0.0729	0.0109	0.0053	0.0754	0.0082
Error		0.0652	0.0078	0.0123	0.542	0.0892
		(1630)	(1472)	(1430)	(1372)	(1195)

Figures in parentheses are the error degree of freedom.

** $P < 0.01$

It was further observed that the culling rates were higher among calves born during winter season (34.4%) than those born in other seasons. Statistical analysis of the data had shown that the effect of season of birth was highly significant. This is in agreement with the findings of Tomar and Verma (1988b), Reddy and Nagarcenkar (1989) and Tomar and Rawal (1996) whereas the reports of Tomar and Verma (1988a), Lathwal *et al.* (1993), Rawal and Tomar (1994b), Mukherjee and Tomar (1997) and Singh and Jain (1997) had shown that season of birth did not affect the culling rates.

The culling rates varied highly significantly from 15.7 to 42.1 percent among the calves born in different parities. There was a decreasing trend from first parity to seventh parity. The highest culling rate was observed in calves produced by cows of first and second parity. The same results of significant effect of dam's parity have been reported by Rawal and Tomar (1994b), Tomar and Rawal (1996), Mukherjee and Tomar (1997) and Singh and Jain (1977). Tomar and Verma (1988a,b), Lathwal *et al.* (1993) and Tomar and Ram (1993) reported that dam's parity had no effect on the culling rates of their female calves contrary to the present results.

The culling rate was high in calves weighing between 18-23 kg at birth and it was low for the calves weighing less than 18 kg and more than 23 kg. The culling rates for the calves with different birth weights varied between 8.3 to 44.2 percent. Statistically the differences in culling rate due to birth weight were highly significant. Similar results were reported by Mukherjee (1993), whereas Ram (1988), Lathwal (1989), Rawal (1991) and Singh and Jain (1997) reported non –significant effect of birth weight on culling rates.

4.2.5. Replacement rates

The average number of female calves survived upto AFC i.e., replacement rate on female calf basis and on total calf born basis in relation to non genetic factors have been given in Table 26 and ANOVA in Table 27. Average replacement rate in different birth weight group and effect of birth weight on replacement rate have been given in Table 28 and Table 29.

(i) Female calf basis

It was observed that only 48.4 percent of the total female calves born reached to the milking herd and more than fifty percent (52.6%) were lost from the herd either due to death or culling. Lemka *et al.* (1973) reported nearly equal replacement rate in desi cattle to the present study and Amble *et al.* (1958), Chaudhary *et al.* (1984), Taneja and Bhatnagar (1983), Tomar and Verma (1988a), Rawal and Tomar (1994b), Lathwal *et al.* (1993) and Tomar and Rawal (1996) reported higher replacement rate than this herd. Whereas low replacement rate than this study was reported by Amble *et al.* (1958) for Red Sindhi and Singh and Jain (1997) for crossbred cattle.

It was observed that replacement rate on female calf basis was highly significantly different among different periods in this herd. It ranged from 34.5 to 60.1 percent percent on total female calf basis. Significant effect of year was reported by Tomar and Verma (1988a), Rawal (1991), Lathwal *et al.* (1993), Tomar and Rawal (1994) Mukherjee (1993) and Singh and Jain (1997), whereas, Tomar and Verma (1988b) reported non –significant effect of year of birth on replacement rate on female calves basis.

Statistically highly significant differences among seasons of birth for replacement rate on female calf basis were observed. It was highest in rainy and autumn season and lowest in winter season. Similar results were reported by Tomar and Verma (1988a), Rawal (1991), Lathwal *et al.* (1993), Tomar and Rawal (1994) and Singh and Jain (1997)

Replacement rate among the calves born to dams of different parity varied from 33.3 to 62.1 percent on female calf basis. Dam's parity had highly significant effect on replacement rate on female calf basis. Replacement rate was high among the calves produced by older cows beyond sixth parity. Similar results have been reported by Tomar and Rawal (1994) for Sahiwal herd and Lathwal *et al.* (1993) for Red Sindhi herd where as Mukherjee (1993) did not observed any significant effect of parity on this trait.

Percentage of female calves survived and retained in the herd upto the age at first calving increased from 37.9 to 86.1 with the increase in birth weight beyond 18 kg.. Birth weight had statistically highly significant effect on replacement rate(Table 29).

(ii) Total calf basis

On total calf basis, the overall replacement rate was 22.5 percent and the rest 77.5 percent calves born were lost from the herd in the form of abnormal birth, male births (sex ratio) and loss of female calves due to death and culling upto AFC. It is evident from the present study that 4 to 5 pregnancies are required to produce one heifer replacement. Present findings were also supported by the findings of Lathwal *et al.* (1993) in Red Sindhi and Tomar and Ram (1993) in Murrah buffaloes, and they also reported that 4 pregnancies are required to produce one heifer replacement.

It was observed that replacement rate varied from 18.4 to 28.2 percent among periods, it was highest in third period and lowest in last period. Period had highly significant effect on replacement rate. This corroborated with the findings of Tomar and Verma (1988a), Rawal (1991), Lathwal (1993), Tomar and Rawal (1994), Mukherjee (1993) and Singh and Jain (1997) whereas contrary to the present result Tomar and Verma (1988b).

Replacement rate was observed to be lowest in winter and highest in autumn season and varied from 20.6 to 25.1 among different season . This corroborated with the findings of Tomar and Verma (1988a) whereas Rawal (1991), Lathwal *et al.* (1993), Tomar and Rawal (1994) and Singh and Jain (1997).

Results also revealed that replacement rate varied from 16.5 to 27.5 percent among different parities and had increasing trend with increase in lactation upto sixth parity. Analysis of variance indicated that parity of dam had highly significant ($P<0.01$) effect on replacement rate on total calf basis. Similar findings have been reported by Mukherjee (1993) whereas, results of Tomar and Verma (1988a,b), Rawal (1991) and Lathwal *et al.* (1993) for cattle and Tomar and Ram (1993) for Murrah buffaloes are contrary to the present results.

4.2.6. Lactation specific demographic parameters

The results on certain lactation specific demographic parameters and overall lifetime statistics are given in Table 32 and 33 respectively.

1. Survival rate (Px)

It is observed that 20.9 percent adult female were lost from the herd either due to death or culling in the first lactation and the survival rate was 79.1 percent at the end of first lactation. The loss rate was minimum in the fourth lactation (12.87%) and hence the probability of survival rate was maximum (0.871) at this lactation. Survival rate of female was more than 80 percent upto seventh lactation and thereafter a decreasing trend along increase in lactation was noted. The probability of survival rate for the female varied between 0.80 to 0.87 between 3 to 7^{th} lactation. Probability of loss rate tend to increase after 4^{th} lactation. Similar results were reported by Harris (1989) and Ahmed *et al.* (1992). The survival rate of about 0.89 have been reported by Greer *et al.* (1980) and Schons *et al.* (1985) upto 8 years of age and thereafter it decreased.

It was observed that for the lifetime the average probability of a female being lost from the herd was 0.21 per female per lactation. Tomar *et al.* (1994), Lathwal *et al.* (1995) and Tomar *et al.* (1996) reported the average probability of loss per lactation per cow as 2.68. 0.302 and 0.26 in Sahiwal, Red Sindhi and Tharparkar cattle. Chaughley (1966) reported mean rate of mortality for all age groups as 0.25 per female per annum for Himalayan Thar. Mukherjee (1993) reported that on an average 0.32 female animal being lost per female per year from the herd of crossbred cattle.

2. Survivorship (Lx)

The survivorship is the probability of an animal to survive or remain in the herd upto a certain age/lactation which is the stayability of a cow in the herd. Present results revealed that the probability of an animal to survive in the herd decreased with the increase in lactation number. It was 1.0 at first lactation, 0.506 at fourth lactation, 0.113 at tenth lactation and 0.01 at 13 lactation. Thus only 50.6, 11.3 and 1.0 percent of the female at first lactation survived or retained in the herd at 4, 10 and 13 lactation. Tomar *et al.* (1994),

Table 32: Lactation specific demographic parameters and expected herd life

Lact. No.	Total cows	Loss rate (Q_x)		Survival rate (P_x)	Survivorship or stayability (L_x)	Herd structure of cows at each lactation		Expected herd life (E_x)	Birth rate (M_x)	Reporductive value (V_x)
						Died & culled (q_x)	Present in the herd (p_x)			
1	660	0.2091	(138)	0.7909	1.00	0.2091	0.2132	3.52	0.514	2.277
2	522	0.2375	(124)	0.7625	0.7909	0.1878	0.1686	3.66	0.486	2.229
3	398	0.1608	(64)	0.8392	0.6030	0.0969	0.1285	3.88	0.506	2.292
4	334	0.1287	(43)	0.8713	0.5060	0.0651	0.1078	3.54	0.482	2.172
5	291	0.1512	(44)	0.8488	0.4409	0.0666	0.0941	3.06	0.481	1.889
6	247	0.1578	(39)	0.8422	0.3742	0.0591	0.0797	2.61	0.478	1.659
7	208	0.1971	(41)	0.8029	0.3151	0.0621	0.0671	2.09	0.452	1.403
8	167	0.3113	(52)	0.6887	0.2530	0.0787	0.0539	1.61	0.469	1.184
9	115	0.3478	(40)	0.6522	0.1742	0.0605	0.0371	1.33	0.415	1.039
10	75	0.3600	(27)	0.6400	0.1136	0.0408	0.0242	1.05	0.500	0.957
11	48	0.5416	(26)	0.4584	0.0727	0.0393	0.0155	0.64	0.432	0.714
12	22	0.6818	(15)	0.3182	0.0333	0.0227	0.0071	0.41	0.333	0.617
13	7	0.7142	(5)	0.2858	0.0106	0.0075	0.0022	0.28	0.750	0.891
14	2	1.00	(2)	0.00	0.0030	0.003	0.0006	0.00	0.500	0.501

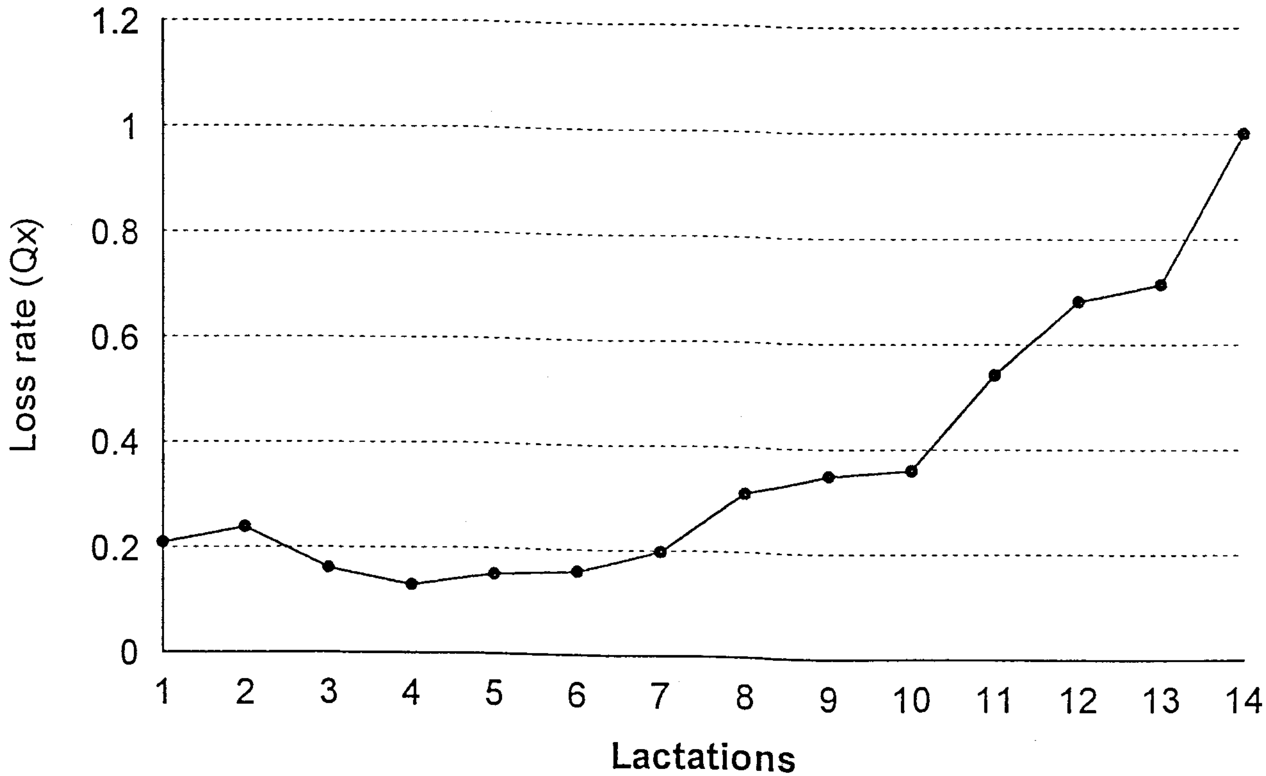


Fig. 1. **Relationship between lactation and total loss.**

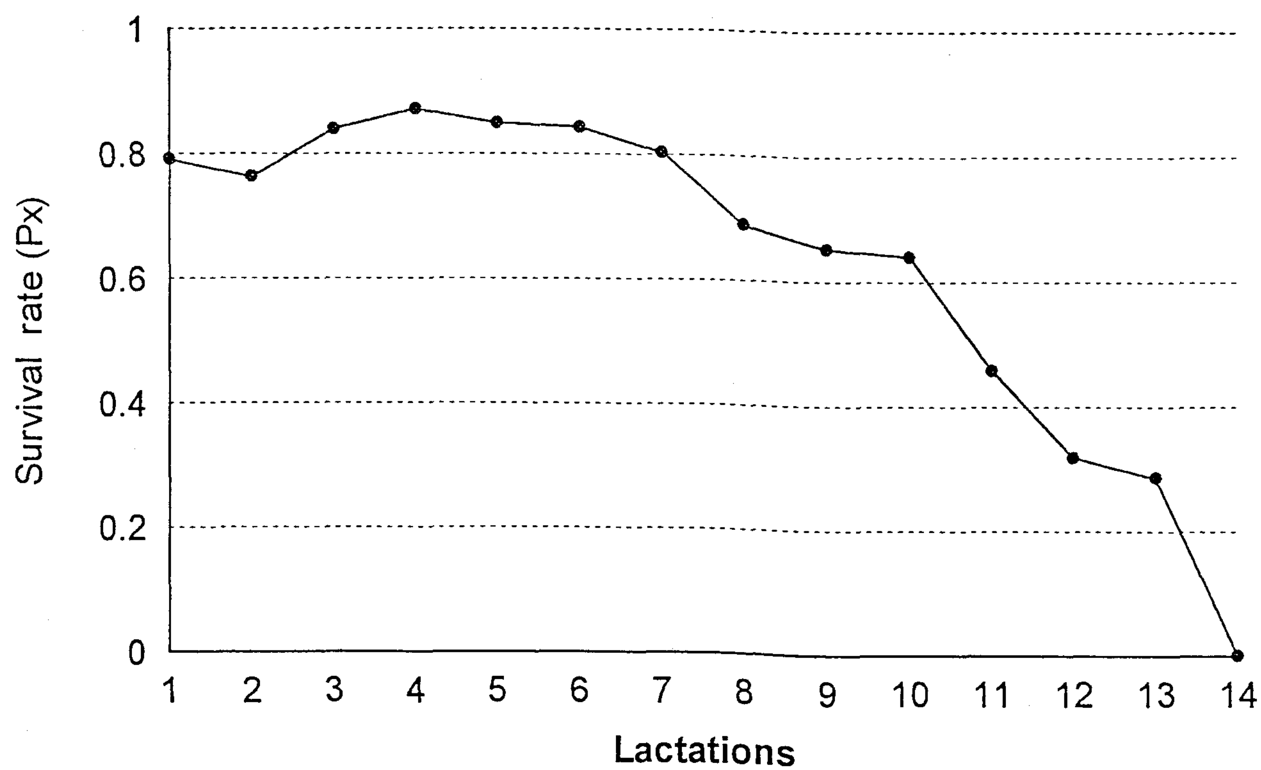


Fig. 2. **Relationship between lactation and survival rate.**

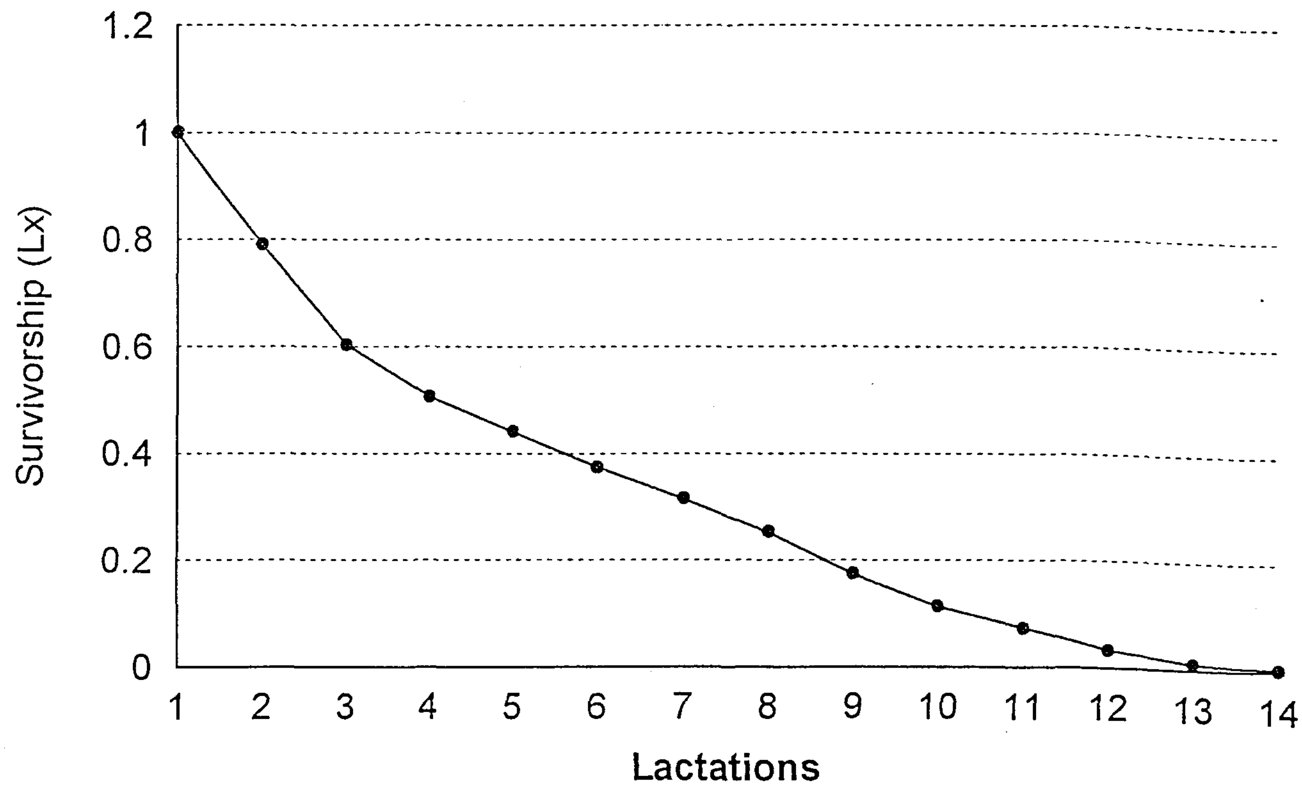


Fig. 3. **Relationship between lactation and survivorship.**

Table 33: Overall life table statistics

Sr.No.	Life Table	Unit	Average value
1.	Mean age of cows		
	i. Present in the herd	Lactation	4.49
	ii. Lost from the herd	Lactation	4.68
2.	Mean rate of loss / cow / lactation	Proportion	0.21
3.	Life expectancy of first lactation	Lactation	4.19
4.	Reproductive rate	Female calves per cow	2.27
5.	Generation interval	Years	3.99

Lathwal *et al.* (1995) and Tomar *et al.* (1996) also reported the decreasing trend along lactation. Greer *et al.* (1980) and Schons *et al.* (1985) reported that about 10 percent of the females survived to age 10 years whereas Ahmed *et al.* (1992) observed that the probability of a buffalo cow entering and remaining in the herd upto the age of 10 years as 0.29. Mukherjee (1993) observed that only 1.0 percent of the total female calves born survived upto 13 years of age in the herd.

The mean age of cows being lost from the herd was 4.68 lactations whereas for the cows being present in the herd was 4.49 lactations. Only 2 cows out of 660 cows survived upto 14 lactation. Greer *et al.* (1980) reported the mean age of cows being lost and present in the herd as 5.7 and 4.8 years, respectively. Tomar *et al.* (1994, 96) and Lathwal *et al.* (1995) reported the average number of lactations completed by the cows which left the herd were low (2.9 to 3.7) as well as for those which were present in the herd were also low (3.0 to 3.5) in comparison to the present results. Mukherjee (1993) also reported low mean age of cows being lost and present in the herd (2.35 and 3.56 years).

3. Structure of females lost from the herd at each lactation

Proportion of female calves being lost from the herd due to their death and culling was found to be 0.209 in this herd upto first lactation . This is the equilibrium replacement rate required to maintain the herd size. The probability of female being lost from the herd was found to be 0.187 in second lactation and 0.096 in third lactation. Results indicated that, about half of the total females of first lactation left the herd till they completed third lactation. It indicated that most of the total loss occurred upto third lactation. After third lactation the probability of a female being lost from the herd was more or less similar upto 9^{th} lactation. Greer *et al.* (1980) reported that 19.3 percent losses occurred upto 2 years of age, about 10 percent upto 3 years of age in each year. Mukherjee (1993) reported that 22.3 percent losses occurred during first year of age, 6.1 percent in the second year of age and 18.0 percent each year during 4 and 5 years of age. Ahmed *et al.* (1992) reported that the proportion of Nili-Ravi buffaloes being culled increased from 0.049 at 3 years of age to 0.127 at 5 years which remained constant upto 8 years of age.

Tomar *et al.* (1994, 1996) reported that of the total cows lost in different lactation a proportion of 0.22 was lost during or after first lactation, 0.21 in second and 0.15 in third lactation whereas Lathwal *et al.* (1995) reported the proportion of cows being lost in first, second and third lactation as 0.29, 0.22 and 0.12 respectively, for Red Sindhi cattle.

4. Structure of females of different lactations being present in the herd

The herd structure means the proportion of females of different lactations present in the herd. It was observed that about one fourth of the total (21.3%) herd comprised the first calvers and 16.8 percent females belonged to the second lactation. It was observed that about 70 percent of the total females present in the herd belonged to one to fourth lactation and about 5 percent female in the herd belonged to 10 or more lactations. Greer *et al.* (1980), Nieuwhof *et al.* (1989), Gadzhier *et al.* (1991) and Mukherjee (1993) reported that the herds were mostly constituted of younger animals upto 5-6 years of age. Ahmed *et al.* (1992) also reported that 56 percent of the total buffaloes present in the herd belonged to the age group between 4-7 years of age. Tomar *et al.* (1994, 96) and Lathwal *et al.* (1995) reported that about 60% of the total cows present in the herd belonged to first three lactations.

5. Expected herd life

The expected herd life (expected to remain in the herd) at first lactation was 3.52 lactations and nearly same upto fourth lactation, thereafter expected herd life decreased alongwith the increase in lactation (Figure 4). Lower expected herd life than the present study were reported by Tomar *et al.* (1994, 96) and Lathwal *et al.* (1995) with a declining trend along the lactation. The expected herd life with a declining trend were also reported by Krehbiel *et al.* (1962), Greer *et al.* *(1980) and Mukherjee (1993). Contrary to the present* findings Schons *et al. (1985) reported higher expected herd life with a* declining trend *along increase in age of the females*

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Average life expectancy of a cow at first lactation was found to be 4.19 lactation. Lower values of life expectancy in first lactation (2.8 to 3.3) than the

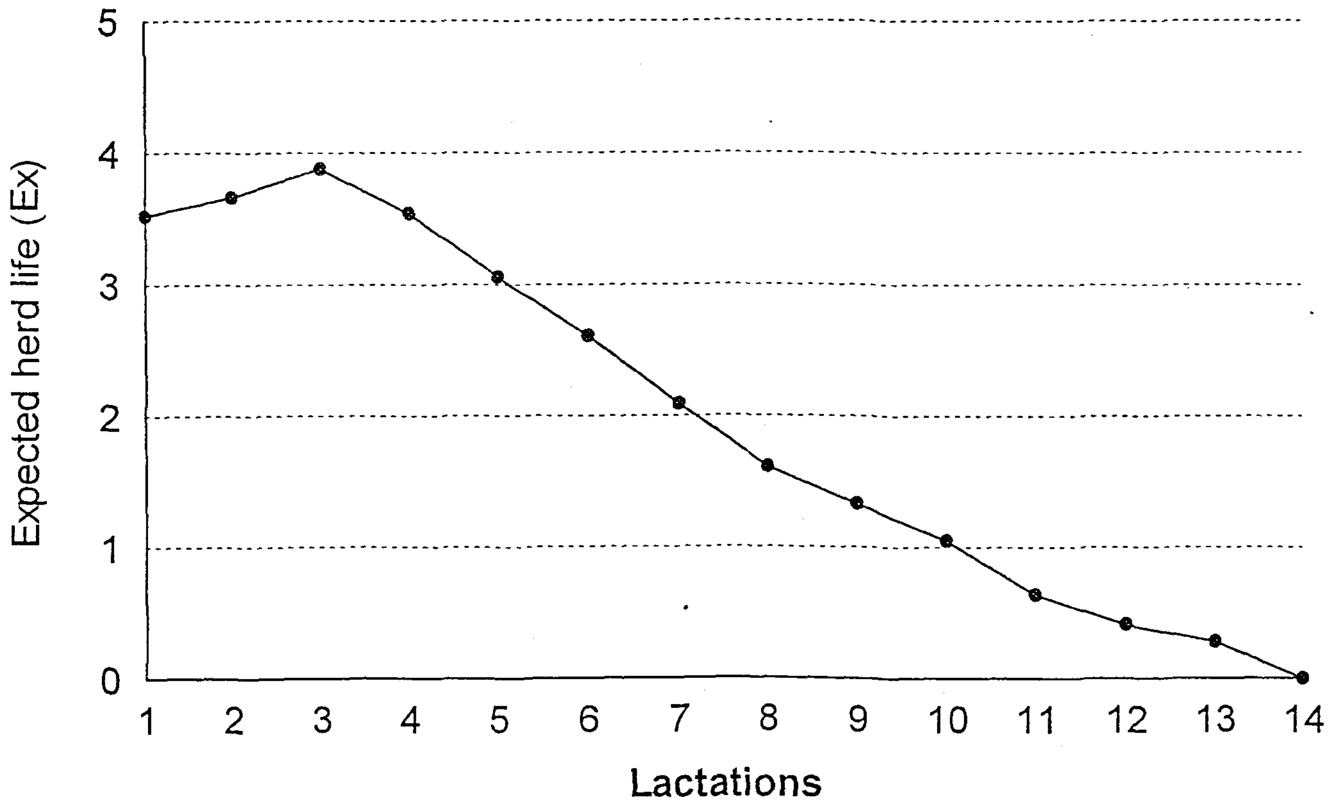

Fig. 4. **Relationship between lactation and expected herd life.**

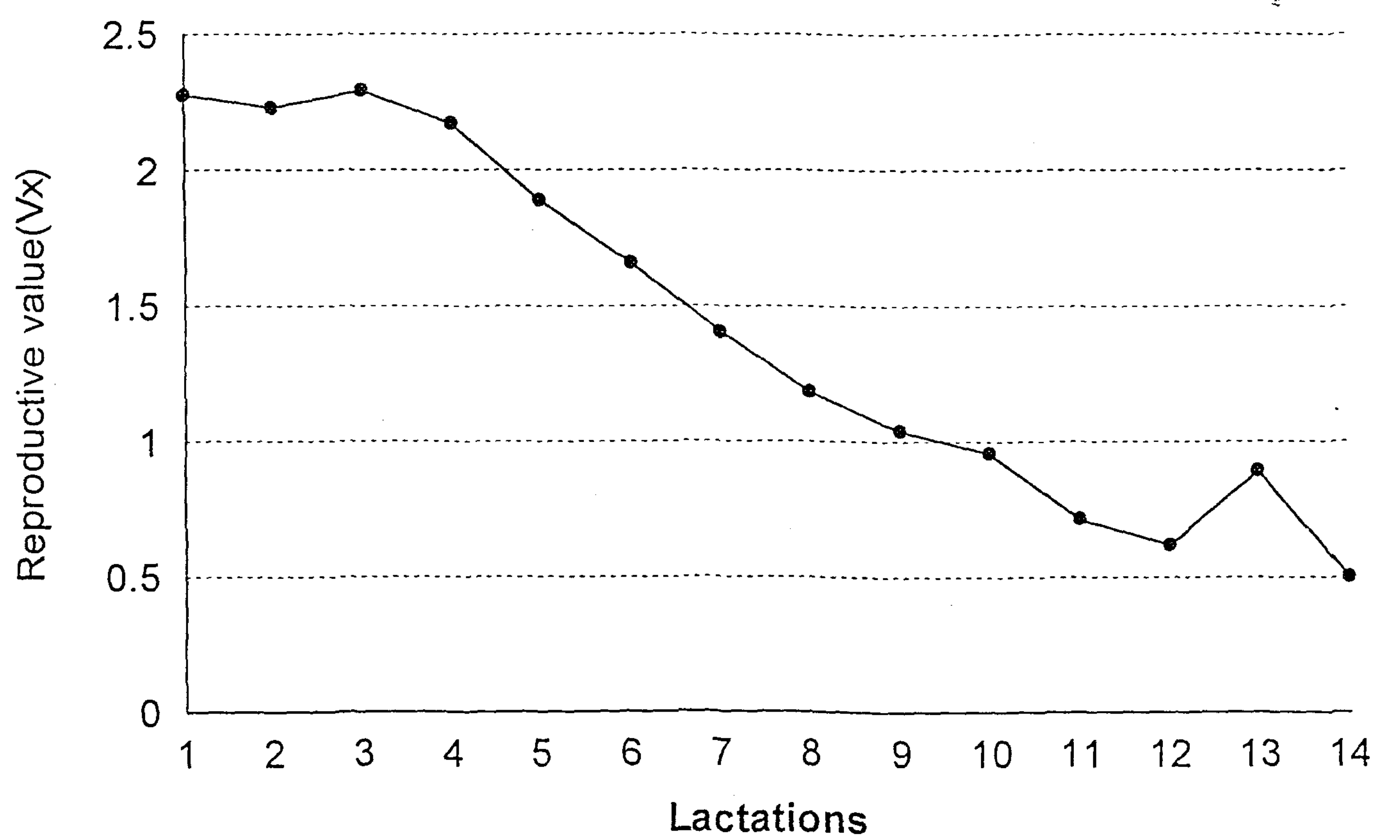

Fig. 5. **Relationship between lactation and reproductive value.**

present study were reported by Tomar *et al.* (1994, 96) and Lathwal *et al.* (1995) for milch breeds of zebu cattle.

6. Reproductive value (Vx)

Results presented in Table 32 indicated that the reproductive value was varied between 2.172 to 2.292 for the cows belonged to 1-4 lactations. The reproduction value was less than one for the cows who completed more than 9 lactation. Thus very old cows had low reproductive value than that of a replacement heifer and younger cows. This suggested that the cow should be culled at an age/lactation when its reproductive value is less than one. Similar results were observed by Tomar *et al.* (1996) for Tharparkar cows. Schons (1985) reported a similar trend in reproductive value in beef breeds of cattle that the cows beyond 12 years of age had reproductive value less than one.

The average net reproductive rate for the lifetime in this herd was found to be 2.27 which means that each cow produced 2.2 female calves. Similar results have been reported by Schons *et al.* (1985) for beef cattle and Mukherjee (1993) for crossbred cattle. Low net reproductive rate from 1.6 to 1.8 have been reported by Tomar *et al.* (1994, 96) and Lathwal *et al.* (1995) in milch breeds of zebu cattle.

4.2.7. Herd replacement

The herd replacement depends on the number of adult females left the herd due to their death and culling and the number of heifer replacements become available in any year.

I. Mortality and Culling of Adult Cows

Average losses of adult cows due to death and culling in different lactation have been given in Table 34 and the results of ANOVA have been presented in Table 35.

It was observed that 11.1 percent of the cows died while they were in the herd and rest 88.9 percent were culled from the herd, which is conformity to the results of Mukherjee (1993) for Karan Swiss cows whereas Lathwal (1989), Rawal *et al.* (1994) and Rawal and Tomar (1998) reported the incidence of mortality in adult cows from 9.3 to 13.4% and of culling from 86.6

Table 34: Loss of adult cows in different lactations

Lactation No.	Total cows	Number of cows				Total loss	
		Died		Culled			
		%	No.	%	No.	%	No.
Total cows	**660**	**11.06**	**(73)**	**88.93**	**(587)**	**100.0**	**(660)**
1.	660	1.6	(11)	19.3	(127)	20.9	(138)
2.	522	1.5	(8)	22.2	(116)	23.7	(124)
3.	398	1.2	(5)	14.8	(59)	16.1	(64)
4.	339	0.3	(1)	12.6	(42)	12.8	(43)
5.	291	2.7	(8)	12.4	(36)	15.1	(44)
6.	247	2.4	(6)	13.5	(33)	15.7	(39)
7.	208	2.8	(6)	16.8	(35)	19.2	(41)
8.	167	5.9	(10)	25.1	(42)	31.2	(52)
9.	115	6.1	(7)	28.8	(33)	34.7	(40)
10.	70	7.1	(5)	31.4	(22)	38.5	(27)
11.	48	8.3	(4)	45.8	(22)	54.2	(26)
12.	22	0.0	(0)	68.2	(15)	68.2	(15)
13.	7	14.2	(1)	57.3	(4)	71.5	(5)
14.	2	0.0	(0)	50.0	(1)	100.0	(2)
Overall	**3091**	**2.34**	**(73)**	**18.99**	**(587)**	**21.35**	**(660)**

Table 35: Analysis of variance for loss of cows in different lactations (m.s. values)

Source of variance	D.F.	Death	Culling	Total loss
Lactation	13	0.0528*	1.3511**	1.8851**
Error	3078	0.0229	0.1541	0.1223

** P < 0.01 * P < 0.05

to 90.7 percent for Red Sindhi, Sahiwal and Tharparkar cows. Sharma and Singh (1974) observed that 13.1 percent of the total cows left the herd due to their death.

It was further observed that 21.4 percent cows left the herd in each lactation either due to their death or culling. Out of the total losses of 21.4 percent per lactation the mortality accounted for 2.3 percent only. Similar results on mortality rate per lactation in adult cows (2.5 to 3.6 %) but higher culling rates per lactation (23.2 to 28.8%) have been reported by Lathwal *et al.* (1989) for Red Sindhi cows, Rawal *et al.* (1994) for Sahiwal cows, Rawal and Tomar (1998) for Tharparkar cows and Mukherjee (1993) for Karan Swiss cows.

Regarding the effect of lactation order on loss of adult cows, it was observed that total losses were less in cows of middle age group of 3-7 lactations. There was a increasing trend of total losses after seventh lactation. The total losses in first two lactations were 20.9 and 23.7 percent, respectively which may be due to culling of females on the basis of production performance of the first two lactations. Total losses (Mortality and culling) were highly significantly affected by lactation order (Tabe 35). This is in agreement with the findings of Lathwal (1989), Rawal *et al.* (1994), Mukherjee (1993) and Ram and Tomar (1993).

Further it was observed that annual loss of cows averaged 15.8 percent. The annual loss of adult cows ranging reported between 15 to 23 percent were reported earlier by Lemka *et al.* (1973), Chikara and Balaine (1977), Lathwal (1989), Rawal *et al.* (1994), Rawal and Tomar (1998) and Mukherjee *et al.* (1993). Out of the total losses the annual mortality was 1.5 percent and culling was 14.3 percent in this Hariana herd. Almost similar estimates of annual mortality have been reported by Reddy and Nagarcenkar (1989b), Lathwal (1989), Rawal *et al.* (1994), Rawal and Tomar (1998) and Mukherjee (1993). The average annual culling rates have been reported as 11.0, 20.7, 16.8, 17.8 and 21.7 percent respectively by these workers. Ram and Tomar (1993) have also reported the average annual mortality and culling rates in Murrah buffaloes as 1.8 and 16.3 percent respectively.

Table 36: Annual mortality and culling in adult cows, heifer calvings and annual replacement index

Year	Opening balance	Addition by heifer calvings	Total cows	Loss of cows						Closing balance	Replacement index
				Death		Culling		Total loss			
				%	No.	%	No.	%	No.		
1981	149	50	199	0.5	1	14.5	29	15.1	30	169	1.6
1982	169	23	192	0	0	14.6	28	14.6	28	164	0.8
1983	164	35	199	1.0	2	12.1	24	13.1	26	173	1.3
1984	173	55	228	0	0	12.3	28	12.3	28	200	1.9
1985	200	51	251	1.6	4	12.4	31	13.9	35	216	1.4
1986	216	62	278	1.1	3	15.4	43	16.5	46	233	1.3
1987	233	41	274	1.8	5	21.2	58	22.9	63	211	0.6
1988	211	58	269	2.9	8	21.2	57	14.1	65	214	0.9
1989	214	45	259	0.8	2	10.5	27	11.3	29	230	1.5
1990	230.	47	277	1.5	4	14.5	40	15.9	44	233	1.1
1991	233	71	304	2.6	8	8.8	27	11.4	35	269	2.0
1992	269	39	308	2.3	7	11.7	36	13.9	43	265	0.9
1993	265	12	277	2.1	6	16.7	47	18.8	53	224	0.2
1994	224	-	-	-	-	-	-	-	-	-	-
Overall	**2950**	**589**	**3315**	**1.5**	**50**	**14.3**	**475**	**15.8**	**525**		**1.2**

Table 37: Analysis of variance to test the year effect on mortality and culling in adult cows (m.s. value)

Source of variance	D.F.	Mortality	Culling
Year	12	0.0224	0.3822**
Error	3302	0.0147	0.1218

** $P < 0.01$

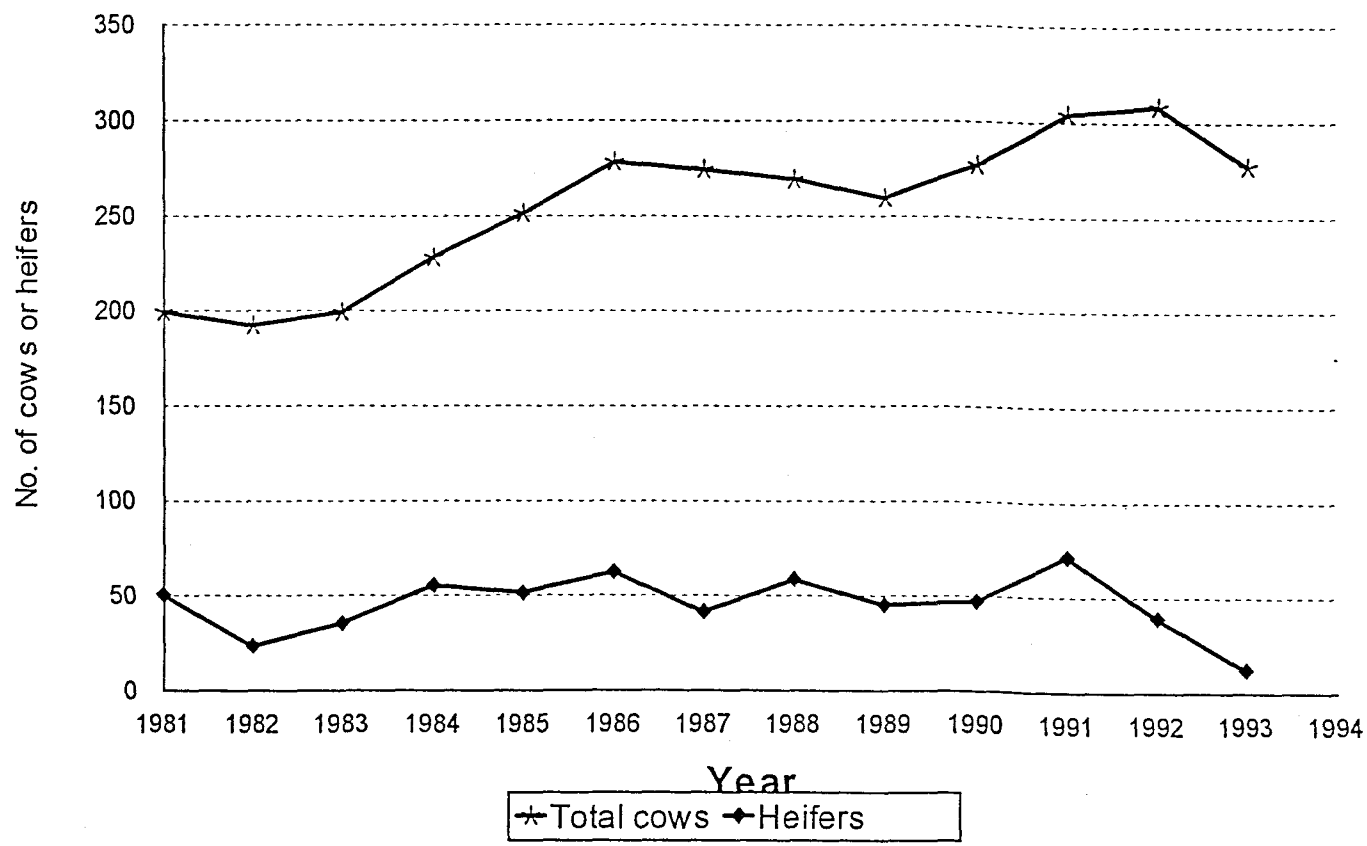

Fig. 6. Fluctuation in herd size.

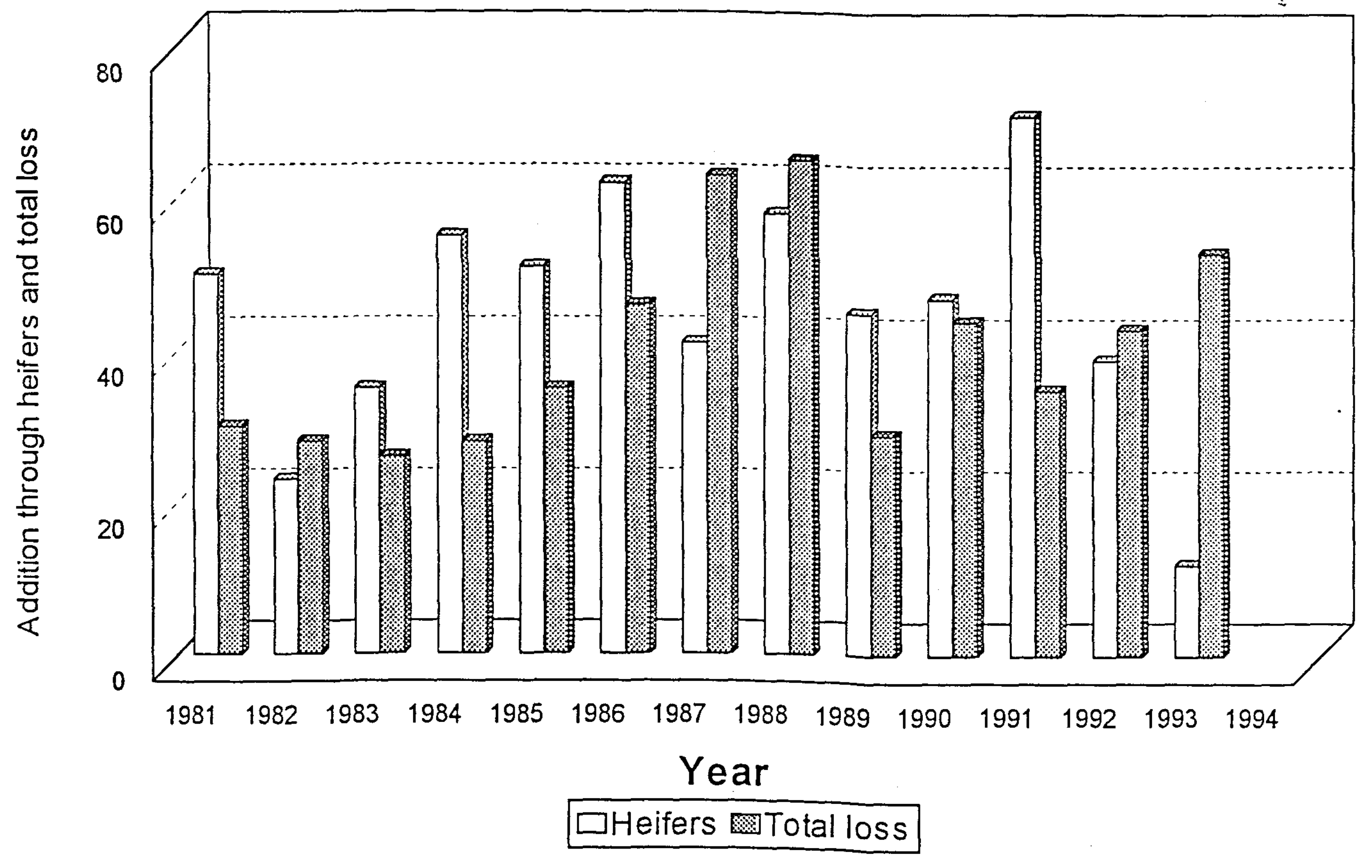

Fig. 7. **Relationship between total heifers and total loss.**

The annual mortality in adult cows varied from 0.5 to 2.9 percent in different years and there was no mortality in 1982 and 1984 years among adult cows, whereas the annual culling rates varied from 8.8 to 21.2 percent in the present study. Year effect was significant on culling rates in this herd while annual mortality did not differ significantly among the years which is similar to the reports of Lathwal (1989), On the contrary, Reddy and Nagarcenkar (1989b), Rawal *et al.* (1994) and Ram and Tomar (1993) observed significant effect of year on both mortality and culling rates.

II. Annual Replacement Index

Annual replacement index (ARI) and annually losses of adult cows and heifer calvings have been presented in Table 36 and the ANOVA to show year effect has been given in Table 37.

The annual replacement index is the ratio of the number of heifer calvings to the number of cows left the herd in a year. The overall replacement index was found to be little more than one (1.2) during the period of study (Table 36) indicating that heifer calvings were nearly equal to that of the number of adult cows left the herd during entire period of study and hence the herd size remained constant. In this herd the annual replacement index varied between 0.6 to 2.0 among different years. Similar results on replacement index and the variation among years were reported by Lathwal (1989), Rawal *et al.* (1994), Rawal and Tomar (1998) and Mukherjee *et al.* (1993) for cattle herd and Ram and Tomar (1993) for Murrah buffalo herd.

4.3. GENETIC ANALYSIS

4.3.1. Selective value and its components

The effect of sire on longevity, productive herd life and life time calf production traits alongwith their heritability estimates have been presented in Table 38.

1. Productive herd life and longevity

It was observed that the sire had highly significant effect on the PHL of their daughters. This showed that the progeny of certain sires had longer herd life than the others or vice versa and hence selection can be effective for genetic improvement in productive herd life. This corroborated with the results reported by Singh and Tomar (1989) and Mukherjee (1993) for crossbred cattle and Tomar and Basu (1981) for Murrah buffaloes.

Heritability estimates obtained for sire component of variance was 0.975±0.25 for PHL and the estimate is higher than those reported by White and Nichols (1965), Hargrove *et al.* (1965), Evans *et al.* (1964) and Tanida *et al.* (1988) for exotic cattle, Singh *et al.* (1964), Basu *et al.* (1983), for indian breeds, Reddy (1979), Singh and Tomar (1989) and Mukherjee (1993) for crossbred cattle.

The sire had also highly significant effect on longevity of their daughters. The heritability was observed to be 0.945±0.28 for longevity.

2. Life time calf production

The life time calf production traits viz. total calves born, total alive calves born, total female calves born and total replacement daughters per cow determines the selective value of an adult female. The effect of sire and their heritability estimates have been presented in table 38.

(i) Number of calves born :

Sire of cow had highly significant effect on total calves born by each cow during lifetime. These results are similar to those of Rawal (1991) for Tharparkar herd, Mukherjee and Tomar (1996) for crossbred cattle and Tomar and Basu (1991), Tomar and Ram (1992) for Murrah buffalo herd, whereas the effect of sire was not significant for Sahiwal herd by Rawal and Tomar (1994a).

The heritability estimate for total calves born was 0.967±0.26 which is higher than reported by White and Nicholas (1965), Hargrove *et al.* (1965) and Tanida *et al.* (1988) for exotic breeds, Basu *et al.* (1983), Rawal (1991) and Rawal and Tomar (1994a) for Indian breeds, Reddy (1979) and Mukherjee and Tomar (1996) for crossbred cattle.

(ii) Number of alive calves born :

The effect of sire of cow was found to be highly significant on the total alive calves born from each cow. This corroborated with the results

Table 38: Analysis of variance to test the effect of sire on PHL, longevity and life time calf production traits (m.s. values)

Source of variation	D.F.	PHL	Longevity	No. of calves born	Alive calves	Female calves	Female calves retained
Between sires	43	68.829**	70.707**	51.628**	49.947**	12.259**	14.226**
Error	616	11.803	12.524	8.933	8.377	2.708	1.532
$h^2 \pm$ S.E.		0.975±0.25	0.945±0.28	0.967±0.26	0.994±0.31	0.761±0.18	0.729±0.18

** $P < 0.01$

K-value=15

reported by Rawal (1991) for Tharparkar herd, Mukherjee and Tomar (1996) for crossbred cattle and Tomar and Basu (1991) and Tomar and Ram (1992) for Murrah buffalo herd, whereas Rawal and Tomar (1994a) did not observed significant effect of sire on total alive calves born for Sahiwal herd

The heritability estimate for total alive calves born was found to be 0.994±0.31. Low heritability than the present estimates was reported by Rawal (1991) and Rawal and Tomar (1994a) for Indian breeds, White and Nicholas (1965), Hargrove *et al.* (1965) and Tanida *et al.* (1988) for exotic breeds, Mukherjee and Tomar (1996) for crossbred cattle and Tomar and Ram (1992) in a herd of Murrah buffaloes.

(iii) Number of female calves born and reached to milking herd:

It was observed that sire of cow had highly significant effect on both, total female calves born and total female calves reached to milking herd. This corroborated with the results reported by Rawal (1991) for Tharparkar herd and Lathwal *et al.* (1992) for Red Sindhi herd and Tomar and Ram (1992) for Murrah buffalo. On the other hand, Rawal and Tomar (1994a) for Sahiwal herd and Mukherjee and Tomar (1996) for crossbred cattle did not observe significant effect of sire on both the traits.

The heritability estimates were 0.761±0.18 and 0.729±0.18 for total female calves born and total female calves reached milking herd, respectively, and were higher than reported by Rawal (1991) and Rawal and Tomar (1994a) for Indian breeds and Mukherjee and Tomar (1996) for crossbred cattle and Tomar and Ram (1992) in a herd of buffaloes.

4.3.2. Replacement rate and its components

Analysis of variance to test the effect of sire and to estimate the heritability of replacement rate and its components have been presented in Tables 39 and 40. Repeatability estimates of abnormal births and sex ratio have been presented in Table 41.

1. Abnormal births

The average incidence of abnormal births was 4.4 percent among 3390 pregnancies from 36 sires. Out of 36 bulls used for breeding, there was no

Table 39: Abnormal births and sex ratio in relation to sire

Class interval (%)	Sire		Average no. of birth/ sire	Total birth	Average incidence of abnormal / male births	
	No.	%			No.	%
Abnormal births						
0	8	22.2	11.0	88	0	0.0
0.1-3.0	6	16.6	88.5	531	13	2.4
3.1-6.0	12	33.3	185.6	2228	90	4.0
6.1-9.0	4	11.1	110.0	440	32	7.3
9.1-12.0	1	2.7	20.0	20	2	10.0
12.1-15.0	2	5.5	20.0	40	5	12.5
15.1-18.0	1	2.7	18.0	18	3	16.6
> 18.0	2	5.5	12.5	25	6	24.0
Overall	**36**	**100.0**	**94.1**	**3390**	**151**	**4.4**
Male births						
< 30.0	2	5.5	11.5	23	4	17.4
30.1-35.0	1	2.7	9.0	9	3	33.3
35.1-40.0	2	5.5	13.0	26	10	38.4
40.1-45.0	2	5.5	38.0	76	34	44.7
45.1-50.0	5	13.9	125.2	626	297	47.4
50.1-55.0	11	30.5	190.4	2095	1087	51.9
55.1-60.0	9	25.0	26.4	238	137	57.5
60.1-65.0	1	2.7	108.0	108	66	61.1
65.1-70.0	1	2.7	15.0	15	10	66.6
> 70.0	2	5.5	11.5	23	17	73.9
Overall	**36**	**100.0**	**89.9**	**3239**	**1667**	**51.4**

Table 40: Analysis of variance (m.s. value) to test the effect of sire on abnormal births and sex ratio

Source of variation	D.F.	Abnormal birth	Sex ratio
Between sires	35	0.0707**	0.5423**
Error		0.0422 (3354)	0.2466 (3203)
$h^2 \pm SE$		0.285±0.12	0.0525±0.31

Figures in parentheses are the error degree of freedom
** P< 0.01
* P < 0.05 ?

Table 41: Repeatability of abnormal births and sex ratios by two different methods

Traits	Repeatability Methods* I	II
Abnormal births	0.0043	0.586
Sex ratio	0.0176	0.037

* **Methods**

I. **Regression of second record on the first**

II. **Intraclass correlation method**

incidence of abnormal births among the pregnancies from 8 sires (22.2% of total bull). About 78 percent out of total bulls used to bred were responsible for abnormal births which varied from 2.4 to 24.0 percent.

The incidence of abnormal births was 3.0 percent among the progeny of 16.6 percent bulls, between 3.1 to 6.0 percent among the progeny of 33.3 percent of the total bulls and the highest abnormal births (24.0%) was observed among the pregnancies of two sires (5.5%). Abnormal births from the sires reported by various workers were 64 percent Sahiwal and 50 percent Holstein (Tomar *et al.*, 1975), 70.6 percent Sahiwal and 78.3 Holstein, (Arun *et al.* 1991b), 50% Sahiwal and 60% Tharparkar bulls (Rawal and Tomar (1996a,c) and 89 percent crossbred bulls (Mukherjee, 1993).

Effect of sire was highly significant on the incidence of abnormal births (Table 40). Tomar *et al.* (1975), Sharma and Jain (1983), Rawal and Tomar (1996a,c)and Arun *et al.* (1991b) for cattle, Tomar and Basu (1981) and Ram and Tomar (1992) for buffalo have also observed significant effect of sire on abnormal births progeny, whereas Tomar and Verma (1988a, b) and Lathwal and Arun (1993) reported non significant effect of sire on abnormal births.

The heritability estimate for abnormal births was found to be 0.285±0.12 in this herd. This estimate value is higher than those reported by Erb *et al.* (1959), Singh *et al.* (1980), Rawal and Tomar (1996a,c), Arun *et al.* (1991b), Lathwal and Arun (1993) and Mukherjee (1993), however, lower than those reported by Lindhe (1967) for cattle and Ram and Tomar (1992) for buffalo.

Frequency of abnormal birth in the second gestation was higher (4.34%) among the cows which gave birth to abnormal calves in the first gestation. The repeatability of abnormal birth based on first two calvings was as good as zero (0.0043). These results suggested that the type of calf (normal versus abnormal) to be born in future gestation can not be predicted based on the type of calf in the previous gestation. These results corroborated with the findings of Rawal and Tomar (1996a,c) in Sahiwal and Tharparkar, Arun *et al.* (1991b) and Mukherjee (1993) in crossbred cattle, Tomar (1984) and Ram and Tomar (1992) in Murrah buffalo.

The repeatability of abnormal births estimated by intra-class correlation method based on all records (Table 41) was found to be high (0.587). This indicated that intra cow variability was present. This is also supported by the data presented in Table 20 regarding the recurrence of abnormal calvings in successive gestations. These were 17.1% of total cows which had abnormal births in their lifetime either once or more time. The percentage of cows which aborted once, twice and three times were 15.0, 1.8 and 0.3, respectively.

2. Sex ratio (% male births)

The sex ratio varied from 17.4 to 73.9 percent among the progeny of different sires. The normal range of sex ratio (45 to 55 percent) was observed among the progeny of 44.4 percent of the total sires used, whereas among the progeny of 19.4 percent sires it was less than 45 percent and the sex ratio was more than 55 percent among the progeny of 36 percent sires. Differences in sex ratio among the progeny of different sires were highly significant. Significant effect of sire on sex ratio have also been reported by Powell *et al.* (1975) in exotic cattle, Rawal and Tomar (1995) for Sahiwal, Rawal and Tomar (1996c) for Tharparkar, Arun *et al.* (1993b) for crossbred and Tomar and Tripathi (1988) in one of two herds of buffalo. On the other hand, no effect of sire on sex ratio were reported by Goswami *et al.* (1963), Tomar and Arora (1970), Tomar *et al.* (1976), Singh *et al.* (1983), Tomar and Verma (1988a,b), Lathwal and Arun (1993) and Mukherjee (1993).

Heritability of sex ratio was low (0.052±0.31). Present results are in close agreement with the findings of Powell *et al.* (1975), Sethi and Rao (1981), Rawal and Tomar (1995), Lathwal and Arun (1993), Rawal and Tomar (1996c), Arun *et al.* (1993b) and Mukherjee (1993) who reported heritability estimates below 0.10 for sex ratio. Tomar and Tripathi (1988) (0.124 and 0.434 for two herd of buffalo) and Ram and Tomar (1992) (0.206 for Murrah buffalo) reported higher estimates of heritability than the present estimate.

The repeatability of sex ratio based on first two calving was found to be 0.0176. Based on these estimates, it may not be possible to predict the sex of calf in subsequent calving. The low estimates of repeatability have also been reported by Sethi and Rao (1981), Tomar and Tripathi (1988), Rawal and Tomar (1995, 1996c), Arun *et al.* (1993b) and Mukherjee (1993) whereas Stonaker and Knapp (1974) and Elbarbery (1983) found a tendency of calves of the same sex to be born in successive parities.

The repeatability of sex ratio based on all calving records estimated by intra class correlation (Table 41) was found to be close to zero (0.037) and hence indicated that intra cow variability in sex ratio was very low.

3. Mortality of female calves

The frequency distribution of sires according to mortality and culling of their female calves have been presented in Table 42 and the ANOVA to see the sire effect alongwith heritability estimates has been given in Table 44. There was no mortality from birth to age at first calving among the progeny of 3 sires only (3.8% sires). The overall mortality was 20.5 percent and it varied from 9.3 to 85.7 percent among the female calves of 33 sires. The mortality less than 20 percent among the progeny of 38.8 percent sires, between 20 to 30 percent among the female calves of 19.4 percent sires, 30 to 40 percent among the female calves of 11 percent sires and above 40 percent mortality was found among the progeny of 22.2 percent sires. Sire had highly significant effect on calf mortality. These results corroborated with the findings of Chaudhary *et al.* (1984) and Mukherjee and Tomar (1997) for crossbred, Rawal and Tomar (1994b) for Sahiwal and Tomar and Rawal (1996) for Tharparkar, Ram and Tomar (1992) for Murrah buffaloes. Rawal and Tomar (1994b) and Tomar and Rawal (1996b) reported that there was no mortality among the female calves of 19.2 and 12.7 percent sires in Sahiwal and Tharparkar, respectively, and Mukherjee and Tomar (1997) reported that only 6.2 percent sires used had no mortality among their female progeny upto age at first calving in crossbred cattle. Contrary to the present study, Parekh and Singh (1981), Tomar and Verma (1988a), Lathwal and Arun (1993) did not observed significant sire effect on female calf mortality.

Present results indicated that sire of the calf had highly significant effect on the mortality of female calves during 1-3 months of age and 12 month-AFC whereas the sire had no effect on calf mortality during first month

Table 42: Mortality and culling of female calves in relation to sire

Class interval (%)	Sire		Average no. of female calves per sire	Total no. of calves	Average mortality/culling	
	No.	%			No.	%
Female calves died						
0	3	8.3	3.7	11	0	0.0
0.1-10.0	3	8.3	43.0	129	12	9.3
10.1-20.0	11	30.5	58.5	644	115	17.8
20.1-30.0	7	19.4	100.6	704	157	22.3
30.1-40.0	4	11.1	9.5	38	13	34.2
40.1-50.0	4	11.1	7.0	28	13	46.4
50.1-60.0	2	5.5	6.5	13	7	53.8
> 60.0	2	5.5	3.5	7	6	85.7
Overall	**36**	**100.0**	**43.7**	**1574**	**323**	**20.5**
Female calves culled						
0	3	8.3	5.6	17	0	0.0
0.1-10.0	0	0.0	0.0	0	0	0.0
10.1-20.0	3	8.3	92.0	276	47	17.0
20.1-30.0	6	16.6	68.3	410	110	26.8
30.1-40.0	14	38.8	49.7	697	238	34.1
40.1-50.0	4	11.1	31.2	125	51	40.8
50.1-60.0	3	8.3	11.7	35	16	45.7
> 60.0	3	8.3	4.7	14	9	64.2
Overall	**36**	**100.0**	**43.7**	**1574**	**477**	**30.3**

Table 43: Replacement rate in relation to sire

Class interval (%)	Sire		Average no. of calves for sire	Total no. of calves	Average replacement rate	
	No.	%			*NCRMH	%
Total calf basis						
0	4	11.1	16.5	66	0	0.0
0.1-10.0	4	11.1	13.7	55	4	7.3
10.1-20.0	9	25.0	45.0	405	70	17.2
20.1-30.0	17	47.2	137.6	2340	536	22.9
30.1-40.0	2	5.5	262.0	524	164	31.2
Overall	36	100.0	94.1	3390	774	22.8
Female calf basis						
0	4	11.1	6.5	26	0	0.0
0.1-10.0	0	0.0	0.0	0	0	0.0
10.1-20.0	2	5.5	7.0	14	2	14.3
20.1-30.0	3	8.3	4.0	12	3	25.0
30.1-40.0	9	25.0	18.3	165	58	35.2
40.1-50.0	11	30.6	84.6	931	445	47.8
50.1-60.0	4	11.1	23.7	95	50	52.6
60.1-70.0	3	8.9	110.3	331	216	65.2
Overall	**36**	**100.0**	**43.7**	**1574**	**772**	**49.0**

NCRMH = No. of calves reached milking herd

Table 44: Analysis of variance to test the effect of sire on mortality, culling of female calves and replacement rate and their heritabilities

Source of variation	D.F.	Mortality	Culling	Replacement rate	
				F	T
Between sires	35	0.4795**	0.4383**	0.4025*	0.4452**
Error		0.1522 (1536)	0.2068 (1536)	0.2466 (1536)	0.1718 (3354)
$h^2 \pm SE$		0.187±0.11	0.1009±0.04	0.571±0.19	0.066±0.02

Figures in parentheses are the error degree of freedom

** P< 0.01

* P < 0.05

Table 45: Analysis of variance to test the effect of sire on age specific mortality (m.s. value)

Source of variation	D.F.	Age group				
		0-1m	1-3m	3-6m	6-12m	12m-AFC
Sire	29	0.0563	0.0327**	0.010	0.054	0.2338**
Within sire		0.0549	0.007	0.009	0.050	0.0838
		(1512)	(1380)	(1353)	(1312)	(1136)
h^2		0.0002	0.2666	0.0096	0.0071	0.1762
K value		51.4	47.0	46.1	44.7	38.8

** $P < 0.01$

Figures in parentheses are the error degrees of freedom.

of age, 3-6m and 6-12 month of age. The results indicated that the progeny of certain sires were more prone to adverse environmental conditions leading to their death in early age.

The heritability of mortality from birth to AFC was found to be 0.187±0.11. Heritability was found to be low for mortality during different ages viz., 0.0002, 0.266, 0.0096, 0.0071 and 0.1762 for 0-1m, 1-3m, 3-6m, 6-9m and 9-AFC age groups, respectively(Table 45). Sethi and Balaine (1978) reported the heritability as 0.05 and 0.33 for mortality upto one month of age in Hariana cows. Low heritability estimates of mortality have been reported by Singh *et al.* (1980), Parekh and Singh (1981) during calfhood, Lathwal and Arun (1993) and Mukherjee and Tomar (1997) from birth to age at first calving. Low heritability of mortality has been reported by Tomar (1984) for Murrah buffalo female calves during first month of age (0.064±0.056) and from birth to age at first calving (0.095±0.061) but moderatge estimate for 1 to 3 months of life (0.332±0.106). Low heritability have also been reported from birth to AFC mortality by Rawal and Tomar (1994b) for Sahiwal and Tomar and Rawal (1996) for Tharparkar female cavles and Ram and Tomar (192) for Murrah buffalo. Singh (1979) reported low estimate in Red Sindhi (0.180.11), moderate for Sahiwal (0.38±0.12) and Tharparkar (0.31±0.09) and moderate to high (0.30±0.12 to 1.0) for crossbreds.

4. Culling of female calves

The results showed that there was no culling from birth to age at first calving among the progeny of 3 sires only (Table 42). The average culling rates varied from 17.0 to 64.2 percent among the progeny of 33 sires and on an average it was found to be 30.3 percent. It was further observed that the culling rates below 30 percent were among the progeny of 25 percent of the total sires and above 30 percent among the female progeny of 66.6 percent sires. Differences in culling rates among the progeny of different sires were highly significant (P<0.01). Present results were in conformity to those of Rawal and Tomar (1994b), Tomar and Rawal (1996), Lathwal and Arun (1993) and Mukherjee and Tomar (1997) for cattle and Ram and Tomar (1992) for Murrah buffaloes. Tomar and Verma (1988a) reported that the culling rates among the progenies of different sires did not differ significantly.

Rawal and Tomar (1994b) and Tomar and Rawal (1996) observed no culling among the progenies of 25 percent Sahiwal and 26.6 percent Tharparkar sires, whereas culling rates ranged from 5.6 to 42.8 percent and 6.8 to 66.7 percent among the progenies of rest of the sires in two breeds, respectively.

The heritability estimate of culling rates of female calves upto age at first calving was found to be low (0.1009±0.04) (Table 44). Almost similar estimates for heritability of culling rates have also been reported by Rawal and Tomar (1994b) for Sahiwal (0.17) and Tomar and Rawal (1996) for Tharparkar (0.21) and Mukherjee and Tomar (1997) for crossbred female calves (0.115) and Ram and Tomar (1992) for Murrah buffalo female calves (0.172) whereas Lathwal and Arun (1993) reported medium (0.347) for Red Sindhi. Low estimates of heritability (0.065±0.025) in exotic breeds have also been reported by Schwenger *et al.* (1989).

5. Number of female calves reached milking herd (Replacement rate)

The frequency distribution of sires according to the replacement rates among their progenies has been given in Table 43 and the ANOVA together with heritability has been given in Table 44. The results showed that there was no replacement rate (no female calves reached upto milking herd) from the progeny of 4 sires (11.1%). The replacement rate ranged from 7.3 to 31.2 percent on total calf basis and 14.3 to 65.2 percent on total female calf basis. On an average, the replacement rate was found to be 22.8 percent on total calf basis and 49.0 percent on total female calf basis. Sire had significant effect on replacement rate on total calf basis and on total female basis. Result indicated that replacement rate was higher among the progenies of certain sires. Contrary to the present study, Tomar and Verma (1988a) reported that sire had no effect on the replacement rate on either basis, whereas, Rawal (1991), Rawal and Tomar (1992), Lathwal and Arun (1993) and Mukherjee and Tomar (1997) reported highly significant effect of sire on replacement rate on both basis.

The heritability of replacement rate was found to be 0.571± for female calves basis and 0.0665± for total calves basis. Present results are similar to those reported by Rawal and Tomar (1992) for Sahiwal (0.28 and 0.06) and

Rawal (1991) for Tharparkar calves (0.11 and 0.03), Lathwal and Arun (1993) for Red Sindhi calves (0.235 and 0.103), Ram and Tomar (1992) for Murrah buffalo calves (0.124 and 0.011) and Mukherjee and Tomar (1997) for crossbred cattle (0.225 and 0.064). The present findings showed that some additive genetic variability existed in replacement rate on female calf basis and this can be exploited through selection.

4.4. SIRE EVALUATION AND RANK CORRELATION AMONG DIFFERENT TRAITS

4.4.1. Estimation of breeding value for AFC and FLMY

The information available on daughters of 29 sires were used to estimate the B.V. of these sires for AFC and FLMY and the results have been presented in Table 46. Breeding value wasestimated by two methods viz., simple daughters average and weighted least square method. It was observed that the rank correlation was high (0.883) between these two methods of sire ranking. This indicated that there was practically no differences of sire ranking by the two methods and the sire can be evaluated by either method for AFC.

The herd average for AFC was 1484 days. The range of AFC for different sires varied from 947 to 1620 days whereas, the range in breeding value was observed from 1312 to 1610 days. It was observed that 17 sires (58.6 %) had the BV for AFC below the herd average and rest of the sires had the B.V. above herd average. The same is true based on simple daughter average for AFC. The superiority of the sires having AFC less than herd average ranged from 5.6 to 73.8 percent.

The herd average for FLMY was 922 kg and varied from 355 to 1327 kg for different sires (simple daughter average), whereas the range in breeding value was observed from 118 to 1312 kg. It was observed that 14 sires had the B.V. for FLMY below the herd average (inferior quality sires) and 15 sires were above the herd average in their B.V. (superior sires). The superiority of these 15 sires ranged from 4.7 to 75.4 percent over the herd average. The rank correlation between the two methods of estimation was high (0.772). This indicated that the sire can be evalauted by either method.

Table 46: Breeding value of sires for age at first calving (AFC) and first lactation milk yield (FLMY)

Sire No.	Age at first calving (AFC)		First lactation milk yield (FLMY)	
	$\overline{D}$	$\overline{W}$	$\overline{D}$	$\overline{W}$
1.	947 (1)	1312 (1)	640 (25)	764 (23)
2.	1435 (13)	1448 (13)	1230 (2)	1253 (3)
3.	1543 (25)	1514 (25)	1327 (1)	1276 (2)
4.	1405 (10)	1372 (6)	970 (14)	1000 (14)
5.	1316 (3)	1416 (10)	1052 (11)	1010 (12)
6.	1361 (5)	1400 (9)	1003 (13)	1002 (13)
7.	1503 (21)	1490 (20)	797 (18)	836 (20)
8.	1487 (19)	1484 (19)	761 (21)	768 (22)
9.	1490 (20)	1492 (21)	493 (28)	118 (29)
10.	1508 (22)	1496 (22)	1075 (9)	1054 (8)
11.	1620 (29)	1516 (26)	899 (16)	912 (16)
12.	1421 (11)	1388 (7)	1148 (5)	1312 (1)
13.	1607 (28)	1510 (24)	735 (23)	844 (19)
14.	1602 (27)	1556 (27)	1018 (12)	1014 (11)
15.	1484 (18)	1482 (18)	738 (22)	846 (18)
16.	1542 (24)	1610 (29)	1088 (7)	1124 (6)
17.	1426 (12)	1394 (8)	1074 (10)	1186 (5)
18.	1589 (26)	1564 (28)	673 (24)	640 (26)
19.	1354 (4)	1454 (14)	1165 (4)	1022 (10)
20.	1447 (15)	1474 (16)	355 (29)	688 (24)
21.	1450 (16)	1426 (11)	898 (17)	876 (17)
22.	1404 (9)	1346 (3)	762 (20)	626 (27)
23.	1393 (8)	1362 (4)	1127 (6)	1252 (4)
24.	1467 (17)	1480 (17)	1207 (3)	1038 (9)
25.	1446 (14)	1458 (15)	1083 (8)	1086 (7)
26.	1383 (6)	1364 (5)	776 (19)	776 (21)
27.	1384 (7)	1336 (2)	579 (25)	336 (28)
28.	1509 (23)	1498 (23)	623 (26)	660 (25)
29.	1266 (2)	1434 (12)	955 (15)	936 (15)

$\overline{D}$ = Simple daughter's average

$\overline{W}$ = $$\text{B.V.} = \frac{2nh^2}{4+(n-1)h^2}(S_i) + \mu$$

4.4.2 Relationship of selective value with breeding values for FLMY and AFC

The sires were ranked according to different traits and the correlation among the ranked values of different traits were estimated and presented in Table 47. It was found that the values of correlation were positive and medium for abnormal birth with sex ratio. (0.44), Female mortality upto AFC (0.49), female calves culling (0.54) and with female calves retained (0.37) which were all highly significant. This showed that the direct selection of sire for reduced abnormal birth will bring the improvement for these traits. It was observed that there was high and positive correlation of ranking of sires between selective value and female calf mortality (0.67) and between selective value and female calves culling (0.68), which were highly significant also. This suggested that direct selection of sire for low mortality and low culling rates may bring improvement in replacement rate. This supported the findings of Mukherjee (1993) who reported that there was a moderate positive correlation of ranking of sires between selective value and female culled (0.69) and between selective value and female mortality (0.58). Westell *et al.* (1982) ranked the sires for different disposal reasons in different lactation and found that correlation between sire ranking for same disposal reason in different lactations. Erf *et al.* (1990-) found high correlation between sire ranking for death and birth, death through 2nd day (0.9) and both the traits had some positive association (0.55) with death from 1-7 day.

The correlation between selective value and FLMY was 0.34 which mean that increase in adaptive value also improve the milk yield whereas the correlation between selective value and AFC was low but positive (0.29). Mukherjee (1993) also reported low but positive correlation (0.19) between selective value and AFC, whereas contrary to the present study, Mukherjee (1993) reported very low positive rank correlation between selective value and FLMY (0.04) that means there was no correlation between selective value and FLMY.

Table 47: Correlation of selective value and its components with FLMY and AFC

	Sex ratio	Mortality	Culling	Selective value	AFC	FLMY
Abnormal birth	0.44**	0.49**	0.54**	0.37**	0.31	0.29
Sex ratio		0.28	0.49**	0.36**	0.27	0.31
Mortality			0.31	0.67**	0.26	0.22
Culling				0.68**	0.19	0.23
Selective value					0.29	0.34*

* P < 0.05
** P < 0.01

4.5 STRATEGIES FOR IMPROVEMENT OF HARIANA BREED

The strategies for genetic improvement of any breed depend on selection and mating system. The selection implies keeping the genetically superior individuals which depends on the nature and amount of genetic variability present in a trait among the individuals of a population viz., additive and non-additive genetic variability. It is well known that milk yield has low heritability. This means that additive genetic variability is low. When h^2 of a trait is low then progeny testing is generally advocated. At present, is the sire rather than dam which is progeny tested. Therefore, the selection criteria to select the genetically superior sires rests on the performance of the progeny of a sire. The correlation of the genotype of parent (G) with the average phenotype of its progeny ($\bar{P}$) is the accuracy of selection. The accuracy of sire selection ($r_{G\bar{P}}$) in a progeny testing (PT) programme is estimated as :

$$r_{G\bar{P}} = \frac{h}{2}\sqrt{\frac{n}{1+(n-1)t}}$$

Where, t = ¼ h^2 when progeny groups are half sibs. Thus, accuracy of selection depends on heritability and number of recorded daughters per sire. It is clear that an increase in number of daughters will improve the accuracy of sire selection and hence the prediction of breeding value (BV) of sire will be more accurate.

It is well known that the animal breeding data is generally non-orthogonal having unequal number of daughters for different sires. Moreover, the non orthogonality is intense at most of the animal farms in the country, it varied from one to several hundred daughters per sire. This results the loss of breeding data and all the sires are not evaluated. The non-orthoganlaity creates problems in analysis of data and biasness in predicting the breeding value.

The results of the present investigation indicated that 3556 pregnancies belonged to 108 sires. Out of these 108 sires, the data of only 36 sires were subjected to genetic analysis taking the criteria that there should be atleast 7 pregnancies from each sire. Thus the data on only 33% of the total sires could be used and the data on two-third of the total sires were wasted. Therefore, all the sires could not be evaluated. Further , the data was so much non orthogonal on these 36 sires that the pregnancies per sire varied from 270 to 515 for 6 sires, 107 to 151 for 4 sires, 42 to 86 for another 6 sires, 10 to 27 for 14 sires and 7 to 9 for rest 6 sires. Such type of non-orthogonality creates biasness and puts restriction to progeny test a large number of sires. Therefore, the first and foremost requirement is that the equal or nearly equal progenies are recorded for different sires for which the proper mating plan should be prepared.

On the basis of the results of this investigation, 5 pregnancies are required to get one replacement daughter. Out of these 5 pregnancies on an average 2 female calves will be born and out of these 2 female calves only one will survive/retain upto age at first calving. The average number of services required to conceive a cow have been found to be 1.86 and hence 9 inseminations are required to get 5 pregnancies which will produce only one heifer that could replace the old and low productive cow. Therefore, to run a P.T. programme effectively it is required to get around 100 inseminations from each bull, which will results in about 10 daughters to be performance recorded. Such a mating plan will avoid the wastage of breeding data and will provide the opportunity for testing large number of sires with more accuracy.

The results of the present study further indicated that most of the deaths occurred during first month of age. Therefore, special care of female calves is required during early age. High mortality among female calves was observed for those which were lighter at birth. Therefore, efforts should be made to take every care of a pregnant cows by providing them adequate concentrate and green fodder to improve birth weight and secondly the female calves with low birth weight, if born, should be given special care.

There was a positive and high correlation between female calf mortality and selective value (0.67) and hence the efforts to reduce the female calf mortality will increase the selective value as well as the replacement rate per unit of time. There was a moderate positive correlation between selective value and FLMY. These results thus showed that direct selection of sire for low mortality will improve the selective value which is positively associated with milk production. Therefore, the efforts made to improve the selective value will also be fruitful to enhance the milk production and hence the improvement of breed.

CHAPTER 5

SUMMARY
&
CONCLUSION

SUMMARY AND CONCLUSION

The present investigation was carried out on the breeding data collected from history cum pedigree sheets of 735 Hariana cows born during 20 years from 1970 to 1989 at GLF Hisar (Haryana). The data comprised 3556 calving records spreading over 26 years from 1973 to 1996. The data on lifetime calf production traits to study the selective value (genetic contributions to future generation and its components) was restricted to 660 cows which completed their herd life and left the herd due to their death and culling. and also the information on their female calves abut their mortality, culling or surviving upto age at first calving (AFC) were complete.

The data were classified into 4 periods according to years of birth of cows and into 5 periods according to the years of calving, in both type of periods consisted of 5 years. The data were also classified into 7 groups according to first lactation milk yield (FLMY) and into 5 groups of AFC on the basis of $\frac{1}{2}\ \sigma$ of the respective trait. The effects of period of birth, FLMY and AFC groups were analysed by least squares analysis of variance on longevity , productive herd life (PHL), selective value and its components viz., total calves born by each cow, total female calves born by each cow and total female calves reached to AFC from each cow during its lifetime. The effects of periods, season and parity of calving were studied on replacement rate and its components viz. Incidence of abnormal births, percentage of male births (sex ratio), mortality and culling of female calves from birth to AFC. The overall replacement index was estimated based on the number of heifer calvings and the number of cows left the herd due to their death and culling. Lactation-specific demographic parameters and overall life time statistics were also estimated. Heritability of these traits were computed from sire component of variance. Repeatability of the abnormal births and sex ratio was also estimation.

Average life span (longevity) of Hariana cow in this herd was found to be *9.12±0.19 years out of which 5.38±0.18 years was the productive herd life and* calved 5.2±0.16 times. Both the traits were significantly affected by the period of birth and first lactation milk yield. Cows mating at higher age, had the shortest herd life. Only a very few (0.4%) females attained the highest longevity of 18-19 years.

The average number of total alive calves, total female calves produced and total replacement daughters from each cow were 4.9, 0.15, 2.38±0.15 and 1.2±0.21, respectively. Results indicated that a cow should produce at least two female calves during its life time for her replacement. The maximum number of total calves born were 14 by only 0.3 percent of the total cows and maximum number of female calves born were 9 by only one cows 0.1%. About 20 percent of the total cows could not produce any female calf, whereas 25.3 percent cows left the herd after producing only one female calf.

Approximately half of the total (49.3%) cows did not leave any replacement daughters whereas 21.4 percent of the total cows left only one, 12.9 percent left two, 8.7 percent left three and 7 percent of the total cows left 4 or more replacement daughters.

The life time calf production traits were highly significantly affected by period of birth and FLMY. AFC had significant effect ($P<0.05$) on total calves and total alive calves born, whereas AFC did not affect the total number of female calves born and replacement daughters. In general, values of all the traits decreased along periods but increasing trend with FLMY.

The coefficient of gene replication, which is the genetic contribution of adult females to the next generation through their replacement daughters was 0.6±0.11 indicated that a cow replicated its genotype in term of calves more than time in the herd.

Average number of services per conception was 1.86±0.18. About 54.4 percent of the total cows conceived with first service. The incidence of repeat breeding was more with older cows. Year, season and parity had significant effect on the number of services per conception.

The average values of abnormal births, sex ratio, mortality and culling of female calves upto AFC were 4.5, 5.14, 21.1 and 30.6 percent respectively. The replacement rates on total calf basis and on female calf basis were 22.5 and 48.4% respectively. Results revealed that at least 4-5 calvings are required to produce one heifer replacement. More than 50 percent female calves were lost from the herd due to death/culling.

Period of birth had highly significant effect on female calves mortality, culling upto AFC and replacement rate. Season of birth had no effect on abnormal birth, sex ratio and female calves mortality. Parity of dam had highly significant effect on culling and replacement rate whereas it had no effect on abnormal birth, sex ratio and female calves mortality upto AFC. Birth weight of female calves had significant effect on culling rate and replacement rate whereas it had no effect on mortality of female calves.

The female calf mortality during different ages viz. 0-1m, 1-3m, 3-6m, 6-12m and 12 months to AFC were observed as 7.0, 0.8, 1.2, 5.8 and 9.9 percent, respectively. It was also observed that 33.5 percent of the total mortality occurred during first month of life. Period of birth was found to have significant ($P<0.01$) effect on mortality in the age group of 1-3 months and 12 months to AFC. Season of birth and dam's parity had no effect on female calf mortality at any age.

Lactation specific demographic results revealed that 20.9 percent adult females were lost from the herd either due to death or culling in the first lactation. Survival rate (Px) was 79.1 percent at the end of first lactation. The survival rate showed an increasing trend upto fourth lactation there after it started decreasing. The average probability of a female being lost from the herd was 0.21 percent per lactation. The mean age of cows being lost from the herd was 4.68 lactations and of those cows which were present in the herd was 4.49 lacatations.

The maximum lactations or the opportunity to a cow to remain in the herd as long as possible was 14 lactations and only 2 cows remained present. It was observed that heifers (cow at first lactation) were expected to remain in herd for 3.52 more lactations and was maximum (3.88) at third lactation. The reproductive value (Vx) which is the lactation specific expectation of future off spring was 2.2 for the cows belonged to 1-4 lactation and less than one for those beyond 9 lactations.

The total losses was found to be 21.4 percent per lactation in the herd, out of which 2.3 percent was mortality and 18.9 percent was culling. About 11.1 percent cows died in the herd and rest 88.9 percent were culled from the herd after entering the milking herd. Dam's parity effect on total losses was highly significant. The annual mortality and culling rates averaged and % respectively. Year had significant effect on culling rates of the adult females but the annual mortality was not significantly affected among years. The overall replacement index was indicated that heifer calvings were nearly equal to number of adult females left the herd in any year and the herd size remained constant. Productive herd life and longevity were both affected significantly ($P<0.01$) by sire. The heritability estimates of these traits were 0.975 and 0.945, respectively.

The components of selective value were significantly affected ($P< 0.011$) by sire. Heritability estimates of total calves born, total alive calves born, total female calves and female calves reached milking herd were 0.967±0.31, 0.994±0.26, 0.761±0.18 and 0.729±0.18, respectively.

The heritability estimates of abnormal births, sex ratio, mortality and culling of female calves, replacement rate on female calf basis and total calf basis were 0.285±0.12, 0.052±0.31, 0.187±0.11, 0.1009±0.04, 0.571±0.19 and 0.066±0.02, respectively.

The repeatability estimates of abnormal births and sex ratio based on first two calvings were low (0.0043 and 0.017). The results suggested that sex of calf to be born in future can not be predicted.

Rank correlation for AFC and FLMY between simple daughters average and weighted least square methods of sire evaluation were high. It was observed that the values of correlation were positive and moderate for abnormal birth with sex ratio (0.44), female calf mortality upto AFC (0.49), culling of female (0.54) and with selective value (0.37) which were all highly significant. This showed that the direct selection of sire for reduced abnormal birth will bring the improvement for these traits. The high positive correlation was observed between selective value and female calf mortality (0.67) and with female calves culling (0.68). This suggested that direct selection of sire for low mortality and low culling rates may bring improvement in replacement rate. The relationship between selective value and breeding value of FLMY showed that there was a positive correlation (0.34) which suggested that improvement or increase in selective value will also improve the milk yield. The relationship between selective value and breeding value of AFC had positive but low correlation.

The following conclusions can be drawn on the basis of findings of this present investigation

(i) For one success pregnancy each cow required about 2 services (1.86).

(ii) The present study indicated that most of the deaths occurred during first month of age. Therefore, more care of female calves is required in that age group.

(iii) High mortality was observed among the calves which were lighter at birth, therefore efforts should be made to take every care of the pregnant dams by providing them adequate concentrate and green fodder to improve birth weightand secondly such calves with low birth weight should be given special care.

(iv) On the basis of replacement rate on total calf basis (22.4%) it was concluded that about 5 pregnancies are required to produce one heifer that could replace the old and low productive cow.

(v) For one heifer replacement, 9 inseminations will be required considering 1.86 insemination for one pregnancy. Based on this research findings it is suggested that at least 90 inseminations per bull should be given under progeny testing programme to get performance record on atleast 10 daughters per sire. This information can thus be of useful for progeny testing programme and to avoid the wastage of breeding data.

(vi) The different components of selective value (life time calf production traits) were significantly affected by sire and all the traits were highly heritable, so sire selection can improve the traits.

(vii) There was a positive and high rank correlation between selective value and female calf mortality (0.67) and with female calves culling (0.68). So direct selection of sire for low mortality and low culling rates may bring improvement in replacement rate.

(viii) There was a moderate positive correlation between selective value and FLMY. It shows that increase in selective value will also improve the milk yield.

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ABSTRACT

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