GENERATIONWISE GENETIC EVALUATION OF KARAN SWISS AND KARAN FRIES CATTLE

THESIS SUBMITTED TO THE
NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL
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IN PARTIAL FULFILMENT OF THE REQUIREMENT
FOR THE DEGREE OF

**DOCTOR OF PHILOSOPHY
IN
ANIMAL GENETICS AND BREEDING**

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2001

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.... to all

my

well wishers..........

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CERTIFICATE

This is to certify that the thesis entitled **"GENERATIONWISE GENETIC EVALUATION OF KARAN SWISS AND KARAN FRIES CATTLE"** submitted by **Mr. SUJIT SAHA**in partial fulfilment of the requirements for the award of the degree of **DOCTOR OF PHILOSOPHY** in **ANIMAL GENETICS AND BREEDING** of the **NATIONAL DAIRY RESEARCH INSTITUTE (DEEMED UNIVERSITY)**, Karnal (Haryana), INDIA, is a bonafide research work carried out by him under my supervision and guidance, and no part of the thesis has been submitted for any other degree or diploma.

(B.K. JOSHI)
MAJOR ADVISOR & CHAIRMAN
(GUIDE)

Dated: 27th April, 2001

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Approved by

EXTERNAL EXAMINER 28/7/01

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Sujit Saha

(Sujit Saha)

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GENERATIONWISE GENETIC EVALUATION OF KARAN SWISS AND KARAN FRIES CATTLE

ABSTRACT

The present study was based on the data collected on 3168 Karan Swiss cows (1963-2000) and 3051 Karan Fries cows (1971-2000). Pedigree of every animal born during this period was traced back upto F_1 generation. Only 3080 Karan Swiss and 2741 Karan Fries animals were found to have complete pedigree records. Paternal and maternal generations were determined separately. Cows upto 8^{th} generation from paternal side and 9^{th} generation from maternal side in Karan Swiss and 5^{th} generation from paternal side and 9^{th} generation from maternal side in Karan Fries was observed. Generation wise evaluation of the performance revealed that there was deterioration in the performance after first generation in both the herds. But from second generation onwards no definite trend was observed. Examination of crossbred population from various angle confirmed the superiority of F_1 animal over the others. However, performance of miscellaneous crosses were found better than F_2, F_3 F_4 etc. for growth, and other first lactation traits. Desired level of exotic inheritance in the herd of *inter-se* mated animals were observed as 50 to 62.5 percent. Animals with intermediate levels of heterozygosity (45 to 60 percent) performed better than others. The present crossbred populations (Karan Swiss or Karan Fries) was found to have inheritance from two, three, four and five breeds. Two breed crosses were found superior than the others for various economic traits as well as herd life.

Studies on inbreeding revealed an increasing trend in the incidence but a declining trend in the level of inbreeding. However effect of inbreeding for majority of the growth, production and reproduction traits was found to be nonsignificant in both the herds. Average performance was found to deteriorate for the animals with inbreeding coefficient above 12 percent.

Studies on disposal showed, about 38.13 percent animals in Karan Swiss and 30.84 percent animals in Karan Fries were disposed off before calving. Maximum mortality was observed upto the age of six months, whereas maximum culling of heifers was observed from 12 month to AFC. Impact of disposal on milk production revealed minor improvement in the herd.

करन स्विस व करन फ्रीज पशुओं में पीढ़ीदर आनुवांशिक मूल्यांकन

सारांश

वर्तमान अध्ययन, 3168 करन स्विस गायों (1963-2000) तथा 3051 करन फ्रीज गायों (1971-2000) के एकत्रित आंकड़ों को लेकर किया गया। इस अवधि में जन्म लेने वाले प्रत्येक पशु की वंशावली को एफ 1 पीढ़ी तक अनुपथित किया गया। मात्र 3080 करन स्विस व 2741 करन फ्रीज पशुओं की पूर्ण वंशावली पाई गई। मैतृक पीढ़ियों को अलग ज्ञात किया गया। करन स्विस में पैत् दिशा में आठवीं पीढ़ी तक तथा मातृक दिशा से बनी पीढ़ी तक तथा करन फ्रीज में पैतृक से पांचवी व मातृक से नौवीं पीढ़ी तक की एऐं प्रेक्षित की गई। पीढ़ीदर निष्पादन के मूल्यांकन से ज्ञात हुआ कि दोनों झुंड़ों में पहली पीढ़ी उपरांत निष्पादन में अवनति हुई। किंतु दूसरी पीढ़ी उपरांत कोई निश्चित प्रवृति नहीं थी। संकरित जनसंख्या के विभिन्न कोणों से परीक्षणोंउपरांत यह निश्चित हो गया कि एफ 1 पीढ़ी अन्य पीढ़ियों से बेहतर थी। किंतु वृद्धि व अन्य प्रथम दुग्द्य स्राव गुणों के लिए निष्पादन मिश्रित संकर एफ 2, एफ 3, एफ 4 आदि से बेहतर थे। इंटर से संगित पशुओं के झुंड में विदेशी वंशागति का वांछित स्तर 50 से 62.5 प्रतिशत पाया गया। मध्यवर्ती स्तर की विष्मयुग्मजता (45 से 60 प्रतिशत) के पशुओं का निष्पादन अन्य से बेहतर था। वर्तमान संकरित संख्या (करन स्विस व करन फ्रीज) में दो, तीन, चार व पांच नस्लों की वंशागति थी। दो नस्लों के संकर अन्य से आर्थिक गुणों व झुंड जीवन के लिए बेहतर पाए गए।

अत: प्रजनन के अध्ययन से आयतन में वृद्धोतर व्रवृति व अत: प्रजनन के स्तर में अधेनतन प्रवृति ज्ञात हुई। किंतु दोनों झुण्डों में अत- प्रजनन का वृद्धि, उत्पादन, पुनउत्पादन विशेषकों पर प्रभाव सार्थक नहीं था। लगभग 12 के अतं: प्रजनन गुणांक से ऊपर के पशुओं के औसतन निष्पादन में अवनति हुई।

निपटारा पर अध्ययन के अनुसार लगभग 38.13 प्रतिशत करन स्विस व 30.84 प्रतिशत करन फ्रीज पशुओं को काविंग से पूर्व ही निपटारा कर दिया गया। अधिकतर मृत्युदर छ: मास की आयु तक पाई गई तथा हैफर की अत्याधिक कलिंग 12 मास से ए.एफ.सी. तक पाई गई। निपटारा के दुग्द्य उत्पादन पर प्रभाव से ज्ञात हुआ कि झुण्ड में मामूली सुधार हुआ।

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List of Abbreviations

AFC	=	Age at first calving (days)
AFS	=	Age at first fertile service (days)
B x H x S x R x T	=	Brown Swiss x Holstein x Sahiwal x Red Sindhi x Tharparkar
B x H x S x T	=	Brown Swiss x Holstein x Sahiwal x Tharparkar
B x R	=	Brown Swiss x Red Sindhi
B x S x R	=	Brown Swiss x Sahiwal x Red Sindhi
B x S x T	=	Brown Swiss x Sahiwal x Tharparkar
B x S	=	Brown Swiss x Sahiwal
B x T	=	Brown Swiss x Tharparkar
B x Zebu	=	Brown Swiss xZebu
B/J x L	=	Brown Swiss/Jersey x Local
BFG	=	Brown Swiss + Friesian + Gir
BSH	=	Brown Swiss + Sahiwal + Holstein
BWT	=	Birth weight
BxS (BS)	=	Brown Swiss x Sahiwal
BxT (BT)	=	Brown Swiss x Tharparkar
EBV	=	Expected Breeding Value
EI	=	Exotic inheritance
F x D	=	Friesian x Desi
F x G	=	Friesian x Gir
F x H	=	Friesian x Hariana
F x K	=	Friesian x Kankrej
F x S	=	Friesian x Sahiwal
F x T	=	Friesian x Tharparkar
F/B/J x H	=	Friesian/Brown Swiss/Jersey x Hariana
F/B/J x O	=	Friesian/Brown Swiss/Jersey x Ongole
F/B/J x Zebu	=	Friesian/Brown Swiss/Jersey x Zebu
F/J x H	=	Friesian/Jersey x Hariana
F/R x S	=	Friesian/Red Dane x Sahiwal
FCI	=	First calving interval
FDP	=	First dry period

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FJG	=	Friesian + Jersey + Gir
FL305DMY	=	First lactation 305 day or less milk yield
FLL	=	First lactation length
FLTMY	=	First lactation total milk yield
H x B x T x S	=	Holstein x Brown Swiss x Tharparkar x Sahiwal
H x J x B x T x S	=	Holstein x Jersey x Brown Swiss x Tharparkar x Sahiwal
H x J x T x S	=	Holstein x Jersey x Tharparkar x Sahiwal
H x T x S	=	Holstein x Tharparkar x Sahiwal
HBT	=	Holstein + Brown Swiss + Tharparkar
HF	=	Holstein Friesian
HJT	-	Holstein x Jersey x Tharparkar
IARI	=	Indian Agricultural Research Institute
IDRI	=	Imperial Dairy Research Institute
J x G	=	Jersey x Gir
J x H	=	Jersey x Hariana
J x K	=	Jersey x Kankrej
J x L	=	Jersey x Local
J x RK	=	Jersey x Red Kandhari
J x RS	=	Jersey x Red Sindhi
J x S	=	Jersey x Sahiwal
JFG	=	Jersey + Friesian + Gir
KF	=	Karan Fries
KS	=	Karan Swiss
LH	=	Level of heterozygosity
MDF	=	Military Dairy Farm
MY/FCI	=	Milk yield per day of first calving interval
MY/FLL	=	Milk yield per day of first lactation length
WFC	=	Weight at first calving (kg)
WFS	=	Weight at first fertile service (kg)
WOY	=	Weight at one year

CHAPTER-1

INTRODUCTION

INTRODUCTION

India has a total bovine population of 275.66 million, which constitute the twenty one percent of the world bovine population and fifty eight percent of the Asian bovine population (FAO, 1997). Out of 199.69 million cattle only 11.41 million are crossbreds whereas 80 percent of our cattle population is non descript. Inspite of very large cattle population in India the milk production per cow is very low (959 kg) in comparison to Israel (9291 kg), USA (7069 kg) and Denmark (6504 kg). Although there are around 26 well-defined breeds of cattle, most of these are either draft purpose or dual purpose with poor milk production potential. The number of animals under milch breed category viz., Sahiwal, Red Sindhi, Gir, and Deoni is very small. The low milk yielding potential of non descript Zebu cows coupled with very high age at first calving and longer calving interval act as major constraints towards making dairying a economically viable enterprise. Genetic improvement of these native cattle by selective breeding is a slow process, therefore it does not seem to be very much effective to meet the demands of milk for the ever growing population in this country. The possibility of replacing of these low producing native cattle with high milk producing temperate genotypes does not seem to be feasible and economically viable in view of problems of non-availability of temperate cattle in large numbers and problem of their adaptability in harsh tropical environment. Under these circumstances crossbreeding of indigenous cattle with high producing temperate breeds have emerged as an effective and suitable alternative to increase milk production and also to reduce the gap between the per capita availability (220 gm/day) and recommended requirement (240 gm/day) of milk.

Recently India has achieved a rare distinction of being world's top milk producing country surpassing USA with an output of 78 million tones of which cows produce about 40.37 percent of milk (30 MT) while crossbred cows contribute about 22 percent of cows milk (6.6 MT) though crossbred animals constitute only 4.14 percent (11.41 million) of the total cattle population (Anon. 1997).

A focus on the zone wise milk production in India reflects that Northern zone (UP, Punjab, Haryana) contributes around 34 percent, while western Zone (Rajasthan, Gujarat, Maharashtra, MP), Southern Zone (Tamil Nadu, Andhra Pradesh, Karnataka and Kerala), and Eastern Zone (Bihar, West Bengal, Assam) contributed 27.2, 20.00 and 13.1 percent respectively, which reflects that the above mentioned 14 states produce almost 94.3 percent of milk, whereas, remaining states along with union territories contribute only 5.7 percent milk. Thus there is an immense scope for further implementation of crossbreeding programme in various state of the country to augment milk production.

The first attempt of crossbreeding began in India in 1857 with the development of the 'Taylor' breed around Patna by crossing Short horn, to Native with the aim of increasing milk production (Amble and Jain, 1966). Subsequently, it was taken up at several stations viz., IDRI, Bangalore (Ayrshire x Hariana); Chennai (Ayrshire x Red Sindhi); Allahabad Agricultural Institute (Jersey/Brown Swiss x Red Sindhi). Various crossbreeding programmes were taken up from time to time to develop new strains of crossbred cattle such as 'Jersind' and Brown Sind' at Allahabad Agricultural Institute, , 'Frieswal' at Military Dairy Farm, Meerut and 'Sunandini' developed under field condition by Kerala Livestock Board, Kerala under Indo Swiss Project.

Crossbreeding programme was started at National Dairy Research Institute, Karnal in 1963 with the prime objective to evolve a strain of crossbred cattle with optimum level of exotic inheritance suited to our tropical climatic conditions. Until now NDRI has developed two crossbred cattle strains i.e., Karan Swiss and Karan Fries. Karan Swiss was developed through crossing Red Sindhi and Sahiwal cows with imported frozen semen of progeny tested Brown Swiss bulls. All the crossbred genetic groups with different levels of Brown Swiss inheritance thus produced through crossbreeding, were merged in 1980 and exotic level of inheritance around 50 percent was maintained and for bringing further genetic improvement of the *inter-se* mated synthetic population selective breeding was followed (Joshi, 1998).

Similarly crossbreeding of Tharparkar cows with Friesian, Brown Swiss and Jersey at National Dairy Research Institute was initiated in 1971 (Bhatnagar et al., 1981). The productivity of various types of crosses were later compared and it was observed that Friesian x Tharparkar had the best performance in comparison to other types of crosses. In 1980 the Breeding Committee of National Dairy Research Institute declared 'Karan Fries' strain by merging the crossbred animals having 50 percent or more Holstein-Friesian inheritance (Joshi, 1998).

Research on crossbreeding all around the world particularly in the tropical countries has shown that performance of the F_1 animals (50 percent exotic and 50 percent zebu) is the best with respect to various production as well as reproduction traits (Syrstad, 1990). But it is not practically feasible to maintain pure F_1 population for a milking herd. *Inter-se* mating of animals with 50 percent exotic inheritance, however is the usual practice. It was found that there was decline in performance from F1 to F2 crossbreds. The comparison of performance of *Bos indicus* x *Bos taurus* at various levels of Taurus inheritance showed the best performance at 50 to 62.5 percent exotic level. At lower grades productivity fell while at higher grades, there was poor adaptability and disease resistance.

Since hybrid vigour or heterosis is a function of heterozygosity i.e., proportion of loci at which the animal is expected to be heterozygous (Falconer and Mackay, 1996), therefore maintenance of heterozygosity in crossbred population is important. Heterozygosity in crossbred populations fluctuates with mating system or type of crosses produced.

The present breeding policy for improvement of synthetic crossbred population is through *inter-se* mating followed by selection with the maintenance of desired level of exotic inheritance. But exotic inheritance is not found to be the key factor in determining the performance of the synthetic population. Therefore, it has now become obvious to examine the performance of population over the generations. Use of artificial insemination coupled with different mating plans has resulted in production of animals with overlapping generations. The animals thus produced must be defined from sire side as well as dam side and performance over the corresponding generations along with exotic inheritance and level of heterozygosity need to be studied. Till now no method is available for direct identification of genes responsible for milk production and estimation of heterozygous loci. Dickerson (1973) introduced the concept of loss of heterozygosity and also suggested a method to measure the level of heterozygosity in a *inter-se* mated crossbred population based on proportionate contribution from different breeds to the individual. Sometimes in a synthetic population more than two breeds are used, thus resulting in change in the level of heterozygosity without changing the level of exotic inheritance. So evaluation of performance for using different types as well as different number of breeds also seems to be necessary.

In a closed synthetic crossbred population use of limited number of bulls often resulted increase in inbreeding level. Thus deterioration in milk production or other traits occur not only due to loss of heterozygosity or recombination loss but also due to accumulation of inbreds in the population.

So keeping all these points in view it is very essential to develop suitable mating plan taking into consideration the number and types of breeds, to be used, level of exotic inheritance and heterozygosity to be maintained so that stability in various production and reproduction traits can be obtained along with the avoidance of inbreeding.

Selection is key for improvement in any population. But the effectiveness of selection depends upon herd size, selection differential and selection intensity. In a large size herd selection differential is more and consequently response to selection is more for future generations. Herd size depends upon disposal pattern. If disposal rate continues to be more than replacement of heifers available then there would be gradual reduction in the herd size. So it is very essential to study the disposal trend of the population to know the population dynamics over the generations.

So keeping all these points in view, the present investigation has been carried out with the following objectives:-

1. Generationwise genetic analysis of growth, production and reproduction traits.
2. To estimate the level of heterozygosity, exotic inheritance, inbreeding and their relationship with growth, production and reproduction traits.
3. To estimate the disposal rate in different age groups over the generations and its effect on milk production performance traits.
4. To suggest optimum breeding programme for improving the herd productivity.

CHAPTER-2

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The literature available on different aspects of the present investigation has been reviewed under the following headings:

2.1. Average performance of body weight at different ages, production and reproduction traits and factors affecting them

2.2. Estimates of various genetic and phenotypic parameters of different traits.

2.3. Paternal and maternal generation wise performance of crossbred cows.

2.4. Level of exotic inheritance/heterozygosity with reference to performance of crossbred cattle.

2.5. Genetic distance studies

2.6. Incidence of inbreeding and its effect on body weight at different ages, production and reproduction traits.

2.7. Disposal pattern and its impact on performance

2.1. AVERAGE PERFORMANCE OF BODY WEIGHT AT DIFFERENT AGES, PRODUCTION AND REPRODUCTION TRAITS AND FACTORS AFFECTING THEM

2.1.1. Average Body Weight at Different Ages in Crossbred Cattle and Factors Affect It

Growth measured in terms of body weight is an important indicator of the management practices in a herd. Better body growth ensures better future for reproduction and production performance by providing larger number of replacements by reducing the culling intensity in female calves and heifers and by reducing age at maturity. Increase in replacement rate gives higher scope for selection of the animals, thereby increasing genetic gain. Lower age at maturity would reduce generation interval, thereby, increasing annual genetic gain. The average body weight at different ages along with effect of various genetic and non-genetic factors as reported by various workers at different farms and locations are summarized in Table 2.1.

2.1.1.1. Birth Weight (BWT)

The range of average birth weight in crossbred cattle was reported to be 23.06 kg in F x T crosses at Jabalpur (Gour and Dave, 1986) to 35.20 kg in F/RD x S crosses at PAU, Ludhiana (Parmar et al., 1986) (Table 2.1).

The effect of sire on birth weight was found to be significant by Narayanswamy et al. (1984) and Tajane and Rai (1989a) in Friesian x Sahiwal crosses by Su (1988) and Singh(1995) in Karan Swiss and Karan Fries at NDRI Farm, Karnal.

The effect of season on birth weight was found to be significant by Rao and Nagarcenkar (1979), Su (1988), Tajane and Rai (1989a) and Roy and Tripathi (1991) in Friesian crosses and non-significant by Gour and Dave (1986), Nautiyal and Bhat (1989a) and Jadhav (1990) in Friesian crosses and by Su (1988) in Karan Swiss cattle.

The effect of period of birth weight was found to be significant by Parmer et al. (1986), Su (1988) and Jadhav (1990) in Friesian crosses.

2.1.1.2. Body Weight at One Year(WOY)

The body weight at one year of age in crossbred females was reported to vary from 121 kg in F x T crosses at Jabalpur (Gour and Dave, 1986) to 288 kg in F x S crosses at Military Farms (Singh et al., 1984) Table 2.1.

The effect of sire on body weight at one year was found to be significant by Su (1988) and Joshi et al. (1991) in Karan Swiss and by Singh (1995) in both the Karan Swiss and Karan Fries cattle at NDRI Farm, Karnal.

Table 2.1. Average body weight at different ages in crossbred cattle and factors affecting them.

Breed/Genetic group	Location/Farm	No. of observations	Mean ± S.E.	Effect of			Reference
				Sire	Season	Period	
1	2	3	4	5	6	7	8
Birth Weight (BWT) in kg							
F x S	MDF	3228	24.25	-	S	S	Rao and Nagarcenkar (1979)
F x H	MDF	-	23.10±0.41	-	NS	NS	Bhat *et al.* (1982)
F x S	MDF	381	23.20±0.12	-	-	-	Singh *et al.* (1984)
F x S	MDF	1396	25.43±0.09	S	NS	S	Narayanswamy *et al.* (1984)
F/B/J x H	IVRI	417	23.34±0.16	-	NS	NS	Shrivastav *et al.* (1985)
F x T	JNKVV	104	23.06±0.42	NS	NS	S	Gour and Dave (1986)
F/R x S	PAU	177	35.20	-	NS	S	Parmar *et al.* (1986)
Crossbred	MPKV	120	20.73±0.43	-	NS	S	Dhumal *et al.* (1988)
KS	NDRI	860	25.70±1.00	S	NS	S	Su (1988)
KF	NDRI	470	26.00±1.20	S	S	NS	Su (1988)
F/B/J x H	IVRI	414	24.17±0.16	-	NS	S	Nautiyal and Bhat (1989a)
F x S	MDF	1717	26.18±0.65	S	S	S	Tajane and Rai (1989a)
F x S	MDF	2674	24.31±0.14	-	NS	S	Jadhav (1990)
F x S	GBPUA&T	225	24.57±0.18	-	-	-	Teotia *et al.* (1990)
KS	NDRI	612	25.80±0.50	NS	S	NS	Joshi *et al.* (1991)
F x S/T	MDF	3527	25.04±0.08	-	S	S	Roy and Tripathi (1991)
F x S/K	GAU	218	24.09±0.04	S	S	S	Dhangar and Patel (1992a)
KS	NDRI	967	26.93±0.26	S	S	S	Singh (1995)
KF	NDRI	1302	27.28±0.28	S	S	S	Singh (1995)
Weight at One Year (WOY) in kg							
F x T	JNKVV	65	200.00	-	NS	NS	Parekh *et al.* (1976)
F x S	MDF	2565	197.00	-	S	S	Rao and Nagarcenkar (1979)

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The effect of season and period was found to be significant by Taneja and Bhat (1982), Narayanswamy et al. (1984) and Tajane and Rai (1989a) in Friesian crosses.

2.1.1.3 Body Weight at First Fertile Service (WFS)

Weight at first fertile service is also an important economic trait since sexual maturity is dependent on weight as well as age of the heifer. Optimum body weight at first service is necessary for better reproduction and production efficiency of animals. Besides being characteristic of a breed, the WFS is largely influenced by level of feeding and management of animals.

The average body weight at WFS was reported to vary from 272 kg in Friesian x Tharparkar (F x T) crosses at NDRI Karnal (Nagarcenkar and Rao, 1982) to 356 kg in F x S crosses at Military Farms (Singh et al., 1984) Table 2.1.

Significant effect of sire of WFS was reported by Su (1988) and Joshi et al. (1991) in Karan Swiss and non-significant effect of sire on this trait was reported by Narayanswamy et al. (1984) IN F x S crosses and Su (1988) in Karan Fries cattle.

The effect of season and period of birth of WFS was found to be significant by Nagarcenkar and Rao (1982) and Jadhav (1990) in Friesian crosses and non-significant effect of these factors was found by Su (1988) in Karan Fries and Karan Swiss cattle and Singh (1995) in Karan Fries cattle.

2.1.1.4. Body Weight at First Calving (WFC)

The average body weight at first calving in crossbred animals was reported to vary from 261 kg in Jersey x Hariana (J x H) crosses at IVRI, Izatnagar (Pandey, 1987) to 427 kg in Friesian x Sahiwal (F x S) crosses at Military Farms (Roy, 1986) Table 2.1.

The effect of sire on WFC was found to be significant by Tajane and Rai (1989a) in Friesian x Sahiwal crosses and by Joshi (1991) in

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1	2	3	4	5	6	7	8
F x S	MDF	90	209.00±3.27	-	S	S	Taneja and Bhat (1982)
F x S	MDF	1349	202.00±0.96	NS	S	S	Narayanswamy *et al.* (1984)
F x S	MDF	145	288.00±4.23	-	-	-	Singh *et al.* (1984)
F/B/J x H	IVRI	417	159.00±1.86	-	NS	S	Shrivastav *et al.* (1985)
F x T	JNKVV	76	121.00±3.20	NS	NS	S	Gour and Dave (1986)
KS	NDRI	620	161.50±2.50	S	S	NS	Su (1988)
KF	NDRI	272	180.50±5.60	NS	NS	NS	Su (1988)
F/B/J x H	North India	216	160.00±1.80	-	-	-	Chopra (1989)
F/B/J x H	IVRI	267	165.00±2.41	-	NS	S	Nautiyal and Bhat (1989a)
F x S	MDF	1814	210.00±1.52	-	S	S	Jadhav (1990)
F x S	GBPUA&T	225	193.00±2.33	-	-	-	Teotia *et al.* (1990)
KS	NDRI	612	165.00±2.64	S	S	S	Joshi *et al.* (1991)
F x T/S	MDF	3607	206.00±0.66	-	S	S	Roy and Tripathi (1991)
KS	NDRI	735	175.00±1.65	S	S	S	Singh (1995)
KF	NDRI	1034	178.05±1.42	S	S	S	Singh (1995)
Weight at First Fertile Service (WFS) in kg							
F x T	NDRI	102	272.00±3.00	-	NS	S	Nagarcenkar and Rao (1982)
B x T	NDRI	39	291.00±6.00	-	S	S	Nagarcenkar and Rao (1982)
HBT	NDRI	28	287.00±7.80	-	NS	NS	Sethi *et al.* (1982)
BHS	NDRI	17	276.00±8.60	-	NS	NS	Sethi *et al.* (1982)
F x S	MDF	1349	307.72±1.16	NS	NS	S	Narayanswamy *et al.* (1984)
F x S	MDF	-	356.00	-	-	-	Singh et al (1984)
KS	NDRI	475	281.20±3.50	S	NS	NS	Su (1988)
KF	NDRI	123	344.00±1.00	NS	NS	NS	Su (1988)
F x S	MDF	2023	316.72±2.29	-	S	S	Jadhav (1990)

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1	2	3	4	5	6	7	8
KS	NDRI	612	291.30±5.00	S	NS	S	Joshi *et al.* (1991)
F x S	MDF	3244	323.00±1.17	-	NS	S	Roy and Tripathi (1991)
KS	NDRI	460	312.53±4.62	S	S	S	Singh (1995)
KF	NDRI	668	306.65±2.82	S	S	NS	Singh (1995)
Gir crosses	MPKVV, Rahuri	1072	277.44±2.18	-	-	-	Nagore and Kulkarni (2000)
Weight at First Calving (WFC) in kg							
F x S	MDF	1108	384.00±2.31	-	S	S	Reddy and Basu (1985)
F x S/T	MDF	13786	426.88±1.20	-	S	S	Roy (1986)
F x H	IVRI	74	310.00±7.50	-	NS	NS	Pandey *et al.* (1987)
B x H	IVRI	47	281.00±6.50	-	NS	S	Pandey *et al.* (1987)
J x H	IVRI	35	261.00±7.60	-	NS	NS	Pandey *et al.* (1987)
F/B/J x H	IVRI	175	308.00±8.34	-	NS	S	Nautiyal and Bhat (1989a)
J x K	Anand	50	352.00±-	-	NS	NS	Patel *et al.* (1989)
F x S	MDF	1717	360.00±3.00	S	NS	S	Tajane and Rai (1989a)
F x S	MDF	1971	390.00±2.25	-	S	S	Jadhav *et al.* (1991b)
KS	NDRi	612	344.50±5.71	S	NS	S	Joshi *et al.* (1991)
F x S	MDF	826	390.00±2.15	-	S	S	Rana (1991)
J x K (F_1)	GAU	61	344.56±5.67	-	NS	NS	Dhangar and Patel (1993)
J x K (F_2)	GAU	124	307.55±3.38	-	NS	S	Dhangar and Patel (1993)
KS	NDRI	645	397.97±3.62	S	S	NS	Singh (1995)
KF	NDRI	668	399.30±6.00	S	NS	NS	Singh (1995)
Gir crosses	MPKVV, Rahuri	1072	382.76±2.68	-	-	-	Nagore and Kulkarni (2000)

Karan Swiss cattle and by Singh (1995) in both the Karan Swiss as well as karan Fries cattle.

The effect of season and period of birth on WFC was found to be significant (Roy, 1986; Rana, 1991; Jadhav et al., 1991b) in Friesian x Sahiwal crosses at Military Farms and non-significant effect in Karan Swiss cattle by Singh (1995).

2.1.2. Factors Affecting Performance of Various First Lactation Production and Reproduction Traits in Crossbred Cattle

The literature available on factors affecting the various first lactation production and reproduction traits like age at first fertile service (AFS), age at first calving (AFC), first lactation yield 305-days or less (FL305DMY), total first lactation yield (FLTMY), first lactation length (FLL), first service period (FSP), first dry period (FDP), first calving interval (FCI), milk yield per day of first lactation length (MY/FLL), milk yield per day of first calving interval (MY/FCI) in crossbred cattle in reviewed under following sub-sections:

2.1.2.1 Age at First Fertile Service (AFS)

The age at first fertile service is an important economic trait directly influencing initiation of production age. A lower AFS is likely to reduce the cost of rearing of animals from birth to maturity. It is desirable to have minimum AFS without affecting the growth, production and reproduction efficiency of the heifers.

The published reports on estimates of average AFS and effect of factors like sire, season and period on it in various exotic x Zebu crosses are summarized in Table 2.2.

The average AFS was reported to range from 578 days in Friesian x Tharparkar (F x T) halfbreds at Karnal (Nagarcenkar and Rao, 1982) to 846 days in Friesian/Jersey x Sahiwal (F/J x S) crosses at Pantnagar (Singh et al., 1990). The effect of season of birth was found to be having significant effect by Nagarcenkar and Rao (1982), Pyne et al. (1988) and

Singh (1995). The effect of period of birth on AFS was found to be significant by Nagarcenkar and Rao (1982), Singh et al. (1990) Table 2.2.

2.1.2.2. Age at First Calving (AFC)

Age at first calving is an important trait which influences the production and reproduction efficiency of an animal. It is desirable to have lower AFC without adversely affecting the growth, production, reproduction performance and economic returns from the animal. A lower AFC also enhances the annual genetic gain by reducing the generation interval.

The published reports of estimates of average AFC in various exotic x Zebu crosses along with the effect of sire, season and period of birth are summarized in Table 2.2.

The average AFC was reported to range from 850 days in F x T at NDRI, Karnal (Nagarcenkar and Rao, 1982) and J x K at Krushinagar (Dhangar and Patel, 1991a) to 1151 days in F x S crosses at Military Farms (Pandey and Desai, 1973).

This large diversity in average AFC among different reports indicates that there is considerable variation in crossbreds genetic groups, environmental influences and managemental practices at various locations. The effect of period and season of birth on AFC was reported to be significant by various investigators (Nagarcenkar and Rao, 1982; Jadhav et al., 1991a; Roy and Tripathi, 1992). The effect of sire on AFC was reported to be significant by Su (1988) in Karan Swiss and Panja (1997) in Karan Fries cattle at NDRI farm, Karnal.

2.1.2.3. First Lactation 305 Days or Less Milk Yield (FL305DMY)

The FL305DMY is the most important economic trait of dairy animals. It has been brought out by researchers around the world that the 'best' indicator of milk producing ability of cows is their own milk production performance. The FL305DMY is the earliest production record and hence it has prime importance to decide whether the animal is to be retained in the herd or not, and to assess the genetic progress of the herd.

Table 2.2 summarizes average FL305DMY is reported by different workers for various genetic groups at various locations along with the significance of genetic (sire) and non-genetic factors like season, period and AFC on FL305DMY. The average FL305DMY was reported to range from 1435 kg in B x L crosses iat Kerala (Iype et al., 1985) to 3517 kg in F x K crosses at Anand (Patel et al., 1987).

The effect of sire was reported to be significant by Su (1988) and Herbert and Bhatnagar (1988) in Karan Swiss; Kishore (1993) in Brown Swiss crosses, and by Panja (1997) on Karan Fries cattle. Significant effect of season and period of calving on FL305DMY was reported by Panda and Sandhu (1983), Parmar et al. (1986) and Dalal et al. (1991) in Friesian crosses, by Dutt and Joshi (1992) in Karan Swiss cattle and by Sahana and Gurnani (2000) in Karan Fries cattle. Table 2.2 reveals a wide variation in different genetic groups for first lactation production performance and effect of genetic and non-genetic factors on it.

2.1.2.4. First Lactation Total Milk Yield (FLTMY)

The crossbred animals are generally high milk producers and their lactation length is likely to be higher than the standard of 305-days. This situation appears to be more pronounced in case of very high producers as their service period tends to be higher and so their lactation length and calving interval would be high. The average of FLTMY in various genetic groups at different locations along with the significant effects of genetic (sire)(and non-genetic factors (season, period and AFC) have been summarized in Table 2.2.

The least-squares average of FLTMY in various genetic groups reported by different workers ranged from 1486 kg in B x L crosses in Kerala (Stephen et al., 1985) to 3908.16 kg in Karan Fries cattle at NDRI, Karnal (Sinha, 1999).

The effect of sire was reported to be significant by Tajane and Rai (1989b) and Raheja et al. (1994a) in Friesian crosses and Herbert (1987) in Karan Swiss cattle and Panja (1997) in Karan Fries cattle. Significant effect of season and period was reported by Parmar et al. (1986), Singh and Tomar (1991), Singh et al. (1993) and Raheja et al. (1994a) in Friesian crosses and Siva Kumar (1998) in Karan Fries but Sahana and Gurnani (2000) reported non-significant effect of period on first lactation total milk yield.

The review of literature revealed that in crossbred cattle, ther is large variation for genetic groups, lactations, lactation length and environmental factors (season and periods etc.)

2.1.2.5. First Lactation Length (FLL)

The FLL is also an important economic trait which is related to the milk production ability to a substantial extent in dairy animals. The estimates of average FLL along with the effect of sire, season, period and AFC as reported in literature have been summarized in Table 2.2. Average FLL has been reported to range from 296 days in F x S crossed by Jadhav et al. (1991a) at Military Farms to 372 days in F x S crosses by Parmar et al. (1986) at PAU, Ludhiana.

The effect of sire on FLL was reported to be significant by Herbert and Bhatnagar (1989) in Karan Swiss cattle at NDRI Farm, Karnal. The effect of season on FLL was reported to be significant by Roy (1986) and Jadhav et al. (1991a), Panja (1997), Siva Kumar (1998) and Sahana and Gurnani (2000),. The Significant effect of period on FLL was reported by Vij (1981), Roy (1986), Kumar (1987) and Su (1988). The effect of AFC on FLL was reported to be non-significant by Gupta et al. (1986), Kumar (1987), Pandey et al. (1988) and Su (1988).

2.1.2.6. First Service Period (FSP)

The service period is an indicator of managemental practices with respect to reproduction. It is always desirable to have optimum service period since very short service period is not conducive for proper involution of uterus and nidation of fertilized ovum, while long service period would lead to higher dry period, thereby increasing the cost of management and generation interval, and thus reducing annual genetic gains.

The estimates of average FSP in various genetic groups of crossbred cattle as reported in the literature have been summarized in Table 2.2.

The range of average FSP in crossbreds was 100 days in F x T crosses at NDRI Farm, Karnal (Nagarcenkar and Rao, 1982) to 171 days in F x S crosses at Military Farms (Arora et al., 1993). The effect of period of calving on FSP was reported to be significant by Nagarcenkar and Rao (1982), Roy (1986), Patel et al. (1989), Arora et al. (1993), Sahana (1996). The favourable season for calving was generally autumn calvers (Roy, 1986; Su, 1988; Jadhav et al., 1991a).

2.1.2.7. First Dry Period (FDP)

The dry period is a measure of efficiency of managemental practices at a farm., Longer dry period is an indication of poor managemental practices as it would affect the profit of the herd. A minimum dry period of around 60 days is necessary to give lactation rest to the cow for the optimum productive performance in subsequent lactation.

The estimate of mean value of FDP in different genetic groups of crossbreds along with effects of non-genetic (season, period and AFC) and genetic factors (sire) as reported in the literature have been summarized in Table 2.2.

The range of average FDP in crossbreds was 61 days in Karan Fries at NDRI Farm, Karnal (Singh and Tomar, 1991) to 174 days in F/B/J x H crosses at IVRI, Izatnagar (Pandey et al., 1988).

The effect of season and period of calving on FDP was reported to be significant by Basu and Ghai (1980), Roy (1986), Jadhav et al.

(1991a). the effect of AFC on FDP was reported to be significant by Pandey et al. (1988) and Garcha and Dev (1994) in Friesian crosses).

2.1.2.8. First Calving Interval (FCI)

The calving interval is an important indicator of reproductive efficiency of a herd. The ideal calving interval is considered to be one year with cows being in milk for 10 months and dry for two months. For improved reproductive efficiency, profitability and faster genetic improvement, it is desirable to have shorter calving interval. The estimates of average FCI as reported in the literature have been summarized in Table . The range of average FCI in crossbreds of different genetic groups was 400 days in B x S crosses (Vij, 1981) at NDRI Farm, Karnal to 482 days in F x H crosses (Raheja et al., 1994a) at Military Dairy Farms.

The effect of season and period on FCI was reported to be significant by Vij (1981), Roy (1986), Kumar (1987) and Raheja et al. (1994a). The effect of sire on FCI was reported to be non-significant by Su (1988), Herbert and Bhatnagar (1989) in Karan Swiss Cattle; Singh (1995) in both the Karan Fries and Karan Swiss cattle and Panja (1997) in Karan Fries cattle.

2.1.2.9. Milk Yield per day of First Lactation Length (MY/FLL)

The average milk yield per day of first lactation length in crossbred cattle as reported in the literature have been summarized in Table 2.2

The average MY/FLL varied from 6.22 kg in F x S crosses at Military Dairy Farms (Reddy and Basu, 1985) to 10.68 in F x S crosses at PAU, Ludhiana (Garcha et al., 1991).

The effect of season and period of calving on My/FLL was reported to be significant by Parmar et al. (1986), Pandey et al. (1988), Kakran and Joshi (1990), Garcha et al. (1991), Arora et al. (1993b) and Siva Kumar (1998).

Table 2.2. Average of various first lactation performance traits in crossbreds and factors affecting them

Breed/Genetic group	Location/Farm	No. of observations	Mean ± S.E.	Effect of				Reference
				Sire	Season	Period	AFC	
1	2	3	4	5	6	7	8	9
Age at First Fertile Service (AFS) in days								
F/B/J x H	IVRI	171	758.00±19.00	-	S	S		Kaushik *et al.* (1979)
F x T	NDRI	106	578.00	-	S	S		Nagarcenkar and Rao (1982)
B X S	NDRI	105	638.00	-	S	S		Nagarcenkar and Rao (1982)
HBT	NDRI	28	784.21±21.00	-	NS	-		Sethi *et al.* (1982)
BHS	NDRI	14	836.00±41.00	-	NS	-		Sethi *et al.* (1982)
J x L	Orissa	383	686.00±10.00	-	-	-		Sahu *et al.* (1987)
J x H	Kalyani	1206	720.00±44.00	-	S	-		Pyne *et al.* (1988)
F/B/F x Zebu	GBPUA&T	299	846.00±18.00	-	NS	S		Singh *et al.* (1990)
F x G	Kenya	235	616.60±9.00	-	NS	S		Wagh *et al.* (1991)
KS	NDRI	478	723.63±13.78	S	NS	NS		Singh (1995)
KF	NDRI	668	697.66±9.80	S	NS	S		Singh (1995)
Gir cross	MPKVV, Rahuri	1072	534.94±3.84	-	-	-		Nagore and Kulkarni (2000)
Age at First Calving (AFC) in days								
HF crosses	MDF	362	1151.00±9.00	-	-	-		Pandey and Desai (1973)
HF crosses	MDF	656	1078.59±5.77	-	-	-		Basu and Ghai (1977)
Crossbred	IVRI	215	998.00±12.55	-	S	S		Kaushik *et al.* (1979)
F x T	NDRI	102	850.00±13.00	-	S	S		Nagarcenkar and Rao (1982)
F x S	MDF	1787	957.00±5.00	-	S	S		Reddy and Basu (1985)
F x S	MDF	1217	1092.00±8.00	-	NS	S		Reddy and Basu (1985)
F/RD x S	PAU	177	878.00	-	NS	S		Parmar *et al.* (1986)
B x T	NDRI	39	927.00±19.00	-	S	S		Kumar (1987)
KS	NDRI	352	1068.00±14.00	S	S	S		Su (1988)
J x K	Anand	76	864.00	-	NS	NS		Patel *et al.* (1989)
J x K (F_1)	GAU	88	850.00±13.00	-	-	-		Dhangar and Patel (1991)
J x K (F_2)	GAU	144	925.00±10.60	-	-	-		Dhangar and Patel (1991)
F x S	MDF	2767	1028.00±5.44	-	S	S		Jadhav *et al.* (1991a)
F x S	MDF	826	1100.00±31.00	-	NS	NS		Rana (1991)
F x S/T	MDF	3421	1057.60±5.10	-	S	S		Roy and Tripathi (1992)

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Frieswal	MDF	1380	875.00±8.83	-	-	-		Arora *et al.* (1993)
F x RS	Puri	28	1059.00±37.00	-	NS	S		Yazdani *et al.* (1993)
J x RS	Puri	30	1008.00±68.00	-	NS	NS		Yazdani *et al.* (1993)
J x S	Nagpur	43	894.00±3.00	-	NS	S		Tekade *et al.* (1994)
KS	NDRI	478	1009.44±19.06	S	NS	S		Singh (1995)
KF	-do-	645	977.97±9.86	S	NS	S		Singh (1995)
-do-	-do-	489	940.00±18.22	S	S	S		Panja (1997)
-do-	-do-	722	985.52±5.46	-	NS	S		Siva Kumar (1998)
-do-	-do-	91	985.90±16.36	-	NS	NS		Sinha (1999)
-do-	-do-	1224	968.5±7.9	-	NS	S		Sahana and Gurnani (2000)
Gir cross	MPKVV, Rahuri	1072	858.72±4.99	-	-	-		Nagore and Kulkarni (2000)
Crosbred	-	493	1168.14±10.92	-	-	-		Rao *et al.* (2000)
First Lactation 305 days or Less Milk yield (FL 305 DMY) in kg								
HF crosses	MDF	656	2741.60±34.43	-	NS	S	-	Basu and Ghai (1977)
F x T	NDRI	98	3292.00±105.00	-	NS	NS	-	Nagarcenkar and Rao (1982)
B x T	NDRI	36	2755.00±124.00	-	NS	NS	-	Nagarcenkar and Rao (1982)
F x H	Haringhatta	675	2584.69±35.62	-	S	S	-	Panda and Sandhu (1983)
J x H	Haringhatta	624	2077.00±37.00	-	NS	NS	-	Panda and Sandhu (1983)
Crossbred	Kerala	-	1434.40±51.00	-	-	-	-	Iype *et al.* (1985)
F x H (F_1)	Kalyani	643	1933.00±42.00	-	NS	S	-	Parmar *et al.* (1986)
F/R x S	PAU	177	2773.00±-	-	S	S	-	Parmar *et al.* (1986)
F x S	MDF	1516	2860.55±38.50	-	NS	S	NS	Kumar (1987)
F x K	Anand	-	3517.00±100.00	-	-	-	-	Patel *et al.* (1987)
J x K	Anand	66	2547.00±64.00	-	S	S	-	Patel *et al.* (1987)
J x H	Kalyani	540	1675.00±9.50	-	-	-	-	Agasti *et al.* (1988)
F/B/J x H	IVRI	129	1961.00±105.00	S	NS	S	S	Pandey *et al.* (1988)
KS	NDRI	224	2819.00±-	S	NS	S	NS	Su (1988)
KS	NDRI	625	2351.00±42.00	S	S	S	-	Herbert and Bhatnagar (1989)
F x S	HAU	360	2523.00±42.00	-	S	S	-	Dalal *et al.* (1991)
F/B/J x 0	Lam (AP)	581	1760.00±8.00	-	-	-	-	Kumar *et al.* (1991)
F x S	MDF	2323	2381.00±45.00	-	NS	S	-	Jadhav *et al.* (1991a)
KS	NDRI	1053	2758.00±116.00	S	S	S	-	Dutt and Joshi (1992)

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Frieswal	MDF	141	2629.50±52.00	-	-	-	-	Arora *et al.* (1993)
J x S	Wadsa	173	1747.00±66.00	-	NS	S	-	Deshmukh *et al.* (`1995)
KS	NDRI	383	2615.74±82.44	S	NS	NS	NS	Singh (1995)
KF	-do-	490	3173.23±82.27	S	NS	S	NS	Singh (1995)
-do-	-do-	461	3199.23±44.24	S	NS	S	-	Panja (1997)
-do-	-do-	716	3197.33±34.29	-	NS	S	-	Siva Kumar (1998)
-do-	-do-	91	3420.37±93.85	-	S	NS	-	Sinha (1999)
-do-	-do-	1212	2919.20±44.70	-	S	S	-	Sahana and Gurnani (2000)
First Lactation Total Milk Yield (FLTMY) in kg								
F x S	MDF	1227	2601.00±38.00	-	NS	S	-	Reddy and Basu (1985)
B/J x L	Kerala	2072	1486.00±24.00	-	NS	S	S	Stephen *et al.* (1985)
F/R x S	PAU	177	3166.00	-	S	S	-	Parmar *et al.* (1986)
F x S	MDF	1516	3029.00±46.00	-	NS	S	NS	Kumar (1987)
F/B/J x H	IVRI	129	2078.00±19.00	-	NS	S	S	Pandey *et al.* (1988)
F x S	Kalyani	202	1987.00±14.00	-	NS	S	-	Pyne *et al.* (1988)
F x S	MDF	2069	2466.00±99.00	S	NS	S	-	Tajane and Rai (1989b)
F/B/J x O	Lam (AP)	581	1930.00±11.00	-	-	-	-	Kumar *et al.* (1991)
F x S	MDF	826	2309.00±90.00	-	NS	S	-	Rana (1991)
KF	NDRI	451	3236.00±76.00	-	S	S	-	Singh and Tomar (1991)
F x S	MDF	2389	2495.00±50.00	-	NS	S	-	Jadhav *et al.* (1991b)
Frieswal	MDF	201	2730.00±61.00	-	-	-	-	Arora *et al.* (1993)
F/B/J x H	Kalyani	660	1698.00	-	S	S	S	Battacharya *et al.* (1993b)
Crossbred	GBPUA&T	299	2286.00±78.00	-	NS	NS	-	Singh *et al.* (1993)
KS	NDRI	1044	2640.00±36.00	-	S	S	-	Singh *et al.* (1993)
KF	NDRI	835	2769.00±55.00	-	NS	S	-	Singh *et al.* (1993)
F X S	MDF	1380	3255.00±27.00	-	NS	S	-	Raheja *et al.* (1994a)
F x H	MDF	690	3255.00±27.00	S	S	S	-	Raheja *et al.* (1994a)
J x S	Nagpur	43	2035.00±70.00	-	S	S	-	Tekade *et al.* (1994)
KS	NDRI	383	2952.42±120.25	-	NS	NS	NS	Singh (1995)

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KF	-do-	490	3676.92±135.00	S	NS	NS	NS	Singh (1995)
-do-	-do-	461	3599.00±54.96	S	NS	NS	-	Panja (1997)
-do-	-do-	716	3617.91±49.81	S	S	S	-	Siva Kumar (1998)
-do-	-do-	91	3908.16±124.46	-	S	NS	-	Sinha (1999)
-do-	-do-	1196	3383.13±69.46	-	S	NS	-	Sahana and Gurnani (2000)
First Lactation Length (FLL) in days								
B x Zebu	NDRI	718	322.00	-	NS	S	-	Vij (1981)
F x S	JNKVV	86	340.00±16.00	-	S	S	NS	Gupta *et al.* (1986)
F/R x S	PSU	177	372.00	-	NS	NS	-	Parmar *et al.* (1986)
F x S	MDF	3665	303.17±1.68	-	S	S	-	Roy (1986)
F x S	MDF	1516	305.44±3.12	-	S	S	NS	Kumar (1987)
F/B/J x H	IVRI	129	303.00±8.50	-	NS	S	NS	Pandey *et al.* (1988)
KS	NDRI	167	318.00±-	NS	NS	S	NS	Su (1988)
KS	NDRI	625	333.00±4.00	S	NS	S	-	Herbert and Bhatnagar (1989)
F x S	MDF	2069	312.00±5.00	S	NS	S	-	Tajane and Rai (1989b)
F/B/J x H	HAU	216	333.00±34.00	-	NS	-	-	Chopra (1990)
F x S	HAU	360	338.00±5.39	-	-	S	-	Dalal *et al.* (1991)
F/B/J x O	Lam (AP)	581	330.00±1.00	-	S	-	-	Kumar *et al.* (1991)
F x S	MDF	2389	295.70±4.00	-	-	S	-	Jadhav *et al.* (1991a)
Frieswal	MDF	201	326.00±4.77	-	S	-	-	Arora *et al.* (1993)
Crossbred	GBPUA&T	299	298.50±7.73	-	-NS	NS	-	Singh *et al.* (1993)
J x K	Nagpur	43	360.00±11.00	-	NS	NS	-	Tekade *et al.* (1994)
J x S	Wadra	173	309.00±3.40	-	NS	S	-	Deshmukh *et al.* (1995)
F x D	MPAU	285	306.00±3.00	-	NS	S	-	Thalkari *et al.* (1995)
KS	NDRI	383	328.34±8.77	NS	NS	NS	NS	Singh (1995)
KF	-do-	490	345.86±10.50	NS	S	S	NS	Singh (1995)
-do-	-do-	161	344.54±3.38	NS	S	S	-	Panja (1997)
-do-	-do-	715	343.19±3.46	-	S	S	-	Siva Kumar (1998)
-do-	-do-	91	346.44±5.12	-	NS	NS	-	Sinha (1999)
-do-	-do-	1196	343.74±5.75	-	S	S	-	Sahana and Gurnani (2000)
First Service Period (FSP) in days								
F x T	NDRI	398	100.00	-	S	S	-	Nagarcenkar and Rao (1982)

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F x T/S	MDF	3313	171.36±1.68	-	S	S	-	Roy (1986)
F x S	MDF	874	129.55±2.83	-	NS	NS	-	Deshpande *et al.* (1988)
F x H	Kalyani	53	134.81±7.73	-	S	-	-	Pyne *et al.* (1988)
KS	NDRI	184	133.90	NS	NS	S	NS	Su (1988)
J x K	Anand	66	109.67	-	S	S	-	Patel *et al.* (1989)
F x S	IVRI	340	169.50±6.43	-	NS	S	NS	Bhatia and Pandey (1990)
BS crosses	NDRI	774	131.00±10.50	-	NS	S	-	Kakran and Joshi (1990)
Crossbred	GBPUA&T	299	139.50±8.39	-	NS	NS	-	Singh *et al.* (1990)
F x S	MDF	2389	140.72±5.33	-	S	NS	-	Jadhav *et al.* (1991a)
F/B/J x 0	Lam (AP)	4682	174.00±17.00	-	-	-	-	Kumar *et al.* (1991)
Frieswal	MDF	106	175.00±12.84	-	S	S	-	Arora *et al.* (1993)
F x S	Kalyani	202	115.53±2.50	-	S	-	-	Pyne and Dattagupta (1994)
J x H	Kalyani	202	135.72±3.02	-	S	-	-	Pyne and Dattagupta (1994)
J x S	Wadsa	173	174.00±7.80	-	NS	S	-	Chaudhary *et al.* (1995)
KS	NDRI	307	148.31±12.19	NS	NS	NS	NS	Singh (1995)
KF	-do-	415	142.90±10.82	NS	S	S	NS	Singh (1995)
-do-	-do-	417	124.24±3.83	NS	S	S	-	Panja (1997)
-do-	-do-	703	133.08±3.67	-	S	S	-	Siva Kumar (1998)
-do-	-do-	91	117.39±20.02	-	S	NS	-	Sinha (1999)
Gir Cross	MPKV, Rahuri	1072	123.24±2.62		-	-	-	Nagore and Kulkarni (2000)
KF	NDRI	965	127.50±6.09	-	S	S	-	Sahana and Gurnani (2000)
First Dry Period (FDP)								
B x S	NDRI	75	76.80±10.70	-	S	NS	-	Taneja and Chawla (1978)
HF crosses	MDF	3313	117.36±1.68	-	S	S	-	Roy (1986)
F x K	ANAND	-	79.00±4.50	-	-	-	-	Patel *et al.* (1987)
F/B/J x H	IVRI	103	174.00±16.90	-	NS	S	S	Pandey *et al.* (1988)
J x K	Anand	66	77.00±4.00	-	-	-	-	Patel *et al.* (1989)
Crossbred	HAU	360	93.00±4.00	-	NS	S	NS	Dalal *et al.* (1991)
F x S	MDF	2336	125.41±5.42	-	S	S	-	Jadhav *et al.* (1991a)
F/B/J x 0	Lam (AP)	490	126.00±19.00	-	-	-	-	Kumar (1991)
KF	NDRI	307	61.00±2.00	-	NS	NS	-	Singh and Tomar (1991)
Crossbred	GBPUA&T	299	120.00±8.74	-	NS	NS	-	Singh *et al.* (1993)

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J x S	Wadsa	173	140.00±5.00	-	NS	S	-	Deshmukh *et al.* (1995)
F x D	Parbhani and Bidar	285	127.00±6.00	-	S	S	-	Thalkari *et al.* (1995)
KS	NDRI	306	103.38±8.63	NS	NS	NS	NS	Singh (1995)
KF	-do-	415	75.44±5.75	NS	NS	NS	NS	Singh (1995)
-do-	-do-	470	64.47±1.46	NS	NS	NS	-	Panja (1997)
-do-	-do-	689	69.77±1.94	-	NS	NS	-	Siva Kumar (1998)
-do-	-do-	91	67.19±5.06	-	NS	S	-	Sinha (1999)
-do-	-do-	964	65.09±2.95	-	NS	NS	-	Sahana and Gurnani (2000)
First Calving Interval (FCI) in days								
F x S	MDF	1348	425.00±9.46	-	S	NS	-	Basu and Ghai (1980)
B x S	NDRI	508	400.00	-	S	S	-	Vij (1981)
F x S	MDF	1136	430.20±3.77	-	NS	S	-	Butte and Deshpande (1986)
F/R x S	PAU	177	438.40±-	-	NS	NS	-	Parmar *et al.* (1986)
F x T/S	MDF	3371	419.62±2.40	-	S	S	-	Roy (1986)
F x S	MDF	1340	441.83±5.67	-	S	S	-	Kumar (1987)
F x S	MDF	874	428.69±3.46	-	NS	NS	-	Deshpande *et al.* (1988)
KS	NDRI	184	418.00	NS	NS	NS	NS	Su (1988)
F/B/J x H	HAU	216	423.40±5.60	-	-	-	-	Chopra *et al.* (1990)
KS	NDRI	782	408.70±9.20	-	S	S	-	Kakran and Joshi (1990)
Crossbred	HAU	345	435.00±5.00	-	S	S	NS	Dalal *et al.* (1991)
F x S	MDF	2389	419.00±5.42	-	S	S	-	Jadhav *et al.* (19919a)
F/B/J x O	Lam (AP)	508	451.00±8.00	-	-	-	-	Kumar *et al.* (1991)
F x S	MDF	826	423.00±10.70	-	S	S	-	Rana *et al.* 1991
KS	NDRI	625	427.50±7.05	NS	-	S	-	Herbert and Bhatnagar (1992)
J x H	Kalyani	202	414.00±3.23	-	S	-	-	Pyne and Dattagupta (1994)
F x H	MDF	690	482.00±3.00	-	S	S	-	Raheja *et al.* (1994a)
F x S	MDF	1380	414.00±2.00	-	S	S	-	Raheja *et al.* (1994a)
J X S	Wadsa	173	452.00±7.80	-	NS	S	-	Chaudhary *et al.* (1995)
KS	NDRI	372	404.00±7.80	-	NS	NS	-	Singh *et al.* (1995)
F x D	Parbhani and Bidar	285	433.00±7.00	-	S	S	-	Thalkari *et al.* (1995)
KS	NDRI	306	425.58±12.68	NS	NS	NS	NS	Singh (1995)

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KF	-do-	415	422.80±10.80	NS	S	S	NS	Singh (1995)
-do-	-do-	406	404.62±3.74	NS	S	NS	-	Panja (1997)
-do-	-do-	691	413.66±3.73	-	S	S	-	Siva Kumar (1998)
KF	NDRI	966	406.75±6.01	-	S	S	-	Sahana and Gurnani (2000)
Gir Cross	MPKV, Rahuri	1072	413.83±2.33	-	-	-	-	Nagore and Kulkarni (2000)
Milk Yield per day of First Lactation Length (MY/FLL) in Kg/day								
F x S	MDF	1227	6.22±0.29	-	NS	S	-	Reddy and Basu (1985)
F/R x S	PAU	177	8.52	-	S	S	-	Parmar *et al.* (1986)
F x S/T	MDF	3313	10.00±0.07	-	S	S	-	Roy (1986)
F x S	Parbhani	1136	9.35±0.05	-	NS	S	-	Butte and Deshpande (1986)
F/B/J x Hr	IVRI	129	6.70±0.31	-	S	S	-	Pandey *et al.* (1988)
KS	NDRI	916	8.90±0.16	-	S	S	-	Kakran and Joshi (1990)
F x S	PAU	508	10.68±1.54	-	S	S	NS	Garcha *et al.* (1991)
F x S	MDF	2389	8.41±0.13	-	S	S	-	Jadhav *et al.* (1991a)
Frieswal	MDF	201	8.32±0.14	-	S	S	-	Arora *et al.* (1993)
Crossbred	GBPUA&T	299	7.82±0.16	S	NS	S	-	Singh *et al.* (1993)
KS	NDRI	386	8.94±0.02	S	NS	S	NS	Singh (1995)
KF	-do-	490	10.65±0.24	S	NS	S	NS	Singh (1995)
-do-	-do-	461	10.50±0.14	S	NS	S	-	Panja (1997)
-do-	-do-	715	10.50±0.10	-	S	S	-	Siva Kumar (1998)
Milk Yield per day of First Calving Interval (MY/FCI) in Kg/day								
F x S	-	1346	5.60±0.11	-	S	S	-	Deshpande and Bonde (1982)
F/R x S	PAU	177	7.32±-	-	S	S	-	Parmar *et al.* (1986)
F x S/T	MDF	3371	8.00±0.06	-	S	S	-	Roy (1986)
F x S	Parbhani	1136	6.49±0.05	-	NS	S	-	Butte and Deshpande (1987)
KF	NDRI	307	9.71±0.16	-	S	S	-	Singh (1987)
F/B/S x T	IVRI	93	4.90±0.39	-	S	S	S	Pandey *et al.* (1988)
J x K	Anand	69	7.01±0.12	-	S	S	-	Patel *et al.* (1989)
F x S	PAU	508	7.61±0.55	-	NS	S	NS	Garcha *et al.* (1991)
F x S	MDF	2389	6.10±0.12	-	S	S	-	Jadhav *et al.* (1991a)
Frieswal	MDF	39	6.14±0.31	-	-	-	-	Arora *et al.* (1993)
KS	NDRI	306	7.18±0.28	S	NS	S	NS	Singh (1995)
KF	-do-	415	8.92±0.25	S	NS	S	NS	Singh (1995)
-do-	-do-	406	7.52±0.26	NS	NS	NS	-	Panja (1997)

2.1.2.10. Milk Yield per day of First Calving Interval (MY/FCI)

The average MY/FCI in crossbred cattle as reported in the literature have been summarized in Table 2.2. The estimated mean value of MY/FCI ranged from 4.9 kg in F/B/J x H crosses at IVRI, Izatnagar (Pandey, 1988) to 9.71 kg in Karan Fries at NDRI Farm, Karnal (Singh, 1987).

The effect of season and period of calving was reported to be significant by Parmar et al. (1986), Pandey et al. (1988), Patel et al. (1989) and Jadhav et al. (1991b). Whereas Singh (1995) reported non-significant effect of season but significant effect of period on milk yield per day of first calving interval.

2.2. ESTIMATES OF VARIOUS GENETIC AND PHENOTYPIC PARAMETERS OF DIFFERENT TRAITS.

2.2.1 Repeatability

Repeatability is the measure of repetition of the expression of the same traits at different times in the life of the same individuals. In the broad sense repeatability represents the upper limit of heritability. It represents the proportion of the variance among individuals due to permanent differences, both genetic and environmental. Since, the repeatability includes both the genetic and environmental influences, therefore, whenever heritability is not known its repeatability value can be used instead as a first approximation.

The knowledge of repeatability is essential for predicting the performance of an animal in its subsequent lactations. If the repeatability is high, the animal can be kept or disposed off based on its first record. If the repeatability of trait is low, more than one observation on same trait is required.

The repeatability estimates of various economic traits in cattle are reviewed and presented in Table 2.3

The repeatability estimates of 305 days or less milk yield ranged from 0.20±0.05 in ¼ Frisian cows(Rao, 1977) to 0.70±0.05 in Sahiwal (Barhat and Chowdhary, 1980)

Table 2.3. Repeatability estimates of various repeatable traits

Breed/Cross	Lactation	No. of observation	R±SE	Reference
305 day or less milk yield				
¼ Frisian	-	87	0.209±0.052	Rao (1977)
Brown Swiss Cross	-	94	0.292±0.051	Rao (1977)
HF Cross	-	122	0.367±0.039	Rao (1977)
Sahiwal	Lucknow	150	0.57	Kumar (1981)
Sahiwal	NDRI	8798	0.386±0.118	Gandhi and Gurnani (1992)
Karan Fries	NDRI	521	0.357±0.028	Singh and Tomar (1990)
HF x T	-	81	0.31±0.17	Parekh (1987)
Holstein	-	348243	0.56	Matri & Funk (1994)
KF	NDRI	761	0.458±0.027	Siva Kumar (1998)
Gir	Brazil	-	0.40±0.02	Souza *et al.* (1996)
Gir cross	Brazil	-	0.38±0.01	Souza *et al.* (1996)
Jersey x Red Sindhi	-	329	0.51±0.055	Subramanian and Ulganathan, (1990)
HF x Deoni	Rajendra Nagar (AP)	250	0.43±0.07	Reddy *et al.* (1991)
Nagori	Nagaur	249	0.27±0.08	Vij *et al.* (1995)
Sahiwal	Anjora (MP)	-	0.57±0.20	Sharma and Khan (1989)
Nagori	Nagaur	195	0.705±0.055	Barhat and Chowdhary (1980)
Holstein	Italy	4015	0.34	Catillo *et al.* (1995)
-	Poland	-	0.69	Grabowsky *et al.* (1993)
Lactation Length				
Nagori	Nagaur	249	0.10±0.08	Vij (1995)
Nagori	Nagaur	195	0.53±0.07	Barhat and Chawdhary (1980)
Sharabi	Iraq	173	0.34	Dabdoub and Nasser (1990)
Jersey	-	3519	0.12±0.02	Murdfa and Tripathi (1992)
Sahiwal	-	8798	0.252±0.0113	Ghandhi and Gurnani (1992)
British Frisian x Serdanese Cattle	Sudan		0.08	Ageeb and Hillers (1991)
Damietta	Egypt		0.399	Alim (1990)
Jersey	Pune	1039	0.11±0.04	Deshpande *et al.* (1992)
HF x Deoni	Rajendra Nagar (AP)	250	0.09±0.06	Reddy *et al.* (1991)

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Service Period				
½ F x ¼ J x ¼ Gir	Rahuri	397	0.17	Bhoite *et al.* (1998)
½ J x ¼ F x ¼ Gir	Rahuri	158	0.17	Bhoite *et al.* (1998)
½ BS x ¼ F x ¼ Gir	Rahuri	220	0.22	Bhoite *et al.* (1998)
Nagori	Nagaur	202	0.16±0.08	Vij (1995)
Nagori	Nagaur	147	0.08±0.07	Barhat and Chowdhary (1980)
Red Kandhari		218	0.14	Dhumal *et al.* (1992)
Jersey x Red Kandhari		161	0.16	Dhumal *et al.* (1992)
HF x Deoni	Rajendra Nagar (AP)	250	0.18±0.07	Reddy *et al.* (1991)
Calving Interval				
½ F x ¼ J x ¼ Gir	Rahuri	362	0.09	Bhoite *et al.* (1998)
½ J x ¼ F x ¼ Gir	Rahuri	147	0.03	Bhoite *et al.* (1998)
½ BS x ¼ F x ¼ Gir	Rahuri	215	0.29	Bhoite *et al.* (1998)
Holstein		-	0.71±0.20	Kaygisiz (1995)
Nagori	Nagaur	223	0.39±0.08	Vij (1995)
Nagori	Nagaur	177	0.40±0.07	Barhat and Chowdhary (1980)
Crossbreds	Maharashtra	-	0.04±0.02	Yeotikar and Deshpande (1991)
Sahiwal	Kenya	-	0.15±0.1	Wakhungu *et al.* (1991)
Sahiwal		8798	0.138±0.014	Gandhi and Gurnani (1992)
British Friesian x Local Sudanese cattle	Sudan	-	0.44	Ageeb and Hillers (1991)
Damietta	Egypt	-	0.182	Alim (1990)
HF x Deoni	Rajendra nagar (AP)	250	0.25±0.07	Reddy *et al.* (1991)
Dry period				
½ F x ¼ J x ¼ Gir	Rahuri	346	0.06	Bhoite *et al.* (1998)
½ J x ¼ F x ¼ Gir	Rahuri	143	0.20	Bhoite *et al.* (1998)
½ BS x ¼ F x ¼ Gir	Rahuri	211	0.06	Bhoite *et al.* (1998)
Crossbreds	Maharashtra	-	0.11±0.02	Yeotikar and Deshpande (1991)
Holstein	Egypt	1641	0.11	Khalil *et al.* (1992)
Sharabi	Iraq	173	0.29	Dabdoub and Nasser (1990)
Red Kandhari		218	0.20	Dhumal *et al.* (1992)
Jersey x Red Kandhari		161	0.24	Dhumal *et al.* (1992)
Damietta	Egypt	-	0.335	Alim (1990)
Jersey	Pune	1030	0.17±0.04	Deshpande (1992)
HF x Deoni	Rajendra nagar (AP)	250	0.24±0.07	Reddy *et al.* (1991)

Repeatability estimates of lactation length were in range between 0.09±0.06 (Reddy, 1991) to 0.53±0.07 (Barhat and Chawdhary, 1980).

The estimates of repeatability for service period ranged from 0.08±0.07 (Barhat and Chowdhary, 1980) to 0.22 (Bhoite et al., 1998).

Repeatability estimates of dry period as reported in different literature ranged from 0.06 in ½ BS x ¼ F ¼ Gir cross (Bhoite et al., 1998) to 0.335 in Damietta cattle of Egypt (Alim, 1990).

The lowest and highest estimate of repeatability for calving interval were reported to be 0.03 for ½ J x ¼ F x ¼ Gir crosses (Bhoite et al., 1998) to 0.71±0.20 for Holstein (Kaygisiz, 1995).

2.2.2 Heritability

Heritability estimate of the quantitative traits is one of their most important properties as it determines the degree of resemblance between relatives and expresses the reliability of phenotypic value. Heritability estimates of the growth, first lactation production and reproduction traits reviewed extensively and are summarized in Table2.4.

The estimates of heritability for birth weight presented in the Table ranged from 0.082 for 5/4 Friesian crosses (Rao, 1977) to 0.72 for HF x S crosses (Jadhav and Singla, 1983).

The range of heritability for weight at one year reported by several workers ranged from 0.080 for 5/4 Friesian crosses (Rao, 1977) to 0.993 in BS cross (F_1) (Rao, 1977). Heritability for weight at fertile service was found to range from 0.11, Singh (1977) to 0.38±0.13 Joshi et al. (1991).

For weight at calving highest estimate of heritability was found to be 0.75 (Naidu and Desai, 1970) where as losest estimate was 0.078 (Rao, 1977)

The estimates of heritability of age at first calving of crossbred cattle range from less than zero for Frisian crossbred at Military Dairy Farms, South India (Naidu and Desai, 1965) to 0.817 for Karan Fries cattle at NDRI, Karnal (Singh, 1995).

Heritability estimates of first lactation 305 day or less milk yield ranged from 0.154±0.101 (Garcha et al., 1989) in crossbred Holstein-Friesian x Sahiwal crosses at MDF, Ambala and Jalandhar to 0.78±0.21 (Kumar and Bhatnagar, 1989) for Karan Swiss cattle at NDRI, Karnal. The perusal of Table indicated that moderate to high estimate of heritability of this trait can contribute towards the improvement in 305 day milk yield through selection.

Heritability estimates of first lactation total milk yield are also presented in Table 2.4. as reported by various workers. The value ranged from 0.18±0.19 for Frisian crossbred at Military Dairy Farm, North India (Naidu and Desai, 1965) to 0.68±0.30 for Frisian crosses in Africa (Ageeb and Hillers, 1991). The moderate to high estimate of heritability of this trait indicated that total milk yield can be improved through selection to a considerable extent.

Heritability of first lactation length reported by several workers ranged from 0.034±0.30 for Brown Swiss x Zebu crosses at NDRI, Karnal (Gurnani, 1971) to 0.894±0.046 for HF x Tharparkar crosses at Livestock Farm, Jabalpur (Gupta et al., 1986).

The range of heritability estimates of first service period was 0.001 for HF x Sahiwal crosses (Deshpande et al., 1988) to 0.48±0.24 for HF x Sahiwal crosses at Military Dairy Farms, India (Sandhu et al., 1973). Though range of heritability of service period was large, but most of the estimates were very low (0.001 to 0.1) in magnitude.

Varying estimates of heritability of first dry period of crossbred cattle have been reported covering the range from 0.010±0.080 in Karan Fries Cattle (Singh, 1995) to 0.40±0.15 for Karan Swiss cattle at NDRI, Karnal (Kumar and Bhatnagar, 1989). These low to moderate estimates of heritability of first dry period indicates that this trait is largely controlled by non-genetic factor and further improvement of this trait may be possible through improved managemental practices.

Table 2.4. Heritability estimates of various growth, production and reproduction traits in crossbred cattle

Breed/Genetic Group	Location	h^2±S.E.	Reference(s)
1	2	3	4
Birth Weight (BWT)			
HF x T	Jabalpur	0.42±0.05	Parekh *et al.* (1976)
HF x S	MDF	0.61±0.13	Taneja *et al.* (1978)
BS x H		0.20±0.21	Bhat and Singh (1978)
Karan Swiss	NDRI Karnal	0.11±0.09	Joshi *et al.* (1991)
HF x S		0.15±0.09	Rao and Nagarcenkar (1992)
Karan Swiss	NDRI Karnal	0.36±0.10	Singh (1995)
Karan Fries	NDRI Karnal	0.50±0.11	Singh (1995)
HF x S		0.72±0.37	Jadhav and Singla (1983).
Karan Fires	NDRI Karnal	0.181±0.12	Singh (1987)
HF x S	MDF	0.29±0.22	Naidu and Desai (1970)
BS cross	NDRI and ISP Patiala	0.44±0.32	Rao (1977)
$^3/_8$ Friesian cross	MDF	0.156±0.125	Rao (1977)
½ Friesian cross	MDF	0.145±0.094	Rao (1977)
$^5/_4$ Friesian cross	MDF	0.082±0.069	Rao (1977)
$^3/_4$ Friesian cross	MDF	0.202±0.104	Rao (1977)
HF x S		0.36±0.27	Murthy (1974)
BS x S	Northern India	0.29±0.12	Singh (1977)
HF x S	Northern India	0.15±0.05	Singh (1977)
Weight at One Year (WOY)			
F x T	Jabalpur	0.09±0.49	Parekh *et al.* (1976)
F x S	MDF	0.66±0.14	Taneja *et al.* (1978)
B x H		-0.11±0.28	Bhat and Singh (1978)
Karan Swiss	NDRI Karnal	0.20±0.10	Joshi *et al.* (1991)
F x S		0.33±0.14	Rao and Nagarcenkar (1992)
Karan Swiss	NDRI Karnal	0.28±0.10	Singh (1995)
Karan Fries	NDRI Karnal	0.37±0.10	Singh (1995)
BS cross (F_1)	NDRI and ISP Patiala	0.993±0.689	Rao (1977)
$^3/_8$ Friesian cross	MDF	0.128±0.128	Rao (1977)
½ Friesian cross	MDF	0.329±0.136	Rao (1977)
$^5/_4$ Friesian cross	MDF	0.080±0.068	Rao (1977)
$^3/_4$ Friesian cross	MDF	0.367±0.158	Rao (1977)
HF x S		0.81±0.04	Murthy (1974)
BS x S	Northern India	0.46±0.19	Singh (1977)
HF x S	Northern India	0.28±0.08	Singh (1977)
Weight at First Fertile Service (WFS)			
Karan Swiss	NDRI, Karnal	0.38±0.13	Joshi *et al.* (1991)
Karan Swiss	NDRI, Karnal	0.16±0.10	Singh (1995)
Karan Fries	NDRI, Karnal	0.10±0.07	Singh (1995)
HF x H		0.15±0.85	Mishra (1973)
HF x T		-0.62±0.52	Mishra (1973)
HF x RS		-0.15±0.27	Mishra (1973)
HF x G		-0.24±0.35	Mishra (1973)
BS x S	Northern India	0.17±0.16	Singh (1977)
HF x S	Northern India	0.11±0.04	Singh (1977)

Contd..

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1	2	3	4
Weight at First Calving (WFC)			
F x S	MDF	0.21±0.08	Taneja *et al.* (1978)
Karan Swiss	NDRI Karnal	0.34±0.12	Joshi *et al.* (1991)
F x S		0.08±0.11	Rao and Nagarcenkar (1992)
Karan Swiss	NDRI Karnal	0.41±0.15	Singh (1995)
Karan Fries	NDRI Karnal	0.19±0.09	Singh (1995)
HF x S	Northern Region	0.56±0.28	Singh and Desai (1966)
HF x S	Southern Region	0.48±0.28	Singh and Desai (1966)
HF x S	MDF	0.75±0.33	Naidu and Desai (1970)
BS cross (F_1)	NDRI and ISP Patiala	0.036±0.215	Rao (1977)
Karan Swiss	NDRI, Karnal	0.374±0.208	Dash (1980)
Karan Swiss	NDRI, Karnal	0.155±0.08	Kakran (1987)
½ Friesian cross	MDF	0.078±0.112	Rao (1977)
$^5/_8$ Friesian cross	MDF	0.140±0.127	Rao (1977)
$^3/_4$ Friesian cross	MDF	0.190±0.273	Rao (1977)
HF x S		0.27±0.39	Khanna (1968)
BS x S	Northern India	0.16±0.20	Singh (1977)
HF x S	Northern India	0.19±0.08	Singh (1977)
Age at First Calving (AFC)			
Friesian crossbred	MDF, North India	0.11±0.02	Naidu and Desai (1965)
-do-	MDF, South India	-0.13±0.13	-do-
HF x Sahiwal	MDF, Ambala, Dehradun, Jabalpur	0.42±0.10	Kaul *et al.*, (1973)
HF-Zebu crosses	CBS, Haringhata	0.09±0.22	Murthy (1974)
-do-	-do-	0.524±0.306	-do-
-do-	-do-	0.341±0.150	-do-
-do-	-do-	0.583±0.246	-do-
Jersey x Zebu	-do-	0.299±0.582	-do-
HF crossbred	NDRI Karnal	0.63	Basu and Ghai (1977)
Karan Swiss	NDRI, Karnal	0.627±0.186	Singh (1995)
-do-	-do-	0.817±0.208	Singh (1995)
-do-	-do-	0.221±0.075	Sahana (1996)
Karan Fries	-do-	0.361±0.197	Panja (1997)
-do-	-do-	0.284±0.109	Siva Kumar (1998)
First Lactation 305-Day or Less Milk Yield (FL305DMY)			
HF x Hariana	Haringhata	0.277±0.255	Panda and Sandhu (1983)
HF x Deshi	-do-	0.424±0.289	-do-
J x Hariana	-do-	0.392±0.324	-do-
J x Deshi	-do-	0.314±0.289	-do-
HF x Sahiwal	MDF, Ambala, Jalandhar	0.154±0.101	Garcha *et al.* (1989)
Karan Swiss	NDRI, Karnal	0.78±0.21	Kumar and Bhatnagar (1989)
HF x Sahiwal	MDF, Meerut, Lucknow, Ambala	0.22±0.02	Teotia *et al.* (1990)
BS x Zebu	NDRI, Karnal	0.796±0.133	Datt and Joshi (1992)
Crossbred	Mexico	0.17	Alba and Kennedy (1994)
Karan Swiss	NDRI, Karnal	0.491±0.175	Singh (1995)
-do-	-do-	0.406±0.133	Singh (1995)
-do-	-do-	0.462±0.105	Sahana (1996)
Karan Fries	-do-	0.217±0.167	Panja (1997)
-do-	-do-	0.448±0.131	Siva Kumar (1998)

Contd..

Contd…

1	2	3	4
First Lactation Total Milk Yield (FLTMY)			
Friesian crossbred	MDF, North India	0.18±0.19	Naidu and Desai (1965)
HF x Zebu	Haringhata	0.07	Murthy (1974)
HF x Sahiwal	MDF, Ambala	0.22±0.10	Basu and Ghai (1977)
HF x Hariana		0.277±0.255	Panda and Sandhu (1983)
HF x Zebu		0.26	Lopez *et al.* (1984)
Karan Swiss	NDRI, Karnal	0.45±0.16	Kumar and Bhatnagar (1989)
HF x Sahiwal		0.24	Tajane and Rai (1989b)
Friesian crosses		0.68±0.30	Ageeb and Hiller (1991)
J x Sindhi		0.32	Gogoi *et al.* (1992)
HF Crosses		0.482	Rao and Nagarcenkar (1992)
J, RD x Sahiwal		0.24±0.07	Singh *et al.* (1993)
J x Sahiwal	Exotic CBF, Wadsa	0.42±0.18	Deshmukh *et al.* (1995
-do-	Pantnagar	0.289±0.222	Tewari *et al.* (1995)
Karan Swiss	NDRI, Karnal	0.421±0.185	Singh (1995)
-do-	-do-	0.346±0.124	Singh (1995)
-do-	-do-	0.317±0.088	Sahana (1996)
Karan Fries	-do-	0.188±0.161	Panja (1997)
-do-	-do-	0.464±0.133	Siva Kumar (1998)
First Lactation Length (FLL)			
BS x Zebu	NDRI, Karnal	0.034±0.30	Gurnani *et al.* (1971a)
-do-	-do-	0.674±0.26	Chopra *et al.* (1973)
HF x Zebu		0.24	Lopez *et al.* (1984)
HF x Tharparkar (F_1)	Livestock Farm, Jabalpur	0.894±0.046	Gupta *et al.* (1986)
Karan Swiss	NDRI, Karnal	0.05±0.08	Kumar and Bhatnagar (1989)
HF x Sahiwal		0.16	Tajane and Rai (1989b)
Friesian crosses	Africa	0.34±0.25	Ageeb and Hillers (1991)
J x Sindhi		0.06	Gogoi *et al.* (1992)
J, RD, Sahiwal	Pantnagar	0.05±0.02	Singh *et al.* (1993)
J x Sahiwal	Exotic CBF, Wadsa	0.13±0.13	Deshmukh *et al.* (1995)
Karan Swiss	NDRI, Karnal	0.191±0.112	Singh (1995)
-do-	-do-	0.095±0.078	Singh (1995)
-do-	-do-	0.131±0.065	Sahana (1996)
Karan Fries	-do-	0.093±0.101	Panja (1997)
-do-	-do-	0.257±0.105	Siva Kumar (1998)
First Service Period (FSP)			
HF x Sahiwal	MDF	0.48±0.24	Sandhu *et al.* (1973)
-do-		0.08±0.77	Mudgal *et al.* (1986)
HF x Sahiwal	MDF, Bangalore, Secundrabad, Pimpri	0.05±0.05	Butte and Deshpande (1987)
-do-	-do-	0.001	Deshpande *et al.* (1988)
Karan Fries	NDRI, Karnal	0.0359±0.126	Singh and Tomar (1991a)
Jersey crosses		0.11±0.09	Deshmukh *et al.* (1992)
J x Sahiwal		0.03±0.29	Rathi *et al.* (1992)
Crossbred	ICDP-Lalna, Miraj, Pune	0.03±0.01	Hayanatgarkar and Deshpande (1993)
Karan Swiss	NDRI, Karnal	-0.105±0.078	Singh (1995)
-do-	-do-	0.038±0.064	Sahana (1996)
Karan Fries	-do-	0.046±0.143	Panja (1997)
-do-	-do-	0.227±0.102	Siva Kumar (1998)

Contd..

Contd…

1	2	3	4
First Dry Period (FDP)			
EF x Sahiwal	MDF, North and South India	-0.34±0.03	Naidu and Desai (1966)
Crossbred		0.213±0.97	Mudgal *et al.* (1986)
Karan Swiss	NDRI, Karnal	0.40±0.15	Kumar and Bhatnagar (1989)
Crossbred		0.10±0.03	Yeotikar and Deshpande (1991)
Jersey x Sindhi		0.22	Gogoi *et al.* (1992)
J x Sahiwal	Pantnagar	0.01±0.002	Singh *et al.* (1993)
-do-	Exotic CBF, Wadsa	0.13±0.10	Deshmukh *et al.* (1995)
-do-	Pantnagar	0.254±0.209	Tewari *et al.* (1995)
Karan Swiss	NDRI, Karnal	0.009±0.012	Singh (1995)
-do-	-do-	0.010±0.080	Singh (1995)
-do-	-do-	0.119±0.075	Sahana (1996)
Karan Fries	-do-	0.112±0.154	Panja (1997)
-do-	-do-	0.195±0.099	Siva Kumar (1998)
First calving Interval (FCI)			
HF x Zebu		0.15±0.06	Palastre *et al.* (1987b)
Karan Swiss	NDRI, Karnal	0.03±0.08	Kumar and Bhatnagar (1989)
Crossbred		0.03	Hayanatgarkar and Deshpande (1990)
HF crosses		0.078	Rao and Nagarcenkar (1992)
Jersey crosses		0.17±0.10	Deshmukh *et al.* (1992)
Jersey x Sindhi		0.25	Gogoi *et al.* (1992)
Karan Swiss	NDRI, Karnal	-0.158±0.068	Singh (1995)
-do-	-do-	0.001±0.078	Singh (1995)
-do-	-do-	0.069±0.071	Sahana (1996)
Karan Fries	-do-	0.017±0.135	Panja (1997)
-do-	-do-	0.164±0.095	Siva Kumar (1998)

The heritability estimates of first calving interval ranged from 0.001±0.078 for Karan Fries cattle at NDRI, Karnal (Sing, 1995) to 0.29±0.35 (Ageeb and Hiller, 1991) for Holstein–Frisian crosses in Africa. These low to moderate heritability of first calving interval are also indicating that this trait is largely controlled by non-genetic factors and further improvement of this trait may be possible through improved mangemental policy.

2.2.3. Estimates of Phenotypic and Genetic Correlation

The estimates of phenotypic and genetic correlation between various growth, first lactation production and reproduction traits as reported in the literature are as follows:

2.2.3.1. BWT with other traits

The reported estimates of phenotypic and genetic correlation of BWT with various growth (WOY,WFC) and reproduction traits (AFS, AFC) have been summarized in Table 2.5.

It is evident from this table that genetic correlation between the growth traits were low to high .

Phenotypic correlations were found to be positive. However, Singh (1977) reported negative estimate of phenotypic correlation between BWT and WFC.

2.2.3.2. WOY with other traits

The range genetic as well as phenotypic correlations between WOY with other growth traits as reported by different workers found to be very wide (Table).

The genetic correlation between WOY and AFS were high but negative, whereas phenotypic correlation was found to be low to moderate.

2.2.3.3. WFC with other traits

The estimates of genetic correlations of WFC with AFS and AFC indicate moderate to high genetic correlation whereas, phenotypic correlation between WFC with AFS and AFC also found be moderate to high.

2.2.3.4. AFC with other first lactation traits

The reported estimates of phenotypic and genetics correlations of age at first lactation total milk yield, first lactation 305 day or less milk yield, first lactation length, first calving interval have been summarized in Table2.5. It is evident from this table that genetic correlation of AFC with FLTMY was low to medium and phenotypic correlation was low. Most of such estimates was positive and some are however, negative.

The estimates of genetic correlation between AFC and FCI was reported to vary from medium to high. However, the phenotypic correlation between the two traits has been reported to be low. Some reports indicate negative association between these two traits. Similar observations were found between AFC with FLL.

2.2.3.5. FSP with other first lactation traits

The estimates of phenotypic and genetic correlations of FSP with first lactation total milk yield, first lactation 305 days or less milk yield, first lactation length, first calving interval as reported in the literature have been summarized in Table 2.5. The table showed that genetic correlation between FSP and first lactation milk yield was medium to high and phenotypic correlation between these two traits was low to medium.

The estimates of genetic and phenotypic correlation FSP with first lactation length and first calving interval were reported to be high.

2.2.3.6. FDP with other first lactation traits

The estimates of phenotypic and genetic correlation of first dry period with first lactation milk yield, first lactation length, and first calving interval have been summarized in Table 2.5. The phenotypic correlation between FDP and FLTMY was low to medium and generally negative.

The genetic correlation of FDP with FLL and FCI was very high and the phenotypic correlation between these two traits was medium to high.

Table 2.5. Genetic and phenotypic correlation of various traits in crossbred cattle

Traits	Breed/Genetic group	rg±S.E.	rp±S.E.	Reference(s)
Birth weight (BWT) with other traits				
WOY	½ Frisian cross	0.74±0.15	0.14	Rao (1977)
-do-	BS cross (F_1)	-	0.38	Rao (1977)
-do-	BS x S	0.29±0.04	0.71±0.16	Singh (1977)
-do-	HF x S	0.11±0.02	0.47±0.18	Singh (1977)
-do-	KS	0.67±0.12	0.38±0.03	Singh (1995)
-do-	KF	-0.20±0.16	0.26±0.30	Singh (1995)
WFS	BS x S	0.11±0.06	0.80±0.19	Singh (1977)
-do-	HF x S	0.11±0.02	0.33±0.24	Singh (1977)
-do-	KS	0.48±0.25	0.32±0.04	Singh (1977)
-do-	KF	-0.54±0.17	0.15±0.03	Singh (1977)
WFC	½ Frisian cows	-	0.12	Rao (1977)
-do-	BS cross (F_1)	-	0.19	Rao (1977)
-do-	BS x S	0.16±0.06	-0.09±0.27	Singh (1977)
-do-	HF z S	0.10±0.02	0.33±0.24	Singh (1977)
-do-	KS	0.77±0.09	0.40±0.04	Singh (1995)
-do-	KF	-0.61±0.14	0.13±0.03	Singh (1995)
AFS	KS	-0.01±0.21	0.05±0.04	Singh (1995)
-do-	KF	0.72±0.08	0.18±0.03	Singh (1995)
AFC	½ Frisian cows	-0.94±0.05	-0.028	Rao (1977)
-do-	BS cross (F_1)	-	-0.150	Rao (1997)
-do-	BS x S	-0.05±0.06	-0.21±0.36	Singh (1977)
-do-	HF z S	-0.01±0.02	-0.19±0.21	Singh (1977)
-do-	KS	0.06±0.04	-0.02±0.21	Singh (1995)
-do-	KF	0.74±0.07	0.17±0.03	Singh (1995)
-do-	KF	-0.64±0.05	-0.04±0.18	Singh (1987)
Body weight at one year (WOY with other traits				
WFS	HF x S	0.17±0.02	0.57±0.16	Singh (1977)
-do-	BS x S	0.27±0.05	-	Singh (1977)
-do-	KS	0.73±0.15	0.32±0.04	Singh (1995)
-do-	KF	0.66±0.19	0.15±0.03	Singh (1995)
WFC	½ Frisian cows	-0.431	0.112	Rao (1977)
-do-	BS cross (F_1)	-	-0.272	Rao (1977)
-do-	HF x S	0.13±0.03	0.83±0.08	Singh (1977)
-do-	BS x S	0.23±0.06	-0.13±0.19	Singh (1977)
-do-	KS	0.91±0.03	0.40±0.04	Singh (1995)
-do-	KF	0.20±0.27	0.13±0.03	Singh (1995)
AFS	KS	-0.51±0.16	0.05±0.04	Singh (1995)
-do-	KF	-0.41±0.15	0.18±0.03	Singh (1995)
AFC	½ Frisian cows	-	-0.272	Rao (1977)
-do-	BS cross (F_1)	-0.260	-0.385	Rao (1977)
-do-	HF x S	-0.23±0.03	-0.74±0.09	Singh (1977)

Contd…./-

Contd…./-

Traits	Breed/Genetic group	rg±S.E.	rp±S.E.	Reference(s)
AFC	BS x S	-0.16±0.09	0.11±0.41	Singh (1977)
-do-	KS	-0.53±0.15	-0.02±0.21	Singh (1995)
-do-	KF	-0.47±0.15	0.17±0.03	Singh (1995)
Weight at first calving (WFC) with other traits				
AFS	KS	-0.86±0.05	0.29±0.04	Rao (1977)
-do-	KF	-0.68±0.11	0.27±0.03	Rao (1977)
AFC	½ Frisian cows	-0.469±0.599	0.411	Singh (1977)
-do-	BS cross	-	0.197	Singh (1977)
-do-	HF x S		0.236	Singh (1995)
-do-	BS x S	0.26±0.05	0.26±0.51	Singh (1995)
-do-	HF x S	0.22±0.03	-0.86±0.08	Singh (1977)
-do-	KS	-0.86±0.05	0.31±0.04	Singh (1995)
-do-	KF	-0.67±0.11	0.28±0.03	Singh (1977)
-do-	KS	-0.66±0.14	0.25±0.03	Singh (1977)
-do-	HF x S	0.10	0.11	Singh (1995)
-do-	KS	-0.59±0.20	0.143	Singh (1995)
Age at first calves (AFC) with other traits				
FLTMY	HF/SW	-0.34±0.25	0.007	Basu and Ghai (1977)
-do-	1/8 HF x 7/8 Zebu	-1.00	-0.089	Rao (1977)
-do-	1/2 HF x 1/2 Zebu	0.149±0.345	0.067	-do-
-do-	HF x SW	-	0.05	Taneja *et al.* (1978)
-do-	-do-	-0.24±0.08	-	Ram *et al.* (1979)
-do-	-do-	-0.056	-	Singh *et al.* (1981)
-do-	-do-	-0.05	0.01	Sharma *et al.* (1982)
-do-	-do-	-8.805	0.037±0.031	Sakhare and Ingale (1984)
-do-	KF	0.573	0.078±0.05	Kakran (1987)
-do-	-do-	-0.006	-0.361±0.272	Singh *et al.* (1988)
-do-	H x SW	> 1	0.05±0.03	Jadhav and Khan (1996)
-do-	KS	0.315±0.205	0.121±0.047	Singh (1995)
-do-	KF	0.680±0.131	0.289±0.038	Singh (1995)
-do-	KF	0.215±0.460	0.261±0.054	Panja (1997)
-do-	KF	0.398±0.197	0.041±0.038	Sivakumar (1998)
FL305DMY	KF	0.296±0.23	0.036±0.05	Kakran (1987)
-do-	-do-	-0.5760±0.231	-0.011±0.048	Singh *et al.* (1988)
-do-	-do-	-	-0.523±0.179	Kumar (1992)
-do-	HF/RD/SW	0.290±0.580	-0.062	Jain *et al.* (1995)
-do-	HF x SW	0.59±0.17	0.58±0.04	Jadhav and Khan (1996)
-do-	KF	-	0.146±0.04	Battacharya (1996)
-do-	KS	-0.188±0.216	0.158±0.047	Singh (1995)
-do-	KF	0.682±0.122	0.333±0.037	Singh (1995)
-do-	KF	-1.215±0.479	0.211±0.060	Panja (1997)
-do-	KF	0.476±0.183	0.059±0.038	Sivakumar (1998)
FLL	HF x SW	0.38	0.10	Taneja *et al.* (1978)
-do-	HF x BS x Zebu	0.76±0.12	0.10±0.05	Singh (1979)
-do-	KF	>1	0.07±0.05	Kakran (1987)
-do-	KF	-0.278±0.39	-0.004±0.04	Singh *et al.* (1988)

Contd…./-

Contd..../-

Traits	Breed/Genetic group	rg±S.E.	rp±S.E.	Reference(s)
FLL	HF x SW	0.13±0.95	0.11±0.03	Jadhav and Khan (1996)
-do-	KF	-	0.101±0.04	Bhattacharya (1996)
-do-	KS	0.694±0.130	0.0740±0.048	Singh (1995)
-do-	KF	0.2858±0.336	0.198±0.039	Singh (1995)
-do-	KF	0.372±0.371	0.169±0.061	Panja (1997)
-do-	KF	-0.089±0.279	0.086±0.038	Sivakumar (1998)
FCI	1/8 HF x 1/8 Zebu	-0.67	0.027	Rao (1977)
-do-	1/2 HF x 1/2 Zebu	>0.67	-	Rao (1977)
-do-	HF/BS/Zebu	>1.0	0.11±0.04	Singh (1979)
-do-	KF	0.91±0.02	0.84±0.05	Kakran (1987)
-do-	HF/RD/SW	0.36±0.04	0.116	Jain *et al.* (1995)
-do-	HF/RD x SW	0.379±0.355	0.04±0.03	Jadhav and Khak (1996)
-do-	KF	0.49±0.20	0.097±0.04	Bhattachrya (1996)
-do-	KS	0.311±0.240	0.072±0.055	Singh (1995)
-do-	KF	-0.352±0.450	0.201±0.042	Singh (1995)
-do-	KF	-0.033±2.178	0.209±0.064	Panja (1997)
-do-	KF	-0.093±0.317	0.042±0.039	Sivakumar (1998)
First service period (FSP) with other traits				
FLTMY	SW	-	0.120±0.067	Chopra *et al.* (1973)
-do-	RS	-	0.194±0.083	Chopra *et al.* (1973)
-do-	BS cross	-	0.225±0.145	Chopra *et al.* (1973)
-do-	KF	0.2379±0.196	0.561±0.050	Singh and Tomar (1991)
-do-	HF x RD x SW	0.622±12.97	0.430	Jain *et al.* (1995)
-do-	Kankrej	0.589±0.227	0.301±0.033	Chaudhary *et al.* (1995)
-do-	KF	-	0.6317±0.032	Bhattacharya (1996)
-do-	KS	-0.478±0.364	0.391±0.047	Singh (1995)
-do-	KF	0.005±0.036	0.052±0.036	Singh (1995)
-do-	KF	-	0.333±0.062	Panja (1997)
-do-	KF	0.695±0.131	0.556±0.032	Sivakumar (1998)
FL305DMY	KF	-0.289±0.9907	0.083±0.06	Singh and Tomar (1991)
-do-	HF x RD x SW	-0.072±0.857	0.033	Jain *et al.* (1995)
-do-	KF	-	0.130±0.04	Bhattacharya (1996)
-do-	KS	-0.256±0.357	0.176±0.054	Singh (1995)
-do-	KF	-0.178±0.336	0.191±0.049	Singh (1995)
-do-	KF	-	-0.057±0.065	Panja (1997)
-do-	KF	0.506±0.190	0.178±0.038	Sivakumar (1998)
FLL	SW	-	0.078±0.042	Chopra *et al.* (1973)
-do-	RS	-	0.258±0.082	Chopra *et al.* (1973)
-do-	BS cross	-	0.781±0.082	Chopra *et al.* (1973)
-do-	KF	-0.054±0.054	0.796±0.037	Singh and Tomar (1991)
-do-	KS	-0.998±0.126	0.670±0.048	Singh (1995)
-do-	KF	0.884±0.140	0.804±0.026	Singh (1995)
-do-	KF	-	0.779±0.041	Panja (1997)
-do-	KF	0.859±0.075	0.792±0.023	Sivakumar (1998)
FCI	KF	-	0.893±0.018	Bhattacharya (1996)
-do-	KF	-0.049±0.922	0.830±0.018	Singh and Tomar (1991)
-do-	KS	-	0.908±0.023	Singh (1995)

Contd..../-

Contd…./-

Traits	Breed/Genetic group	rg±S.E.	rp±S.E.	Reference(s)
FCI	KF	0.875±0.019	0.986±0.369	Singh (1995)
-do-	KF	-0.033±2.178	0.809±0.039	Panja (1997)
-do-	KF	0.891±0.080	0.977±0.008	Sivakumar (1998)
FLMY/FLL	KF	-	0.994±0.004	Bhattacharya (1996)
-do-	Kankrej	0.028±0.360	0.088±0.032	Chaudhary *et al.* (1995)
MY/FLL	KS	-0.059±0.55	0.01±0.55	Singh (1995)
-do-	KF	-0.439±0.296	-0.098±0.043	Singh (1995)
-do-	KF	-	0.249±0.060	Panja (1997)
FLMY/FCI	KF	-	-0.124±0.041	Bhattacharya (1996)
-do-	HF x SW	0.955±0.03	-0.341±0.026	Deshpande *et al.* (1982)
-do-	Kankrej	0.150±0.409	-0.300±0.031	Chaudhary *et al.* (1995)
-do-	KF	-	-0.13±0.041	Bhattacharya (1996)
MY/FCI	KS	-0.099±0.381	-0.044±0.055	Singh (1995)
-do-	KF	-0.314±0.335	-0.084±0.042	Singh (1995)
-do-	KF	-	0.246±0.064	Panja (1997)
First Dry period with other traits				
FLTMY	HF x SW	-	-0.156	Basu and Ghai (1980)
-do-	J x SW		0.33±0.05	Singh (et al. (1993)
-do-	J x SW	-	-0.343±0.065	Tewari *et al.* (1995)
-do-	KF	-	-0.02±0.03	Bhattacharya (1996)
-do-	KS	-0.637±0.380	-0.211±0.054	Singh (1995)
-do-	KF	-0.389±0.410	-0.084±0.043	Singh (1995)
-do-	KF	0.494±0.703	0.017±0.064	Panja (1997)
-do-	KF	-0.450±0.216	-0.225±0.038	Sivakumar (1998)
FL305DMY	KF	-	-0.0770±0.042	Bhattacharya (1996)
-do-	KS	-0.266±0.478	-0.287±0.053	Singh (1995)
-do-	KF	-0.585±0.247	-0.126±0.043	Singh (1995)
-do-	KF	-0.358±1.063	-0.067±0.064	Panja (1997)
-do-	KF	-0.497±0.204	-0.247±0.038	Sivakumar (1998)
FLL	J x SW	1.00±0.68	0.037±0.05	Singh *et al.* (1993)
FLL	KF	-	0.0176±0.042	Bhattacharya (1996)
-do-	KS	-0.278±0.492	0.574±0.045	Singh (1995)
-do-	KF	0.385±0.642	0.383±0.040	Singh (1995)
-do-	KF	-0.285±1.276	0.470±0.050	Panja (1997)
-do-	KF	-0.196±0.383	0.416±0.036	Sivakumar (1998)
FCI	Kankrej	0.731±0.367	0.753±0.020	Chaudhary *et al.* (1995)
FCI	KF	-	0.472±0.037	Bhattacharya (1996)
-do-	KS	-0.765±0.302	-0.701±0.054	Singh (1995)
-do-	KF	-0.364±0.501	-0.031±0.043	Singh (1995)
-do-	KF	0.551±0.691	0.122±0.064	Panja (1997)
-do-	KF	-0.564±0.213	-0.217±0.038	Sivakumar (1998)
FLMY/FLL	J x SW	-1.00±0.69	-0.21±0.06	Singh *et al.* (1993)
-do-	KS	0.178±0.532	-0.243±0.054	Singh (1995)
-do-	KF	-0.486±0.251	-0.075±0.043	Singh (1995)
-do-	KF	-0.012±0.940	0.022±0.064	Panja (1997)
FLMY/FCI	KF	-	-0.046±0.04	Bhattacharya (1996)
-do-	KS	-0.468±0.439	-0.473±0.049	Singh (1995)
-do-	KF	-0.614±0.245	-0.322±0.041	Singh (1995)
-do-	KF	-0.012±1.254	-0.276±0.064	Panja (1997)

Contd…./-

Low and Negative correlation between FDP and FLTMY is reported by Singh et al. (1993) and Bhattacharya (1996) in various crosses.

2.2.3.7. FCI with other first lactation traits

The estimates of phenotypic and genetic correlations of first calving interval with first lactation total milk yield, first lactation 305 day or less milk yield, first lactation length have been summarized in the Table.

The phenotypic correlation of FCI with FLTMY and FL 305 DMY was generally positive. Magnitude of phenotypic correlation found to range between (0.17 to 0.79). Positive but high phenotypic correlation was observed between FCI and FLL.

The genetic correlation of FCI with FLTMY, FL 305DMY was mostly positive, but negative genetic correlation was reported by Singh (1995). However available literature suggested very high genetic correlation between FCI and FLL.

2.3. PATERNAL AND MATERNAL GENERATION WISE PERFORMANCE OF CROSSBRED COWS

Sinha (1999) studied the paternal and maternal generation wise performance of 77 Karan Fries cows at NDRI herd. Karan Fries cows upto fourth generation from paternal side and sixth generation from maternal side and sixth generation from maternal side were reported. It was found that Karan Fries cows upto third generation from paternal side and upto fourth generation from maternal side maintained the level of productivity ranging from 3700 kg to 4500 kg for 305 days milk yield with a corresponding level of heterozygosity of 49 to 52 percent from paternal and 50 to 62 percent from maternal side having exotic level of inheritance to 50 to 62.5 percent.

2.4. LEVEL OF EXOTIC INHERITANCE/HETEROZYGOSITY WITH REFERENCE TO PERFORMANCE OF CROSSBRED CATTLE

Work done abroad

Branton et al. (1966) Studied J/F/BS x RS crosses and found F_2 females were older than F1 at 1st calving, had shorter lactation and 27 percent less milk. Wijeratne (1970) found milk yield to be 35 percent less in F_2 had shorter lactations as well in J/Fx Sinhala crossbreds.

Contd…./-

Traits	Breed/Genetic group	rg±S.E.	rp±S.E.	Reference(s)
First calving interval (FCI) with other traits				
FLTMY	HF	0.43	0.20	Paul Miller *et al.* (1967)
-do-	HF	0.65	-	-do-
-do-	HF	0.44±0.06	-	Svavarsson and Johnnundsson (1987)
-do-	KF	0.650±0.244	0.799±0.276	Singh (1987)
-do-	KS	-0.595±0.024	0.189±0.053	Singh (1995)
-do-	KF	0.006±0.050	0.059±0.035	Singh (1995)
-do-	KF	0.332±1.610	0.501±0.056	Panja (1997)
-do-	KF	0.748±0.127	0.542±0.033	Sivakumar (1998)
-do-	KF	0.470±0.362	0.610±0.037	Singh (1987)
-do-	KS	-0.316±0.286	0.189±0.053	Singh (1995)
-do-	KF	-0.294±0.434	0.192±0.042	Singh (1995)
-do-	KF	0.669±1.049	0.177±0.064	Panja (1997)
-do-	KF	0.567±0.196	0.173±0.039	Sivakumar (1998)
FLL	KS	-	0.758±0.036	Singh (1995)
-do-	KF	0.826±0.258	0.850±0.022	Singh (1995)
-do-	KF	-	0.853±0.034	Panja (1997)
-do-	KF	0.910±0.058	0.787±0.024	Sivakumar (1998)

Madsen and Vinther (1975) reported that AFC increased in Indian milch breeds and milk yield increases in crossbreds with increase in level of exotic inheritance but higher grades had high mortality. Therefore, he concluded that 60-80 percent was the best exotic level in Red Dane x Native/Indian crosses.

Buvanendran and Mahadevan (1975) in a study of Jersey/Friesian x Sinhala crosses found that milk production was markedly superior in F_1 and interbreeding of F_1 results in a decline in milk Yield by about 30-40 percent. Lobo et al. (1984) studied Red poll x Guzeeat *inter-se* bred animals and found a decline of about 400 kg (2877 to 2482) from F_1 to F_2, but no further decline was seen in subsequent generations.

Cunningham and Syrstad (1987) reviewed reports on dairy cattle crossbreeding in 25 countries across the tropics and reported that the first crossbred generation (F_1) derived from indigenous females mated to exotic males performed well in almost all cases, but further upgrading gave disappointing results as milk yield increased only slightly or declined, fertility deteriorated and mortality increased.

Syrstad (1989) gave a review of performance of F_1 animals involving Holsteian –Friesian inheritance by considering the traits like age at first calving, milk yield and lactation length an extract of which is presented in Table .

Table 2.6. Averages of performance traits of crossbreds with 50 percent level of exotic inheritance.

Author	**AFC (month)**	**MY (kg)**	**LL (days)**
Wijeratne (1970)	36.9	1573	327
Buvanendran and Mahadevan (1977)	-	1482	387
Parmar et al. (1986)	35.0	933	433
Bala and Nagarcenkar (1981)	34.0	1926	341
Alexander et al. (1984)	-	2010	-

Syrstad (1989) also compared the performance of F_1 and F_2 population with Holstein-Friesian inheritance. Age at first calving increased by 2.3 months (7%), milk yield decreased by 452 kg (24%) and lactation length decreased by 12 days (4%). The explanation for this was given as a reduction in heterozygosity from F_1 to F_2 as well as a breakdown of epistatic gene combinations (recombination loss) for milk yield traits.

Syrstad (1996) reported the least-squares means of age at first calving and milk yield under different grades of *Bos indicus* crosses presented in Table 13.

Table 2.7. Least-squares means of performance traits under different grades of *Bos Taurus* x *Bos indicus*.

Proportion of *Bos Taurus* (%)	Age at First Calving (m)	Milk Yield (kg)
0	43.6	1052
12.5	40.1	1371
25	37.5	1310
37.5	36.6	1472
50	32.4	2039
62.5	33.8	1984
75	33.8	2000
87.5	34.4	2086
100	31.6	2162

It was found that *least-squares* means of dairy performance was best at 50 to 75 percent exotic level for a milk yield (2039 to 2091 kg) and 32.4 to 33.9 months for age at first calving.

Work Done in India

Most of the reports on cattle crossbreeding in India are based on data from military farms or organized Institutions, with a few reports on analysis of field data. Moreover, literature on HF x Tharparkar crosses were found scanty. However, the literatures on crosses of Holstein-Friesian with breeds other than Tharparkar are available.

Amble and Jain (1966,1967) studied data on 1000 Sahiwal and Red Sindhi crosses with Friesian and Ayrshire collected over a period of 22 years (1934-55). All animals were sired by either Zebu or European bulls and traits studied were age at first calving, first lactation yield. It was concluded that with respect to production characters halfbreds and five-eighths excelled all grades, irrespective of breed used in crosses.

Katpatal (1970) studied records on 521 (Sahiwal x HF) crosses where the proportion of production of Holstein-Friesian inheritance ranged from 5/16 to 15/16. Estimates by least squares showed that intermediate grades were superior in growth and milk production traits, while a quadratic regression function fitted to least –squares means showed at 5/8 HF inheritance was best with respect to milk yield.

Dhillon and Jain (1977) reported that average milk yield per day of calving interval for a 648 Holstein-Friesian x Sahiwal crosses was highest for 5/8 Holstein-Friesian (6.58 kg/day) and 1/2 Holstein-Friesian (6.4 kg/day) crosses.

Bhat et al. (1978) used data from eight Military Farms over 30 years (1939-68) where purebred sires were used. One thousand and eight hundred Sahiwal and 1800 Sahiwal x Holstein grades (ranging from 1/16 to 63/64 HF) were studied. Traits studied were age at first calving, first lactation yield. Lactation length, calving interval, service period and dry period. Age at first calving decreased with increasing proportion of HF upto 50 percent, while first lactation yield yield and lactation length increased upto 38/64 HF grades with lowest AFC and highest lactation yield for 63/64 HF crosses.

Taneja and Bhat (1978) studied the same data in an attempt to separate additive and heterotic effects and found that the effects of proportion of HF inheritance in sire and dam to be significant for first lactation milk yield. Moreover, breed of sire had significant effect on age at first calving and first lactation length.

Rao and Nagarcenkar (1979) collected data from four military and five civil farms in the Indo-Gangetic plains. Traits studied were first lactation 305 days milk yield. The least-squares model considered included effect of farm, period, season and genetic group. All grades with less than 50 percent Friesian inheritance were observed for purebred Friesian, followed by 50 per cent Friesian. Significant effect of grade was found for lactation length of Friesian crosses.

Rao and Taneja (1980) studied data on about 3500 HF x Zebu crossbred cows from ten military farms in Northern and six in Southern India. Traits examined were age at first calving, first lactation 305 days milk yield and first lactation length. In both the regions, 50 per cent HF was significantly superior to all other groups ion first lactation milk yield and age at first calving, while 3/8 HF had the lowest milk yield.

Matharu and Gill (1981) compared data over more than 30 years (1942-76) on Holstein-Friesian x Sahiwal crosses at five military farms and found that cows with 5/8 Holstein Friesian inheritance had the highest milk yield per day of productive life, while milk yield per day of total life was highest in halfbreds.

Nagarcenkar et al. (1982) found that 3/4 exotic with 2 exotic breeds was not superior to 3/4 exotic with single exotic (HF) for most traits in HF x T, J x T, BS x crosses.

Despande and Bonde (1982, 1983) examined first lactation milk records of 1346 Friesian x Sahiwal at four military farms in the Southern regions and least-squares means of various traits were reported for various traits with respect to various grades of HF. Highest milk yield was observed in ½ HF and 5/8 HF with slight decrease in yield above this level.

In a study of Holstein-Friesian/Jersey x Zebu, Mangrurkar et al. (1984) found that optimum level of exotic inheritance in Maharashtra needs to be above 50 per cent to maintain productivity.

Parmar et al. (1986) studied data on Holstein-Friesian x Hariana crossbreds and found that age at first calving, lactation length, calving interval, dry period and 305 days milk yield in F_1 and F_2 populations were 35 and 33.2 months, 433 and 427 days, 506 and 537 days, 73.2 and 109.2 days and 1933 and 1349 kg, respectively.

Nagarcenkar and Rao (1982) reported the performance of F_1 and Backcross animals having 50 and 75 per cent Holstein-Friesian inheritance with other kinds of exotic inheritance as presented in Table showed that 305 days milk yield was higher and age at first calving lower in both 50 and 75 per cent of Holstein-Friesian inheritance than other types of crosses.

Table 2.8. Performance of Friesian (F), Brown Swiss (BS) and Jersey (J) crosses with Tharparkar (T) at NDRI, Karnal

Breed of Sire/Dam	Proportion Exotic	First Lactation 305 DMY (kg)	AFC (months)
F T	50	3392	28.5
BS T	50	2755	30.5
J T	50	2714	27.8
F F x T	75	2755	30.3
F BS x T	75	2526	32.8
F J x T	75	2283	31.6

Sinha (1999) studied average performance of various traits in relation to different exotic level and heterozygosity level on Karan Fries cows with 51 to 62.5 percent exotic inheritance had highest milk yield (38.61kg). While animals with intermediate heterozygosity level (45 to 60 percent) were found to be superior with respect to production traits than the other animals.

2.5. GENETIC DISTANCE STUDIES

Literature on determination of similarities and dissimilarities based on various biochemical and phenotypic traits of cattle were reviewed and presented below:

Perez-Beato and Fernandez (1981) estimated the average proportion of heterozygosity at the milk protein loci to determine the genetic distance between Zebu, Sahiwal, Hariana, Holstein-Friesian, HF x Zebu, (HF x Zebu) x Zebu and Criollo cattle in Cuba. Graml and Pirchner (1981) found the differences on Simmental-Pinzgau crosses (F_1 reciprocal crossbred and backcross cows) based on their genetic distances with relation to age at first calving, calving interval and milk and fat yields for 90 days and the whole lactation. The population of various crosses were used to relate heterosis to genetic distance estimated from marker genes and to the absolute yield difference of parental breeds and found that the relationships were almost linear.

Goddard and Ahmed (1982) used the genetic distance analysis in cattle and concluded that heterosis in crossbreds can be predicted from the genetic distance between parent breeds. Baker (1982) observed the genetic relationship amongst cattle breeds and suggested that the preservation of breed identity coupled with enough genetic difference to increase variation by the distance studies, if South African South Devous breeders import cattle from other South Devon populations. Kidd (1974), Khaertdinov (1982) and Mashurov et al. (1982) studied the genetic distances of cattle breeds based on serum protein complex and biochemical polymorphism.

Meshcheryakov (1983) estimated the coefficients of similarities and differences between groups of Ukrainian White-headed, Ukrainian Grey and Russian Simmental cattle based on the frequencies of B blood group antigens and polymorphic protein types.

Chang Hong et al. (1999) studied the consanguinity of 42 native cattle populations in the areas of southeast to central Asia based on allle frequencies at Hb, Alb, Tf loci. The 42 populations were clusters into 3 major groups showed a close consanguinity (0.975).

Dutt and Saravanna Kumar (1999) studied the genetic divergence among 1/2 Frisian +1/2 Hariana (FBH) and 1/2 Frisian + 1/4 Jersey +1/4 Hariana crossbreds, on the basis of some first lactation (AFC, FLMY,FPY, FDP,FCI) and life time traits (LTMY and HL). Data on 227 FH, 187FBH and 197 FJH was taken for the study. Only FH-FJH combination was found to have significant differences for d^2 value based on first lactation and life time traits. The FBH genetic group did not differ significantly from FH and FJH. The there genetic group had found to form individual clusters. The total d^2 values contributed by all the 7 traits was reported to be 0.61. The percentage contribution of LTMY to total d^2 value was the maximum (36.31 percent) followed by FLMY (17.71 percent), FPY (16.08 percent) and AFC (14.72 percent).

Sinha (1999) studied the similarity or disimilarity of Karan Fries cows within a particular level of exotic inheritance considering 5 phenotypic characters (305 DMY, AFC, SP, LL, DP) and level of heterozygosity by Euclidean distance (complete linkage) method. Six, five and four sub groups (clusters) of Karan Fries cows were obtained in the three exotic levels, respectively and thus concluded that Karan Fries cows within a particular level of exotic inheritance were not found similar with respect to level of heterozygosity, 305 days milk yield, age at calving, service period, lactation length and dry period.

2.6. INCIDENCE OF INBREEDING AND ITS EFFECT ON PERFORMANCE

2.6.1. Incidence of inbreeding

Inbreeding is the mating of individuals more closely related by common ancestors than the average relationship of animals in the population. Higher levels of inbreeding are obtained due to closed breeding system or when few bulls are used in a herd for long time. Most of the pedigree studies have been conducted on *Bos Taurus* cattle in temperate countries and some on *Bos indicus* in organized herds. However, information is scanty on new breeds or strains of dairy breeds evolved by crossbreeding and subsequent selection. The published reports are reviewed in the following:

Willham (1937) analysed the pedigree of Hereford cattle in USA by taking samples at interval at 10 years from 1870 to 1930 and reported that the average coefficient of inbreeding rose to 8.1 percent in 13 generations from 1870 to 1930. Stonacker (1943) took five samples of 400 pedigreed animals from the Aberdeen Angus herd book from 1900 to 1939 and traced them back to the foundation stock (born 1850). From 1900 to 1933, average inbreeding increased by 0.3 percent per year. In 1939, it reached 14.2 percent. About 50 percent of the ancestral lines were traced back to 6 animals.

Stewart (1954) analysed the levels of inbreeding in New Zealand pedigreed Jersey cattle from 1905 to 1950 and total inbreeding over the same period relative to 1895. He reported that the New Zealand herd descended from 279 bulls and 255 cows and the average level of inbreeding was 2.4 percent in 1950. Ragab and Asker (1957) reported an average coefficient of inbreeding as 0.6 percent for Holstein Friesian herd in Egypt. Rottensten (1961) found an average inbreeding coefficient of 2.19 percent for the period from 1914 to 1957 in Red Dane breed in Denmark, the average increase in inbreeding coefficient per generation was 0.27 percent.

Kshirasagar and Kulkarni (1963) reported an inbreeding coefficient of 3 percent for a small herd of Dangi cattle. Hillers and Freeman (1964) estimated an average inbreeding coefficient of 6.4 percent, ranging from 0 to 31 percent for a closed Guernsey herd. Allaire and Henderson (1965) reported an average inbreeding coefficient of inbred Holstein Friesian cows to be 4.9 percent, for the entire herd it was 0.4 percent. Thompson and Freeman (1967) reported that the average inbreeding coefficient in

Holstein Friesian cows was 10.20 ranging from 0 to 47 percent during the period 1930 to 1964 in USA.

Bonadonna et al. (1966) reported an average inbreeding coefficient of 4 percent in dairy cows. It was further observed that percentage of inbred animals increased from 16.1 percent in 1958 to 52.7 percent in 1964. The high rate of inbreeding was attributed to intensive use of few bulls through artificial insemination.

Gurnani et al. (1971) traced back the ancestory of Tharparkar herd at NDRI Karnal to seven generations and obtained an average inbreeding coefficient to be 9.7 ± 6 percent ranging from 2 to 30 percent over a period of 40 years (1923-65). Khanna et al. (1979a) estimated the rate of inbreeding in two closed herds of Hariana and Sahiwal cattle to be 6.96 and 14.03 percent, respectively. The corresponding annual increments of inbreeding were 0.51 and 0.80 percent, respectively. Srinivas and Gurnani (1981) reported average inbreeding coefficient in Sahiwal at NDRI, Karnal to be 7.2 percent with a range of 0.11 to 28.13 percent over a period of 27 years (1951-78).

Hudson and VanVleck (1984a) estimated inbreeding coefficient of Ayrshire cows from 1961 to 1980 in USA. The coefficients of inbreedings for all cows increased from 0.16 in 1961 to 2.0 percent in 1980 and the percentage of inbred cows increased from 23 percent in 1972 to 43 percent in 1980. However, the average inbreeding coefficient of inbred cows was 5.4 percent. Hudson and VanVleck (1984b) estimated coefficients of inbreeding of various dairy breeds. Percentage of inbred cows and average inbreeding coefficient of inbred cows were 26 and 11 for Ayrshire; 11 and 4 for Guernsey; 31 and 11 for Holstein; 23 and 2 for Jersey, and 23 and 2 percent for Brown Swiss. Hermas et al. (1987) reported an average inbreeding coefficient of 4.1 percent over a period of 24 years in Guernsey herd. The inbreeding coefficient ranged between 0 and 25.3 percent.

Su (1988) reported an average inbreeding coefficient of inbred Karan Swiss females as 3.98 percent with a range of 1.56 to 16.0 percent over a period of 9 years. For Karan Fries inbred females, it was 7.4 percent with a range of 0.20 to 18.50 percent over a period of 4 years. The percent inbred cows of the total herd was 47.4 percent in Karan Swiss and 21.9 percent in Karan Fries females.

Reddy and Sampath (1989) estimated inbreeding coefficient of Red Sindhi herd as 17 percent during the period 1966-75. Inbreeding coefficient for inbred groups ranged between 1.56 and 25 percent with an average of 7.96 percent. Reddy and Nagarcenkar (1989c) estimated the coefficient of inbreeding for Sahiwal cattle at Karnal, Hisar, Meerut and Lucknow herds. The average coefficient of inbreeding were 5.73, 11.80, 5.15 and 8.88 percent, respectively. About 54 percent animals in all herds were inbred, though most of them were marginally inbred, the inbreeding coefficient ranged between 0 to 6 percent.

Miglior et al. (1992) reported that 32.4 percent of bulls and 36.3 percent of cows of Jersey breed were inbred over a period of 34 years (1955-1988). However, the average inbreeding coefficient of inbred cows was very low (3.3%). Ehiobu (1993) observed average incidence of inbreeding as 6.2 percent in White Fulani dairy herd in Nigeria over a period of 19 years.

Dahlin et al. (1995) estimated the inbreeding coefficient of Sahiwal cattle of 11 farms in Pakistan. The average inbreeding coefficient varied from 2.3 to 12.9 percent and the individual value of inbreeding coefficient ranged upto 32.5 percent. Mating between animals with common parent observed to be the major reason of inbreeding.

Singh (1995) reported the average inbreeding coefficient of inbred female as 6.65 percent in Karan Fries females and 5.53 percent in Karan Swiss females. The average percentage of inbreds were reported to be 20.96 percent in Karan Fries and 36.24 percent in Karan Swiss herd. A gradual increasing trend in proportion of inbreds and decreasing trend in inbreeding coefficient was found over the years as well as generations.

Kaygisiz and Vanli (1995) reported inbreeding coefficient of American Brown Swiss cattle, which ranged from 0 to 34.48 percent with a mean of 6.88±0.96 percent.

Krogmeier et al. (1997) analysed on the data of 98,628 cows and 602 bulls of German Gelbveih breed and 7,79,749 cows and 9972 bulls of German Brown breeds and observed that there was an increase in the inbreeding coefficient from 0.79 and 0.58 percent respectively in 1981 to 1.71 and 0.64 percent in 1992 in Gelbveih cows and bulls whereas in German Brown the corresponding fugures were 0.32 and 0.13 percent and 1.26 and 0.79 percent.

The review of literature on incidence of inbreeding in various breeds of cattle in India and abroad indicates that in a closed herd the coefficient of inbreeding increases at the rate of about 0.2 to 0.5 percent per year ranging from 5 to 25 percent inbreeding coefficient. The main reasons of building up of inbreeding are : I) breeding policy of the herd, ii) herd size, iii) duration, and iv) use of limited number bulls.

2.6.2. Effect of inbreeding on various performance traits

High level of inbreeding is often associated with a decline in vigour and performance and an occasional appearance of genetic defects in animals. Inbred animals beyond certain level of inbreeding are usually less able to adapt to their existing environment compared to outbred animals. Inbreeding of high degree generally causes slower growth rate, reduction in fertility rate, increase in morbidity, mortality and susceptibility to diseases. Many of the adverse effects of inbreeding are believed to be caused by recessive genes. These adverse effects are probably not due to presence of any particular pair of recessive genes, but to the combined effects of many pairs of genes.

Since inbreeding increases the incidence of homozygosity, more pairs of recessive genes are expected to occur among inbred animals. The most logical explanation of why homozygous recessive genotypes result in detrimental effects is because of deficiencies of important or essential enzymes that would have been produced by their dominant alleles. Recessive genes may sometimes result in the production of abnormal of defective proteins (Stufflebeam, 1987).

2.6.2.1. Effect of inbreeding on body weight at various ages at animals

Nelson and Lush (1950) reported the intra-sire regression coefficient of body weight at birth, 6, 12 and 24 months of age on inbreeding coefficient as –0.16, -0.72, -2.74 and –4.75 lb per one percent inbreeding, respectively, in Friesian cattle. Sutherland and Lush (1962) in the same breed estimated intra-sire regression coefficient of body weights at birth, 6, 12, 24 months on inbreeding coefficient to be –0.32, -0.99, -1.83, -4.95 lb per one percent, respectively. They also reported that the effect of inbreeding was at maximum upto 3 years of age and tended to diminish later age. Hillers and Freeman (1964) estimated the intra-sire regression coefficient of body weights at birth, 6, 12 and 24 months on inbreeding coefficient as 0.3, -0.7, -1.5 and –1.2 lb per one percent in inbred herd of Guernsey cattle.

Holtman et al. (1970) compared the body weights of inbred vis-à-vis outbred (control) Holstein cows at birth, 3,6, 12, 18 months of age and 3 months after first calving. The average differences in weights were –3, -13.5, -23.9, -30.4, -43 and –29.3 kg, respectively which was equivalent to 3 to 15 percent of average body weight. The investigations further indicated that the adverse effect of inbreeding on body weight was more pronounced at early ages. Negative regression coefficient on weaning weight on inbreeding coefficient in Angus, Hereford and Shorthorn calves was reported by Carter (1973).

Krishna (1974) in two inbred shorthorn lines observed that one percent increase in inbreeding reduced weaning weight by 0.2 and 3.1 percent, and pre-weaning average daily gain by 1.9 and 3.8 percent, and pre-weaning average daily gain by 1.9 and 3.8 percent in non-repeat and repeat mating data set, respectively. One percent increase in dam's inbreeding coefficient reduced calf birth weight, pre-weaning average daily gain and weaning weight by 0.2, 1.1 and 0.9 percent, respectively. Pirchner et al. (1983) in German cattle, Ehiobu and Nigreva (1986) in White Fulani cattle, and Flade and Zeller (1989) in Black Pied breed also observed depression in growth rate at various ages due to inbreeding.

Young (1984) reported a reduction of 0.68, 1.36 and 2.72 kg birth weight in lowly inbred (6.25%), moderately inbred (12.5%) and highly inbred (25.0%) Holstein cattle in comparison to outbreds. The reduction of body weight among the above three inbred groups were 9, 18 and 27 kg, respectively.

Reddy and Sampath (1989) reported adverse effect of inbreeding on birth weight in Red Sindhi calves. The non-inbreds had significantly higher birth weight than inbred calves (23.13 vs. 20.56 kg). The correlation between birth weight and inbreeding coefficient was also negative and significant (P>0.01). However, the effect of inbreeding on weight at first calving was statistically non-significant.

Bartlett et al. (1942) observed non-significant differences between the body weight at different ages of inbred and non-inbred Holstein calves. Similar non-significant effect of inbreeding on body weight at various ages was observed by Fuentas et al. (1971) in Crilio cattle; Vachal and Teslik (1971) in Czeck Pied cattle; Primakin (1974) in dairy cattle and Brinckman and Zemmelink (1976) in White Fulani cattle, Srinivas and Gurnani (1981) in Sahiwal and Su (1988) in Karan Swiss cattle.

Singh (1995) reported significant effect of inbreeding on birth weight in Karan Fries Female and on birth weight and 3 month body weight in Karan Swiss females. However, there was lower body weight found in highly inbred (F>12%) group of female calves and heifers as compared to nonbred and lowly inbred (F<6%). The regression analysis showed significantly adverse effect of inbreeding on birth weight, 3 month, 6 month, 12 month in Karan Fries herd whereas none of the body weight traits was significantly affected by inbreeding in Karan Swiss herd.

The published reports on effect of inbreeding on body weight at various ages are variable. This may be attributed to differences in herd size and level of inbreeding. However, following general inferences can be drawn:

i) Higher level of inbreeding tended to depress both body weight and growth of cattle.

ii) Effect of inbreeding on body weight is usually small in magnitude which is further reduced at later ages.

2.6.2.2. Effect of inbreeding on production traits

Tyler et al. (1949) reported in Friesian cows that the intra-sire regression of lactation milk yield on inbreeding amounted to an average reduction of 33.57 kg for one percent increase in inbreeding which was statistically significant. Robertson (1954) reported that in Holstein cows first lactation yield decreased by 34.6 kg per one percent increase in inbreeding. Von Krosigk and Lush (1958) also observed a significant reduction of 54 lbs of lactation milk yield for each increase of one percent of inbreeding in Holsteih cows.

However, Arzumanjan (1962) observed that the milk production of low to moderate inbred cows exceeded that of outbreds. Gaalas et al. (1962) obtained the intra-sire regression of first lactation yield on inbreeding as 105.3 lbs for each one percent increase of inbreeding in dairy cows.

The depressing effect of inbreeding on first lactation yield was also noticed by Birjukov and Degtijarenko (1964) in Alatam breed. They observed first lactation yield to be 3105 kg for the closely inbreds, 3341 kg for moderately inbred and 3607 kg for lowly inbred group of cattle.

However, Malik (1967) observed a beneficial effect of mild inbreeding on milk yield in Hariana cows. He reported first lactation yield as 943, 1100 and 830 kg in the three groups with 1.56 and 3.12 percent, 6.25 percent and 12.5 to 25 percent coefficient of inbreeding, respectively.

The regression of first lactational yield on inbreeding coefficient was 0.36 per one percent inbreeding, which was statistically significant ($P<0.05$).

Gurnani et al. (1971) observed the regression coefficient to be – 21.9 kg of milk for each increase of 1 percent of inbreeding in a herd of Tharparkar cattle. However, the effect was statistically non-significant. Various other reports showed negative, but not discernible effect of inbreeding on milk yield (Ahmed et al., 1974; Beller and Plensik, 1977).

Kumar and Narain (1977) reported a reduction of 20 percent in milk yield and 47 percent in lactation length in highly inbred group of Sahiwal cows as compared to outbreds. The adverse effects were discernible beyond an inbreeding coefficient of 4 percent.

Khanna et al. (1979b) observed a reduction of 13.53 kg and 2.48 kg in milk yield with each 1 percent increase of inbreeding in Sahiwal and Hariana cows, respectively. However, the estimate of regression coefficient was non-significant. On the contrary, they reported significant increase in lactation length by 2.81 days for every one percent increase of inbreeding level in Sahiwal cows. Hodges et al. (1979) observed a significant reduction of 22-85 kg in 305 day lactation yield with 1 percent increase in inbreeding coefficients in Holstein cows.

Srinivas and Gurnani (1981) reported a reduction of 2.10 kg in first lactation yield for every one percent increase in level of inbreeding in Sahiwal cows. They also observed lactation length to be shorter by 32 days for inbred cows as compared to non-inbrds in Karan Swiss cattle. The effect of inbreeding on both the breeds were, however, non-significant. Whereas, Singh (1981) reported significant effect of inbreeding on milk yield per day of lactation length and milk yield per day of calving interval in Sahiwal herds maintained at Hisar, Meerut and Ganjaria except Karnal, where the effect was non-significant. However, the effect of inbreeding was non-significant on first lactation yield at all the farms.

Hudson and VanVleck (1984a) reported that first lactation milk yields were reduced by 14.8, 19.3, 21.1, 27.1 and 39.50 kg per one percent inbreeding in Jersey, Guernsey, Holstein, Ayrshire and Brown Swiss cows, respectively. They suggested tht inbreeding is not justified unless the mating is to an animal with exceptionally high breeding value. Young (1984) also reported significant depressing effect of inbreeding on milk yield in Holstein cattle. In comparison to outbreds, he observed a reduction of 136, 272 and 544 kg milk yield in the three groups with 6.25, 12.5 and 25.0 percent level of inbreeding.

Kalmykov and Sokolov (1984) reported significant depression of milk yield in animals beyond 8.1 percent inbreeding coefficient in Russian Black Pied cattle. On the other hand, Pogrebenyak (1990) observed a beneficial impact of milk inbreeding (F=4%) in the same breed of cattle; inbred cows produced 81 to 326 kg more milk per lactation than outbreds.

Su (1988) found that Karan Swiss inbred groups of cows had lower milk yield in comparison to non-inbreds. However, the effect was non-significant. The lower milk yield among inbred Caracu dairy cows was also reported by Oliveira et al. (1989). However, Reddy and Sampath (1989) in Red Sindhi cows, and Reddy and Nagarcenkar (1988) and Singh (1992) in Sahiwal cows did not observe discernible difference for first lactation yield and first lactation length between inbred and non-inbred groups of cattle.

Miglior et al. (1992) reported linear regression of first lactation milk yield to be –9.84 kg per one percent increase in inbreeding in Jersey cattle. Casnova et al. (1992) found that first to fourth lactation milk yields were sizeably depressed by 26 kg per one percent increase of inbreeding in Brown Swiss cows. Vij et al. (1992) also reported significantly lower milk yield of inbred animals than outbreds in Tharparkar cattle.

Rege and Wakhungu (1992), however, reported first lactation milk yield to be higher by 139 kg among inbred Kenyan Sahiwal cows than the outbreds. Ehiobu (1993) also observed positive linear regression of milk yield and lactation length on inbreeding. The estimates were 0.84±3.33 kg and 0.46±0.73 day per 1 percent increase of inbreeding coefficient.

Krogmeier (1997) reported inbreeding depression of 7.8-9.9 percent, 0.26-0.39 percent and 0.26-0.37 percent for milk yield, m9ilk fat yield and milk protein yield respectively in German Galbvcih cattle whereas corresponding depression the German Brown Cattle wee reported to be 10.1-13.1, 0.36-0.51, 0.35-0.47 percent.

Singh (1995) reported significant effect of inbreeding on first lactation milk yield, milk yield per day of first calving interval in Karan Fries herd. However, the milk production traits were found to be adversely affected beyond 6 percent level of inbreeding.

The above review indicates variable effect of inbreeding on production traits. Most of the studies carried out in India on Zebu breeds indicate that inbreeding depressed the milk production traits insignificantly. The higher level of inbreeding was found to be more harmful. Investigations on temperate breeds showed that inbreeding depressed milk yield from 10 to 105 kg approximately for every one percent increase in inbreeding. However, low to moderate inbreeding had a favourable impact on milk yield and lactation length. Inbreeding due to more extensive use of high breeding value bulls or cows tended to improve production performance.

2.6.2.3. Effect of inbreeding on reproductive traits

Nowicki (1963) reported adverse effect of inbreeding on fertility and calving interval in Black Pied dairy cattle. Bonadonna et al. (1966) also observed longer calving interval in inbred cows as compared to that of non-inbred cows in Black Pied cattle.

Malik et al. (1967) observed that average age at first calving (AFC) was lowest (52.7 months) in the inbreeding group of 1.56 to 3.12 percent in Hariana cattle and level of inbreeding beyond 3.12 percent increased the AFC. However, AFC at level of inbreeding 3.12 to 6.25 percent (61.5 months) and 12.5 to 25 percent (60.6 months) did not differ significantly from each other. The average FCI registered an increase with the increase in inbreeding. It being lowest (528 days) in 1.56 to 3.2 percent inbreeding group and highest (608 days) in 12.5 to 25 percent inbreeding groups.

Pirela and Ilea (1970) reported higher age at first calving and longer FCI for inbreds ranging from 32.9 to 33.4 months and 451 to 484 days, respectively, in Simmental cows. The corresponding figures for non-inbreds were 27.8 to 28.30 months and 412 to 420 days.

Gurnani et al. (1971) reported that the regression of AFC and FCI on inbreeding coefficient was 0.23±1.44 months and 23.9 days, respectively, in Tharparkar cattle. However, the estimates were found to be statistically non-significant.

Plensik (1974) reported non-significant effect of inbreeding on age at first calving (AFC) in Slovakian Pied cattle. The average AFC for non-inbreds and inbreds were 28.2 and 28.3 months. He, however, reported discernible adverse effect of inbreeding on first calving interval (FCI). The average FCI for non-inbreds and inbreds were 423 and 459 days, respectively.

Ahmad et al. (1974) reported favourable impact of inbreeding on AFC and FCI in Sahiwal herd of Pakistan. They obtained regression estimates as –1.2±2.7 and –1.1±2.1 days, respectively, which were, however, statistically non-significant. Odedra et al. (1979) also observed beneficial effect of mild inbreeding on AFC, FCI and first dry period (FDP) in Gir cattle.

Plensik (1977) reported that service period and calving interval were significantly adversely influenced by very high levels of inbreeding, but there were no discernible differences between non-inbred and high, medium and lowly inbred Slovakian Pied animals. The service period in very high, high, medium and lowly inbred groups were 154, 96, 90 and 75 days, respectively. The average calving interval was 434, 381, 378 and

352 days, respectively for the corresponding groups indicating reduction in calving interval as inbreeding level decreased.

Khanna et al. (1979a) reported discernible effect of inbreeding on service period and calving interval in Hariana cows. The averages of both traits among non-inbreds and inbreds were 210 versus 222 and 463 versus 529 days, respectively. On the contrary, they reported considerable favourable influence of inbreeding on service period and calving interval in Sahiwal breed. The corresponding figures of service period and calving interval for non-inbreds and inbreds were 241 versus 205 and 522 versus 490 days, respectively. They did not observe any significant difference between non-inbreds and inbreds for age at first calving in both the breeds.

Srinivas and Gurnani (1981) observed significantly higher service period among inbred groups with inbreeding level above 10 percent in Sahiwal cattle. They also found that an increase in inbreeding level by one percent was likely to increase the first service period by 2.29 days. The regression of AFC and FCI on inbreeding was positive buyt statistically non-significant. Kalmykov and Sokolov (1984) also reported larger service period among inbreds by 7 days than that of non-inbreds Russian Black Pied dairy cattle. The difference in both groups were, however, found to be statistically non-significant.

Hudson and VanVleck (1984a) observed regression of FCI on inbreeding coefficient to be –0.095 days per one percent increase of inbreeding coefficient in Ayrshire cattle.

Young (1984) reported that in Holstein cattle, inbred heifers had reduced conception rates to first service and required more services per conception. Inbred heifers were also slowere to reach puberty. Hermas et al. (1987) reported that AFC increased by 3.7 days with one percent increase of inbreeding in Guernsey cows. Guaragna et al. (1988) found that in Mantiquerire cows the age at first calving increased by 60.56 days with an increase of one percent in the inbreeding coefficient beyond 5 percent level of inbreeding. However, they observed no effect of inbreeding on calving interval.

Su (1988) observed non-significant effect of inbreeding on age at first calving, first service period and first calving interval in Karan Swiss cattle at NDRI, Karnal. Reddy and Nagarcenkar (1988) reported poor performance of inbreds as compared to that of non-inbred Sahiwal cattle in terms of service period, dry period and calving interval. The inbred heifers were, however, found to freshen earlier than the outbred ones. However, no significant difference was observed between these two groups. In Red Sindhi cows, non-significant effect of inbreeding on FDP and FCI was also observed by Reddy and Sampath (1989).

Drumond et al. (1990) in a study on Nellore cattle observed that for each additional 1 percent inbreeding, the AFC and FCI was prolonged by 2.36±0.95 days and 1.59±0.62 days, respectively. The effect of inbreeding, however, w2as found to statistically non-significant. Vij et al. (1992) reported non-significant effect of inbreeding on AFC and FCI in Tahrparkar cattle.

Rege and Wakhungu (1992) observed higher age at first calving by 45 days, longer calving interval by 9 days, 2.37 more inseminations per conception in inbred cows as compared to that of non-inbred cows of Sahiwal herd in Kenya.

Kaygisiz and Vanli (1995) reported the regression coefficient for age at first calving on inbreeding coefficient was 1.72±1.66 days in American Brown Swiss cattle.

Singh (1995) found that reproduction traits were adversely affected by higher level of inbreeding (F>12%) in both Karan Fries and Karan Swiss herds. Regression analysis showed the unfavourable effect of inbreeding on first dry period in Karan Swiss herd, which was found to be statistically significant.

From the above review, it may be concluded that reproduction traits like AFC, FCI and FSP were generally adversely affected by higher level of inbreeding in dairy cattle. However, low to moderate inbreeding appeared to have favourable effect on different reproduction traits in exotic as well as Zebu cattle.

2.7. DISPOSAL PATTERN

Culling and mortality together constitute disposal pattern among animals. Culling is the removal of undesirable animals from the herd to facilitate the entry of replacement heifers for improving the herd performance or to keep the herd size constant. The removal of animals from the herd is either voluntary on the basis of low milk production or involuntary removal for the reasons such as reproductive problems, teat and udder disorders, disease and poor growth, etc.

The knowledge of mortality rate, its causes and factors affecting it at various ages is very essential in a given herd for producing replacements to maintain proper herd structure. In every farm, some calves leave the herd due to death. Such loses of calves not only reduces the economic soundness, but also limits the genetic progress by providing fewer replacements.

Culling in herd is practiced to remove the unproductive animals and to obtain phenotypic and genetic improvement by retaining the best cows for future lactations, and to obtain genetic improvement by breeding replacement stock only from the selected cows (Hill, 1980). In principle, any individual cow should be culled, regardless of her age, if there is a heifer available which is expected to out perform her. It is observed that rate of culling as reported by various workers in different breeds under different set of managemental and environmental conditions ranged from 11.6 to 33.2 percent per year (Augsteburger et al., (1988).

Disposal of cattle has been classified as :

1. Disposal by culling
2. Disposal by mortality

The disposal pattern of animals under two categories, i.e., from birth to first calving and in adult cows (after age of first calving) are reviewed separately.

2.7.1. DISPOSAL OF ANIMALS BEFORE AGE AT FIRST CALVING

2.7.1.1. Mortality rate and reasons of mortality

The mortality rate for different age groups of animals reported in literature have been summarized in Table 2.9.

2.7.1.2. Culling rate and reasons of culling

Amble and Jain (1967) obtained 9 percent culling rate upto first calving in crossbreds at various military farms. Whereas, Dutt and Desai (1968) reported a higher culling rate (34%) upto age at first calving in Hariana cattle. The culling rates in Hariana and Desi cattle in the age group of one year to first calving were 22.8 and 26.9 percent, respectively (Lemka et al., 1973).

Allaire et al. (1977) investigated the culling pattern of heifers prior to first calving in Holstein-Friesian in USA. They observed reproductive disorders, disease, dairy type, accident and ill health as the major reasons accounting for 25.7, 36.8, 24.4 and 4.7 percent of all cullings, respectively.

Rao (1982a) observed a culling rate of 4.23 percent in Sahiwal calves upto first calving. The investigation further revealed disease, breeding problems, dairy type, poor growth and dam's low yield as the major reasons of culling. Whereas, Des Raj (1987) reported higher culling rate (23.09%) in Kankrej heifers upto first calving. The main reasons of culling were dam's low yield (30.7%), stunted growth (20%) and miscellaneous (30.2%).

Singh et al. (1987) reported the culling rate upto first calving in Red Sindhi, Sahiwal, Tharparkar, Brown Swiss crosses and other crossbreds as 13, 12.3, 13.6, 4.0 and 3.2 percent, respectively at IVRI, Izatnagar during the period 1963 to 1967.

Jadhav (1990) in Friesian x Sahiwal crossbred reported 26.46, 25.80 and 17.03 percent culling at Ambala, Dehradun and Jalandhar farm with overall culling rate of 22.38 percent. He noticed highest culling rate (12.82%) in the age group of 12 month of AFC. Poor growth, surplus, poor health, breeding problems and low birth weight were the major reasons of culling accounting for 8.18, 3.67, 2.91, 1.90 and 2.00 percent, respectively.

Kulkarni and Sethi (1990) in Karan Fries and Karan Swiss cattle observed 9.3 and 14.3 percent culling, respectively, at NDRI herd, Karnal. Reproductive disorders, health problems and low growth rate accounted for 3.02, 3.16 and 3.67 percent in Karan Fries, while the corresponding values in Karan Swiss were 5.14, 4.54 and 4.60 percent, respectively. They also reported higher culling among progeny of low ranking sires (P.D. < 3100 kg) than for progeny of high ranking sires (PD > 3100 kg).

Singh (1995) studied mortality rate in Karan Fries and Karan Swiss females from birth to 1st calving and reported mortality rate for different age group like upto 1 month, 1-3 month, 3-6 month, 6-12 month, 12-18 month and 18 month to AFC was 3.78, 3.02, 2.16, 1.32, 1.14 and 2.90 percent of herd strength respectively. In case of Karan Swiss females calves and heifers it was 5.54, 4.18, 2.24, 0.81, 0.62 and 2.23 percent respectively for the above mentioned age group.

Mukherjee and Tomar (1999) studied in Brown Swiss crosses and reported the average mortality rate in different age group as 8.4 percent (0-1 month), 5.6 percent (1-3 month-AFC). Around 45 percent of thetotal death was observed during first month of life, 30 percent during 1-3 month of age and thus about 75 percent of the total loss through mortality occurred upto 3 month of age.

The disposal pattern pertaining to the various age groups upto first calving reviewed here showed that the mortality rate from birth to age at first calving varied from 10 to 30 percent and majority of losses occurred in first month of life. The main causes of calf mortality were: pneumonia, calf scours, gastroenteritis, enteritis and septicemia. The culling among

Table 2.9. Mortality rate in various age groups upto age at first calving in dairy cattle

Breed/Genetic group	Location/Farm	Upto 1 month (%)	Upto 3 months (%)	Upto 6 months (%)	Upto 1 year (%)	Upto 1st calving (%)	Reference(s)
1	2	3	4	5	6	7	8
Friesian x Sahiwal	MDF	-	-	22.00	-	28.00	Amble and Jain (1967)
Hariana	Hisar	-	-	-	19.72	-	Dutt and Desai (1968)
Shanta Gertrudis	Sri Lanka	-	-	-	15.70	-	Mahadevan *et al.* (1972)
Sahiwal	Sri Lanka	-	-	-	18.10	-	Mahadevan *et al.* (1972)
Hariana	Heringhata	-	-	-	23.60	-	Lemka *et al.* (1973)
Desi	Heringhata	-	-	-	17.00	-	Lemka *et al.* (1973)
Hariana	SCF (UP	-	11.50	-	-	-	Tomar (1973)
Friesian x Zebu	SCF (UP	-	3.40	-	-	-	Tomar (1973)
Brown Swiss x Zebu	SCF (UP	-	8.10	-	-	-	Tomar (1973)
Sahiwal	NDRI, Karnal	9.68	-	-	-	-	Sharma and Jain (1976)
Red Sindhi	NDRI, Karnal	4.51	-	-	-	-	Sharma and Jain (1976)
Crossbred	NDRI, Karnal	11.06	-	-	-	-	Sharma and Jain (1976)
Friesian x Hariana	MDF	-	8.50	13.40	13.80	-	Katpatal (1977)
Brown Swiss x Hariana	MDF	-	11.50	15.10	15.90	-	Katpatal (1977
Jersey x Hariana	MDF	-	7.40	9.50	12.50	-	Katpatal (1977
Friesian x Tharparkar	NDRI, Karnal	-	-	6.72	-	-	Rao and Nagarcenkar (1982)
Exotic x Hariana	MDF	-	-	-	13.00	-	Bali *et al.* (1980)
Friesian x Gir		-	-	-	9.00	-	Jenny *et al.* (1981)
Jersey x Gir		-	-	-	10.00	-	Jenny *et al.* (1981)
Dairy Cattle	India	55.79*	16.82*	-	-	-	Khera (1981)
Karan Fries	NDRI, Karnal	1.80	4.80	6.20	-	-	Nagarcenkar *et al.* (1981)
Karan Swiss	NDRI, Karnal	4.80	6.40	7.70	-	-	Nagarcenkar *et al.* (1981)
Gri crossbred	Jabalpur	4.95	-	-	-	-	Singh and Parekh (1981)
Sahiwal	A.P.	-	-	-	-	4.53	Rao (1982b)
Gir crossbred	Jabalpur	20.50*	-	-	-	-	Singh and Parekh (1982)

Contd.../-

Contd…./-

Friesian x Tharparkar	NDRI, Karnal	-	-	7.22	-	-	Sharma and Jain (1982)
Brown Swiss x Tharparkar	NDRI, Karnal	-	-	5.02	-	-	Sharma and Jain (1982)
Jersey x Hariana	Kalyani	-	-	5.64	-	-	Chaudhary *et al.* (1984)
Friesian x Hariana	Kalyani	-	-	9.45	-	-	Chaudhary *et al.* (1984)
Kankrej	SCF, Gujarat	-	-	-	-	15.36	Des Raj (1987)
Ongole crossbred	Lam	5.63	12.17	14.31	13.60	-	Reddy *et al.* (1987)
Red Sindhi	IVRI, Izxat.	-	-	9.90	-	12.10	Singh *et al.* (1987)
Sahiwal	IVRI, Izxat.	-	-	8.60	-	12.10	Singh *et al.* (1987)
Tharparkar	IVRI, Izxat.	-	-	15.60	-	18.80	Singh *et al.* (1987)
Brown Swiss crosses	IVRI, Izxat.	-	-	16.00	-	19.50	Singh *et al.* (1987)
Tharparkar	NDRI, Karnal	-	-	-	-	14.60	Tomar and Verma (1988)
Exotic x Gir	Rahuri	-	-	-	-	24.00	Kulkarni *et al.* (1989)
Sahiwal	MDF & NDRI	-	-	-	-	4.50	Reddy and Nagarcenkar (1989b)
Friesian x Hariana	IVRI, Izxat.	-	-	-	-	18.40	Taneja *et al.* (1989a)
Brown Swiss x Hariana	IVRI, Izxat.	-	-	-	-	32.57	Taneja *et al.* (1989a)
Jersey x Haryana	IVRI, Izxat.	-	-	-	-	27.33	Taneja *et al.* (1989a)
Crossbred	Palampur	-	-	-	24.35	-	Katoch *et al.* (1991)
Jersey crosses	UAS, Dharwad	54.30*	-	-	-	-	Patil *et al.* (1991)
Jersey crosses	UAS, Dharwad	-	-	-	-	15.13	Patil *et al.* (1991)
Exotic x Gir	Rahuri	10.07-17.31	-	-	-	27.07	Kulkarni *et al.* (1993)
Jersey x Red Sindhi	Tamilnadu	57.86*	-	-	14.10	-	Veerapandian *et al.* (1993)
Sahiwal & BS x Sahiwal	NDRI, Karnal	-	-	-	-	15.40	Rawal and Tomar (1994)
Crossbred	MDF (Leh)	-	28.13	-	-	-	Jadhav *et al.* (1995a)
Friesian x Sahiwal	MDF	-	5.61	6.29	7.00	8.87	Jadhav *et al.* (1955 b)
Karan Swiss	NDRI, Karnal	8.40	14.00	16.10	-	20.70	Mukherjee and Tomar (1999)

* Percent of total mortality upto age at first calving

female calves were very less upto one year of age and it increases with the progress in age. The important reasons of culling among heifers were breeding problems, poor growth and late maturity, disease, udder problems and undesirable diary type.

2.7.2. DISPOSAL OF COWS AFTER AGE AT FIRST CALVING

Arisnabarreta and Echenique (1984) reported 25.3, 18.4, 14.1, 12.3, 9.7 and 20.3 percent culling from 1st to 6th lactation in dairy cows in Argentina. Runov et al. (1986) compared the culling rate of Kholmogor cows maintained on pasture and indoors. The lactation specific percentage of culling for the two groups was 9 and 17 percent in 1st parity, 10 and 22 percent in 2nd parity, 26 and 24 percent in the 3rd parity and 19 and 22 percent in the 4th parity.

Hocking and McAllister (1986) reported 25 percent culling rate during first lactation in Friesian and Ayrshires cows in Canada

Zarnecki and Stolzman (1987) studied the lactation specific cu8lling rate upto 3rd lactation among Friesian strains in 10- European and North American countries. They reported 18.1, 16.5 and 24.8 percent culling rate in 1st, 2nd and 3rd lactation, respectively. The major reasons of culling were: breeding problems, low milk yield and teat and udder disorders accounting for 8 to 9.4 percent, 2 to 3.3 percent, 1 to 2.2 percent of herd strength, respectively. They further noticed that culling due to teat and udder disorders increases significantly as the parity order increases.

Taneja and Bhatnagar (1987) reported 2.7, 0.0, 4.2, 7.2, 7.8, 8.5, 9.4, 11.6, 13.1 and 21.2 percent culling from 1st to 10th lactation in Karan Swiss cows at NDRI Farm, Karnal.

Danuser and Gaillard (1990) reported 20 to 35 percent culling from 1st lactation to 4th lactation in Brown Swiss, Simmental and Friesian cattle in Switzerland. They also observed that reproductive problems (silent heat, repeat breeding, ovarian cysts) and acetonemia increased with increase in milk production particularly in high yielding animals. However, the occurrence of teat and udder disorders showed no correlation with increase in milk yield.

Jadhav (1990) reported 1.173, 4.57, 5.17, 6.01, 5.06, 4.97 percent parity specific culling rate from 1st to 6th lactation in Friesian x Sahiwal crossbreds at various Military Farms during the period 1955 to 1983. The corresponding mortality rate was 2.60, 4.87, 3.96, 4.17, 4.60 and 3.0 percent, respectively. The average values of herd life and productive life was 7.30 and 4.57 years, respectively. The average number of lactations completed before disposal was 4.02.

Mukherjee and Tomar (1994) reported the culling rate as 29.0, 39.4, 29.0, 25.3, 17.6, 14.1 and 14.9 percent from 1st to 7th lactation in Karan Swiss cattle at NDRI Farm, Karnal during the period 1963 to 1988. The corresponding lactation specific mortality was 2.6, 3.2, 3.4, 5.5, 3.8, 4.8 and 3.6 percent, respectively.

Singh (1995) reported that culling of cows on the basis of low milk production become almost negligible after second parity in Karan Fries and after 3rd parity in Karan Swiss cows. However, the culling rate of cows on the basis of teat and udder disorder increased with the increase in parity order in both the strains. The culling rate due to reproductive disorders, disease, leg and hoof problems remain more or less same in all the parities.

Rawal and Tomar (1998) studied on Tharparkar cattle and reported that out of 13.68 cows taken for study 132 cows (9.6 percent) died and 1236 culled (90.4 percent). Out of total annual losses, the mortality accounted for 1.9 percetn while the annual culling rate were 17.78 percent. The total loss of adult cows per lactation was 26.0 percent of which 2.5 percent through mortality and 23.5 percent through culling of cows. Lactationwise analysis of data showed that the total loss was around 26 percent among cows of first to seventh parity and thereafter, the rate of loss increased along increase in parity.

2.7.3. Impact of culling on milk production performance

Renkema and Stelwagen (1979) compared the two models in similar herds with average lactation of 5.3 and 3.3. They observed 20 percent more income, when average lactation was 5.3. They further suggested that reduction of involuntary culling through improved health is very important economic factor in organized dairy herd.

Replacement of unproductive animals from the herd is likely to produce genetic improvement in the progeny, but substantial improvement in performance is not observed even with intensive culling. In view of the rise in yield with parity, intensive culling is not likely to increase mean yield substantially if it increases the proportion of young cows (Korner and Renkena, 1979).

Allaire and Cunningham (1980) found that intensity of voluntary culling be at most 3-8 percent unit in addition to involuntary culling to maximize milk yield, whereas, Allaire (1981) in another study indicated that with 20 percent involuntary culling, milk yield was increased by additional 10-15 percent of voluntary culling. Hill (1980) reported on the basis of theoretical analysis that at the optimum when about 70 percent cows were retained, the increment in yield was about one percent.

Angelov (1981) concluded that in Brown Swiss cows, highest average milk yield would be obtained by 20-25 percent replacement with high yielding heifers. Fistecg et al. (1984) suggested in Holstein Friesian animals that cows producing less than 3500 kg milk (standard milk yield) in first lactation should be culled; this recommendation is based on high correlation of first lactation yield with age at first calving, age at culling, number of lactations completed and maximum yield.

Simonyan (1984) reported that culling of low yielders in first lactation resulted in increased 3^{rd} lactation yields as compared when no culling had been carried out. Corresponding to culling rates of 10, 2-0 and 50 percent in first lactation, the yield in third lactation increased by 3.65, 9.24 and 16.93 percent, respectively.

Kulkarni and Sethi (1990) in a study in Karan Fries and Karan Swiss cows during the period 1976-84 reported annual culling rate due to various reasons as 18 and 24 percent, respectively. However, they could not find a consistent trend in milk production throughout the period either due to replaced animals or culled animals. Overall, they observed 6.09 percent average annual increase in milk production of selected animals in Karan Swiss and 0.05 percent in Karan Fries for the same period.

Beaudean et al. (1993) reviewed the impact of involuntary culling on dairy animals. They reported that level of involuntary culling greatly influenced the genetic gain by reducing the number of replacements and annual income per cow per year. The loss due to forced replacement of a cow varies from 460 to 1200 kg. Moreover, they observed that the possibilities of disposal based on voluntary replacement and selection are limited by involuntary culling. They also reported that health disorders (specific diseases, infertility etc.) which contributed to nearly 50 percent of total culling, increased the risk factors for culling in the subsequent lactation or later age.

Singh (1995) did not found any significant impact of culling on the improvement of herd performance in both the Karan Swiss and Karan Fries herd which was reported to be due to small herd size, lower replacement rates as compared to disposal rate and high involuntary culling rate (85 percent in KF, 76 percent in KS)

CHAPTER-3

MATERIALS & METHODS

MATERIALS AND METHODS

3.1. SOURCE OF DATA

The investigations were carried out on the two crossbred strains of dairy cattle, namely, Karan Swiss and Karan Fries developed at National Dairy Research Institute, Karnal. These strains have been developed initially by crossbreeding followed by *interse* mating. The Karan Fries have been developed mainly by crossing of Tharparkar cattle with imported semen of progeny tested Holstein Friesian bulls, whereas, the Karan Swiss have been developed mainly by crossing of Sahiwal with imported semen of progeny tested Brown Swiss bulls. The data were collected on 3168 Karan Swiss cows sired by 107 bulls (1963-2000) and 3051 Karan Fries cows sired by 163 bulls (1971-2000) from history sheets, stock registers, body weight and growth registers. The pedigree of the animals born during these periods was traced back upto F_1 generation. The body weight of such animals was recorded at birth, at 1 year, weight at first fertile service and weight at first calving. Information was also recorded on disposal (culling and mortality) in female calves and adult cows for the period from 1971 to 2000 for KF and 1963-2000 for KS.

The animals with unknown pedigree, lactation length less than 100 days were considered as abnormal and not included for the estimation of genetic parameters of the different economic traits. Calving intervals affected by abnormal calving were excluded from the purview of study.

3.1.1. Collection of Data

The following information on Karan Swiss and Karan Fries cows were collected:

1. Animal number
2. Date of birth
3. Genetic group
4. Sire number
5. Sire-breed
6. Dam number
7. Dam-breed
8. Date of fertile service
9. Date of calving
10. Sex of the calf
11. Body weight of females at birth, at one year, weight at first fertile service and weight at first calving.
12. Lactation number
13. 305 days or less milk yield
14. Total milk yield
15. Date of dry
16. Date of disposal
17. Mode of disposal
    a. Culled
    b. Died

3.1.2. Traits Generated

On the basis of information gathered under section 3.1.1., the following traits were generated.

1. Age at first fertile service (days)
2. Age at first calving (days)
3. Service period (days)
4. Dry period (days)
5. Calving interval (days)

6. Milk yield per day of lactation length (MY/LL): MY/LL (kg) was calculated by deviding the total milk yield by lactation length of respective lactations.

   MY/LL = TMY/LL

7. Milk yield per day of calving interval (MY/CI) (kg) : MY/CI (Kg) was calculated by deviding the total milk yield by calving interval of respective lactations

   MY/CI = TMY/CI

8. Herd life (days)

3.1.3. Location and Climatic Condition

The geographical location of NDRI Livestock Farm is Trans-Gangetic Plain Region. It is located at an altitude of 250 metres above the mean sea level on 29°42' N Latitude and 72°02' Longitude. The mean annual rainfall ranges from 500 mm to 1000 mm. More than 70 percent rain is received during July to September. Normal rainy days are more than 30 per annum. Intensity of monsoon rainfall varies from 20 to 30 mm per day and in inter cyclonic rainfall varies from 8-14 mm per day.

Temperature varies greatly in this region during the year. The minimum temperature falls near 5 to 6°C in December-January and maximum temperature raises above 40°C in May-June and hot dry winds are common feature. Relative humidity ranges from 41 percent to a high of 85 percent.

3.2. MANAGEMENT PRACTICES

3.2.1. Feeding

The nutritional requirements of animals are met through a balanced ration of various green fodders, dry fodders and concentrates. The calves are weaned at birth and till fifth day after birth the calves are fed on colostrums of its own dam and later on whole milk upto 30 days. Beyond this age they are fed on different proportions of whole milk and skim milk upto 4 months and on skim milk only upto 6 months. Minerals, concentrates and roughages are made available to the calves from one month of age and fed according to body weights as per nutritional standards. During later age, feeding schedules are laid down according to age groups considering the requirements for maintenance, growth, reproduction and production. Extra concentrate of 1 to 1.5 kg is provided to pregnant heifers/cows after 7 months of pregnancy. A let-down ration of 0.25 kg of concentrate is provided at the time of milking and additional concentrate is provided to meet the requirements of high milk (greater than 8 kg) producers. For adult heifers and cows, green fodder and other roughages are provided *ad libitum*. All the animals are exclusively stall fed in open paddocks.

3.2.2. Housing

Irrespective of sex and genetic group/breed, all the calves were housed together in concerned calf pens upto six months of age. After that male and female calves were reared separately. Most of the male calves were disposed off, leaving a few from elite dams for being used as future bulls. The female calves in the age group of six months to two years and heifers from two years to conception were kept in different open paddocks with sheds. The separate open paddocks with sheds under loose housing system were provided for dry, lactating and advanced pregnant cows.

3.2.3. Milking

The cows are milked thrice a day, i.e., morning, noon and evening. All the crossbred cows, the high yielding were milked by machine and Sahiwal and Tharparkar cows by hand. The milk recording of cows was started from fifth day after calving till the date of drying.

3.3. BREEDING POLICY

3.3.1. Development of Karan Swiss Cattle

A breeding project was started at National Dairy Research Institute, Karnal in 1963 with the prime objective to evolve a strain/breed of crossbred cattle of suitable level of exotic inheritance suited to our tropical climatic conditions. The Sahiwal and few Red Sindhi cows were used as

The Indigenous (Zebu) breeding stock and Brown Swiss breed as an Exotic breeding stock. The American Brown Swiss was selected because of its high fat content and sufficiently high milk production among exotic breeds. The colour also matched with that of Sahiwal and Red Sindhi. The project commenced by importing frozen semen of nine proven bulls with average breeding value based on daughters performance in U.S.A. of 5,400 kg per lactation (ranging from 5045 to 6543 kg). The aim was to develop a herd of around 200 Brown Swiss crossbred cows. The following type of crossbreds were obtained : F_1, F_2, ¾ BS x ¼ Zebu and halfbreds (miscellaneous crosses like F_1 x F_2, F_2 x F_1 etc.). The comparative performance of their crosses indicated that the F_1 were the best in terms of growth, reproduction and production followed by ¾ breds and halfbreds. The F_2 had the lowest performance. There was improvement in subsequent generations of mating due to better selection practices. There was no significant effect of heterosis found in various genetic groups of crossbreds with respect to growth, reproduction and production. Therefore, in April 1980, the breeding committee of the Institute decided to merge all genetic groups and to practice selective breeding for further genetic improvement of the crossbreds. The level of exotic inheritance was desired to be kept at ½ to 5/8, but selection of animals was done essentially on the basis of their expected breeding value (EBV). The females were selected on the basis of their own performance and males were selected on the basis of their pedigree. In 1980, when all the Brown Swiss crossbreds were merged to form 'Karan Swiss' the genetic composition of herd was 86 percent halfbreds, 6.4 percent cows had above 50 percent of exotic inheritance, 4.8 percent of cows were below 50 percent of exotic inheritance and 2.8 percent were those whose filial group was not known. Presently, most of the Karan Swiss cows are expected to have 50 percent level of exotic inheritance (Gurnani et al., 1986a).

The current breeding programme is to bring about genetic improvement by selection of females on the basis of their own performance and of males by pedigree, sibs and progeny performance.

3.3.2. Development of Karan Fries Cattle

Another crossbreeding project was started in 1971 at National Dairy Research Institute, Karnal by using Tharparkar (T) as a Zebu breed and three exotic breeds, namely, Holstein Friesian (H), Brown Swiss (B), and Jersey (J). the main objective of this project was to determine the appropriate choice of exotic breed and optimum level of exotic germplasm for evolving a breed suitable to Indian climatic conditions. The halfbreds were further mated to Holstein-Friesian to obtain crossbreds with 75% exotic inheritance consisting of two breed crosses (3/4 H x 1/4 T) and 3-breed crosses (1/2 H x 1/4 B x 1/4 T and 1/2 H x 1/4 J x 1/4 T). No significant improvement was shown by 3 breed crosses over the F_1 (H x T) crosses. Few H x S crossbreds were also transferred from Indian Agricultural Research Institute (IARI), New Delhi to NDRI, Karnal in 1976. The comparative performance of 75 percent HS with 50 percent HS crossbreds also did not show any significant advantage of having 75 percent exotic level. Since performance of two and three-breed crosses did not show any manifestation of heterosis for growth, reproduction and production performance so best possible genetic improvement could be obtained by exploitation of additive genetic variance. The breeding committee of the Institute in 1980, thus, decided to merge all crossbreds with 50 percent or above Holstein Friesian inheritance and further improvement to be brought about by selective breeding. The new strain was named as 'Karan Fries'. The population at that time had 50 percent Karan Fries animals with 50 percent exotic level, 25 percent with 75 percent exotic from one breed and 25 percent with 75 percent exotic inheritance from two breeds (HJT and HBT) (Sinha, 1999). The level of exotic inheritance was subsequently reduced to 62.5 percent by using halfbred bulls of high breeding value from other organizations (Gurnani et al., 1986b). The NDRI has embarked upon a programme of proper selection of Karan Fries males on the basis of their pedigree, own performance in terms of growth, fitness, freezing quality of semen and half sibs. Semen of these bulls is being distributed to the different regions of the country to evaluate their performance on the basis of their daughters performance.

3.4. CLASSIFICATION OF DATA

The data were classified and coded according to genetic group, season of birth, season of calving, period of birth and period of calving.

3.4.1. Classification Based on Genetic Group

For the purpose of statistical analysis, all the animals under Karan Swiss and Karan Fries were classified into 4 and 5 genetic groups respectively on the basis of crosses involving different breeds.

Table 3.1. Classification of data according to genetic group and their codes for Karan Swiss

Sl. No.	Genetic Groups	Code
1.	Brown Swiss x Sahiwal (BS)	1
	Brown Swiss x Red Sindhi (BR)	
2.	Brown Swiss x Tharparkar (BT)	2
3.	Brown Swiss x Sahiwal x Holstein (BSH)	3
4.	Karan Swiss (KS) *inter-se* mated	4

Table 3.2. Classification of data according to genetic group and their codes for Karan Fries cattle

Sl. No.	Genetic Groups	Code
1.	Holstein x Tharparkar (HT)	1
2.	Holstein x Sahiwal (HS)	2
3.	Holstein x Jersey x Tharparkar (HJT)	3
4.	Holstein x Brown Swiss x Tharparkar (HBT)	4
5.	Karan Fries (KF) *inter-se* mated	5

3.4.2. Classification Based on Season of Birth and Season of Calving

The months were grouped into four seasons based on climatic condition and codes were as follows:

Table 3.3. Classification based on season of birth and season of calving in Karan Swiss and Karan Fries

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

3.4.3. Classification Based on Period of Birth and Period of Calving

The data utilized for the present study were spread over 37 years for Karan Swiss and 29 years for Karan Fries. Therefore, there would be differences in the performance of animals from year to year due to the effect of various non-genetic factors like feed and fodder availability, management practices and environmental factors. However, that variation might not be significant enough to detect the effect of each year separately due to small number of records per year. Therefore, all the data were grouped into periods with an aim of minimizing within period variance and maximizing between period variance.

In Karan Swiss animal data were grouped into 12 period of birth and 11 periods of calving respectively.

Table 3.4. Classification based on period of birth in Karan Swiss

Years of birth	Period of birth
1963 – 1965	1
1966 – 1968	2
1969 – 1971	3
1972 – 1974	4
1975 – 1977	5
1978 – 1980	6
1981 – 1983	7
1984 – 1986	8
1987 – 1989	9
1990 – 1992	10
1993 – 1995	11
1996 – 1999	12

Table 3.5. **Classification based on period of calving in Karan Swiss**

Years of Calving	Period of Calving
1966 – 1968	1
1969 – 1971	2
1972 – 1974	3
1975 – 1977	4
1978 – 1980	5
1981 – 1983	6
1984 – 1986	7
1987 – 1989	8
1990 – 1992	9
1993 – 1995	10
1996 – 2000	11

Due to very small number of observation in certain traits (viz., weight at one year, weight at first fertile service, weight at first calving).The data were grouped into 4 periods in Karan Swiss

Table 3.6. Classification based on period of birth in Karan Swiss (For WOY, WFS, WFC)

Years of birth	Period of birth
1963 – 1974	1
1975 – 1980	2
1981 – 1986	3
1987 – 1999	4

In Karan Fries cattle data were grouped into 8 period of birth and 7 periods of calving respectively.

Table 3.7. Classification based on period of birth in Karan Fries.

Years of birth	Period of birth
1965 – 1972	1
1973 – 1976	2
1977 – 1980	3
1981 – 1984	4
1985 – 1988	5
1989 – 1992	6
1993 – 1996	7
1997 – 2000	8

Table 3.8.Classification based on period of calving in Karan Fries

Years of calving	Period of Calving
1967 – 1975	1
1976 – 1979	2
1980 – 1983	3
1984 – 1987	4
1988 – 1991	5
1992 – 1995	6
1996 – 2000	7

3.5. DETERMINATION OF PATERNAL AND MATERNAL GENERATION

The generation to which an animal belongs was determined by tracing back the pedigree of each animal to the foundation stock i.e., pure bred Zebu and exotic animals which were present at the time of commencement of crossbreeding programme and the paternal and material generation was determine separately as given in Fig. 3.1.

3.6. STATISTICAL ANALYSIS

3.6.1. Least Squares Analysis

As the data were non-orthogonal with disproportionate sub class number, they are subjected to least squares analysis as suggested by

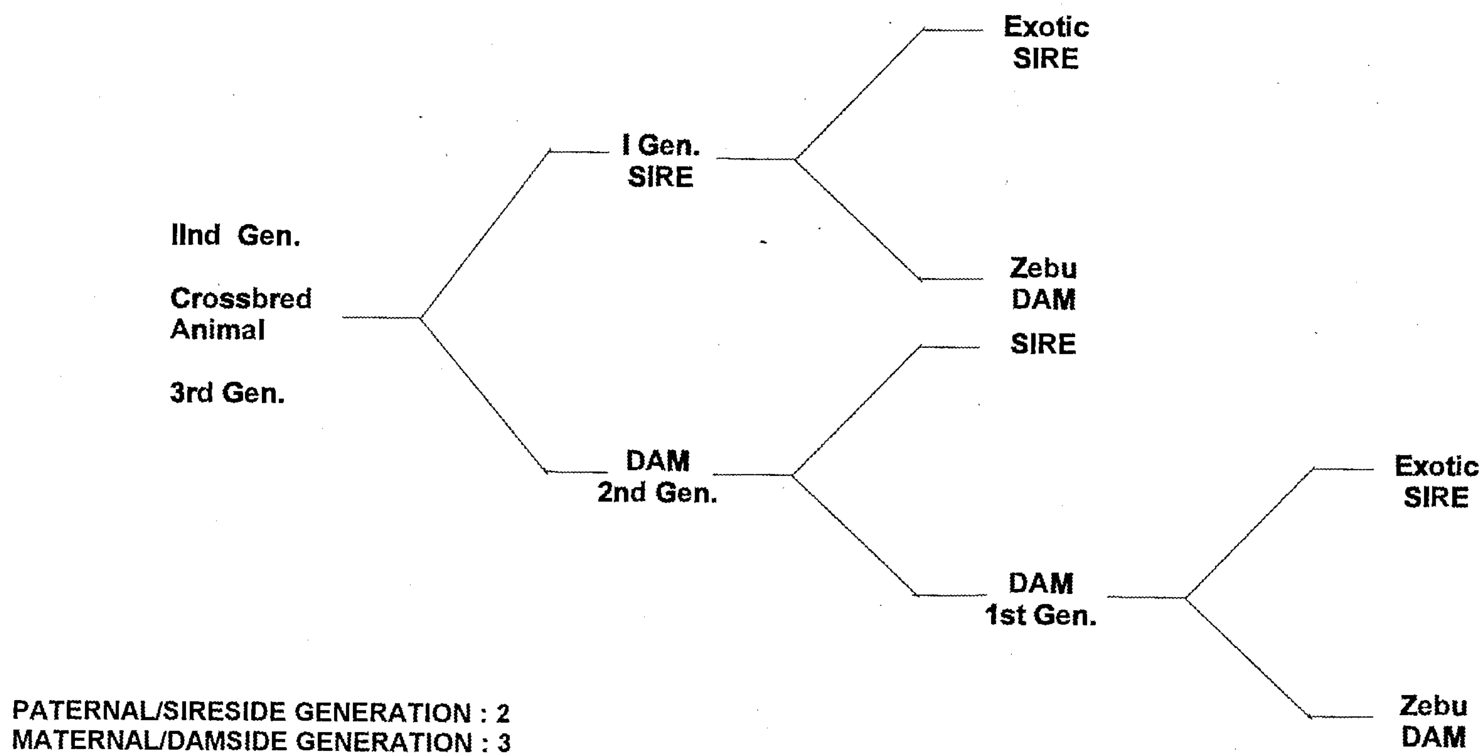

Fig. 3.1. Determination of generation of Crossbred cows.

Harvey (1975). The model was used with the assumption that different components being fitted into model are fixed, linear, independent and additive.

The least squares analysis was conducted separately for birth weight, age at first fertile service, age at first calving; weight at one year, weight at first fertile service, weight at first calving, production and reproduction performance traits of the crossbred cows.

3.6.1.1. Factors affecting birth weight, age at first fertile service, and age at first calving

The statistical model used for the least squares analysis of birth weight, age at first fertile service, and age at first calving were

$$Y_{ijklmn} = \mu + G_i + PG_j + MG_k + S_l + P_m + e_{ijklmn}$$

Where.

Y_{ijklmn} = The observation on the n^{th} animal belonging to i^{th} genetic group, j^{th} paternal generation, K^{th} maternal generation, l^{th} season of birth and m^{th} period of birth

μ = Population mean for trait under consideration

G_i = Effect of i^{th} genetic group

PG_j = Effect of j^{th} paternal generation

MG_k = Effect of k^{th} maternal generation

S_l = Effect of l^{th} season of birth

P_m = Effect of m^{th} period of birth

e_{ijklmn} = Random error associated with Y_{ijklmn} and assumed to be NID $(0,\sigma^2_e)$

3.6.1.2. Factors affecting bodyweight at one year, weight at first fertile service and weight at first calving.

The statistical model used for least squares analysis body weight at one year, weight at first fertile service, and weight of first calving.

$$Y_{ijklm} = \mu + PG_i + MG_j + S_k + P_l + e_{ijklm}$$

Where.

Y_{ijklm}	=	The observation on the m^{th} animal belonging to i^{th} paternal generation, j^{th} maternal generation, K^{th} season of birth, l^{th} period of birth
μ	=	Population mean
PG_i	=	Effect of i^{th} paternal generation
MG_j	=	Effect of j^{th} maternal generation
S_K	=	Effect of K^{th} season of birth
P_l	=	Effect of l^{th} period of birth
e_{ijklm}	=	Random error associated with Y_{ijklm} and assumed to be NID $(0,\sigma^2_e)$

3.6.1.3. Factors affecting production and reproduction traits

The statistical model used for analyzing the factors affecting first lactation production and reproduction performance were:

$$\mathbf{Y_{ijklmn} = \mu + G_i + PG_j + MG_k + S_l + P_m + b_{YA}(A_{ijklmn} - \bar{A}) + e_{ijklmn}}$$

Where.

Y_{ijklmn}	=	The observation on the n^{th} animal belonging to i^{th} genetic group, j^{th} paternal generation, K^{th} maternal generation, l^{th} season of calving and m^{th} period of calving
μ	=	Population mean for trait under consideration
G_i	=	Effect of i^{th} genetic group
PG_j	=	Effect of j^{th} paternal generation
MG_K	=	Effect of k^{th} maternal generation
S_l	=	Effect of l^{th} season of calving
P_m	=	Effect of m^{th} period of calving
b_{YA}	=	Regression of Y_{ijklmn} on Age of first Calving (A_{ijklmn})
$\bar{A}$	=	Average age at first calving, and

e_{ijklmn} = Random error associated with Y_{ijklmn} and assumed to be NID $(0,\sigma^2_e)$

3.6.1.4. Duncan's multiple range test

The statistical significance of various fixed effects in the least-squares model were determined by 'F' test. Wherever, the effects were significant, the differences between pairs of levels of effects were tested for significance by Duncan's Multiple Range Test as modified by Kramer (1957). (Using the inverse coefficient matrix).

The difference in pairing of two means was considered significant if :

$$(\overline{Y}_i - \overline{Y}_j)\sqrt{\frac{2}{c^{ii} + c^{jj} - 2c^{ij}}} > \sigma_e . Z_p, n_e$$

Where,

$(\overline{Y}_i - \overline{Y}_j)$ = Difference between two means,

C^{ii} = Corresponding i^{th} diagonal element of C matrix,

C^{jj} = Corresponding j^{th} diagonal element of C matrix,

C^{ij} = ij^{th} element of C matrix,

z_p, n_e = Studentised ranged value in Duncan's Table (0.05) at N_e degrees of freedom

p = Number of means in range chosen and

σ_e = Standard deviation of error

n_e = Degrees of freedom for error

3.6.2. Estimation of Genetic Parameters

In order to estimate the effect of sires and test the significance of sire effects, the data were adjusted for all non-genetic effects estimated by least-squares method. Genetic analysis was conducted on such adjusted records on body weight at different ages, and first lactation production and reproduction traits. Sires which had at least 5 daughters were considered for analysis.

3.6.2.1. Estimation of Repeatabilities

The Repeatabilities of traits repeated in various lactations were estimated as intra-class correlation from the analysis of variance using the records of same animal in successive lactations. Animals with a minimum of two lactation records were considered for the study. The following model was used:

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

Where,

Y_{ij} = The j^{th} record of i^{th} individual

μ = Population mean

a_i = Effect of i^{th} animal (I = 1,2 ...., a), and

e_{ij} = Random error assumed to be normally and independently distributed with mean 0 and constant variance σ_e^2

As per Becker (1986), the repeatability was estimated from analysis of variance.

Table 3.9: Analysis of variance for estimation of repeatability

Source of variation	d.f.	SS	M.S.	E.M.S.
Between individual	a-1	$SS_b = \sum_{i=1}^{a} \frac{Y^2i.}{ni} - \frac{Y^2..}{n.}$	MS_c	$\sigma_e^2 + K\,\sigma_b^2$
Within individual	N-a	$SS_e = \sum_i \sum_j Y_{ij}^2 - \sum_{i=1}^{a} \frac{Y^2_{i.}}{n_i}$	MS_e	σ_e^2
Total	N-1			

Where,

K = Average number of records per individual

$$= \frac{1}{a-1}\left[N - \sum_{i=1}^{a} \frac{n_i^2}{N}\right]$$

a = Number of animals

N = Total number of records

ni = Number of lactation records of the i^{th} animal

σ_b^2 = $(MS_b - MS_e)/K$

The repeatability coefficient (R) = $\frac{\sigma_b^2}{\sigma_b^2 + \sigma_e^2}$

The standard error of repeatability was calculated as per formula given by Swiger et al. (1964)

$$S.E.(R) = \sqrt{\frac{2(N-1)(1-R)^2[1+(K-1)R]^2}{K^2(N-a)(a-1)}}$$

3.6.2.2. Estimation of Heritability

The heritability estimates of all the traits were obtained by the paternal half-sib correlation method (Becker, 1986) using adjusted data. The following model was used:

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

Where,

Y_{ij} = Record of the j^{th} daughter of i^{th} sire

μ = Population mean

S_i = Effect of i^{th} sire (I = 1,2 ………, s) assumed to be random,

S = Number of sires

e_{ij} = Random error associated with record on j^{th} daughter of i^{th} sire assumed to be normally distributed with mean zero and constant variance (σ^2_e)

Table 3.10. Analysis of variance for estimation of heritability

Source of variation	d.f.	S.S.	M.S.	E.M.S.
Sires	S-1	$\sum_{i=1}^{s} \frac{Y_{i.}^2}{n_i} - \frac{(Y_{..})^2}{N}$	MS_S	$\sigma^2_e + K\sigma^2_s$
Error	N-s	$\sum_{ij} Y_{ij}^2 - \sum_{i=1}^{s} \frac{Y_{i.}^2}{n_i}$	MS_e	σ^2_e

Where,

K = Average number of progeny/sire

$$= \frac{1}{(S-1)}\left[N - \sum_{i=1}^{s} \frac{ni^2}{N}\right]$$

Where,

S = Number of sires,

N = Total number of observations,

n_i = Number of daughters of i^{th} sire

The sire component of various (σ^2_s) was estimated as

$$\sigma^2_s = \mathbf{MS_s - MS_e / K}$$

Where,

σ^2_s = Sire component of variance

σ^2_e = Error component of variance

Intra class (intra sire) correlation(t) was calculated as :

$$t = \frac{\sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

and

Heritability (h^2) was estimated as:

$$h = 4t = 4.\ \frac{\sigma_s^2}{\sigma_s^2 + \sigma_e^2}$$

σ^2_p = Total phenotypic variance ($\sigma^2_s + \sigma^2_e$)

The standard error of heritability was calculated as given by Swiger *et al.* (1964)

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

Where, N, t, h, s have been defined above.

3.6.2.3. Estimation of genetic and phenotypic correlations

The genetic and phenotypic correlations among all possible pairs of traits were estimated from the analysis of variance using half-sib correlation method as suggested by Becker (1986). The same statistical model as used in the estimation of h^2 was used. The analysis of covariance is given in the Table 3.11.

Table 3.11. Analysis of covariance

Source of variation	**d.f.**	**SCP**	**MCP**	**EMCP**
Sires	S-1	$SCP_s = \sum_{i=1}^{s} \frac{Xi.Yi.}{ni} - \frac{X..Y..}{N}$	MCPs	$\sigma_{e(xy)} + K\ \sigma_{s(xy)}$
Error	N-s	$SCPe = \sum_i \sum_j X_{ij} Y_{ij} - \sum_{i=1}^{s} \frac{X_i.Y_i.}{n_i}$	MCPe	$\sigma_{e(xy)}$
Total	N-1			

The genetic correlation was calculated by using the following formula

$$r_{G(xy)} = \frac{\sigma_{s(xy)}}{\sigma^2_{s(x)} . \sigma^2_{s(y)}}$$

Where,

$\sigma_{s(xy)}$ = The sire component of covariance between the x^{th} and y^{th} characters recorded on the same animals

$\sigma^2_{s(x)}$ and $\sigma^2_{s(y)}$ = The sire component of variance for the traits x and y, respectively.

The standard error (SE) of genetic correlation was estimated by using the formula given by Robertson (1959):

$$\text{S.E. } (r_G) = \frac{1-r^2_{G(xy)}}{\sqrt{2}} \sqrt{\frac{S.E.(h^2_x) S.E.(h^2_y)}{h^2_x . h^2_y}}$$

Where,

h^2_x and h^2_y = The heritabilities of X and Y characters, respectively.

Phenotypic correlations

The phenotypic correlations were estimated by the following formula:

$$r_{P(xy)} = \frac{\sigma_{s(xy)} + \sigma_{e(xy)}}{\sqrt{\left(\sigma^2_{S(x)} + \sigma^2_{e(x)}\right)\left(\sigma^2_{S(y)} + \sigma^2_{e(y)}\right)}}$$

The standard error of phenotypic correlation was obtained using the following formula suggested by Panse and Sukhatme (1967)

$$\text{S.E. } (r_{P(xy)}) = \sqrt{\frac{\left(1-r^2_{P(xy)}\right)}{N-2}}$$

Where,

$r_{p(xy)}$ = Phenotypic correlation between x^{th} and y^{th} characters of the same animal, and

N-2 = Degrees of freedom.

3.7. ESTIMATION OF AVERAGE PERFORMANCE OF VARIOUS ECONOMIC TRAITS BASED ON DIFFERENT CRITERIA

The crossbred population (Karan Swiss and Karan Fries) considered in this study were classified into different groups based on different criteria and the average performance of various economic traits were studied under each group.

Classification of the animals based on different criteria are as follows:

3.7.1. Type of crosses

In a synthetic population like Karan Swiss and Karan Fries different types of animals exists. Some of the animals were obtained from pure cross i.e., F_1, F_2, F_3, F_4 while others were from miscellaneous cross such as BC, $F_1 \times F_2$, $F_1 \times$ BC and so on. To compare the performance of different types, the animals were classified into following groups and average performance under each group was studied.

Table 3.12. Classification based on types of animal in Karan Swiss

Type	Groups
F_1	1
F_2	2
F_3	3
F_4	4
Others	5

Table 3.13. Classification based on types of animal in Karan Fries

Type	Groups
F_1	1
F_2	2
F_3	3
Others	5

3.7.2. Level of exotic inheritance

The level of exotic inheritance of the crossbred cows was obtained by the process of halving of inheritance from the pedigree of each animal. Animals with different exotic inheritance are classified into 3 groups to compare the performance of various economic traits for different exotic inheritance level. Animals belong to interse mated population were considered for this study (F_1 were excluded).

Table 3.14: **Classification based on exotic inheritance level**

EI Level (percent)	Group
50	1
50-62.5	2
>62.5	3

3.7.2.1. Classification of different exotic inheritance by Euclidean Distance (complete linkage) method

Animals within a particular level of exotic inheritance (50, 50-62.5, above 62.5 percent) were further classified into subgroups (clusters) by using Euclidean Distance (Complete Linkage) method (Fig. 3.2.) so that animals in a particular cluster are similar but different from the animals of other clusters. The details of Euclidean Distance (Complete Linkage) method is discussed below.

The proximity matrix of adjusted performance traits is arranged in profiles as shown below

No. of KF Cows	Adjusted Performance Traits			
	X_1	X_2	X_3	.... X_P
1st (profile)	X_{11}	X_{12}	X_{13}	.... X_{1p}
2nd (profile)	X_{21}	X_{22}	X_{23}	.... X_{2p}
::	::	::	::	::
rth (profile)	X_{r1}	X_{r2}	X_{r3}	.... X_{rp}
sth (profile)	X_{s1}	X_{s2}	X_{s3}	.... X_{sp}
::	::	::	::	::
nth (profile)	X_{n1}	X_{n2}	X_{n3}	.... X_{np}

A profile is a row of adjusted performance traits of a crossbred cow. The Euclidean distance is the distance between two rows or profiles denoted as rth and sth rows and was calculated by the following method as suggested by Jobson (1992):

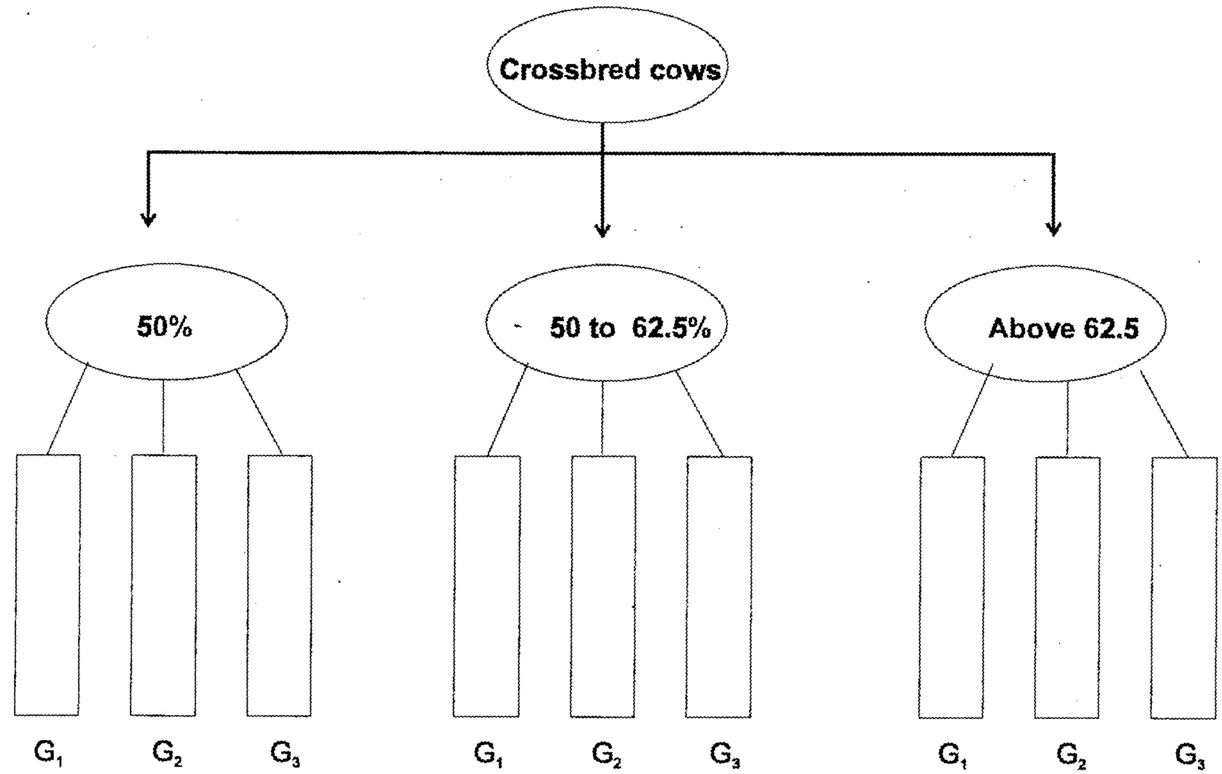

Fig. 3.2. Clustering of Crossbred cows under various exotic inheritance levels by using Euclidean distance (complete linkage) method.

$$d^2_{rs} = \sum_{j-1}^{p} \left(x_{rj} - x_{sj}\right)^2$$

Where,

d^2_{rs} = Squared Euclidean distance between two points,

X_{rj} = j^{th} observation of r^{th} row/profile,

X_{sj} = Corresponding j^{th} observation of s^{th} row/profile, and

p = Number of characters/variable (1 top).

The maximum or complete linkage method measures the greatest distance between any two profiles and leads to discrete clusters containing one or more than one animals. The hierarchial approach proceeds sequentially such that profiles are joined one by one till one final cluster is obtained. At each step of the hierarchial process, the value of objective function or clustering criterion (d^2_{rs}) is determined which shows which two clusters are to be joined to form a new cluster. Since each step is a cluster solution the appropriate number of clusters is determined by a second optimality criterion for final classification of the animals. Moreover, since the complete linkage method is based on the weakest link between two profiles an isolated animal becomes more quickly close to an existing cluster.

The average level of heterozygosity, age at first fertile service, age at first calving, first lactation 305 day milk yield of animals in the different clusters was estimated and compared to find out the variability of various economic traits and level of heterozygosity between clusters in a particular exotic level of inheritance.

3.7.3. Number of breed used

The Karan Swiss as well as Karan Fries cows under study were found to have inheritance from two, three, four or five breeds as recorded in the pedigree. The animals were classified into different categories based on number of breed used and average performance under different categories were compared. Only those animals belonging to *interse* mated population were considered for this study.

Table 3.15. Classification based on number of breed used in Karan Swiss

No. of breed used	Type	Group
2	B x S, B x R, B x T	1
3	B x H x S, B x S x R, B x S x T	2
4	B x S x R x T , B x H x S x T	3
5	B x H x S x R x T	4

Table 3.16. Classification based on number of breed used in Karan Fries

No. of breed used	Type	Group
2	H x T, H x S	1
3	H x J x T, H x B x T, H x T x S	2
4	H x J x T x S, H x B x T x S	3
5	H x J x B x T x S	4

3.7.4. Level of heterozygosity

The crossbred cows considered in this study are the result of *interse* mating. The proportion of maximum heterozygosity retained in *interse* mated population is $1-\Sigma Pi^2$ as suggested by Dickerson (1973) where, P_1 is the proportion of genes contributed to the inter-se bred animal from the i^{th} source breed (Fig. 3.3).

Animals with different heterozygosity level were classified into different groups to compare the performance in various economic traits between the performance in various economic traits between different groups. The class interval of five percent was taken to get sufficient number of observation in each group. Animals with 100 percent heterozygosity are F_1 and not belongs to *interse* mated population.

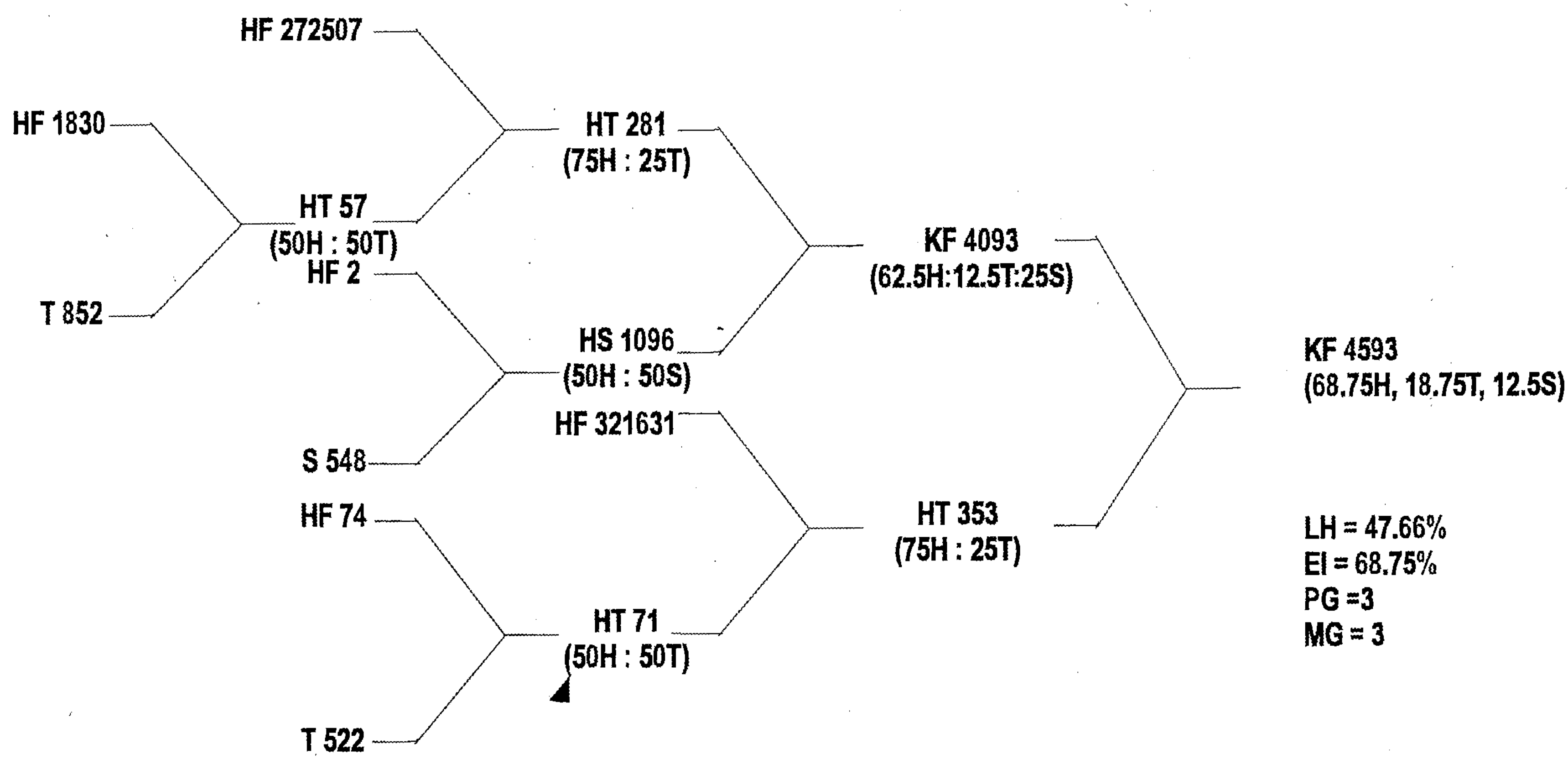

Fig. 3.3. Pedigree of KF 4593 for estimation of level of heterozygosity

Table 3.17: Classification based on level of Heterozygosity in Karan Swiss

Heterozygosity Level	Group
Upto 40	1
40-45	2
45-50	3
50-55	4
55-60	5
60-65	6
65-70	7
70-80	8
100	9

Table 3.18: Classification based on level of Heterozygosity in Karan Fries

Heterozygosity Level (%)	Group
Upto 35	1
35-40	2
40-45	3
45-50	4
50-55	5
55-60	6
60-65	7
65-80	8
100	9

3.8. ESTIMATION OF INBREEDING COEFFICIENT AND ITS IMPACT ON PERFORMANCE TRAITS

3.8.1. Estimation of Inbreeding Coefficient

The pedigree of each animal was traced back to the foundation stock, i.e., the pure breeds, Zebu cows and exotic bulls which were present at the time of commencement of crossbreeding programme and inheritance chart was prepared. All the animals in the first filial generation (F_1) were having coefficient of inbreeding as zero.

The coefficient of inbreeding of every animal was estimated by the following formula (Wright, 1922)

$$F_X = \sum\left[\left(\frac{1}{2}\right)^{n+1}(1+F_A)\right]$$

F_X	=	Inbreeding coefficient of animal (x)
n	=	Number of paths from one parent of animal to other parent through common ancestor.
F_A	=	Inbreeding coefficient of the common ancestor (A), and
Σ	=	Summation of all independent paths which connect the sire and dam of individual x.

3.8.2. Effect of Inbreeding on Various Traits

Animal were classified into different groups based on the level of inbreeding coefficient in the following way:

Table 3.19. Classification based on levels of inbreeding

Inbreeding coefficient (%)	Code
Below 1	1
1 – 6	2
6 – 12	3
> 12	4
Non inbred	5

The effect of inbreeding on various traits of growth, production and reproduction were studied by least squares analysis by including the level of inbreeding as an effect in the model.

Model $\quad Y_{ij} = \mu + I_i + e_{ij}$

Where,

Y_{ij}	=	Performance of j^{th} individual for i^{th} inbreeding level
μ	=	Population mean
I_i	=	Effect of i^{th} inbreeding level

e_{ij} = Random error for each observation assumed to be normally and independently distributed with mean 0 and constant variance σ_e^2

Beside least square analysis, the effect of inbreeding was estimated by regression analysis.

3.9. DISPOSAL OF CROSSBRED COWS

3.9.1. Disposal Pattern

Disposal pattern of the herd was studied by broadly classifying all the animals disposed from the herd into two groups. First group consisting of animals from birth upto age at first calving and second group consisting of animals after age at first calving which entered into the milking herd.

The first group was further devided into different age group as given below:

Table : 3.20. Classification based on age groups

Age group	Code
Upto 1 month	1
1-3 month	2
3-6 month	3
6-12 months	4
12-18 month	5
18-AFC	6

The second group was devided into various parities. The number female removed from the herd by culling or death were counted separately over both the paternal and maternal generations for the above mentioned two groups.

3.9.2. Impact of Disposal on the Milk Production Performance of the Herd

To study the impact of disposal on the milk production performance of the herd the analysis was conducted only for those females which were disposed off after first calving i.e., after entering the milk producing herd by estimating and comparing average expected breeding value (EBV) of the herd and disposed animals over the year.

The Expected Breeding Value (EBV) was estimated on the basis of available all lactation records of individual animals by using following formula.

$$EBV = \mu + \frac{nh^2}{1+(n-1)R}(\bar{x} - \mu)$$

Where,

EBV	=	Expected Breeding Value
μ	=	Population mean
n	=	Number of lactation milk production records available
h^2	=	Heritability of 305 days milk yield
R	=	Repeatability of 305 days milk yield
x	=	Cows average performance.

CHAPTER-4

RESULTS & DISCUSSION

RESULTS AND DISCUSSION

The results are presented and discussed in the light of review of literature in the following order:

4.1. Description of the crossbred population

4.2. Estimation of average performance and the effect of various genetic and non genetic factors on various growth, first lactation traits and herd life in crossbred cattle.

4.3. Estimation of the genetic and phenotypic parameters of various growth, first lactation traits and herd life in crossbred cattle

4.4. Estimation of the average performances of various economic traits in crossbred cattle based on different criteria

4.5. Incidence and level of inbreeding and its effect on various performance traits in crossbreds

4.6. Disposal pattern of crossbred cows

4.7. Development of appropriate breeding strategy for improvement of crossbred cattle

4.1. DESCRIPTION OF THE CROSSBRED POPULATION

4.1.1. Description of Karan Swiss Population

In the Karan Swiss population out of 3168 animals (females), the complete pedigrees of only 3080 animals were traced back. In the population around 79.51 percent animals were found to be miscellaneous type crosses, whereas, only 16.46 percent of the animals were found to be F_1

followed by F_2 which constitute only 3.08 percent. Less than 1 percent of the population was found to be F_3 and F_4 animals (Fig. 4.1). With respect to exotic inheritance around 74 percent (2281) of the animals were found to have exotic inheritance 50 percent or below. 571 animals (18.53 percent) were found to possess 50 to 62.5 percent exotic inheritance. However only 7.40 percent of the animals found to have exotic inheritance above 62.5 percent (Fig. 4.2).

Paternal and maternal generation was determined separately for each animal. Paternal and maternal generations were different in most of the animals except inF_1, F_2, F_3 and F_4 animals. Karan Swiss cows upto eighth generation from paternal side and ninth generation from maternal side was observed in the study. Types of sires and dams used to produce the crossbred animals of different generation are presented in the Table 4.1 and Table 4.2.

The results indicate that as the generation progressed the number of pure crosses (i.e., F_1, F_2, F_3, F_4 etc.) were decreased where as frequency of miscellaneous crosses showed an increasing trend. Various miscellaneous type sires and dam used for mating are also presented in The Table 4.3.

Table 4.1 and 4.2 revealed that average level of heterozygosity was maximum in the first generation from paternal side (87.2 percent) as well as maternal side (93.9 percent) may be due to inclusion of F_1 animals in which heterozygosity level is considered as 100 percent. However for rest of generations no specific trend was observed. Exotic inheritance also did not follow any specific trend over the generations. From paternal side generation it ranged from 50.2 percent (eighth generation) to 57.9 percent (second generation) whereas from maternal side it varied from 48.6 percent (first generation) to 0.552 (third generation).

Paternal generationwise distribution of Karan Swiss cows indicated that animals belonging to first generation remained in the milking herd from

Table 4.1. Description of Karan Swiss population over the paternal generation

Paternal Generation	Sire	Dam	Avg. LH	Avg. EI	Total female born	F_1	F_2	F_3	F_4	Other
1.	Exotic	Zebu, F_1, F_2, BC, Miscellaneous	0.872	0.545	646	507 (78.48)	-	-	-	139 (21.51)
2.	F_1, BC	Zebu, F_1, F_2, (BC x Zebu) (F_1 x Zebu), (Exotic x F_2), Miscellaneous	0.503	0.579	467	-	95 (20.34	-	-	372 (79.65)
3.	F_2, (BC x F_2), (F_1 x F_2)	Zebu, F_1, F_2, (BC x Zebu), (Exotic x F_2), (Exotic x F_1) Miscellaneous	0.564	0.504	478	-	-	21 (4.39)	-	457 (95.60)
4.	F_3 (F_2 x F_1) Miscellaneous	Zebu, F_1, F_2, F_3 (BC x F_1), Miscellaneous	0.560	0.506	424	-	-	-	8 (1.88)	416 (98.11)
5.	(F_3 x F_1), F_3 x F_2) Miscellaneous	F_1, BC, (BC x F_1) Miscellaneous	0.564	0.506	309	-	-	-	-	309 (100)
6.	Miscellaneous	F_1, (F_2 x F_1) Miscellaneous	0.572	0.505	374	-	-	-	-	374 (100)
7.	Miscellaneous	Miscellaneous	0.587	0.509	378	-	-	-	-	238 (100)
8.	Miscellaneous	Miscellaneous	0.588	0.502	172	-	-	-	-	172 (100)

Figures in the parenthesis represent the percentage of total female born,
BC = Exotic x F_1, BC* = F_1 x Zebu

Table 4.2. Description of Karan Swiss population over the maternal generation

Paternal Generation	Sire	Dam	Avg. LH	Avg. EI	Total female born	F_1	F_2	F_3	F_4	Other
1.	Exotic, F_1, BC	Zebu	0.939	0.486	588	507 (86.24)	-	-	-	81 (13.77)
2.	Exotic, F_1, F2, BC, (BC x F_2) Miscellaneous	F_2, BC*, (F1 x F_1)	0.537	0.529	1045	-	95 (9.09)	-	-	950 (90.90)
3.	Exotic, F_1, F2, BC Miscellaneous	F_2, (Exotic x F_1), BC, Miscellaneous	0.550	0.552	730	-	-	21 (2.87)	-	709 (97.12)
4.	F_2, F_3, BC (F_2 x F_1) Miscellaneous	F_3, (Exotic x F_2) (F_2 x BC), Miscellaneous	0.559	0.538	383	-	-	-	8 (2.08)	375 (97.91)
5.	F_3 BC, x (BC x F_1), (BC x F_2), (F2 x F_1) Miscellaneous	(BC x BC, Miscellaneous	0.571	0.517	211	-	-	-	-	211 (100)
6.	BC, (BC x F_1), (BC x F_2) Miscellaneous	Miscellaneous	0.573	0.513	120	-	-	-	-	120 (100)
7.	Miscellaneous	Miscellaneous	0.584	0.504	42	-	-	-	-	42 (100)
8.	Miscellaneous	Miscellaneous	0.568	0.508	8	-	-	-	-	8 (100)
9.	Miscellaneous	Miscellaneous	0.588	0.499	3	-	-	-	-	3 (100)

Figures in the parenthesis represent the percentage of total female born,
BC = Exotic x F_1, BC* = F_1 x Zebu

Table 4.3. Various miscellaneous sires and dams used in Karan Swiss population

Sire	Dam
(F_2 x F_1) x F_1, (BC x F_2) x F_1, (BC x F_1) x F_1	Exotic x (F_1 x Zebu), Exotic x (BC x Zebu)
(Exotic x F_1) x F_2, ((F_2 x F_1) x (BC x F_1))	((F_2 x F_1) x (BC x F_1)), (((F_2 x F_1) x F_1) x F_1)
((F_2 x F_1) x F_1) x F_1, BC x (BC x F_2)	((BC x (F_2 x F_1) x F_1))
(((F_2 x F_1) x F_1) x F_1) x F_1	(BC x (BC x (Exotic x F_2)))
(((F_2 x F_1)x F_1)x F_1)(F_1 x (BC x F_1))	((Exotic x F_1) x F_4)
(((F_2 x F_1) x F_1) x F_1) x ((F_2 x F_1) x (F_2 x F_1))	((F_1 x F_1)* x (BC x (Exotic x F_2)))
	((BC x F_2) x (BC x (Exotic x F_2)))
	(((F_2 x F_1) x F_1) x (BC x (F_2 x F_1)))
	(((F_2 x F_1) x F_1) x F_1) x (F_1 x (BC x F_1)))
	(((F_2 x F_1) x F_1) x F_1) x (((F_2 x F_1) x F_1) x ((F_1 x F_1)* x(Exotic x (BC x Zebu)))

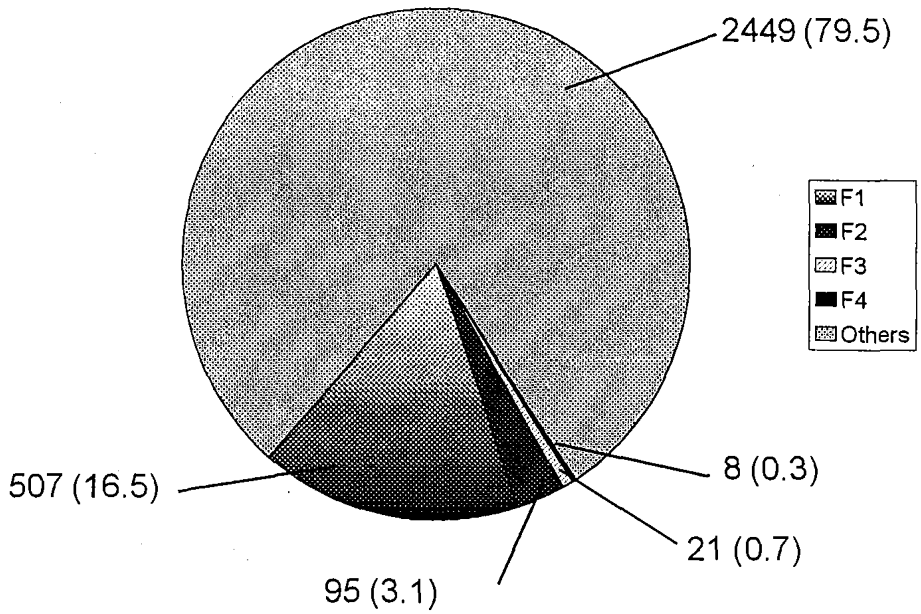

Fig.4.1. Distribution of diferent types of crosses in Karan Swiss population

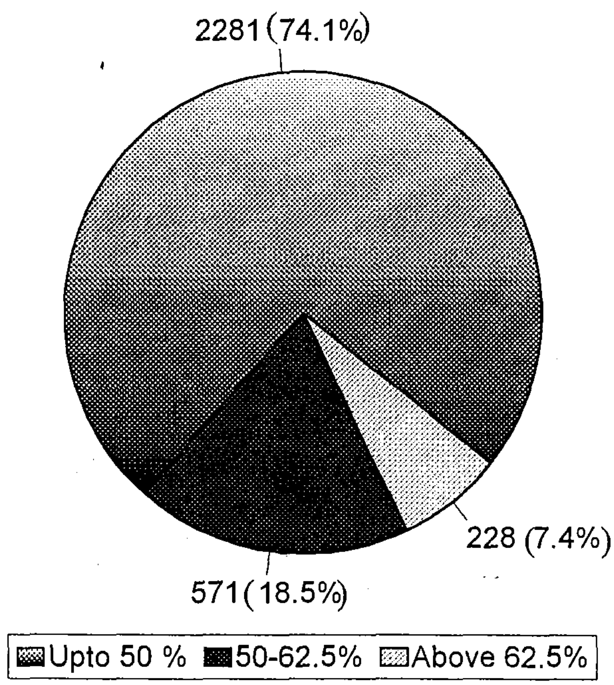

Fig.4.2. Distribution of diferent levels of exotic inheritance in Karan Swiss population

1966 to 1983 (Table 4.7). No heifers from first generation were found after sixth period, whereas majority of animals belonging to second generation present in the herd during 1969 to 1986 (Table 4.7). At present the existing animals were in sixth and eighth generation.

Maternal generationwise distribution of Karan Swiss cows presented in the Table 4.8 revealed that no heifer from first generation entered in the milking herd after sixth period i.e., after 1983. Majority of the animals in the present herd are found to be *interse* mated animals.

4.1.2. Description of Karan Fries Population

In the Karan Fries population out of 3051 animals (females) recorded for the study, the complete pedigree of only 2741 was traced back. In the population approximately 89 percent (2441) animals were found to be miscellaneous cross type, whereas, only 9.5 percent of the animals were found to be F_1 type followed by F_2 which constitute only 1.2 percent of the total pedigreed animals (Fig 4.3) with respect to exotic inheritance about 11.67 percent of animals were found to have exotic inheritance 50 percent or below. Whereas, 39.18 percent had exotic inheritance 50 to 62.5 percent but maximum number of animals (49.14 percent) in the Karan Fries population were observed to have exotic inheritance above 62.5 percent (Fig. 4.4).

Generation of each animal was determined separately from paternal side and maternal side. Except in F_1, F_2 F_3 animals the paternal and maternal generation was found to be different. Karan Fries cows upto fifth generation from paternal side and ninth generation from maternal side was observed in the study. Paternal side generation found to be less than maternal generation which may be due to use of exotic bulls (or semen) to mate with crossbred cows of different generations from maternal side. More advanced generation from maternal side was observed may be due to limited use of Zebu females to mate with crossbred bulls. However, in the Karan Fries cattle, animals upto fourth generations for paternal side and seventh generation from maternal side were considered for least squares analysis.

The number of animals of fifth generation from paternal side and eighth and ninth generation, respectively from maternal side were very less and yet to enter in the milking herd and thus not considered for least squares analysis.

Various sires and dams used to produce crossbred animals of different generation are presented in the Table 4.4 and Table 4.5. The figures presented in the Table indicate that as the generation progressed forward the frequency of pure crosses (i.e., F_1, F_2, F_3) were decreased whereas the reverse trend was observed for miscellaneous crosses. Various complex miscellaneous crosses used as sires and dams are also presented in the Table 4.6.

The average level of heterozygosity as observed from the Table 4.4 and Table 4.5 was maximum in the first generation from paternal side (66.2 percent) and maternal side (99.7 percent), which may be due to presence of F_1 animals with average level of heterozygosity 100 percent. For rest of the generation it ranged from 45 to 60 percent. Exotic inheritance did not follow any specific trend over the generations. From paternal side generation it ranged form 61.3 percent (in fifth generation) to 67.4 percent (second generation) whereas from maternal side it varied from 49 percent (first generation) tc 69 percent (second generation).

Distribution of Karan Fries animals of different paternal generation over the periods revealed (Table 4.9) that upto Period-3 i.e., upto 1983, majority of the animals were from first generation. During 1988 to 1995 very few heifers were entered in the milking herd which indicting less representation from first generation in the population during that period. However there was an increasing trend was observed from 1996 onward which was due to use of pure exotic germplasm in the herd. Majority of animals in the herd were found to be from fourth generation.

Table 4.4. Description of Karan Fries population over the paternal generation

Paternal Generation	Sire	Dam	Avg. LH	Avg. EI	Total female born	F_1	F_2	F_3	F_4	Other
1.	Exotic	Zebu, F_1, BC	0.662	0.665	862	262 (30.39)	-	-	-	600 (69.60)
2.	F_1, BC	Zebu, F_1, F_2, BC (Exotic x BC) (BC x BC), (BC x F_1) Miscellaneous	0.469	0.674	645	-	33 (5.11)	-	-	612 (94.88)
3.	F_2, (BC x BC), (BC x F_1)	Zebu, F_1, F_2, BC (BC x F_1), (F_1 x F_2), (BC x F_1) Miscellaneous	0.517	0.621	855	-	-	5 (0.58)	-	850 (99.41)
4.	Miscellaneous	F_1, F_2, BC, (F_1 x F_2), BC x F_1) (BC x BC), (F_1 x BC)	0.539	0.615	634	-	-	-	-	634 (100)
5.	Miscellaneous	Miscellaneous	0.5305	0.613	5	-	-	-	-	5 (100)

Figures in the parenthesis represent the percentage of total female born,
BC = Exotic x F_1

Table 4.5. Description of Karan Fries population over the maternal generation

Maternal Generation	Sire	Dam	Avg. LH	Avg. EI	Total female born	F_1	F_2	F_3	F_4	Other
1.	Exotic (BC x F_1)	Zebu	0.997	0.499	274	262 (95.62)	-	-	-	12 (4.37)
2.	Exotic, F_1, F_2, BC, (F_1 x F_1) (BC x F_1), Miscellaneous	F_1	0.496	0.690	735	-	33 (4.48)	-	-	702 (95.51)
3.	Exotic, F_1, F_2, BC, (F_1 x BC) (BC x F_1), Miscellaneous	F_2, BC, (Exotic x F_1), Miscellaneous (BC x F_1)	0.474	0.680	639	-	-	5 (0.78)	-	634 (99.21)
4.	Exotic, F_1, F_2, BC, (F_1 x BC) (BC x F_1), (F_2 x BC) Miscellaneous	F3, (Exotic x BC), (BC x BC), (F1 x BC), Miscellaneous	0.509	0.641	492	-	-	-	-	492 (100)
5.	F_1, F_2, BC, (F_1 x BC), (F_2 x BC) (BC x F_1) miscellaneous	Miscellaneous	0.528	0.624	377	-	-	-	-	377 (100)
6	F_2, BC, (F_1 x BC), Miscellaneous	Miscellaneous	0.545	0.608	207	-	-	-	-	207 (100)
7	Miscellaneous	Miscellaneous	0.547	0.608	56	-	-	-	-	56 (100)
8	Miscellaneous	Miscellaneous	0.562	0.604	10	-	-	-	-	10 (100)
9.	Miscellaneous	Miscellaneous	0.580	0.657	1	-	-	-	-	1 (100)

Figures in the parenthesis represent the percentage of total female born,
BC = Exotic x F_1

Table 4.6. Various miscellaneous sires and dams used in Karan Fries population

Sire	Dam
(BC x F_1) x BC, (BC x F_1) x F_1	(BC x F_1) x F_1, (BC x BC) x F_1, (BC x F_1) x (BC x BC)
(BC x F_1) x (BC x BC), (BC x F_1) x(BC x F_1)	Exotic x (Exotic x F_1), F_1 x (BC x F_1) ((BC x F_1) x F_1) x F_1)
(BC x F_1) x ((BC x F_1) x (BC x BC))	(BC x F_1) x(BC x (Exotic x F_2), (BC x F_1) x (F_1 x (BC x F_1))
(BC x BC) x BC	((BC x F_1) x F_1) x ((BC x F_1) x F_2), ((BX x F_1) x F_1) x (F_1 x BC)
((BC x F_1) x BC) x ((BC x F_1) x(BC x F_1))	((BC x F_1) x F_2) x (BC x BC) x BC, F_2 x (BC x F_1)
	F_2 x ((BC xF_1) x ((BC x F_1) x F_1))
	F_2 x (F_1 x (BC x F_1)), F_1 x ((BC x F_1) x (BC x F_1))
	((F_1 x BC) x BC) x (BC x F_1) x (BC x F))
	(BC x (BC x (Exotic x F_1))), F_2 x ((F_1 x F_1) x (BC x F_1)), (F_1 x F_1) x (F_1 x (F_1 x (BC x BC)))
	(F_1 x F_1) x ((BC x F_1) x (BC x (BC x BC)))
	((BC x F_1) x (F_1 x F_1)) x (((BC x F_1) x F_1) x ((BC x F_1) x (BC x (BC x BC)))

Table 4.7. Distribution of Karan Swiss cows (Paternal Generationwise) over different periods

PG	Periods											Grand Total
	1 (1966-68)	2 (1969-71)	3 (1972-74)	4 (1975-77)	5 (1978-80)	6 (1981-83)	7 (1984-86)	8 (1987-89)	9 (1990-92)	10 (1993-95)	11 (1996-2000)	
1	36	35	81	108	72	8	-	-	-	-	-	340
2	-	42	8	77	31	11	15	-	-	1	-	185
3	-	-	30	50	45	30	-	1	-	-	-	156
4	-	-	-	-	51	52	34	-	1	-	-	138
5	-	-	-	-	-	36	47	28	-	-	-	111
6	-	-	-	-	-	-	31	-	50	66	12	161
7	-	-	-	-	-	-	-	54	21	-	-	75
8	-	-	-	-	-	-	-	-	1	10	15	26

Table 4.8. Distribution of Karan Swiss cows (Maternal Generationwise) over different periods

MG	Periods											Grand Total
	1 (1966-68)	2 (1969-71)	3 (1972-74)	4 (1975-77)	5 (1978-80)	6 (1981-83)	7 (1984-86)	8 (1987-89)	9 (1990-92)	10 (1993-95)	11 (1996-2000)	
1	34	36	43	118	67	5	-	-	-	-	-	303
2	3	41	57	77	75	77	53	15	7	4	1	410
3	-	-	22	30	52	34	42	34	19	11	3	247
4	-	-	-	11	6	16	35	17	27	26	5	133
5	-	-	-	-	2	1	6	14	13	18	11	65
6	-	-	-	-	-	1	2	1	7	11	7	29
7	-	-	-	-	-	-	-	1	-	6	2	9
8	-	-	-	-	-	-	-	-	-	1	-	1

PG = Paternal Generation, MG = Maternal Generation

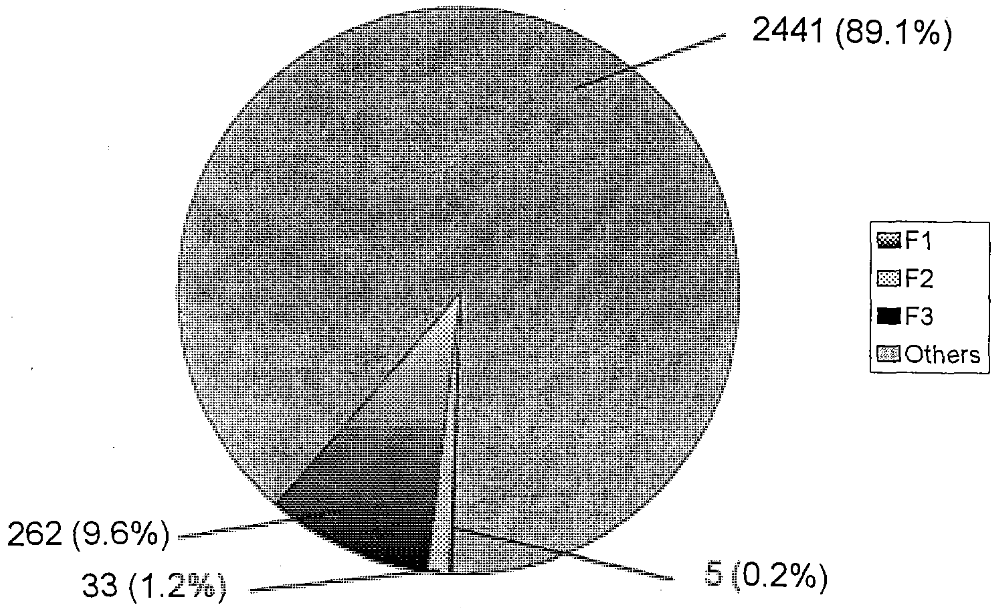

Fig.4.3. **Distribution of diferent types of crosses in Karan Fries population**

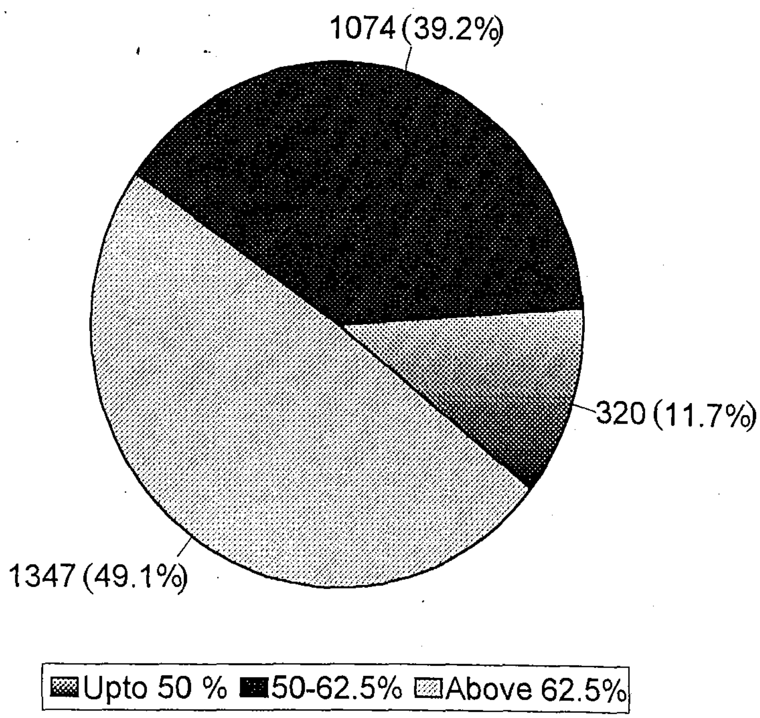

Fig.4.4. **Distribution of diferent levels of exotic inheritance in Karan Friespopulation**

Table 4.9. Distribution of Karan Fries cows (Paternal Generationwise) over different periods

PG	Periods							Grand Total
	1 (1967-75)	2 (1976-79)	3 (1980-83)	4 (1984-87)	5 (1988-91)	6 (1992-95)	11 (1996-2000)	
1	98	232	238	20	1	7	17	613
2	-	-	65	227	34	46	6	378
3	-	-	-	70	226	99	14	409
4	-	-	-	-	-	120	173	293
5	-	-	-	-	-	-	1	1

Table 4.10. Distribution of Karan Fries cows (Maternal Generationwise) over different periods

MG	Periods							Grand Total
	1 (1967-75)	2 (1976-79)	3 (1980-83)	4 (1984-87)	5 (1988-91)	6 (1992-95)	11 (1996-2000)	
1	90	79	11	12	1	7	17	217
2	1	116	207	92	30	11	15	472
3	-	4	68	147	83	40	4	346
4	-	-	3	44	89	103	33	272
5	-	-	-	3	32	70	81	186
6	-	-	-	-	2	23	36	63
7	-	-	-	-	-	3	10	13
8	-	-	-	-	-	-	4	4
9	-	-	-	-	-	-	1	1

PG = Paternal Generation, MG = Maternal Generation

Similar trend was observed from maternal side generation (Table 4.10). Value presented in the Table indicated that as time progressed the proportion of *interse* mated animals increased in the herd.

4.2. ESTIMATION OF AVERAGE PERFORMANCE AND THE EFFECT OF VARIOUS GENETIC AND NON GENETIC FACTORS ON VARIOUS GROWTH, FIRST LACTATION TRAITS AND HERD LIFE IN CROSSBRED CATTLE

4.2.1. Estimation of Average Performance and the Effect of Various Genetic and Non Genetic Factors on Various Growth, First Lactation Traits and Herd Life in Karan Swiss Cattle

4.2.1.1. Average Birth Weight (BWT) in Karan Swiss Cattle

The overall least-squares mean of birth weight was 26.26±0.37kg (Table 4.14). this estimate was close to those reported by Narayanswamy *et al.* (1984), Tajane and Rai (1989a) Roy and Tripathi (1991) in Friesian crosses, by Su (1988) and Joshi *et al.* (1991) in Karan Swiss calves and by Singh (1995) in Karan Swiss and Karan Fries calves. The estimate of birth weight reported by these workers ranged from 25 to 27 kg. However, Bhat *et al.* (1982), Gour and Dave (1986) obtained lower birth weight (below 23 kg) in crossbred calves than in present study.

4.2.1.1.1. Effect of Genetic Groups on Birth Weigh (BWT) in Karan Swiss Cattle

The least squares analysis of variance (Table 4.11) showed that genetic groups had significant (P < 0.-05) effect on BWT. BT crosses found to have maximum BWT (27.41±0.69kg) while BS/BR crosses have the minimum BWT (25.23±0.37kg). However no significant difference was between other [illegible] groups for BWT.

4.2.1.1.2. Effect of Paternal Generation on Birth Weight (BWT) in Karan Swiss Cattle

Significant effect of paternal generations was observed on birth weight (P<0.01). Maximum birth weight was observed in first generation (27.43±0.53 kg) while minimum birth weight was in fifth generation (25.30±0.52 kg). No specific trend was observed for birth weight over the generations. Mean birth weight of animals which belongs to second, fourth, fifth and sixth generations did not differ significantly from each other.

4.2.1.1.3. Effect of Maternal Generation on Birth Weight (BWT) in Karan Swiss Cattle

The average birth weight over the maternal generations ranged from 23.32±0.85 kg (seventh generation) to 27.86±0.38 (second generation). However average birth weight of animal in the second, third and fourth generations do not differ significantly from each other. There was a decreasing trend in birth weight was observed from second generation onward. (Table 4.14).

4.2.1.1.4. Effect of season of birth on birth weight in Karan Swiss females

Season of birth was found to have significant effect (P<0.01) on birth weight. The highest birth weight was observed for calves born during winter (26.88±0.37 kg) and the lowest birth weight was obtained for calves born during summer (25.62±0.41 kg) (Table 4.14) . The average birth weight of calves born during summer and rainy seasons did not differ significantly from each other. The higher average birth weight of autumn and winter born calves is likely to be due to availability of quality feed and succulent fodder and pleasant environment (low temperature and humidity).

Significant effect of season of birth on birth weight was also observed by Rao and Nagarcenkar (1979), Tajane and Rai (1989a), Joshi *et al.* (1991) and Dhangar, Patel (1992a) and Singh (1995) in crossbreds. However, Shrivastav *et al.* (1985), Su (1988) and Roy and Tripathi (1991) reported non-significant effect of season of birth in crossbred calves.

4.2.1.1.5. Effect of Period of Birth on Birth Weight (BWT) in Karan Swiss Cattle

Birth weight in Karan Swiss calves was found to be significantly (P<0.01) influenced by period of birth (Table 4.11). There was no specific trend in birth weight of female calves over the periods of birth. The highest average birth weight was observed in the eighth periods (28.50±0.82). However it is not significantly different from ninth, tenth and eleventh period.

Narayanswamy *et al.* (1984), Su (1988), Nautiyal and Bhat (1989a), Jadhav (1990) in Friesian crosses and Joshi *et al.* (1991) and Dhangar and Patel (1992a) in Jersey crosses also reported significant effect of period/year on birth weight in crossbred calves.

4.2.1.2. Average Weight at One Year (WOY) in Karan Swiss Cattle

The overall least squares mean of weight at one year (WOY) was 145.84±1.84 kg (Table 4.15). This estimate was in agreement with those reported by Shrivastav *et al.* (1985) and Nautiyal and Bhat (1989a) in Friesian crossbreds; Nagarcenkar *et al.* (1981), Su (1988), Nautiyal and Bhat (1989a), Joshi *et al.* (1991) and Singh (1995), in various crosses who reported body weight at one year in the range of 159 to 180 kg in their findings.

4.2.1.2.1. Effect of Paternal Generation on Body Weight at One Year (WOY) in Karan Swiss Cattle

Paternal generation found to have a significant effect ($P<0.05$) on body eight at one year (WOY) in Karan Swiss cattle (Table 4.12).

A difference of 18.63 kg was found between maximum value (155.94±9.53kg) in first generation and minimum value (137.31±9.80kg) value in fifth generation. However animals belongs to seventh and eighth generation did not differ significantly from animals of fifth generation.

Animals from fifth generation onward found to have low birth weight (except sixth generation) compared to animals of early generations. Highest WOY at first generation observed may be due to presence of animals with 75 percent exotic inheritance.

4.2.1.2.2. Effect of Maternal Generation on Body Weight at One Year (WOY) in Karan Swiss Cattle

The least squares analysis of variance showed no significant effect of maternal generation on weight at one year. Highest WOY was observed at first generation (149.99±3.67kg) while lowest WOY was observed at seventh generation (134.83±9.61kg) from fourth generation onward a decreasing trend was observed for WOY.

4.2.1.2.3. Effect of Season of Birth on Weight at One Year (WOY) in Karan Swiss Cattle

The WOY was found to be significantly (P<0.01) affected by season of birth in Karan Swiss cattle (Table 415) Maximum WOY was observed in calves born during summer season (150.06±2.48 kg). The WOY of winter (142.53±2.09) rainy (146.48±2.49) and autumn season (144.31±3.08) born animals did not differ significantly from each other. Higher weight at one year of age of animals born during summer season could be due to adequate availability of quality feed and fodder in autumn, winter and spring seasons.

Significant effect of month/season of birth on WOY in crossbreds was also reported by Rao and Nagarcenkar (1979), Taneja and Bhat (1982), Narayanswamy *et al.* (1984), Su (1988), Roy and Tripathi (1991), Joshi *et al.* (1991) and Singh (1995) in crossbred.

4.2.1.2.4. Effect of Period of Birth on Weight at One Year (WOY) in Karan Swiss Cattle

It was found that period of birth significantly (P<0.01) affected WOY in Karan Swiss female calves. However, no consistent trend was observed for WOY over the period of birth. Maximum WOY was observed for animals born during period-3 (158.07±9.30kg). The lowest average WOY was observed for period-2 (136.27±9.09 kg) which significantly differed (by DMRT) from calves born in Period 1 and Period 3 and Period 4.

Taneja and Bhat (1982), Naryanaswamy *et al.* (1984), Nautiyal and Bhat (1989a), Roy and Tripathi (1991), Joshi *et al.* (1991) and Singh (1995) also observed significant effect of year of birth on one year body weight in crossbred cattle. However, Su (1988) reported non-significant effect of year of birth on WOY in Karan Swiss cattle at this farm.

4.2.1.3. Average Weight at First Fertile Service (WFS) in Karan Swiss Cattle

The overall least-squares mean for WFS in Karan Swiss females was 287.84±3.72 kg. This estimate was close to those reported by Nagarcenkar and Rao (1982), Sehti *et al.* (1982, Su (1986) and Joshi *et al.* (1991).

4.2.1.3.1. Effect of Paternal Generation on Weight at First Fertile Service (WFS) in Karan Swiss Cattle

The effect of paternal generation on WFS was found statistically significant (P <0.05) (Table 4.12). Maximum average WFS was observed for the animals belong to first generation from sire side. It may be due to presence of F_1 and other miscellaneous crosses with higher levels of exotic inheritance. However, minimum WFS (272.55±10.84) was observed in eighth generation. No specific trend for WFS was observed over the generations.

4.2.1.3.2. Effect of Maternal Generation on Weight at First Fertile Service (WFS) in Karan Swiss Cattle

Highly significant effect (P<0.01) of maternal generation was observed on WFS (Table 4.12). There was no specific trend in WFS over different maternal generation was found. However animals in seventh generation have minimum WFS (258.81±18.16 kg) and maximum WFS (304.91±6.26 kg) was observed for first generation animals.

4.2.1.3.3. Effect of Season of Birth on Weight at First Fertile Service (WFS) in Karan Swiss Cattle

The effect of season of birth on WFS was found non significant in Karan Swiss cattle. The WFS for various seasons of birth varied from 283.72±4.19 kg for winter season to 294.33±4.69 kg for spring seasons.

Narayanswamy *et al.* (1984) and Roy and Tripathi (1991) in Friesian crossbred and Joshi *et al.* (1991) in Karan Swiss reported non-significant effect of season of birth on WFS. While Nagarcenkar and Rao (1982), Singh (1995) in Karan Fries and Karan Swiss found significant effect of season.

4.2.1.3.4. Effect of Period of Birth on Weight at First Fertile Service (WFS) in Karan Swiss Cattle

Least squares analysis of variance revealed significant (P<0.01) effect of period of birth on WFS in Karan Swiss cattle (Table 4.12). The WFS for different periods of birth varied form 255.19±7.79 (period 2) to 318.39±6.24 kg (Period 4). The WFS for period 1 and period 2 did not differ significantly from each other, but these estimates were differed significantly from the heifers born during period 3 and period 4.

Significant effect of period of birth was reported by Nagarcenkar and Rao (1982) in F x T and B x T crosses, by Joshi *et al.* (1991) in Karan Swiss cattle and by Singh (1995) in Karan Fries cattle.

4.2.1.4. Average Weight at First Calving (WFC) in Karan Swiss Cattle

The overall least-squares mean for WFC in Karan Swiss cattle was found to be 347.55±5.17 kg. The average WFC obtained in present study was in close agreement with estimates reported by Reddy and Basu (1985), Roy (1986), Tajane and Rai (1989a) in Friesian crosses. Whereas, Roy (1986), in Friesian crosses, Rana (1991) in Karan Swiss and Nagare and Kulkarni (2000) in Gir crosses reported higher WFC than the estimate obtained in the present study.

4.2.1.4.1. Effect of Paternal Generation on Weight at First Calving (WFC) in Karan Swiss Cattle

Significant effect of paternal generation was observed in WFC (Table 4.12). The maximum WFC was found (359.05±8.49kg) in first generation while minimum WFC (324.57±13.38 kg) was in eighth generation. However DMRT result shows that animals belong to second to seventh generation did not differ significantly form the animals in first generation.

4.2.1.4.2. Effect of Maternal Generation on Weight at First Calving (WFC) in Karan Swiss Cattle

Analysis of variance (Table 4.12) indicated that effect of maternal generation was highly significant (P<0.01). No specific trend was observed with respect to WFC over the generations. Animals in fourth generation with maximum WFC (365.95±6.79 kg) found to be significantly different from the animals with minimum WFC (321.46±10.19 kg) in sixth generation.

4.2.1.4.3. Effect of Season of Birth on Weight at First Calving (WFC) in Karan Swiss Cattle

Significant effect of season of birth was found in Karan Swiss cattle. Animal born in autumn found to have high WFC (351.76±7.81 kg) which was statistically not different for the animal born in winter (351.69±5.49kg) and summer (349.45±6.05 kg), Calf born in rain season have low WFC (387.31±6.11kg).

4.2.1.4.4. Effect of Period of Birth on Weight at First Calving (WFC) in Karan Swiss Cattle

The WFC according to period of birth varied from 325.27±7.72 kg for period 1 to 376.06±5.89 kg for period 4 (Table 4.15). There was an consistently increasing trend was observed for WFC over the periods.

The results were in agreement with those reported by Nautiyal and Bhat (1989b) and Jadhav *et al.* (1991b) in Friesian crosses and Joshi *et al.* (1991) in Karan Swiss who reported significant influence of period of birth on WFC. However, non significant effect of period on WFC was reported by Patel *et al.* (1989), Singh (1995) in Karan Swiss.

4.2.1.5. Average Age at First Fertile Service (AFS) in Karan Swiss Cattle

The overall least squares mean of Karan Swiss heifers for AFS was 783.76±16.25 days (Table 4.14). The estimate was close to the estimates reported by Sethi *et al.* (1982), Nagarcenkar and Rao (1982), Sahu *et al.* (1987) and Wagh *et al.* (1991) who observed lower AFS (<700 days) in crossbred cattle.

4.2.1.5.1. Effect of Genetic Group on Age at First Fertile Service (AFS) in Karan Swiss Cattle

The effect of genetic group was on AFC was found to be highly significant (P<0.01) (Table 4.11). Among the different genetic groups AFS ranged from 689.18±25.52 days in BS/BR crosses to 814.24±32.23days in BT crosses.

Low AFS in BS/BR crosses may be due to presence of F1 which attained early maturity in comparison to other groups. BSH crosses were found low AFS (696.24±45.20 days) in comparison to BT crosses (814.24 days) and KS *interse* mated animals (809.46±18.34 days). However, no significant difference in mean AFS was observed (DMRT) between BS/BR crosses and BSH crosses.

4.2.1.5.2. Effect of Paternal Generation on Age at First Fertile Service (AFS) in Karan Swiss Cattle

There was no clear cut trend was observed over AFS over the generation (Table 4.14). The average AFC of the animals belong sixth generation and onward found to be more than 800 days and were significantly different from those animals in the first generation with average AFS 701.72±22.55 days.

4.2.1.5.3. Effect of Maternal Generation on Age at First Fertile Service (AFS) in Karan Swiss Cattle

A fluctuating trend was observed for AFS over the maternal generations. Minimum average AFS (747.52±20.38 kg) observed for the animals in first generation and maximum average AFS (820.71±16.44 kg) for the animal in third generation. However, the effect of maternal generation was found statistically significant (P<0.01) for AFS.

4.2.1.5.4. Effect of Season of Birth on Age at First Fertile Service (AFS) in Karan Swiss Cattle

It was found that AFS was not significantly affected by season of birth in Karan Swiss cattle. The results were in agreement with those reported by Sethi (1982) in HBT and BHS triple crossbreds; Pyne *et al.* (1988) in J x H; Singh *et al.* (1990) in F/B/J x Zebu and Wagh *et al.* (1991) in F x G crosses, and Singh (1995) in both Karan Swiss and Karan Fries cattle.

4.2.1.5.5. Effect of period of birth on Age at First Fertile Service (AFS) in Karan Swiss Cattle

Significant effect of period of birth was observed in AFS. Minimum AFS observed in period 3(666.03±24.79) while maximum AFS at period 5 (864.85±20.05 days) (Table 4.14). No specific trend was observed over the period. The results were in agreement with those reported by Nagarcenkar and Rao (19872) inF x T and B x S crosses and Wagh *et al.* (1991) in F x G reported significant effect of period on AFS. However, Sethi (1982) and Singh (1995) in Karan Swiss cattle.

4.2.1.6. Average Age at First Calving (AFC) in Karan Swiss Cattle

The overall least squares mean for AFC in Karan Swiss heifers was found to be 1046.96±16.20 days (Table 4.11). The average was close to those reported by Su (1988) and Yazdani *et al.* (1993). Whereas, Reddy and Basu (1985), Parmer *et al.* (1986), Kumar (1987), Dhangar and Patel (1991) and Tekade (1994), Sinha (1999), Sahana and Gurnani (2000), and Nagore and Kulkarni (2000) reported low estimate of AFC (<100 days) in crossbred cattle.

4.2.1.6.1. Effect of Genetic Group on Age at First Calving (AFC) in Karan Swiss Cattle

The effect of genetic group was highly significant (P<0.01) on AFC (Table 4.11). AFC was highest among KS *interse* mated animals (1155.32±45.59days) and lowest average AFC was observed in case of BSH crosses (955.53±32.75 days). However, for BS/BR and BT crosses the average AFC was 959.34 days and 1055.48 days, respectively. The mean AFC in BXS (F_1) was significantly different from mean AFC in BXT (F_1).

Similar to the observation in the present study, Aziz and Sadhu (1983), Kale *et al.* (1984), Parmar *et al.* (1984) observed that among H x S crosses and Sahana and Gurnani in H x T crosses, halfbreds had the lowest AFC. On the other hand Sharma *et al.* (1983) found that females with nearly

75 percent Friesian inheritance calved significantly earlier than those in other grades.

4.2.1.6.2. Effect of Paternal Generation on Age at First Calving (AFC) in Karan Swiss Cattle

The effect of paternal generation on AFC was highly significant ($P < 0.01$) (Table 4.11). The lowest average AFC (975.33±22.79 days) was found in the first generation. Whereas, highest average AFC (1113.83±33.26 days) was observed in eighth generations. However, animals belong to the second, fourth, sixth, seventh and eighth generations were significantly different from those animals in firsts and third generation for AFC. Sinha (1999) in Karan Fries reported minimum average AFC for first generation animals where as maximum AFC was observed for the animals in the fourth generation.

4.2.1.6.3. Effect of Maternal Generation on Age at First Calving (AFC) in Karan Swiss Cattle

The influence of maternal generation on AFC was found to be highly significant ($P<0.01$) (Table 4.11). The minimum AFC was observed in Seventh generation (1015.84±44.74 days) while maximum AFC was in third generation. Sinha (1999) in Karan Fries animals reported shortest and longest AFC in first and sixth generation respectively.

4.2.1.6.4. Effect of Season of Birth on Age at First Calving (AFC) in Karan Swiss Cattle

The effect of season of birth on age at firs calving was found to be statistically non significant. The AFC of KF animals born in different season ranged between 1043.14±18.42 days (autumn) to 1051.44±17.89 days (summer). Rana (1991), Yazdani *et al.* (1993), Singh (1995), Sivakumar (1998), Sinha (1999) and Sahana and Gurnani (2000) also reported non significant effect of season of birth on AFC.

4.2.1.6.5. Effect of Period of Birth on Age at First Calving (AFC) in Karan Swiss Cattle

Table 4.11. Least Squares Analysis of variance (MSS Value) Of BWT, AFS, AFC In Karan Swiss cows

Source of variation	BWT	AFS	AFC
Genetic Group	63.354* (3)	118440.700** (3)	95718.359** (3)
Paternal Generation	116.174** (7)	137528.030** (7)	116742.700** (7)
Maternal Generation	261.099** (6)	92224.617** (6)	87231.867** (6)
Season of birth	211.813** (3)	11553.251 (3)	7298.778 (3)
Period of birth	63.980** (11)	433709.59** (11)	465612.470** (11)
Error	21.772 (3022)	21277.039 (1610)	23240.473 1737

Table 4.12. Least squares analysis of variance (MSS Value) of WOY, WFS, WFC In Karan Swiss cows

Source of variation	WOY	WAS	WAC
Paternal Generation	2311.772* (7)	5689.933* (7)	6612.757** (7)
Maternal Generation	539.631 (6)	5701.263** (6)	7987.845** (6)
Season of birth	2742.4333** (3)	4083.491 (3)	7332.671** (3)
Period of birth	3325.104** (3)	21745.588** (3)	14023.556* (3)
Error	825.780 (946)	1817.063 (678)	2029.393** (658)

* Significant ($P<0.05$), ** Significant ($P<0.01$) Figures in the parentheis are degrees of freedom

Table 4.13. Least squares analysis of variance (MSS Value) of various first lactation traits in Karan Swiss cows

Source of variation	FL305 DMY	FLTMY	FLL	FSP	FDP	FCI	MY/FLL	MY/FCI	HL
Genetic group	1127321.9 (4)	1600574.9 (4)	10755.267 (4)	476.963 (4)	59.945 (4)	874.747 (4)	6.991 (4)	3.813 (4)	214679.440 (4)
Paternal Generation	5227292.5** (7)	7660011.0** (7)	9365.139 (7)	3553.161 (7)	1661.661 (7)	4140.949 (7)	28.941** (7)	17.203* (7)	2769801.5** (7)
Maternal Generation	1594585.6 (6)	4018222.2** (6)	14099.897 (6)	6194.168 (6)	1011.292 (6)	11851.821 (6)	19.317** (6)	6.279 (6)	5935506.0** (6)
Season of calving	3120179.8** (3)	5615194.5** (3)	26638.412* (3)	26927.486** (3)	471.048 (3)	50773.168 (3)	14.421** (3)	8.736* (3)	1868987.6 (3)
Period of calving	6598503.5** (10)	8520205.0** (10)	43078.949** (10)	6632.233 (10)	3210.028** (10)	10741.521** (10)	58.749** (10)	29.133** (10)	27129772.0** (10)
Regression	21961.336 (1)	40220.027 (1)	130797.30** (1)	117.309 (1)	87.967 (1)	23.081 (1)	70.469** (1)	0.844 (1)	24454948.00** (1)
Error	837450.69 (1628)	1515688.8 (1626)	9744.129 (1457)	4174.719 (1003)	910.348 (1009)	6862.622 (1084)	4.227 (1451)	3.360 (1059)	1021787.9 (1604)

* Significant (P<0.05), ** Significant (P <0.01) Figures in the parentheis are degrees of freedom

Table 4.14 Least squares mean along with standard error of BWT, AFS, AFC in Karan Swiss

Effect	BWT	AFS	AFC
1	2	3	4
Overall	**26.26 ± 0.37 (3054)**	**783.76 ± 16.25 (1642)**	**1046.96 ± 16.20 (1749)**
Genetic Group			
1.	25.23 ± 0.37 [b] (428)	689.18 ± 25.52[a] (307)	959.34 ± 15.98 [a] (350)
2.	27.41 ± 0.69 [a] (81)	814.24 ± 32.23 [b] (69)	1055.48 ± 26.94 [b] (71)
3.	26.07 ± 0.69 [ab] (60)	696.24 ± 45.20 [a] (27)	955.53 ± 32.75 [a] (28)
4.	26.40 ± 0.10 [ab] (2485)	807.46 ± 18.34 [b] (1239)	1055.78 ± 15.98 [b] (1326)
Paternal Generation			
1.	27.43 ± 0.53 [a] (645)	701.72 ± 22.55 [a] (454)	975.33 ± 22.79 [a] (502)
2.	26.06 ± 0.45 [bc] (463)	779.19 ± 20.34 [cd] (248)	1044.37 ± 20.44 [bc] (261)
3.	26.67 ± 0.46 [ab] (471)	733.66 ± 20.57 [ab] (239)	1003.15 ± 20.69 [a] (254)
4.	25.43 ± 0.51 [c] (415)	792.39 ± 22.67 [cd] (193)	1057.11 ± 22.99 [bc] (201)
5.	25.30 ± 0.52 [c] (305)	762.18 ± 23.21 [bc] (181)	1022.32 ± 23.54 [ab] (182)
6.	25.90 ± 0.53 [bc] (367)	806.75 ± 23.19 [cd] (182)	1078.50 ± 23.49 [c] (204)
7.	27.20 ± 0.57 [ab] (226)	817.97 ± 25.16 [dc] (108)	1081.10 ± 25.46 [c] (114)
8.	26.09 ± 0.68 [bc] (162)	876.22 ± 34.76 [e] (37)	1113.83 ± 33.26 [c] (51)
Maternal Generation			
1.	25.69 ± 0.50 [bc] (574)	747.52 ± 20.38 [a] (417)	1016.98 ± 20.60 [a] (465)
2.	27.86 ± 0.38 [a] (1032)	813.93 ± 16.60 [b] (569)	1076.88 ± 16.61 [b] (595)
3.	27.58 ± 0.38 [a] (705)	820.71 ± 16.44 [b] (339)	1081.34 ± 16.58 [b] (355)
4.	27.60 ± 0.43 [a] (373)	804.92 ± 18.72 [b] (178)	1066.18 ± 18.88 [ab] (188)
5.	26.68 ± 0.50 [b] (209)	792.00 ± 22.69 [b] (82)	1054.94 ± 22.45 [ab] (97)
6.	25.09 ± 0.59 [c] (119)	770.79 ± 27.27 [ab] (45)	1016.58 ± 26.59 [a] (55)
7.	23.32 ± 0.85 [d] (42)	776.44 ± 46.01 [ab] (12)	1015.84 ± 44.74 [a] (14)

Contd...../-

Contd...../-

1	2	3	4
Season of Birth			
1.	26.88 ± 0.37 [a] (1337)	784.78 ± 16.18 (704)	1050.10 ± 16.06 (755)
2.	25.62 ± 041 [b] (683)	791.64 ± 17.98 (354)	1051.44 ± 17.89 (383)
3.	25.94 ± 0.41 [b] (625)	778.35 ± 17.95 (356)	1043.17 ± 18.00 (385)
4.	26.54 ± 0.43 [a] (409)	780.29 ± 18.42 (228)	1043.14 ± 18.42 (246)
Period of Birth			
1.	25.31 ± 0.77 [cde] (67)	734.39 ± 35.71 [a] (27)	1052.95 ± 30.30 [b] (56)
2.	24.33 ± 0.62 [e] (144)	888.00 ± 25.58 [b] (107)	1158.56 ± 25.84 [c] (117)
3.	24.72 ± 0.59 [de] (197)	666.03 ± 24.79 [a] (123)	938.01 ± 25.18 [a] (129)
4.	24.86 ± 0.49 [de] (492)	779.39 ± 21.26 [a] (350)	1057.25 ± 21.57 [b] (369)
5.	24.69 ± 0.44 [e] (553)	864.85 ± 20.05 [b] (271)	1134.33 ± 20.35 [c] (282)
6.	25.41 ± 0.42 [cde] (402)	862.82 ± 18.41 [b] (187)	1149.95 ± 18.71 [c] (195)
7.	26.34 ± 0.65 [bcd] (284)	771.69 ± 28.24 [a] (151)	1025.88 ± 28.54 [ab] (152)
8.	28.50 ± 0.72 [a] (299)	716.50 ± 31.45 [a] (172)	973.86 ± 31.90 [ab] (177)
9.	28.37 ± 0.70 [a] (210)	778.15 ± 30.64 [a] (115)	1026.82 ± 31.09 [ab] (118)
10.	27.91 ± 0.76 [a] (153)	775.72 ± 33.23 [a] (83)	1019.38 ± 35.59 [ab] (91)
11.	27.45 ± 0.78 [ab] (144)	794.62 ± 38.45 [ab] (39)	1012.74 ± 37.03 [ab] (59)
12.	27.23 ± 0.83 [abc] (109)	772.96 ± 47.90 [a] (17)	1013.86 ± 44.95 [ab] (24)

Figures in the parenthesis indicate number of observations

Table 4.15. Least squares mean along with standard error of WOY, WFS, WFC in Karan Swiss

Effect	WOY	WFS	WFC
1	2	3	4
Overall	**145.84 ± 1.84 (966)**	**287.84 ± 3.72 (698)**	**347.55 ± 5.17 (678)**
Paternal Generation			
1.	155.94 ± 9.53 [a] (186)	304.21 ± 7.93 [a] (153)	359.05 ± 8.49 [a] (176)
2.	147.44 ± 9.29 [ab] (131)	288.33 ± 6.77 [ab] (86)	342.50 ± 8.01 [ab] (74)
3.	152.24 ± 9.13 [a] (154)	292.72 ± 6.82 [ab] (108)	343.15 ± 8.05 [ab] (96)
4.	142.60 ± 8.75 [ab] (56)	280.40 ± 12.49 [b] (13)	350.31 ± 10.70 [ab] (31)
5.	137.31 ± 9.80 [b] (148)	279.84 ± 7.67 [b] (137)	345.95 ± 8.49 [ab] (118)
6.	152.97 ± 9.46 [a] (123)	282.51 ± 8.06 [b] (97)	344.73 ± 8.22 [ab] (84)
7.	138.83 ± 9.36 [b] (123)	302.15 ± 7.42 [a] (80)	342.17 ± 8.33 [a] (83)
8.	139.68 ± 9.88 [b] (45)	272.55 ± 10.84 [b] (24)	324.57 ± 13.38 [b] (16)
Maternal Generation			
1.	149.99 ± 3.67 (203)	304.91 ± 6.26 [ab] (159)	354.75 ± 6.69 [ab] (152)
2.	147.44 ± 2.07 (272)	300.75 ± 3.86 [a] (194)	358.91 ± 5.45 [ab] (205)
3.	146.02 ± 2.05 (239)	297.09 ± 4.14 [a] (156)	361.27 ± 5.60 [ab] (154)
4.	149.36 ± 2.85 (123)	293.48 ± 5.17 [a] (98)	365.95 ± 6.72 [a] (88)
5.	148.85 ± 3.72 (72)	287.87 ± 6.65 [ab] (54)	347.66 ± 8.40 [ab] (45)
6.	144.40 ± 4.76 (47)	271.98 ± 8.64 [b] (31)	321.46 ± 10.19 [b] (27)
7.	134.83 ± 9.61 (10)	258.81 ± 18.16 [b] (6)	322.88 ± 18.06 [b] (7)
Season of Birth			
1.	142.53 ± 2.09 [b] (396)	283.72 ± 4.19 (284)	351.69 ± 5.49 [a] (274)
2.	150.06 ± 2.48 [a] (230)	294.33 ± 4.69 (155)	349.45 ± 6.05 [ab] (156)
3.	146.48 ± 2.49 [ab] (213)	284.46 ± 4.81 (159)	337.31 ± 6.11 [b] (153)
4.	144.31 ± 3.08 [ab] (127)	288.85 ± 5.50 (100)	351.76 ± 6.81 [a] (95)
Period of Birth			
1.	144.47 ± 9.35 [b] (378)	265.14 ± 7.04 [b] (257)	325.27 ± 7.72 [b] (314)
2.	136.27 ± 9.09 [c] (146)	255.19 ± 7.79 [b] (77)	327.83 ± 16.22 [b] (10)
3.	158.07 ± 9.30 [a] (233)	312.64 ± 6.84 [a] (182)	361.06 ± 6.00 [a] (223)
4.	144.56 ± 8.88 [b] (209)	318.39 ± 6.24 [a] (182)	376.06 ± 5.89 [a] (131)

Figures in the parenthesis indicate number of observations

Significant effect of period of birth on AFC was found in the present study. The average AFC was found minimum for those animal which born on period 3 (938.0-1±25.18) and maximum for the animals born during the period 2 (1158.56±25.84 days). The present study was found close in agreement with the findings of Reddy and Basu (1985), Tekade *et al.* (1994), Panja (1997), Sivakumar (1998) and Sahana and Gurnani (2000). However, Sinha (1999) reported non significant effect of period on AFC in Karan Fries.

4.2.1.7. Average First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

The overall least squares mean for FL305DMY was found to be 2443.79±101.22 (Table 4.16). Higher estimates of average FL305DMY (>3000 kg) were reported by Nagarcenkar and Rao (1982), Patil *et al.* (1987), Panja (1997), Sivakumar (1998) and Sinha (1999) in crossbred animals. However, lower estimates (<2000 kg) were reported by lype *et al.* (1985), Parmer *et al.* (1986), Kumar *et al.* (1991), and Deshmukh *et al.* (1995) in various crosses.

4.2.1.7.1. Effect of Genetic Group on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

The least squares analysis of variance indicated the non significant effect of genetic group on FL305DMY (Table 4.13). It was found that the BS/BR (F_1) had highest average FL305DMY (2763.10±109.37kg), where BT (F_1) had the lowest average (2306.53±111.58kg). Animal with 75 percent exotic inheritance (BSH) and Karan Swiss *interse* mated females found to have almost similar FL 305 MY.

However, contrary to the present study, other workers like Jadhav *et al.* (1991), Datt and Joshi (1992) and Sahana and Gurnani (2000) reported significant effect of genetic group on FL305DMY.

4.2.1.7.2. Effect of Paternal Generation on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

Effect of paternal generation on FL305DMY was found statistically highly significant ($p<0.01$). No specific trend was observed over the generations for FL305DMY. Maximum average FL305DMY (2788.98±148.72 kg) was observed in the sixth generation, which was significantly not different from the average FL305DMY in the first (2732.01±134.05 kg) and seventh (2558.15±155.96kg) generation. The minimum average FL305DMY was observed in the fifth generation (2171.33±137.42).

However, Sinha (1999) reported highest average 305 days milk yield in the second generation in Karan Fries.

4.2.1.7.3. Effect of Maternal Generation on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

The analysis of variance indicated that the maternal generation did not have significant effect on FL305DMY. However, maximum average FL305DMY (2647.37±124.85 kg) was observed in the first generation and minimum average FL305DMY was found in the seventh generation (2265.89±298.95 kg). There was a decreasing trend in average FL305DMY was observed over the generation. Maximum average in the first generation may be due to high production of the F_1 animals.

4.2.1.7.4. Effect of Season of Calving on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

The least squares mean of FL305 DMY varied from 2298.26±13.26 (rainy calvers) to 2665.93±132.89 kg (autumn calvers). The effect of season of calving was found to be statistically significant ($P<0.01$). Significant effect of season on FL305DMY was reported. Datt and Joshi (1992) in Karan Swiss, Deshmukh *et al.* (1995) in Jersey cross, Sahana and Gurnani (2000) in Karan Fries. While non significant effect was found by Nagarcenkar and Rao (1982) in BXT crosses at NDRI, Karnal; Pandey *et al.* (1988) in B x H at IVRI, Izatnagar; Kumar (1991) in B x O at Lam.

4.2.1.7.5. Effect of Period of Calving on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

Least squares ANOVA revealed significant (P<0.01) effect of periods of FL305DMY in KS cattle (Table 4.13). Highest least squares average was found in Period 1 (2936.85±204.18) and lowest in period 10 (1776.26±213.07) kg). However, no definite trend in average FL305DMY was observed over the periods of calving (Table 4.16).

Significant effect of periods on FL305DMY was reported by Basu and Ghai (1977), Kumar (1987), Jadhav *et al.* (1991a) and Arora *et al.* (1993) in Friesian crosses at Military Farms and by Pandey *et al.* (1988) in B x H crosses at IVRI, Su (1988) in Karan Swiss at this farm, by Patel *et al.* (1989) in Jersey crosses at Anand, Siva Kumar (1998) and Sahana and Gurnani (2000) in Karan Fries at NDRI, Karnal.

4.2.1.7.6 Effect of Age at First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Swiss Cattle

The least squares regression of AFC on FL305DMY was found to be non significant in Karan Swiss cattle. Non significant effect was also reported by Su (1988), Singh (1992) and Singh (1995) in this breed.

4.2.1.8. Average First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

The overall least squares mean of FLTMY was found to be 2791.14±136.79 kg (Table4.16). The average FLTMY was in range of estimates reported by Reddy and Basu (1985), Kumar (1987), Tajane and Rai (1989b), Arora *et al.* (1993) and Raheja *et al.* (1994a) in Friesian x Sahiwal crosses at Military Dairy Farms. The average FLTMY observed by these authors was 2601, 3029, 2466, 2730 and 3255 kg, respectively. Whereas, Stephan *et al.* (1985) in B x L in Kerala; Pandey *et al.* (1988) in B x H at IVRI, Izatnagar; Kumar *et al.* (1991) in B x O at Lam; Bhattacharya *et al.* (1993b) in B x H and Singh *et al.* (1993) in B x S at Pantnagar obtained lower estimates of average FLTMY which was in the range of 1600 to 2280 kg.

4.2.1.8.1. Effect of Genetic Group on First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

The least squares analysis of variance (Table 4.13) showed that the genetic groups had no significant effect on first lactation total milk yield (FLTMY). BS/BR crosses found to have maximum average FLTMY (3240.7±190.85kg) and BSH found to have the minimum FLTMY (2566.94±222.08 kg). The mean FLTMY observed for other crosses were 2802.11 kg (for BT cross) and 2674.95kg (for KS- *interse* mated)

Dalal *et al.* (1991), Jadhav *et al.* (1991) and Singh *et al.* (1993) observed significant effect of genetic group on FLTMY in crossbreds.

4.2.1.8.2 Effect of Paternal Generation on First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

The least squares analysis of variance (Table 4.13) indicated that paternal generation had highly significant effect on first lactation total milk yield. Maximum average FLTMY was observed in the sixth generation (3237.99±200.15kg) followed by first generation (3049.91±180.43kg). Minimum average FLTMY was observed (2521.67±160.95kg) in the second generation. However, average FLTMY in the third and fifth generation did not differ significantly from average milk yield in second generation (Table).

4.2.1.8.3 Effect of Maternal Generation on First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

Significant effect ($P<0.01$) of maternal generation as observed on FLTMY in he present study. (Table 4.13). Animals belong to first generation had maximum average total milk yield (3122.33±168.11 kg), which was significantly different from the average FLTMY observed in the other generations. No specific trend was observed with respect to FLTMY over the generations. However, minimum average FLTMY was found (2584.81±156.56 kg) in the fourth generation.

4.2.1.8.4 Effect of Season of Calving on First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

The effect of season of calving on FLTMY was found to be statistically significant (P<0.01)The least squares average of FLTMY for seasons of calving varied from 2553.37±152.36 kg for rainy calvers to 2983.89±178.81 kg for autumn calvers. However, the autumn calvers were not significantly different from winter calvers (2782.43±138.81 kg) and summer calvers (2844.86±142.03). Significant effect of season of calving on FLTMY was reported by Raheja (1994a) in FxH cross. Tekade *et al.* (1994) in J x S cross, Sivakumar (1998), Sinha (1999) and Sahana and Gurnani (2000) in Karan Fries cows.

4.2.1.8.5 Effect of Period of Calving on First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

Highest least squares average of FLTMY was found for period I (3222.20±274.72kg) and lowest in Period 10 (2043.81±286.65 kg) in Karan Swiss cattle. The effect of periods, was found to be statistically significant (P<0.01). There was no consistent trend of FLTMY observed over the periods. The maximum FLTMY in the first period may be due to use of exotic proven bulls of high genetic merit. Significant effect of period of calving of FLTMY was reported by Singh *et al.* (1993), Raheja (1994a), Tekade *et al.* (1994) and Sivakumar (1998).

4.2.1.8.6. Effect of Age at First Lactation Total Yield (FLTMY) in Karan Swiss Cattle

Age at first calving did not significantly affect the FLTMY in this herd. Non significant effect of AFC on FLTMY was reported by Kumar (1987) in Friesian x Sahiwal crosses at Military Farms, and Singh (1995) in Karan Swiss as well as Karan Fries at NDRI.

4.2.1.9 Average First Lactation Length (FLL) in Karan Swiss Cattle

The overall least squares average of FLL in Karan Swiss herd was found to be 331.69±11.59 days. (Table 4.16.). The present estimate is close to the estimates of average FLL reported by Viz (1981) and Su (1988) as 322 and 318 days, respectively in Karan Swiss cattle at this farm and by Kumar *et al.* (1991) as 330 days in F/B/J x O crosses at Lam; Chopra (1990) as 319 days in B x H at Hisar; Tajane and Rai (1989b) as 312 days; Arora *et al.* (1993) as 326 days in F x S crosses at Military Farm and Singh (1995) as 328 days in Karan Swiss at NDRI, Karnal. However, lower estimate of average of FLL (in range of 290-310 days) was reported by Roy (1986), Kumar (1987) and Jadhav *et al.* (1991a) in Friesian x Sahiwal crosses at Military Farms.

4.2.1.9.1. Effect of Genetic Group on First Lactation Length (FLL) in Karan Swiss Cattle

The least squares analysis of variance (Table 4.13) indicated that the genetic group had non significant effect on FLL. The average first lactation length of different genetic group varied from minimum 305.74±23.00 days in BSH crosses to maximum 358.16±15.04 days in BS/BR crosses. Similar to the present study , Parmar *et al.* (1984), Dalal *et al.* (1991), Singh *et al.* (1993) and Sahana and Gurnani (2000) also reported non significant effect of genetic group on FLL. However, significant effect of genetic group on lactation length were observed by Sharma *et al.* (1983) and Taneja and Rai (1989).

4.2.1.9.2 Effect of Paternal Generation on First Lactation Length (FLL) in Karan Swiss Cattle

The effect of paternal generation was found to have non significant effect on FLL (Table 4.13)_. A fluctuating trend in FLL was observed over the paternal generation which ranged from 317.21±13.68 days (second generation) to 346.51±16.83 days (sixth generation). Sinha (1999) reported maximum FLL in fourth generation from sire side in Karan Fries.

4.2.1.9.3. Effect of Maternal Generation on First Lactation Length (FLL) in Karan Swiss Cattle

Over the maternal generation first lactation length (FLL) was found to range between 297.89±19.61 days in the sixth generation to 359.26±33.77

days in the seventh generation (Table 4.16). However, effect of maternal generation on FLL was found non significant

Sinha (1999) in Karan Fries cattle found maximum average FLL (3.72.37 days) in fifth generation while minimum average FLL (301.75 days) was observed in first generation.

4.2.1.9.4. Effect of Season of Calving on First Lactation Length (FLL) in Karan Swiss Cattle

The effect of season on FLL was found to be statistically significant ($P<0.05$). For seasons of calving, the FLL varied from 318.45±13.02 days for rainy calvers to 342.81±12.05 days for summer calvers. Significant effect of season of calving on FLL were reported by Singh (1995), Panja (1997), Sivakumar (1998) and Sahana and Gurnani (2000).

4.2.1.9.5. Effect of Period of Calving on First Lactation Length (FLL) in Karan Swiss Cattle

Period of calving significantly ($P<0.01$) affected the FLL in Karan Swiss cattle. The highest FLL was found to occur during Period-5 (379.04±14.25 days) and the lowest during period 10 (297.83±28.33 days).

Vij (1981) and Su (1988) reported significant effect of periods on FLL in same breed at this farm. Significant effect of period in FxS crosses was also reported by Roy (1986), Arora *et al.* (1993) at Military Farms and in J x K by Patel *et al.* (1989) at Anand. Singh (1995) and Sahana and Gurnani (2000) at NDRI also found significant effect of period of calving on FLL.

4.2.1.9.6. Effect of Age at First Calving on First Lactation Length (FLL) in Karan Swiss Cattle

Age at first calving was found to significantly affect the FLL in this herd. However, Su (1988) at NDRI Farm, Karnal and Bhatia and Pandey at IVRI, Izatnagar, Singh (1995) at NDRI Farm, Karnal reported non-significant effect of AFC on FLL in crossbreds.

4.2.1.10. Average First Service Period (FSP) in Karan Swiss Cattle

The overall least squares mean of FSP was found to be 123.58±9.67 days (Table 4.16). The estimate of average FSP found in present investigation was near to the estimate reported by Nagore and Kulkarni (2000) as 123 days in Gir crosses at MPKV, Rahuri; Sahana and Gurnani (2000) 127.50 days in Karan Fries at NDRI, Karnal.

Higher estimate of average FSP was reported in FXS crosses by Roy (1986) as 172 days; Arora *et al.* (1993) as 175 days at Military Farms and by Bhatia and Pandey (1990) as 170 days at IVRI, Izatnagar. However, low estimate of FSP was reported by Sinha (1999) in Karan Fries.

4.2.1.10.1. Effect of Genetic Group on First Service Period (FSP) in Karan Swiss Cattle

The various genetic group did not differ significantly in average FSP. The average FSP ranged from minimum 122.31±10.25 days (KS *interse* mated) to maximum 129.38±19.04 days (BSH crosses) (Table 4.16). Verma *et al.* (1973), Sahana and Gurnani (2000) reported non significant effect of genetic group on FSP. However, the significant effect of genetic group on service period was reported by Sharma *et al.* (1983), Butte and Deshpande (1987), Kale *et al.* (1984) and Jadhav *et al.* (1991).

4.2.1.10.2. Effect of Paternal Generation on First Service Period (FSP) in Karan Swiss Cattle

Paternal generationwise average FSP was presented in the Table 4.16 and it was ranged from 111.17±11.37 days in second generation to 136.31±13.01 days in the fifth generation. No definite trend was observed in mean FSP over the generations. However, least squares analysis of variance (Table) indicated that effect of paternal generation on FSP was non significant. Sahana (1999) studied in Karan Fries cattle and reported maximum and minimum average FSP in fourth and first generation respectively.

4.2.1.10.3. Effect of Maternal Generation on First Service Period (FSP) in Karan Swiss Cattle

The influence of maternal generation on FSP was non significant as observed from least squares analysis of variance (Table 4.13). The average FSP ranged from 88.30 ±16.68 days in sixth generation to 155.11±30.76 days in seventh generation. No definite trend was observed in FSP over the generations. Sinha (1999) also reported no specific trend over the generations in Karan Fries cattle.

4.2.1.10.4. Effect of Season of First Service Period (FSP) in Karan Swiss Cattle

The effect of season of calving was found to be statistically significant. The FSP was found to vary from 115.53±10.62 days for rainy calvers to 139.77±10.03 days for summer calvers. Mean FSP on winter calvers (122.05±9.86 days) and autumn calvers (116.98±12.10 days were significantly no different from rainy calvers.

Significant effect of season of calving on FSP was reported by Singh (1995), Panja (1997), Sivakumar (1998) and Sahana and Gurnani (2000) in Karan Fries. However non significant effect of season of calving on FSP was reported by Deshpande *et al.* (1988) in FXS crosses at Military Farms .

4.2.1.10.5. Effect of Period of Calving on First Service Period (FSP) in Karan Swiss Cattle

The average FSP was found to range from 111.09±13.66 days for period 3 to 138.67±12.31 days for period 5 and no definite trend was observed over the periods inks cattle. The effect of period of calving on FSP was found to be non-significant.

Non significant effect of period of FSP was reported by Singh (1995) in KS cattle at this farm, Deshpande *et al.* (1988) and Jadhav *et al.* (1991a) in F x S crosses at Military Farms and by Singh *et al.* (1990) in F/JxS crosses at Pantnagar.

4.2.1.10.6. Effect of Age at First Calving on First Service Period (FSP) in Karan Swiss Cattle

The regression of FSP on AFC was found to be non-significant and this was in agreement with the findings of Su (1988) and Bhatia and Pandey (1990) in Brown Swiss and Friesian crosses, respectively by Singh (1995) in Karan Swiss as well as in Karan Fries.

4.2.1.11. Average First Dry Period (FDP) in Karan Swiss Cattle

The overall least squares mean of FDP was found 76.39 days in Karan Swiss cattle (Table 4.16). Higher estimate of average FDP was reported by Roy (1986) and Jadhav *et al.* (1991a) in FxS crosses at Military Farms. The estimate of average FSP was 117 and 125 days, respectively. Kumar (1991) and Singh *et al.* (1993) also reported higher estimates of FDP (126 and 120 days) in Brown Swiss crosses at Lam and Pantnagar Farms, respectively. Whereas, lower average of FDP were reported by Panja (1997), Sivakumar (1998), Sinha (1999) and Sahana and Gurnanai (2000) in Karan Fries cattle.

4.2.1.11.1 Effect of Genetic Group on First Dry Period (FDP) in Karan Swiss Cattle

The least squares analysis of variance (Table 4.13) indicated that difference among various genetic group with respect of first dry period were not significant. The average FDP ranged from minimum 72.30±5.50 days in BS/BR (H) to a maximum 77.62±4.63 in BT crosses (Table 4.16).

Choudhary *et al.* (1977) and Singh *et al.* (1993), Sahana and Gurnani (2000) also reported that the influence of genetic group on first dry period was non significant.

However, Naidu and Desai (1966b), Sharma *et al.* (1983), Mudgal *et al.* (1986), Chand (1998) and Jdhav *et al.* (1991) reported significant effect of genetic group as dry period.

4.2.1.11.2. Effect of Paternal Generation on First Dry Period (FDP) in Karan Swiss Cattle

The least squares analysis of variance (Table 4.13) indicated the non significant effect of paternal generation on FDP. The mean FDP ranged between 64.56±6.32 days (first generation) to 100.09±11.81 days (eighth generation). However, an increasing trend in FDP was observed over the paternal generation except in sixth generation. Sinha (1999) in Karan Fries observed maximum FDP in third generation while minimum average FDP was reported in the first generation.

4.2.1.11.3. Effect of Maternal Generation on First Dry Period (FDP) in Karan Swiss Cattle

Effect of maternal generation on FDP was also found to be statistically non significant (Table 4.13). A distinct decreasing trend in FDP was observed over the maternal generation except in fifth generation. The average FDP was found to range between 62.92±14.56 days (seventh generation) to 85.08±5.85 days (first generation).

4.2.1.11.4. Effect of Season of Calving on First Dry Period (FDP) in Karan Swiss Cattle

The least squares average of FDP varied form 73.44±6.23 days for autumn calvers to 78.39±5.30 days for summer calvers. The effect of season of calving, however, was found to be statistically non significant.

Non significant effect of season was reported by Pandey *et al.* (1988) and Singh (1995) in Brown Swiss at IVRI, Izatnagar and NDRI Farm, Karnal, respectively. And in Friesian crosses by Dalal *et al.* 91991) and Singh *et al.* (1993) at Hisar and Pantnagar Farms and by Panja (1997), Sivakumar (1998), Sinha (1999) and Sahana and Gurnani (2000) in Karan Fries at NDRI, Karnal.

4.2.1.11.5. Effect of Period of Calving on First Dry Period (FDP) in Karan Swiss Cattle

The effect of period on FDP was found to be statistically significant (P<0.01). The least squares average for various periods varied from 69.18±6.37 days (period 4) to 94.45±9.75 days (period 10). No consistent trend of dry period was observed over the periods of calving.

Significant effect of period of FDP was reported by Roy (1986) in HF crosses, Dalal *et al.* (1991) in crossbreds, Deshmukh *et al.* (1995) in J x S crosses and Sinha (1999) in Karan Fries.

4.2.1.11.6. Effect of Age at First Calving on First Dry Period (FDP) in Karan Swiss Cattle

The AFC was found to affect FDP non significantly in Karan Swiss cattle. Dalal *et al.* (1991) in Friesian/Brown Swiss x Hariana crosses and Singh (1995) in Karan Swiss and Karan Fries also reported non-significant effect of AFC on FDP.

4.2.1.12. Average First Calving Interval (FCI) in Karan Swiss Cattle

The overall least squares mean of FCI was found to be 410.33±12.59 days in Karan Swiss cattle (Table 4.16). This estimate was near to the estimates reported by Kakran and Joshi (1990) in Karan Swiss, Pyne and Dattagupta (1994) in J x Hr crosses, Raheja *et al.* (1994a) in F x S crosses.

4.2.1.12.1. Effect of Genetic Group on First Calving Interval (FCI) in Karan Swiss Cattle

The influence of various genetic group on first calving interval was non significant as observed from least squares analysis of variance (Table 4.13). The average FCI was different genetic group ranged from 412.90±24.22days for BSH cross to 428.32±13.30 days in BS/BR crosses.

Parmar (1984) in HF x Sahiwal crosses and Sahana and Gurnani (2000) in Karan Fries also reported non significant effect of genetic group on FCI. However, significant effect of genetic group on FCI was reported by Bulte and Deshpande (1986), Singh and Bhat (1986).

Dalal *et al.* (1991) observed significantly lower calving interval among brown Swiss crosses in comparison to Holstein and Jersey crosses.

4.2.1.12.2. Effect of Paternal Generation on First Calving Interval (FCI) in Karan Swiss Cattle

The least squares analysis of variance indicated the non significant effect of paternal generation on FCI (Table 4.13). The lowest average FCI was observed in eighth generation (394.57±29.41 days) and highest average was observed in seventh generation (431.83±18.00 days). However, no specific trend was over the paternal generation for mean FCI.

4.2.1.12.3. Effect of Maternal Generation on First Calving Interval (FCI) in Karan Swiss Cattle

Maternal generation had non significant effect on FCI. A decreasing trend in mean FCI was observed over the generation except in seventh generation. The mean FCI was found to range between 432.26±14.45 days to 384.84±21.36 days (Table 4.16).

4.2.1.12.4. Effect of Season of Calving on First Calving Interval (FCI) in Karan Swiss Cattle

It was found that season of calving had statistically non significant effect on FCI in Karan Swiss herd. Present findings were in agreement with those reported by Su (1988) in Karan Swiss cattle at NDRI farm; Parmar *et al.* (1986) in F/RDxS crosses at PAU, Ludhiana; by Butte *et al.* (1986) and Deshpande *et al.* (1988) in FxS crosses at Military Farms and Singh (1995) in Karan Swiss cattle at NDRI farm.

4.2.1.12.5. Effect of Period of Calving on First Calving Interval (FCI) in Karan Swiss Cattle

The least squares average of FCI for periods varied from 385.23±21.57 (period-1) to 427.39±26.50 days (period 11). However, there was no consistent trend observed for FCI over the periods. The effect of period of calving was found to be statistically non-significant. Su (1988) and Singh *et al.* (1995) in Karan Swiss cattle also reported non-significant effect of period of calving on FCI. Basu and Deshpande *et al.* (1988) in F x S crosses at Military Farms and Panja (1997) in Karan Fries also reported non-significant effect of periods of FCI.

4.2.1.12.6. Effect of Age at First Calving on First Calving Interval (FCI) in Karan Swiss Cattle

It was found that AFC had statistically non-significant effect on FCI. Su (1988) and Singh (1995) at NDRI, Karnal and Dalal *et al.* (1991) at Hisar also reported non-significant effect of AFC on FCI in Brown Swiss crosses.

4.2.1.13. Average Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

The overall least squares average of MY/FLL as found to be 8.72±0.24 kg per day. (Table 4.16). Kakran and Joshi (1990) and Singh *et al.* (1995) in Karan Swiss cattle at this farm reported in F x S crosses by Parmar *et al.* (1986) at PAU, Ludhiana; Butte and Deshpande (1987) at Parbhani; Jadhav *et al.* (1991a) and Arora *et al.* (1993) at Military Farms. The estimates in their findings ranged from 8.32 kg to 9.30 kg per day. However, Singh (1995), Panja (1997) and Sivakumar (1998) in Karan Fries reported higher estimate of MY/FLL.

4.2.1.13.1. Effect of Genetic Groups on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

The various genetic groups did not differ significantly in average MY/FLL. The mean MY/FLL over different groups ranged from 8.23±0.39 kg (BT crosses) to 9.54±0.27 kg (BS/BR crosses).

F_1 animal from Brown Swiss x Sahiwal (BS) or Brown Swiss x Red Sindhi (BR) found to perform better than the F_1 from Brown Swiss x Tharparkar crosses (BT).

4.2.1.13.2. Effect of Paternal Generation on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

The paternal generation wise average of MY/FLL was presented in Table 4.16. It was found to range between 9.66±0.35 kg in sixth generation to 8.82±0.52 kg in eight in generation. However, average of MY/FLL observed in second, third, fourth and fifth generation did not differ significantly from each other.

4.2.1.13.3. Effect of Maternal Generation on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

The least squares analysis of variance indicated significant effect (P<0.01) of maternal generation on MY/FLL in Karan Swiss cattle (Table 4.13). The animals belong to first generation haad highest mean of MY/FLL (9.46±0.30kg) while lowest mean of MY/FLL (8.32kg) in both the second and third generation. The mean values of MY/FLL presented in the Table 4.16 did not show any specific trend over the generations.

4.2.1.13.4. Effect of Season on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

The least squares average of MY/FLL ranged from 8.45±0.25 kg per day for summer season to 9.15±0.31 kg per day for autumn season. The effect of season of calving, however, was found to be statistically significant (Table 4.13).

Significant effect of season on MY/FLL was reported by Kakran and Joshi (1990), Garcha *et al.* (1991), Jadhav *et al.* (1991a), Arora *et al.* (1993) and Sinha (1999).

Non Significant effect of season on MY/FLL was reported in FxS crosses by Reddy and Basu (1985), Butte and Deshpande (1987), Singh *et al.* (1993) at Military Farms, Parbhani and Pantnagar, respectively.

4.2.1.13.5. Effect of Period of Calving on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

Period of calving was found to have significant ($P<0.01$) effect on MY/FLL in Karan Swiss cattle (Table 4.13). Highest least squares average was found for period-7 (9.93±0.45 kg per day) and lowest for period 10 (7.06±0.53 kg per day).

Significant effect of period on MY/FLL in Karan Swiss cattle was reported by Kakran and Joshi (1990) and Singh (1995) and in FxS crosses by Roy (1986), Jadhav *et al.* (1991a) and Arora *et al.* (1993) at Military Farms and by Parmar *et al.* (1986) and Garcha *et al.* (1991) at PAU, Ludhiana.

4.2.1.13.6. Effect of Age at First Calving on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Swiss Cattle

The effect of AFC on MY/FLL was found to be statistically significant ($P<0.01$). However, Singh (1995) reported non-significant effect of AFC on MY/FLL in Karan Swiss

4.2.1.14. Average Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

The overall least squares mean of MY/FCI in Karan Swiss cattle was found to be 7.56±0.28 kg/day (Table 4.16). Roy (1986), Jadhav *et al.* (1991b) and Arora *et al.* (1993) reported average MY/FCI as 8.0, 6.1 and 6.1 kg/day, respectively in FXS crosses at Military Farms. Parmar *et al.* (1986) and Garcha *et al.* (1991) reported MY/FCI as 7.3 and 7.6 kg/day, respectively at PAU Ludhiana in FXS crosses. In Karan Swiss cattle, Singh (1995) reported average MY/FCI as 7.18 kg/day.

4.2.1.14.1. Effect of Genetic Group on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

Average MY/FCI for different genetic groups were presented in the Table 4.16 and it was ranged from 7.04±0.53 kg (BSH crosses) to 7.97±0.30 kg (BS/BR crosses). However least squares analysis of variance (Table 4.13) showed that genetic groups had no significant effect on MY/FCI.

4.2.1.14.2. Effect of Paternal Generation on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

The least squares analysis of variance indicated significant ($P<0.05$) effect of paternal generation on MY/FCI. The maximum MY/FCI (8.50±0.35kg) was observed for first generation while minimum MY/FCI (6.63±0.06 kg) was observed for eight generation. However, average MY/FCI observed in third, fourth, fifth and in seventh generation respectively did not differ significantly from the average MY/FCI in eighth generation.

4.2.1.14.3. Effect of Maternal Generation on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

The influence of maternal generation on MY/FCI in Karan Swiss was non significant as observed from least squares analysis of variance (Table 4.13).

The average MY/FCI ranged from 7.64±0.03 in fifth generation to 7.02±0.27 kg in second and third generation.

Table 4.16. Least squares mean along with standard error of various first lactation traits and herd life in Karan Swiss cows.

Effect	FL 305DMY	FLTMY	FLL	FSP	FCI	FDP	MY/FLL	MY/FCI	HL
1	2	3	4	5	6	7	8	9	10
Overall	**2443.79 ± 101.22 (1660)**	**2791.14 ± 136.79 (1658)**	**331.69 ± 11.59 (1489)**	**123.58 ± 9.67 (1035)**	**410.33 ± 12.59 (1116)**	**76.39 ± 5.14 (1041)**	**8.72 ± 0.24 (1483)**	**7.56 ± 0.28 (1091)**	**2280.88 ± 113.02 (1636)**
Genetic Group									
1.	2763.30 ± 109.37 (318)	3240.70 ± 190.85 (318)	358.16 ± 15.04 (299)	126.73 ± 13.28 (226)	428.32 ± 13.30 (249)	72.30 ± 5.50 (229)	9.45 ± 0.27 (298)	7.97 ± 0.30 (245)	2971.35 ± 130.58 (393)
2.	2306.53 ± 111.58 (71)	2802.11 ± 150.12 (71)	342.47 ± 18.80 (67)	126.39 ± 14.26 (50)	418.33 ± 17.62 (54)	77.00 ± 6.53 (54)	8.23 ± 0.39 (67)	7.21 ± 0.39 (53)	2380.75 ± 183.68 (70)
3.	2348.53 ± 165.13 (28)	2566.94 ± 222.08 (28)	305.74 ± 23.08 (25)	129.38 ± 19.04 (15)	412.90 ± 24.22 (15)	76.11 ± 8.93 (15)	8.44 ± 0.48 (25)	7.04 ± 0.53 (15)	2174.01 ± 223.16 (28)
4.	2372.01 ± 105.33 (1243)	2680.41 ± 127.54 (1241)	323.99 ± 12.57 (1098)	122.31 ± 10.25 (744)	433.45 ± 12.72 (744)	77.62 ± 4.63 (743)	8.52 ± 0.25 (1093)	7.46 ± 0.27 (778)	2037.40 ± 114.08 (1145)
Paternal Generation									
1.	2732.01 ± 134.05 [a] (469)	3049.91 ± 180.43 [ab] (470)	321.20 ± 15.26 (435)	119.87 ± 12.29 (330)	400.39 ± 15.77 (359)	64.56 ± 6.32 (334)	9.49 ± 0.31 [a] (434)	8.50 ± 0.35 [a] (354)	2464.40 ± 149.93 [a] (472)
2.	2299.45 ± 115.57 [bc] (255)	2521.67 ± 160.96 [d] (255)	317.21 ± 13.68 (223)	111.17 ± 11.37 (137)	401.50 ± 14.63 (156)	68.83 ± 5.93 (137)	8.50 ± 0.28 [b] (221)	7.55 ± 0.32 [bc] (152)	2205.20 ± 133.83 [bc] (256)
3.	2333.26 ± 124.11 [bc] (242)	2607.44 ± 167.07 [cd] (242)	318.11 ± 14.11 (211)	111.63 ± 11.65 (138)	401.27 ± 14.95 (149)	72.03 ± 5.95 (141)	8.58 ± 0.29 [b] (211)	7.35 ± 0.33 [c] (145)	2152.13 ± 139.15 [bc] (242)
4.	2359.24 ± 135.72 [b] (197)	2724.50 ± 182.65 [bc] (197)	340.01 ± 15.56 (170)	122.07 ± 12.39 (127)	411.79 ± 15.88 (137)	72.35 ± 6.24 (132)	8.60 ± 0.32 [b] (168)	7.55 ± 0.35 [c] (133)	2323.58 ± 151.38 [abc] (199)
5.	2171.33 ± 137.42 [c] (180)	2532.10 ± 184.97 [d] (180)	323.69 ± 15.73 (161)	136.31 ± 13.01 (107)	424.00 ± 16.74 (107)	80.61 ± 6.53 (103)	8.13 ± 0.32 [b] (161)	7.28 ± 0.37 [c] (106)	2035.89 ± 154.17 [c] (179)
6.	2788.98 ± 148.72 [a] (178)	3237.99 ± 200.15 [a] (176)	346.51 ± 16.83 (158)	130.98 ± 13.46 (104)	417.16 ± 17.35 (112)	73.89 ± 6.70 (105)	9.66 ± 0.35 [a] (158)	8.24 ± 0.38 [ab] (106)	2380.28 ± 166.93 [abc] (158)
7.	2558.15 ± 155.96 [ab] (109)	3022.24 ± 209.87 [abc] (109)	344.97 ± 17.66 (104)	136.19 ± 14.04 (79)	431.83 ± 18.00 (82)	78.74 ± 6.99 (78)	8.76 ± 0.36 [ab] (104)	7.37 ± 0.40 [c] (82)	2453.24 ± 175.12 [ab] (106)
8.	2307.89 ± 235.34 [bc] (30)	2633.26 ± 319.65 [bcd] (29)	341.82 ± 27.40 (27)	120.46 ± 23.69 (13)	394.57 ± 29.41 (14)	100.09 ± 11.81 (11)	8.02 ± 0.57 [b] (26)	6.63 ± 0.66 [c] (13)	2232.34 ± 278.77 [abc] (24)

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1	2	3	4	5	6	7	8	9	10
Maternal Generation									
1.	2647.37 ± 124.85 (432)	3122.33 ± 168.11[a] (433)	349.60 ± 14.39 (402)	128.80 ± 11.27 (303)	432.26 ± 14.45 (332)	85.08 ± 5.85 (309)	9.46 ± 0.30[a] (401)	7.55 ± 0.32 (328)	2794.29 ± 138.51[a] (435)
2.	2369.57 ± 105.22 (578)	2705.03 ± 136.30[bc] (578)	334.78 ± 11.72 (510)	125.51 ± 9.43 (341)	419.41 ± 12.26 (374)	81.90 ± 5.08 (352)	8.32 ± 0.24[b] (507)	7.07 ± 0.27 (363)	2202.60 ± 112.73[b] (577)
3.	2341.92 ± 100.63 (338)	2623.28 ± 135.71[bc] (336)	326.07 ± 11.56 (299)	128.22 ± 9.45 (202)	418.34 ± 12.19 (212)	81.39 ± 5.06 (196)	8.32 ± 0.24[b] (297)	7.07 ± 0.27 (207)	2143.20 ± 112.19[b] (337)
4.	2322.16 ± 116.37 (178)	2584.81 ± 156.56[d] (178)	324.17 ± 13.29 (156)	117.78 ± 10.62 (114)	397.35 ± 13.64 (118)	75.51 ± 5.51 (112)	8.42 ± 0.27[b] (156)	7.41 ± 0.30 (116)	2205.27 ± 129.64[b] (172)
5.	2450.42 ± 141.40 (81)	2742.37 ± 190.71[bc] (80)	330.08 ± 16.20 (71)	121.36 ± 13.10 (47)	392.91 ± 16.62 (51)	78.42 ± 6.63 (46)	8.66 ± 0.33[ab] (71)	7.64 ± 0.37 (49)	2202.31 ± 162.65[b] (70)
6.	2309.19 ± 176.27 (42)	2569.93 ± 237.51[d] (42)	297.89 ± 19.61 (41)	88.30 ± 16.68 (23)	384.84 ± 21.36 (24)	69.49 ± 8.43 (21)	8.49 ± 0.40[ab] (41)	7.56 ± 0.48 (23)	2028.81 ± 206.65[ab] (35)
7.	2265.89 ± 298.95 (11)	3090.22 ± 402.49[b] (11)	359.26 ± 33.77 (10)	155.11 ± 30.76 (5)	427.18 ± 39.38 (5)	62.92 ± 14.56 (5)	8.35 ± 0.70[ab] (10)	7.63 ± 0.87 (5)	2389.68 ± 346.87[b] (10)
Season of Calving									
1.	2412.52 ± 103.14[ab] (857)	2782.43 ± 138.81[a] (859)	337.28 ± 11.98[a] (768)	122.05 ± 9.86[a] (526)	413.94 ± 12.80 (564)	77.07 ± 5.22 (527)	8.70 ± 0.24[ab] (765)	7.47 ± 0.28[b] (555)	2277.84 ± 115.85 (844)
2.	2398.44 ± 105.53[b] (484)	2844.86 ± 142.03[a] (482)	342.81 ± 12.05[a] (440)	139.77 ± 10.03[b] (295)	431.43 ± 13.06 (333)	78.39 ± 5.30 (305)	8.45 ± 0.25[b] (438)	7.35 ± 0.29[b] (323)	2203.05 ± 118.06 (471)
3.	2298.26 ± 113.25[b] (213)	2553.37 ± 152.36[b] (212)	318.45 ± 13.02[b] (180)	115.53 ± 10.62[a] (135)	395.45 ± 13.73 (139)	76.65 ± 5.50 (137)	8.57 ± 0.27[ab] (179)	7.42 ± 0.30[b] (135)	2203.42 ± 125.09 (216)
4.	2665.93 ± 132.89[a] (106)	2983.89 ± 178.81[a] (106)	328.23 ± 15.10[ab] (101)	116.98 ± 12.10[a] (79)	400.48 ± 15.59 (80)	73.44 ± 6.23 (72)	9.15 ± 0.31[a] (101)	8.01 ± 0.34[a] (78)	2439.20 ± 148.24 (105)

Contd……/-

Contd…./-

1	2	3	4	5	6	7	8	9	10
Period of Calving									
1.	2936.85 ± 204.18 [a] (36)	3222.20 ± 274.72 [a] (36)	358.88 ± 22.93 [bc] (35)	121.11 ± 17.17 (34)	385.23 ± 21.57 (36)	60.64 ± 8.55 [a] (29)	9.45 ± 0.47 [ab] (35)	8.40 ± 0.48 [ab] (35)	4182.88 ± 217.22 [a] (42)
2.	2620.10 ± 166.42 [ab] (76)	2970.32 ± 223.98 [abc] (76)	335.48 ± 19.08 [bc] (72)	126.77 ± 15.26 (58)	410.98 ± 18.87 (70)	86.00 ± 7.40 [bc] (61)	9.10 ± 0.39 [abcd] (72)	7.33 ± 0.42 [bcd] (68)	2725.34 ± 184.81 [b] (76)
3.	2376.79 ± 142.98 [bc] (186)	2591.30 ± 192.49 [bcd] (186)	315.27 ± 16.78 [bc] (156)	111.09 ± 13.66 (129)	397.90 ± 17.17 (142)	79.47 ± 6.70 [abc] (121)	9.40 ± 0.35 [ab] (156)	7.87 ± 0.38 [ab] (134)	2230.52 ± 159.38 [cd] (186)
4.	2375.05 ± 131.86 [bc] (333)	2707.14 ± 177.53 [bc] (333)	352.91 ± 15.39 [b] (297)	121.47 ± 12.82 (202)	404.94 ± 16.30 (217)	69.18 ± 6.37 [a] (201)	8.18 ± 0.32 [bcde] (296)	7.23 ± 0.36 [bcd] (216)	1752.89 ± 147.00 [cd] (334)
5.	2314.79 ± 122.80 [bc] (268)	2841.67 ± 165.39 [abc] (269)	379.04 ± 14.25 [a] (248)	138.67 ± 12.31 (141)	423.33 ± 15.61 (154)	74.66 ± 6.10 [abc] (157)	7.83 ± 0.29 [cde] (245)	6.95 ± 0.34 [cd] (152)	1806.84 ± 137.23 [cd] (265)
6.	2497.67 ± 116.51 [abc] (177)	2943.74 ± 156.90 [abc] (177)	358.13 ± 13.34 [ab] (159)	136.39 ± 11.03 (107)	418.61 ± 14.32 (116)	73.10 ± 5.73 [abc] (114)	8.72 ± 0.27 [abcde] (158)	7.62 ± 0.31 [bcd] (115)	2249.40 ± 130.02 [cd] (177)
7.	2776.19 ± 185.53 [ab] (192)	3155.46 ± 249.71 [ab] (192)	320.58 ± 21.63 [bc] (169)	118.22 ± 16.07 (126)	403.84 ± 20.24 (131)	71.53 ± 7.91 [ab] (126)	9.93 ± 0.45 [a] (169)	8.57 ± 0.45 [ab] (129)	2302.42 ± 205.74 [bc] (193)
8.	2464.60 ± 203.17 [ab] (150)	2781.51 ± 273.45 [abc] (150)	303.10 ± 23.49 [c] (137)	111.74 ± 17.52 (104)	389.91 ± 22.19 (104)	79.58 ± 8.63 [abc] (98)	9.24 ± 0.49 [abc] (137)	7.76 ± 0.49 [bc] (103)	2410.99 ± 225.25 [bc] (150)
9.	2798.25 ± 200.27 [ab] (117)	3210.30 ± 269.47 [ab] (117)	331.54 ± 23.32 [bc] (110)	129.82 ± 17.37 (72)	426.17 ± 22.06 (81)	79.51 ± 8.55 [abc] (79)	9.64 ± 0.49 [ab] (110)	8.77 ± 0.49 [a] (79)	2146.00 ± 223.43 [cd] (110)
10.	1776.26 ± 213.07 [c] (76)	2043.81 ± 286.65 [d] (76)	297.83 ± 25.33 [c] (66)	127.08 ± 20.12 (32)	425.30 ± 25.11 (36)	94.45 ± 9.75 [c] (32)	7.06 ± 0.53 [e] (65)	6.24 ± 0.56 [d] (34)	1728.11 ± 237.55 [d] (71)
11.	1945.12 ± 237.97 [c] (49)	2235.08 ± 323.80 [cd] (46)	315.84 ± 28.49 [bc] (40)	117.06 ± 21.85 (23)	427.39 ± 26.50 (29)	72.37 ± 10.50 [ab] (23)	7.32 ± 0.59 [de] (40)	6.44 ± 0.60 [cd] (26)	1554.30 ± 286.14 [d] (32)

Figures in the parenthesis indicate number of observations

4.2.1.14.4 Effect of Season of Calving on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

Significant (P<0.01) effect of season calving on MY/FCI was found in the present study (Table 4.13). the least squares average of Karan Swiss cattle according to season of calving ranged form 7.35±0.29 kg/day for summer season to 8.01±0.34 kg/day for autumn season. However MY/FCI of winter calver, and rainy season calver no significantly different from summer calver. Significant effect of season on MY/FCI was reported by Singh (1987), Patel *et al.* (1989), Jadhav *et al.* (1991a). However, non significant effect of season of calving on MY/FCI was reported by Butte and Deshpande (1987) at Parbhani and by Garcha *et al.* (1991) at PAU, Ludhiana in FxS crosses.

4.2.1.14.5. Effect of Period of Calving on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

MY/FCI was found to be significantly (P<0.01) affected by period of calving in Karan Swiss cattle (Table4.13). The highest least squares average occurred for period 9 (8.77±0.49 kg) and lowest for period 10 (6.24±0.56 kg).

4.2.1.14.6. Effect of Age at First Calving on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Swiss Cattle

The effect of age at first calving on MY/FCI was found to be statistically non-significant. Non-significant effect of AFC on this trait as reported by Garcha *et al.* (1991) in FxS crosses and by Singh (1995) in Karan Swiss as well as Karan Fries.

4.2.1.15. Average Herd life (HL) in Karan Swiss Cattle

The overall least squares mean for herd life in Karan Swiss was presented in the Table 4.16 and the value was 2280.88±113.02 days.

4.2.1.15.1. Effect of Genetic Groups on Herd life (HL) in Karan Swiss Cattle

Maximum mean herd life was observed for BS/BR crosses (2971.35±130.58 days) whereas, minimum HL was observed for KS *interse*

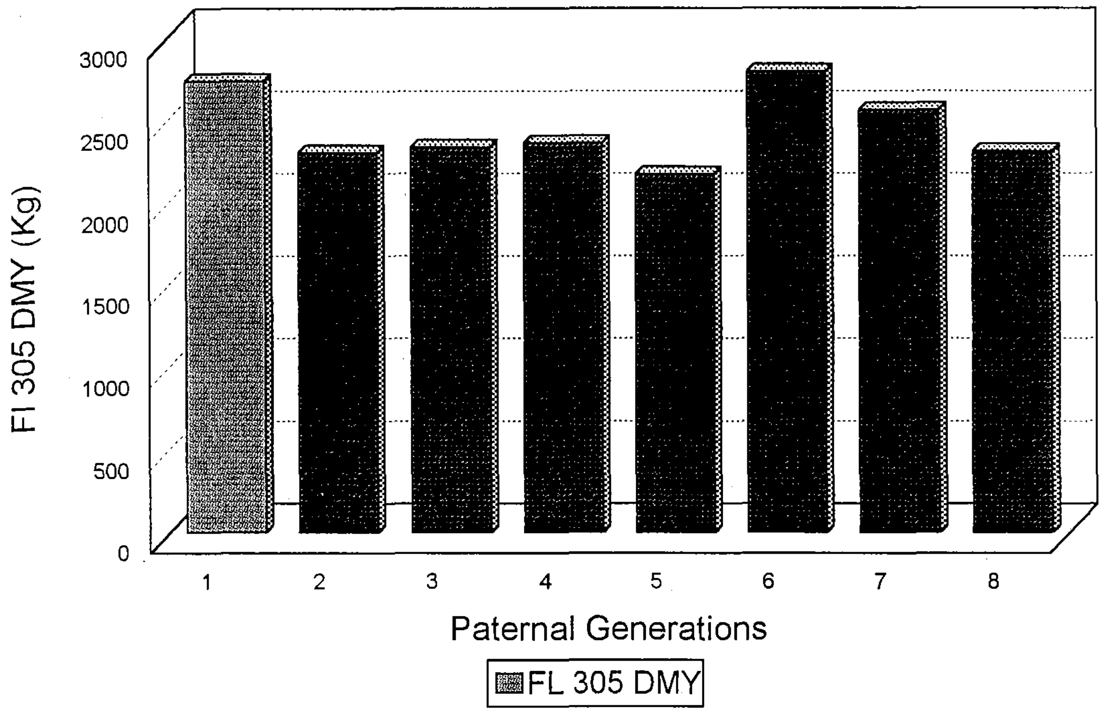

Fig.4.5. Paternal Generationwise first lactation 305 day milk yield in Karan Swiss cows

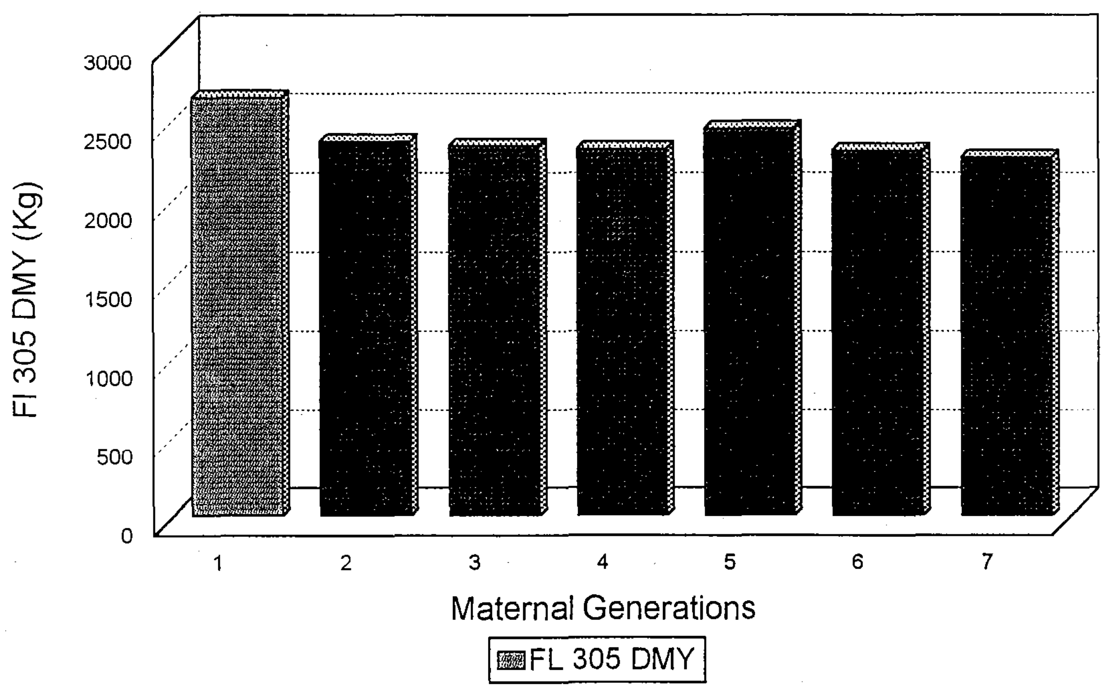

Fig.4.6. Maternal Generationwise first lactation 305 day milk yield in Karan Swiss cows

mated animals (2032.40±114.80 days). However, HL over the different genetic groups did not found the significantly different from each other (Table 4.16).

4.2.1.15.2. Effect of Paternal Generation on Herd life (HL) in Karan Swiss Cattle

The least squares analysis of variance indicated a highly significant effect ($P<0.01$) of paternal generation on HL in Karan Swiss cattle (Table 4.13). The animals in the first generation were found to have highest average HL (2464.40±149.93 days) while lowest average HL (2035.89±154.17 days) was observed for the animals belonging to fifth generation.

4.2.1.15.3. Effect of Maternal Generation on Herd life (HL) in Karan Swiss Cattle

The influence of maternal generation on HL was highly significant ($P<0.01$) as observed from least squares analysis of variance (Table 4.13).

The animals belonging to first generation from maternal side had maximum average HL (2794.29±138.51 days). The mean HL as observed over different maternal generation from second generation onward was not statistically significantly different from each other (Table 4.16). However, no specific trend in HL was observed over the maternal generations in Karan Swiss cattle.

4.2.1.15.4. Effect of Season of Calving on Herd life (HL) in Karan Swiss Cattle

Effect of calving was found to have no significant effect on HL. Maximum HL was observed for autumn calvers (2439.20±148.24 days) whereas minimum herd life was observed for summer season calvers (2203.05±118.06 days). Whereas animal which calved during winter season and rainy season had HL 2277.84 days and 2203.42 days respectively.

4.2.1.15.5. Effect of Period of Calving on Herd life (HL) in Karan Swiss Cattle

Period of calving had significant effect ($P<0.01$) on HL. Animals calved in period 1 had maximum herd life (4182.88±217.22). It may due to the presence of more F_1 during that period who were found to be superior in performance and kept for longer time in the herd. However, minimum herd life was found for those animals which calved during period 11.

4.2.1.15.6. Effect of Age at First Calving on Herd life (HL) in Karan Swiss Cattle

AFC found to have significant effect on HL in Karan Swiss cattle (Table 4.13).

4.2.2. Estimation of Average Performance and the Effect of Various Genetic and Non Genetic Factors on Various Growth, First Lactation Traits and Herd Life in Karan Fries cattle

4.2.2.1. Average Birth Weight (BWT) in Karan Fries Cattle

The overall least squares mean for birth weight was 26.16±0.35 kg (Table 4.20). This estimate was higher than those reported by Bhat *et al.* (1982) as 23 kg; Narayanswamy *et al.* (1984) as 25 kg; Shrivastaav *et al.* (1985) as 23 kg; Nautiyal and Bhat (1989a) as 24 kg in Friesian x Hariana at IVRI, Izatnagar and Dhangarand Patel (1992a) in Frisian crosses at GAU..

4.2.2.1.1. Effect of Genetic Groups on Birth Weigh (BWT) in Karan Fries Cattle

The influence of various genetic group on BWT was observed highly significant P($\leq$0.01) in Karan Fries cattle Table 4.17. The average BWT observed in HT, HBT and KF *interse* mated animals ere 27.14kg, 27.64kg and 26.26kg, respectively. These estimates were not statistically significantly different from each other. The lowest BWT (23.56±0.67kg) was observed for HJT crosses.

4.2.2.1.2. Effect of Paternal Generation on Birth Weight (BWT) in Karan Fries Cattle

Effect of paternal generations on BWT was observed to be non significant. maximum birth weight was observed in first generation (26.93±0.51) while minimum birth weight was in fourth generation (26.14±0.07kg). A decreasing trend was observed for birth weight over the generations (Table 4.20) .

4.2.2.1.3. Effect of Maternal Generation on Birth Weight (BWT) in Karan Fries Cattle

Significant effect of maternal generation on BWT was observed in Karan Fries. The average birth weight over the maternal generations ranged from 25.18±0.75kg (seventh generations) to 27.29±0.40kg (second generation). However, average birth weight of animal in the first, third and seventh generation did not differ significantly from each other. There was no specific trend in birth weight observed over the generations (Table 4.20).

4.2.2.1.4. Effect of season of birth on birth weight in Karan Fries females

BWT was found to be statistically significantly affected by season of birth ($P<0.01$). The highest least squares mean birth weight (27.19±0.35 kg) was found for the female calves born during winter, whereas; it was lowest (24.97±0.42kg) for calves born during autumn (Table 4.20). This may be due to comparatively poor availability of green fodder during early part of November.

Significant effect of season/month on birth weight was also reported by Rao and Nagarcenkar (1979), Narayanswamy *et al.*, (1984), Su (1988), Tajane and Rai (1989a), Dhangar and Patel (1992a) and Singh (1995) crossbred calves. However, Bhat *et al.* (1982) and Nautiyal and Bhat (1989a) observed non-significant effect of season/month of birth on birth weight.

4.2.2.1.5. Effect of Period of Birth on Birth Weight (BWT) in Karan Fries Cattle

Period of birth was found to have significant ($P<0.01$) effect on birth weight. There was no specific trend of birth weight over the periods. The birth weight varied from 24.80±0.62kg (Period 8) to 27.15±0.71 kg(Period 1). The birth weight for period 8 differed significantly while there was no significant difference in birth weight between the birth weight in all other periods (Table 4.20).

4.2.2.2. Average Weight at One Year (WOY) in Karan Fries Cattle

The overall least squares mean for WOY was 179.77±2.29 kg. Rao and Nagarcenkar (1979), Taneja and Bhat (1982), Roy and Tripathi (1991) reported 197, 209 and 211 kg body weight at one year of age, respectively in Friesian x Sahiwal crossbreds atMilitary Farms. Nautiyal and Bhat (1989a) at IVRI, Izatnagar; Chopra *et al.* (1990) in North India; Su (1988) at NDRI Farm, Karnal reported 165, 160 and 180 kg one year weight, respectively.

4.2.2.2.1. Effect of Paternal Generation on Body Weight at One Year (WOY) in Karan Fries Cattle

Paternal generation found to have a non significant effect on WOY in Karan Fries cattle (Table 4.18). Maximum average was observed (182.66±4.15 kg) in third generation which was very close to WOY at second generation (182.21±4.88kg). Minimum WOY (175.21±6.55kg) was found in first generation. An increasing trend in WOY upto third generation was observed (Table 4.21).

4.2.2.2.2. Effect of Maternal Generation on Body Weight at One Year (WOY) in Karan Fries Cattle

The least squares analysis of variance ($P<0.01$) showed highly significant effect of maternal generation on WOY. Highest WOY was observed at first generation (204.25±6.57) while lowest WOY was observed at third generation (168.50±3.23kg). WOY from second generation onward did not differ significantly from each other. No specific trend was observed for WOY in the present study.

4.2.2.2.3. Effect of Season of Birth on Weight at One Year (WOY) in Karan Fries Cattle

Season of birth had significant effect on WOY of Karan Fries females (Table 4.18). The females born during summer season were found to have maximum body weight (192.36±3.01kg). The WOY of females born autumn seasons were lowest (160.33±3.58kg), respectively (Table 4.21) which was significantly different from the average WOY of females born during other seasons.

Significant effect of season of WOY was also reported by Taneja and Bhat (1982), Naryanswamy *et al.* (1984), Su (1988) and Roy and Tripathi (1991) in Friesian crossbreds at various dairy farms in India and by Singh (1995) in Karan Swiss and Karan Fries. However, Shrivastav *et al.* (1985) and Nautiyal and Bhat (1989b) did not notice significant effect of season on this trait in crossbred cattle.

4.2.2.2.4. Effect of Period of Birth on Weight at One Year (WOY) in Karan Fries Cattle

Period of birth was found to have significant ($P<0.01$) effect on WOY. There was no specific trend in WOY was observed. The maximum WOY was observed of females born in Period 1 (211.09±8.03kg). The minimum WOY was observed in Period 3 (123.64±11.63kg) which was significantly different from corresponding body weights during all other periods of birth (Table 4.21).

Significant effect of period of birth on WOY was also reported by Shrivastav *et al.* (1985), Nautiyal and Bhat (1989b), Jadhav (1990) and Roy and Tripathi (1991) in crossbred cattle at various Military Farms in India and by Singh (1995) in Karan Swiss and Karan Fries cattle at NDRI Farm.

4.2.2.3. Average Weight at First Fertile Service (WFS) in Karan Fries Cattle

The overall least squares mean of WFS was found to b 303.11±4.91 kg (Table 4.21). This estimate was close to those reported by Narayanswamy *et al.* (1984) in Frisian crosses at MDF and Singh (1995) in Karan Swiss and Karan Fries at NDRI, Karnal. Whereas, Nagarcenkar and Rao (1982) and Sethi *et al.* (1982) reported lower (<286 kg) estimates of WFS in crossbred cattle.

4.2.2.3.1. Effect of Paternal Generation on Weight at First Fertile Service (WFS) in Karan Fries Cattle

The effect of paternal generation on WFS as found statistically significant ($P<0.05$) (Table 4.18). Maximum average WFS was observed for the animals belong to second generation from sire side (320.24±7.68kg). However, minimum WFS (282.06±10.35kg) was observed in first generation, which was significantly different from those animals belongs to other generations. No specific trend for WFS was observed over the generations.

4.2.2.3.2. Effect of Maternal Generation on Weight at First Fertile Service (WFS) in Karan Fries Cattle

The present study indicated non significant of maternal generation on WFS (Table 4.18). No trend in WFS over different maternal generations was found. however animals in seventh generation have minimum WFS (294.94±17.60 kg) and maximum WFS (314.59±8.38 kg) was observed for first generation animals.

4.2.2.3.3. Effect of Season of Birth on Weight at First Fertile Service (WFS) in Karan Fries Cattle

Least squares analysis of variance revealed significant ($P<0.05$) effect of season of birth on WFS (Table 4.18). The heifers which born during summer had significantly higher body weights (312.29±5.64kg) as compared to heifers born during ,other seasons (Table4.21). This may be due to availability of good quality of green fodder during months (winter season) preceding to their sexual maturity (about 23 months of age).

Significant effect of season of birth on WFS was also reported by Reddy and Basu (1985) and Jadhav *et al.* (1991a) in Friesian crossbreds at Military Farms and Singh (1995) at NDRI, Karnal. however, Nautiyal and Bhat (1989a), Patel *et al.* (1989), Rana (1991) and Dhangar and Patel (1993) did not observe significant effect of season of birth on WFS in various grades of crossbred cattle.

4.2.2.3.4. Effect of Period of Birth on Weight at First Fertile Service (WFS) in Karan Fries Cattle

The period of birth was found to have a significant effect ($P<0.01$) on WFS (Table 4.18). The WFS varied from 273.07±9.08; kg (Period 8) to 334.43±31.04 kg (Period 3). However, no consistent trend was observed over the periods of birth for this trait. Nagarcenkar and Rao (1982) in Frisian and Brown Swiss crosses, Narayanswamy *et al.* (1984) in Frisian crosses, Joshi *et al.* (1991) in Karan Swiss also reported significant effect of period on WFS. However, Sethi *et al.* (1982) and Su (1988) reported non-significant effect of period on WFS in Friesian and Brown Swiss crosses at NDRI, Karnal.

4.2.2.4. Average Weight at First Calving (WFC) in Karan Fries Cattle

The overall least squares mean of WFC was found to be 366.85±5.08 kg (Table 4.21). This estimate is close to those reported by Tajane and Rai (1989a) in Frisian crosses at MDF. However, higher estimates were reported by Reddy and Basu 91985) as 384kg; Singh *et al.* (1990), Jadhav *et al.* (1991) and Rana (1991) as 390 kg; and Arora *et al.* (1993) as 391 kg in Friesian crossbreds. Nautiyal and Bhat (1989a) and Dhangar and Patel (1993) observed considerably lower average bodyweight at first calving in crossbred cattle at Military Farms and Krushinagar Farm (GAU), respectively.

4.2.2.4.1. Effect of Paternal Generation on Weight at First Calving (WFC) in Karan Fries Cattle

The least squares analysis of variance indicated non-significant effect of paternal generation on WFC (Table 4.18). The minimum WFC was found (354.88±11.86kg) in first generation while maximum WFC (373.67±7.43kg) as observed in fourth generation. An increasing trend in WFC over the generations was observed (except in second generation) in the present study.

4.2.2.4.2. Effect of Maternal Generation on Weight at First Calving (WFC) in Karan Fries Cattle

Analysis of variance (Table 4.18) indicated that effect of maternal generation was non significant. Overall a decreasing trend was observed with respect to WFC over the generations. The average WFC varied from 351.51±16.23 kg (seventh generation) to 383.33±9.77 kg (first generation).

4.2.2.4.3. Effect of Season of Birth on Weight at First Calving (WFC) in Karan Fries Cattle

The season of birth had significant ($P<0.05$) effect on WFC in Karan Fries cattle (Table 4.18). The WFC according to season of birth varied from 362.81±5.59 kg (Season 1) to 374.03±5.90 kg (season 3). The winter and autumn born heifers differ significantly from summer and rainy season born heifers (Table 4.21).

Significant effect of season of birth on WFC was also reported by Reddy and Basu (1985), Roy (1986), Rana (1991), Jadhav *et al.* (1991) in Friesian crossbreds at Military Farms and by Singh (1995) in Karan Swiss and Karan Fries at NDRI, Karnal. However, Nautiyal and Bhat (1989a), Tajane and Rai (1989a), Dhanar and Patel (1992) reported non-significant effect of season of birth on this trait.

4.2.2.4.4. Effect of Period of Birth on Weight at First Calving (WFC) in Karan Fries Cattle

The WFC varied from 334.76±10.04kg (Period-1) to 389.80±5.83 kg (Period 6), but their was no consistent trend over the periods of birth. The effect of period of birth on WFC in Karan Fries heifers was found to be statistically significant (Table 4.18).

Reddy and Basu (1985), Roy (1986), Joshi *et al.* (1991) and Rana (1991) and Dhangar and Patel (1993) also reported significant effect of period on WFC.

However, Pandey *et al.* (1988) in FxH; Patel *et al.* (1989) and Dhangar and Patel (1993) in Jersey crosses reported non-significant effect of period of birth on weight at first calving.

4.2.2.5. Average Age at First Fertile Service (AFS) in Karan Fries Cattle

The overall lest squares mean for AFS in Karan Fries heifers was found to be 745.46±14.32 days (Table 4.20).

The results obtained in the present study were in agreement with those reported by Kaushik *et al.* (1979) in F/B/J x H crosses. However, Nagarcenkar and Rai (1982), Singh 1995) and Nagore and Kulkarni observed lower estimate of AFS compared to the present study.

4.2.2.5.1. Effect of Genetic Group on Age at First Fertile Service (AFS) in Karan Fries Cattle

Present study conducted on Karan Fries cattle revealed that genetic group had significant effect on AFS (Table 4.17). HT crosses were found to attain early puberty, where average AFS observed as 594.69±26.75 days. However, HJT crosses, HBT crosses and KF *interse* mated animals were not found to be significantly different from each other. The maximum AFS was observed in HS crosses (826.95±22.72 days).

4.2.2.5.2. Effect of Paternal Generation on Age at First Fertile Service (AFS) in Karan Fries Cattle

There was no clear cut trend was observed over in AFS over the generations (Table 4.20). The average AFS of the animals belong second generation was maximum (769.63±19.29 days) while in the third generation minimum average of AFS was observed (731.49±18.54 days). However, the effect of paternal generation on AFS found to be statistically significant ($P<0.05$).

4.2.2.5.3. Effect of Maternal Generation on Age at First Fertile Service (AFS) in Karan Fries Cattle

A fluctuating trend was observed for AFS over the maternal generations. Minimum average AFS (638.45±21.69days) was observed for the animals in first generation and maximum average AFS (800.69±23.57 days) for the animals in sixth generation. Lower AFS in the first generation may be due to the early attainment of puberty by F1 and animals with high level of exotic inheritance. However, the effect of maternal generation was found statistically significant ($P<0.01$) (Table 4.17).

4.2.2.5.4. Effect of Season of Birth on Age at First Fertile Service (AFS) in Karan Fries Cattle

The season of birth had non significant influence on AFS in Karan Fries heifers. The results were in agreement with those reported by Sethi *et al.* (1982), Pyne *et al.* (1988), Singh *et al.* (1990) and Wagh *et al.* (1991) and Singh (1995) in crossbred heifers.

4.2.2.5.5. Effect of period of birth on Age at First Fertile Service (AFS) in Karan Fries Cattle

The least squares ANOVA revealed significant (P<0.01) effect of period of birth on AFS in Karan Fries heifers (Table 4.17). The AFS for various periods of birth varied from 683.12 ±24.91 days (Period 5) to 798.15±16.81 days (Period 3). Similar to the present study Singh (1990), Wagh *et al.* (1991) also found significant effect of period on AFS.

4.2.2.6. Average Age at First Calving (AFC) in Karan Fries Cattle

The overall least squares mean for AFC as estimated in the present study was 1009.40±13.53 days (Table 4.20). The estimate obtained in the present study was in close agreement with those reported by Kaushik *et al.* (1979), Yazdani *et al.* (1993) and Singh (1995) in Karan Swiss cattle, whereas Nagarcenkar and Rao (1982), Parmar *et al.* (1986), Kumar (1987), Arora *et al.* (1993) and Nagore and Kulkarni (2000) reported lower AFC (800-900 days) and Pandey and Desai (1973), Reddy and Basu (1985), Rana (1991) and Rao *et al.* (2000) reported slightly higher average AFC (above 10.66 days) in Friesian crosses.

4.2.2.6.1. Effect of Genetic Group on Age at First Calving (AFC) in Karan Fries Cattle

The effect of genetic group was highly significant (P<0.01) on AFC (Table 4.20). AFC was highest among HS crosses (1982.16±24.97days) and lowest average AFC was observed in case of HT (F_1) crosses (854.93±18.76 days) For HJT, BHT and KF *interse* mated crosses the average AFC was 941.76±21.70 days, 996.07±24.37 days, and 1028.69±11.18 days, respectively. Among these genetic groups, HJT, HBT and KF did not differ significantly for average AFC. Similar to the observation of present study, Aziz and Sadhu (1983), Kale *et al.* (1984), and Parmar *et al.* in Holstein x Sahiwal crosses and Sahana and Gurnani (2000) in Karan Fries cattle reported that the halfbreds had the lowers age at first calving. Similar to the present study effect of grade on AFC was found to be significant by Nobre *et al.* (1984a) and Reddy and Basu (1985).

4.2.2.6.2. Effect of Paternal Generation on Age at First Calving (AFC) in Karan Fries Cattle

The effect of paternal generation was highly significant (P<0.01) (Table 4.16). The lowest average AFC (990.62±20.17days) was found in he first generation whereas, highest average AFC (1935.60±17.45days) was observed in second generations. However animals belong to the second generation were found to be significantly different from those animals in first and third generation for AFC.

Sinha (1999) in Karan Fries reported minimum average AFC for first generation animals where as maximum AFC as observed for the animals in the fourth generation.

4.2.2.6.3. Effect of Maternal Generation on Age at First Calving (AFC) in Karan Fries Cattle

The influence of maternal generation on AFC was found to be highly significant (P<0.01) (Table 4.16). The minimum AFC was observed in first generation (990.62±20.17 days) while maximum AFC was in sixth generation (1959.22±22.44 days). Similar to the results observed in present study Sinha (1999) in Karan Fries animals also reported shortest and longest AFC in first and sixth generation respectively.

4.2.2.6.4. Effect of Season of Birth on Age at First Calving (AFC) in Karan Fries Cattle

The season of birth did not have significant effect on AFC in Karan Fries heifers (Table 4.16). The results were in agreement with those reported by Reddy and Basu (1985), Parmar *et al.* (1986), Jadhav *et al.*

Table 4.17. Least squares analysis of variance (MSS Value) ff BWT, AFS, AFC In Karan Fries cows

Source of variation	BWT	AFS	AFC
Genetic Group	439.413** (4)	232076.520** (4)	334278.750** (4)
Paternal Generation	3.868 (3)	63515.500* (3)	69588.820** (3)
Maternal Generation	228.974** (6)	202046.830** (6)	214295.300** (6)
Season of birth	504.673** (3)	8071.940 (3)	3888.140 (3)
Period of birth	112.280** (7)	164837.450** (7)	216974.500** (7)
Error	23.212 (2648)	21877.710 (1536)	20956.640 (1620)

Table 4.18. Least squares analysis of variance (MSS Value) of WOY, WFS, WFC In Karan Fries cows

Source of variation	WOY	WFS	WFC
Paternal Generation	544.720 (3)	6667.870* (3)	1403.670 (3)
Maternal Generation	6547.120** (6)	1824.870 (6)	3300.650 (6)
Season of birth	31116.070** (3)	6964.600* (3)	7351.160* (3)
Period of birth	41009.840** (7)	7776.240** (7)	9524.50** (7)
Error	1171.52 (997)	1872.340 (737)	2215.94 (794)

* Significant (P<0.05), ** Significant (P <0.01) Figures in the parentheis are degrees of freedom

Table 4.19. Least squares analysis of variance (MSS Value) of various first lactation traits and herd life in Karan Fries cows

Source of variation	FL 305 DMY	FLTMY	FLL	FSP	FDP	FCI	MY/FLL	MY/FCI	HL
Genetic group	12074124.000** (4)	18697458.000** (4)	17384.75 (4)	11907.141 (4)	7356.223* (4)	16119.373 (4)	95.578** (4)	46.879** (4)	6366075.000** (4)
Paternal Generation	1620171.500 (3)	8187430.50** (3)	39362.66** (3)	22319.369* (3)	2798.122 (3)	13825.294 (3)	10.339 (3)	12.598* (3)	1428045.00 (3)
Maternal Generation	2593273.500** (6)	1561765.10 (6)	27803.36* (6)	22500.023* (6)	893.872 (6)	20984.197* (6)	47.952** (6)	21.316** (6)	7189240.00** (6)
Season of calving	2592200.500* (3)	5122858.50* (3)	17012.85 (3)	37302.840** (3)	1910.277 (3)	50014.535** (3)	16.853 (3)	5.969 (3)	174233.800 (3)
Period of calving	3055992.800** (6)	1412414.90 (6)	18601.240 (6)	6946.973 (6)	3959.352 (6)	9597.966 (6)	54.225** (6)	5.611 (6)	4839156.50** (6)
Regression	9951580.0** (1)	16434309.00** (1)	37008.598 (1)	5618.471 (1)	2047.305 (1)	14855.887 (1)	618.31287** (1)	125.82376** (1)	17812702.00** (1)
Error	695089.100 (1430)	1577898.90 (1423)	10228.030 (1399)	7039.065 (1012)	2268.285 (1034)	8357.021 (1048)	8.857 (1394)	3.997 (1024)	782011.81 (1365)

* Significant (P<0.05), ** Significant (P <0.01) Figures in the parenthesis are degrees of freedom

Table 4.20. Least squares mean along with standard error of BWT, AFS, AFC in Karan Fries cows

Effect	BWT	AFS	AFC
1	2	3	4
Overall	**26.16 ± 0.35 (2672)**	**745.46 ± 14.32 (1560)**	**1009.40 ± 13.53 (1644)**
Genetic Groups			
1.	27.14 ± 0.27 [a] (121)	594.69 ± 26.75 [a] (108)	854.93 ± 18.76 [a] (111)
2.	25.33 ± 0.48 [b] (73)	826.95 ± 22.72 [c] (39)	1082.16 ± 24.47 [c] (64)
3.	23.56 ± 0.67 [b] (150)	687.01 ± 25.26 [ab] (102)	941.76 ± 21.70 [a] (158)
4.	27.64 ± 0.57 [a] (58)	741.04 ± 11.93 [b] (65)	996.07 ± 24.37 [b] (65)
5.	26.26 ± 0.78 [a] (2270)	760.99 ± 19.60 [b] (1246)	1028.69 ± 11.18 [bc] (1246)
Paternal Generation			
1.	26.93 ± 0.51 (724)	733.65 ± 21.35 [ab] (522)	990.62 ± 20.17 [a] (558)
2.	26.27 ± 0.45 (590)	769.63 ± 18.29 [b] (354)	1035.60 ± 17.45 [b] (368)
3.	26.28 ± 0.44 (777)	731.49 ± 18.54 [a] (368)	1000.24 ± 17.64 [a] (385)
4.	26.14 ± 0.47 (581)	747.07 ± 18.88 [ab] (316)	1011.14 ± 17.87 [ab] (333)
Maternal Generation			
1.	25.43 ± 0.59 [bc] (264)	638.45 ± 21.69 [a] (191)	894.78 ± 20.90 [a] (221)
2.	27.29 ± 0.40 [a] (688)	762.51 ± 16.20 [bc] (460)	1022.92 ± 15.36 [b] (472)
3.	25.29 ± 0.41 [c] (607)	765.45 ± 16.41 [bc] (347)	1027.52 ± 15.51 [b] (360)
4.	26.38 ± 0.42 [b] (479)	759.52 ± 16.93 [b] (275)	1028.03 ± 16.01 [b] (293)
5.	26.71 ± 0.44 [ab] (374)	756.68 ± 18.23 [b] (201)	1021.51 ± 17.33 [b] (207)
6.	26.81 ± 0.51 [ab] (203)	800.69 ± 23.57 [a] (69)	1059.22 ± 22.44 [b] (72)
7.	25.18 ± 0.75 [c] (57)	734.97 ± 39.20 [b] (17)	1011.83 ± 36.45 [b] (19)

Contd...../-

Contd...../-

1	2	3	4
Season of Birth			
1.	27.19 ± 0.35 [a] (1090)	744.39 ± 14.30 (631)	1009.01 ± 13.46 (668)
2.	26.44 ± 0.40 [b] (544)	745.71 ± 16.47 (313)	1012.21 ± 15.57 (328)
3.	26.02 ± 0.39 [b] (656)	739.36 ± 16.00 (395)	1004.90 ± 15.09 (415)
4.	24.97 ± 0.42 [c] (382)	752.39 ± 16.99 (221)	1011.48 ± 16.20 (233)
Period of Birth			
1.	27.15 ± 0.71 [a] (78)	784.07 ± 28.59 [bc] (42)	1062.13 ± 24.61 [cd] (67)
2.	26.34 ± 0.47 [a] (277)	747.36 ± 18.71 [ab] (215)	1042.83 ± 17.67 [c] (221)
3.	26.92 ± 0.43 [a] (404)	798.15 ± 16.81 [c] (279)	1094.10 ± 15.90 [d] (286)
4.	25.25 ± 0.60 [a] (468)	697.20 ± 24.66 [ab] (269)	945.78 ± 23.32 [ab] (277)
5.	25.78 ± 0.62 [a] (420)	683.12 ± 24.91 [a] (252)	924.82 ± 23.62 [a] (262)
6.	26.71 ± 0.60 [a] (369)	762.28 ± 24.00 [bc] (240)	1002.64 ± 22.67 [bc] (262)
7.	26.27 ± 0.62 [a] (393)	743.19 ± 25.25 [ab] (238)	987.83 ± 23.93 [bc] (244)
8.	24.80 ± 0.62 [b] (263)	748.32 ± 36.94 [abc] (25)	1015.09 ± 35.78 [bc] (25)

Figures in the parenthesis indicate number of observations

Table 4.21. Least squares mean along with standard error of WOY, WFS, WFC in Karan Fries cows

Effect	WOY	WFS	WFC
1	2	3	4
Overall	**179.77 ± 2.29 (1017)**	**303.11 ± 4.91 (757)**	**366.85 ± 5.08 (814)**
Paternal Generation			
1.	175.21 ± 6.55 (204)	282.06 ± 10.35 [c] (201)	354.88 ± 11.86 (171)
2.	182.21 ± 4.88 (126)	320.24 ± 7.68 [a] (107)	369.86 ± 7.34 (180)
3.	182.66 ± 4.15 (445)	309.91 ± 6.99 [ab] (280)	368.97 ± 6.90 (304)
4.	179.01 ± 4.91 (243)	300.19 ± 7.58 [b] (169)	373.67 ± 7.43 (159)
Maternal Generation			
1.	204.25 ± 6.57 [a] (140)	314.59 ± 8.38 (131)	383.33 ± 9.77 (135)
2.	175.79 ± 3.36 [b] (146)	302.24 ± 5.77 (143)	365.97 ± 6.18 (134)
3.	168.50 ± 3.23 [b] (196)	297.13 ± 5.72 (151)	361.38 ± 6.02 (197)
4.	178.09 ± 3.14 [b] (240)	299.39 ± 5.76 (172)	362.49 ± 6.29 (175)
5.	171.78 ± 3.38 [b] (191)	302.93 ± 6.36 (115)	356.79 ± 6.87 (121)
6.	173.20 ± 4.61 [b] (82)	310.53 ± 8.86 (38)	352.44 ± 9.14 (42)
7.	186.80 ± 7.96 [ab] (22)	294.94 ± 17.60 (7)	351.51 ± 16.23 (10)
Season of Birth			
1.	186.23 ± 2.54 [a] (419)	299.31 ± 5.23 [b] (294)	362.81 ± 5.59 [b] (302)
2.	192.36 ± 3.01 [ab] (224)	312.29 ± 5.64 [a] (178)	370.12 ± 5.78 [a] (182)
3.	180.17 ± 3.03 [b] (237)	302.07 ± 5.77 [b] (188)	374.03 ± 5.90 [a] (214)
4.	160.33 ± 3.58 [c] (137)	298.76 ± 6.32 [b] (97)	360.42 ± 6.43 [b] (117)
Period of Birth			
1.	211.09 ± 8.03 [a] (29)	280.95 ± 10.61 [b] (35)	234.76 ± 10.04 [b] (42)
2.	164.79 ± 5.98 [b] (128)	276.80 ± 8.88 [b] (144)	340.12 ± 8.72 [b] (94)
3.	123.64 ± 11.63 [c] (15)	334.43 ± 31.04 [a] (2)	389.02 ± 33.92 [ab] (2)
4.	201.50 ± 4.30 [a] (97)	317.58 ± 6.37 [ab] (112)	369.05 ± 6.16 [b] (182)
5.	204.56 ± 3.52 [a] (265)	321.89 ± 5.90 [a] (197)	383.03 ± 6.052 [ab] (214)
6.	186.89 ± 3.16 [a] (231)	312.79 ± 5.69 [ab] (121)	389.80 ± 5.83 [a] (11)
7.	196.89 ± 4.03 [a] (124)	307.36 ± 6.58 [ab] (120)	372.08 ± 5.74 [ab] (143)
8.	148.82 ± 3.55 [b] (128)	273.07 ± 9.08 [b] (26)	356.76 ± 9.78 [b] (26)

Figures in the parenthesis indicate number of observations

(1991a), Yazdani *et al.* (1993) in Friesian crosses and by Patel *et al.* (1989), Dhangar and Patel (1993), Tekade *et al.* (1994) in Jersey crosses and Singh (1995), Siva Kumar (1998), Sinha (1999) and Sahana and Gurnani (2000) in Karan Fries cattle.

4.2.2.6.5. Effect of Period of Birth on Age at First Calving (AFC) in Karan Fries Cattle

The period of birth was found to have significant (P<0.01) effect on AFC in Karan Fries heifers (Table 4.16). The average AFC for different periods of birth varied from 924.82±23.62 days (Period 5) to 1094.10±15.90 days (Period 3). There was no specific trend was over the periods for this trait (Table 4.20).

Significant effect of period of birth on AFC was reported by Nagarcenkar and Rao (1982), Reddy and Basu (1985), Parmar *et al.* (1986), Kumar (1987), Jadhav *et al.* (1991a), Roy and Tripathi (1992), Arora *et al.* (1993) and Raheja *et al.* (1994a) in Friesian crosses and Singh (1995), Panja (1997), Sivakumar (1998) and Sahana and Gurnani (2000) in Karan Fries cattle.

4.2.2.7. Average First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

The overall least squares mean for FL305DMY in Karan Fries cattle was 2470.35±80.75 kg (Table 4.22).

Nagarcenkar and Rao (1982) reported FL305DMY as 3392±105 kg for FxT crosses at NDRI Farm, Karnal during the period 1974-78. Patel *et al.* (1987) reported FL305DMY of FxK crossbreds (F_1) as 3517±100 kg at Anand.

The estimate in the present study was found to be lower than the estimates of Singh (1995), Panja (1997), Siva Kumar (1998), Sinha (1999) and Sahana and Gurnani (2000).

4.2.2.7.1. Effect of Genetic Group on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

The least squares analysis of variance indicated that the effect of genetic group was highly significant ($P<0.01$) on FL305DMY in Karan Fries cattle (Table 4.19). It was found that HT (F_1) animals had highest average FL305DMY (3462.87±108.40kg) followed by HS (F_1) animals (3217.35±144.10 kg). The lowest average FL305DMY was found to occur in case of HJT crosses (2039.78±129.32kg). Though KF *interse* mated and HBT crosses had higher average FL305DMY but the difference were not significant (Table 4.22). Jadhav *et al.* (1991), Datt and Joshi (1992), and Sahana and Gurnani (2000) observed significant effect of genetic group on FL305DMY.

4.2.2.7.2. Effect of Paternal Generation on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

Effect of paternal generation on FL305DMY was found statistically non significant. A decreasing trend was observed over the generation for FL305DMY. Maximum average FL305DMY was observed in the first generation (2644.09±111.19kg) while lowest FL305DMY was observed in the fourth generation (2284.09±112.43kg) (Table (4.22). However, Sinha (1999) reported highest average 305 days milk yield in the second generation in Karan Fries.

4.2.2.7.3. Effect of Maternal Generation on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

The analysis of variance indicated that the maternal generation had significant ($P<0.01$) effect on FL305DMY. Maximum average FL305DMY (2939.74±127.80kg) was observed in the first generation which was significantly different from the average FL305DMY observed in other generations. However, minimum average FL305DMY was found in the seventh generation (2014.88±268;.42kg). There was no definite trend in average FL305DMY was observed over the generations. Maximum average in the first generation may be due to higher production of the F_1 animals.

4.2.2.7.4. Effect of Season of Calving on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

The least squares average for FL305DMY varied from 2361.42±95.95 kg for rainy calvers to 2606.04±187.42 kg for autumn calvers. The effect of season of calving on FL305DMY was found to be significant (P<0.05).

Significant effect of season on FL305DMY was reported by Panda and Sandhu (1983), Parmar (1986) in Frisian crosses, Patil *et al.* (1987) in Jersey crosses, Datt and Joshi (1992) in Karan Swiss and Sahana and Gurnani (2000) in Karan Fries.

4.2.2.7.5. Effect of Period of Calving on First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

The effect of period of calving was found to be statistically significant (P<0.01). The least squares average of FL305DMY varied from 2115.63±147.82 kg for Period 7 to 2676.18±134.38kg for Period 1. However FL305DMY in all other periods except in period 7 did not differ significantly from Period 1. Significant effect of period of FL305DMY was reported by Dalal *et al.* (1991), Datt and Joshi (1992), Deshmukh *et al.* (1995), Panja (1997), Siva Kumar (1998) and Sahana and Gurnani (2000)

4.2.2.7.6 Effect of Age at First Lactation 305 Days or Less Milk Yield (FL305DMY) in Karan Fries Cattle

It was found that age at first calving had significant effect on FL305DMY in Karan Fries cows. Significant effect of AFC on FL305DMY in Friesian crossbreds was reported by Pandey *et al.* (1988) at IVRI, Izatnagar and Bhattacharya *et al.* (1993b) at Kalyani. Non-significant effect of AFC on FL305DMY was reported by Kumar (1987). However in FxT and FxS crosses at NDRI Farm, Karnal and Military Farms, respectively ; Su (1988) in Karan Swiss heifers and Singh (1995) in Karan Fries and Karan Swiss cattle at NDRI Farm, Karnal.

4.2.2.8. Average First Lactation Total Yield (FLTMY) in Karan Fries Cattle

The overall least squares mean for FLTMY in Karan Fries cattle was 2822.91±121.94 kg (Table 4.22). this estimate was higher than estimates reported by Reddy and Basu (1985) in FxS crosses at Military Farms (2601 kg); Pandey *et al.* (1988) in F/B/JxH crosses at IVRI, Izatnagar (2028 kg); Jadhav *et al.* (1991a) in FxS crosses at Military Farms (2495kg).

4.2.2.8.1. Effect of Genetic Group on First Lactation Total Yield (FLTMY) in Karan Fries Cattle

Least squares analysis of variance (Table 4.19) showed that the genetic group had highly significant effect ($P<0.01$) on FLTMY in Karan Fries cattle. The average FLTMY was found to be 3823.13±163.62 kg in case of HT (F_1) animals whose production was significantly higher from all other crosses except in HS crosses. Among all the genetic groups, HJT crossbred had lowest average FLTMY (2336.80±194.96kg).

Significant effect of genetic groups on lactation yield was reported by [illegible] Datt and Joshi (1992), Singh (1993) and Sahana and Gurnani (2000)

4.2.2.8.2 Effect of Paternal Generation on First Lactation Total Yield (FLTMY) in Karan Fries Cattle

The least squares analysis of variance (Table 4.19) indicated that paternal generation had highly significant effect ($P<0.01$) on first lactation total milk yield. Maximum average FLTMY was observed in the first generation (3343.20±168.17 kg). Minimum average FLTMY was observed (2472.30±170.86kg) in the fourth generation. Though a decreasing trend was observed over the generation, the average FLTMY in the second, third and fourth generations did not differ significantly from each other (Table 4.22).

4.2.2.8.3 Effect of Maternal Generation on First Lactation Total Yield (FLTMY) in Karan Fries Cattle

Non significant effect of maternal generation on FLTMY was observed in the present study (Table 4.19). Animals belonging to fourth generation had maximum average total milk yield (3008.66±137.35 kg). Whereas minimum value of FLTMY was observed in the seventh generation. No specific trend was observed with respect to FLTMY over the generations.

4.2.2.8.4 Effect of Season of Calving on First Lactation Total Yield (FLTMY) in Karan Fries Cattle

The least squares mean for FLTMY ranged from 2614.27±144.79 kg for rainy season to 2926.72±120.92 kg for summer calvers. Effect of season of calving on FLMTY was found to be statistically significant ($P<0.05$). Significant effect of season of calving on FLTMY was also reported by Parmar *et al.* (1986) in FxS crosses at PAU, Ludhiana and by Singh (1992) in Karan Swiss at NDRI Farm, Karnal. Whereas, non significant effect of season of calving of FLTMY was reported by Kumar (1987), Tajane and Rai (1989b), Rana (1991) and Raheja *et al.* (1994a) in Friesian crosses at Military Farms and by Pyne *et al.* (1988) and Bhattacharya *et al.* (1993b) in Friesian crossbreds at Kalyani.

4.2.2.8.5 Effect of Period of Calving on First Lactation Total Yield (FLTMY) in Karan Fries Cattle

The least squares mean for FLTMY in KF calves varied from 2660.60±223.46 kg for Period 7 to 2930.56±208.16 kg for Period 4 (Table 4.22). However, effect of period of calving was found to be non significant. Non-significant effect of periods on FLTMY was also reported by Singh *et al.* (1993) in Friesian Crossbreds at Pantnagar Farm and Singh (1995), Panja (1997), Sinha (1999) and Sahana and Gurnani (2000) at NDRI Farm. However, Jadhav *et al.* (1991a), Raheja *et al.* (1994a) In FxS crosses at Military Farms; Singh (1992) in Karan Fries at NDRI Farm Karnal reported significant effect of periods of FLTMY.

4.2.2.8.6. Effect of Age at First Calving on first Lactation Total Yield (FLTMY) in Karan Fries Cattle

The AFC had significant effect of FLTMY in Karan Fries cows. Significant effect of AFC on FLTMY was reported by Stephen *et al.* (1985) in Brown Swiss crosses in Kerala and by Pandey *et al.* (1988) in FxH crosses at IVRI, Izatnagar. However, non significant effect of AFC was reported by Kumar (1987) in FxT crosses at NDRI Farm, Karnal and FxS crosses at Military Farms and by Su (1988) in Karan Swiss cattle at the same farm.

4.2.2.9. Average First Lactation Length (FLL) in Karan Fries Cattle

The overall least squares average for FLL was found to be 315.25±days (Table 4.22). The estimate was quite close to those reported by Vij (1981), in Brown Swiss Cross, Su (1988) in Karan Swiss, Tajane and Rai (1989) in Frisian crosses, Arora *et al.* (1993) in Frieswal was who obtained 322, 318, 312, 326 days, respectively.

4.2.2.9.1. Effect of Genetic Group on First Lactation Length (FLL) in Karan Fries Cattle

The least squares analysis of variance (Table 4.19) indicated that the genetic groups had non significant effect on FLL. The average FLL of different genetic groups varied from maximum 333.60±13.48 days in HT crosses to minimum 297.36±15.96 days for HJT crosses.

Non-significant effect of genetic group on FLL was reported by Dalal *et al.* (1991) and Singh *et al.* (1993).

Sahana and Gurnani (2000) reported highest average FLL in HJT crosses and minimum average FLL in HS crosses.

4.2.2.9.2 Effect of Paternal Generation on First Lactation Length (FLL) in Karan Fries Cattle

The effect of paternal generation on FLL was found to be highly significant (P<0.01) (Table 4.19). A decreasing trend in FLL was observed over the paternal generations which ranged from 351.64±13.72 days (first generation) to 288.48±14.02 days (fourth generation). However, Sinha (1999) observed maximum FLL (367.95 days) in the fourth generation and minimum FLL (301.73 days) in the first generation in Karan Fries cattle.

4.2.2.9.3. Effect of Maternal Generation on First Lactation Length (FLL) in Karan Fries Cattle

Over the maternal generation first lactation length (FLL) was found to range between 271.24±35.64 days in the seventh generation to 342.04±17.62 days in the sixth generation (Table 4.22). However, effect of maternal generation on FLL was found statistically significant (P<0.05) (Table 4.19). Sinha (1999) in Karan Fries cattle found maximum average FLL (372.37 days) in fifth generation while minimum average FLL (301.73 days) was observed in first generation,

4.2.2.9.4. Effect of Season of Calving on First Lactation Length (FLL) in Karan Fries Cattle

The highest average FLL was found to occur for summer calvers (323.59±10.93 days) and lowest for winter calvers (304.98±11.98 days). The effect of season of FLL was found to be non significant (Table 4.19). Non-significant effect of season on FLL was reported by Parmar *et al.* (1986) at PAU Ludhiana and Tajane and Rai (1989b) at Military Farms in Friesian crosses, and Su (1988) in Karan Swiss at NDRI Farm, Karnal. However, significant effect of season on FLL was also reported by Roy (1986), Kumar (1987) and Jadhav *et al.* (1991a) in FxS crosses at Military Farms and by Gupta *et al.* (1986) and Dalal *et al.* (1991) in FxS crosses at jabalpur and Hisar Farms, respectively.

4.2.2.9.5. Effect of Period of Calving on First Lactation Length (FLL) in Karan Fries Cattle

The least squares mean for FLL varied from 297.76±17.05 days for Period 4 to 339.31±18.34 days for Period 7. No uniform trend was observed with respect to periods. However, the effect of period of calving on FLL was found to be non-significant. Non significant effect of period of calving was also reported by Parmar *et al.* (1986) at Ludhiana; Singh and Tomar (1991) at NDRI Farm, Karnal; Singh *et al.* (1993) at pantnagar inFriesian crosses and by Tekade *et al.* (1994) in J x K crosses at nagpur Farm and Sinha (1999) in Karan Fries at NDRI Farm.

Significant effect of period of calving on FLL was reported by Roy (1986), Tajane and Rai (1989b), Jadhav *et al.* (1991a) in Friesian x Sahiwal crossbreds at Military Farms, Su (1988) in Karan Swiss at NDRI Farm, Karnal, Garcha and Dev (1994) in FxS crossbreds at PAU, Ludhiana and by Sahana and Gurnani (2000) in NDRI, Karnal.

4.2.2.9.6. Effect of Age at First Calving on First Lactation Length (FLL) in Karan Fries Cattle

The regression of FLL on AFC was found to be statistically non significant. Gupta *et al.* (1986), Kumar (1987) and Pandey*et al.* (1988) in Friesian crosses; Su (1988) and Singh (1995) in Karan Swiss also reported non significant effect of AFC on FLL. However, Garcha and Deve (1994) reported significant effect of AFC on FLL in Friesian crossbreds.

4.2.2.10. Average First Service Period (FSP) in Karan Fries Cattle

The overall least squares mean of FSP was estimated to be 127.69±11.27 days (Table 4.22). This estimate was within the range of estimates reported by Deshpande *et al.* (1988) in FxS crosses at Military Farm; Pyne *et al.* (1988) in FxH crosses at Kalyani; Su (1988) in Karan Swiss at NDRI Farm, Karnal; Kakran and Joshi (1998) in Brown Swiss crosses at NDRI Karnal; Pyne and Duttagupta (1994) in FxS crosses at Kalyani. Sinha (1999), Sahana & Gurnani (2000) in Karan Fries. These authors obtained average FSP to range from 115 to 134 days in above mentioned crosses. However, Roy (1986) in FxS crosses at Military Farms; Bhatia and Pandey (1990) in FxS crosses at IVRI and Arora *et al.* (1993) in Frieswal at Miliary Farms reported higher average of FSP, being 171, 170 and 175 days, respectively.

4.2.2.10.1. Effect of Genetic Group on First Service Period (FSP) in Karan Fries Cattle

The least squares analysis of variance (Table 4.19) showed that the various genetic group did not differ significantly in average FSP. The average FSP ranged from 110.24±18.81 days in HS crosses to 130.47 days in Karan Fries. Verma *et al.* (1973) and Sahana and Gurnanai (2000) also reported that influence of genetic grade on FSP was not significant in crossbreds. However, significant effect of genetic group on service period was reported by Sharma *et al.* (1983), Butte and Deshpande (1987), Kale *et al.* (1984) and Jadhav *et al.* (1991).

4.2.2.10.2. Effect of Paternal Generation on First Service Period (FSP) in Karan Fries Cattle

Paternal generation wise average FSP presented in the Table 4.22 and it was ranged from 113.90±14.08 days in third generation to 161.23±14.56 days in the first generation. No definite trend was observed in mean FSP over the generations. However, least squares analysis of variance (Table 4.19) indicated that effect of paternal generation on FSP was statistically significant (P<0.05). Sinha (1999) studied in Karan Fries cattle and reported maximum and minimum average FSP in fourth and first generation respectively.

4.2.2.10.3. Effect of Maternal Generation on First Service Period (FSP) in Karan Fries Cattle

The influence of maternal generation on FSP was statistically significant (P<0.05) as observed from least squares analysis of variance (Table 4.19). The average FSP ranged from 88.18±14.89 days in first generation to 147.92±17.26 days in sixth generation. No definite trend was observed in FSP over the generations. Similar to the present study, Sinha (1999) also did not found any definite trend over the generations in Karan Fries cattle for FSP.

4.2.2.10.4. Effect of Season of First Service Period (FSP) in Karan Fries Cattle

The effect of season of calving on FSP was found to be statistically significant (P<0.01) in this herd (Table 4.19). Autumn calvers had lower FSP (114.61±13.99 days) and the average was not significantly different from winter calvers and rainy calvers which had average FSP of 127.55 and 121.15 days respectively.

Nagarcenkar and Rao (1982) in FxT crosses at NDRI Farm, Karnal; Roy (1986), Jadhav *et al.* (1991a) and Arora *et al.* (1993) in FxS crossbreds at Military Farms and Pyne and Duttagupta (1994) inFxS and JxH crossbreds at Kalyani, Sivakumar (1998), Sinha (1999) also reported significant effect of season on FSP.

Non significant effect of season on FSP was reported by Deshpande *et al.* (1988) and Bhatia and Pandey (1990) in Friesian crosses and by Su (1988) in Karan Swiss at this farm.

4.2.2.10.5. Effect of Period of Calving on First Service Period (FSP) in Karan Fries Cattle

The least squares average for FSP varied form 99.19±13.97 days for period-2 to 145.94±17.92 days for period 5. There was no consistent trend observed for FSP over periods of calving. The effect of periods was found to be statistically non significant on FSP in this herd (Table 4.19).

Non significant effect of period of FSP was reported by Deshpande *et al.* (1988) and by Jadhav *et al.* (1991a) in Friesian x Sahiwal crossbreds at Military Farms and by Sinha (1999) in Karan Fries cattle. However, Nagarcenkar and Rao (1982) in FxT crosses and Su (1988) in Karan Swiss at NDRI Farm, Karnal; Roy (1986) and Arora *et al.* (1993) in Frieswal cattle at Military Farms and Patel *et al.* (1989) in J x K crosses at Anand reported significant effect of period of calving on FSP.

4.2.2.10.6. Effect of Age at First Calving on First Service Period (FSP) in Karan Fries Cattle

The least squares estimate of regression of FSP on AFC was found to be statistically non-significant. Su (1988) in Karan Swiss cattle at NDRI Farm, Karnal, Bhatia and Pandey (1990) in FxS crosses at Izatnagar, Jadhav *et al.* (1991a) in FxS crosses at Military Farms and Singh(1995) in Karan Swiss and Karan Fries, also reported non significant effect of AFC on FSP.

4.2.2.11. Average First Dry Period (FDP) in Karan Fries Cattle

The overall least squares average for FDP in KF cattle was found to be 80.72±5.96 days (Table 4.22). It was within the range of estimates reported by Taneja and Chawla (1978) in BxS crosses at Karnal; Patel *et al.* (1987) in FxK and JxK crosses at Anand; Singh and Tomar (1991) and Singh (1995) in KF and at NDRI Farm, Karnal. These authors reported range of average FDP as from 61 to 87 days. however, Bala and Nagarcenkar (1979) in FxH; Roy (1986) and Jadhav *et al.* (1991a) in FxS crosses at Military Farms reported higher average FDP ranging from 117 to 151 days.

4.2.2.11.1 Effect of Genetic Group on First Dry Period (FDP) in Karan Fries Cattle

The least squares average of FDP for various season of calving varied from 75.53±7.62 days (autumn calvers) to 84.12±6.35 days (summer calvers). However, the effect of season of calving was statistically non significant.

Non-significant effect of season of calving was also reported by pandey *et al.* (1988) in FxH, BxH and JxH crosses at IVRI, Izatnagar; Singh and Tomar (1991) in KF; Dalal *et al.* (1991) in F/H crosses at Hisar and by Garcha and Dev (1994) inFx S crosses at Ludhiana, and Panja (1997), Siva Kuamr (1998) and Sahana and Gurnani (2000) in Karan Fries, respectively.

Significant effect of season of calving was reported by Basu and Ghai (1980) in FxS crosses at NDRI Farm, Karnal; Roy (1986) and Jadhav *et al.* (1991a) in FxS crosses at Military Farms.

4.2.2.11.2. Effect of Paternal Generation on First Dry Period (FDP) in Karan Fries Cattle

The least squares analysis of variance (Table 4.19) indicated that the influence of various genetic groups on FDP was statistically significant (P<0.05). The average FDP ranged from 65.26±7.63 days (in HT crosses) to 101.60±9.84 days (HS cross). However, average FDP in its crosses did not differ significantly from KF *interse* mated population. Sharma *et al.* (1983), Mudgal *et al.* (1986), Chand (1988) and Jadhav *et al.* (1991) reported significant effect of genetic group of dry period. Whereas, Chaudhary *et al.* (1977), Singh *et al.* (1993), Sahana dna Gurnani (2000) reported that the influence of genetic group on FDP as non significant.

Dalal *et al.* (1991) found that Brown Swiss crosses had longer dry period in comparison to Frisian and Jersey crossbreds.

4.2.2.11.3. Effect of Maternal Generation on First Dry Period (FDP) in Karan Fries Cattle

The least squares analysis of variance (Table 4.19) indicated the non significant effect of paternal generation on FDP. The mean FDP ranged between 68.83±8.01 days (first generation) to 86.60.7.61 days (third generation). However, an increasing trend in FDP was observed upto third generation from paternal side. Sinha (1999) in Karan Fries observed maximum FDP in third generation while minimum average FDP was reported in the first generation.

4.2.2.11.4. Effect of Season of Calving on First Dry Period (FDP) in Karan Fries Cattle

Effect of maternal generation on FDP was also found to be statistically non significant (Table 4.19). No specific trend was observed over the maternal generation with repeat to FDP. The average FDP was found to range between 59.48±24.62 days (seventh generation) to 87.82.9.85 days (sixth generation)

4.2.2.11.5. Effect of Period of Calving on First Dry Period (FDP) in Karan Fries Cattle

The highest least squares average of FDP was obtained for Period 1(84.71±9.43 days) and lowest in Period 4(73.30±9.55 days). There was no consistent trend in average FDP over the periods of calving. Further, the effect of periods was statistically non significant.

Non significant effect of period of calving was reported by Taneja and Chawla (1978) in BxS crosses; Singh and Tomar (1991) in KF at NDRI

Farm, Klarnal; Singh *et al.* (1993) inFriesian crosses at Pantnagar and by Sahana and Gurnani (2000) in Karan Fries. However, significant effect of period of calving on FDP was reported by Roy (1986) and Jadhav *et al.* (1991a) in Friesian x Sahiwal crosses at Military Farms.

4.2.2.11.6. Effect of Age at First Calving on First Dry Period (FDP) in Karan Fries Cattle

Effect of AFC on FDP was found to be statistically non significant in Karan Fries cattle. Non-significant effect of AFC on FDP was reported by Singh and Tomar (1991) and Jadhav *et al.* (1991a) in Friesian crosses at NDRI Farm, Karnal and Military Farms, respectively. However, significant effect of AFC on FDP was reported by Pandey *et al.* (1988) in FxH crosses at IVRI Izatnagar Farm.

4.2.2.12. Average First Calving Interval (FCI) in Karan Fries Cattle

The overall least squares average of FCI was 423.20±13.17 days (Table 4.22). Basu and Ghai (1980); Butte *et al.* (1986), Roy (1986), Kumar (1987), Jadhav *et al.* (1991b), Raheja *et al.* (1994a) at various Military Farms in FxS crossbreds and Singh (1995) in KS and KF, reported the average FCI to be ranged from 414 to 442 days. Whereas, Kumar *et al.* (1991) in F/B/JxO crosses at Lam and Garcha and Dev (1994) in FxS crosses at Ludhiana reported average FCI 423 and 457 days, respectively.

4.2.2.12.1. Effect of Genetic Group on First Calving Interval (FCI) in Karan Fries Cattle

The influence of various genetic groups on FCI was non significant as observed from least squares analysis of variance (Table 4.19). The average first calving interval for different genetic group ranged from 398.23±16.15 days for HT crosses to 429.33±12.44 days for KF *interse* mated crossbreds. Parmar *et al.* (1984) also reported non significant effect of genetic groups on FCI in HF x S crosses. However, significant effect of genetic group on FCI was reported by Butte and Deshpande (1986), Singh and Bhat (1986) and Polastre *et al.* (1987b).

Dalal *et al.* (1991) observed significantly lower calving interval among Brown Swiss crosses in comparison to Holstein and Jersey crosses.

4.2.2.12.2. Effect of Paternal Generation on First Calving Interval (FCI) in Karan Fries Cattle

The least squares analysis of variance indicated the non significant effect of paternal generation on FCI (Table 4.19). The lowest average FCI was observed in third generation (410.86±16.06 days) and highest average was observed in first generation (450.42±16.48 days).

A decreasing trend compared to first generation lower estimate in FCI was observed in subsequent generations.

4.2.2.12.3. Effect of Maternal Generation on First Calving Interval (FCI) in Karan Fries Cattle

Maternal generation had significant effect ($P<0.05$) on FCI. The mean FCI was found to range between 432.26±14.45 days to 384.84±21.36 days (Table 4.19). However, no specific trend with respect to FCI was observed over the generations.

4.2.2.12.4. Effect of Season of Calving on First Calving Interval (FCI) in Karan Fries Cattle

The least squares average was found to be the highest for summer calvers (445.22±13.83 days) and the lowest for autumn calvers (409.32±15.83 days) (Table 4.22). The effect of season of calving was found to be statistically significant ($P<0.01$). The average FCI of summer calvers differed significantly from that of other seasons of calving. The longest FCI of summer calvers might be due to longest FSP of such cows.

Significant effect of season on FCI was reported by Basu and Ghai (1980) in BxS crosses; Roy (1986), Kumar (1987), Jadhav *et al.* (1991a) and Raheja *et al.* (1994a) in FxS crossbreds at various Military Farms by Pyne and Dattagupta (1994) in JxH crosses at Kalyani and by Sivakumar (1998) and Sahana and Gurnani (2000) in Karan Fries. However, non significant effect of season of calving on FCI was reported by Butte *et al.* (1986) and Deshpande *et al.* (1988) in FxS crosses at Military Farms.

4.2.2.12.5. Effect of Period of Calving on First Calving Interval (FCI) in Karan Fries Cattle

Period of calving was found to have non significant effect of FCI in Karan Fries cattle (Table 4.19). The least squares average of FCI for various periods of calving varied from 392.92±15.86 days for Period 2 to 442.73±20.06 days for Period 5. No definite trend was observed over periods of calving.

Non significant effect of period of FCI was reported by Basu and Ghai (1980), Deshpande *et al.* (1988) in FxS crosses at Military Farms and by Su (1988) in Karan Swiss cattle at NDRI Farm, Karnal. However, Butte *et al.* (1986), Roy (1986), Kumar (1987), Rana (1991), Jadhav *et al.* (1991a) and Raheja *et al.* (1994a) in FxS crossbred at Military Farms also reported significant effect of periods on FCI.

4.2.2.12.6. Effect of Age at First Calving on First Calving Interval (FCI) in Karan Fries Cattle

The AFC had non-significant effect on FCI in Karan Fries cows. Kumar (1987) and Jadhav *et al.* (1991a) in FxS crosses at Military Farms, Su (1988) in Karan Swiss cattle at NDRI Farm, Karnal and Singh (1995) in Karan Swiss and Karan Fries cattle also reported non significant effect of AFC on FCI.

4.2.2.13. Average Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

The overall least squares mean for MY/FLL was 8.76±0.29 kg in KF cattle (Table 4.22). The estimate was low in comparison to the estimates reported by Roy (1986), Butte and Deshpande (1987) and Garcha *et al.* (1991) in FxS crossbreds at Military Farms, Parbhani and Ludhiana and Panja (1997) and Siva Kumar (1998) at NDRI Farm, Karnal. The least squares average reported were in the range of 9.40 to 10.68 kg. Parmar *et* *al.* (1986) in F/RDxS crosses at PAU, Ludhiana; Jadhav *et al.* (1991a) and Arora *et al.* (1993) in FxS crossbred at Military Farms obtained lower average for MY/FLL. These estimates were in the range of 6.0 kg to 8.40 kg.

4.2.2.13.1. Effect of Genetic Groups on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

Significant (P<0.01) effect of genetic group was observed on MY/FLL (Table 4.19). HT crosses found to have maximum average MY/FL (1.54±0.35kg) followed by HS crosses (10.99±0.52kg) and KF intermated animals (8.49±0.27). The average MY/FLL did not differ significantly among these groups. However lowest MY/FLL was observed in HJT crosses (7.85±0.47kg).

4.2.2.13.2. Effect of Paternal Generation on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

The paternal generation wise average of MY/FLL was presented in Table 4.22. It was found to range between 8.48±0.412 kg in fourth generation to 9.26±0.40 kg in first generation. However, influence of paternal generation on MY/FLl was found to be statistically non significant.

4.2.2.13.3. Effect of Maternal Generation on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

The least squares analysis of variance indicated significant effect (P<0.01) of maternal generation on MY/FLL in Karan Fries cattle (Table 4.19).

The animals belong to first generation had highest mean of MY/FLL (10.35±0.45kg) while lowest mean of MY/FLL (7.99±0.51kg) was observed in the sixth generation. The mean values of MY/FLL presented in the table did not show any specific trend over the generations.

4.2.2.13.4. Effect of Season on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

Maximum least squares average of MY/FLl was found for autumn calvers (8.99±0.29 kg) and minimum for rainy clavers (8.41±0.35 kg). The effect of season of calving, however, was found to be statistically non significant.

Non significant effect of season on MY/FLL was also reported by Reddy and Basu (1985), Butte and Deshpande (1987) in FxS at Military Farm, Singh *et al.* (1991) in FxS and JxS crosses at Pantnagar and by Singh (1995) in Karan Swiss and Karan Fries cattle at NDRI Farm, Karnal.

4.2.2.13.5. Effect of Period of Calving on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

The least squares ANOVA revealed significant (P<0.01) effect of periods on MY/FLL in Karan Fries cattle (Table 4.19). The (9.48±0.50 kg) and lowest for Period 7 (7.22±0.54 kg). There was no specific trend of MY/FLL observed over the periods of calving (Table 4.22).

In Friesian x Sahiwal crossbreds, Reddy and Basu (1985), Roy (1986), Jadhav *et al.* (1991a) and Arora *et al.* (1993) at Military Farms; Butte and Deshpande (1987) at Parbhani; Garcha *et al.* (1991) at PAU, Ludhiana; Singh *et al.* (1993) at Pantnagar also reported significant effect of periods on MY/FLL.

4.2.2.13.6. Effect of Age at First Calving on Milk Yield per day of First Lactation Length (MY/FLL) in Karan Fries Cattle

The AFC was found to have significant (P<0.01) effect on MY/FLL in Karan Fries cattle. However, Garcha *et al.* (1991) in Friesian x Sahiwal crossbred and Singh (1995) in Karan Swiss and Karan Fries also reported non-significant effect of AFC on MY/FLL.

4.2.2.14. Average Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

The overall least squares mean of MY/FCI was 7.78±0.28 kg in KF cattle (Table 4.19).In Friesian x Sahiwal crosses at Military farms, Deshpande and Bonde (1982), Roy (1986), Jadhav *et al.* (1991b) and Arora *et al.* (1993) reported average MY/FCI as 5.6, 8.0, 6.10 and 6.14 kg, respectively. Whereas, Parmar *et al.* (1986) and Garcha *et al.* (1991) in FxS crosses at PAU, Ludhiana reported average MY/FCI as 7.32 and 7.61 kg, respectively.

4.2.2.14.1. Effect of Genetic Group on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

The least squares analysis of variance revealed significant ($P<0.01$) effect of genetic group on MY/FCI. The average MY/FCI was found to range between 9.82±0.35 kg (in HT crosses) to 6.78±0.41 kg (HJT crosses). However, average MY/FCI observed in HBT crosses and in KF *inderse*mated population not significantly different from MY/FCI observed in HJT crosses.

4.2.2.14.2. Effect of Paternal Generation on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

The least squares analysis of variance indicated significant ($P<0.05$) effect of paternal generation on MY/FCI. The maximum MY/FCI (8.43±0.36kg) was observed for first generation while minimum My/FCI (7.11±0.36kg) was observed for the fourth generation. However, average MY/FCI observed in second and third generation did not differ significantly from the average MY/FCI in first generation. A distinct decreasing trend for the MY/FCI over the generation was observed in the present study.

4.2.2.14.3. Effect of Maternal Generation on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

The influence of maternal generation on MY/FCI was statistically significant ($P<0.01$) as observed form least squares analysis of variance (Table 4.19) in Karan Fries.

The average MY/FCI ranged from 7.17±0.42 kg in sixth generation to 8.98±0.35 kg in the first generation. Maternal generation wise average performance in MY/FCI did not show any specific trend in the present study.

4.2.2.14.4 Effect of Season of Calving on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

The least squares average of MY/FCI varied from 7.56±0.32 kg for rainy calvers to 8.05±0.34 kg for autumn calvers, However, the effect of season of calving as found to be statistically non significant in KF cattle. Non significant effect of season of calving was reported by Butte and Deshpande (1987) in FxS crosses, by Garcha *et al.* (1991) in same crossbred at PAU, Ludhiana, by Panja (1997) in Karan Fries at NDRI Farm, Karnal.

4.2.2.14.5. Effect of Period of Calving on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

Effect of period of calving on MY/FCI was found to be statistically non significant in KF cattle. The least squares average for periods ranged from 7.49±0.40 kg for Period 1 to 8.26±0.42 kg for Period 4 (Table 4.22). There was no specific trend for MY/FCI over the periods was observed. Panja (1997) reported non significant effect of period of calving on MY/FCI. However Reddy and Basu (1985), Roy (1986), Jadhav *et al.* (1991a) at Military Farms; Parmar *et al.* (1986), Garcha *et al.* (1991) at PAU, Ludhiana; Butte and Deshpande (1987) at Parbhani also reported significant effect of period of calving on MY/FCI in Friesian x Sahiwal crosses.

4.2.2.14.6. Effect of Age at First Calving on Milk Yield per day of First Calving Interval (MY/FCI) in Karan Fries Cattle

The influence of AFC was found statistically significant on MY/FCI in Karan Fries cattle. However, Garcha *et al.* (1991) and Singh (1995) also reported non significant effect of AFC on MY/FCI in crossbred cattle.

4.2.2.15. Average Herd life (HL) in Karan Fries Cattle

The overall least squares mean of HL for Karan Fries was observed to be 1809.80±85.11 days (Table 4.22).

4.2.2.15.1. Effect of Genetic Groups on Herd life (HL) in Karan Fries Cattle

The effect of genetic group was highly significant ($P<0.01$) on HL. Maximum average HL (3119.56±;113.70 days) was observed in HT crossbreds, which was not significantly different from the HL observed in HS crosses (3071.80±151.88 days).(Table 4.22)

On other hand, HJT, BHT and KF *interse* mated animals were not significantly different from each other with respect to average HL. The average HL as observed in the above mentioned groups were 1565.78 days, 1562.46 days, 1615.96 days respectively.

4.2.2.15.2. Effect of Paternal Generation on Herd life (HL) in Karan Fries Cattle

The least squares analysis of variance indicated non significant (P<0.01) of paternal generation on HL in Karan fries cattle. The average HL observed in the first, second, third and fourth generation were 1827.27±84.24 days, 1820.92±93.43 days, 1833.24±100.42 days and 1757.76±117.14 days respectively. The present study indicated that change in average Hl over the generation did not follow any specific trend.

4.2.2.15.3. Effect of Maternal Generation on Herd life (HL) in Karan Fries Cattle

The influence of maternal generation on HL was highly significant (P<0.01) as observed from least squares analysis of variance (Table 4.19). The animals belong to first generation from maternal side had maximum average of HL (2694.44±136.76 days). The mean HL as observed over different maternal generation from second generation onward was not statistically significantly different from each other except in seventh generation, which was significantly different from the rest (Table 4.20). However, no specific trend in HL was observed over the maternal generation in Karan Swiss cattle.

4.2.2.15.4. Effect of Season of Calving on Herd life (HL) in Karan Fries Cattle

Least squares analysis of variance revealed non significant effect of season on Hl. (Table 4.19). However, average HL was found to range from 1757.76±117.14 days (autumn calvers) to 1833.24±100.42 days (rainy calvers).

4.2.2.15.5. Effect of Period of Calving on Herd life (HL) in Karan Fries Cattle

Statistically highly significant (P<0.01) effect of period of calving on HL was found in the present study. A decreasing trend was observed in average

Table 4.22. Least squares mean along with standard error of various first lactation traits and herd life in Karan Fries cows

Effect	FL 305DMY	FLTMY	FLL	FSP	FCI	FDP	MY/FLL	MY/FCI	HL
1	2	3	4	5	6	7	8	9	10
Overall	**2470.35 ± 80.75 (1454)**	**2822.91 ± 121.94 (1447)**	**315.25 ± 10.10 (1423)**	**127.69 ± 11.27 (10.36)**	**423.20 ± 13.17 (1072)**	**80.72 ± 5.96 (1058)**	**8.76 ± 0.29 (1418)**	**7.78 ± 0.28 (1048)**	**1809.80 ± 85.11 (1389)**
Genetic Group									
1.	3462.87 ± 108.40^{a} (109)	3823.13 ± 163.62^{a} (109)	333.60 ± 13.48 (109)	121.15 ± 14.13 (106)	398.23 ± 16.15 (103)	65.26 ± 7.63^{a} (98)	11.54 ± 0.39^{a} (109)	9.82 ± 0.35^{a} (101)	3119.56 ± 113.70^{a} (117)
2.	3217.35 ± 144.10^{a} (62)	3498.31 ± 217.59^{a} (62)	319.45 ± 17.90 (58)	110.24 ± 18.81 (33)	417.14 ± 19.84 (51)	101.60 ± 9.84^{b} (45)	10.99 ± 0.52^{a} (57)	9.05 ± 0.43^{a} (49)	3071.80 ± 151.88^{a} (70)
3.	2039.78 ± 129.32^{b} (97)	2336.80 ± 194.96^{b} (97)	297.36 ± 15.96 (95)	114.43 ± 16.74 (62)	418.44 ± 18.75 (65)	77.58 ± 9.18^{a} (62)	7.85 ± 0.47^{b} (95)	6.78 ± 0.41^{b} (64)	1565.78 ± 134.14^{b} (104)
4.	2221.49 ± 147.35^{b} (58)	2531.98 ± 222.12^{b} (58)	308.02 ± 18.14 (57)	123.57 ± 19.21 (34)	407.84 ± 21.39 (95)	75.68 ± 10.74^{a} (33)	7.89 ± 0.53^{b} (57)	7.73 ± 0.46^{b} (135)	1562.46 ± 152.22^{b} (63)
5.	2398.08 ± 75.22^{b} (1121)	2745.415 ± 113.42^{b} (1121)	315.13 ± 9.43 (1104)	130.47 ± 10.38 (801)	429.33 ± 12.44 (758)	81.26 ± 5.53^{ab} (820)	8.49 ± 0.27^{ab} (1100)	7.49 ± 0.27^{b} (699)	1615.96 ± 77.98^{b} (1035)
Paternal Generation									
1.	2644.09 ± 111.19 (520)	3343.20 ± 168.17^{a} (516)	351.64 ± 13.72^{a} (507)	161.23 ± 14.56^{b} (377)	450.42 ± 16.48 (401)	68.83 ± 8.01 (382)	9.26 ± 0.40 (506)	8.43 ± 0.36^{a} (396)	1758.91 ± 119.20 (519)
2.	2464.91 ± 104.75 (340)	2744.29 ± 157.96^{b} (340)	314.38 ± 12.98^{ab} (336)	116.46 ± 13.94^{a} (240)	418.50 ± 15.89 (245)	81.09 ± 7.51 (245)	8.55 ± 0.38 (335)	7.85 ± 0.34^{a} (242)	1731.25 ± 111.28 (348)
3.	2488.30 ± 107.60 (341)	2731.83 ± 162.22^{b} (342)	306.48 ± 13.30^{ab} (339)	113.90 ± 14.08^{a} (260)	410.86 ± 16.06 (264)	86.80 ± 7.61 (268)	8.74 ± 0.39 (337)	7.74 ± 0.35^{a} (257)	1934.27 ± 114.85 (343)
4.	2284.09 ± 112.43 (253)	2472.30 ± 170.86^{b} (249)	288.48 ± 14.02^{b} (241)	119.18 ± 14.85^{a} (159)	413.02 ± 16.66 (162)	86.16 ± 8.16 (163)	8.48 ± 0.41 (240)	7.11 ± 0.36^{b} (153)	1814.77 ± 130.92 (179)

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1	2	3	4	5	6	7	8	9	10
Maternal Generation									
1.	2939.74 ± 127.80[a] (210)	2996.58 ± 192.91 (206)	281.68 ± 15.59[b] (202)	88.18 ± 14.89[a] (163)	382.15 ± 16.19[a] (180)	80.51 ± 8.45 (166)	10.35 ± 0.45[a] (201)	8.98 ± 0.35[a] (176)	2694.44 ± 136.76[a] (191)
2.	2532.15 ± 89.11[b] (435)	2860.47 ± 134.67 (434)	327.17 ± 10.92[a] (429)	138.70 ± 10.72[b] (310)	425.47 ± 11.46[b] (320)	85.54 ± 5.97 (313)	8.40 ± 0.32[b] (429)	7.47 ± 0.25[b] (317)	1886.24 ± 96.38[b] (448)
3.	2456.91 ± 86.05[b] (327)	2900.12 ± 129.71 (327)	325.13 ± 10.55[a] (324)	139.52 ± 10.47[b] (236)	430.30 ± 11.19[b] (236)	85.90 ± 5.78 (236)	8.74 ± 0.31[b] (322)	7.57 ± 0.24[b] (233)	1721.61 ± 91.72[b] (331)
4.	2542.91 ± 91.18[b] (254)	3008.66 ± 137.35 (256)	328.06 ± 11.16[a] (252)	141.81 ± 10.96[b] (190)	426.42 ± 11.23[b] (189)	82.13 ± 6.05 (197)	9.02 ± 0.32[ab] (252)	7.87 ± 0.25[b] (185)	1741.95 ± 99.79[b] (231)
5.	2370.35 ± 101.74[b] (165)	2838.39 ± 154.25 (162)	331.39 ± 12.59[a] (157)	144.12 ± 12.98[b] (96)	443.04 ± 13.64[b] (107)	83.66 ± 7.10 (106)	8.73 ± 0.37[b] (155)	7.78 ± 0.30[b] (101)	1629.13 ± 114.61[b] (134)
6.	2435.49 ± 142.64[b] (52)	2927.49 ± 216.79 (51)	342.04 ± 17.62[a] (50)	147.92 ± 17.26[b] (38)	451.89 ± 18.60[b] (38)	87.82 ± 9.85 (36)	7.99 ± 0.51[b] (50)	7.17 ± 0.42[b] (34)	1613.21 ± 166.05[b] (41)
7.	2014.88 ± 268.42[b] (11)	2228.64 ± 404.96 (11)	27124 ± 35.64[b] (9)	93.60 ± 49.73[b] (3)	403.13 ± 65.73[b] (2)	59.48 ± 24.62 (4)	8.09 ± 1.04[b] (9)	7.64 ± 1.43[b] (2)	1382.03 ± 269.35[c] (13)
Season of Calving									
1.	2512.73 ± 80.08[a] (730)	2926.72 ± 120.92[a] (726)	320.03 ± 10.05 (713)	127.55 ± 11.20[a] (525)	426.08 ± 13.21[a] (537)	80.66 ± 5.96 (520)	8.93 ± 0.29 (713)	7.83 ± 0.29 (525)	1827.27 ± 84.24 (713)
2.	2401.20 ± 87.78[b] (381)	2861.52 ± 132.71[ab] (379)	323.59 ± 10.93 (376)	147.45 ± 11.96[b] (267)	445.22 ± 13.83[b] (278)	84.12 ± 6.35 (282)	8.70 ± 0.32 (373)	7.69 ± 0.30 (269)	1820.92 ± 93.43 (361)
3.	2361.42 ± 95.95[b] (207)	2614.27 ± 144.79[b] (206)	304.98 ± 11.98 (199)	121.15 ± 12.98[a] (145)	412.18 ± 14.83[a] (155)	82.57 ± 6.84 (156)	8.41 ± 0.35 (197)	7.56 ± 0.32 (152)	1833.24 ± 100.42 (194)
4.	2606.04 ± 107.42[a] (136)	2889.11 ± 161.83[bb] (136)	312.38 ± 13.24 (135)	114.61 ± 13.99[a] (99)	409.32 ± 15.82[a] (102)	75.53 ± 7.62 (100)	8.99 ± 0.39 (135)	8.05 ± 0.34 (102)	1757.76 ± 117.14 (121

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1	2	3	4	5	6	7	8	9	10
Period of Calving									
1.	2676.18 ± 134.38 [a] (84)	2784.10 ± 204.56 (84)	313.59 ± 16.81 (80)	105.62 ± 17.59 (59)	393.19 ± 18.51 (75)	84.71 ± 9.43 (70)	9.17 ± 0.49 [ab] (79)	7.49 ± 0.40 (74)	2424.14 ± 154.82 [a] (86)
2.	2627.12 ± 106.56 [a] ()185	2923.39 ± 162.14 (185)	319.15 ± 13.27 (183)	99.19 ± 13.97 (152)	392.92 ± 15.86 (152)	73.98 ± 7.81 (144)	9.42 ± 0.39 [a] (183)	7.81 ± 0.34 (150)	2110.53 ± 121.25 [a] (191)
3.	2466.07 ± 98.95 [a] (258)	2805.34 ± 149.92 (258)	323.96 ± 12.27 (255)	120.76 ± 13.29 (170)	418.62 ± 15.20 (176)	80.36 ± 7.30 (174)	8.76 ± 0.36 [ab] (254	7.56 ± 0.33 (175)	1824.06 ± 107.41 [a] (280)
4.	2548.70 ± 138.01 [a] (285)	2930.56 ± 208.16 (285)	297.76 ± 17.05 (282)	137.52 ± 17.30 (216)	433.86 ± 19.42 (218)	73.30 ± 9.55 (218)	9.48 ± 0.50 [a] (282)	8.26 ± 0.42 (217)	1871.79 ± 144.51 [ab] (294)
5.	2370.37 ± 144.52 [a] (222)	2771.09 ± 217.71 (222)	303.96 ± 17.80 (270)	145.94 ± 17.92 (162)	442.73 ± 20.06 (164)	75.32 ± 9.88 (172)	8.58 ± 0.52 [ab] (218)	7.94 ± 0.44 (161)	1643.49 ± 150.05 [b] (233)
6.	2488.36 ± 138.26 [a] (236)	2885.26 ± 208.92 (236)	308.99 ± 17.03 (234)	140.91 ± 17.08 (187)	438.52 ± 19.13 (191)	82.89 ± 9.46 (184)	8.66 ± 0.50 [ab] (234)	7.92 ± 0.42 (182)	1577.87 ± 146.76 [b] (201)
7.	2115.63 ± 147.82 [b] (184)	2660.60 ± 223.46 (177)	339.31 ± 18.34 (169)	143.90 ± 19.32 (90)	442.55 ± 21.44 (96)	84.49 ± 10.64 (96)	7.22 ± 0.54 [b] (168)	7.50 ± 0.47 (89)	1216.71 ± 170.50 [c] (104)

Figures in the parenthesis indicate number of observations

HL over the period, except in Period 4. Minimum average HL was observed in the Period 7 (1216.71±170.50days) while maximum average HL (2424.14±154.82 days) at period 1. which was not statistically significantly different from Period 2 and Period 4.

4.2.2.15.6. Effect of Age at First Calving on Herd life (HL) in Karan Fries Cattle

Least squares analysis of variance (Table 4.19) indicated a significant effect of AFC on HL.

In the present study revealed a declining trend with respect to first lactation traits and herd life in both the Karan Swiss and Karan Fries population in the later generations, which may be due to any of the following reasons:

a. Segregation of genes and loss of heterozygosity in the later generations.

b. Use of unproven farmbred crossbred bulls that are of inferior merit compared to proven exotic bulls, used to producing animals belonging to first paternal generation.

c. In a close herd use of limited number of bulls also resulted in incidence of inbreeding. Deleterious effect of inbreeding may be another reason for such deterioration of the performance.

d. Involuntary culling of animals of high genetic merit may be responsible for such deterioration in performance.

4.3. ESTIMATION OF THE GENETIC AND PHENOTYPIC PARAMETERS OF VARIOUS GROWTH, FIRST LACTATION TRAITS AND HERD LIFE IN CROSSBRED CATTLE

The estimates of phenotypic and genetic parameters are required to evaluate the variation in performance with respect of genetic and nongenetic factors and to investigate whether any association exists between the characters. For estimation of genetic parameters, the data were adjusted for significant nongenetic effect.

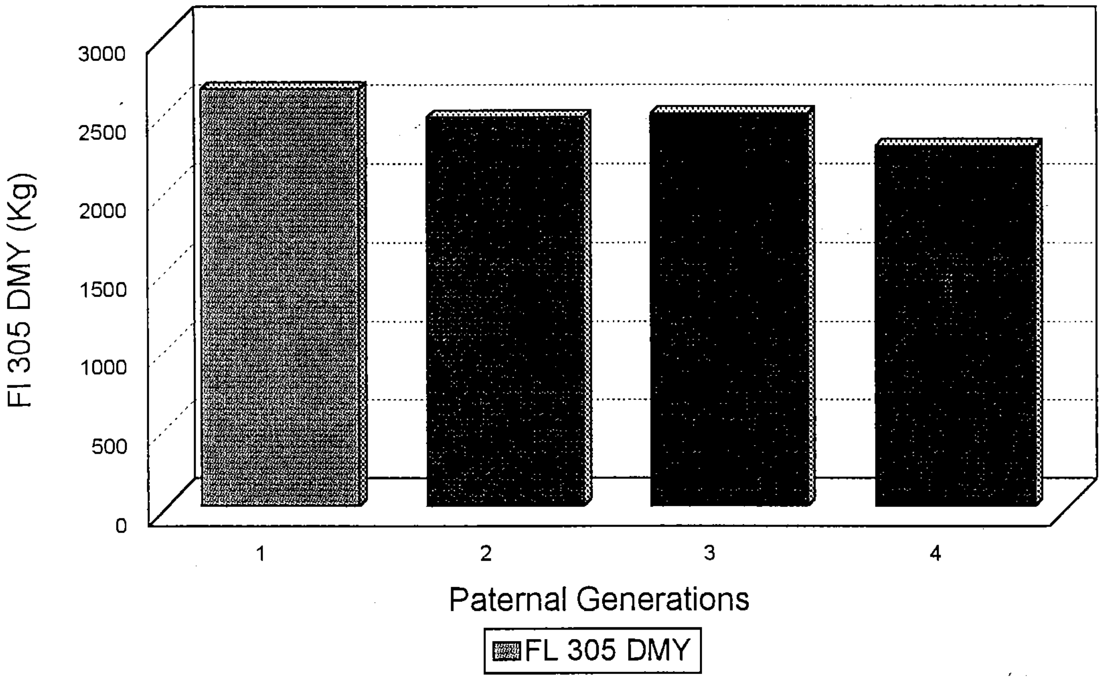

Fig.4.7. Paternal Generationwise first lactation 305 day milk yield in Karan Fries cows

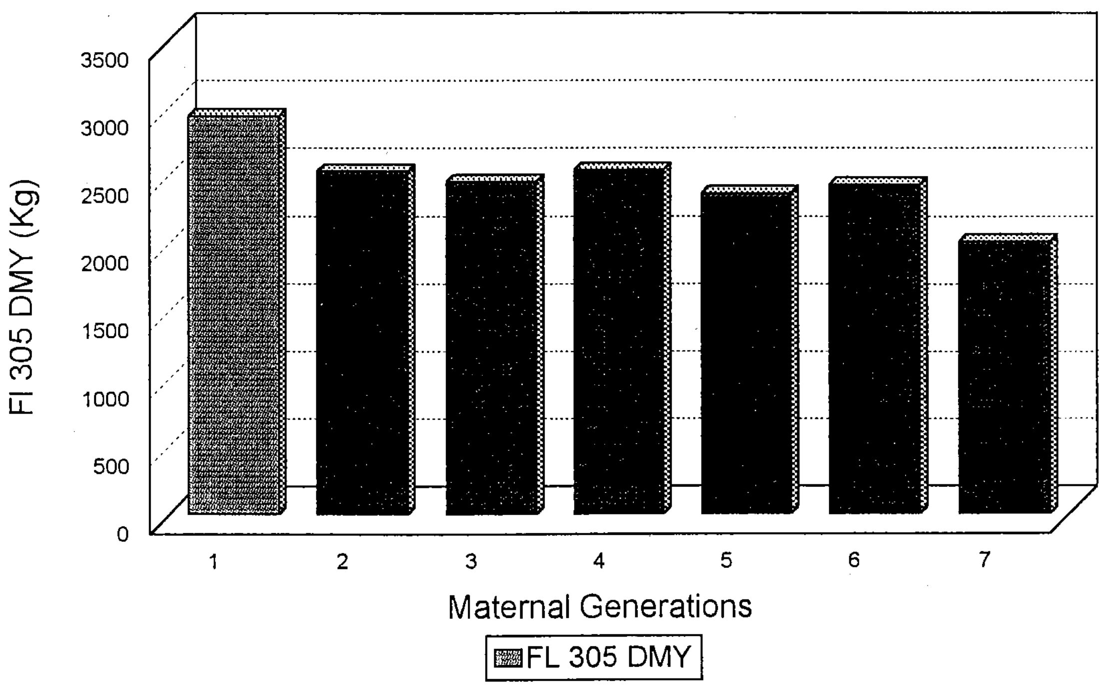

Fig.4.8. Maternal Generationwise first lactation 305 day milk yield in Karan Fries cows

4.3.1. Repeatability Estimates

Repeatability was estimated as intraclass correlation from the analysis of variance. Animals with minimum of two location records were considered for the estimation of repeatability.

4.3.1.1. Repeatability Estimates in Karan Swiss

The repeatability estimates of various repeatable traits in Karan Swiss are presented in Table 4.23.

The repeatability of 305 day or less milk yield, lactation length, dry period, service period and calving interval was found to be 0.344±0.015, 0.116±0.015, 0.102±0.017, 0.089±0.017, 0.150±0.020, respectively.

The estimates were found to be similar to those reported by Singh and Tamar (1990), Gandhi and Gurnani (1992) for 305 day milk yield, Vij (1995) for lactation length, Yeotikar and Deshpande (1991) for dry period. Whereas repeatability estimates of calving interval was reported to be range between 0.03 (Bhoite *et al.*, 1998) to 0.71±0.20 (Kaygisiz, 1995).

4.3.1.2. Repeatability Estimates in Karan Fries

The estimates of repeatability of 305 day or less milk yield, lactation length, dry period, service period, and calving interval for Karan fries cattle are presented in the Table 4.24 and the values are found to be 0.338±0.016, 0.120±0.014, 0.220±0.017, 0.201±0.019, 0.391±0.010, respectively.

Similar estimates were reported by Souza *et al.* (1996) in Gir Cross, Catillo *et al.* (1995) in Nagori for 305 day milk yield, Murdfa and Tripathi (1992) in Jersey for lactation length, Bhoite *et al.* (1998) for service period and Vij (1995) in Nagori cattle for calving interval.

In general, the repeatability estimates of lactation length service period and dry period in both the Karan Swiss and Karan Fries and Calving interval in Karan Swiss were low to moderate which indicated that heritable causes together with the permanent environmental factors had less influence on these traits. Thus, the prediction of breeding value for these traits based

Table 4.23. Repeatability estimates of various repeatable traits in Karan Swiss Cattle

Sl. No.	Traits	Repeatability ± S.E.
1.	305 day Milk Yield	0.344±0.015
2.	Lactation Length	0.116±0.015
3.	Service Period	0.089±0.017
4.	Dry Period	0.102±0.017
5.	Calving Interval	0.150±0.020

Table 4.24. Repeatability estimates of various repeatable traits in Karan Fries Cattle

Sl. No.	Traits	Repeatability ± S.E.
1.	305 day Milk Yield	0.338±0.016
2.	Lactation Length	0.120±0.014
3.	Service Period	0.201±0.019
4.	Dry Period	0.220±0.017
5.	Calving Interval	0.319±0.018

on one record will not be very accurate and addition of records will add to the accuracy of prediction. In other words, in such a situation (low heritability) selection based on early records can hardly lead to better performance in later lactations.

4.3.2. Heritability Estimates

4.3.2.1. Heritability Estimates in Karan Swiss Cattle

The estimates of heritability of birth weight (BWT), weight at one year of age (WOY), weight at first fertile (WFS), weight at first cawing (WFC), age at first fertile service (AFS), age at first calving (AFC), first lactation total milk yield (FLTMY), first lactation 305 day or less milk yield (FL 305 DMY), first lactation length (FLL), first service period (FSP), first dry period (FDP), first calving interval (FCI), milk yield per day of first lactation length (MY/FLL) and milk yield per day of first calving interval (MY/FCI) and hard life (HL) of Karan Swiss animals are presented in the Table 4.25..

Among the growth traits heritability estimates of BWT was found to be 0.24±0.04. However weight at later stage such as WOY (0.12±0.08), WFS (0.13±0.09), WFC (0.16±0.05) was found to be lower than BWT.

The low estimate of heritability of various growth traits indicate that additive genetic effects are lower as compared to effects of non-genetic factor on these traits.

Singh (1977) in BSxS crosses and Bhat and Singh (1978) for BSxHS crosses reported similar estimates of heritability for BWT. Heritability estimates for weight at one year of age was found to range between 0.08 (Rao, 1977) in 5/4 Frisian cross to 0.99 (Rao, 1977) for BS cross (F1).

The present estimate of heritability for WFS, WFC was found to be in close agreement with the estimates of Mishra (1973). Singh (1995) for WFS and Singh (1977) for WFC in BSxS cross.

The heritability estimates of various reproduction traits in Karan Swiss were found to be as 0.15±0.05 for AFS, 0.17±0.05 for AFC, 0.10±0.05 for FSP, 0.03±0.05 for FCI. Low estimates of heritability indicate that these

Table 4.25. Heritability genetic and phenotypic correlation for various traits in Karan Swiss

Traits	BWT	WOY	|WFS	WFC	AFS	AFC	FL305DMY
BWT(3054)	**0.24 ± 0.04****	0.04 ± 0.03	0.27 ± 0.03**	0.27 ± 0.03**	0.02 ± 0.02	0.01 ± 0.02	0.02 ± 0.02
WOY (966)	0.23 ± 0.29	**0.12 ± 0.06***	0.06 ± 0.04	0.09 ± 0.05	- 0.06 ± 0.03	- 0.05 ± 0.03	0.05 ± 0.03
WFS (698)	0.44 ± 0.31	>1	**0.13 ± 0.09**	0.56 ± 0.04**	0.47 ± 0.03**	- 0.36 ± 0.03**	0.08 ± 0.03
WFC (678)	0.69 ± 0.16**	0.88 ± 0.15	0.26 ± 0.44	**0.16 ± 0.05****	0.31 ± 0.03	- 0.34 ± 0.03**	0.16 ± 0.03
AFS (1642)	- 0.03 ± 0.24	- 0.12 ± 0.38	- 0.04 ± 0.46	- 0.57 ± 0.15**	**0.15 ± 0.05**	0.85 ± 0.01**	0.03 ± 0.02
AFC (1749)	- 0.12 ± 0.21	- 0.21 ± 0.29	- 0.01 ± 0.44	- 0.59 ± 0.14	>1	**0.17 ± 0.05****	0.47 ± 0.02**
FL305DMY (1658)	- 0.25 ± 0.21	- 0.12 ± 0.39	- 0.14 ± 0.47	0.10 ± 0.29	- 0.39 ± 0.19	- 0.25 ± 0.21	**0.28 ± 0.05****
FLTMY (1660)	- 0.27 ± 0.26	- 0.01 ± 0.39	>1	0.17 ± 0.33	- 0.33 ± 0.26	- 0.17 ± 0.27	0.89 ± 0.05**
FLL (1429)	0.05 ± 0.30	- 0.05 ± 0.55	>1	0.18 ± 0.33	0.34 ± 0.25**	- 0.01 ± 0.29	0.55 ± 0.16**
FSP (1035)	>1	0.08 ± 0.32	>1	0.51 ± 0.27	>1	≥	0.16 ± 0.41
FDP (1041)	0.05 ± 0.38	- 0.46 ± 0.44	0.16 ± 0.80	- 0.14 ± 0.70	0.91 ± 0.07**	0.57 ± 0.26	0.09 ± 0.33
FCI (1116)	- 0.93 ± 0.08	0.46 ± 0.48	>1	>1	0.18 ± 0.66	0.58 ± 0.26	0.16 ± 0.41
MY/FLL (1483)	- 0.08 ± 0.22	- 0.08 ± 0.32	- 0.09 ± 0.42	0.24 ± 0.24	- 0.13 ± 0.20	- 0.105 ± 0.215	0.79 ± 0.06**
MY/FCI (1091)	- 0.08 ± 0.29	0.22 ± 0.46	0.13 ± 0.65	0.21 ± 0.43	- 0.27 ± 0.28	- 0.36 ± 0.38	0.91 ± 0.03**
HL (1636)	- 0.67 ± 0.24	- 0.14 ± 1.82	- 0.40 ± 0.46	- 0.70 ± 0.18	- 0.10 ± 0.49	- 0.33 ± 0.40	0.57 ± 0.52

Traits	FLTMY	FLL	FSP	FDP	FCI	MY/FLL	MY/FCI	HL
BWT (3054)	0.05 ± 0.02	0.08 ± 0.02	0.04 ± 0.03	-0.02 ± 0.03	0.06 ± 0.03	0.04 ± 0.02	0.08 ± 0.03	0.07 ± 0.05
WOY (966)	0.05 ± 0.03	0.09 ± 0.03	- 0.06 ± 0.04	- 0.08 ± 0.04	0.005 ± 0.04	0.08 ± 0.04	0.08 ± 0.03	0.04 ± 0.03
WFS (698)	0.09 ± 0.03	0.02 ± 0.04	- 0.04 ± 0.04	- 0.01 ± 0.04	0.01 ± 0.04	0.15 ± 0.04	0.19 ± 0.04	0.17 ± 0.03
WFC (678)	0.15 ± 0.03	0.04 ± 0.04	0.07 ± 0.05	0.02 ± 0.05	0.01 ± 0.04	0.24 ± 0.04	0.16 ± 0.04	0.14 ± 0.03
AFS (1642)	0.02 ± 0.02	0.01 ± 0.02	- 0.08 ± 0.03	- 0.0013 ± 0.03	0.01 ± 0.03	0.05 ± 0.02	0.05 ± 0.03	0.10 ± 0.02
AFC (1749)	0.46 ± 0.02**	0.11 ± 0.02**	- 0.01 ± 0.03	0.02 ± 0.03	- 0.03 ± 0.03	0.11 ± 0.02**	0.02 ± 0.03	0.106 ± 0.02**
FL305DMY (1658)	0.88 ± 0.01**	0.51 ± 0.02**	0.16 ± 0.30	0.23 ± 0.03**	0.16 ± 0.02**	0.88 ± 0.01**	0.74 ± 0.01**	0.39 ± 0.02**
FLTMY (1660)	**0.27 ± 0.04****	0.72 ± 0.01**	0.47 ± 0.02**	0.11 ± 0.03**	0.49 ± 0.02**	0.62 ± 0.02**	0.75 ± 0.02**	0.37 ± 0.02**
FLL (1429)	0.59 ± 0.19**	**0.22 ± 0.05****	0.70 ± 0.02**	0.004 ± 0.03	0.75 ± 0.02**	0.02 ± 0.02	0.28 ± 0.02	0.21 ± 0.02**
FSP (1035)	- 0.24 ± 0.45	0.70 ± 0.02**	**0.10 ± 0.05****	0.26 ± 0.03**	0.87 ± 0.007**	0.02 ± 0.03	- 0.005 ± 0.03	0.08 ± 0.03**
FDP (1041)	0.12 ± 0.37	0.004 ± 0.03	0.26 ± 0.03**	**0.09 ± 0.06**	0.29 ± 0.03**	- 0.15 ± 0.03**	- 0.44 ± 0.02**	- 0.08 ± 0.03
FCI (1116)	- 0.24 ± 0.45	0.07 ± 0.58	0.91 ± 0.28**	0.38 ± 0.51	**0.03 ± 0.05**	- 0.02 ± 0.03	- 0.71 ± 0.03**	0.13 ± 0.03**
MY/FLL (1483)	0.82 ± 0.06**	0.30 ± 0.20	- 0.89 ± 0.24	0.16 ± 0.25	0.30 ± 0.04	**0.34 ± 0.07****	0.80 ± 0.01**	0.25 ± 0.02**
MY/FCI (1091)	0.78 ± 0.08**	0.64 ± 0.18**	- 0.46 ± 7.10	- 0.06 ± 0.33	- 0.24 ± 0.40	0.93 ± 0.02**	**0.33 ± 0.08****	0.28 ± 0.02**
HL (1636)	0.41 ± 0.50	0.41 ± 2.22	>1	0.51 ± 0.35**	0.77 ± 0.04**	>1	- 0.06 ± 0.34	**0.02 ± 0.03**

Diagonal Value : Heritability
Lower diagonal value : Genetic Correlation
Upper diagonal Value : Phenotypic correlation
Figures in the parenthesis are number of observation

* Significant ($P < 0.05$)
** Significant ($P < 0.01$)

reproduction traits are more influenced by non-genetic factors and there is a scope to improve the performance by improving non-genetic practices.

Such low estimates of heritability for various reproductive traits were also reported by Naidu and Desai (1965) for AFC, Deshmukh *et al.* (1992) for FSP, Kumar and Bhatnagar (1989) for FCI.

The heritability estimates of FL-305DMY, FLTMY, FLL, FDP, MY/FLL, MY/FCI were found to be 0.28±0.05, 0.27±0.04, 0.22±0.05, 0.09±0.06, 0.34±0.07, 0.33±0.08 respectively. The estimates were observed to be moderate and statistically significant for MY/FLL, MY/FCI. The result indicate that these traits are more governed by additive genetic factors and improvement in these traits is possible by selection.

High estimates of heritability for milk production traits were reported by Kumar and Bhatnagar (1989), Datt and Joshi (1992), Singh (1995); whereas low estimate of heritability compared to the present study traits were reported by Murthy (1974), Naidu and Desai (1965).

Heritability estimates for FDP was found to be similar to that of estimate by Singh *et al.* (1993).

The heritability for hard life found to be 0.02±0.03. Very low estimate of heritability for this trait indicates it is mostly governed by non-genetic factors and hard life of the animals in the population can be improved by improving the managemental practices.

4.3.2.2. Heritability Estimates in Karan Fries Cattle

The estimates of heritability of birth weight (BWT), weight at one year of age (WOY), weight at first fertile (WFS), weight at first cawing (WFC), age at first fertile service (AFS), age at first calving (AFC), first lactation total milk yield (FLTMY), first lactation 305 day or less milk yield (FL 305 DMY), first lactation length (FLL), first service period (FSP), first dry period (FDP), first calving interval (FCI), milk yield per day of first lactation length (MY/FLL) and milk yield per day of first calving interval (MY/FCI) and hard life (HL) of Karan Fries animals are presented in the Table 4.26..

Table 4.26. Heritability, genetic and phenotypic correlation for various traits in Karan Fries

Traits	BWT	WOY	WFS	WFC	AFS	AFC	FL305DMY
BWT (2672)	**0.191 ± 0.044****	0.223 ± 0.030**	0.203 ± 0.035**	0.246 ± 0.033**	-0.080 ± 0.024*	-0.055 ± 0.024*	0.051 ± 0.025
WOY (1017)	0.008 ± 0.214**	**0.161 ± 0.105****	0.031 ± 0.036	0.124 ± 0.034**	-0.103 ± 0.025**	-0.082 ± 0.024**	0.079 ± 0.039
WFS (757)	0.418 ± 0.274	-0.383 ± 0.290	**0.192 ± 0.093****	0.468 ± 0.032**	-0.510 ± 0.031**	-0.489 ± 0.031**	0.147 ± 0.037
WFC (814)	> 1	-0.705 ± 0.295	0.771 ± 0.283**	**0.027 ± 0.068**	-0.349 ± 0.032**	-0.329 ± 0.32**	0.221 ± 0.035
AFS (1560)	-0.005 ± 0.234	-0.232 ± 0.192	-0.277 ± 0.236	-0.569 ± 0.288**	**0.194 ± 0.060****	0.844 ± 0.013**	0.116 ± 0.025**
AFC (1644)	- 0.233 ± 0.152	-0.038 ± 0.163	-0.636 ± 0.133**	-0.436 ± 0.352	0.553 ± 0.106**	**0.173 ± 0.099****	0.116 ± 0.025**
FL305DMY (1454)	0.173 ± 0.189	0.287 ± 0.248	0.294 ± 0.276	0.050 ± 0.538	0.581 ± 0.121	0.556 ± 0.092**	**0.304 ± 0.024**
FLTMY(1447)	0.540 ± 0.167	0.142 ± 0.294	0.073 ± 0.345	0.456 ± 0.521	0.711 ± 0.111	0.039 ± 0.142	0.822 ± 0.070**
FLL (1423)	0.349 ± 0.262	- 0.160 ± 0.465	- 0.145 ± 0.400	0.375 ± 0.260	0.024 ± 0.277	0.043 ± 0.219	0.102 ± 0.284
FSP (1036)	0.417 ± 0.252	0.275 ± 0.651	- 0.046 ± 0.331	0.557 ± 0.396	0.147 ± 0.299	0.053 ± 0.207	0.058 ± 0.251
FDP (1058)	0.154 ± 0.286	- 0.666 ± 0.315	- 0.185 ± 0.329	0.339 ± 1.574	0.015 ± 0.283	0.416 ± 0.189*	0.484 ± 0.272
FCI (1072)	- 0.120 ± 0.190	- 0.203 ± 0.313	- 0.027 ± 0.296	0.826 ± 0.305	0.241 ± 0.185	0.806 ± 0.049**	0.402 ± 0.135**
MY/FLL (1418)	0.311 ± 0.190	0.168 ± 0.248	0.492 ± 0.196	0.545 ± 0.411	0.722 ± 0.092	0.765 ± 0.059**	> 1
MY/FCI (1048)	0.258 ± 0.191	0.678 ± 0.174	0.172 ± 0.256	0.042 ± 0.833	0.748 ± 0.088	0.271 ± 0.135**	0.801 ± 0.059**
HL (1389)	- 0.056 ± 0.206	0.201 ± 0.338	0.069 ± 0.618	0.510 ± 0.564	0.225 ± 0.354	0.161 ± 0.264	0.449 ± 0.215

Traits	FLTMY	FLL	FSP	FDP	FCI	MY/FLL	MY/FCI	HL
BWT (2672)	0.052 ± 0.025	0.029 ± 0.026	0.053 ± 0.031	0.027 ± 0.030	0.033 ± 0.030	0.053 ± .026	0.050 ± 0.030	0.027 ± 0.022
WOY (1017)	0.050 ± 0.039	- 0.005 ± 0.039	0.029 ± 0.046	0.059 ± 0.046	0.033 ± 0.046	0.075 ± 0.039	0.051 ± 0.041	0.084 ± 0.036
WFS (757)	0.133 ± 0.038	- 0.013 0.038	0.116 ± 0.043	- 0.003 ± 0.044	0.101 ± 0.043	0.253 ± 0.037	0.162 ± 0.043	0.116 ± 0.039
WFC (814)	0.177 ± 0.036	0.035 ± 0.037	0.009 ± 0.044	0.041 ± 0.043	- 0.0006 ± 0.043	0.224 ± 0.036	0.215 ± 0.043	0.126 ± 0.037
AFS (1560)	0.093 ± 0.026	- 0.244 ± 0.026	0.036 ± 0.031	- 0.011 ± 0.030	0.014 ± 0.030	0.160 ± 0.025	0.166 ± 0.030	0.125 ± 0.026
AFC (1644)	0.072 ± 0.025**	0.068 ± 0.025**	0.012 ± 0.031	- 0.015 ± 0.030	- 0.092 ± 0.030	0.243 ± 0.025**	0.148 ± 0.030**	0.096 ± 0.026**
FL305DMY (1454)	0.814 ± 0.014**	0.418 ± 0.023**	0.158 ± 0.030**	0.223 ± 0.029**	0.174 ± 0.029**	0.661 ± 0.019**	0.852 ± 0.015**	0.362 ± 0.025**
FLTMY(1447)	**0.268 ± 0.057****	0.733 ± 0.017**	0.594 ± 0.024**	0.120 ± 0.030**	0.536 ± 0.025**	0.529 ± 0.021**	0.705 ± 0.021**	0.319 ± 0.025**
FLL (1423)	0.290 ± 0.303	**0.211 ± 0.050****	0.804 ± 0.018**	0.068 ± 0.050**	0.744 ± 0.020**	0.048 ± 0.025**	0.135 ± 0.030	0.207 ± 0.026**
FSP (1036)	0.406 ± 0.231	0.769 ± 0.139**	**0.164 ± 0.075****	0.250 ± 0.030**	0.886 ± 0.014**	0.018 ± 0.031	-0.340 ± 0.031**	0.084 ± 0.032**
FDP (1058)	0.062 ± 0.276	0.484 ± 0.272	0.182 ± 0.280	**0.128 ± 0.069**	0.255 ± 0.029**	- 0.417 ± 0.028**	- 0.091 ± 0.030**	0.108 ± 0.032**
FCI (1072)	0.187 ± 0.175	0.089 ± 0.233	0.268 ± 0.232	-0.577 ± 0.145**	**0.353 ± 0.102****	0.026 ± 0.030	- 0.123 ± 0.030**	0.091 ± 0.032**
MY/FLL (1418)	0.775 ± 0.087**	0.211 ± 0.296	0.064 ± 0.263	- 0.284 ± 0.235	0.496 ± 0.129**	**0.385 ± 0.067****	0.716 ± 0.021**	0.205 ± 0.027**
MY/FCI (1048)	0.925 ± 0.026**	0.336 ± 0.201	0.291 ± 0.248	- 0.023 ± 0.216	0.018 ± 0.166	0.625 ± 0.106**	**0.402 ± 0.098****	0.231 ± 0.022**
HL (1389)	0.464 ± 0.278	0.614 ± 0.463	0.161 ± 0.264	0.216 ± 0.321	0.326 ± 0.233	0.495 ± 0.268	0.405 ± 0.235	**0.158 ± 0.049****

Diagonal Value : Heritability
Lower diagonal value : Genetic Correlation
Upper diagonal Value : Phenotypic correlation
Figures in the parenthesis are number of observation

* Significant ($P < 0.05$)
** Significant ($P < 0.01$)

For Birth weight heritability estimate was 0.191±0.044. Whereas, heritability for subsequent growth traits were observed as 0.161±0.105 for WOY. 0.192±0.93, for WFS, 0.027±0.68, for WFC. Low estimates of heritability indicates major influence of non-genetic factors and requires improvement in managemental aspects for improvement in these traits. Taneja (1978) in HF X S cross reported higher estimates of heritability for BWT, WOY, WFS.

Singh (1987) reported similar estimates of heritability for BWT. Comparatively low estimate of heritability can found by Parekh *et al.* (1976) for WOY in FXT crosses. The heritability for various reproductive traits such as AFS, AFC, FSP, FCI were estimated and the estimates were 0.194±0.060, 0.173±0.99, 0.164±0.75, 0.353±0.102 respectively.

The estimate of heritability for FCI was found to be higher in comparison to the estimates available in the literature that ranges from 0.03±0.08 (Kumar and Bhatnagar, 1989) to 0.25 Gogoi *et al.* (1992).

The heritability estimate for AFC reported by Naidu and Desai (1976) and Rao (1977) found to be similar to the finding in the present study.

Pande *et al.* (1988), Mudgal *et al.* (1986), and Singh and Tomar (1991) reported low estimate of heritability for FSP where Sandhu *et al.* (1973) reported higher estimate (0.48) of heritability for FSP.

Heritability of various first lactation production traits are estimated and the estimates were found to be 0.304±0.074 (for FL305DMY), 0.268±0.057, (for FLTMY), 0.211±0.050 (for FLL), 0.128±0.089 (for FDP), 0.385±0.067 (for MY/FLL), 0.402±0.098 (for MY/FCI).

Relatively high estimate for MY/FLL, MY/FCI indicates that there is a scope for improvement for these traits by selection. However, low to moderate heritability for FDP, FLL, FLTMY, FL305DMY suggests improvement in the managemental practices to improve the performance in these traits. A considerable variation in the heritability estimates for various first lactation production traits was found in the literature.

For FL305DMY it ranged between 0.154 (Garcha *et al.*, 1989) to 0.796 (Datt and Joshi, 1992), For FLMY it was 0.07 (Murthy, 1974) to 0.68±0.30 (Ageeb and Hiller, 1971). For FLL heritability estimate varied from 0.034 (Gurnani *et al.*, 1971) to 0.894 Gupta *et al.* (1986). Whereas for FDP range was reported to be 0.01 by Singh *et al.* (1993) to 0.40 by Kumar and Bhatnagar (1989).

4.3.3. Phenotypic and Genetic Correlations in Karan Swiss Cattle

4.3.3.1.1. Phenotypic Correlations in Karan Swiss Cattle

Phenotypic correlation between different growth, production and reproduction traits of Karan Swiss Cattle were presented in the Table 4.25.

BWT found to have very low to moderate but no significant and positive correlations with all the traits except AFS, AFC and FDP, in which negative correlation was observed. WOY also had similar trend with respect to phenotypic correlation and the correlation co-efficient was found to be very small. WFS and WFC had significant negative and high phenotypic correlations with AFS and AFC, and the correlation co-efficient were found to be –0.47±0.03, -0.36±0.03 for WFS and –0.31±0.03 and –0.34±0.03 for WFC respectively.

The results obtained in the present study indicate that higher birth weight and higher weight at subsequent ages results in attaining early maturity of the animals and thus the animals had low AFS and AFC, while growth characters had very little impact on first lactation production and reproduction traits as were as hard life.

AFS had highly significant phenotypic correlation with AFC (0.85±0.01). However phenotypic correlation of AFS with other traits did not found to be statistically significant.

Whereas AFC had positive but significant phenotypic correlation with FL305DMY, FLTMY, FLL, MY/FLL and HL. The results indicate that animal with high AFC may yield more amount of milk. However, negative but low phenotypic correlation was observed with FSP and FCI.

In the present study FL305DMY found to have positive and significant phenotypic correlation with FLTMY, FLL, MY/FLL, MY/FCI and the correlation co-efficient were observed as 0.88±0.01, 0.51±0.02, 0.88±0.01, 0.74±0.01.

Positive correlation of FL305DMY with FSP, FDP and FCI indicate that high producer animals were generally poor with respect to reproduction traits. Thus high producing animals were found to be poorer with respect to reproductive traits.

High milk producing animals were kept in the hard for longer time and this was confirmed by obtains positive phenotypic correlation between FL305DMY and HL.

Phenotypic correlation of FLTMY with FLL, FSP, FDP, FCI, MY/FLL, MY/FCI and HC found to be positive and significant.

Very high and positive phenotypic correlation of FLL with FSP and FCI was found in the present study which revealed that high producing animals took more time to conceive and thus had higher calving interval.

FSP is an integral part of calving interval. Increase in the service period resulted in higher calving interval and it was confirmed from the present study with very high estimate of phenotypic correlation (0.87±0.007) between FSP and FCI ; and negative phenotypic correlation with MY/FCI.

Positive phenotypic correlation between HL and FCI was obtained which may be due to the fact that high producing animals having high CI kept in the herd for longer period.

MY/FLL found to have high and significant correlation with MY/FCI. However the phenotypic correlation of HL with MY/FLL and MY/FCI was found to be moderate but statistically significant.

4.3.3.1.2. Phenotypic correlations in Karan Fries Cattle

Phenotypic correlation between different growth, production and reproduction traits were presented in the Table 4.26.

The BWT had positive, significant and moderate phenotypic correlation with WOY, WFS, WFC, whereas low and negative but statistically significant correlation was observed with AFS and AFC. Which showed that animals with higher BWT tend to mature early. However the phenotypic correlation of BWT with all other first lactation production as well as reproduction traits were found to be positive, low and statistically non-significant.

WOY had positive, low to moderate phenotypic correlation with WFS and WFC whereas AFS and AFC showed highly significant, and negative phenotypic correlation with WOY. Whereas phenotypic correlations of WOY with all other first lactation production as well as reproduction traits were found to be statistically non-significant.

Significant, negative and high phenotypic correlations were observed between WFS, AFS and AFC as well as WFC, AFS, AFC. Whereas other first lactation production as well as reproduction traits had very low to moderate but statistically non-significant correlations with WFS and WFC.

The above results indicated that animals with high BWT, WOY, WFS, WFC tend to mature early thus had lower AFS and AFS.

However other first lactation economic traits and hard life did not affected significantly with the growth traits.

AFS had very high positive and significant phenotypic correlation with AFC. Low but positive and significant phenotypic correlation of AFC with FL305DMY, FLTMY, FLL, MY/FLL and MY/FCI indicate that high AFC is desirable to obtain better production performance.

Similar results were also reported by Gurnani *et al.* (1976), Taneja *et al.* (1978) , Basu and Ghai (1977), Sharma *et al.* (1982), Jadhav and Khan (1996).

FL305DMY, FLTMY and FLL had positive and significant phenotypic correlations with FSP, FDP, FCI, MY/FLL, MY/FCI and HL. The results obtained in the present study indicated that high producing animals were generally poor with respect to reproduction traits but due to high producing ability animals were kept in the hard for longer periods.

The phenotypic correlation of FSP with FDP, FCI, HL was significant and positive. While MY/FCI showed negative correlation with FSP. The results indicate that longer FSP not only increase the dry period and calving interval, but also lower the MY/FCI. Bhattacharya (1996) also reported the similar results in the Karan Fries Cattle.

Significant and negative phenotypic correlation of FDP with MY/FLL and MY/FCL indicated that longer FDP is responsible for lowering the production efficiency traits. Singh *et al.* (1993) in JXS crosses and Bhattacharya (1996) in KF also found similar result. FCI had negative but significant phenotypic correlation with MY/FCI however HL had significant but positive correlation with FCI.

MY/FLL and MY/FCI had high and positive phenotypic correlation with each other however HL had moderate but positive phenotypic correlation with MY/FLL and MY/FCI respectively.

4.3.3.2.1. Genetic Correlations in Karan Swiss Cattle

Genetic correlation observed between different growth, production and reproduction traits of Karan Swiss Cattle were presented in the Table 4.25..

BWT had positive and moderate genetic correlation with WOY, WFS and WFC. While genetic correlation of BWT with AFS and AFC found to be negative and non significant.

Negative but non significant genetic correlation was observed for BWT with FL305DMY and FLTMY. Among the reproduction traits negative correlation was observed between BWT and FCI while genetic correlation between FSP and BWT found to be non estimable (>1).

WOY had positive and significant genetic correlation with WFC while genetic correlation of WOY with all other traits found to be statistically non significant.

In case of WFS genetic correlation with all other traits found to be statistically non significant.

The genetic correlation of AFS and AFC with all the growth traits were observed to be negative which indicate that higher body weight of animals resulted in early maturity of the animals. Negative estimate of genetic correlation of AFS and AFC with first lactation production traits (FL305DMY, FLTMY, FLL) reflected that influence of environmental correlations were more between these traits. However positive genetic correlations was observed for FDP with AFS and AFC.

Among the reproduction traits the genetic correlation between FSP with AFS and AFC found to be not estimable (>1).

FL305DMY had high, significant and positive correlation with FLTMY, FLL, MY/FLL, MY/FCI. While positive and non significant correlation was observed for FL305DMY with various first lactation reproduction traits (FSP, FCI) and FDP.

The obtained result confirmed that high producing animals were generally poor with respect to reproduction traits. Similar trend in genetic correlation of FLTMY and FLL with other traits were observed. However, positive genetic correlation of HL with FL305DMY, FLTMY and FLL revealed that high producer had higher HL. Very high and significant genetic correlation between FSP and FCI indicated that FSP is integral component of FCI and higher FSP resulted in higher FCI.

Negative but non significant genetic correlation of MY/FLL, MY/FCI with FSP was observed in the present study. However, genetic correlation between FSP and HL was found to be non estimable.

A positive estimate of genetic correlation between FDP and FCI and between FDP and MY/FLL was observed in the study.

However, negative genetic correlation between FDP and FCI indicated that higher FDP resulted in higher FCI thus reduces the MY/FCI.

A positive and negative genetic correlation of FCI with MY/FLL and MY/FCI was observed respectively in the present study. HL had positive and highly significant genetic correlation with FDP and FCI while genetic correlation of HL with MY/FLL was not estimable (> 1).

However negative genetic correlation between HL and MY/FCI indicates the greater influence of environmental correlation between these two traits.

4.3.3.2.2. Genetic correlations in Karan Fries Cattle

Genetic correlation between various traits presented in the Table 4.26 revealed that there was a positive but non-significant genetic correlation of BWT with WOY, WFS was found in the present study whereas genetic correlation between BWT and WFC were not estimable. However AFS and AFC had negative but non-significant genetic correlation with BWT. The various first lactation production (FL305DMY, FLTMY, FLL, FDP) and production efficiency (MY/FLL, MY/FCI) traits had non-significant but positive genetic correlation with BWT. Among the reproduction traits FSP had the positive and FCI had the negative genetic correlation with BWT. However in both the cases estimates were found to statistically non-significant. HL had low negative and non-significant correlation with BWT.

The genetic correlation of WOY was found negative as well as non-significant with WFS, WFC, AFS, AFC, FLL, FDP and FCI whereas positive but non significant correlation was found with FL305DMY, FLTMY, FSP, MY/FLL and HL. WFS had positive and highly significant genetic correlation with WFC but negative and significant genetic correlation with AFC. However WFC had only significant genetic correlation with AFS.

For the various growth traits negative genetic correlation with AFS and AFC indicates that animals with higher weight at different ages to mature and parturate early.

AFS had high and positive genetic correlation with AFC, FL305MY, FLTMY, MY/FLL, MY/FCI. The results indicate that late matures animals to produce more as compared to early maturing animals. However positive estimate of genetic correlation of AFS with FSP, FDP and FCI revealed that increase in various reproduction traits occurred with the increase of AFS.

High, positive and statistically significant correlation was observed for AFC with FL305DMY, FCI, MY/FLL, MY/FCI. Which signifies that more milk yield was obtained from late calvers but at the same time FCI was also found to be increased with the increase in AFC. A positive and moderate genetic correlation was observed between AFC and HL.

Jadhav and Khan (1996) also reported high and positive genetic correlation of AFC with FL305DMY and FCI. Deshpande *et al.* (1992) also reported very high genetic correlation between AFC and MY/FCI. While genetic correlation with FLL, FSP and FDP were found as positive but non significant.

FLTMY showed positive, significant and very high genetic correlation with MY/FLL, MY/FCI.

Genetic correlation of HL with FL305DMY and FLTMY was found to be 0.449±0.215 and 0.464±0.278 respectively.

The above results indicate that high produces generally had high FSP, FDP, FCI and due to high production the animals also kept in the hard for longer time thus had high HL. Correlation of FSP with FDP, FCI, MY/FLL, MY/FCI and HL were found to be positive but low to moderate in magnitude which were statistically. Negative genetic correlation of FDP with MY/FLL, MY/FCI which indicates that increase in the FDP resulted in increase of FCI as well as FLL. Thus reduces the production efficiency traits. Singh *et al.* (1993) found negative genetic correlation between FDP and MY/FLL is JXS crosses and the coefficient was reported to be –1.00.

FCI found to have negative but non-significant genetic correlation with MY\FCI which reflects that increase in FCI causes reduction in MY/FCI. MY/FLL found to have significant and positive correlation with MY/FCI. HL had positive but non-significant genetic correlation with MY/FLL and MY/FCI.

The result revealed than animals with high production efficiency tend to remain in hard for higher period thus had higher HL.

4.4. ESTIMATION OF THE AVERAGE PERFORMANCES OF VARIOUS ECONOMIC TRAITS IN CROSSBRED CATTLE BASED ON DIFFERENT CRITERIA

Adjusted records of performance traits of Karan Swiss and Karan Fries cows were used for this study. The crossbred cows (both Karan Swiss and Karan Fries) were classified into groups on the basis of various criteria like type of crosses, levels of exotic inheritance, levels of heterozygosity and number of breed used in developing the crossbred cows. The average of performance traits under different groups were estimated and discussed below.

4.4.1. Performance of Different Types of Crosses in Crossbred Population

In the crossbred population the animals can be broadly categorized into two types of crosses namely pure cross consists of F_1, F_2, F_3, F_4 etc. and miscellaneous crosses (viz., F_1x F_2, FxBC and others). The performance with respect to various growth, reproduction and production traits under different types of crosses were studied and discussed below.

4.4.1.1. Performance of different types of crosses in Karan Swiss cattle

The performance of various growth, reproduction and production traits for different types of crosses are presented in the Table 4.27.

The average level of heterozygosity for F_1, F_2, F_3, F_4 and miscellaneous crosses were observed as 100, 50, 50, 50 and 55 percent respectively.

The growth traits (BWT, WOY, WFS, WFC) did not show any significant difference among the various crosses. No specific trend with respect of growth traits was observed in the present investigation. The miscellaneous crosses found to have higher estimates of BWT, WOY, WFS, WFC than the pure crosses.

Among the reproduction traits significant difference between various crosses were observed only for AFS and AFC. F_1s were found to be superior to the rest of crosses with minimum AFS (697.94±8.52 days) and AFC (975.78±8.01 days) respectively. There was a deterioration in the performance in F_2 and F_3 crosses, respectively. However, miscellaneous crosses showed improvement in the performance with respect to AFS on AFC with the average 776.86 days and 1058.36 days respectively.

No significant difference between various crosses was observed for FSP on FCL. FSP was found to ranged between 108.90±11.99 days (F_2 crosses) to 177.00±29.36 days (F_3 crosses). Whereas, average FCI varied from 409.60±13.65 days(F_2 crosses) to 460.60±37.64 days (F_3 crosses).

Statistically significant difference between various types of crosses was observed for various production (FL305DMY, FLTMY and FLL) and production efficiency traits (MY/FLL, and MY/FCI). F_1 crosses were found to produce maximum FL305DMY (2757.11 kg). FL305DMY was found to reduce by 33 percent (908.78 kg) in F_2 crosses, 21 percent (566.82 kg) in F_3 crosses, 16 percent (445.52kg) inF_4 crosses, respectively in comparison to F_1 crosses. However average FL305DMY in miscellaneous crosses (2365.90±27.04 kg)was higher than the F_2, F_3 and F_4 crosses.

Similar trend was observed in FLTMY, in which F_2, F_3 and F_4 crosses found to produce 27 percent (894.84 kg), 17 percent (576.22kg) and 14 percent (471.48kg) less milk yield compared to F_1 crosses. Among the miscellaneous crosses average FLTMY was estimated as 2882.69±35.03 kg.

Average FLL was found to be maximum in F_4 crosses (363.80±45.28 days), however, the estimate was not found to be significantly different from average FLL in F_1 crosses (362.45±5.29 days), F_3 crosses (350.00±41.34 days). In the F_2 and miscellaneous crosses the estimate observed to be

Table 4.27. Average performance of different types of crosses in Karan Swiss cows

Type	Avg. LH	BWT	WOY	WFS	WFC	AFS	AFC	FSP
F_1	1.00	25.26 ± 0.21 (507)	174.15 ± 3.64 (162)	283.34 ± 4.09 (131)	343.39 ± 4.34 (128)	697.94 ± 8.52 ^{a} (376)	975.78 ± 8.01 ^{a} (420)	127.27 ± 3.95 (276)
F_2	0.50	24.45 ± 0.49 (95)	159.80 ± 14.66 (10)	274.07 ± 12.52 (14)	289.90 ± 15.52 (10)	854.69 ± 22.68 ^{c} (53)	1105.59 ± 21.36 ^{c} (59)	108.90 ± 11.99 (30)
F_3	0.50	26.28 ± 1.05 (21)	170.66 ± 26.77 (3)	298.00 ± 33.13 (2)	340.00 ± 34.70 (2)	881.56 ± 62.42 ^{c} (7)	1183.87 ± 58.01 ^{c} (8)	177.00 ± 29.36 (5)
F_4	0.50	26.75 ± 1.70 (8)	134.00 ± 46.37 (1)	301.00 ± 46.85 (1)	357.00 ± 35.00 (2)	746.01 ± 73.85 ^{c} (5)	1085.19 ± 73.38 ^{bc} (5)	138.00 ± 29.36 (5)
Misc.	0.55	26.71 ± 0.99 (2388)	180.62 ± 1.66 (782)	307.28 ± 2.02 (537)	365.17 ± 2.15 (521)	776.86 ± 4.83 ^{b} (1169)	1058.36 ± 4.65 ^{b} (1242)	122.57 ± 2.48 (701)

Type	FCI	FDP	FLTMY	FL305DMY	FLL	MY/FLL	MY/FCI	HL
F_1	429.86 ± 4.84 (302)	72.17 ± 1.82 ^{a} (283)	3274.40 ± 62.60 ^{a} (387)	2757.11 ± 46.41 ^{a} (369)	362.45 ± 5.29 ^{a} (369)	9.48 ± 0.12 ^{a} (365)	7.94 ± 0.12 ^{a} (298)	2458.33 ± 54.83 ^{a} (472)
F_2	409.60 ± 13.65 (38)	84.20 ± 5.26 ^{b} (34)	2379.56 ± 120.98 ^{c} (60)	1848.33 ± 122.16 ^{c} (56)	323.75 ± 14.61 ^{b} (48)	7.35 ± 0.34 ^{b} (47)	6.04 ± 0.34 ^{c} (35)	1421.82 ± 124.88 ^{b} (91)
F_3	460.60 ± 37.64 (5)	79.80 ± 13.72 ^{ab} (5)	2707.18 ± 360.55 ^{bc} (7)	2190.29 ± 345.54 ^{bc} (7)	350.00 ± 41.34 ^{a} (6)	8.22 ± 0.94 ^{b} (6)	6.84 ± 0.90 ^{bc} (5)	1126.67 ± 273.31 ^{c} (19)
F_4	427.40 ± 37.64 (5)	63.60 ± 13.72 ^{a} (5)	2802.92 ± 975.15 ^{bc} (5)	2311.59 ± 408.84 ^{b} (5)	363.80 ± 45.28 ^{a} (5)	8.25 ± 1.03 ^{b} (5)	7.02 ± 0.90 ^{b} (5)	1387.79 ± 397.11 ^{bc} (9)
Misc.	419.03 ± 3.08 (745)	78.22 ± 1.16 ^{a} (693)	2882.69 ± 35.03 ^{b} (1143)	2365.90 ± 27.04 ^{b} (1143)	329.58 ± 3.14 ^{b} (1036)	8.61 ± 0.72 ^{b} (1032)	7.26 ± 0.74 ^{b} (727)	1247.57 ± 25.48 ^{bc} (2185)

Figures in the parenthesis indicate number of observations

323.75 and 329.58 days, respectively. Average MY/FLL as observed in the present study varied from 7.35±0.34 kg in F_2 crosses to 9.48±0.12 kg in F_1 crosses whereas in case of MY/FCI the maximum and minimum estimates were found to be 7.94±0.12 kg and 6.04±0.34 kg respectively in F_1 and F_2 crosses.

In Karan Swiss cattle the highest average HL was observed in F_1 crosses (2458.33±54.33 days). There was a decline in the average HL in the subsequent crosses was observed in the present study. Minimum average HL was observed for F_3 crosses (1126.67±273.31 days).

Extensive research work on crossbreeding confirmed that performance of F_1 was better than the subsequent crosses i.e., F_2 F_3 etc. (Parmer *et al.*, 1986; Bhatnagar *et al.*, 1981; Nagarcenkar and Rao, 1982; Cunningham and Syrstad, 1987). Sharma *et al.* (1982) also reported that similar to the trend in the milk yield, fat and SNF yield also showed a declining trend from F_1 to F_2. Superiority of F_1 was ascribed due to maximum heterotic effect. The decrease in the performance from F_1 to F_2 generations can be attributed to recombination loss and to differences in the breeding values of the bulls used in producing these generations.

4.4.1.2 Performance of different types of crosses in Karan Fries cattle

The average performance of various growth, reproduction and production traits as observed in the present study for different types of crosses are presented in the Table 4.28. The average level of heterozygosity for F_1, F_2, F_3 and miscellaneous crosses were found as 100, 50, 50 and 54 percent , respectively.

Significant difference was observed for the growth traits among various crosses. Females produced from miscellaneous crosses had higher birth weight (27.41±0.10kg) and the estimate was significantly different from the estimates found in F_1 (26.24±0.31kg) and F_3 crosses (25.75±2.51kg).

Maximum WOY was observed for F_1 (203.68±3.49kg) followed by F_2 (192.28±11.02kg), F_3 (188.00±29.16 kg) and miscellaneous crosses (185.33±1.39kg). However, in case of WFS and WFC no significant difference was observed between F_2 F_3 and miscellaneous crosses. For both the WFS and WFC average estimate was minimum in F_1 crosses. Various reproduction traits considered for the study were AFS, AFC, FSP and FCI. In case of AFS and AFC minimum estimates were observed in F_1 crosses as 641.58±11.24 days and 921.80±10.37 days, respectively. Though there was an increasing trend observed in the subsequent F_2, F_3 crosses, the average estimates of AFS and AFC in F_2 were not significantly different from F_1 crosses. Miscellaneous crosses were not found to be significantly different from F_3 crosses for AFS and AFC.

Minimum average FSP and FCI was observed in F_1 crosses and values were 117.03±6.95days and 403.83±7.00 days respectively. However, an increasing trend was observed in F_2 and F_3 crosses for FSP and FCI.

The highest average FL305DMY was observed among F_1 individuals (3370.38±61.15 kg). In comparison to F_1 individuals, FL305DMY was found to reduce by 18 percent (417.38±8 kg) in F_2, 32 percent (1082.91 kg) in F_3 and 15 percent (507.44 kg) in other miscellaneous crosses. However, the average FL305DMY observed in other miscellaneous crosses was not significantly different fromF_2 and F_3 individuals.

Maximum average of FLTMY (3746.66±90.42kg) was observed among F_1 individuals followed by miscellaneous crosses (3388.06±37.12 kg). Average FLTMY for F_2 and F_3 animals observed to be 3104.98±315.53 kg and 2520.09±919.93kg respectively which was 17.12 percent and 32.73 percent lesser than the average production in F_1.

No significant difference with respect to average FDP and FLL was observed among the various crosses in the present study. Average FDP was found to range between 73.73±3.73 days (in F_1) to 174.00±48.11 days (in F_3). While FLL ranged from 291.50±72.95 days (F_3) to 341.82±2.97 days (Miscellaneous crosses).

In the present study F_1 animals were found to be significantly different from the rest of the crosses with highest average MY/FLL (11.38±0.22kg). Miscellaneous crosses had higher MY/FLL (9.99±0.91 kg) than F_2 and F_3 crosses. The minimum average MY/FCI (6.47±2.11 kg) was observed in F_3 crosses. While maximum average MY/FCI was found inF_1 crosses (9.70 ±0.16 kg). However, no significant difference was observed between F_2 crosses and miscellaneous crosses where the corresponding values for MY/FLL were observed as 8.92±0.58 kg and 8.567±0.72kg, respectively.

The highest average HL was observed in F_1 as 2755.09±73.17 days. Whereas the corresponding values for F_2, F_3 and miscellaneous crosses were observed as 1444.68±218.54 days, 1097.50±546.36 days and 1327.85±24.44 days respectively. However, the difference in average HL among F_2, F_3 and miscellaneous crosses were not statistically significant.

Studies on the comparative performance of F_1 and subsequent generation (F_2 onwards) revealed that there was a decline in the performance on *interse*-mating among F_1s ranging from 20 to 40 percent depending upon the indigenous and exotic breeds used (Buvanendran and Mahadevan, 1975; Parmar *et al.*, 1980 and Parmar *et al.*, 1986).

Syrstad (1989) also compared the performance of F_1 and F_2 populations with Holstein Frisian inheritance and found that there was an 7 percent increase in AFC and 24 percent and 4 percent reduction in milk yield and lactation length, respectively compared to F_1.

The explanation for this was given as a reduction in heterozygosity from F_1 to F_2 as well as a break down of epistatic gene combination (recombination loss) for milk yield traits. The lack of selection of F_1 bulls may be another factor responsible for lack of such deterioration.

Table 4.28. Average performance of different types of crosses in Karan Fries cows

Type	LH	BWT	WOY	WFS	WFC	AFS	AFC	FSP
F_1	1.00	26.24 ± 0.31^{b} (262)	203.68 ± 3.49^{a} (140)	273.60 ± 4.23^{b} (131)	350.54 ± 4.20^{b} (135)	641.58 ± 11.24^{a} (191)	921.80 ± 10.37^{a} (221)	117.03 ± 6.95^{a} (164)
F_2	0.50	27.65 ± 0.98^{a} (26)	192.28 ± 11.02^{ab} (14)	328.73 ± 14.61^{a} (11)	358.83 ± 14.09^{a} (12)	651.01 ± 40.11^{a} (15)	932.88 ± 36.33^{a} (18)	141.31 ± 24.67^{a} (13)
F_3	0.50	25.75 ± 2.51^{b} (4)	188.00 ± 29.16^{ab} (2)	347.00 ± 34.27^{a} (2)	359.98 ± 48.82^{a} (1)	745.00 ± 109.85^{b} (2)	1027.04 ± 108.98^{b} (2)	271.00 ± 88.96^{b} (1)
Misc.	0.54	27.41 ± 0.10^{a} (2396)	185.33 ± 1.39^{b} (873)	309.65 ± 1.95^{a} (614)	372.66 ± 1.89^{a} (670)	728.73 ± 4.22^{b} (1351)	1005.07 ± 4.11^{b} (1404)	143.43 ± 3.04^{a} (855)

Type	FCI	FDP	FLTMY	FL 305DMY	FLL	MY/FLL	MY/FCI	HL
F_1	403.83 ± 7.00^{a} (181)	73.73 ± 3.73 (166)	3746.66 ± 90.42^{a} (207)	3370.38 ± 61.15^{a} (211)	332.19 ± 7.24 (203)	11.38 ± 0.22^{a} (202)	9.70 ± 0.16^{a} (176)	2755.09 ± 73.17^{a} (223)
F_2	486.01 ± 26.11^{b} (13)	76.07 ± 12.86 (14)	3104.98 ± 315.53^{b} (17)	2753.00 ± 215.43^{ab} (17)	306.29 ± 25.03 (17)	9.96 ± 0.77^{b} (17)	8.92 ± 0.58^{b} (13)	1444.68 ± 218.54^{b} (25)
F_3	542.98 ± 94.16^{b} (1)	174.00 ± 48.11 (1)	2520.09 ± 919.93^{c} (2)	2287.47 ± 628.08^{b} (2)	291.50 ± 72.95 (2)	8.33 ± 2.24^{b} (2)	6.47 ± 2.11^{b} (1)	1097.50 ± 546.36^{b} (4)
Misc.	428.96 ± 3.18^{a} (874)	75.45 ± 1.62 (878)	3388.06 ± 37.12^{b} (1228)	2862.94 ± 25.31^{b} (1232)	341.82 ± 2.97 (1204)	9.99 ± 0.91^{b} (1200)	8.56 ± 0.72^{b} (855)	1327.85 ± 24.44^{b} (1999)

Figures in the parenthesis indicate number of observations

4.4.2. Performance of Crossbred Population With Respect to Exotic Level of Inheritance

Crossbred animals (excluding F_1) were classified into 3 classes based on level of exotic inheritance as 50 percent, 50 to 62.5 percent and above 62.5 percent. The performance with respect to various growth, reproduction, production traits, and herd life for different levels exotic inheritance were investigated and discussed below.

4.4.2.1.1. Performance of Karan Swiss animals with respect to exotic level of inheritance

The average performance of various growth, reproduction and production traits for different levels of exotic inheritance was studied and presented in the Table 4.29.

The average level of heterozygosity for different exotic inheritance levels was observed as 56 percent (for 50%EI), 56 percent (50-62.5%EI) and 40 percent (for EI>62.5%).

Various growth traits (viz., BWT, WOY,WFS,WFC) did not differ significantly for the animals with different exotic inheritance levels. The highest average BWT, WOY,WFS, WFC was observed for those animals with exotic inheritance 50 to 62.5 percent and corresponding values were observed as 26.86±0.22 kg, 181.75±3.37 kg, 309.26±4.28 kg and 370.99±4.53 kg respectively for the traits mentioned above.

Significant difference between the animals with different exotic inheritance level was observed for AFS and AFC in the present study. Minimum AFS and AFC were observed for those animals with exotic inheritance more than 62.5 percent. The corresponding values were observed as 734.93±17.19 days for AFS and 1020.03±17.04 days for AFC. However, the average estimate of AFS and AFC did not differ significantly between the animals with 50 percent and 50 to 62.5 percent exotic inheritance.

Average FSP was found to range between 118.16±5.31 days (EI level 50-62.5 percent) to 122.83±2.72 days (EI level 50 percent). Whereas, average estimate of FCI range between 406.51±6.52 days (EI level above 62.5 percent) to 420.42±3.29 days (EI level 50 percent). However, average estimates of FSP and FCI did not differ significantly among the groups with various levels of exotic inheritance.

Animals with exotic inheritance 50 to 62.5 percent had maximum FL305DMY (2450.99±62.00kg) followed by the animals with 50 percent and above 62.5 percent exotic inheritance where the corresponding values for FL305DMY were observed as 2311.26±32.18 kg and 2272.79±92.73 kg respectively. Similar trend was observed in FLTMY with maximum FLTMY (2729.91±81.24 kg) among the animals with exotic inheritance 50 to 62.5 percent. However, the animals with exotic inheritance more than 62.5 percent found to have minimum estimate of FLTMY (2521.10±121.00kg).

Average estimates of FLL and FDP did not differ significantly between the groups with different exotic inheritance level. Maximum FLL was observed for the animals with exotic inheritance 50 percent whereas minimum FDP was observed with high level of exotic inheritance (>62.5 percent).

Among the production efficiency traits MY/FLL differed significantly between different exotic inheritance level whereas, no significant difference was observed for MY/FCI between different levels of exotic inheritance.

The maximum MY/FLL (8.96±0.16kg) was observed for those animals with exotic inheritance 50 to 62.5 percent whereas maximum MY/FCI (7.54±0.26kg) was observed for those animals with exotic inheritance level more than 62.5 percent.

No significant difference with respect to HL was observed in the present study in the Karan Swiss animals for different exotic levels.

Table 4.29. Average performance of with respect to different levels of exotic inheritance in Karan Swiss cows

EI Level (%)	LH	BWT	WOY	WFS	WFC	AFS	AFC	FSP
50	0.56	26.52 ± 0.11 (1774)	180.00 ± 1.96 (580)	306.90 ± 2.38 (415)	362.35 ± 2.70 (369)	789.98 ± 5.98 ^{b} (933)	1070.36 ± 5.76 ^{b} (997)	122.83 ± 2.72 (562)
50-62.5	0.56	26.86 ± 0.22 (509)	181.75 ± 3.37 (197)	309.26 ± 4.28 (128)	370.99 ± 4.53 (131)	780.37 ± 11.63 ^{b} (247)	1058.27 ± 11.14 ^{b} (267)	118.16 ± 5.31 (148)
>62.5	0.40	26.85 ± 0.33 (228)	171.22 ± 6.69 (50)	286.69 ± 8.56 (32)	352.69 ± 6.75 (59)	734.93 ± 17.19 ^{a} (113)	1020.03 ± 17.04 ^{a} (114)	119.01 ± 8.07 (64)

EI Level (%)	FCI	FDP	FLTMY	FL305DM Y	FLL	MY/FLL	MY/FCI	HL
50	420.42 ± 3.29 (607)	79.45 ± 1.34 (564)	2638.18 ± 42.02 ^{b} (912)	2311.26 ± 32.18 ^{b} (913)	330.13 ± 3.54 (820)	8.45 ± 0.08 ^{b} (818)	7.11 ± 0.09 (588)	1257.17 ± 24.94 (1736)
50-62.5	412.33 ± 6.52 (155)	76.26 ± 2.64 (146)	2729.91 ± 81.24 ^{a} (244)	2450.99 ± 62.00 ^{a} (246)	326.30 ± 6.71 (228)	8.96 ± 0.16 ^{a} (225)	7.44 ± 0.17 (153)	1260.29 ± 48.40 (461)
>62.5	406.51 ± 9.99 (66)	72.10 ± 4.08 (61)	2521.10 ± 121.00 ^{c} (110)	2272.79 ± 92.73 ^{b} (110)	313.55 ± 10.13 (100)	8.30 ± 0.24 ^{b} (100)	7.54 ± 0.26 (65)	1159.67 ± 70.71 (216)

Figures in the parenthesis indicate number of observations

Table 4.30. Averages of various early lactation traits along with LH in different clusters under various Exotic levels of Karan Swiss cows

EI Level	Cluster	No. of Observations	LH	AFS	AFC	FL 305 DMY
50 percent	1	69	0.56	817.15	1105.71	3991.44
	2	506	0.56	792.50	1073.20	2575.17
	3	179	0.56	778.40	1065.30	999.47
50-62.5 percent	1	145	0.58	749.00	1036.39	3616.10
	2	3	0.57	564.00	851.00	3805.10
> 62.5 percent	1	76	0.40	712.82	999.34	2669.00
	2	3	0.37	830.33	1114.00	4849.73
	3	31	0.40	767.77	1043.45	1051.98

However, animals with 50 to 62.5 percent exotic inheritance had maximum average HL (1260.29±48.40 days).

Extensive research work conducted on crossbreeding confirmed that crossbred animals with 50 percent to 62.5 percent exotic inheritance showed superior performance with respect to adaptability production and reproduction traits (Amble and Jain, 1966, 1967; Katpatal, 1970; Dhillon and Jain, 1977; Rao and Nagarcenkar, 1979; Deshpande and Bonde, 1982a,b, 1983; Sinha 1999).

4.4.2.1.2. Performance of Karan Fries animals with respect to exotic level of inheritance

The average performance of various growth, reproduction and production traits for different levels of exotic inheritance was studied and presented in the Table 4.31.

The average level of heterozygosity for different exotic inheritance levels were observed as 51 percent, 53 percent and 48 percent for the animals with exotic inheritance 50 percent, 50 to 62.5 percent and greater than 62.5 percent, respectively.

No significant difference was observed for BWT and WOY for different levels of exotic inheritance. However, WFS and WFC differed significantly for different levels of exotic inheritance. In the present study maximum WFS and WFC was observed for the animals with exotic inheritance 50 percent and the corresponding values were 331.47±12.02 kg and 377.50±10.94kg.

Animals with 50 to 62.5 percent exotic inheritance were found to have minimum AFS and AFC and the estimates were observed to be 690.07±6.42 days and 967.07±6.15 days respectively. However, the estimates were not significantly different from the estimates observed among the animals with 50 percent exotic inheritance in which mean AFS and AFC was found to be 709.87±28.78 days and 982.77±26.31 days.

Average FSP was found to range between 103.19±19.44 days (50 percent EI) to 50.22±4.10 days (EI level > 62.5 percent). Whereas FCI was observed to vary between 386.43±20.29 days (50 percent EI) to 436.30±4.21 days (EI level >62.5 percent)

Animals with exotic inheritance 50 to 62.5 percent had maximum FL305DMY (2870.48±39.56kg) followed by the animals with more than 62.5 percent and 50 percent exotic inheritance where the corresponding values for FL305DMY were observed as 2865.32±33.48 kg and 2672.66±165.90kg, respectively (Table 4.31 & Fig. 4.9).

The maximum estimate of FLTMY observed for those animals with exotic inheritance more than 62.5 percent (3485.71±49.44kg). However, for the animals with exotic inheritance 50 percent and 50-62.5 percent the average FLTMY was observed to be 2849.48±244.81 kg and 3368.44±58.55 kg respectively. The estimated mean FLTMY did not found to be significantly different between the two groups with EL level 50-62.5 percent and above 62.5 percent.

Average estimate of FLL and FDP for different exotic inheritance level indicated superiority of the animals with exotic inheritance greater than 62.5 percent where the average were found to be 354.07±3.94 days and 72.43 ±2.06 days for FLL and FDP, respectively.

MY/FLL was found to range between 9.29±0.60 kg (EI level 50 percent) to 10.04±0.12 kg (EL level above 62.5 percent). Whereas MY/FCI ranged between 8.34±0.47 kg (50 percent EI) to 8.59±0.95 kg EI > 62.5 percent. However, difference in the mean MY/FLL and MY/FCI observed for different EI levels was not statistically significant.

Animals with exotic inheritance above 62.5 percent had maximum average HL (1361.84±29.84 days). The estimates for those animals with 50 percent exotic inheritance level and 50 to 62.5 percent exotic inheritance were observed to be 1348.73±152.18 days and 1280.29±35.80 days

Table 4.31. Performance with respect to different levels of exotic inheritance in Karan Fries cows

EI Level (%)	LH	BWT	WOY	WFS	WFC	AFS	AFC	FSP
1 50	0.51	27.29 ± 0.69 (54)	181.23 ± 7.31 (31)	331.47 ± 12.02 [a] (17)	377.50 ± 10.94 [a] (20)	709.87 ± 28.78 [a] (28)	982.77 ± 26.31 [a] (32)	103.19 ± 19.44 [a] (21)
2 50-62.5	0.53	27.30 ± 0.15 (1068)	187.44 ± 1.81 (503)	317.85 ± 2.69 [a] (340)	376.57 ± 2.50 [a] (384)	690.07 ± 6.42 [a] (562)	967.97 ± 6.15 [a] (586)	136.13 ± 4.60 [a] (375)
3 >62.5	0.48	27.50 ± 0.14 (1304)	183.00 ± 2.16 (355)	299.15 ± 3.01 [b] (271)	366.29 ± 2.92 [b] (280)	742.66 ± 5.46 [b] (778)	1021.63 ± 5.24 [b] (806)	150.22 ± 4.10 [b] (473)

EI Level (%)	FCI	FDP	FLTMY	FL305MY	FLL	MY/FLL	MY/FCI	HL
1 50	386.43 ± 20.29 [a] (21)	84.04 ± 9.57 (23)	2849.48 ± 244.81 [b] (29)	2672.66 ± 165.90 [b] (29)	295.38 ± 19.30 [b] (29)	9.29 ± 0.60 (29)	8.34 ± 0.47 (20)	1348.73 ± 152.18 (45)
2 50-62.5	420.80 ± 4.78 [b] (379)	78.62 ± 2.38 (371)	3368.44 ± 58.55 [a] (507)	2870.48 ± 39.56 [a] (510)	326.06 ± 4.65 [b] (499)	9.94 ± 0.14 (497)	8.53 ± 0.11 (364)	1280.29 ± 35.80 (813)
3 >62.5	436.30 ± 4.21 [b] (488)	72.43 ± 2.06 (499)	3305.71 ± 49.44 [a] (711)	2865.32 ± 33.48 [a] (712)	354.07 ± 3.94 [a] (695)	9.69± 0.12 (693)	8.49 ± 0.95 (485)	1361.84 ± 29.84 (1170)

Figures in the parenthesis indicate number of observations

Table 4.32. Averages of various early lactation traits along with LH in different clusters under various Exotic levels of Karan Fries cows

EI Level	Cluster	No. of Observations	LH	AFS	AFC	FL 305 DMY
50 percent	1	13	0.51	631.23	918.46	3383.53
	2	14	0.53	750.85	1033.78	1859.35
	3	221	0.54	704.00	979.00	2977.00
50-62.5 percent	1	13	0.53	775.15	1003.84	4665.53
	2	46	0.54	745.04	1013.15	1381.63
> 62.5 percent	1	85	0.47	727.35	1015.80	2669.21
	2	43	0.51	734.11	1011.82	1439.81
	3	43	0.43	816.76	1098.44	3594.30

respectively. However, the average HL observed at different exotic level of inheritance was not found to be statistically significant.

Numerous literature as available on crossbreeding indicated superior performance of the animals with 50 percent to 62.5 percent exotic inheritance with respect to various economic traits.

Rao and Taneja (1980) studied on HF x Zebu crosses and found that 50 percent HF was significantly superior to all other groups whereas animals with below 50 percent exotic inheritance had the lowest milk yield.

Matharu and Gill (1981) on HF x Sahiwal crosses at MDF found that cows with 5/8 Holstein Frisian inheritance had the highest milk yield per day of productive life, while milk yield per day of total life was highest in halfbreds.

Syrstard (1996) reported the least squares means of AFC and milk yield under different grades of *Bos tausus* x *Bos indicus* crosses and found that least squares means of dairy performance was best at 50 to 75 percent exotic level for milk yield and AFC. In most of the studies superiority in the performance of animals with 50 percent exotic inheritance was observed may be due to presence of F_1 animals under this category. However, Syrstad (1996) reported that for a composite population or in rotational crossing slightly higher than 50 percent exotic inheritance was found to be desirable level of exotic inheritance in the population.

4.4.2.2. Classification of different exotic levels of crossbred cows. Using Euclidean distance (complete linkage) mated

Crossbred females (excluding F_1 animals) were classified on the basis of exotic level of inheritance into three groups, viz., 50 percent, 50 to 62.5 percent and above 62.5 percent were further classified based on different early lactation traits (AFS, AFC, FL305DMY), along with the level of heterozygosity of each animal using Euclidean distance (complete linkage) method.

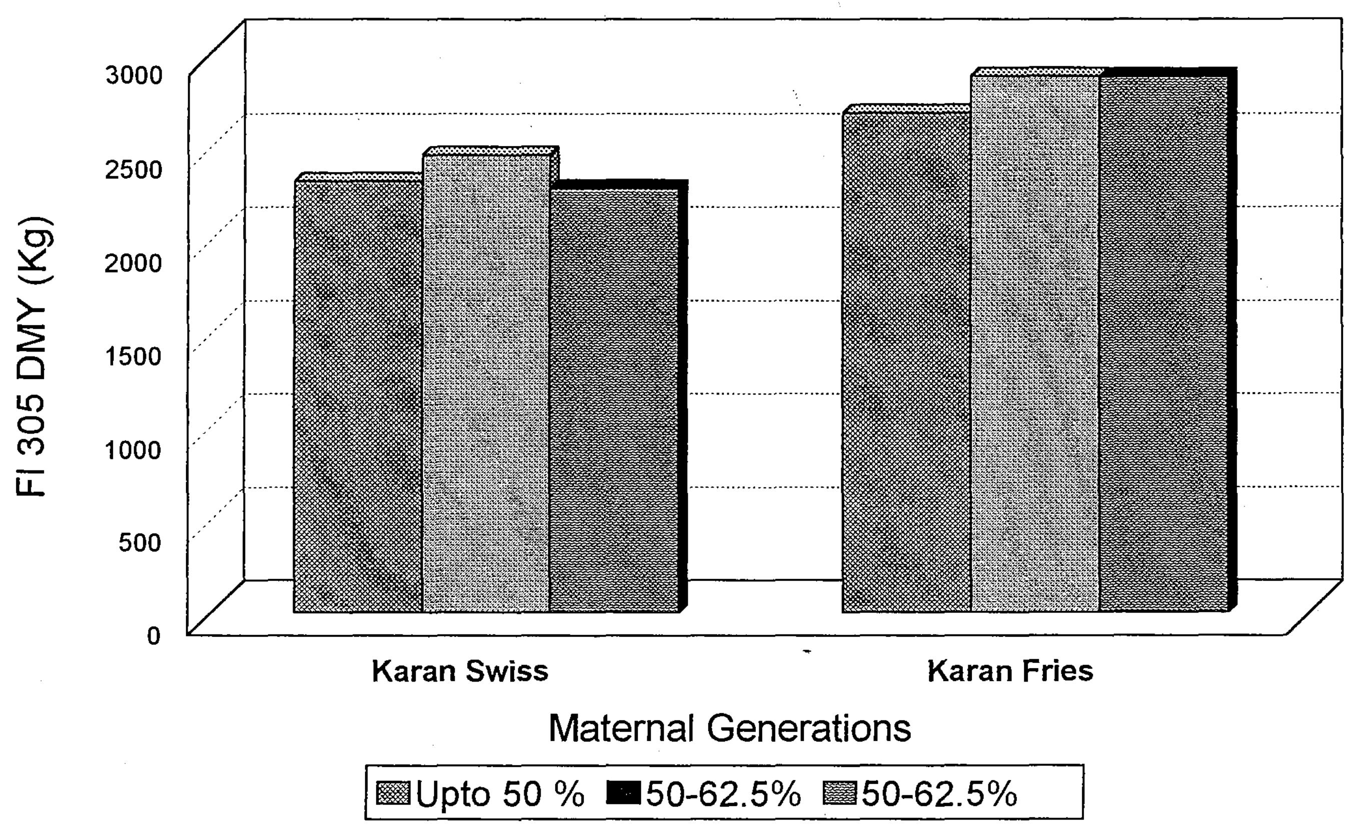

Fig. 4.9. Average first lactation 305 day milk yield for different levels of exotic inheritance in crossbred cows

4.4.2.2.1. Classification of different exotic levels of Karan Swiss cows using Euclidean distance (complete linkage) method

Karan Swiss cows under each of the three groups of exotic inheritance levels viz., 50 percent, 50-62.5 percent and above 62.5 percent were classified further into three, two and three clusters with a criterion value of 1731.314, 2263.697, 1803.781, respectively. The average performance of various traits (AFS,AFC,FL305DMY) along with average level of heterozygosity for different clusters under each categories of exotic inheritance level was presented in Table 4.30. The distance studies have shown that within a particular level of exotic inheritance animals were not similar with respect to the traits considered for this study.

4.4.2.2.2. Classification of different exotic levels of Karan Fries cows using Euclidean distance (complete linkage) method

Karan Fries cows under each of the three groups of exotic inheritance levels viz., 50 percent, 50-62.5 percent and above 62.5 percent were further classified into three, two and three clusters with a criterion value of 1107.363, 1873.420, 2051.009, respectively.

The estimated value of different early lactation reproduction and production traits (AFS,AFC,FL305DMY) along with average level of heterozygosity presented in the Table 4.32. The result revealed that animals under a particular exotic inheritance group were not similar with respect to the traits considered for this study.

4.4.3. Performance of the Crossbred Cows Based on the Number of Breeds Used

The crossbred populations (except F_1) considered for the present investigation were found to have inheritance from two, three, four and five breeds as recorded in the pedigree. The various breeds used for mating for Karan Swiss and Karan Fries was already presented in Table 3.17 and Table 3.18. The average performance of various growth, first lactation reproduction, production traits and herd life were studied and discussed below:

4.4.3.1. Performance of the Karan Swiss cows based on the number of breeds used

The average performance of various growth, first lactation production and reproduction traits under different category in Karan Swiss were studied and presented in the Table 4.33, along with corresponding level of exotic inheritance and heterozygosity.

The level of exotic inheritance corresponding to two, three, four and five breed source was found was 55, 51, 52 and 53 percent whereas, the level of heterozygosity for the same was 46, 57, 62 and 65 percent. The level of heterozygosity was found to increase with the increase in number of breeds involved in producing Karan Swiss cattle.

Among the various growth traits, considered for the study, only BWT and WOY indicated significant differences between different categories. With respect to all the growth traits (BWT, WOY, WFS and WFC) an increasing trend in the corresponding traits with the increase in the number of breeds, which were involved in breeding. For growth traits mated animals carrying inheritance from five breeds were found to be superior.

Various reproductive traits considered for this study were AFS, AFC,FSP and FCI. Minimum average AFS and AFC were observed for two breed crosses and the corresponding values were 746.62±8.77 days and 1035.068.47 days. However, two breed crosses were not significantly different from three breed crosses with respect to AFS and AFC. The average FSP and FCI did not differ significantly with the involvement of different number of breeds. However minimum FSP was observed for two breed crosses (119.24±4.05 days). While three breed crosses had the minimum average FCI (417.71±4.02 days).

Trends in various production traits presented in the Fig. 4.10 indicated the superiority of the two breed and three breed crosses over the four breed and five breed crosses in Karan Swiss animals. This findings was in conformity with the result Nagarcenkar and Rao (1982) and Sinha (1999).

Table 4.33. Average Performance based on number of breeds used in developing crossbred in Karan Swiss Cows

No. of breed used	LEI	LH	BWT	WOY	WFS	WFC	AFS	AFC	FSP
2	0.55	0.46	26.13 ± 0.167 [b] (852)	174.25 ± 3.20 [b] (216)	296.94 ± 3.89 (155)	359.11 ± 3.77 (189)	746.62 ± 8.77 [a] (435)	1035.06 ± 8.47 [a] (456)	119.24 ± 4.05 (260)
3	0.51	0.57	26.87 ± 0.13 [ab] (1323)	179.73 ± 2.17 [ab] (469)	308.63 ± 2.72 (318)	365.26 ± 3.08 (283)	756.82 ± 7.15 [a] (654)	1038.20 ± 6.87 [a] (693)	124.89 ± 3.27 (397)
4	0.52	0.62	26.99 ± 0.31 [a] (250)	191.42 ± 5.19 [a] (82)	313.71 ± 6.11 - (63)	369.93 ± 7.41 (49)	776.26 ± 17.07 [b] (115)	1075.83 ± 15.88 [b] (130)	127.24 ± 8.29 (62)
5	0.53	0.65	28.44 ± 0.60 [a] (68)	198.11 ± 9.22 [a] (26)	320.82 ± 11.72 (17)	372.07 ± 14.40 (13)	779.64 ± 32.86 [b] (31)	1060.44 ± 30.17 [b] (36)	129.34 ± 14.60 (20)

No. of breed used	FCI	FDP	FLTMY	FL305DM Y	FLL	MY/FLL	MY/FCI	HL
2	419.79 ± 4.84 (288)	77.75 ± 1.94 (268)	2772.25 ± 61.28 [a] (427)	2661.82 ± 46.77 [a] (427)	332.78 ± 5.13 (385)	8.80 ± 0.12 (382)	7.40 ± 0.12 (280)	1256.17 ± 36.37 (821)
3	417.71 ± 4.02 (417)	78.63 ± 1.61 (388)	2716.29 ± 50.17 [a] (637)	2661.44 ± 38.23 [a] (639)	329.33 ± 4.17 (582)	9.46 ± 0.09 (580)	7.45 ± 0.10 (405)	1274.59 ± 29.97 (1209)
4	429.12 ± 10.36 (63)	80.27 ± 4.14 (59)	2694.82 ± 119.61 [b] (112)	2405.66 ± 90.92 [b] (113)	321.43 ± 10.16 (98)	8.71 ± 0.23 (98)	7.04 ± 0.26 (63)	1150.85 ± 72.43 (1207)
5	437.21 ± 17.15 (23)	93.28 ± 6.94 (21)	2578.59 ± 223.86 [c] (32)	2369.15 ± 170.86 [c] (32)	314.93 ± 18.37 (30)	8.73 ± 0.43 (30)	7.21 ± 0.45 (22)	1199.62 ± 135.67 (59)

Figures in the parenthesis indicate number of observations

The average HL for different categories were presented in Table 4.33 indicated the corresponding values of HL as 1256.17 days, 1274.59 days, 1150.85 days and 1199.62 days for two, three, four and five breed crosses respectively. However the average estimate of HL did not differ significantly from each other.

4.4.3.2. Performance of the Karan Fries cows based on the number of breeds used

The results presented in the Table 4.34 indicated the level of exotic inheritance for two, three, four breed crosses were 57, 65, 62 and 61 percent, respectively, whereas, the level of heterozygosity was 48, 54, 56 and 58 percent respectively. The level of heterozygosity was found to increase with the increase in the number of breeds involved in producing Karan Fries cows.

No significant difference was observed with respect to various growth traits (viz. BWT, WFS, WFC) between different groups except in WOY. Maximum WOY (191.73±2.02 was observed for 3 breed crosses followed by 2 breed crosses (183.88±2.33kg). However, WOY in 4 breed crosses (179.39±2.89kg) and 5 breed crosses (140.80±9.41kg) significantly differed from each other.

Reproduction traits like AFS, AFC, FSP and FCI did not show any significant difference between different groups. The average estimate of AFS was found to range between 723.26±6.25 days (3 breed cross) to 764.33±63.77 days (5 breed cross). Whereas, for AFC it varied from 998.96±6.87 days (3 breed crosses) to 1032.49±63.22 days (5 breed crosses). In the present study, the lowest average of FSP and FCI were observed for the 2 breed and 3 breed crosses and the corresponding values were 105.73 days and 419.98 days respectively.

Significant difference between the different categories was observed for the production traits (FL305DMY, FLTMY, FLL,MY/FCI, MY/FLL) except in FDP in Karan Fries cattle.

Table 4.34. Average performance based on number of breeds used in developing crossbred in Karan Fries cows

No. of Breed used	EI	LH	BWT	WOY	WFS	WFC	AFS	AFC
2	0.57	0.48	27.52 ± 0.15 (1058)	183.88 ± 2.33^{ab} (294)	308.55 ± 3.26 (245)	364.98 ± 2.94 (283)	742.24 ± 6.37 (600)	1019.03 ± 6.10 (643)
3	0.65	0.54	27.08 ± 0.15 (1030)	191.73 ± 2.02^{a} (389)	306.45 ± 2.95 (301)	374.47 ± 2.80 (313)	723.26 ± 6.25 (623)	998.96 ± 6.07 (650)
4	0.62	0.56	27.28 ± 0.24 (422)	179.39 ± 2.89^{b} (191)	311.03 ± 5.07 (102)	371.10 ± 4.52 (120)	726.88 ± 11.07 (199)	1002.14 ± 10.79 (206)
5	0.61	0.58	25.91 ± 0.85 (35)	140.83 ± 9.41^{c} (18)	268.33 ± 29.59 (3)	374.99 ± 24.78 (4)	764.33 ± 63.77 (6)	1032.49 ± 63.22 (6)

No. of Breed used	FSP	FCI	FDP	FLTMY	FL 305DMY	FLL	MY/FLL	MY/FCI	HL
2	105.73 ± 3.30 (421)	435.76 ± 4.53 (423)	76.00 ± 2.31 (426)	3514.31 ± 54.25^{a} (585)	2967.86 ± 36.81^{a} (585)	343.71 ± 4.36^{b} (576)	10.30 ± 0.13^{a} (576)	8.75 ± 0.10^{a} (417)	1471.88 ± 32.87^{a} (969)
3	113.78 ± 2.80 (405)	419.98 ± 4.63 (406)	75.59 ± 2.38 (401)	3231.83 ± 55.21^{b} (565)	2768.97 ± 37.42^{b} (566)	336.98 ± 4.45^{b} (553)	9.61 ± 0.13^{b} (550)	8.31 ± 0.10^{b} (395)	1335.83 ± 34.01^{b} (905)
4	112.60 ± 4.62 (102)	436.29 ± 9.19 (103)	79.66 ± 4.59 (108)	3219.37 ± 102.16^{b} (165)	2689.50 ± 68.69^{b} (168)	339.09 ± 8.27^{b} (160)	9.56 ± 0.25^{b} (159)	8.29 ± 0.20^{b} (100)	1004.58 ± 63.33^{c} (261)
5	117.39 ± 40.78 (2)	367.00 ± 93.36 (2)	70.00 ± 47.75 (2)	3182.99 ± 757.67^{b} (3)	2347.65 ± 514.70^{b} (3)	408.33 ± 60.43^{a} (3)	7.59 ± 1.84^{b} (3)	5.22 ± 2.08^{c} (1)	994.81 ± 308.51^{c} (11)

Figures in the parenthesis indicate number of observations

The higher average FL305DMY and FLTMY were observed in 2 breed crosses and the corresponding values were 2967.86±36.81 kg and 3514.31±54.25 kg respectively. 2 breed crosses were found to be significantly different from all other groups with respect to FL305DMY and FLTMY.

5 breed crosses had highest average FLL (408.33±60.43days), which was significantly different from all other groups. The average FLL for 2 breed, 3 breed and 4 breed crosses were found to be 343.71, 336.98, and 339.09 days, respectively.

Nagarcenkar and Rao (1982) and Sinha (1999) in their study reported superiority of 3 breed crosses over the others with respect to milk production performance.

Maximum MY/FLL was observed in 2 breed crosses (10.30±0.13kg) while 3breed, 4 breed and 5 breed crosses did not show any significant difference from each other with respect to MY/FLL.

MY/FCI was found to range between 5.22±2.08 kg (5 breed crosses) to 8.75±0.10 kg (2breed crosses) in present study. A distinct decreasing trend in average HL with the increase in number of breed involved in the crosses was observed in the present investigation. The corresponding HL for 2, 3, 4 and 5 breed crosses were found to be 1471.88, 1335.83, 1004.58 and 994.81 days respectively. However, 4 breed and 5 breed crosses did not differ significantly from each other.

4.4.4 Performance of Crossbred Cows Having Different Level of Heterozygosity

The level of heterozygosity of each of the crossbred cows under study (Karan Swiss and Karan Fries) was estimated. The level of heterozygosity was further subdivided into different groups to study the variability of growth, production and reproduction traits.

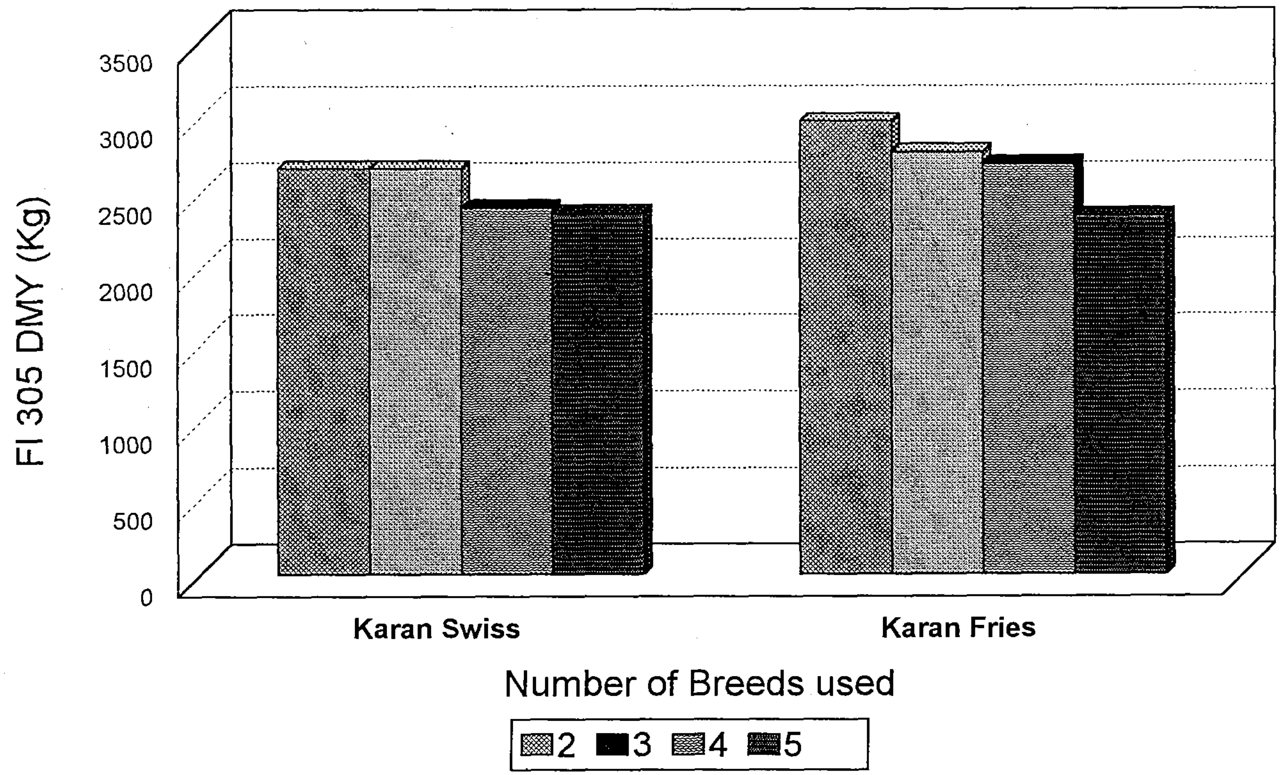

Fig. 4.10. Average first lactation 305 day milk yield for different number of breeds used in developing crossbred cows

4.4.4.1. Performance of Karan Swiss cows having different level of heterozygosity

The level of heterozygosity of the Karan Swiss cows under study was estimated and it was further subdivided into 9 groups as upto 40 percent, 40-45 percent, 45-50 percent, 50-55 percent, 55-60 percent, 60-65 percent, 65-70 percent, 70-80 percent and 100 percent. Animals with 100 percent heterozygosity consist of only F_1s.

The average of various growth, reproduction and production traits of Karan Swiss cows under different levels of heterozygosity was presented in the Table 4.35.

Effect of heterozygosity level on growth traits (BWT, WOY, WFS, WFC) were found significant. The maximum BWT (27.12±0.20 kg) was observed for those animals with level of heterozygosity 60 to 65 percent whereas minimum birth weight was observed as 25.26±0.21 kg for F_1 animals with 100 percent heterozygosity level. However, WOY varied from 151.99±22.90 kg (heterozygosity level 70 to 80 percent) to 188.92±4.96 kg (heterozigosity level 50-55 percent). Maximum WFS and WFC was observed for the animals with heterozygosity level 50 to 55 percent with the values 318.05±5.36 kg and 367.32±6.37 kg respectively.

Performance of Karan Swiss cows with respect to AFS and AFC under different levels of heterozygosity presented in the Table 4.35, which showed that animals with 100 percent heterozygosity had the minimum average AFS (707.97±10.39 days) and AFC (975.78±8.01 days). The maximum average AFS (877.38±47.43 day) and average AFC (1160.68±46.27 days) was observed for the animals with average level of heterozygosity 70-80 percent.

The average estimate of FSP and FCI did not differ significantly for different heterozygosity levels in Karan Swiss. No specific trend was observed for FSP over the different heterozygosity level. However, animals with heterozygosity lower than 60 percent found to have slightly lower estimate for FSP.

Average estimate of FCI was observed to be lower for those animals in which level of heterozygosity ranges from 40 to 55 percent.

The average FL305DMY was found maximum (2757.11±46.41kg) for F_1 animals with 100 percent heterozygosity level. However, the estimate was not significantly differed from the average FL305DMY observed for these animals with heterozygosity levels 45 to 50 percent and 55 to 60 percent. However, the estimate was found to be low for the animals with heterozygosity level below 40 percent and above 60 percent (Fig. 4.11). Almost similar trend was observed in case of FLTMY. F_1 animals with 100 percent heterozygosity level had the maximum FLTMY (3274.40±62.60kg) followed by 2731.55 kg (heterozygosity level 45 to 50 percent), and 2706.53±67.31 kg (heterozygosity levels 55 to 60 percent), respectively.

The average FLL estimated for differed heterozygosity level indicted that maximum FLL was observed for those animals with heterozygosity level 100 percent (362.45±5.30 days). However, the *interse* mated population with different heterozygosity level did not differ significantly from each other with respect to FLL.

F_1 animals with 100 percent heterozygosity level found to have maximum estimate of MY/FLL (9.48±0.12 kg) followed by the animals with level of heterozygosity 50 to 55 percent where the average MY/FLL was observed as 8.87±0.24kg.

Minimum estimate of MY/FCI was observed for the animals with heterozygosity level 40 to 45 percent (6.67±0.82 kg). While maximum MY/FCI was observed for the animals with heterozygosity level 100 percent (7.94±0.12kg).

F_1 animals with 100 percent heterozygosity found to remain in the herd for longer period with average HL estimated as 2458.33±54.83 days.

Table 4.35. Average performance with respect to different levels of heteroygosity in Karan Swiss cows

Heterozygosity level (%)	EI	BWT	WOY	WFS	WFC	AFS	AFC	FSP	FCI
Upto 40	0.753	26.84 ± 0.35^{b} (183)	168.48 ± 6.98^{b} (43)	287.06 ± 8.34^{b} (31)	350.63 ± 6.70^{ab} (55)	716.35 ± 20.64^{a} (95)	1000.87 ± 20.58^{ab} (96)	124.43 ± 8.73 (57)	410.39 ± 10.86 (60)
40-45	0.740	26.43 ± 0.84^{b} (32)	156.75 ± 16.19^{b} (8)	226.00 ± 32.83^{c} (2)	352.00 ± 22.25^{ab} (5)	764.41 ± 58.09^{ab} (12)	1052.83 ± 58.22^{abc} (12)	104.83 ± 26.91 (6)	389.00 ± 34.42 (6)
45-50	0.515	26.01 ± 0.18^{b} (685)	175.99 ± 3.41^{ab} (180)	298.55 ± 4.10^{b} (128)	364.62 ± 4.22^{a} (139)	767.87 ± 10.80^{ab} (347)	1066.08 ± 10.52^{bc} (367)	119.09 ± 4.59 (206)	404.51 ± 5.54 (231)
50-55	0.535	27.04 ± 0.31^{a} (225)	188.92 ± 4.96^{a} (85)	318.05 ± 5.36^{a} (75)	367.3 ± 6.37^{a} (61)	763.41 ± 19.45^{ab} (107)	1043.81 ± 18.80^{abc} (115)	124.05 ± 8.89 (55)	407.82 ± 11.26 (56)
55-60	0.504	26.70 ± 0.17^{b} (716)	177.14 ± 2.76^{ab} (274)	313.52 ± 3.52^{a} (174)	367.24 ± 4.14^{a} (144)	794.87 ± 10.88^{b} (342)	1078.46 ± 10.44^{bc} (373)	120.96 ± 4.53 (211)	417.58 ± 5.58 (228)
60-65	0.501	27.12 ± 0.20^{a} (529)	184.31 ± 3.49^{a} (172)	310.34 ± 4.23^{a} (120)	365.17 ± 4.81^{a} (107)	792.03 ± 12.38^{b} (264)	1078.91 ± 12.03^{bc} (281)	126.79 ± 5.18 (162)	422.77 ± 6.50 (168)
65-70	0.553	26.55 ± 0.50^{b} (90)	152.46 ± 8.98^{b} (26)	301.77 ± 10.94^{ab} (18)	358.66 ± 11.72^{ab} (18)	759.49 ± 29.04^{ab} (48)	1089.16 ± 25.52^{bc} (50)	127.23 ± 12.03 (30)	410.06 ± 15.14 (31)
70-80	0.568	26.11 ± 0.36^{b} (30)	151.99 ± 22.90^{b} (4)	315.50 ± 23.21^{a} (4)	331.60 ± 22.25^{b} (5)	877.38 ± 47.43^{b} (18)	1160.68 ± 46.27^{c} (19)	127.58 ± 19.03 (12)	415.36 ± 25.42 (11)
100	0.500	25.26 ± 0.20^{c} (507)	174.15 ± 3.62^{ab} (169)	283.03 ± 4.07^{b} (131)	343.39 ± 4.39^{b} (128)	707.97 ± 10.39^{a} (376)	975.78 ± 8.01^{a} (420)	127.27 ± 3.96 (276)	429.50 ± 4.84 (302)

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Heterozygosity level (%)	FDP	FLTMY	FL305DMY	FLL	MY/FCI	MY/FLL	HL
Upto 40	74.20 ± 4.21 (53)	2450.56 ± 127.75^{b} (93)	2209.37 ± 95.22^{b} (93)	315.25 ± 11.17^{b} (82)	7.32 ± 0.26^{b} (59)	8.27 ± 0.25^{b} (82)	1191.09 ± 89.79^{cd} (176)
40-45	69.33 ± 12.53 (6)	2597.49 ± 371.48^{b} (11)	2279.71 ± 276.88^{b} (11)	297.63 ± 30.51^{b} (11)	6.67 ± 0.82^{c} (6)	8.07 ± 0.69^{b} (11)	1080.63 ± 229.26^{d} (27)
45-50	78.83 ± 2.06 (221)	2731.55 ± 66.72^{ab} (341)	2488.71 ± 49.73^{ab} (341)	337.07 ± 5.76^{b} (308)	6.95 ± 0.13^{c} (224)	8.36 ± 0.13^{b} (305)	1273.36 ± 46.40^{c} (659)
50-55	74.43 ± 4.21 (53)	2615.69 ± 124.45^{b} (98)	2323.69 ± 91.83^{b} (100)	327.10 ± 10.78^{b} (88)	7.48 ± 0.27^{b} (55)	8.87 ± 0.24^{ab} (87)	1082.17 ± 84.87^{d} (197)
55-60	79.04 ± 2.11 (210)	2706.53 ± 67.31^{ab} (335)	2424.51 ± 50.09^{ab} (336)	334.10 ± 5.79^{b} (305)	7.35 ± 0.13^{b} (220)	8.67 ± 0.13^{b} (304)	1262.72 ± 46.87^{c} (646)
60-65	79.69 ± 2.46 (155)	2665.68 ± 76.55^{b} (259)	2365.80 ± 57.06^{b} (259)	325.76 ± 6.55^{b} (238)	7.07 ± 0.15^{b} (164)	8.54 ± 0.15^{b} (238)	1287.89 ± 54.77^{c} (473)
65-70	82.10 ± 5.69 (29)	2557.45 ± 176.00^{b} (49)	2342.03 ± 131.19^{b} (49)	313.09 ± 15.43^{b} (43)	7.43 ± 0.36^{b} (31)	8.52 ± 0.35^{b} (43)	1298.89 ± 127.72^{c} (37)
70-80	84.66 ± 10.23 (9)	2590.04 ± 215.49^{b} (20)	2354.66 ± 205.34^{b} (20)	392.44 ± 23.85^{a} (18)	7.07 ± 0.60^{b} (11)	8.52 ± 0.54^{b} (18)	1743.32 ± 225.13^{b} (28)
100	72.17 ± 1.82 (283)	3274.40 ± 62.60^{a} (387)	2757.11 ± 46.41^{a} (369)	362.45 ± 5.30 (369)	7.94 ± 0.12^{a} (298)	9.48 ± 0.12^{a} (363)	2458.33 ± 54.93^{a} (472)

Figures in parenthesis indicate number of observations

Among the *interse* mated animals maximum herd life was observed as 1743.32±225.13 days for those with heterozygosity level 70 to 80 percent. Whereas minimum herd life was found as 1080.63±229.26 days for those animals with heterozygosity level 40 to 45 percent.

Sinha (1999) from their studies also reported that animals with intermediate heterozygosity level (45 to 60 percent) had shown better performance.

4.4.4.2. Performance of Karan Fries cows having different level of heterozygosity

The level of heterozygosity estimated in the Karan Fries cows were subdivided into 9 groups as upto 35 percent, 35-40 percent, 40-45 percent, 45-50 percent, 50-55 percent, 55-60 percent. The average performance of various growth, reproduction and production traits of Karan Fries cows under different heterozygosity level was estimated and presented in the Table 4.36.

Effect of level of heterozygosity on various growth traits (BWT, WOY, WFS, WFC) was found statistically not significant. The maximum BWT (28.57±1.88kg) was observed for the animals with heterozygosity level 65 to 80 percent where minimum BWT was observed for F_1 animals with heterozygosity level. However, the range of WOY observed as 130.00±40.04kg (heterozygosity level 65 to 80 percent) to 205.85±5.84 kg (heteozygosity level 40-45 percent). Maximum WFS and WFC was observed for the animals with heterozygosity level 45 to 50 percent with the values 298.46±2.50 kg and 378.46±2.13 kg.

Average estimate of AFS and AFC for various heterozygosity levels indicted that F_1 individuals with 100 percent heterozygosity had minimum AFS and AFC and the values are found to be 641.31±11.04 days and 921.55±10.14 days, respectively. However, in the *interse* mated population animals with intermediate heterozygosity levels i.e., 40 percent to 60 percent found to have lower estimate of AFS and AFC.

Present study indicated no significant difference with respect to FSP and FCI for different heterozygosity level. F_1 animals were found to be superior with minimum average FSP (116.55±6.87 days) and FCI (402.50±6.93 days) Animals with heterozygosity level below 40 percent found to have higher estimate of FSP and FCI compared to others.

The average FL 305 DMY was found maximum (3362.77±59.89 kg) for F_1 animals with 100 percent heterozygosity level. However, the estimate was not significantly different from the animals with 35 to 40 percent heterozygosity (3045.75±55.40 kg), 40-45 percent heterozygosity (3110.28±115.79 kg), and 45-50 percent heterozygosity (2915.61±50.55 kg). Karan Fries animals with more than 60 percent heterozygosity found to have lower average FL 305 DMY (Fig 4.12).

Average estimates of FLTMY found to range between 2363.99±643.57 kg (65 to 80 percent heterozygosity) to 3776.79±407.03 kg (heterozygosity level upto 35 percent). Animals with intermediate heterozygosity (40 to 60 percent) did not differ significantly from each other with respect to FLTMY.

A declining trend in the milk production with level of heterozygosity beyond 60 percent was observed in the present study.

No significant difference in average FLL and FDP was observed for different level of heterozygosity. Average FLL was varied from 327.41±13.71 days to 391.55±34.20 days. Whereas, average FDP was observed to range form 67.67±6.93 to 111.33±27.75 days.

Animals with heterozygosity level below 35 percent had maximum MY/FLL (12.57±1.09kg). The estimate was not found to be significantly different from those animals with level of heterozygosity 35 to 40 percent (10.39±0.19 kg), 40 to 45 percent (11.05±0.41 kg), 45 to 50 percent (10.19±0.18 kg), 50 to 55 percent (10.89±0.20 kg) and 100 percent (11.35±0.21 kg), respectively. However, a slight declining trend with respect

Table 4.36. Average performance with respect to different levels of heterozygosity in Karan Fries cows

Heterozygosity level (%)	EI	BWT	WOY	WFS	WFC	AFS	AFC	FSP	FCI
upto 35	0.857	27.07 ± 1.33 (14)	136.00 ± 15.13 (7)	240.00 ± 38.57 (2)	314.36 ± 37.82 (2)	915.22 ± 51.03^{c} (9)	1243.09 ± 47.80^{c} (10)	166.33 ± 36.07 (6)	461.75 ± 46.88 (4)
35-40	0.750	28.09 ± 0.24 (426)	156.84 ± 5.00 (64)	258.54 ± 6.25 (51)	334.74 ± 6.00 (55)	767.67 ± 9.40^{b} (265)	1049.19 ± 9.23^{b} (269)	169.55 ± 6.67 (175)	452.62 ± 6.96 (181)
40-45	0.708	27.93 ± 0.46 (116)	205.85 ± 5.84 (47)	295.29 ± 5.93 (39)	375.29 ± 5.85 (43)	655.72 ± 19.44^{a} (62)	948.23 ± 18.89^{a} (64)	119.84 ± 13.32 (44)	406.71 ± 13.97 (45)
45-50	0.618	27.55 ± 0.20 (622)	191.46 ± 2.37 (285)	298.46 ± 2.50 (205)	378.46 ± 2.13 (223)	711.04 ± 8.55^{b} (320)	982.90 ± 8.21^{a} (339)	138.36 ± 6.14 (287)	421.60 ± 6.45 (211)
50-55	0.624	27.19 ± 0.22 (514)	188.64 ± 2.74 (213)	296.87 ± 3.05 (146)	374.87 ± 2.48 (146)	721.12 ± 9.24^{b} (274)	992.37 ± 9.00^{ab} (282)	136.33 ± 6.81 (168)	420.93 ± 7.14 (172)
55-60	0.599	27.40 ± 0.23 (436)	181.31 ± 2.72 (216)	290.31 ± 3.00 (128)	364.34 ± 3.05 (149)	714.92 ± 10.20^{b} (225)	989.56 ± 9.86^{a} (235)	133.73 ± 7.33 (145)	426.36 ± 7.75 (146)
60-65	0.707	26.26 ± 0.29 (292)	181.37 ± 5.35 (56)	288.34 ± 4.04 (59)	364.38 ± 3.95 (49)	742.75 ± 10.59^{b} (209)	1021.34 ± 10.14^{b} (222)	139.82 ± 8.03 (121)	425.34 ± 8.35 (126)
65-80	0.638	28.57 ± 1.88 (7)	130.00 ± 40.04 (2)	263.25 ± 41.05 (2)	341.25 ± 90.90 (2)	730.50 ± 76.55^{b} (4)	1017.24 ± 75.58^{b} (4)	157.33 ± 51.01 (3)	412.99 ± 54.13 (3)
100	0.500	26.24 ± 0.30 (264)	203.67 ± 3.38 (140)	273.60 ± 4.23 (131)	350.54 ± 4.20 (135)	641.31 ± 11.04^{a} (192)	921.55 ± 10.14^{a} (222)	116.55 ± 6.87 (165)	402.50 ± 6.93 (183)

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Heterozygosity level (%)	FDP	FLTMY	FL 305 DMY	FLL	MY/FLL	MY/FCI	HL
upto 35	83.79 ± 21.05 (5)	3776.79 ± 407.03 ^{a} (10)	2639.80 ± 276.44 ^{bc} (10)	391.55 ± 34.20 (9)	12.57 ± 1.04 ^{a} (9)	8.33 ± 1.03 ^{b} (4)	1892.22 ± 301.29 ^{b} (13)
35-40	71.56 ± 3.55 (183)	3760.09 ± 81.57 ^{a} (249)	3045.73 ± 55.40 ^{a} (249)	364.38 ± 6.56 (244)	10.39 ± 0.19 ^{ab} (244)	8.91 ± 0.15 ^{b} (181)	1544.62 ± 53.78 ^{b} (408)
40-45	67.67 ± 6.93 (48)	3554.53 ± 170.48 ^{b} (57)	3110.28 ± 115.79 ^{a} (57)	327.41 ± 13.71 (56)	11.05 ± 0.41 ^{ab} (56)	9.35 ± 0.31 ^{a} (44)	1264.16 ± 110.29 ^{bc} (97)
45-50	68.86 ± 3.27 (216)	3350.41 ± 74.43 ^{b} (290)	2915.61 ± 50.55 ^{ab} (299)	331.27 ± 5.95 (297)	10.19 ± 0.18 ^{ab} (297)	8.71 ± 0.14 ^{b} (206)	1269.58 ± 47.50 ^{bc} (523)
50-55	73.50 ± 3.69 (169)	3326.64 ± 83.08 ^{b} (240)	2868.80 ± 56.19 ^{b} (242)	332.25 ± 6.69 (235)	10.89 ± 0.20 ^{ab} (232)	8.63 ± 0.16 ^{b} (166)	1232.85 ± 55.36 ^{bc} (385)
55-60	83.61 ± 3.95 (148)	3249.35 ± 92.17 ^{b} (195)	2851.33 ± 62.44 ^{b} (196)	337.13 ± 7.46 (189)	9.72 ± 0.22 ^{b} (188)	8.34 ± 0.17 ^{b} (140)	1184.31 ± 62.40 ^{c} (303)
60-65	78.75 ± 4.37 (121)	3099.41 ± 92.65 ^{bc} (193)	2509.30 ± 62.76 ^{bc} (194)	343.34 ± 7.46 (189)	8.87 ± 0.22 ^{bc} (189)	7.73 ± 0.18 ^{bc} (125)	1412.04 ± 63.35 ^{b} (294)
65-80	111.33 ± 27.75 (3)	2363.99 ± 643.57 ^{c} (4)	1950.73 ± 437.09 ^{c} (4)	376.50 ± 51.31 (4)	6.41 ± 1.56 ^{c} (4)	5.10 ± 1.19 ^{c} (3)	1174.78 ± 485.82 ^{c} (5)
100	73.62 ± 3.72 (167)	3735.30 ± 89.03 ^{a} (209)	3362.77 ± 59.89 ^{a} (213)	331.71 ± 7.16 (205)	11.35 ± 0.21 ^{a} (204)	9.67 ± 0.15 ^{a} (178)	2756.94 ± 72.42 ^{a} (225)

Figures in the parenthesis indicate number of observations

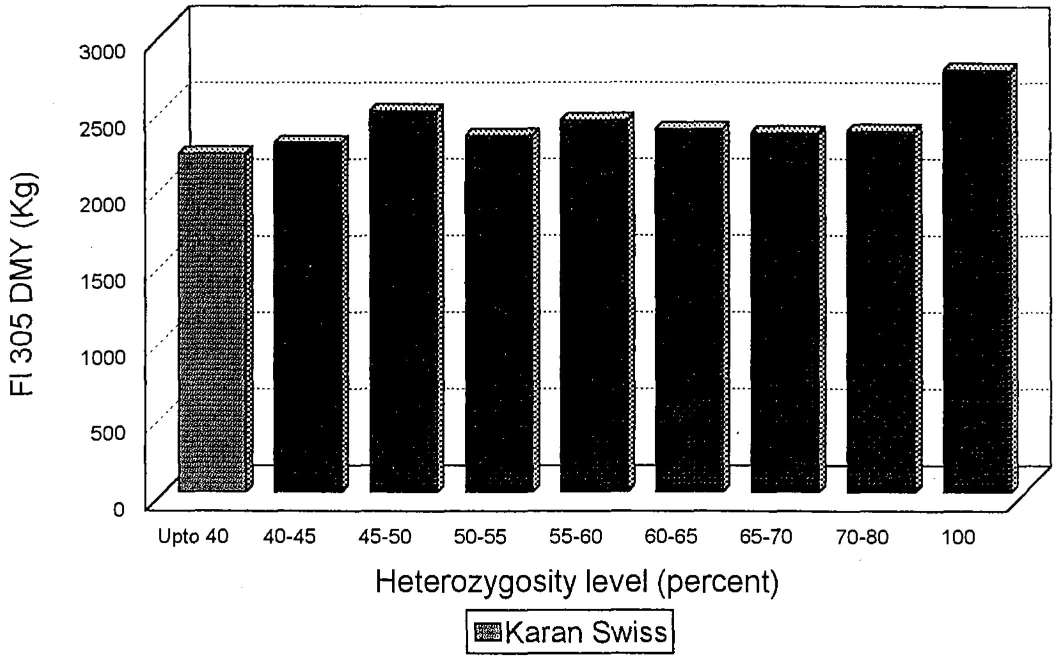

Fig. 4.11. Average first lactation 305 day milk yield for different levels of heterozygosity in Karan Swiss cows

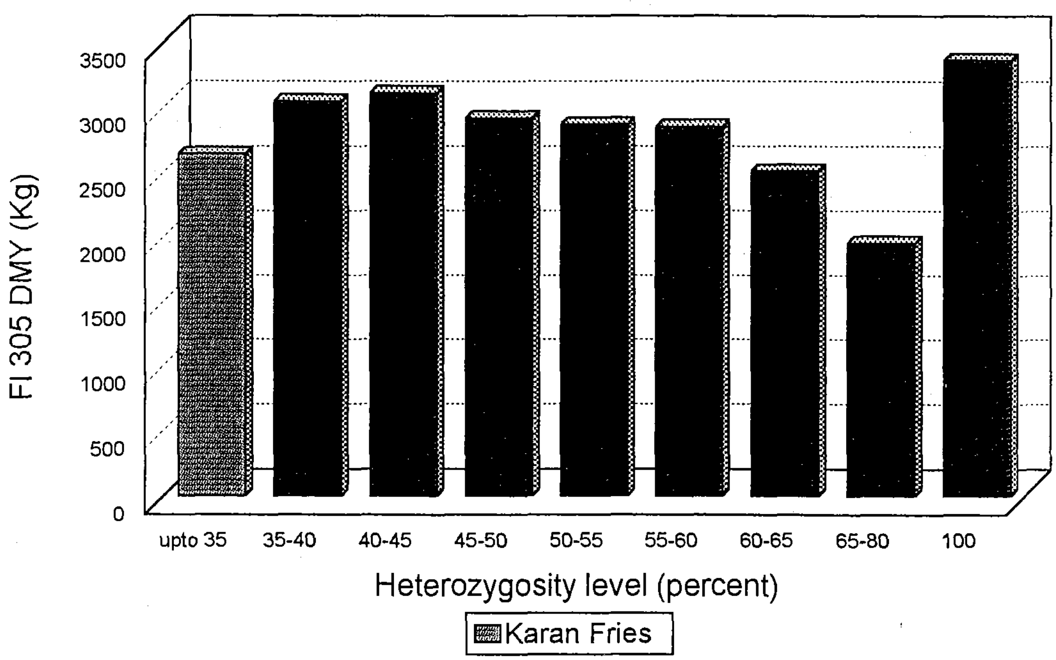

Fig. 4.12. Average first lactation 305 day milk yield for different levels of heterozygosity in Karan Fries cows

to MY/FLL beyond 60 percent of heterozygosity was observed in the present study.

The average estimates of MY/FCI did not found to differ significantly for the animals in which with level of heterozygosity rash from 35 percent to 60 percent. However, F_1 animals with 100 percent heterozygosity levels were found to significantly different from all other animals with maximum estimate of MY/FCL (9.67±0.15 kg).

The average HL of the *interse* mated animals found to range between 1174.78±485.82 days to 1892.22±301.29 days with corresponding heterozygosity level observed as 65 to 80 percent and upto 35 percent, respectively. Average HL of around 1250 days was observed for the animals with intermediate heterozygosity.

The literature available on level of heterozygosity also confirmed the superiority of the animals with intermediate heterozygosity for various production performance (Sinha,1999)

4.5. INCIDENCE AND LEVEL OF INBREEDING AND ITS EFFECT ON VARIOUS PERFORMANCE TRAITS IN CROSSBREDS

4.5.1. Incidence and Level of Inbreeding in Karan Swiss cows

Incidence and level of inbreeding over paternal as well as maternal generation in Karan Swiss females are presented in the Table 4.37 and Table 4.38 respectively.

Out of total 3168 Karan Swiss animals taken for this study 16 percent animals (507) were found to be inbred with average inbreeding coefficient of 5.94 percent. Around 65 percent of the total inbreds were found to have inbreeding coefficient less or equal to 6 percent. Whereas, 11 percent and 24 percent of the total inbred were found to be in moderate (inbreeding coefficient 6 to 12 percent) and highly inbred (> 12 percent) category.

The incidence of inbreeding was found to be lower than that of the results reported by Su (1988) and Singh (1995) in Karan Swiss, where 47 and 36.24 percent of animals were found to inbred respectively. Maximum

Table 4.37. Incidence and level of inbreeding over the paternal generations in Karan Swiss cows

Paternal Generation	Total Number of Female Born	Number of Inbred	Inbred Groups				Average Inbreeidng Coefficient (%)
			< 1%	1-6%	6-12%	>12%	
1	646	-	-	-	-	-	-
2	467	26 (5.56)	-	1	3	22	14.84
3	478	21 (4.39)	1	-	1	19	16.79
4	424	33 (7.38)	1	9	2	21	9.33
5	309	65 (21.03)	14	14	7	30	7.68
6	374	183 (48.93)	60	84	20	19	4.42
7	238	50 (21.00)	22	20	2	6	3.05
8	172	129 (75.00)	43	59	18	9	3.05
NK	60	-	-	-	-	-	-
Overall	3168	507 (16.00)	141	187	53	126	5.94

Figures in the parenthesis indicate percentage, NK : Generation not known

Table 4.38. Incidence and level of inbreeding over the maternal generations in females Karan Swiss

Maternal Generation	Total Number of Female Born	Number of Inbred	Inbred Groups				Average Inbreeidng Coefficient (%)
			< 1%	1-6%	6-12%	>12%	
1	588	-	-	-	-	-	-
2	1045	29 (2.77)	2	3	5	19	14.09
3	730	123 (16.84)	32	31	7	53	8.49
4	383	130 (33.94)	39	47	16	28	4.85
5	211	167 (50.70)	33	47	9	18	4.45
6	120	77 (64.16)	20	41	10	6	3.38
7	42	32 (76.19)	11	15	4	2	3.74
8	8	6 (75.00)	3	2	1	-	2.01
9	3	3 (100.00)	1	1	1	-	2.92
NK	38	-	-	-	-	-	-
Overall	3168	507 (16.10)	141	187	53	126	5.94

Figures in the parenthesis indicate percentage, NK : Generation not known

82.38 percent of the animals were found to be inbred in Sahiwal herd at NDRI by Reddy and Nagarcenkar (1989). The available literature on the level of inbreeding in India and abroad indicates that in a closed herd the average inbreeding coefficient ranged from 2 percent in Brown Swiss (Hurdson and Vanvleck 1984b) to 14.03 percent in Sahiwal (Khanna *et al.*, 1979a)

The number of female born during different paternal generation showed a decreasing trend whereas, the percentage of inbred born showed a fluctuating trend, ranging from 4.39 percent in third generation to 75 percent in eighth generation. The average inbreeding coefficient of the inbreds showed a decreasing trend over the paternal generations. (Fig. 4.13)

From maternal generation there was increasing trend in the percentage of inbred born was observed, which range from 2.77 percent in the second generation to 76.19percent in the seventh generation. However, the number of female born in 8^{th} and 9^{th} generation were very less and majority of them are found to be inbred. The average inbreeding coefficient of the inbreds was found to be reduce from 14.09 percent in the second generation to 2.01 percent in the eighth generation (Fig. 4.14). In the ninth generation there was a slight increase in the average inbreeding coefficient and value was 2.92 percent.

4.5.2. Incidence and Level of Inbreeding in Karan Fries Females

Incidence and level of inbreeding over the paternal and maternal generations in Karan Fries females were studied and presented in the Table 4.39 and Table 4.40, respectively.

Karan Fries population was consists of 3051 animals, in which 282 (9.24 percent) animals were inbred with an average inbreeding coefficient of 3.65 percent. About 76.5 percent of inbred animals found to have inbreeding coefficient below 6 percent (Lowly inbreed) whereas, 15.60 percent and 7.80 percent inbred animals were found to be moderately (F=6.12%) and high inbred (F> 12%), respectively.

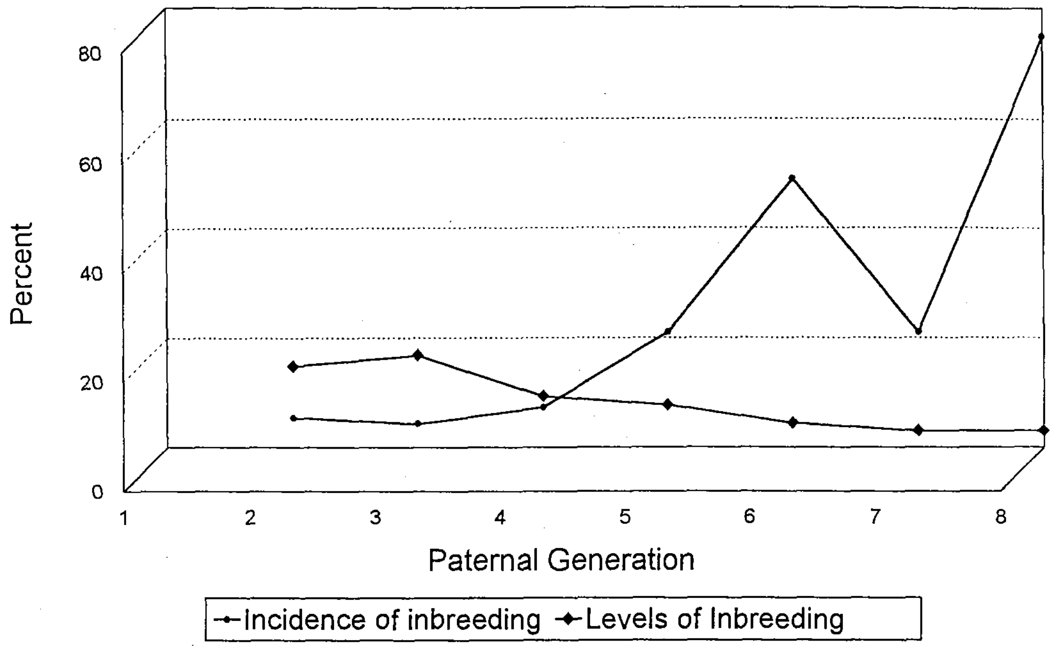

Fig. 4.13. Incidence and levels of inbreeding over the paternal generation in Karan Swiss cows

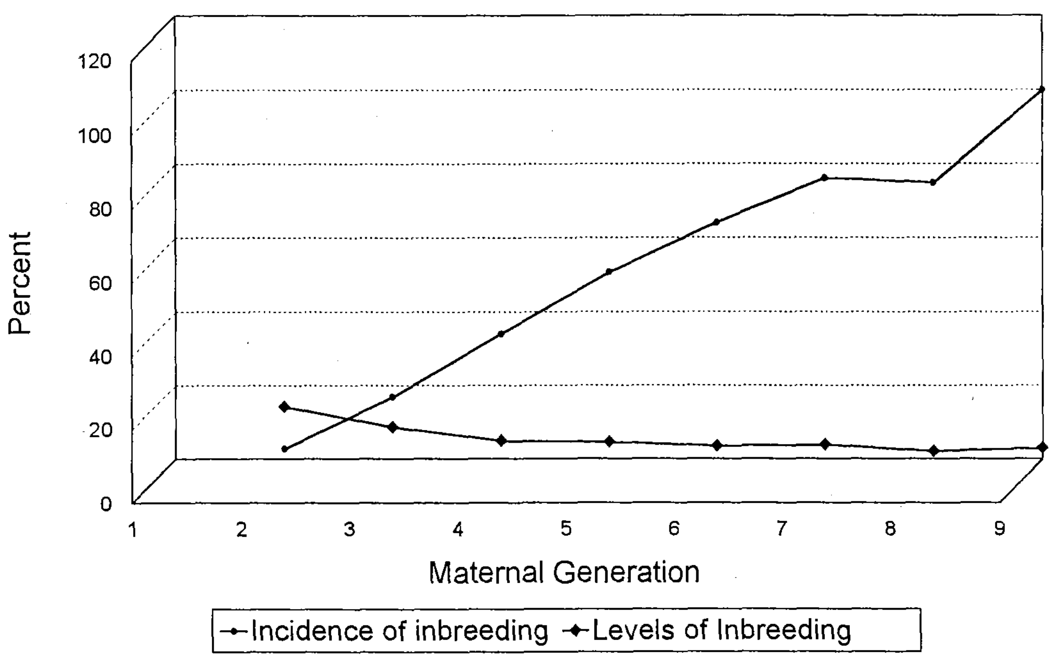

Fig. 4.14. Incidence and levels of inbreeding over the maternal generation in Karan Swiss cows

Table 4.39. Incidence and level of inbreeding over the paternal generations in Karan Fries cows

Paternal Generation	Total Number of Female Born	Number of Inbred	Inbred Groups				Average Inbreeidng Coefficient
			< 1%	1-6%	6-12%	>12%	
1	862	-	-	-	-	-	-
2	645	7 (1.08)	-	2	4	1	6.25
3	855	67 (7.83)	17	28	8	14	5.59
4	64	208 (32.80)	60	109	32	7	2.94
5	5	-	-	-	-	-	-
NK	50	-	-	-	-	-	-
Overall	3051	282 (9.24)	77	139	44	22	3.65

NK : Generation not known

Table 4.40. Incidence and level of inbreeding over the maternal generations in Karan Fries cows

Maternal Generation	Total Number of Female Born	Number of Inbred	Inbred Groups				Average Inbreeidng Coefficient
			< 1%	1-6%	6-12%	>12%	
1	274	-	-	-	-	-	-
2	735	4 (0.54)	-	2	-	2	10.93
3	639	29 (4.53)	7	13	4	5	8.11
4	492	63 (12.80)	11	35	9	8	4.30
5	377	95 (25.19)	25	47	19	4	3.24
6	207	59 (28.50)	20	29	8	2	2.36
7	56	26 (46.42)	12	12	2	-	1.61
8	10	6 (60.00)	2	1	2	1	6.92
9	1	-	-	-	-	-	-
NK	258	-	-	-	-	-	-
Overall	3051	282 (9.24)	77	139	44	22	3.65

Figures in the parenthesis indicate percentage, NK : Generation not known

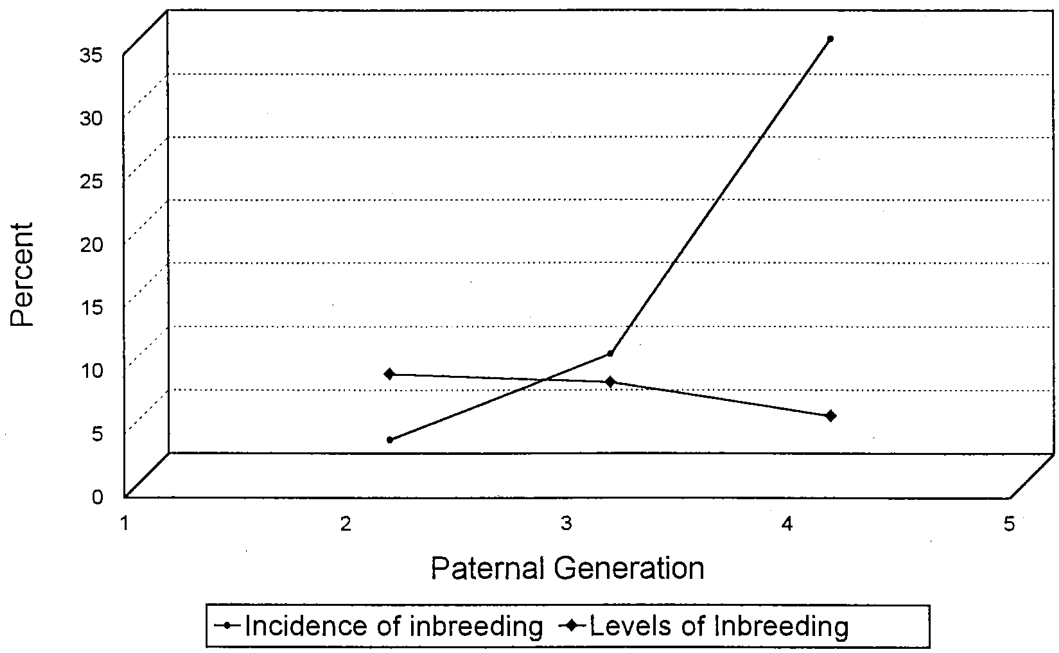

Fig. 4.15 Incidence and levels of inbreeding over the paternal generation in Karan Fries cows

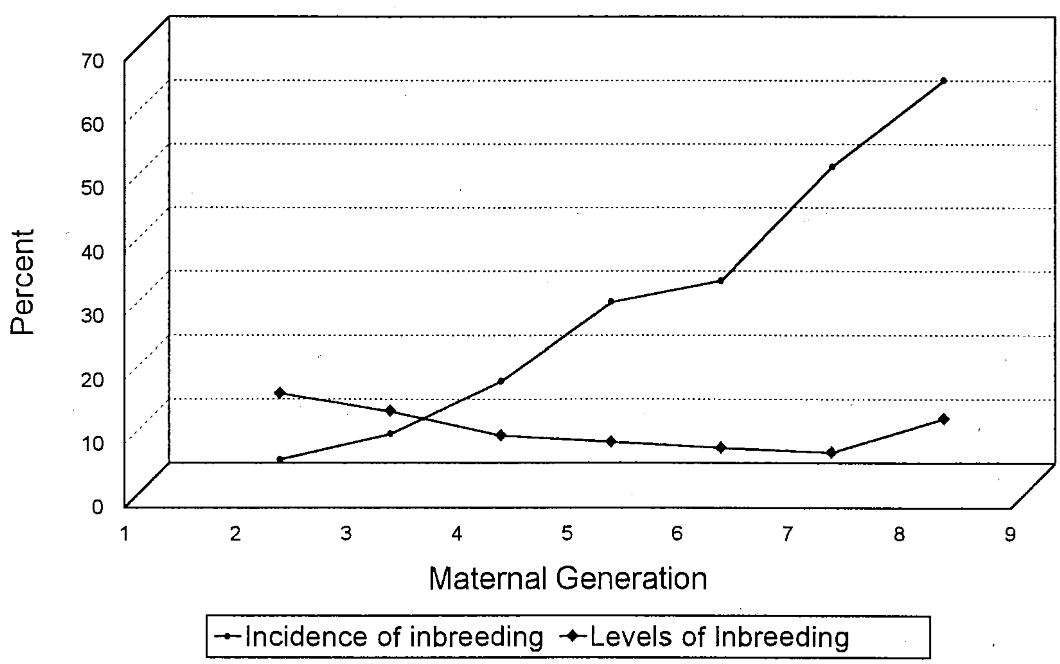

Fig. 4.16 Incidence and levels of inbreeding over the maternal generation in Karan Fries cows

The literature available on incidence of inbreeding varies from 11.00 percent (Hillers and Freeman, 1964) in Guerensey cattle to 82.38 percent (Reddy and Nagarcenkar, 1989) in Sahiwal cattle.

The level of inbreeding was found similar to the findings of Kshirasagar and Kulkarni (1963), Miglior *et al.* 1992. Whereas most of workers in India reported high average inbreeding coefficient of the inbred animals in the herd.

There was no inbred in the first generation and fifth generation from paternal side. From second generation onward an increasing trend was observed upto fourth generation in percentage of inbred with corresponding decrease in the average inbreeding coefficient from 6.25 percent to 2.94 percent (Fig. 4.15)

From maternal side there was a gradual increase in the incidence of inbreeding from second generation (0.54 percent) to eighth generation (60 percent) with corresponding decrease in the average inbreeding coefficient from 10.93 percent to 6.92 percent among inbreds (Fig. 4.16)

Overall, in both the Karan Swiss and Karan Fries population the percentage of inbreds were found to be less (with high average inbreeding coefficient) in early generation but, as generation progressed the incidence of inbreeding showed an increasing trend with corresponding decrease in the level of inbreeding. It may explained due to presence of less number of bulls in the earlier generations. Bulls are found to be the main source of inbreeding either directly or through collateral relatives. So, as generation progressed the common ancestor became remote to the descendents and thus resulted in the reduction of level of inbreeding.

4.5.3. Effect of Inbreeding on Various Growth, First lactation Traits and Herd Life in Karan Swiss Cattle

4.5.3.1. Effect of inbreeding on Birth Weight (BWT) in Karan Swiss Cows

The least squares mean for different level of inbreeding are presented in the Table 4.41 and found to be statistically significant in Karan Swiss cattle. The least squares means for different level of inbreeding varied from 27.36±0.09 ((non inbreds) to 24.75±0.67 kg for highly inbred animals (F>12%). As the table reveals the average birth weight was the lowest for groups with inbreeding above 12 percent. The average birth weight of inbred animals with inbreeding level upto 12 percent was not significantly different significantly from each other. However, highly inbred calves (F=>12%) had significantly lower birth weight (by 9.5%) as compared to non-inbreds. This is further supported by the estimate obtained from regression analysis. The regression of birth weight on inbreeding was –0.114±0.035 kg per one percent, which, was also found to be statistically significant (Table 4.42). The negative estimate indicates that the inbreeding tends to reduce the birth weight.

Sutherland and Lush (1962), Singh (1995) also reported negative value of regression of birth weight on inbreeding per one percent inbreeding coefficient in Friesian female calves and Karan Swiss, respectively. Similarly in Red Sindhi calves significantly depressing effect of inbreeding on birth weight as reported by Reddy and Sampath (1989). However, Srinivas and Gurnani (1981) in Sahiwal and Su (1988) in Karan Swiss and Karan Fries claves observed statistically non-significant effect of inbreeding on birth weight

4.5.3.2. Effect of Inbreeding on Body Weight at One Year (WOY) in Karan Swiss Cows

The average 12-month body weight according to level of inbreeding varied from 143.85±3.94 kg (highly inbreds) to 147.57±1.04 kg (non-inbreds) Table 4.41. However, mean WOY for different level of inbreeding was not statistically significantly different from each other. The regression of WOY on level of inbreeding was –0.046±0.471 kg per 1 percent level of inbreeding which was statistically not significant.

Nelson and Lush (1950), Sutherland and Lush (1962), Hillers and Freeman (1964) and Thompson and Freeman (1967) also reported non-significant effect of inbreeding on 12-month body weight in Friesian heifers.

Su (1988) and Singh, (1995) also observed non-significant effect of inbreeding on one-year weight in Karan Swiss cattle at this farm.

4.5.3.3. Effect of Inbreeding on Weight at First Fertile Service (WFS) in Karan Swiss Cows

Level of inbreeding had non-significant effect on WFS in Karan Swiss cattle. However, maximum WFS of 289.74±1.96 kg was observed for non inbred heifers and lowest in highly inbred 285.09±10.60 kg) (Table 4.41). The regression of WFS on inbreeding as –2.842±0.852 kg per 1 percent level of inbreeding which was statistically significant.

Non-significant effect of inbreeding on body weight at higher age (i.e., 24 months) were reported by Nelson and Lush (1950), Sutherland and Lush (1962) and Hillers and Freeman (1964) in Friesian cattle; Srinivas and Gurnani (1981) and Reddy (1983) in Sahiwal cattle and Su (1988) and Singh (1995) in Karan Swiss cattle.

4.5.3.4. Effect of Inbreeding on Weight at First Fertile Service (WFC) in Karan Swiss Cows

The WFC according to inbreeding level varied from 345.62±9.20 kg (highly inbreds) to 356.23±2.06 (non inbred) and a decreasing trend of WFC was obtained with respect to level of inbreeding (Table 4.41). However, least squares ANOVA showed that WFC of Karan Swiss heifers was non-significantly influenced by level of inbreeding. The regression of WFC on inbreeding was 1.148±1.008 kg per 1 percent level of inbreeding, the estimate being statistically non-significant.

The results are in agreement with those reported by Nelson and Lush (1950), Sutherland and Lush (1962), Hillers and Freeman (1964) and Holtman *et al.* (1970) in Friesian cattle; Srinivas and Gurnani (1981) and Reddy (1983) in Sahiwal cattle who also obtained non-significant effect of inbreeding on body weight at higher ages (24 months).

4.5.3.5. Effect of Inbreeding on Age at First Fertile Service (AFS) in Karan Swiss Cows

The least-squares average of AFS according to level of inbreeding varied from 732.78±38.93 days for moderately inbred (6<F<12) to 796.86±21.90 days for highly inbred (F=>12%). No uniform trend in AFS was observed with respect to level of inbreeding. However, the effect of inbreeding on AFS in Karan Fries cattle was found to be non-significant.

The regression estimate of AFS on inbreeding coefficient as 1.19±2.494 days per 1 percent level of inbreeding coefficient, which was found to be statistically non-significant. (Table 4.42)

4.5.3.6. Effect of Inbreeding on Age at First Calving (AFC) in Karan Swiss Cows

The least-squares average according to levels of inbreeding varied from 1011.47±18.82 days for lowly inbred to 1071.92±22.04 days for highly inbreds (F>12%). There was no specific trend of AFC with respect to increase in level of inbreeding (Table 4.41). However, least-squares analysis of variance revealed statistically non-significant effect of inbreeding on AFC. The regression coefficient of AFC on inbreeding was found to be 6.225±3.397 days per 1 percent level of inbreeding, which was statistically significant. (P < 0.05).

Similarly Malik *et al.* (1967) also reported lowest AFC (53 months) in lowly inbred group and maximum AFC (60.6 months) in highly inbred group in Hariana cattle.

4.5.3.7. Effect of Inbreeding on First Lactation 305 Day or Less Milk Yield (FL305DMY) in Karan Swiss Cows

Least squares average for inbreeding levels varied from 2296.`14±129.28 kg for highly inrbed (F>12 %) to 2646.17±25.82 kg for non inbreds (Table 4.41). However, the effect of inbreeding levels on FL305DMY days was found to be statistically non-significant. A definite decreasing trend was observed over the levels of inbreeding. This result is further supported by non-significant regression of FL305DMY days on inbreeding coefficient, which was –5.85±8.720 kg per one percent increase in level of inbreeding (Table 4.42).

Several reports on influence of inbreeding on FL305DMY in exotic as well as in Zebu cattle are available. Which indicated that higher level of inbreeding (F>10-15%) significantly lowered the FL305DMY. These includes Robertson (1954), Von Krosigk and Lush (1958), Hodges *et al.* (1979) and Young *et al.* (1984) in Friesian cattle; Kalmykov and Sokolov (1989) in Black Pied; Miglior *et al.* (1992) in Jersey; Hudson and VanVleck (1984a) in Brown Swiss, Ayrshire and Guernsey cattle.

Several other authors reported that higher levels of inbreeding (F>10%F) reduced the FL305DMYperformance though the effect was non-significant.

4.5.3.8. Effect of Inbreeding on First Lactation Total Milk Yield (FLTMY) in Karan Swiss Cows

The least squares average of FLTMY in KS cattle for inbreeding levels varied from 2591.65±170.80 kg for highly inbreds (F>12%) to 2790.07±34.11 kg for non inbred cows (Table 4.41). The effect of inbreeding, however, was found to be statistically non-significant. A declining trend in FLTMY was found to occur with increasing levels of inbreeding coefficient. This is quantified by estimate of regression on inbreeding levels (-3.640±10.040 kg per 1%) which, however, as found to be statistically non significant (Table 4.42).

The literature on effect of inbreeding on FLTMY revealed that inbreeding coefficient at higher level (F>10%) adversely affected the performance of animals. Such authors were Gurnani *et al.* (1971) and Vij *et al.* (1992) in Tharparkar; Srinivas and Gurnani (1981), Reddy and Nagarcenkar (1988) and Singh (1992) in Sahiwal; Hudson and VanVleck (1984a). In Friesian, Jersey, Brown Swiss, Ayreshire and Guernsey; Miglior *et al.* (1992) in Jersey cattle, Singh (1995) in Karan Swiss.

On the other hand, following authors found beneficial effect of mild inbreeding (F = 6-8%) on FLTMY. Such authors were Beckett *et al.* (1979) in Friesian cattle who also supported the hypothesis that decline in productive and reproductive performance due to inbreeding is due to accumulation of undesirable recessive alleles rather than the loss of merit due to heterozygous per se; Malik (1967) in Hariana; Odedra *et al.* (1979) in Gir; Singh (1992) in Sahiwal; Rege and Wakhungu (1992) in Kenian Sahiwal and Ehiobu (1993) in White Fulani dairy cattle reported beneficial effect of milk inbreeding on production.

4.5.3.9. Effect of Inbreeding on First Lactation Length (FLL) in Karan Swiss Cows

The highest average FLL was found for non inbred group of cattle (337.93±2.82 days) and lowest for moderately inbreds (325.24±25.69 days) (Table 4.41). However, the effect of inbreeding was found to be statistically non significant. The regression of FLL on inbreeding coefficient found to be non significant (-0.684±1.031).

Non significant effect of inbreeding on FLLwas reported by Gurnani *et al.* (1971) and Vij *et al.* (1982) in Tharparkar; Kumar and Narain (1977, Srinivas and Gurnani (1981), Reddy and Nagarcenkar (1988), Singh (1992) and Ehiobu (1993) in Sahiwal cattle and Reddy and Sampath (1989) in Red Sindhi cows, Singh (1995) in Karan Swiss cows.

Srinivas (1978) in Karan Swiss cattle at the NDRI farm and Ehiobu (1993) in White Fulani cattle also obtained 3-4 percent longer FLL among low to moderate inbreds (F=4-10%) group of cattle as compared to non inbreds.

4.5.3.10. Effect of Inbreeding on First Service Period (FSP) in Karan Swiss Cows

The least squares average of FSP for various levels of inbreeding varied from 107.45±11.35 days for very lowly inbred to 133.92±10.06 days for highly inbreds (F>12%) (Table 4.41). The results revealed that level of inbreeding beyond 12 percent adversely affected the FSP in this herd. The effect of levels of inbreeding of FSP, however, was found to be statistically non-significant. The regression coefficient being estimated on 0.557±0.373 days per 1 percent level of inbreeding (Table 4.42).

Su (1988) in Karan Swiss cattle, however, reported favourable effect of inbreeding on FSP beyond 8 percent inbreeding coefficient though the effect was non-significant. The non-significant effect of inbreeding on FSP was also reported by Khanna *et al.* (1979) in Hariana, Reddy and Nagarcenkar (1988) in Sahiwal cows and Singh (1995) in Karan Swiss.

4.5.3.11. Effect of Inbreeding on First Dry Period (FDP) in Karan Swiss Cows

Least squares means of FDP for different inbred groups are presented in the Table 4.41. The maximum dry period (82.50±5.45) was observed for those animals with inbreeding coefficient more than 12 percent. The FDP for animals with inbreeding coefficient below 1 percent and 1 to 6 percent was found almost equal (77 days). However, difference in FDP for different inbred groups was not found statistically significant. The regression of FDP on inbreeding coefficient was 1.150±0.227 days per 1 percent increase in level of inbreeding, which was found to be statistically non significant (Table 4.42).

Odedra *et al.* (1979) reported that in Gir cattle lowest dry period occurred in lowly inbreds and highest dry period was observed in highly inbreds. Whereas, Reddy (1983) reported non-significant effect of inbreeding on dry period in Sahiwal cattle.

4.5.3.12. Effect of Inbreeding on First Calving Internal (FCI) in Karan Swiss Cows

The least squares average of FCI for inbreeding levels varied from 421.07±12.77 days (Lowly inbreds) to 467.54±14.75 days (Highly inbreds) in Karan Swiss cattle (Table 4.41). There was no specific trend of FCI as the level of inbreeding increased. The effect of inbreeding on FCI, however, was found to be statistically non-significant. The regression of FCI on inbreeding coefficient was 1.718±1.205 days per 1 percent increase in inbreeding, which was found to be statistically non-significant (Table 4.42).

Non-significant effect of inbreeding on FCI was reported by Malik *et al.* (1967), Gurnani *et al.* (1971), Su (1988), Reddy and Nagarcenkar (1988), Rege and Wakhungu (1992) and Singh (1995) in Hariana, Tharparkar, Karan Swiss, Sahiwal, and Kenyan Sahiwal and in Karan Swiss cows, respectively. However, Odedra *et al.* (1977) in Gir; Srinivas and Gurnani (1981) in Sahiwal and Hudson and VanVleck (1984a) in Friesian cows observed favourable impact on low to moderate inbreeding levels (3<F<8%) on FCI.

4.5.3.13. Effect of inbreeding on Milk Yield Period in First Lactation Length (MY/FLL) in Karan Swiss Cows

Highest least squares mean of MY/FLL (8.86±0.06 kg per day) occurred in non-inbred and lowest (8.67±0.33 kg per day) in highly inbred group of Karan Swiss cattle. The effect of inbreeding level was found to be non-significant. There was no definite trend in MY/FLL with the increase in level of inbreeding as shown in Table 4.41.

The estimate of regression of MY/FLL on inbreeding level (0.0372±0.029 kg per day per 1%) was found to be statistically non-significant. Reddy and Nagarcenkar (1988) and Singh (1992) also reported non-significant effect of inbreeding on MY/FLL in Sahiwal cattle.

4.5.3.14 Effect of Inbreeding on Milk Yield per Day of First Calving Interval (MY/FCI) in Karan Swiss Cows

The least squares average of MY/FCI according to inbreeding levels ranged from 7.26±0.57 kg/day for highly inbreds (F>12%) to 7.55±0.06 kg for non-inbreds. There was consistently declining trend in MY/FCI as the level of inbreeding increased. The effect of inbreeding, however, was found to be statistically non-significant. The regression of MY/FCI on inbreeding coefficient was –0.023±-0.022 kg/day per 1 percent increase in level of inbreeding. The coefficient of regression, however was found to be statistically non significant.

Singh (1992) reported depressing effect of inbreeding on MY/FCI beyond 8 percent in Sahiwal cattle, though the effect as non-significant.

Table 4.41. Average performance of various economic traits in different inbred groups in Karan Swiss

Group	BWT	WOY	WFS	WFC	AFS	AFC	FL 305 DMY	FLTMY
Upto 1%	26.50 ± 0.41^{b} (121)	145.72 ± 4.17 (50)	286.08 ± 6.91 (47)	348.23 ± 7.69 (42)	741.39 ± 19.86 (73)	1025.95 ± 19.16 (82)	2509.50 ± 121.32 (67)	2756.02 ± 161.49 (66)
1-6%	26.36 ± 0.35^{b} (185)	145.98 ± 3.66 (65)	286.43 ± 6.98 (46)	347.99 ± 8.04 (30)	747.20 ± 20.58 (68)	1011.47 ± 18.82 (85)	2518.14 ± 122.23 (66)	2619.57 ± 162.72 (65)
6-12%	26.16 ± 0.40^{b} (53)	144.59 ± 7.62 (15)	285.11 ± 15.80 (9)	347.72 ± 14.94 (11)	732.78 ± 38.93 (19)	1032.84 ± 38.81 (20)	2352.01 ± 234.07 (18)	2601.39 ± 309.32 (18)
>12%	24.75 ± 0.67^{c} (124)	143.85 ± 3.94 (56)	285.09 ± 10.60 (20)	345.62 ± 9.20 (29)	796.86 ± 21.90 (60)	1071.91 ± 22.04 (62)	2296.14 ± 129.28 (59)	2591.65 ± 170.80 (59)
Non inbreds	27.36 ± 0.09^{a} (2323)	147.57 ± 1.04 (801)	289.74 ± 1.96 (583)	356.23 ± 2.06 (574)	763.37 ± 4.46 (1446)	1044.39 ± 4.41 (1594)	2646.17 ± 25.82 (1479)	2790.07 ± 34.11 (1479)

Group	FLL	FSP	FDP	FCI	MY/FLL	MY/FCI	HL
Upto 1%	331.70 ± 14.39 (66)	107.45 ± 11.35 (42)	77.27 ± 5.07 (37)	421.07 ± 12.77 (43)	8.75 ± 0.29 (65)	7.49 ± 0.31 (43)	1178.67 ± 124.38 (102)
1-6%	326.45 ± 13.61 (57)	110.36 ± 10.87 (36)	77.58 ± 5.07 (37)	454.40 ± 12.48 (45)	8.70 ± 0.31 (57)	7.38 ± 0.31 (41)	1101.67 ± 105.04 (143)
6-12%	325.24 ± 25.69 (16)	123.60 ± 18.09 (13)	79.27 ± 8.56 (13)	423.78 ± 22.36 (14)	8.72 ± 0.59 (16)	7.30 ± 0.57 (13)	1070.32 ± 198.82 (40)
>12%	325.45 ± 14.39 (51)	133.92 ± 10.06 (33)	82.50 ± 5.45 (32)	467.54 ± 14.75 (35)	8.67 ± 0.33 (51)	7.26 ± 0.57 (34)	907.67 ± 108.92 (133)
Non inbreds	357.93 ± 2.82 (1322)	123.67 ± 2.14 (926)	72.50 ± 1.01 (935)	421.65 ± 2.65 (994)	8.86 ± 0.06 (1317)	7.55 ± 0.06 (973)	1511.12 ± 25.29 (2466)

Figures in the parenthesis indicate number of observations

Table 4.42. Regression of different performance traits on inbreeding coefficient in Karan Swiss

Sl. No.	Trait	Intercept Constant	Regression coefficient ± SE
1	BWT	27.155	-0.114 ± 0.035**
2	WOY	48.837	-0.046 ± 0.471
3	WFS	88.472	-2.842 ± 0.852**
4	WFC	86.386	-1.148 ± 1.008
5	AFS	320.913	1.191 ± 2.494
6	AFC	521.173	6.225 ± 3.397*
7	FL-305 DMY	1006.334	-5.853 ± 8.720
8	FLTMY	1095.927	-3.640 ± 10.040
9	FLL	120.901	-0.684 ± 1.091
10	FSP	31.159	0.557 ± 0.373
11	FDP	18.130	0.150 ± 0.227
12	FCI	118.044	1.718 ± 1.205
13	MY/FLL	3.380	-0.0372 ± 0.029
14	MY/FCI	2.002	-0.023 ± 0.022
15	HL	778.798	-10.656 ± 6.637

* Significant ($P<0.05$), ** Significant ($P<0.01$)

4.5.3.15. Effect of Inbreeding on Herd Life (HL) in Karan Swiss Cows

Highest least squares mean of herd life (1511.12±25.29 days) observed in non inbred and lowest herd life (907.67±10892 days) in highly inbred group of Karan Swiss cattle. Herd life in non inbred groups was found to statistically significantly different from other inbred groups.

The estimate of regression of herd life or inbreeding level (010.656±6.637 day per 1 percent) was found to be statistically non significant.

4.5.4.1. Effect of inbreeding on Birth Weight (BWT) in Karan Fries Cows

The least squares mean over different levels of inbreeding found to be range between 25.85±1.06 (non inbreds) to 27.31±0-.02 kg (upto 1 percent) (Table 4.43). The level of inbreeding was found to have non significant effect on birth weight.

The regression coefficient of birth weight on inbreeding coefficient was –0.005±0.061 kg per 1 percent increase in inbreeding, the estimate being statistically non significant (Table 4.44).

Hillers and Freeman (1964) reported the intrasire regression coefficient of birth weight on inbreeding coefficient as –0.135 kg per 1 percent in inbred herd of Guernsey. The inbreeding coefficient in their study ranged upto 31 percent with an average of 6.4 percent.

Reddy and Sampath (1989) also reported significantly lower birth weight of inbred calves than non-inbred (20.56 vs. 23.13 kg) in Red Sindhi cattle. The correlation between birth weight and inbreeding coefficient was negative and significant (P>0.01). However, Srinivas and Gurnani (1981) observed negative but statistically non-significant effect of inbreeding on birth weight in Sahiwal calves.

4.5.4.2. Effect of Inbreeding on Body Weight at One Year (WOY) in Karan Fries Cows

The WOY for various levels of inbreeding varied from 172.17±18.43 kg for highly inbred to 2.05.60±1.30 kg for non inbreds (Table 4.43).

However, the effect of inbreeding on WOY was found to be statistically significnat. It was observed that cows having high level of inbreeding (F>12%) tended to have lower WOY. Singh (1995) also reported similar result in Karan Swiss cattle.

The regression on WOY on level of inbreeding was –1.29±1.024 kg per one percent which was statistically non significant.

4.5.4.3. Effect of Inbreeding on Weight at First Fertile Service (WFS) in Karan Fries Cows

The effect of level of inbreeding of WFS was found to be statistically non-significant. However, the regression of WFS on coefficient of inbreeding was –0.556±1.671 kg per one percent level of inbreeding which is small in magnitude and statistically non significant (Table 4.44).

Sutherland and Lush 91962), Hillers and Freeman (1964) and Holtman *et al.* (1970) in Holstein Friesian cattle and Su (1988) in Karan Swiss heifers reported adverse but statistically non-significant effect of inbreeding (F>8.0%) on weight at higher ages (at 24 to 30 months).

4.5.4.4. Effect of Inbreeding on Weight at First Fertile Service (WFC) in Karan Fries Cows

The least squares ANOVA revealed that the level of inbreeding had non-significant effect on WFC in Karan Fries heifers (Table 4.43). The maximum WFC observed for non inbreds (368.73±1.74kg) and minimum for highly inbreds (352.19±14.42 kg). The regression of WFC on inbreeding coefficient was –1.654±1.916 kg per 1 percent level of inbreeding. The estimate, though small in magnitude and has statistically non significant (Table 4.44).

The findings are in agreement with the findings of Nelson and Lush (1950) and Hillers and Freeman (1964) in Friesian, Singh (1981) in Sahiwal and Su (1988) in Karan Swiss cattle. These authors had also reported non-significant effect of inbreeding on WFC.

4.5.4.5. Effect of Inbreeding on Age at First Fertile Service (AFS) in Karan Fries Cows

For various levels of inbreeding the AFS varied from 717.28±4.05 days for non inbreds to 751.24±39.88 days for moderately inbreds. (6<F<12 percent). The regression of AFS on inbreeding coefficient was found to be 1.966±1.316 days per 1 percent level of inbreeding. The estimate was statistically non-significant.

4.5.4.6. Effect of Inbreeding on Age at First Calving (AFC) in Karan Fries Cows

The average AFC for different levels of inbreeding did not differ significantly (Table 4.43). The AFC varied from 985.64±24.61 days (very lowly inbred) to 1033.16±31.90 days (moderately inbred). The regression of AFC on inbreeding was found to be statistically non-significant. The coefficient of regression was 1.480±2.730 days per 1 percent level of inbreeding (Table 4.44).

Malik *et al.* (1967) in Hariana Heifers reported higher AFC (1870 days) in the highly inbred group (F>12%) as compared to lowly inbred (F=3.12-6.20%) group (1818 days). Pirela and Ilea (1970) reported lower AFC in non-inbred Simmental heifers as comapred to inbreds by 155 days.

Gurnani *et al.* (1971) in Tharparkar and Srinivas and Gurnani (1981) in Sahiwal heifers reported that 1 percent increase of inbreeding coefficient would increase the AFC by 6.99 days and 3.40 days, respectively. The regression estimate, however, was statistically non-significant. Ramchandran *et al.* (1987) also reported non-significant effect of inbreeding on AFC in Red Sindhi heifers. Hermas *et al.* (1987) also reported that AFC increased by 3.7 days with 1 percent increase of inbreeding coefficient in Guernsey cows.

4.5.4.7. Effect of Inbreeding on First Lactation 305 Day or Less Milk Yield (FL305DMY) in Karan Fries Cows

FL305DMY for different levels of inbred and non inbred are presented in the Table. No significant differences in FL305DMY between non inbreds and inbreds was found. The cows with level of inbreeding above 12 percent had lower FL305DMY of 2643.05±223.42 kg. Whereas, Non inbreds found to had maximum FL305DMY (2921.62±23.69kg). the estimate of regression of FL 305 MY on inbreeding level was found to be –2.480±1.755 kg per 1 percent, this was, however, found to be statistically non significant (Table 4.44)

Robertson (1954), Von Krosigk and Lush (1958) and Gaalas *et al.* (1962) reported significantly adverse effect of inbreeding on FL305DMY in Friesian cattle beyond 10.0 to 12.5 percent level of inbreeding. Mi *et al.* (1965) observed that inbred cows were inferior to non-inbreds by 584 kg in a herd of Friesian with an average inbreeding coefficient of 25 percent.

Malik *et al.* (1967) reported that the regression coefficient of FL305DMY on inbreeding coefficient was –17 kg per one percent in Hariana cows. The estimate was statistically significant. The inbreeding coefficient ranged between 1.6 to 25 percent with an average inbreeding coefficient of 6.25 percent. Khanna *et al.* (1979) reported significantly lower FL305DMY in inbred Sahiwal and Hariana cows. The average FL305DMY of non-inbred Sahiwal and Hariana cows was 1710 and 908 kg and of inbreds was 1529 and 630 kg, respectively. The average coefficient of inbreeding in Sahiwal and Hariana cows was 6.96 and 14 percent, respectively.

Srinivas and Gurnani (1981) observed significantly adverse effect of inbreeding of FL305DMY in Sahiwal cattle at NDRI Farm, Karnal. The inbred cows had significantly lower FL305DMY (1868 kg) as compared to non-inbreds (2276kg). They further indicated that level of inbreeding upto 5 percent had beneficial effect on FL305DMY. However, the effect was non-significant by regression analysis (b=-2.10 kg per 1%).

Hudson and VanVleck (1984a) reported regression coefficient of FL305DMY on inbreeding coefficient in Ayrshire cattle as –27.1, Guernsey as –19.30, Holstein as 21.1, Jersey as –14.8 and in Brown Swiss as –39.5 lbs per 1 percent level of inbreeding. Miglior *et al.* (1992) obtained regression of FL305DMY on inbreeding coefficient as –9.84 kg in Jersey cattle which was significant. They furtgehr reported that level of inbreeding beyond 12.5 percent had significantly adverse effect on FL305DMY. Vij *et al.* (1992) reported significantly lower milk yield of highly inbred cows (F>12.5) as comapred to non-inbred ones in Tharparkar cattle.

Several other authors have reported that inbreeding at higher levels (F>10%) tended to depress FL305DMY. These included Tyler *et al.* (1949), Thompson and Freeman (1964). Allaire and Henderson (1965) and Hodge *et al.* (1979) in Friesian cattle; Casanova *et al.* (1992) in Brown Swiss; Hermas *et al.* (1987) in Guernsey cattle; Gurnani *et al.* (1971) in Tharparkar cattle; Srinivas and Gurnani (1981), Reddy and Nagarcenkar (1988) in Sahiwal cows; Srinivas (1978) Su (1988) in Brown Swiss crosses at NDRI Farm and Singh (1995) in Karan Swiss in Karnal.

4.5.4.8. Effect of Inbreeding on First Lactation Total Milk Yield (FLTMY) in Karan Fries Cows

A consistently declining trend in FLTMY with the increase in level of inbreeding was found in this study However, no significant difference was observed between non-inbreds and inbred. Further, inbreds above 12% F had significantly lower FLTMY of 3084.50± 326.61 kg (Table 4.43) However, regression of FLTMY on inbreeding coefficient was found to be statistically non-significant (-3.600±2.106 kg per percent) (Table 4.44)

Similar to this study Ramchandran *et al.* (1987) and Singh (1992) observed non significant effect of inbreeding on FLTMY in Red Sindhi and Sahiwal cattle. Singh (1995) in Karan Fries found significantly lower milk yield for those animals with inbreeding coefficient more than 12 percent.

4.5.4.9. Effect of Inbreeding on First Lactation Length (FLL) in Karan Fries Cows

The least squares means of FLL for various level of inbreeding ranged from 331.82±13.10 days for lowly inbred (1<F<6 percent) to 351.30±21.51 days for moderately inbred (6<F<12 percent) (Table 4.43) However, the effect of level of inbreeding was found to be statistically non-significant.

There was no definite trend observed for FLL with increase in level of inbreeding. This is quantified by statistically non-significant regression of FLL on level of inbreeding which was –2.968±2.052 days per 1 percent increase in inbreeding (Table 4.44).

Non-significant effect of inbreeding on FLL was reported by Kumar and Narain (1977) in Sahiwal, Khanna *et al.* (1979) in Hariana, Ramchandran *et al.* (1987) , Reddy and Sampath (1989) in Red Sindhi; Reddy and Nagarcenkar (1998) in Sahiwal; Ehiobu (1993) in White Fulani cattle; Singh (1995) in Karan Fries cattle.

On the other hand, Odedra *et al.* (1977) in Gir cattle; Srinivas and Gurnani (1981) in Sahiwal cattle at NDRI and Su (1988) in Karan Swiss cattle obtained beneficial effect of low to moderate inbreeding (0<F<8%) on FLL upto inbreeding coefficient (F) of 8 percent.

4.5.4.10. Effect of Inbreeding on First Service Period (FSP) in Karan Fries Cows

The least squares mean of FSP for levels of inbreeding ranged from 137.57±2.75 days (non inbred) to 142.14±23.69 days (highly inbred) (Table 4.43) There was an increasing trend in average FSP with the increase in level of inbreeding. The effect of inbreeding levels of FSP was also found to be non-significant. On the other hand, the regression of FSP on inbreeding coefficient was found to be statistically significant. The value being 1.304±0.916 days per 1 percent increase in level of inbreeding (Table 4.44).

Srinivas and Gurnani (1981) reported significantly higher FSP for inbreeding coefficient (above 19%) in Sahiwal cows at NDRI Farm, Karnal over a period of 27 years, whereas, Su (1988) reported favourable effect of inbreeding at higher level (8<F<18%) in KS cattle, though the effect was statistically non significant. Khanna *et al.* (1979) and Reddy and Nagarcenkar (1988) in Sahiwal cattle reported non significant effect of inbreeding of FSP.

Plensik (1977) reported significantly longer FSP in highly inbred cows (F>16%). However, inbreeding coefficient below 16 percent did not cause any difference in FSP as compared to non inbreds.

4.5.4.11. Effect of Inbreeding on First Dry Period (FDP) in Karan Fries Cows

The least squares means of FDP for different levels of inbreeding varied from 71.28±1.49 days for non-inbreds to 82.50±6.82 days for highly inbreds (Table 4.43). However, least squares ANOVA revealed non-significant effect of inbreeding level of FDP in this herd. This is quantified by low and statistically non-significant estimate of regression of FDP on inbreeding level (0.618±0.561 days per 1%).

Odedra *et al.* (1979) in Gir cattle reported FDP for cows having more than 12 percent inbreeding coefficient. However, effect of inbreeding on FDP was non-significnat. The non-significant effect of inbreeding on FDP was also reported by Khanna *et al.* (1979) in Hariana and Sahiwal cows, by Reddy and Sampath (1989) in Red Sindhi cows and by Singh (1995) in Karan Fries cows.

4.5.4.12. Effect of Inbreeding on First Calving Internal (FCI) in Karan Fries Cows

The least squares average of FCI for inbreeding levels ranged from 423.72±2.89 days (non inbreds) to 441.05±25.34 days (highly inbred) (Table 4.43). However, the effect of inbreeding levels on FCI as statistically non significant. There was an increasing trend observed for average FCI with the increase in level of inbreeding. This is quantified by regression of FCI on inbreeding coefficient (3.574±2.355 days per 1% increase in level of inbreeding). The regression coefficient, however, was statistically non significant (Table 4.44).

Favourable effect of low to mild inbreeding (F<8%) as reported by Malik *et al.* (1967) in Hariana cows; Hudson and VanVleck (1984a) in Friesian cows; Khanna *et al.* (1979 in Hariana cows; Odedra *et al.* (1979) in

Gir cows, and Srinivas and Gurnani (1981) in Sahiwal cows. The effect, however, was found to be statistically non-significant.

Adverse effect of inbreeding on FCI beyond 10-12 percent level of inbreeding was reported by Ahmad (1974), Khanna *et al.* (1980), Singh (1981) and Reddy and Nagarcenkar (1988a) in Sahiwal cows; Gurnani *et al.* (1971) and Vij *et al.* (1992) in Tharparkar cows; Nowicki (1963) and Bonadonna *et al.* (1966) in Black Pied cattle; Hudson and VanVleck (1984a, b) in Ayrshire and Friesian cattle. The effect as, however, statistically non significant..

4.5.4.13. Effect of inbreeding on Milk Yield Period in First Lactation Length (MY/FLL) in Karan Fries Cows

The least squares average of MY/FLL for different levels of inbreeding varied from 9.66±0.78 kg for highly inbreds (F>12%) to 10.19±0.40 kg for moderately inbreds (Table 4.43) A consistent declining trend of MY/FLL as observed with the increase in level of inbreeding except in the group whose inbreeding coefficient was between 1 to 6 percent. The regression coefficient of MY/FLL on inbreeding –0.078±0.064 kg/day per one percent level of inbreeding which was non significant (Table 4.44).

Reddy and Nagarcenkar (1988) and Singh (1992) reported unfavourable influence of inbreeding on MY/FLL in Sahiwal cattle beyond 12 percent of inbreeding coefficient..

4.5.4.14 Effect of Inbreeding on Milk Yield per Day of First Calving Interval (MY/FCI) in Karan Fries Cows

The least squares average for inbreeding levels varied from 8.16±0.53 kg for moderately inbred (6>F>12%) to 8.70±0.06 kg for non inbreds (Table 4.43). There was a decreasing trend of average MY/FCI observed with the increase in level of inbreeding was observed. The estimate of regression of MY/FCI on inbreeding levels (-0.081±0.047 kg per 1%) was, however, found to be statistically not significant (Table 4.44). Singh (1992), however, reported non-significant effect of inbreeding on MY/FCI in Sahiwal cattle.

Table 4.43. Average performance of various economic traits for different inbred groups in Karan Fires cows

Group	BWT	WOY	WFS	WFC	AFS	AFC	FL 305 TMY	FLTMY
Upto 1%	27.73 ± 0.02 (76)	180.54 ± 4.46[b] (35)	301.87 ± 15.91 (27)	365.72 ± 9.79 (26)	718.41 ± 24.91 (41)	985.64 ± 24.61 (42)	2916.71 ± 168.92 (29)	3394.39 ± 246.89 (28)
1-6%	27.31 ± 0.57 (139)	176.26 ± 6.96[b] (48)	308.23 ± 9.86 (47)	360.36 ± 8.70 (38)	739.36 ± 18.06 (78)	1019.30 ± 17.72 (81)	2835.95 ± 112.83 (65)	3278.35 ± 164.59 (63)
6-12%	27.15 ± 0.42 (44)	175.81± 5.94[bc] (23)	299.06 ± 7.34 (16)	352.40 ± 12.89 (15)	759.26 ± 31.29 (26)	1033.165 ± 31.90 (25)	2865.71 ± 189.68 (23)	3289.02 ± 266.68 (24)
>12%	25.85 ± 1.06 (22)	172.17±18.43[c] (5)	298.74 ± 15.91 (10)	352.19 ± 14.42 (12)	751.24 ± 39.88 (16)	1028.58 ± 38.90 (17)	2643.05 ± 227.42 (16)	3084 ± 50 ± 326.61 (16)
Non inbreds	27.55 ± 0.09 (2689)	205.60±1.30[a] (993)	320.80 ± 1.84 (743)	368.73 ± 1.74 (817)	717.28 ± 4.05 (1545)	993.15 ± 3.92 (1651)	2921.31 ± 23.69 (1474)	3407.24 ± 34.09 (1468)

Group	FLL	FSP	FDP	FCI	MY/FLL	MY/FCI	HL
Upto 1%	344.07 ± 19.85 (27)	139.00 ± 22.16 (16)	75.24 ± 12.19 (16)	425.70 ± 23.00 (17)	10.04 ± 0.60 (27)	8.46 ± 0.20 (17)	1198.57 ± 183.79[b] (40)
1-6%	331.82 ± 13.10 (62)	141.75 ± 12.53 (50)	75.50 ± 6.82 (51)	427.70 ± 13.28 (51)	10.19 ± 0.40 (62)	8.22 ± 0.52 (47)	1051.09 ± 183.79[b] (86)
6-12%	351.30 ± 21.51 (23)	142.06 ± 22.88 (15)	76.00 ± 11.82 (19)	432.56 ± 23.70 (16)	10.03 ± 0.67 (22)	8.16 ± 0.53 (16)	1015.31 ± 253.66[b] (21)
>12%	327.68 ± 25.79 (16)	142.14 ± 23.69 (14)	82.50 ± 6.82 (14)	441.05 ± 25.34 (14)	9.66 ± 0.78 (16)	8.18 ± 0.57 (14)	961.49 ± 125.34[c] (16)
Non inbreds	338.10 ± 2.71 (1440)	137.57 ± 2.75 (1036)	71.28 ± 1.49 (1060)	423.72 ± 2.89 (1075)	10.11 ± 0.08 (1436)	8.70 ± 0.06 (1052)	1492.82 ± 24.08[a] (2329)

Figures in the parenthesis indicate number of observations

Table 4.44. Regression of different performance traits on inbreeding coefficient in Karan Fries

Sl. No.	Trait	Intercept Constant	Regression coefficient ± SE
1	BWT	27.121	-0.005 ± 0.061
2	WOY	74.874	-1.29 ± 1.024
3.	WFS	106.224	-0.556 ± 1.671
4	WFC	109.892	-0.654 ± 1.916
5	AFS	413.664	1.966 ± 1.306
6	AFC	562.151	1.480 ± 2.770
7	FL-305DMY	1235.070	-2.480 ± 1.755
8	FLTMY	1396.720	-3.600 ± 2.106
9	FLL	142.280	-2.968 ± 2.052
10	FSP	41.450	1.304 ± 0.916
11	FDP	25.580	0.618 ± 0.561
12	FCI	134.020	3.574 ± 2.355
13	MY/FLL	4.152	-0.078 ± 0.064
14	MY/FCI	2.535	-0.081 ± 0.047
15	HL	574.889	-21.45 ± 10.65

4.5.4.15. Effect of Inbreeding on Herd Life (HL) in Karan Fries Cows

Herd life was found to be significantly ($P<0.05$) affected by level of inbreeding in Karan Fries cattle. The least squares mean for HL ranged from 961.49±125.34 days (highly inbreds) to 1492.82±24.08 (non inbreds). Average HL in highly inbred group was significantly different from other inbred groups (Table 4.43). A consistent decreasing trend of HL as observed with increase in level of inbreeding. It is further quantified by regression coefficient of HL on levels of inbreeding (-21.45±10.65 kg per 1 %) which was found to be statistically non significant (Table 4.44.

Overall, from this study detrimental effect of inbreeding on growth, production and reproduction traits was confirmed. However, for majority of traits depressing effect of inbreeding as not found statistically significant. Since inbreeding increases the incidence of homozyosity, more pair and recessive genes are expected to occur among inbred animals. The most logical explanation of why homozygous recessive genotype result in detrimental effect in because deficiencies of important or essential enzyme that would have been produced by dominant alleles. Recessive gene may sometime result in production of abnormal or defective proteins (Stuff lebeam, 1987).

4.6. DISPOSAL PATTERN OF CROSSBRED COWS

In order to facilitate genetic improvement in the herd through various breeding schemes, it is necessary to remove the low producing animals and by retaining the high producing for future lactation and also to obtain genetic improvement by breeding replacement stock only from selected cows (Hill, 1`980). Although removal of less productive animals from the herd is likely to bring genetic improvement in the progeny, but substantial removal of animals by involuntary culling hampers the genetic improvement in any breeding scheme. These losses reduce the opportunity for selection of more desirable animals. Hence, to bring about improvement in the herd, it is necessary to study the mode of disposal of calves, heifers and adult cows on the basis of various reasons. The results on these aspects for Karan Swiss and Karan Fries are presented in the following subsections:

4.6.1. Disposal Pattern of Female Calves and Heifers in Crossbred Cows

4.6.1.1. Disposal pattern in Karan Swiss female calves and heifers

The disposal through mortality and culling in the age group 0-1 month, 1-3 month, 3-6 month, 6-12 month, 12-18 month and 18 month to first calving over the paternal and maternal generations are presented in the Table 4.45and Table 4.46 .

In the population as a whole, 38.13 percent of the animals were found to be disposed before first calving. The percentage of animal disposed was found to be 8.71, 5.74, 2.68, 4.35, 2.71, 14.20 for various age groups such as 0-1 month, 1-3 month, 3-6 month, 6-12 months, 12-18 month and 18 month to first calving respectively. The incidence of calf mortality was found high in early stage of life around 76.85 percent of total mortality observed upto 6 month of age. In case of culling reverse trend was observed. About 79.23 percent of the culling observed from 12 month to AFC.

The result obtain in the present study was found similar to that of Singh (1995) in Karan Swiss who reported 39.51 percent of disposal before first calving. Whereas, Dutt and Desai (1968) obtained a higher percent of disposal (50 percent) upto AFC in Hariana cattle, Desraj (1987) in Kankrej cattle and Jadhav (1995) in Frisian x Sahiwal crosses also noticed a high culling rate in the age of 18 month to AFC.

No specific trend for disposal was found over the paternal generations. The minimum percentage of disposal (20.12 percent) was found in first generation whereas maximum disposal (49.20 percent) was observed in the third generation. For the remaining generation it was ranged from 38.11 to 48.25 percent (Table 4.45..

Minimum disposal was observed (18.36 percent) for the first generation from maternal side whereas in the ninth generation 100 percent

Table 4.45. Paternal generationwise disposal of female calves and heifers in Karan Swiss

Paternal Generation	Total female born	0-1 month			1-3 month			3-6 month			6-12 month			12-18 month			18-AFC			Overall
		D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	
1	646	66	-	66	13	-	13	4	-	4	7	1	8	6	2	8	6	25	31	130 (20.12)
2	467	34	1	35	32	-	32	6	3	9	16	7	23	6	6	12	6	68	74	185 (39.61)
3	478	27	1	28	12	-	12	15	1	16	12	7	19	7	6	13	11	106	117	205 (42.88)
4	424	48	-	48	21	-	21	5	1	6	7	19	26	4	14	18	4	86	90	209 (49.29)
5	309	23	-	23	11	1	12	4	6	10	6	11	17	2	10	12	5	39	44	118 (38.18)
6	374	33	2	35	27	3	30	2	13	15	9	8	17	5	5	10	9	28	37	144 (38.50)
7	238	8	1	9	12	-	12	4	8	12	4	14	18	0	11	11	4	39	43	105 (44.10)
8	172	25	-	25	34	-	34	7	5	12	2	6	8	1	-	1	2	1	3	83 (48.25)
NK	60	7	-	7	7	-	7	1	-	1	2	-	2	1	-	1	3	8	11	29 (48.33)
Total	3168	271 (8.55)	5 (0.15)	276 (8.71)	169 (5.33)	4 (0.12)	173 (5.46)	48 (1.51)	37 (1.16)	85 (2.68)	65 (2.05)	73 (2.30)	138 (4.35)	32 (1.01)	54 (1.70)	86 (2.71)	50 (1.57)	400 (12.62)	450 (14.20)	1208 (38.13)

Figures in parentheses indicate percentage NK : Generation not known, D = Death; C = Culled, T = Total

Table 4.46. Maternal generationwise disposal of female calves and heifers in Karan Swiss

Maternal Generation	Total female born	0-1 month			1-3 month			3-6 month			6-12 month			12-18 month			18-AFC			Overall
		D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	
1	588	47	-	**47**	11	1	**12**	3	-	**3**	6	2	**8**	5	1	**6**	7	25	**32**	**108 (18.36)**
2	1045	75	2	**77**	45	-	**45**	16	6	**22**	21	26	**47**	11	27	**38**	16	167	**183**	**412 (39.42)**
3	730	68	1	**69**	39	-	**39**	15	9	**24**	16	20	**36**	10	17	**27**	14	128	**142**	**336 (46.02)**
4	383	38	2	**40**	30	2	**32**	5	7	**12**	10	16	**26**	3	7	**10**	5	49	**54**	**174 (45.43)**
5	211	25	-	**25**	21	-	**21**	2	7	**9**	7	6	**13**	1	1	**2**	2	25	**27**	**97 (45.97)**
6	120	8	-	**8**	12	-	**12**	3	4	**7**	3	1	**4**	-	-	-	5	6	**11**	**42 (35.00)**
7	42	6	-	**6**	6	1	**7**	2	2	**4**	2	1	**3**	1	-	**1**	-	-	-	**21 (50.00)**
8	8	1	-	**1**	1	-	**1**	-	-	-	-	-	-	-	-	**1**	1	-	**1**	**3 (37.50)**
9	3	1	-	**1**	1	-	**1**	-	-	-	-	1	**1**	-	-	-	-	-	-	**3 (100.00)**
NK	38	3	-	**3**	3	-	**3**	2	2	**4**	-	-	-	1	1	**2**	-	-	-	**12 (31.57)**
Total	3168	271 (8.55)	5 (0.15)	**276 (8.71)**	169 (5.33)	4 (0.12)	**173 (5.46)**	48 (1.51)	37 (1.16)	**85 (2.68)**	65 (2.05)	73 (2.30)	**138 (4.35)**	32 (1.01)	54 (1.70)	**86 (2.71)**	50 (1.57)	400 (12.62)	**450 (14.20)**	**1208 (38.13)**

Figures in parentheses indicate percentage NK : Generation not known, D = Death; C = Culled, T = Total

animals was found to be disposed off before first calving for other generation's value found to be ranged between 35 to 50 percent (Table 4.46).

4.6.1.2. Disposal pattern in Karan Fries female calves and heifers

The disposal rate in various age groups for Karan fires females is given in Table 4.47 and Table 4.48. As the table reveals that 4.22, 5.53, 1.34, 1.60, 0.65 and 1.83 percent females were disposed off on account of mortality in the age group of 0-1 month, 1-3 month, 3-6 month, 6-12 month, 12-18 month, 18 month to AFC, respectively. The corresponding figures for animal disposed off by culling were 0.13, 0.22, 0.95, 2.72, 2.62 and 8.98 percent respectively. Similar to Karan Swiss population about 73.06 percent of total calf mortality observed upto 6 month of age while 91.61 percent of culling was observed from 6 month to AFC in Karan Fries cattle.

In the population as a whole 30.84 percent were disposed off before first calving. The result of mortality as found to be normal range to the findings of Amble and Jain (1967), Katpatal (1977), Nagarcenkar *et al.* (1980), Chudhary *et al.* (1984), Reddy *et al.* (1987), Taneja *et al.* (1989a), Thakur *et al.* (1994) and Jadhav *et al.* (1995b), Mukherjee and Tomar (1999). These authors reported 18-30 percent mortality prior to first calving in Exotic x Zebu crossbred at various organized farms. Whereas, Singh (1995) reported slightly higher disposal rate (35.95 percent) in Karan Fries cattle.

The disposal rate over the paternal generation indicated that minimum 20 percent as found to be disposed off before calving in the fifth generations whereas; maximum 36.72 percent was disposed off in the third generation (Table 4.47).

Maternal generation wise disposal pattern presented in the Table 4.48 reveals that only 11.31 percent of animals were disposed off before first calving in the first generations whereas 35.36 percent were disposed off in the third generation. No literature was found on disposal over the paternal as well as maternal generations.

Table 4.47. Paternal generationise disposal of female calves and heifers in Karan Fries

Paternal Generation	Total female born	0-1 month			1-3 month			3-6 month			6-12 month			12-18 month			18-AFC			Overall
		D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	
1	862	19	-	19	28	1	29	6	4	10	13	8	21	5	10	15	16	96	112	206 (23.89)
2	645	29	-	29	23	-	23	9	3	12	12	16	28	4	26	30	12	92	104	226 (35.03)
3	855	44	4	48	54	5	59	21	16	37	11	47	58	3	38	41	12	59	71	314 (36.72)
4	634	33	-	33	61	1	62	5	6	11	12	12	24	8	4	12	15	24	39	181 (28.54)
5	5	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	3	1 (20)
NK	50	4	-	4	2	-	2	-	-	-	1	-	1	-	2	2	1	3	4	13 (126)
Total	3051	129 (4.22)	4 (0.23)	133 (4.35)	169 (5.53)	7 (0.22)	176 (5.76)	41 (1.34)	29 (0.95)	70 (2.29)	49 (1.60)	83 (2.73)	132 (4.30)	20 (0.65)	80 (2.62)	100 (3.27)	56 (1.83)	274 (8.98)	330 (10.81)	941 (30.84)

Figures in parentheses indicate percentage NK : Generation not known, D = Death; C = Culled, T = Total

Table 4.48 Maternal generationise disposal of female calves and heifers in Karan Fries

Maternal Generation	Total female born	0-1 month			1-3 month			3-6 month			6-12 month			12-18 month			18-AFC			Overall
		D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	D	C	T	
1	274	4	-	**4**	8	-	**8**	1	3	**4**	1	1	**2**	1	-	**1**	4	8	**12**	**31 (11.31)**
2	735	26	-	**26**	32	1	**33**	11	4	**15**	16	7	**23**	4	10	**14**	11	87	**98**	**209 (28.43)**
3	639	27	-	**27**	17	3	**20**	9	6	**15**	9	32	**41**	5	22	**27**	17	79	**96**	**226 (35.36)**
4	492	20	3	**23**	27	1	**28**	7	10	**17**	8	18	**26**	7	12	**19**	8	41	**49**	**162 (32.92)**
5	377	17	1	**18**	33	1	**34**	5	1	**6**	8	13	**21**	3	1	**4**	9	20	**29**	**112 (29.70)**
6	207	14	-	**14**	30	-	**30**	3	2	**5**	4	6	**10**	-	2	**2**	4	7	**11**	**72 (34.78)**
7	56	7	-	**7**	5	-	**5**	1	-	**1**	-	1	**1**	-	-	-	-	-	-	**14 (25.00)**
8	10	-	-	-	3	-	**3**	-	-	-	-	-	-	-	-	-	-	-	-	**3 (30.00)**
9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NK	260	14	-	**14**	14	1	**15**	4	3	**7**	3	5	**8**	-	33	**33**	3	32	**35**	**112 (43.07)**
Total	3051	129 (4.22)	4 (0.13)	**133 (4.35)**	169 (5.53)	7 (0.22)	**176 (5.76)**	41 (1.34)	29 (0.95)	**70 (2.29)**	49 (1.60)	83 (2.73)	**132 (4.30)**	20 (0.65)	80 (2.62)	**100 (3.27)**	56 (1.83)	274 (8.98)	**330 (10.81)**	**941 (30.84)**

Figures in parentheses indicate percentage NK : Generation not known, D = Death; C = Culled, T = Total

The result on disposal pattern on both the Karan Swiss and Karan Fries population indicated that incidence of mortality was high at the early stage which may be due to less resistance towards various disease.

Whereas, incidence of culling was high at later stage compared to early stage. It was noticed that the females were mainly culled at early age due to reasons of health disorders and poor growth while in later age due to infertility, late maturity and reproductive problems.

4.6.2. Disposal Pattern in Adult Cows

Parity specific disposal rate over the paternal and maternal generation for Karan Swiss and Karan Fries cattle were studied separately and discussed below.

6.6.2.1. Disposal of adult cows in Karan Swiss

Parity specific paternal as well as maternal generation wise disposal of Karan Swiss cattle are presented in Table 4.49 & Table 4.50..

Over the paternal generation, the culling rate of adult cows varies from 76.85 percent in seventh generation to 94.20 percent in second generation while mortality rate ranged from 5.94 percent (second generation) to 23.14 percent (seventh generations).

Parity specific disposal of cows indicated that in the first generation only 20 percent of the cows were disposed after first parity. Whereas incidence of disposal was found to be more after first parity in the later generation with maximum of 60 percent was observed in eighth generation.

The average number of lactation completed by the animals over the paternal generation was presented in the Table 4.49. Animals belong to the first generation observed to complete on an average 4.71 lactations while for the animals of later generations it ranged from 1.5 to 3.12 lactations.

Over the maternal generation maximum culling rate was observed in second generation (90.95 percent) where as maximum mortality (100 percent) in the eighth generations. Minimum 20.36 percent of the animals were found to be disposed off after first parity whereas from second

Table 4.49. Parity specific paternal generationwise disposal of Karan Swiss cows

Paternal Generation	Total female in milk	Total disposed	Total died	Total culled	Parity														Average Lactation
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	475	475	62 (1305)	413 (86.94)	98 (20.63)	987 (20.42)	56 (11.78)	34 (7.15)	29 (6.10)	23 (4.84)	17 (3.57)	24 (5.05)	23 (4.84)	21 (4.42)	22 (4.63)	20 (4.21)	6 (1.26)	5 (1.05)	4.71
2	259	259	15 (5.79)	244 (94.20)	102 (39.38)	82 (31.66)	25 (9.65)	16 (6.17)	8 (3.08)	5 (1.93)	10 (3.86)	5 (1.93)	2 (0.77)	3 (1.15)	-	1 (0.38)	-	-	2.49
3	242	240	24 (9.91)	216 (89.35)	88 (36.66)	93 (38.75)	28 (11.66)	18 (7.50)	3 (1.25)	4 (1.66)	3 (1.25)	1 (0.41)	-	1 (0.41)	-	1 (0.41)	-	-	2.17
4	199	199	26 (13.06)	173 (86.93)	61 (30.65)	50 (25.12)	38 (19.09)	21 (10.55)	14 (7.03)	9 (4.52)	4 (2.01)	1 (0.50)	-	1 (0.50)	-	-	-	-	2.66
5	182	182	27 (14.83)	157 (86.26)	70 (38.46)	50 (27.47)	25 (13.73)	17 (9.34)	12 (6.59)	6 (3.29)	1 (0.54)	-	1 (0.54)	-	-	-	-	-	2.34
6	177	157	33 (21.01)	124 (78.98)	59 (37.57)	42 (26.75)	20 (12.73)	17 (10.82)	13 (8.28)	3 (1.91)	2 (1.27)	1 (0.63)	-	-	-	-	-	-	2.39
7	110	108	25 (23.14)	83 (76.85)	24 (22.22)	29 (26.85)	18 (16.66)	14 (12.96)	8 (7.40)	7 (6.48)	3 (2.77)	3 (2.77)	2 (1.85)	-	-	-	-	-	3.12
8	29	20	3 (15.00)	17 (85.00)	12 (60.00)	6 (30.00)	2 (10.00)	-	-	-	-	-	-	-	-	-	-	-	1.50

Figures in parentheses indicate percentage

Table 4.50. Parity specific maternal generationwise disposal of Karan Swiss cows

Maternal Generation	Total female in milk	Total disposed	Total died	Total culled	Parity														Average lactation
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	442	442	56 (12.66)	386 (87.33)	90 (20.36)	95 (21.49)	50 (11.31)	30 (6.78)	23 (5.80)	20 (4.52)	15 (3.39)	23 (5.20)	22 (4.97)	21 (4.75)	22 (4.97)	20 (4.52)	6 (1.35)	5 (1.13)	4.16
2	586	586	53 (9.04)	533 (90.95)	200 (34.12)	190 (32.42)	74 (12.62)	48 (8.19)	27 (4.69)	18 (3.07)	13 (2.21)	5 (0.85)	4 (0.68)	4 (0.68)	-	3 (0.51)	-	-	2.53
3	339	337	44 (13.05)	293 (86.94)	123 (36.50)	103 (30.56)	50 (14.84)	~25 (7.42)	15 (4.45)	6 (1.78)	8 (2.37)	4 (1.19)	2 (0.59)	1 (0.30)	-	-	-	-	2.39
4	179	176	34 (19.31)	142 (80.68)	57 (32.39)	47 (26.70)	27 (15.34)	18 (10.23)	12 (6.82)	10 (5.68)	3 (1.70)	2 (1.14)	-	-	-	-	-	-	2.62
5	80	76	16 (21.05)	60 (78.94)	28 (36.84)	14 (18.42)	5 (6.58)	12 (15.79)	7 (9.21)	7 (9.21)	2 (2.63)	1 (1.32)	-	-	-	-	-	-	2.87
6	42	33	3 (9.09)	30 (90.90)	16 (48.4/8)	6 (18.18)	8 (18.18)	3 (9.09)	1 (3.03)	1 (3.03)	-	-	-	-	-	-	-	-	2.27
7	11	9	2 (22.22)	7 (77.77)	5 (55.56)	1 (11.11)	1 (11.11)	-	-	-	-	1 (11.11)	1 (11.11)	-	-	-	-	-	3.00
8	1	1	1 (100.00)	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.00

Figures in parentheses indicate percentage

generation it as increased with value ranges from 32.39 percent to 100 percent.

Studies over the maternal generation revealed that animals belong to first generation found to complete more number of lactations (4.16) before being disposed off. While for later generation it ranged from 2.27 to 3.0 lactations.

Animals belonging to first generation either from paternal or maternal side found to complete more number of lactations, which may be due to superiority of F_1 animals in milk production performance and thus were kept in the herd for longer period.

4.6.2.2. Disposal of adult cows in Karan Fries

Figure presented in the Table 4.51 and Table 4.52 represents parity specific paternal and maternal generation wise disposal in Karan Fries cows. Maximum culling rate of 85.06 percent was observed in second generation whereas maximum 22.85 percent of mortality was observed in the third generation from paternal side. In the fifth generation only 1 animal entered in the milking herd and disposed off after first parity.

Disposal pattern over maternal side generation indicates that 83.88 percent animals were culled in third and eighth generation respectively, whereas maximum mortality was observed at fourth generation (22.26 percent).

Paternal generationwise disposal of animals showed that only 25.46 percent of the animal disposed off after first parity in the first generation whereas in the later generations it ranged from 29.87 percent (3rd generation) t0 41.41 percent in 4th generation. The average number of lactation completed by the animals found to range between 1.00 lactation (5th generation) to 3.82 (1st generation)

Similar trend was also observed over the maternal generation where average lactation completed by the animals found to range between 1.42 (7th generation) to 5.93 (1st generation).

Table 4.51. Parity specific paternal generationwise disposal of Karan Fries cows

Paternal Generation	Total female in milk	Total disposed	Total died	Total culled	Parity														Average Lactation
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	623	593	107 (18.04)	486 (81.95)	151 (25.46)	128 (21.59)	98 (16.53)	41 (6.91)	47 (7.93)	24 (4.05)	21 (3.54)	27 (4.55)	22 (3.71)	12 (2.02)	7 (1.18)	6 (1.01)	7 (1.18)	7 (1.34)	3.82
2	381	375	56 (14.93)	319 (85.06)	122 (32.53)	83 (22.13)	69 (18.40)	40 (10.67)	22 (5.87)	21 (5.60)	10 (2.67)	4 (1.07)	3 (0.80)	-	-	1 (0.27)	-	-	2.75
3	418	385	88 (22.85)	297 (77.14)	115 (29.87)	87 (22.60)	70 (18.18)	40 (10.39)	35 (9.09)	13 (3.38)	6 (1.56)	11 (2.86)	5 (1.30)	3 (0.78)	-	-	-	-	3.05
4	342	198	36 (18.18)	162 (81.18)	82 (41.41)	72 (36.36)	27 (13.64)	7 (3.54)	6 (3.03)	3 (1.52)	-	-	1 (0.51)						1.98
5	1	1	1 (100.00)	0	1 (100.00)														1.00

Figures in parentheses indicate percentage

Table 4.52. Parity specific maternal generationwise disposal of Karan Fries cows

Maternal Generation	Total female in milk	Total disposed	Total died	Total culled	Parity														Average Lactation
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	228	195	44 (22.56)	151 (77.43)	19 (9.74)	24 (12.31)	23 (11.79)	13 (6.67)	19 (9.74)	13 (6.67)	12 (6.15)	18 (6.23)	21 (10.77)	11 (5.64)	6 (3.08)	7 (3.60)	7 (3.60)	2 (1.03)	5.93
2	473	461	80 (17.35)	381 (82.64)	133 (28.85)	120 (26.03)	97 (21.04)	38 (8.24)	31 (6.72)	14 (3.04)	11 (2.39)	12 (2.60)	2 (0.43)	1 (0.22)	1 (0.22)	1 (0.22)	-	-	2.77
3	353	342	57 (16.66)	285 (83.33)	113 (33.04)	82 (23.98)	54 (15.79)	34 (9.94)	22 (6.43)	12 (3.51)	12 (3.51)	8 (2.34)	3 (0.88)	2 (0.58)	-	-	-	-	2.78
4	285	247	55 (22.26)	192 (77.73)	82 (33.20)	56 (22.67)	42 (17.00)	23 (9.31)	21 (8.50)	13 (5.26)	1 (0.40)	3 (1.21)	5 (2.02)	1 (1.21)	-	-	-	-	2.76
5	205	137	29 (21.16)	108 (78.83)	57 (41.61)	34 (24.82)	28 (20.44)	8 (5.84)	7 (5.11)	2 (1.46)	-	1 (0.73)	-	-	-	-	-	-	2.16
6	72	44	5 (11.36)	39 (88.63)	20 (45.45)	19 (43.18)	5 (11.36)	-	-	-	-	-	-	-	-	-	-	-	1.66
7	18	12	2 (16.66)	10 (83.33)	9 (75.00)	2 (16.67)	-	1 (8.33)	-	-	-	-	-	-	-	-	-	-	1.42
8	4	2	0	2 (100)	1 (50.00)	1 (50.00)	-	-	-	-	-	-	-	-	-	-	-	-	1.50
9	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

Figures in parentheses indicate percentage

First generation's animals (both paternal and maternal) found to have high productive life which may be due to superiority of F_1 individuals with respect to production performance.

In both the Karan Swiss and Karan Fries herd low milk production was observed to be principal reason of culling upto 3rd lactation, after that incidence of culling due to this reason become negligible. Teat and udder problems, hoof and leg problems were found to be another reasons for culling. In both the herd percentage of culled was found to exceed percentage died in the adult cows.

Taneja *et al.* (1989) reported in F x H, B x H and J x H half breds that nearly 30, 25 and 16 percent was left the herd upto 3rd lactation. The average number of lactation completed was 4.97, 5.11 and 5.36 respectively by F x H, B x H and J x H half bred groups. They also found that nearly 50 percent was left the herd upto 5th lactation in all the half bred groups. The reproductive disorders were found to be the major reason for culling accounting for nearly 33, 28 and 22 percent of total cullings.

Jadhav (1990) reported lower parity specific culling rate in F x S crossbred ranging from 1.73 to 6.01 percent during first to 6th lactation. The mortality rate was 2.60 and 4.87 percent for above parities. However, slightly higher culling rate was reported by Mukherjee and Tomar (1994) in Karan Swiss cattle. They found 29, 39, 29 and 75 percent culling from 1st to 4th lactation.

4.6.3. Impact of Disposal on Milk Production Performance

Average expected breeding value (EBV) of all the lactating cows based on all available lactation yield (305 days or less milk yield) which were in the herd in different years, the EBV of cows which were disposed off due to culling and mortality, the EBV of culled cows, the EBV of retained cows and the cows which newly entered in the herd in that specific year was estimated separately for Karan Swiss and Karan Fries herd. These estimates provide the information on the trend of production performance of cows in different years.

4.6.3.1. Impact of disposal on milk production performance in Karan Swiss cattle

The average expected breeding value on the basis of 305 day or less milk yield (all lactations) presented in the Table 4.53; which varied from 2800.91 kg in the year 1997 to 3403.86 kg in the year 1966. The lower breeding value in the later years may be due to incorporation of less number of lactations (1 to 2) in estimation and higher breeding value in the early years may be due to presence of F_1 animals which were kept in herd for longer time for higher milk production.

The number of cows in the milking herd also showed fluctuating trend with very less number of animals in the later years which may be due to higher disposal rate as compared to replacement rate of cows (Table 4.53).

Trends of average EBV of existing and disposed animals presented in the Fig. 4.17 indicates that during early years (in 1970's) there was a wide gap for EBV between existing and disposed animals whereas, it reduced gradually. Average EVB found to be same for existing and disposed animals in the year 1986, 1995. Which may be due to disposal of superior animals by death or high incidence of involuntary culling.

Figure 4.18 represents the difference in EBV between retained and disposed animals the difference was maximum (824.8 kg in the year 1971 and minimum in the year 1999 (29.31 kg). It may be due to disposal off superior animals either through mortality or culling (voluntary and involuntary). The difference in EBV between retained and culled are given in the table and Fig.4.18. The minimum value was found in the year 1999. (29.31 kg). Though a fluctuating trend was found, the difference in average EBV between retained and culled animals found to be reduced in the later years.

Table 4. 53. Impact of disposal on milk production performance in Karan Swiss

Year	Average EBV of the					Difference in Avg. EBV between	
	Existing animals	Retained animals	Newly entered animals	Disposed animals	Culled animals	Retained and disposed animals	Retained and culled animals
1966	3403.86 (12)	–	3403.86 (12)	–	–	–	–
1967	3310.11 (27)	3387.78 (12)	3253.15 (15)	–	–	–	–
1968	3335.92 (37)	3306.55 (27)	3400.53 (10)	–	–	–	–
1969	3317.59 (44)	3391.20 (37)	2581.56 (7)	–	–	–	–
1970	3093.51 (70)	3257.67 (43)	2862.47 (27)	3432.87 (1)	–	824.80	–
1971	2961.69 (114)	3149.63 (67)	2705.78 (47)	2746.21 (3)	2746.20 (3)	403.42	403.43
1972	2828.26 (171)	2923.17 (97)	2694.57 (74)	2409.30 (17)	2403.13 (14)	513.87	520.04
1973	2894.20 (189)	2971.80 (137)	2723.19 (52)	2412.75 (34)	2371.92 (31)	559.05	599.88
1974	2894.09 (211)	2985.25 (133)	2669.94 (78)	2483.44 (56)	2489.61 (55)	501.81	495.64
1975	2849.46 (260)	3002.77 (168)	2604.18 (92)	2471.55 (43)	2448.08 (33)	531.22	554.69
1976	2822.42 (329)	2925.65 (202)	2625.10 (118)	2521.69 (58)	2491.25 (53)	403.96	434.40
1977	2815.40 (332)	2921.06 (184)	2626.29 (148)	2564.49 (136)	2559.26 (132)	356.57	361.80
1978	2883.07 (297)	2952.24 (210)	2666.89 (87)	2621.29 (122)	2592.17 (117)	330.95	360.07
1979	2857.23 (281)	3051.26 (187)	2585.27 (94)	2664.26 (100)	2657.36 (97)	387.00	393.90
1980	2885.64 (257)	2989.40 (172)	2656.07 (85)	2574.34 (109)	2569.18 (101)	415.06	420.22
1981	2973.05 (205)	3066.03 (174)	2622.77 (31)	2679.77 (83)	2606.17 (73)	386.26	459.86
1982	2942.06 (197)	3108.52 (144)	2640.05 (53)	2710.82 (61)	2682.58 (56)	397.72	425.94
1983	2949.09 (204)	3101.13 (134)	2638.20 (70)	2593.60 (63)	2550.94 (54)	507.53	550.19

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Year	Average EBV of the					Difference in Avg. EBV between	
	Existing animals	Retained animals	Newly entered animals	Disposed animals	Culled animals	Retained and disposed animals	Retained and culled animals
1984	3054.15 (217)	3135.17 (152)	2868.80 (65)	2743.89 (52)	2727.16 (48)	391.28	408.01
1985	3045.15 (229)	3126.10 (157)	2865.00 (72)	2858.87 (60)	2848.93 (52)	267.23	277.17
1986	2981.19 (211)	3077.92 (157)	2692.83 (54)	2783.14 (72)	2757.02 (60)	294.78	320.90
1987	2963.29 (199)	3089.99 (151)	2702.09 (48)	2972.93 (60)	2967.38 (45)	117.06	122.61
1988	2917.10 (176)	3020.40 (144)	2597.61 (32)	2830.90 (55)	2831.58 (41)	189.50	188.82
1989	2948.57 (148)	2999.75 (108)	2795.03 (40)	2718.31 (68)	2679.16 (58)	281.44	320.59
1990	3031.75 (137)	3009.82 (95)	3078.10 (42)	2868.03 (53)	2865.33 (45)	141.79	144.49
1991	3094.98 (119)	3168.05 (100)	2764.24 (19)	3023.33 (37)	2816.61 (31)	144.72	351.44
1992	2952.31 (120)	3026.14 (77)	2865.04 (43)	2860.96 (42)	2847.66 (37)	165.18	178.48
1993	2949.59 (111)	3030.37 (80)	2710.13 (31)	2869.82 (40)	2883.71 (23)	160.55	146.66
1994	2985.42 (83)	3048.54 (69)	2674.34 (14)	2938.65 (42)	2950.29 (39)	109.89	98.25
1995	2869.74 (85)	3064.81 (48)	2529.94 (37)	2860.36 (35)	2897.67 (25)	204.45	167.14
1996	2895.42 (68)	2979.30 (49)	2622.79 (19)	2744.08 (36)	2742.18 (33)	235.22	237.12
1997	2800.91 (58)	2945.46 (37)	2511.81 (21)	2588.83 (31)	2506.02 (23)	356.63	439.44
1998	2891.37 (37)	2929.53 (32)	2576.47 (5)	2650.86 (26)	2609.92 (21)	278.67	319.61
1999	3041.62 (37)	3118.59 (30)	2744.74 (7)	3089.28 (7)	2888.55 (5)	29.31	230.04
2000	2882.54 (28)	2882.54 (28)	–	2800.15 (9)	2801.37 (7)	82.39	81.17

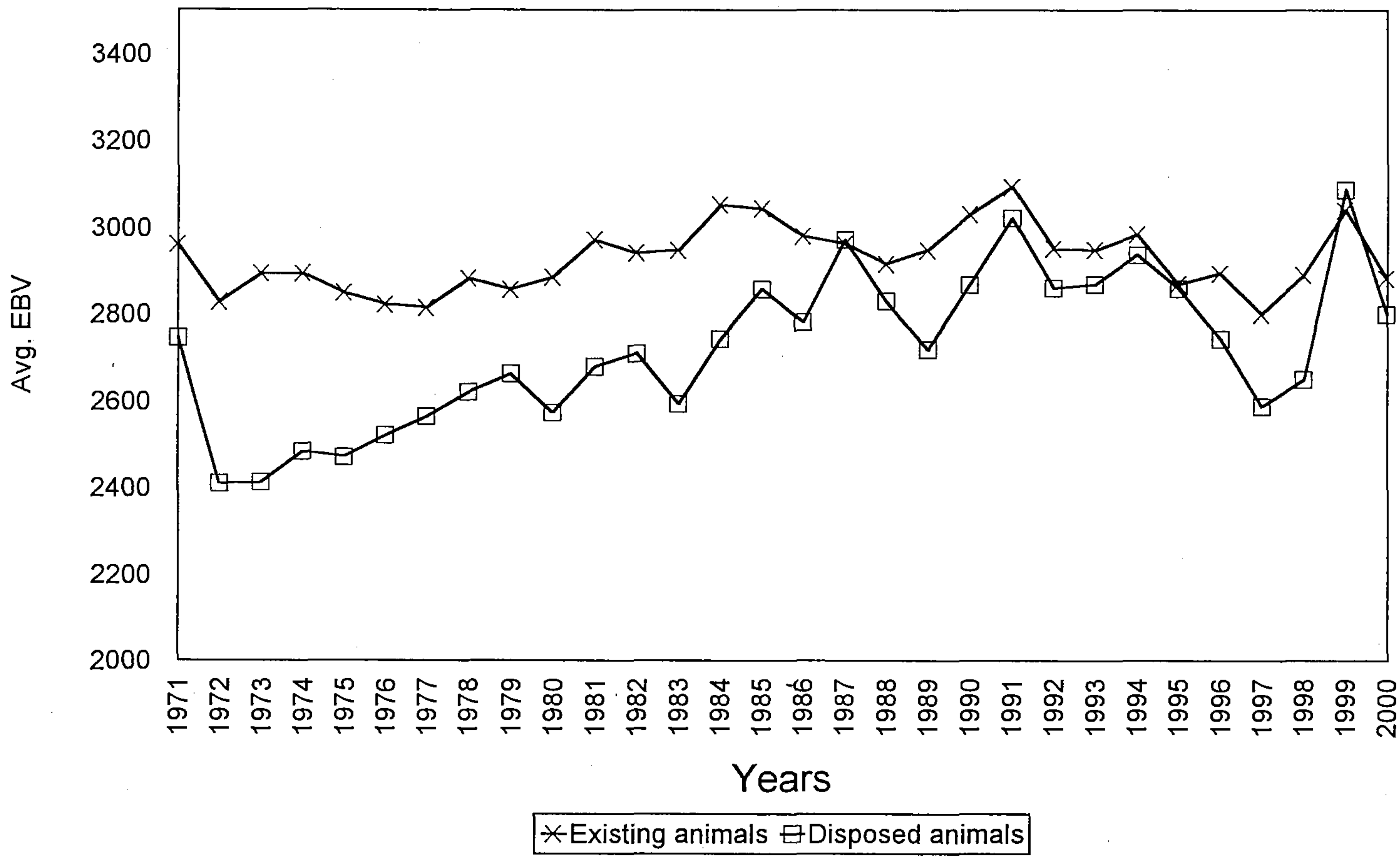

Fig. 4.17. Trends of average EBV of the existing and disposed animals in Karan Swiss cows

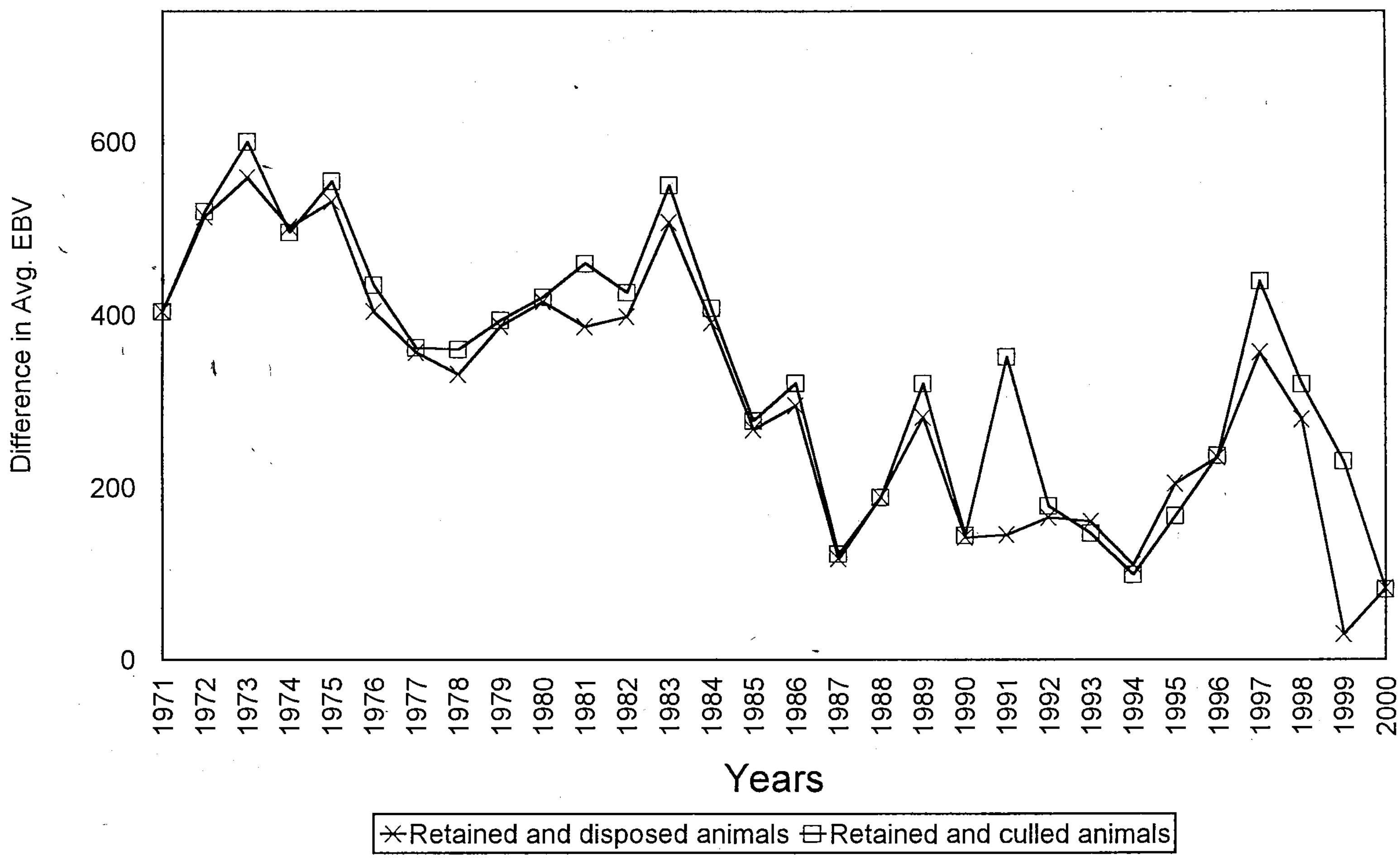

Fig. 4.18. Trends of differene in average EBV in Karan Swiss cows

It may be due to equal genetic potential of the animals which newly entered the herd in later year as compared to animals which were exiting in the herd. The result indicates that individual selection of females resulted in minor improvement in the herd.

Moreover, from the year 1986 onward the number of animal newly entered in the herd was found to be less than the number of animals disposed off thus resulting in reduction of herd size of the Karan Swiss cattle, thereby leaving a little scope to exert higher degree of selection pressure.

4.6.3.2. Impact of disposal on milk production performance in Karan Fries cattle

In Karan fries herd, the average breeding value of cows on the basis of all available lactation milk yield (305 day or les) varied from 3141.91 kg in the year 1997 to 4374.63 kg in the year 1967 and 1968 (4.54).

Trends of average EBV of the existing and disposed animal over the year as presented in Fig. 4.19. which revealed that in early stages of crossbreeding programme there was wide difference in EBV between existing and disposed animal, which narrowed down gradually. During early 90's the EBV of disposed and existing animals were found to be similar. But from 1995 onwards an increasing trend in the difference in average EBV was found.

The difference in average EBV between retained and disposed animals are graphically represented in Fig. 4.20 where maximum difference as observed in the year 1975 (827.8 kg), whereas, minimum 64.97 kg observed in 1994. Similar trend was observed for the difference in average EBV between retained and culled animals (Fig. 4.20) the result indicate that individual selection of animals resulted in a minor improvement of herd. This may be due to small herd size, low replacement rate, and death of superior animals and higher incidence of involuntary culling. Which could led to negative selection by limiting culling on the basis of voluntary culling and thus resulted in reduction of selection intensity. Interestingly it was observed from

Table 4. 54. Impact of disposal on milk production performance in Karan Fries

Year	Average EBV of the					Difference in Avg. EBV between	
	Existing animals	Retained animals	Newly entered animals	Disposed animals	Culled animals	Retained and disposed animals	Retained and culled animals
1967	4374.63 (1)	–	4374.63 (1)	–	–	–	–
1968	4374.63 (1)	4374.63 (1)	–	–	–	–	–
1969	3590.87 (3)	4374.63 (1)	3203.18 (2)	–	–	–	–
1970	3665.65 (9)	3597.13 (3)	3595.51 (6)	–	–	–	–
1971	3641.00 (15)	3720.38 (9)	3791.12 (6)	–	–	–	–
1972	3484.80 (21)	3558.92 (14)	3288.57 (7)	3478.51 (1)	3478.51 (1)	80.41	80.41
1973	3546.28 (28)	3639.58 (21)	3440.84 (7)	–	–	–	–
1974	3257.78 (52)	3392.29 (28)	3256.72 (24)	–	–	–	–
1975	3356.49 (95)	3335.18 (49)	3397.98 (46)	2507.37 (3)	2507.37 (3)	827.81	827.81
1976	3378.73 (166)	3460.07 (83)	3244.37 (83)	2869.67 (12)	2909.25 (11)	590.40	550.82
1977	3362.54 (171)	3434.65 (137)	3150.16 (34)	2773.02 (29)	2734.57 (27)	661.63	700.08
1978	3371.30 (191)	3468.42 (136)	3136.64 (55)	2996.33 (35)	2914.23 (28)	472.09	554.19
1979	3324.76 (211)	3425.57 (156)	2968.23 (55)	3049.93 (35)	2914.91 (24)	375.64	510.66
1980	3280.67 (223)	3439.26 (133)	2995.52 (90)	2994.64 (78)	2984.36 (72)	444.62	454.90
1981	3330.49 (219)	3415.71 (173)	3078.56 (46)	3048.74 (50)	2993.69 (44)	366.97	422.02
1982	3288.51 (258)	3396.04 (156)	3032.49 (102)	3011.84 (63)	2968.96 (55)	384.20	427.08

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Year	Average EBV of the					Difference in Avg. EBV between	
	Existing animals	**Retained animals**	**Newly entered animals**	**Disposed animals**	**Culled animals**	**Retained and disposed animals**	**Retained and culled animals**
1983	3329.79 (230)	3389.59 (192)	3139.08 (38)	3075.47 (66)	2920.74 (47)	314.12	468.85
1984	3362.17 (264)	3435.54 (180)	3213.66 (84)	3124.80 (50)	3080.34 (61)	310.74	355.20
1985	3429.90 (234)	3492.06 (142)	3319.48 (92)	3194.42 (122)	3188.17 (105)	297.64	303.89
1986	3445.11 (206)	3544.96 (172)	3290.36 (34)	3244.52 (62)	3224.01 (55)	300.44	320.95
1987	3403.99 (231)	3530.76 (162)	3060.58 (69)	3299.58 (44)	3264.40 (34)	231.18	266.36
1988	3280.42 (225)	3367.99 (178)	3104.59 (47)	3235.24 (53)	3171.51 (42)	132.75	196.48
1989	3295.52 (238)	3363.21 (157)	3079.95 (81)	3208.25 (68)	3110.21 (53)	154.96	253.00
1990	3230.96 (215)	3294.61 (158)	3095.85 (57)	3203.68 (80)	3129.71 (57)	90.93	164.90
1991	3233.13 (192)	3298.84 (128)	3075.16 (64)	3178.23 (87)	3144.05 (67)	120.61	154.79
1992	3248.72 (196)	3306.72 (124)	3035.79 (72)	3269.81 (68)	3211.49 (59)	36.91	95.23
1993	3192.11 (219)	3248.61 (153)	3158.39 (66)	3096.85 (43)	3001.09 (30)	151.76	247.52
1994	3221.08 (182)	3205.49 (136)	3321.45 (46)	3140.52 (83)	3082.17 (67)	64.97	123.32
1995	3264.06 (201)	3336.19 (115)	3085.16 (86)	3155.91 (67)	3022.29 (53)	180.28	313.90
1996	3178.77 (197)	3286.01 (153)	2982.84 (44)	3001.96 (48)	2918.75 (42)	284.05	367.26
1997	3141.91 (193)	3275.49 (141)	2961.44 (52)	3012.77 (56)	2921.91 (40)	262.72	353.58
1998	3141.94 (177)	3229.42 (138)	2872.12 (39)	2919.03 (55)	2852.12 (42)	310.39	377.30
1999	3226.10 (160)	3272.93 (145)	3140.84 (15)	2910.37 (32)	2846.60 (27)	362.56	426.33
2000	3197.86 (136)	3200.81 (134)	3000.41 (2)	3127.69 (26)	3127.69 (26)	73.12	73.12

Figures in parenthesis indicate number of observations the study that as time progressed the average EBV of the newly entered animals became almost similar or lower than the selected animals. Thus, resulted in overall reduction of average EBV of the existing animals in the herd.

Available literature on impact of disposal on milk production performance indicated that in dairy cows involuntary culling not only associated with lower sale price but also consists of loss of production, cost of veterinary treatment prior to disposal. An unbalanced ratio of involuntary and voluntary culling resulted loss of both production level and genetic improvement (Van Arendonk, 1985).

Similarly Kulkarni and Sethi (1990) studied the impact of culling on Karan Fries and Karan Swiss herd during 1976 to 1983. the could not find any improvement by culling in both herds. They further reported that cows which were culled on the basis of involuntary reasons (Teat and Udder problems and reproductive disorders) were of equal genetic potential as compared to those which were selected. Similar findings were also reported by Singh (1995) for Karan Fries and Karan Swiss cattle.

4.7. DEVELOPMENT OF APPROPRIATE BREEDING STRATEGY FOR IMPROVEMENT OF CROSSBRED CATTLE

The present investigation on Karan Swiss and Karan Fries cattle indicated that animals belong to first generation performed better than animals of the later generations. But it is practically not feasible to maintain a population consisting of only F_1. Studies on *interse* mated population revealed the superiority of miscellaneous crosses over the F_2, F_3 F_4 etc. The desirable level of exotic inheritance was observed as ranging from 50 percent to 62.5 percent with corresponding heterozygosity level as 45 to 60 percent. Therefore, an appropriate breeding strategy with an aim to attain the desirable exotic inheritance level (50 to 62.5 percent) and heterozygosity level (45 to 60 percent) within a shortest period can be suggested for the improvement of the crossbred herd. The mating plan was presented in Fig.

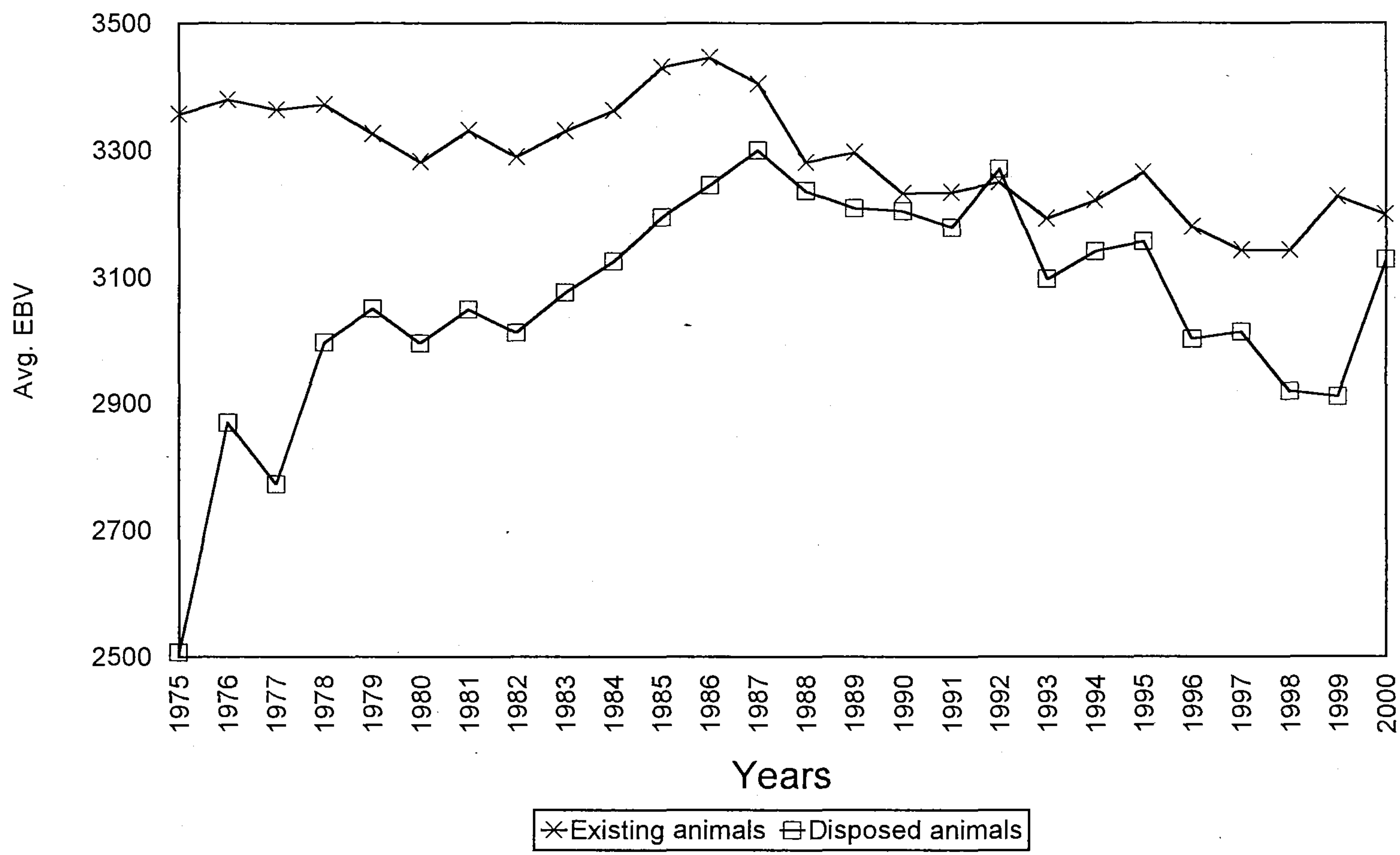


Fig. 4.19. Trends of average EBV of the existing and disposed animals in Karan Fries cows

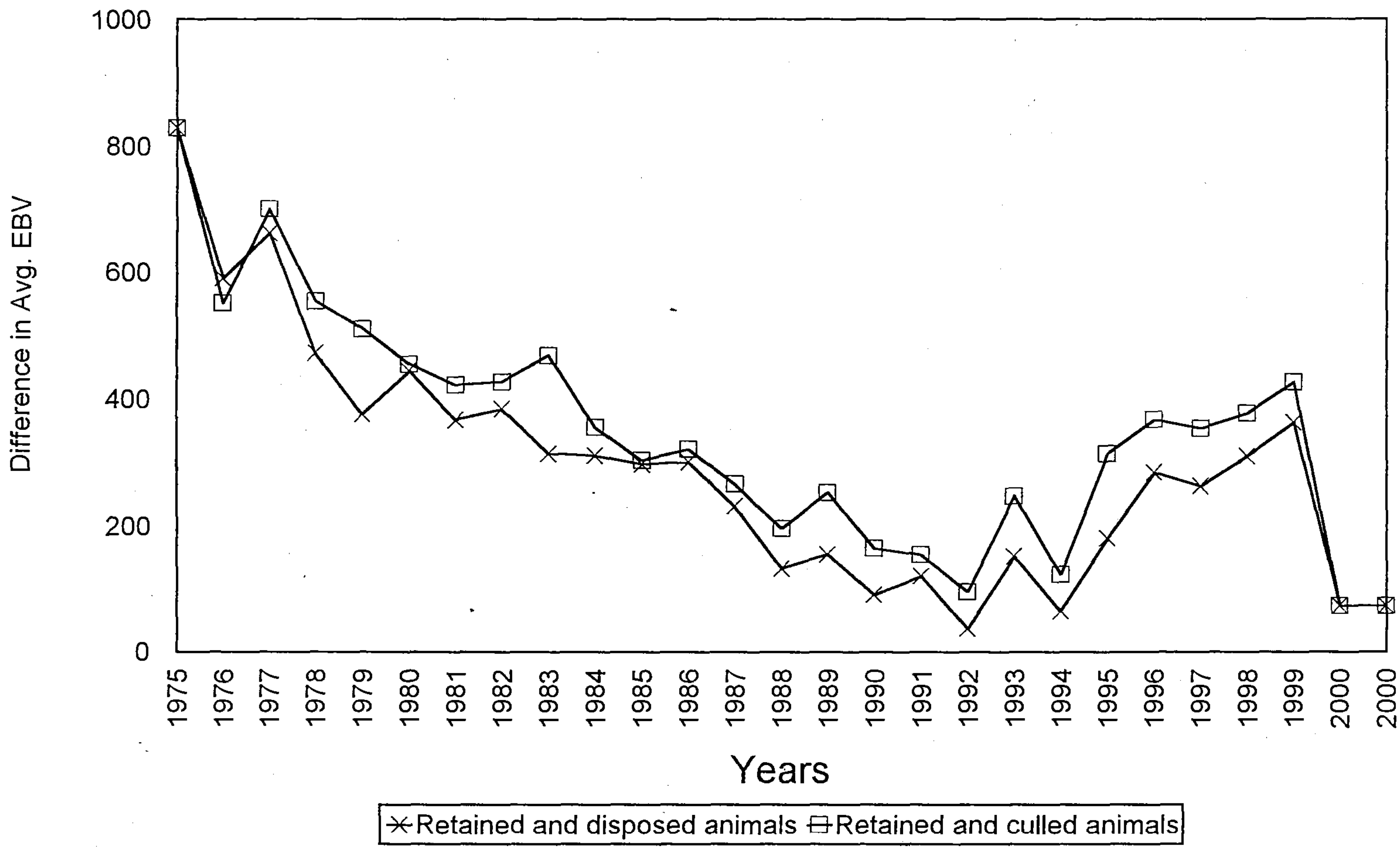
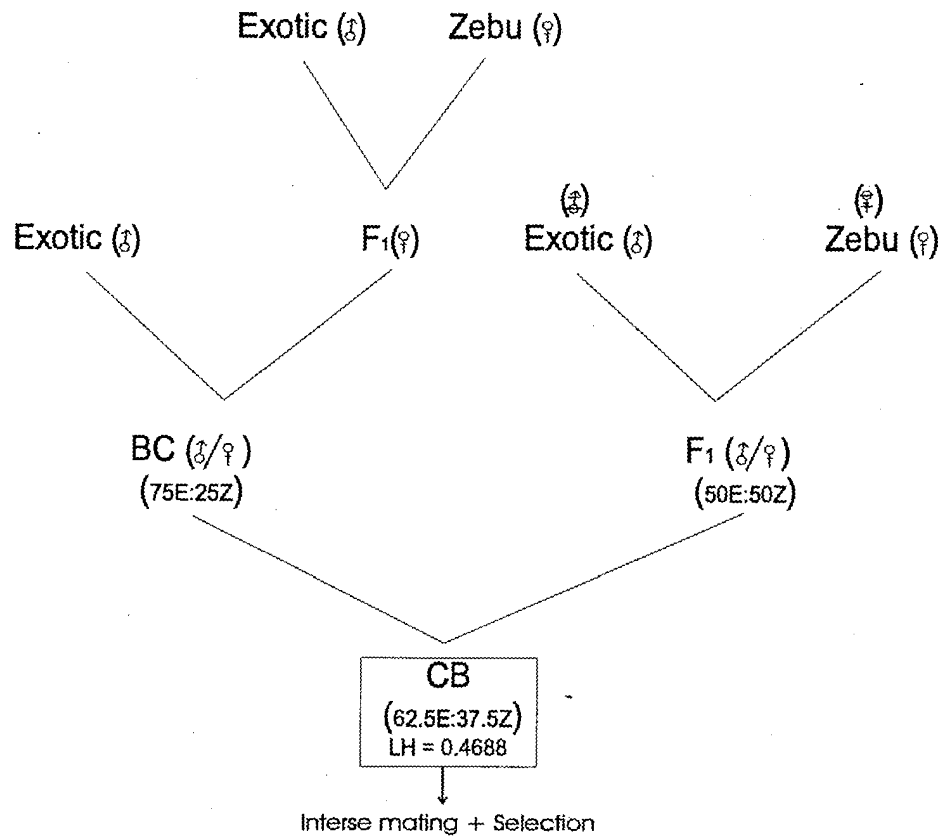


Fig. 4.20. Trends of differene in average EBV in Karan Fries cows



BC = Back Cross
CB = Crossbred

Fig. 4.21 Breeding Plan (with 2 breeds)

4.21 which represents the breeding plan with 2 breeds (one exotic and one zebu). In this plan bulls with 75% exotic inheritance can be mated with F_1 dam or F_1 bulls can be mated with dams having 75 percent exotic inheritance and thus will produce the progenies with exotic inheritance 62.5 percent with level of heterozygosity 46.88 percent.

With this strategy it is possible to maintain animals with 50 to 75 percent exotic inheritance in the population without producing F_2, F_3 F_4 etc. Because of uncertainty about the optimum blend of germplasm in the composite population, it may be a better approach to establish a base population with a wide range of genetic types which can be further improved by selective breeding. It is also suggested that use of high yielding proven exotic bulls should continue for producing F_1 and backcrosses with 75 percent exotic inheritance

Care should also be taken to avoid incidence of inbreeding in the herd. Sire should be mated to less related females. For this purpose coefficient of relationship of bull with all available breedable females will have to be determined. Such relationship should be less than 12 percent, so that inbreeding level of the progeny is less than 6 percent. .

Herd size is another key factor which determines the extent of genetic improvement in the population. Present study indicated that in both the Karan Swiss and Karan Fries populations number of animals disposed off were found to be more than the number of heifers entering in the milking herd in the later years and thus resulting in reduction of herd size over the years. Mortality of female calves and heifers and high incidence of involuntary culling of the heifers and cows were found to be responsible of such low replacement rate. Thus it is necessary for any breeding programme to take suitable measures like better feeding, management and disease control etc. not only to minimize the disposal rate, but also to improve the level of milk production.

CHAPTER-5

SUMMARY & CONCLUSIONS

Summary and Conclusions

The present study was conducted on Karan Swiss (KS) and Karan Fries (KF) cattle maintained at National Dairy Research Institute (NDRI) Karnal. The data were collected on 3168 Karan Swiss cows sired by 107 bulls (1963-2000) and 3051 cows sired by 163 bulls (1971-2000) for various growth (BWT, WOY, WFS and WFC) reproduction (AFS, AFC,FSP,FCI,), production (FL 305 DMY, FLTMY, FLL, FDP, MY/FLL, MY/FCI) traits and herd life. The data on females were classified according to various genetic groups, season and period of birth, season and period of calving.

The pedigree of every animal born during this period was traced back upto F_1 generation. Only 3080 animals from Karan Swiss and 2741 animals from Karan Fries cows were found to have complete pedigree records (from both paternal as well as maternal side). Paternal and maternal generations were determined separately for each animal. Except in F_1, F_2 and F_3 etc. animals, in most cases paternal and maternal generations were found different. Cows upto eighth generation from paternal side and ninth generation from maternal side in Karan Swiss and, fifth generation from paternal side and ninth generation from maternal side were observed in the present study. However due to lack of sufficient records only the cows upto seventh generation from maternal side in Karan Swiss and cows upto fourth generation from paternal side and seventh generation from maternal side in Karan Fries were considered for comparing the performance in different generation.

The influence of genetic and non-genetic factors in female calves and heifers was studied by method of least squares analysis of variance of non-orthogonal data.

The least squares averages of BWT, WOY, WFS, WFC, AFS, AFC, FL 305 DMY,FLTMY, FLL, FSP, FCI, FDP, MY/FLL, MY/FCI and HL were 26.26 kg, 145.84kg, 287.84 kg, 347.55kg, 783.76 days, 1046.96 days, 2443.79 kg, 2791.14 kg, 331.69 days, 123.58 days, 410. 33 days, 76.39 days, 8.72 kg, 7.56 kg and 2280.88 days respectively, in Karan Swiss and 26.16 kg, 179.77 kg, 303.11 kg, 366.85 kg, 745.46 days, 1009.40 days, 2470.35 kg, 2822.91 kg, 315.25 days, 127.69 days, 423.20 days, 80.72 days, 8.76 kg, 7.78 kg and 1809.80 days respectively, Karan Fries cattle.

Least squares analysis of variance showed significant effect of genetic groups on BWT, AFS and AFC in Karan Swiss and on BWT, AFS, AFC, FL 305 DMY, FLTMY, FDP, MY/FLL, MY/FCI, and HL in Karan Fries.

BS/BR crosses (F_1) in Karan Swiss and HT crosses in Karan Fries cattle found to be superior with respect to various first lactation production, reproduction traits and Herd life.

The effect of paternal generation was found significant on BWT, WOY, WFS, WFC,AFS, AFC, FL 305 DMY, FLTMY, MY/FLL, MY/FCI and HL in Karan Swiss and on WOY, AFS, AFC, FLTMY, FLL, FSP, MY/FCI in Karan Fries. For majority of traits in both the Karan Swiss and Karan Fries cattle the first generation animals were found to perform better, which may be due to use of proven exotic bulls of high genetic merit. However, no specific trend was observed in the later generation.

Significant effect of maternal generation was observed BWT, WFS, WFC, AFS,AFC, FLTMY, MY/FLL and HL in Karan Swiss and on BWT, WOY, AFS, AFC, FL 305DMY, FLL, FSP, FCI, MY/FLL, MY/FCI and HL in Karan Fries. Animals belonging to first generation were found to be superior than the later generation animals.

Decline in production in the later generations may be due to incidence of inbreeding or removal of animals with high production potential due to involuntary culling.

However, season of birth had significant effect on BWT, WOY, WFC in Karan Swiss and on BWT, WOY, WFS and WFS in Karan Fries. While significant effect of season on calving was observed on FL 305 DMY, FLTMY, FSP and FCI in Karan Swiss and on FLTMY, FL 305 DMY, FSP and FCI in Karan Fries.

Least squares analysis revealed significant effect of period of birth on BWT, WOY, WFS, WFC, AFS and AFC for both the Karan Swiss and Karan Fries cattle. However, period of calving was found to have significant effect on FL 305 DMY FLTMY, FLL, FDP, MY/FLL, MY/FCI and HL in Karan Swiss and in Karan Fries significant effect of period of calving was observed for FL 305 DMY, MY/FLL and HL.

Performance of various production and reproduction traits was observed to be deteriorating in the later periods, which may be due to less representation of first generation animals.

The repeatability of various repeatable traits such as 305-day or less milk yield, lactation length, dry period, service period and calving interval was estimated. For Karan Swiss the estimates were found to be 0.344±0.015, 0.116±0.015, 0.102±0.017, 0.089±0.017, 0.150±0.020, respectively whereas for Karan Fries cows the estimates were observed as 0.338±0.016, 0.120±0.014, 0.220±0.017, 0.201±0.019, 0.319±0.018. Low to moderate estimates of repeatability indicated heritable causes together with permanent environmental factors had less influence on these traits. Thus, prediction of breeding value for these traits based on single record may not be very accurate and addition of records will add to the accuracy of prediction.

The heritability estimates for various body weight, first lactation traits and herd life were estimated by paternal half-sib correlation method. The heritability estimates of BWT, WOY, WFS, WFC, AFS, AFC, FL305DMY, FLTMY,FLL, FSP,FDP,FCI, MY/FLL, MY/FCI and HL were 0.24±0.04, 0.12±0.06, 0.13±0.09, 0.16±0.05, 0.15±0.05, 0.17±0.05, 0.28±0.05, 0.27±0.04, 0.22±0.05, 0.10±0.015, 0.09±-0.06, 0.03±0.05, 0.34±0.07, 0.33±0.018, 0.02±0.03 in Karan Swiss herd and 0.191±0.044, 0.161±0.105, 0.192±0.093, 0.027±0.068, 0.194±0.060, 0.173±0.099, 0.304±0.024, 0.268±0.057, 0.211±0.050, 0.164±0.075, 0.128±0.069, 0.353±0.102, 0.385±0.067, 0.402±0.098 and 0.158±0.049 respectively in Karan Fries herd.

Low heritability estimates of various growth and reproduction traits and herd life indicates that these traits by and large influenced by management and other environmental factors. However moderate to high heritability of the production traits indicates that these traits are more governed by additive genetic factors and improvement in this traits is possible by selection.

The genetic and phenotypic correlations among various growth traits were found to be positive which indicate that heavier body weight at early in likely to persist at later ages whereas, negative phenotypic and genetic correlation between growth traits with AFS and AFC indicate that animals with high body weight tend to mature early.

The phenotypic correlation among AFC, FL 305 DMY, FLTMY, FLL, MY/FLL, MY/FCI was high in Karan Swiss while in Karan Fries high phenotypic correlation was observed among AFC, FL 305DMY, FLTMY.

The positive correlation among the production (FL 305 DMY, FLTMY) and reproduction traits (FSP, FCI) indicates that high producing animals generally show poor performance in reproduction traits.

However, herd life had high genetic and phenotypic correlation with FL 305DMY and FLTMY, which indicate that high producer, were generally kept in the herd for longer time,.

A comparison between various types of crosses in Karan Swiss and Karan Fries confirmed the superiority of F_1 animals over others. FLTMY was found to reduce by 27 percent, 17 percent, 14 percent and 13 percent in F_2, F_3, F_4 and miscellaneous crosses respectively in Karan Swiss and 17.32 percent, 32 percent and 9.57 percent in F_2, F_3 and miscellaneous crosses in Karan Fries compared to FLTMY in the F_1 of the respective crossbred population. However miscellaneous crosses were better than F_2, F_3 crosses for majority of traits considered for the study. Average herd life of F_1 animals were found to be significantly higher than the rest of the crosses in both Karan Swiss and Karan Fries.

Crossbred animals (excluding F_1) were classified into different exotic inheritance level to compare various economic traits. Karan Swiss animals with exotic level above 62.5 percent had significantly lower AFS and AFC. However with respect to milk production traits Karan Swiss animals with 50 to 62.5 percent exotic inheritance were found superior with average FLTMY and FL 305 DMY observed as 2729.91 kg and 2450.99 kg respectively.

In Karan Fries population, animals with 50 to 62.5 percent exotic inheritance had lower AFS and AFC. Maximum average FLTMY was observed for the animals with exotic inheritance between 50 to above 62.5 (3368.44±58.55 kg). However maximum average FLL was observed for those animals with exotic inheritance above 62.5 percent (354.07 days). The crossbred animals with different exotic inheritance level were not found to be significantly different with respect to BWT, WOY, FDP, MY/FLL, MY/FCI and HL in Karan Fries.

To find out similarities and dis-similarities of crossbred cows within a particular level of exotic inheritance early lactation characters viz., AFS, AFC, and FL 305DMY along with level of heterozygosity were used to classify both the Karan Swiss and Karan Fries cows by the Euclidian distance method. In Karan Swiss three, two and three sub groups (clusters) and in Karan Fries three, two and three sub groups (clusters) were obtained respectively, under the three exotic inheritance levels (50 percent, 50-62.5 percent and above 62.5 percent). The distance studies have shown that crossbred cows within a particular level of exotic inheritance were not found similar with respect to level of heterozygosity, AFS, AFC, and FL305DMY.

Karan Swiss and Karan Fries taken for the study were found to have inheritance from two, three, four and five breeds respectively, as recorded in the pedigree. The level of exotic inheritance was found to range between 51 to 55 percent in Karan Swiss and 57 to 65 percent in Karan Fries cattle. The level of heterozygosity increased with the increase in number of breeds involved.

Two breed and three breed crosses were found to be superior than four and five breed crosses with respect to average AFS and AFC and corresponding values were found to be 746.62 and 756.82 days for AFS and 1035.06 and 1038.20 days for AFC in Karan Swiss. Maximum FLTMY (2772.25 kg) and FL 305 DMY (2661.82 kg) was observed for two breeds crosses in Karan Swiss. However, three breed crosses were not significantly different from two breed crosses in Karan Swiss cattle.

In Karan Fries, significant effect of number of breed was observed for WOY, FLTMY, FL 305 DMY, FLL, MY/FLL.MY/FCI and HL. With respect to production traits viz., FLTMY, FL 305 DMY, FLL, MY/FLL, MY/FCI and Herd life (HL) two breeds crosses were found to be superior and the average values were observed as 3514.31 kg, 2967.86 kg, 343.71 days, 10.30 kg, 8.75 kg and 1471.88 days, respectively.

To find out the variability of performance traits in crossbred cows, the level of heterozygosity has been further classified into 9 subclasses in Karan Swiss cows. The sub classes were upto 40, 40 to 45, 45 to 50, 50 to 55, 55 to 60, 60 to 65, 65 to 80, 70 to 80 and 100 percent. In Karan Fries cows also the level of heterozygosity has been classified into 9 subclasses and the subclasses were upto 35, 35 to 40, 40 to 50, 50 to 55, 55 to 60, 60 to 65, 65 to 80 and 100 percent.

F_1 animals with 100 percent heterozygosity levels were found to be superior for majority of traits considered for this study while for the *interse* mated populations, animals with intermediate heterozygosity levels (45 to 60 percent) performed better than the rest. Among the *interse* mated animals (in Karan Swiss) maximum average FL 305 DMY (2486.71±49.73 kg) and FLTMY (2731.55±66.72 kg) was observed for the animals with heterozygosity level 45 to 50 percent. Whereas in Karan Fries *interse* mated population animals with heterozygosity level 35 percent or below were found to have maximum average FLTMY

(3776.79±407.03 kg), but these animals were found to be poor with respect to reproduction traits like AFC (1243.09±47.80 days), FCI (461.75±46.88 days).

The animals with heterozygosity level below 45 percent were found to have very high level of exotic inheritance (75 percent or more), whereas animals with high heterozygosity levels were found to have inheritance from more than two breeds. In both the cases animals were found to be poor with respect to production and reproduction traits.

The coefficient of inbreeding of every animal was estimated by using the formula given by Wright, 1922. Based on inbreeding coefficient, the inbred animals of Karan Swiss and Karan Fries were classified into different groups namely, less than 1 percent, 1 to6 percent, 6 to 12 percent and more than 12 percent, respectively.

Incidence and level of inbreeding was studied over the generations. Out of total 3168 Karan Swiss animals 16 percent of the animals were found to be inbred with average inbreeding coefficient of 5.94 percent. Whereas in Karan Fries out of 3051 animals only 9.24 percent animals were found to be inbreeds with an average inbreeding coefficient of 3.65 percent. In both the herds majority of the animals (65 percent in KS, 76.5 percent in KF) were found to be lowly inbred with inbreeding coefficient below 6 percent. No inbreds were found in the first generation from paternal as well as maternal side in both the Karan Swiss and Karan Fries herd under study. Incidence of inbreeding followed an increasing trend over the generation in Karan Swiss and Karan Fries cattle whereas level of inbreeding reduced over generations in both the herds.

Detrimental effect of inbreeding on various performance traits was observed for both the Karan Swiss and Karan Fries cattle. Animals with inbreeding coefficient more than 12 percent were poorer with respect to various growth, first lactation production and reproduction traits and herd life. However, the effect of inbreeding was found significant only for BWT in Karan Swiss females and for WOY and HL in Karan Fries females, whereas, for other traits the effect was found to be statistically non significant.

Regression of various performance traits on inbreeding indicated the deleterious effect of inbreeding on the respective traits. Regression coefficients were found non significant for all the traits except for BWT, WFS and AFC in Karan Swiss cattle. Depressing effect of inbreeding may be due to increase in the homozygosity with respect to recessive alleles.

The disposal rate of female calves and heifers in various age groups was investigated over the generations (paternal and maternal). These age groups were : birth to 1 month, 1 month to 3 months, 3 month to 6 month, 6 month to12 month, 12 month to18 month, 18 month to AFC and overall rate from birth to AFC. The mortality rate in the Karan Swiss females in the above-mentioned age groups was 8.55, 5.33, 1.51, 2.05, 1.01, 1.57 percent of herd strength, respectively. The mortality rate in Karan Fries herd in the same age groups were 4.22, 5.53, 1.34, 1.60, 0.65,1.13 percent of herd strength. The culling rates of Karan Swiss female calves and heifers in the above mentioned age groups were 0.15, 0.12, 1.16, 2.30, 1.70, 12.62 percent of herd strength, respectively, whereas, in Kara Fries herd the culling rates were 0.13, 0.22, 0.95, 2.13, 2.62, 8.98 percent of the herd strength, respectively. These figure show that mortality rate decreased with increase in age, whereas, culling rate increased with the increase in age. The overall disposal from birth to first calving was 38.13 percent in Karan Swiss and 30.84 percent in Karan Fries herd. Disposal rate over the generations (both paternal and maternal) revealed less incidence of disposal in the first generation compared to later generations.

Parity specific paternal as well as maternal generation wise disposal of Karan Swiss and Karan Fries adult cows revealed low incidence of disposal after first parity in the first generation. Whereas in later generations incidence of disposal was more. Superiority with respect to performance traits of F_1 animals which belong to first generation may be one of the major reason for keeping these animals in the herd for longer period.

Impact of disposal on milk production performance trait was studied by comparing the average expected breeding values of existing, disposed, culled retained and newly entered animals over the years. The obtained results showed high average expected breeding value at the initial years when crossbreeding project was started but in the later years disposed and retained animals were of equal genetic potential for milk yield. This indicate that individual selection of animals resulted in a minor improvement of herd. It may be due to small sized herd, low replacement rate, death of superior animals and higher incidence of involuntary culling, which led to negative selection by limiting culling on the basis of voluntary culling and thus resulted in reduction in selection intensity.

Appropriate breeding strategy for improvement of crossbred population is suggested particularly with an aim to maintain desired exotic inheritance and heterozygosity level in the herd to improve the production performance. It is suggested that to reduce the incidence and level of inbreeding mating of the less related animals should be followed. Periodically, introduction of pure proven exotic bull or semen of bulls of high genetic merit is also suggested to produce more F_1 bulls, which are to be used as breeding bulls in the future. To improve the milk production by proper selection it is also required to maintain a stable herd size, which can be achieved by reducing disposal rate over average replacement rate and for that culling due to involuntary reason should be reduced by ensuring good quality feed and fodder, reproduction and health management.

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