MULTI-TRAIT SELECTION STRATEGY FOR PRODUCTION, REPRODUCTION AND FUNCTIONAL TRAITS IN KARAN FRIES CATTLE

THESIS SUBMITTED TO THE

ICAR-NATIONAL DAIRY RESEARCH INSTITUTE, KARNAL

(DEEMED UNIVERSITY)

IN PARTIAL FULFILMENT OF THE REQUIREMENTS

FOR THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

ANIMAL GENETICS AND BREEDING

BY

Dr. DIMPEE SINGH GONGE
M.V.Sc.

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ICAR- NATIONAL DAIRY RESEARCH INSTITUTE

(DEEMED UNIVERSITY)

KARNAL-132001 (HARYANA), INDIA

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Approved By:

(15.9.2018)
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CERTIFICATE

This is to certify that the thesis entitled **"Multi-trait Selection Strategy for Production, Reproduction and Functional Traits in Karan Fries Cattle"** submitted by Ms. Dimpee Singh Gonge in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Animal Genetics & Breeding** of the National Dairy Research Institute, (Deemed University), Karnal, Haryana, India, bonafide research work carried out under my guidance and supervision and no part of the thesis has been submitted for any other degree or diploma.

Date: 28-7-2018

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Dated: 28/7/2018

DIMPEE SINGH GONGE

Place: Karnal

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LIST OF ABBREVIATIONS

<	= Less than
>	= More than
/	= Per
%	= Per cent
σ_A	= Additive genetic standard deviation
a	= Vector of relative economic values
ABRC	= Artificial Breeding Research Centre
AFC	= Age at First Calving
AR	= Annual Report
CV	= Coefficient of Variation
COD	= Cystic ovarian disease
CFI	= Calving to First Insemination
DPR	= Daughter Pregnancy Rate
FL305MY	= First Lactation 305 Days or Less Milk Yield
FTMY	= First Lactation Total Milk Yield
FLL	= First Lactation Length
FSP	= First Service Period
FCI	= First Calving to First Insemination
FCFS	= First Calving Interval
g	= Grams
G	= Genotypic variance-covariance matrix
ΔG	= Expected Genetic Gain
GI	= Generation Interval
GG	= Genetic Group
h^2	= Heritability
HF	= Holstein Friesian
i	= Intensity of selection

KF	=	Karan Fries
kg	=	Kilogram
MY/FLL	=	Milk Yield per day of First Lactation Length
MY/LL	=	Milk Yield per day of Lactation Length
MY/CI	=	Milk Yield per day of calving interval
NID	=	Normally and Independently Distributed
NDRI	=	National Dairy Research Institute
P	=	Phenotypic variance-covariance matrix
p	=	Proportion selected
P<0.01	=	Significant at 1% level
P<0.05	=	Significant at 5% level
SD	=	Standard Deviation
SE	=	Standard Error
TPI	=	Total Performance Index
VWP	=	Voluntary Waiting Period
VG	=	Genotypic variance
VP	=	Phenotypic Variance
WA	=	Wet Average

Multi-trait Selection Strategy for Production, Reproduction and Functional Traits in Karan Fries Cattle

ABSTRACT

The study was carried out on production, reproduction, functional and longevity traits of Karan Fries cattle (Holstein Tharparkar crossbred), maintained at ICAR-NDRI, Karnal. Data were spread over a period of 24 years from (1993-2016). The study was designed with the objectives to analyse functional traits viz., calving traits, female fertility, uterine and udder health status using conventional and logistic regression approach; to estimate the weightage to be assigned to production, reproduction in selection; to assess genetic gain based on production and reproduction performance and finally to develop the sustainable breeding strategy for Karan Fries cattle. Functional traits measured as Incidence (proportion) of major health indicator traits such as flakes, cystic ovary disorders (COD), anoestrous and retention of placenta (ROP) were 0.33, 0.21, 0.22 and 0.18, respectively. The overall incidence of clinical mastitis was 0.41. Statistical analysis revealed that season had significant effect on incidence of flakes and blood in milk, fertility and post calving disorders. Period had significant effect on incidence of udder health indicator traits, fertility and post calving disorders, calving traits (abortions and Dystocia). Whereas, Parity had significant effect on incidence of flakes and blood in milk, cystic ovary, metritis, endometritis, repeat breeding, anoestrous and retention of placenta (ROP). A total of four selection indices were constructed using three traits combinations i.e. production (305DMY, WA), reproduction (CFI, SP) and longevity (herd life). Among these selection indices, index comprising wet average (WA), calving to first insemination (CFI) and longevity were found to be best suited with R_{IH}= 0.363 giving 57.6%, 28.6%, 14.9% weightage respectively. Further, the indices were assessed for robustness by increasing relative economic value (REV) by 25% and 50% and it was found that increase in relative economic values upto 50% had little impact on accuracy of selection indices thereby indicating robustness of developed selection indices. Lactation wise genetic persistency was calculated using two different methods. Expected genetic gain (ΔG) in 305DMY, WA and CFI was assessed using three different methods. Method III (direct selection method) was found to be best to over two other methods. Expected genetic gain was also assessed for FL305DMY, WA and CFI by simulating different parameters involved in Method I, II and III and was compared for the expected genetic gain. It was found that generation interval and intensity of selection in KF cattle should preferably be less than 5 years and 75% for achieving highe expected ΔG/year for milk yield in an organized herd. Further the cows were classified based on productivity and expected genetic gain in different productivity levels was assessed and it was observed that at higher selection intensities i.e. when the proportion of animals selected was less, a higher expected genetic gain was obtained

करण फ्रिज गोपशुओ में उत्पादन प्रजनन और कार्यात्मक लक्षणों के लिए बहु विशेषता चयन नीति

सारांश

यह अध्ययन राष्ट्रीय डेरी अनुसंधान संस्थान की करण फ्रिज गोपशुओ में 24 वर्षों (1993-2016) की अवधि में फैले उत्पादन, प्रजनन, कार्यात्मक और दीर्घायु गुणों से सबंधित के आंकड़ों पर आधारित है । अध्ययन के उद्देश्य पारंपरिक और लॉजिस्टिक रिग्रेशन दृष्टिकोण का उपयोग करके कार्यात्मक लक्षणों जैसे ब्यांत के आकड़े, मादा प्रजनन क्षमता, गर्भाशय और उदर स्वास्थ्य स्थिति का विश्लेषण करना ; उत्पादन, प्रजनन और स्वास्थ्य लक्षणो के अनुपात को विकसित करना; अनुवांशिक लाभ का आकलन करना और करण फ्रिज गोपशुओ के लिए सतत प्रजनन रणनीतियों को तैयार करना था । पशु समूहों के कार्यात्मक लक्षणों के लिए विभिन्न संकेतक जैसे फलैक्स, अण्डाशय रसौली, ताव में न आना तथा जेर का न गिरना का घटक क्रमशः 0.33, 0.21, 0.22 और 0.18 पाया गया । स्तनशोथ का संपूर्ण घटक 0.41 पाया गया । सांख्यिकीय विश्लेषण से पता चला कि फ्लेक्स, दूध में रक्त, प्रजनन क्षमता और ब्यांत के बाद होने वाले विकार की घटनाओं पर मौसम का महत्वपूर्ण प्रभाव पड़ा । अवधि का उदर स्वास्थ्य संकेतक लक्षण, प्रजनन क्षमता और ब्यांत के बाद होने वाले विकार की घटनाओं पर महत्वपूर्ण प्रभाव पड़ा जबकि पैरिटी का फ्लेक्स, दूध में रक्त, अण्डाशय रसौली, जरायु-प्रदाह, अन्तःगर्भाशय-प्रदाह, ताव में न आना, प्रजनन दोहराव तथा जेर का न गिरना की घटनाओं पर महत्वपूर्ण प्रभाव पाया गया । तीन विशेषता संयोजी यानी उत्पादन, प्रजनन और दीर्घायु गुणों का उपयोग करके निर्मित कुल तीन प्रदर्शन सूचकांक में से प्रदर्शन सूचकांक WA, CFI LNG, 57.6%, 28.6% और 14.9% अनुपात में संयोजन देने वाला सर्वोत्तम सूचकांक पाया गया । विकसित सूचकांक का मूल्यांकन सापेक्ष आर्थिक मूल्यों को 25 % और 50% तक बढ़ाकर मजबूती के लिए किया गया और यह पाया गया कि 50% तक सापेक्ष आर्थिक मूल्य में वृद्धि के चयन सूचकांक की सटीकता पर कम प्रभाव पड़ा जिससे विकसित चयन सूचकांक की मजबूती का संकेत मिलता है। अनुवांशिक दृढ़ता की गणना दो अलग-अलग विधियों का उपयोग करके देखी गयी । करण फ्रिज गोपशुओ में में तीन अलग-अलग तरीकों का उपयोग करके 305DMY, WA और CFI लिए अपेक्षित अनुवांशिक लाभ (ΔG) का आकलन किया गया । सीधी चयन विधि द्वारा विभिन्न लक्षणों के लिए अपेक्षित अनुवांशिक लाभ तीन तरीकों में सबसे अच्छा पाया गया । अपेक्षित अनुवांशिक लाभ का निर्धारण विधि I, II और III में शामिल विभिन्न मानकों को अनुकरण करके पहले ब्यात के 305DMY, WA और CFI के लिए किया गया था और मौजूदा स्थिति के तहत प्राप्त अपेक्षित अनुवांशिक लाभ की तुलना में इसकी तुलना की गई और यह पाया गया कि पीढ़ी के अंतराल और तीव्रता संगठित झुंड में दूध उपज के लिए 50% से अधिक अपेक्षित ΔG/वर्ष प्राप्त करने के लिए 5 वर्ष से कम और 75% होनी चाहिए । इसके अलावा करण फ्रिज गोपशुओ को उत्पादकता के आधार पर वर्गीकृत किया गया और विभिन्न उत्पादकता स्तरों में अपेक्षित अनुवांशिक लाभ का आकलन किया गया और यह देखा गया कि उच्च चयन तीव्रता पर यानी जब चयनित जानवरों का अनुपात कम था, तो उच्च आनुवांशिक लाभ प्राप्त हुआ।

CHAPTER –1

Introduction

INTRODUCTION

India is endowed with a rich genetic resource of bovines, with an estimated population of 299.6 million (Livestock Census, 2012). Livestock sector is a back bone of Indian agricultural system and plays an important role in Indian economy. Approximately 20.5 million people are dependent upon livestock for their livelihood in the country. Livestock sectors contribute 4.11% GDP and 25.6% of total agricultural GDP in India. Contribution of livestock to agriculture GDP has been rising steadily during the last three decades from 13.88% in 1980-81 to 27.25% in 2012-13 (BAHS 2014). About 70% population of the country is engaged in agriculture and more than 50% of people below poverty line are solely associated with livestock production. India ranks first in milk production, accounting for 18.5% of world production, achieving an annual output of 146.3 million tonnes with per capita availability of 322 g/day. Total cattle population in the country is 190 million out of which total crossbred population accounts for 39.73 million (19^{th} Livestock Census, 2012). Out of total milk production 66.42 million tonnes (45.4%) is shared by cattle, of which 44.39% shared by indigenous/ non-descript cows and 55.61% by crossbred and exotic dairy cattle. Exotic and crossbred with a small number alone contributes nearly 24% of total milk production in the country.

India with vast livestock resources plays an important role in the national economy and also in the socio-economic development of millions of rural households. India has one of the largest stocks of cattle and buffaloes and dairy sector contributes a large share of the agricultural gross domestic product (GDP). Through crossbreeding, grading up or other breeding methods, a significant increase in milk production has been achieved in India. Economics of any dairy enterprise is dependent on production, reproduction and health status of animal. Higher production performance is not only function which determines the greater stayability of the dairy cattle in the herd but it is also determined by superiority of the animal with respect to functional traits. The term functional trait refer to those characters that increase the efficiency of animal not by higher output of the products but by minimizing cost of input (Groen 1996). These traits mainly include calving traits, female fertility traits, uterine and udder health status. Clinical mastitis and other udder problems are considered to evaluate udder health, while retention of placenta and uterus infection are for uterine health (Lyons *et al.,* 1991).

Fertility being one of the major categories of functional traits that defined as the ability to produce a living offspring during economically and physiologically approved period; as a character it can be classified into female and male fertility (Hyppanen and Juga, 1995).

Fertility is one of the most critical factors influencing the biological and functional performance of animal production system (Feugang *et al*., 2009) and is affected by both genetic and non-genetic factors. Amongst the various factor affecting fertility, management is an important component for good production and reproduction performance which is a key element in the modern dairy practices. Management that includes estrus detection and feeding strategies is of major importance for the reproductive performance in dairy herd (Roche *et al*., 2009). Genetic analysis has indicated that the fertility traits are lowly heritable, further the estimates from a number of studies present negative genetic correlations between various fertility and production traits (Philipsson *et al*., 1994). Hodel *et al*. (1995) reported that nearly 20-30% of all culling is due to poor fertility in animals.

Over the years, animal breeders have focused mainly on milk production traits, such as selection criteria has resulted in a positive genetic trend in milk production associated with the decline in reproductive performance and health status of dairy cattle. Intense selection of animals for milk production is quite often is associated with the increase of reproductive problems of calving traits, female fertility, uterine and udder health problems. According to some reports in cattle, cost of udder problems including mastitis and unusable milk together with those of reproductive problems accounted about 70-80% of the total health costs. A study on the economic losses due to mastitis in India puts the extent of total financial loss to Rs. 1607.20 crores and out of this an amount of Rs. 1089.97 crores are singly due to sub-clinical mastitis and 520.23 crores due to clinical mastitis (Singh and Singh, 1994). Further, reports revealed that total milk losses were estimated to be 9899.73 Kg in Karan Fries crossbred cows due to incidence of mastitis (Sharma *et al*., 2010).

Although, selection pressure on production traits has increased milk productivity, but with the cost of increased in incidence of disease and reduced fertility. So, application of better herd management could overcome the problems despite this may increase the cost of productivity of animal. Therefore, a combination of better management and genetic selection for functional traits is an effective long term selection solution.

Karan Fries (KF) crossbred dairy cattle were named in 1980 as a result of crossbreeding of Holstein Friesian Bull (*Bos taurus*) with Tharparkar cow (*Bos indicus)* followed by selection among interbreds at ICAR-NDRI, Karnal. So far selection is being done mainly based on 305DMY and not much emphasis has been laid where appropriate weightage are given to production, reproduction and functional traits in the selection criteria. Keeping in view the importance of production, reproduction and functional traits for selection of superior animals, the present investigation has been planned in Karan Fries crossbred cattle with the following specific objectives:

1. To study functional traits viz., calving traits, female fertility, uterine and udder health status using conventional and logistic regression approach in Karan Fries cattle
2. To estimate the weightage to be assigned to production, reproduction in selection of Karan Fries cattle
3. To assess the genetic gain based on production and reproduction performance of Karan Fries cattle
4. To develop the sustainable breeding strategy for Karan Fries cattle

CHAPTER –2

Review of Literature

REVIEW OF LITERATURE

Fertility is influenced by changes in physiology, environment and some aspects of genetics in which males are meant for fertilization and females for conception (Nadeem, 2011). With the advent of artificial insemination, embryo transfer and cloning technology the multiplication of superior germplasm has become much easier and has also increased the genetic progress with reduced generation interval. Over the years breeders have put more emphasis on the production traits in sire evaluation which has resulted in the decreased performance with respect to fertility and decline in fertility is expected to cause a decline in lifetime performance. The ultimate goal of the animal breeder is to bring improvement in the herd life of the dairy cattle, improvement in production along with reproductive performance would eventually improve the herd life or stayability and hence overall profitability.

In view of the objectives of the present study available literature on performance traits, functional traits and effect of functional traits on production and reproduction performance has been compiled and reviewed as under:

2.1 Production, reproduction and functional traits

2.1.1 Production traits

2.1.1.1 305 Days or less milk yield (305 DMY)

The 305 Days or less Milk Yield (305 DMY) is considered to be standard measure of production performance of dairy cattle. The 305 day milk yield is standardized in such a way so as to give around 60 days dry period, thus optimizing the productive and reproductive performance while achieving the management goal of “one calf one year”. Genetic evaluation for selection of sires and cows based on 305 day milk yield is considered as most important trait and is principle trait for assessing genetic progress of a herd. The 305-days or less milk yield in various lactations of Karan Fries cows reported previously by several researchers were tabulated (Table 2.1). Most of the findings observed an increased in lactation milk yield with an increased in parity upto third and four lactations. Overall reports showed that 305-days or less milk yield in Karan Fries cows ranged from 2470 ± 80 Kg (Saha *et al*., 2010) to 3243 ± 47 Kg (Nehra , 2011).

Table 2.1: Mean first lactation 305-days or less lactation milk yield (Kg) in Karan Fries cattle

LSM ± S.E. (kg)	Reference
3173.23 ± 82.27	Singh (1995)
2919.2 ± 44.66	Sahana (1996)
3199.23 ± 34	Panja (1997)
3197 ± 34	Sivakumar (1998)
2919 ± 45	Sahana and Gurnani (2000)
3173 ± 82	Singh and Gurnani (2004)
3197 ± 43	Singh *et al*. (2005)
3068 ± 22	Kokate (2009)
2470 ± 80	Saha *et al.* (2010)
3243 ± 47	Nehra (2011)
3234 ± 66	Divya (2012)
3160 ± 43	Singh *et al.*(2015)
3027 ± 20	Dash *et al*. (2016)

2.1.1.2 Total milk yield (TMY)

Total milk yield is an important indicator of production potential of dairy cows**.** Total milk yield of animal varied from lactation to lactation. The first lactation total milk yield was found to vary from 2823 ± 122 kg (Saha, 2001) to 3908 ± 124 kg (Sinha, 1999) in Karan Fries cows (Table 2.2). Dash (2014) reported the overall lactation total milk yield of 3646.36 ± 20.04 in KF cattle

Table 2.2: Mean first lactation total milk yield (kg) in Karan Fries cow

Mean ± SE (kg)	Reference
3236 ± 76	Singh and Tomar (1991)
3676 ± 135	Singh (1995)
3599 ± 54	Panja (1997)
3617 ± 49	Sivakumar (1998)
3908 ± 124	Sinha (1999)
3383 ± 69	Sahana and Gurnani (2000)
2823 ± 122	Saha (2001)
3672 ± 67	Nehra (2011)

2.1.1.3 Lactation length

Lactation length is a trait which influences the magnitude of milk yield obtained in a lactation. The length of lactation is clearly one of the traits of interest in this concern in tropical dairy cattle production like in India due to variability in lactation lengths of tropical animals and their temperate counterparts. Most of the temperate dairy cattle breeds and their crossbreds produce milk at profitable levels for 305 days while the lactation lengths in high producing dairy cows have increased over the last decade (Van Raden *et al*., 2004 and Steri *et al*., 2010). Studies have shown that over 55% of US Holstein cows had lactations longer than 305 days (Tsuruta *et al*., 2005 and Van Raden *et al.*, 2006). Similarly, in KF cattle showed average lactation length ranging from 314.97 days (Zadeh, 2012) to 359.92 days (Nehra, 2011) as presented in Table 2.3. The reason could be attributed to extended days open, mainly because of decreased fertility and reproductive failures in dairy cattle (Butler 1998 and Silvia 2003).

Table 2.3: Mean first lactation length in Karan Fries and Holstein Friesian cattle

Breed	Mean ± SE (days)	Reference
KF	345 ± 11	Singh (1995)
KF	343.74 ± 5.75	Sahana (1996)
KF	345 ± 4	Panja (1997)
KF	343 ± 4	Sivakumar (1998)
KF	346 ± 6	Sinha (1999)
KF	344 ± 6	Sahana and Gurnani (2000)
KF	315.25 ± 10.10	Saha (2001)
KF	359.92 ± 4.33	Nehra (2011)
HF, Iran	314.97	Zadeh (2012)
HF, Saudi Arabia	364	Ali *et.al*. (1996)
HF, Pakistan	315.09 ± 17.75	Afridi (1999)
HF, Pakistan	319 ± 56	Nawaz *et al.* (2013)

2.1.1.4 Milk yield per day of 305 days or less lactation length (WA)

Wet average is most important trait for a dairy farmer. It is defined as average per day milk yield upto 305 days or less during lactation period of a particular cow. Any selection strategy, adaptable in field level, should translate it in terms that could easily be understanded by farmers. In such regards, wet average possibly strengthens selection of dairy animals in Indian scenario. The first lactation wet average of Karan Fries cattle is scanty which is reported to be in average of 10.0 ± 0.05 kg (Dash *et al*., 2016).

2.1.1.5 Milk yield per day of first calving interval (MY/CI)

Earlier reports illustrated that average 305 milk yield per day of first calving interval (MY/FCI) ranged between 5.44 kg (Nehra, 2011) to 9.58 (Dash, 2014) in Karan Fries cows (Table 2.4).

Table 2.4: Average milk yield per day of calving interval (kg) in Karan Fries cattle

Mean ± SE (kg)	Reference
7.78 ± 0.28	Saha (2010)
5.44	Nehra (2011)
9.58 ± 0.04	Dash (2014)

2.1.2 Reproduction traits

2.1.2.1 Age at First Calving (AFC)

Age at first calving (AFC) is an important factor contributing to life time productivity of a cow. A higher AFC have shown to have a positive effect on milk yield and fat percentage (Pirlo *et al*., 2000 and Ettema and Santos, 2004). However extending AFC beyond 750 days did not improve lactation, reproduction or health of primiparous cow in case of HF breeds (Ettema and Santos, 2004). In addition, life time production would be negatively compromised due to less number of calvings. Conversely, a below optimum AFC would result in birth of weak calves and low first lactation milk production. Incidence of stillbirths was higher for cow with low AFC (Ettema and Santos, 2004). So, a lower/optimum AFC is desirable as it will reduce the generation interval and thereby facilitate earlier evaluation of animals, thus leading to faster genetic improvement. Perusal of literature revealed that, average age at first calving in KF cattle ranged from 850 days (Nagarcenkar and Rao, 1982) to 1023 days (Divya, 2012) as shown in table 2.6.

Table 2.6: Average age at first calving (days) in Karan Fries cow

Mean ± S.E.	Reference
850 ± 13	Nagarcenkar and Rao (1982)
977.97 ± 9.86	Singh (1995)
968.52 ± 7.91	Sahana (1996)
940.98 ± 18.22	Panja (1997)
985.26 ± 5	Shivkumar (1998)
985 ± 16	Sahana and Gurnani (2000)
1009.40 ± 14	Saha (2001)
1006 ± 8	Nehra (2011)
1023 ± 5	Divya (2012)
957.48 ± 6.54	Dash *et al*. (2016)

2.1.2.2 Service Period (SP)

Minimizing service period helps to control the calving interval and maximize calf crop and milk yield. Variability in SP of Karan Fries cows was observed in different time and period (Table 2.7). Sinha (1999) reported the average first service period in KF was minimum (117±20 days) whereas, highest average (130±3days) of the same trait was reported by Divya (2012).

Table 2.7: Average service period (days) in Karan Fries cows

Mean ± SE	Reference
137.61 ± 5.03	Singh and Tomar (1991)
142.90 ± 10.8	Singh (1995)
127.50 ± 6.09	Sahana (1996)
124.24 ± 3.83	Panja (1997)
117 ± 20.0	Sinha (1999)
122 ± 7.0	Singh *et al*. (2001)
143 ± 11	Singh and Gurnani (2004)
130 ± 3	Divya (2012)
130 ± 4.4	Dash (2014)

2.1.2.3 Calving to first insemination

Calving to first insemination is an economically significant trait as it measures the cow's ability to resume estrus cyclicity after calving. Moreover, it is also correlated with the animal's ability to conceive soon after insemination and become pregnant (Ismael *et al*., 2016). It is evident from the fact that cows with a shorter CFI have higher first insemination non-return rates, higher pregnancy rates and shorter calving intervals (Halie-Mariam *et al*., 2003). After threshold linear analysis of measure of fertility in artificial insemination data and days to calving, Donoghue *et al*. (2004) opined that calving to first insemination is a potential measure of fertility, as the parameter estimates for this trait were close to those for calving success.

Literature has shown an average calving to first insemination (CFI) in HF cattle were ranges from 77 days (Halie-Mariam *et al*., 2003) to 197.9 days (Hou *et al*., 2009) in HF cattle (Table 2.8). However in KF cows, Dash (2014) reported an average CFI of 76.29 ± 0.67 days which is lower than average of pure HF cow, although, Divya (2012) reported the value as 88 ± 2 days (Table 2.8).

Table 2.8: Average calving to first insemination (days) in Holstein Friesian and Karan Fries cows

Breed	Mean ± SE	Reference
HF	91.5	Weigel &Rekyaya (2000)
HF	77 ± 30	Halie-Mariam *et al*. (2003)
HF	141.98	Shiferaw *et al*. (2006)
HF	113 ± 3	Satter *et al*. (2006)
HF	170	Asimwe and Kifaro (2007)
HF	111.55 ± 3.73	Cilek (2009)
HF	197.9 ± 61.1	Hou *et al*.(2009)
HF	115 ± 7	Tadesse *et al*. (2010)
HF	88.4 ± 1.1	Hammound *et al*. (2010)
HF	87	Fouz *et al* (2011)
HF	72.93 ± 35.01	Ghiasi *et al*. (2012)
HF	81	Zink *et al*. (2012)
KF	88 ± 2	Divya (2012)
KF	76.29 ±0.67	Dash *et al*. (2016)

2.1.2.4 Voluntary Waiting Period (VWP)

Period between calving and when the management of the herds decides that the cow is ready for breeding is known as VWP which gives a cow some times to resume normal ovarian cyclicity (Lof *et al*., 2012). Getting a cows pregnant too early may affect milk producers and force producers to dry off few still high producing cows, for which decision regarding fixing VWP needs to be done only after considering the economics of the farm (Lof *at el*., 2012). The VWP of 60 is considered to be ideal in case of Karan Fries and related breed as reported earlier by Singh *et al.* (2001). Previous reports of VWP for Holstein Friesian and Karan Fries cows are tabulated below (Table 2.9). The standardization of VWP should be done considering the post-parturient resumption of cyclicity of the animal, involution of uterus, recovery from negative energy balance (Sakaguchi *et al*., 2004; Petersson *et al*., 2006). The average calving to first service and days to successful service of the dairy cattle of the herd should be taken into consideration for overall performance of dairy herd.

Table 2.9: Voluntary Waiting Period (VWP) for Holstein Friesian and Karan Fries cows

Breed	VWP (days)	Reference
KF	60	Singh *et al.* (2001)
HF	60	Van Raden *et al*. (2004)
HF	55.6	DeJarnette *et al*. (2007)
HF	66.5	Lof *et al*. (2012)

2.1.2.5 Pregnancy Rate (PR)

Pregnancy Rate (PR) is a direct measure on how quickly a cow becomes pregnant again after calving. It may be defined as the percentage of non-pregnant cows that become pregnant during each 21-day period. In February, 2003, USDA introduced National genetic evaluations for cow fertility. These evaluations finalized that pregnancy rate of animals has to be based on days open (Van Raden *et al*., 2004). Pregnancy rate calculations are more current, cows that do not become pregnant are included in calculations more easily, and larger rather than smaller values are desirable. Pregnancy rate indicates a cow's ability to return to normal reproductive status after calving, to display visible signs of oestrus, to conceive when inseminated, and to maintain the pregnancy.

Estimation of Daughter Pregnancy Rate (DPR) as per USDA guidelines is as mentioned below:

DPR = 21/ (First service period-Voluntary waiting period+11)

The constant factor "11" serves to centralize the measure of possible conception within each 21-day time period (Van Raden *et al*., 2004). The pregnancy rate of most important cattle breeds has been reported by Van Raden *et al*. (2004) (Table 2.10). In 2003, USDA also began estimating the genetic merit of bulls for reproduction based on PR. The most recent revision to Net Merit in January 2010 increased the emphasis on PR from 9 to 11% of total emphasis.

Table 2.10: Pregnancy Rate in important cattle breeds

Breeds	**Pregnancy rate (%)**	**Reference**
Ayrshire	23.2	Van Raden *et al*. (2004)
Brown Swiss	20.3	Van Raden *et al*. (2004)
Guernsey	19.1	Van Raden *et al*. (2004)
Holstein	22.0	Van Raden *et al*. (2004)
Jersey	26.4	Van Raden *et al*. (2004)
Shorthorn	24.8	Van Raden *et al*. (2004)
KF	41	Divya (2012)
KF	33	Dash (2014)

2.1.3 Longevity

Longevity influences the overall profitability in the dairy enterprise and is calculated as the duration between birth and disposal (Smith and Quaas, 1984). The major reasons for disposal of cow are low production, reproductive diseases, udder problems, sold for dairy purposes and death of the animal (O'bleness *et al*., 1962; Evans *et al*., 1964; Burnside *et al*., 1971 and Allaire *et al*., 1977). With exception of sold for dairy purposes, the other reasons for cow disposal are indicative of a negative quality of dairy herd management (Smith and Quaas, 1984), which can be due to the intrinsic genetics of the animal or due to improper management practices in the herd.

Generally, culling due to poor milk production is called voluntary culling and culling for other reasons may be called involuntary culling. Thus reducing the rate of involuntary culling will provide enough space for a higher voluntary replacement rate, which will in turn facilitate the farm manager to raise more of dairy animals with higher production that ultimately increases profitability of the dairy enterprise. The mean longevity has been found to vary from 1042 days (Tsuruta, *et al*., 2005) to 2196 days (Tekereli, 2005 and Kokate, 2009) in HF and its crosses in different countries. In KF cows the longevity was found to range between 1048 days (Singh and Tomar, 1991) and 2974 days (Sharma, 2010).

2.1.4 Functional traits

The term functional trait is used to summarize those characters of an animal which increases its efficiency, not by higher output of product but by reduced cost of input (Groen, 1996). Major groups of breeding goal traits belonging to functional category are health, fertility, calving and efficiency of feed utilization and milking ability (Groen *et al*., 1997). A general characteristic of functional traits is that these are genetically unfavorably correlated to milk production and have low heritability with considerable genetic variability (Philipsson and Lindhe, 2003).

Clinical mastitis and other udder problems are considered to evaluate the udder health, whereas, abortion and uterus infection is considered for uterine health (Lyons *et al*., 1991). Fertility measures broadly fall into two categories i.e., interval traits and fertility scores. Fertility scores are usually all-or-none trait and refer to whether the cow has conceived or not (Groen *et al*., 1997). Linear and threshold models are used for genetic analysis of binary traits but threshold models were theoretically better than Linear Gaussian model (Gianola, 1982). Threshold model heritability could be estimated by Dempster and Lerner (1950) equation. Binomial distribution is approximately normal when the expected value of $n\theta$ is equal to or more than five where 'n' is the smallest subclass number and θ is the incidence of disease (Lyon *et al*., 1991).

Udder and reproductive disorders are in general the two most common reasons for involuntary culling of dairy cows. Genetic evaluation for health traits was practiced in Nordic countries to minimize health problems. These traits are defined as binary traits (i.e., either the presence or absence of disease during specific time intervals).

2.1.4.1 Udder health

Mastitis is one of the most common and costly diseases of dairy cattle. Major udder problem of dairy cattle is mastitis including the symptoms of flakes, blood in milk and teat block. The disease is complex as it is caused by a number of different pathogens to which there are a variety of physiological responses. Clinical signs of mastitis are swelling and pain in udder, fever, abnormal milk appearance, altered milk composition and reduced milk yield.

Mastitis is the inflammation of the mammary gland resulting from the introduction and multiplication of pathogenic microorganisms in the udder. Clinical mastitis is generally considered as an all-or-none trait, with cows reported with mastitis in a defined period of the lactation as diseased and cows with no report in this period as healthy. The considered period varies among countries, e.g., period of 10 days before to 180 days after calving in Denmark; 7 days before to 150 days after calving in Finland; 15 days before calving to 120 days after calving in Norway and 10 days before to 150 days after calving in Sweden (Philipsson and Lindhe, 2003).

2.1.4.1.1 Mastitis

Mukherjee (1989) reported non- significant differences in incidence of mastitis and significant differences in incidence of blood in milk and teat block between different seasons in Karan Fries cattle of NDRI, Karnal. Teat block and blood in milk were significantly lower during winter months and these symptoms increased, as the animal grew older. Period showed significant effect on blood in milk and teat block traits (Mukherjee, 1989).

Chand and Behra (1993) reported that incidence of mastitis was lower in winter, while period had no significant effect and it increased with the increased parity in Karan Fries. Jadhav *et al*. (1995) and Singh (1979) also observed similar effect of season and parity in Holstein Friesian crossbreds. Kulkarni *et al* (2002) also found significant effect of season on clinical mastitis. However, Satypal (2003) reported non-significant differences in incidence between season and parities while period was found to have significant effect on the incidence of blood in milk and teat block in Karan Fries cattle. Kaushik and Khanna (2004) also reported non-significant effect of season and period of calving while parity had significant effect on incidence of mastitis in Haryana cattle. Taraphder (2002) observed significant effect of season and parity of calving on incidence of clinical mastitis and non-significant effect on milk and teat block in Murrah buffaloes. It was observed that incidence of clinical mastitis was highest in rainy season and lowest in winter season of calving and showed an increasing trend over the parity. Period had non-significant effect on incidence of mastitis and teat block and significant effect on blood in milk (Taraphder, 2002). Incidence of udder disorders in KF cattle as reported by various workers has been summarized in table 2.11.

Table 2.11: Incidence rate of udder disorders in Karan Fries cattle

Indicator traits	**No. of observation**	**Period**	**Incidence (%)**	**Reference**
Clinical mastitis	528	1984-88	36.5	Mukherjee *et al*. (1993)
	1274	1984-88	37.96	Chand and Behra (1993)
	1707	1993-01	14.18	Satyapal (2003)
	997	1996-08	29.0	Sharma *et al.* (2011)
	2154	2000-11	13.91	Jingar *et al*. (2017)
Teat block	528	1984-88	3.91	Mukherjee *et al*. (1993)
	1707	1993-01	0.81	Satyapal (2003)
	997	1996-08	1.00	Sharma *et al.* (2011)

Jadhav *et al*. (1995) reported highly significant effect of genetic group on mammary gland disorders. They observed that mammary gland disorders were lowest in 1/4 graded (22.34) and highest in 7/8 graded cows. It was also observed that higher level of inheritance increased the incidence of mastitis in Holstein Friesian (Jadhav *et al*., 1995).

2.1.4.2 Uterine health disorders

2.1.4.2.1 Metritis

Endometritis or chronic uterine infection is the inflammation of superficial (endometrial) layer of uterine lining with mild tissue involvement and characterized by an increased number of inflammatory cells in uterus. No external signs and discharge are seen in such chronic cases and diagnosed by internal examination of uterus by Veterinarian. Metritis (deep uterine infection) is the inflammation of endometrium and myometrium (muscular layer) of uterus and characterized as watery or mucous uterine discharge with or without fever (103.5° F). The average incidence of uterine health disorders i.e. metritis, endometritis and pyometra as reported by various workers has been summarized in Table 2.12.

Table 2.12: Average incidence of metritis in Karan Fries cow

Indicators	Observations	Period	Incidence (%)	Reference
Metritis	1098	1984-88	14.11	Mukherjee *et al*. (1993)
	1707	1993-01	19.70	Satyapal (2003)
	1174	2001-06	28.93	Balasundaram (2008)
	997	1996-08	8.00	Sharma *et al*. (2011)
Endometritis	1174	2001-06	1.62	Balasundaram (2008)
	997	1996-08	2.00	Sharma *et al*. (2011)
pyometra	1174	2001-06	2.30	Balasundaram (2008)
	997	1996-08	0.30	Sharma *et al*. (2011)

2.1.4.2.2 Fertility Health

Unfavorable relationship between fertility traits and milk yield necessitate the consideration of inclusion of fertility traits in breeding programme. Genetic correlations between milk yield and fertility measures ranged between –0.1 to – 0.8 in Holstein Friesian cattle (Van Arendonk, 1985; Oltenacu *et al*., 1983; Hoekstra *et al*., 1994). In a study, Kadermideen *et al*. (2000) estimated genetic correlation of conception to first service (binary trait) with milk yield. The estimate was found as -0.42 ± 0.12. Redbo *et al*. (1992) reported a significantly positive correlation between sire's breeding value for milk yield and mastitis. It indicated that udder health showed an unfavorable correlation with milk yield traits.

2.1.4.2.3 Abnormal calving

Incidence of calving health indicators in different herds reported by various workers has been summarized and presented in Table 2.13. From available reports it could be conferred that average incidence of calving disorders ranged from 2 - 3.32% dystocia, 2 - 4.51% still birth, 4,36 - 7.85% abortion and 1 - 1.15% premature birth in Karan Fries cows (Mukherjee, 1989; Satypal, 2003; Balasundaram *et al*., 2011b)

Table 2.13: Incidence of calving health indicator disorders in Karan Fries cattle

Indicator traits	Observations	Period	Incidence (%)	Reference
Dystocia	2306	1984-88	2.0	Mukherjee *et al*. (1993)
	1707	1993-01	3.05	Satyapal (2003)
	1174	2001-06	3.32	Balasundaram *et al*. (2011b)
	977	1996-08	2.0	Sharma *et al.* (2011)
Still-birth	1098	1984-88	2.0	Mukherjee *et al. (*1993)
	1707	1993-01	3.05	Satyapal (2003)
	1174	2001-06	4.51	Balasundaram *et al*. (2011b)
Abortion	977	1996-08	3.0	Sharma *et al.* (2011)
	1098	1984-88	4.36	Mukherjee *et al*. (1993)
	1707	1993-01	7.85	Satyapal (2003)
	1174	2001-06	7.67	Balasundaram *et al*. (2011b)
	977	1996-08	6.0	Sharma *et al.* (2011)
Pre mature birth	1098	1984-88	1.5	Mukherjee *et al*. (1993)
	1707	1993-01	1.0	Satyapal (2003)
	977	1996-08	1.0	Sharma *et al.* (2011)

2.2 Non genetic factors affecting production, reproduction and functional traits in Karan Fries cattle

Variation in climatic conditions over the years influence the reproduction and production performance of the animals leading to reduced precision in the estimates of genetic parameters which may indirectly affect the genetic progress. Hence, assessing the effect of various non-genetic factors like period of birth, season of birth, period of calving, season of calving, parity etc is very important.

2.2.1 Production traits

2.2.1.1 305-days or less milk yield

The effect of various non-genetic factors like period of calving, season of calving and age at first calving on 305-days or less milk yield and least-squares means of FLL305DMY as presented by various workers has been presented in table 2.14. The reports available in the literature indicated that the least-squares means of 305DMY ranges from 2470 ± 20 (Saha, 2001) to 3562 ± 27 (Rashia, 2010).

Sahana and Gurnani (2000), Rashia (2006) and Kokate (2009) found significant effect of season of calving on this trait, whereas, Sivakumar (1998) and Nehra (2011) could not find its significant effect. Period of calving was reported to have significant effect on this trait (Sahana and Gurnani, 1999; Saha, 2001; Kokate, 2009). In contrast, non significant effect of period of calving was observed by Sinha (1999), Singh and Gurnani (2004) and Nehra (2011). Divya (2012) reported non-significant effect of season of calving, period of calving, parity and genetic group on overall lactation 305 days milk yield in Karan Fries cattle. Different reports showed that AFC had significant effect on 305DMY (Sahana, 1996), but Divya (2012) and Dash (2014) observed no significant effect of AFC on 305DMY in KF cattle.

Table 2.14. Non genetic factors affecting production, reproduction and functional traits in Karan Fries cattle

Mean ± SE	Season of calving	Period of calving	AFC group	Reference
2919.2 ± 44.66	S	S	S	Sahana (1996)
3199.23 ± 44.24	NS	NS	NS	Panja (1997)
3197 ± 34	NS	S	-	Sivakumar (1998)
3420 ± 94	S	NS	-	Sinha (1999)
3470 ± 20	S	S	-	Saha (2001)
3173 ± 82	S	NS	-	Singh and Gurnani (2000)
3197 ± 43	NS	S	-	Singh *et al*. (2006)
3068 ± 22	S	S	-	Kokate (2009)
3562 ± 27	NS	S	-	Rashia (2010)
3243.59 ± 47.3	NS	NS	-	Nehra (2011)
3234 ± 66	NS	NS	NS	Divya (2012)
3213.91 ± 47.6	NS	S	NS	Dash (2014)

2.2.1.2 Total milk yield

The least-squares means of total milk yield in KF cattle ranged from 2769 Kg (Singh *et al.*, 1993) to 3908 Kg (Sinha, 1999). According to Singh and Tomar (1991), Sivakumar (1998) and Dash (2014), season of calving and period of calving significantly influenced total milk yield, while, Singh (1995), Panja (1997) and Nehra (2011) could not found significant influence of season of calving, period of calving and AFC on total milk yield in KF cattle (Table 2.15).

Table 2.15: Least-squares means and effect of non-genetic factors on total milk yield in Karan Fries cattle

Mean ± SE	Season of calving	Period of calving	AFC group	Reference
3236 ± 76	S	S	-	Singh and Tomar (1991)
2769 ± 55	N S	S	-	Singh *et al*.(1993)
3676 ± 135	N S	N S	N S	Singh (1995)
3599 ± 54	N S	N S	N S	Panja (1997)
36 17 ± 49	S	S	-	Sivakumar (1998)
3908 ± 124	S	NS	-	Sinha (1999)
3383 ± 69	S	NS	S	Sahana and Gurnani (2000)
2823 ± 122	S	NS	S	Saha (2001)
3762 ± 67	NS	NS	NS	Nehra (2011)
3415.05 ± 32	S	S	-	Dash (2014)

2.2.1.3 Lactation length

Previous reports of effect of season of calving, period of calving and AFC on lactation length along with the least square means have been summerized in table 2.16. The least squares means of lactation length ranged from 315.25 days (Saha, 2001) to 359.92 ± 4.33 (Nehra, 2011). Season of calving was reported to have significant effect on lactation length (Singh, 1995; Sahana, 1996; Panja, 1997; Sahana and Gurnani, 2000 and Dash, 2014) in Karan Fries cattle. On the contrary, some studies were not able to establish any significant influence of season of calving on lactation length (Saha, 2001 and Sharma, 2010). Period of calving was reported to have significant influence on lactation length (Singh, 1995; Sahana, 1996; Panja, 1997; Sivakumar, 1998; Nehra, 2011 and Dash, 2014) while, Sinha (1999) and Saha (2001) observed non-significance association among the trait with period of calving.

Table 2.16: Least-squares means and effect of non-genetic factors on lactation length in Karan Fries cattle

Mean ± SE	Season of calving	Period of Calving	AFC group	Reference
345 ± 11.	S	S	S	Singh (1995)
343.74 ± 5.75	S	S	S	Sahana (1996)
345 ± 4	S	S	NS	Panja (1997)
343 ±4	-	S	S	Sivakumar (1998)
346 ± 5	-	NS	NS	Sinha (1999)
344 ± 6	S	S	S	Sahana & Gurnani (2000)
315.25 ± 10.10	NS	NS	NS	Saha (2001)
359.92 ± 4.33	NS	S	NS	Nehra (2011)
335.23 ± 2.39	S	S	-	Dash (2014)

2.2.1.4 Milk yield per day of 305 or less lactation length (wet average)

The least-squares means of wet average in KF cattle was reported to be 10.49 ±0.012 kg (Dash, 2014). Period of calving and season of calving had highly significant effect on wet average, while, effect of age at first calving was not found to be significant (Dash, 2014).

2.2.1.5 Milk yield per day of calving interval

Reports of least-squares means and effect of non-genetic factors on milk yield per day of first calving interval in Karan Fries cattle are summarized in the Table 2.17. The least-square means of milk yield per day of first calving interval in KF cattle ranged from 5.44 Kg (Nehra, 2011) to 9.58 ± 0.04 Kg (Dash, 2014). Milk yield per day of calving interval was found to be significantly influenced by season of calving (Nehra, 2011), period of calving (Dash, 2014) and age at first calving (Nehra, 2011) in KF cattle. Conversely, other researchers were not able to establish any significant influence of season of calving (Saha *et al.*, 2010 and Dash, 2014) and age at first calving (Dash, 2014) on milk yield per day of calving interval in Karan Fries cattle.

Table 2.17: Least-square means and effect of non-genetic factors on milk yield per day of calving interval in Karan Fries cattle

Mean ± SE	Season of calving	Period of calving	AFC group	Reference
7.78 ± 0.28	NS	-	-	Saha *et al.* (2010)
5.44	S	-	S	Nehra (2011)
9.58 ± 0.04	NS	S	NS	Dash (2014)

2.2.2 Reproduction traits

2.2.2.1 Age at first calving (AFC)

Influence of season and period of birth on the age at first calving were studied by various researchers in KF cattle and the results were summarized (Table 2.18). Least-square means of age at first calving in Karan Fries cattle was ranged from 850 ± 13 days (Nagarcenkar and Rao, 1982) to 1023 ± 5 days (Divya, 2012).

Table 2.18: Least-squares means and effect of non-genetic factors on age at first calving in Karan Fries cattle

Mean ± SE (days)	Season of calving	Period of calving	Reference
850 ± 13	S	S	Nagarcenkar and Rao (1982)
977.97 ± 9.86	NS	S	Singh (1995)
968.52 ± 7.91	NS	S	Sahana (1996)
940.98 ± 18.22	S	S	Panja (1997)
985.26 ± 5	NS	NS	Sivakumar (1998)
985 ± 16	NS	S	Sinha (1999)
1009.40 ± 13.53	NS	S	Saha (2001)
1006 ± 8	NS	-	Nehra (2011)
1023 ± 5	NS	S	Divya (2012)
957.48 ± 6.54	NS	S	Dash (2014)

Nagarcenkar and Rao, (1982) and Panja, (1997) reported that season of birth had a significant effect on age at first calving, while, Singh (1995), Sahana (1996), Sivakumar (1998), Saha (2001), Divya, (2012) and Dash (2014) could not find significant effect of season of birth on age at first calving. Period of birth had a significant effect on the age at first calving as reported by Nagarcenkar and Rao (1982), Singh (1995), Sahana (1996), Panja (1997), Sivakumar (1998), Saha (2001), Divya, (2012), Dash (2014), while, Sinha (1999) reported that the period of birth had no significant effect on age at first calving.

2.2.2.2 Calving to first insemination (CFI)

Least-square means and effect of non-genetic factors on calving to first insemination in HF and crossbred cattle were summarized (Table 2.19). Least-square means of calving to first insemination varied from 77 days (Potgieter, 2012) to 170 days (Asimwe and Kifaro, 2007). In KF cattle reported least square means of CFI were 78.21 days (Dash, 2014) and 88 ± 2 days (Divya, 2012).

Calving to first insemination was reported to be significantly influenced by season of calving by Satter *et al*., (2006), Asimwe and Kifaro (2007), Hammound *et al*., (2010) and Potgieter (2012). Wherein, researchers by Tadesse *et al*. (2010), Divya (2012) and Dash (2014) could not reveal any significant influence of season of calving on CFI. Calving to first insemination was significantly influenced by period of calving according to Asimwe and Kifaro (2007), Tadesse *et al*. (20 10), Hammound *et al*. (20 10), Potgieter (2012) and Dash (20 4). Meanwhile, Divya (2012) reported that there is no significant influence of period of calving on CFI.

2.19: Least-squares means and effect of non-genetic factors on calving to first insemination in HF and KF cattle

Breed	Mean ± SE (days)	Season of calving	Period of calving	Reference
HF	113 ± 3	S	-	Sattar *et al*. (2006)
HF	170	S	S	Asimwe & Kifaro (2007)
HF	115 ± 1.7	NS	S	Tadesse *et al*. (2010)
HF	88.4 ± 1.1	S	S	Hammound *et al*. (2010)
HF	77 ± 30	S	S	Potgieter (20 12)
KF	88 ± 20	NS	NS	Divya (2012)
KF	78.21 ± 20	NS	S	Dash (2014)

2.2.2.3 Service period

Least-squares means and effect of non-genetic factors on service period in KF were summarized in the Table 2.20. The least- squares means were in the range between 124.24 ± 3.83 days (Panja, 1997) and 142.90 ± 10.82 days (Singh, 1995).

Sahana (1996), Panja (1997), Saha (2001), Dash (2014) reported a significant effect of season of calving on service period. While, Singh (1995), Sharma (2010), and Divya (2012) could not find significant effect of season of calving on service period

Table 2.20: Least-square means and effect of non-genetic factors on service period in Karan Fries cattle

Mean ± SE (days)	**Season of calving**	**Period of calving**	**Reference**
142.90 ± 10.82	NS	NS	Singh (1995)
127.50 ± 6.09	S	S	Sahana (1996)
124.24 ± 3.83	S	S	Panja (1997)
127.69 ± 11.27	S	NS	Saha (2001)
124.12 ± 4.83	NS	NS	Sharma (2010)
130 ±3.00	NS	S	Divya (2012)
130.03 ± 4.43	S	S	Dash (2014)

2.2.2.4 Pregnancy rate (PR)

The least-squares means of pregnancy rates in KF cattle were reported to be 0.38 ± 0.03 (Divya, 2012) and 0.33 ± 1.42 (Dash, 2014). Season of calving, period of calving and age at first calving had no significant effect on pregnancy rates in KF cattle (Divya, 2012), while, Dash (2014) reported a significant effect of the period of calving on pregnancy rates in KF cattle.

2.2.3 Longevity

Least-square means of longevity in KF cattle was reported to be 2571.25 ± 27.3 1 days (Dash, 20 14). Singh *et al*. (2002) reported non-significant effect of periods of calving and age at first calving on longevity. Meanwhile, Dash (2014) reported significant effect of age at first calving on longevity.

2.3 Genetic and phenotypic parameters

The genetic constitution of a population is explained mainly by the heritability, genetic and phenotypic correlation among the performance traits. The estimates of genetic and phenotypic parameters are essential for formulating any successful breed improvement programme.

2.3.1 Heritability of production, reproduction and longevity trait in Karan Fries cattle

2.3.1.1 Heritability estimate of production traits

2.3.1.1.1 305 or less milk yield

The genetic analysis of 305-days or less milk yield indicated that it is low to moderately heritable. So a good selection response can be achieved on this trait through artificial selection. Heritability estimates of 305-days or less milk yield as observed by different authors in KF cattle are summarized in Table 2.21.

Table 2.21: Heritability estimate of FL305DMY or less milk yield in Karan Fries cattle

Heritability ± SE	**Reference**
0.45 ± **0.18**	Singh (1995)
0.46 ± 0.10	Sahana (1996)
0.21 ± 0.16	Panja (1997)
0.44 ± 0.13	Sivakumar (1998)
0.41 ± 0.13	Sahana and Gurnani (2000)
0.30 ± 0.02	Saha (2001)
0.20 ±0.06	Rashia (2010)
0.48 ± 0.14	Nehra *et al*. (2012)
0.39 ± 0.09	Dash (2014)

2.3.1.1.2 Total milk yield

Heritability estimates of total milk yield in Karan Fries cattle showed moderately heritable trait (Table 2.22). The heritability value rangeed from 0.24 ± 0.07 (Dash, 2014) to 0.41 ± 0.13 (Nehra *et al*., 2012).

Table 2.22: Heritability estimate of first lactation total milk yield in Karan Fries cattle

Heritability ± SE	Reference
0.35 ± 0. 12	Singh *et al*. (1995)
0.26 ± 0.05	Panja (1997)
0.32 ± 0.08	Sahana and Gurnani. (2000)
0.27 ± 0.04	Saha (2001)
0.4 1 ± 0.13	Nehra *et al*. (2012)
0.24 ± 0.07	Dash (2014)

2.3.1.1.3 Lactation length (LL)

Lactation length in KF cattle has low to moderate heritability. Heritability values of first lactation length in KF cattle were between 0.09 ± 0.0 1 (Panja, 1997) and 0.21 ± 0.05 (Saha, 2001). Heritability estimates of lactation length as observed by different researchers in KF cattle are summarized in the Table 2.23.

Table 2.23: Heritability estimate of lactation length in Karan Fries cattle

Heritability ± SE	Reference
0.13 ± 0.06	Sahana (1996)
0.09 ± 0.01	Panja (1997)
0.13 ± 0.07	Sahana and Gurnani (2000)
0.21± 0.05	Saha (2001)
0.19 ± 0.11	Nehra *et al*. (2012)
0.13 ± 0.06	Dash (2014)

2.3.1.1.4 Milk yield per day or less Lactation length (wet average)

Literature on heritability estimates of milk yield per day or less Lactation length in KF cattle is scanty. Dash (2014) reported the heritability estimate of wet average as 0.40 ± 0.09 in KF cows, indicating medium heritability

2.3.1.1.5 Milk yield per day of calving interval (MY/CI)

Milk yield per day of calving interval is moderate to highly heritable. The estimate obtained by various researchers ranged from 0.38 (Hayatnagarkar *et al*., 1990) to 0.42 (Dash, 2014) in crossbred HF breeds as summarized in the table 2.24.

Table 2.24: Heritability estimate of milk yield per day of calving interval (MY/CI) in Karan Fries cattle

Breed	**Heritability ± SE**	**Reference**
HF x local cattle	0.38 ± 0. 10	Hayatnagarkar *et al.* (1990)
KF	0.40 ± 0.10	Saha *et al.* (2010)
KF	0.42 ± 0. 10	Dash (2014)

2.3.1.2 Heritability estimate of reproduction traits

2.3.1.2.1 Age at first calving (AFC)

Review of literature on inheritance of age at first calving showed that the trait is moderate to highly heritable. Heritability estimates of age at first calving in KF cattle are in range between 0.17 ± 0.99 (Saha, 2001) and 0.86 ± 0.21 (Singh, 1995). The heritability estimates of age at first calving in KF cattle, as reported by various researchers are summarized in the Table 2.25.

Table 2.25: Heritability estimate of age at first calving in Karan Fries cattle

Heritability ± SE	**Reference**
0.86 ± 0.21	Singh (1995)
0.22 ± 0.075	Sahana (1996)
0.36 ± 0.19	Panja (1997)
0.17 ± 0.99	Saha (2001)
0.43 ± 0.13	Nehra (2011)
0.54 ± 0.17	Divya (2012)
0.36 ± 0.08	Dash (2014)

2.3.1.2.2 Calving to first insemination

Calving to first insemination has very low heritability. Various researchers have reported heritability estimates ranging from 002 ± 0.008 (Berry *et al*., 2003) to 0.13 ± 0.02 (Halie-Marium *et al*., 2003) in HF cattle, while Divya (2012) and Dash (2014) had reported heritability values of 0.016 ± 0.12 and 0.06 ± 0.04 respectively, in KF cattle. The reported heritability estimate of calving to first insemination by various researchers are indicated in Table 2.26.

Table 2.26: Heritability estimate of calving to first insemination in Holstein Friesian and Karan Fries cattle

Breed	**Heritability ± SE**	**Reference**
HF	0.037 ±0.01	Wall *et al*. (2003)
HF	0.13 ± 0.02	Halie- Marium *et al*. (2003)
HF	0.02 ± 0.008	Berry *et al*. (2003)
HF	0.05 ±0.009	Gonzala'lez-Recio (2006)
HF	0.09	Sun *et al*. (2010)
HF	0.06 ± 0.01	Ghiasi *et al*. (2011)
HF	0.05 ±0.02	Potgieter (2012)
HF	0.04 ±0.01	Zink *et al*. (2012)
KF	0.016 ± 0.124	Divya (2012)
KF	0.06 ± 0.04	Dash (2014)

2.3.1.2.3 Service Period

First Service period of Karan Fries cattle has low heritability. The heritability estimates of Service Period by various researchers are presented in the table 2.27 which shows that the heritability values ranged from 0.04 (Singh and Tomar, 1991) to 0.18 (Dash, 2014) in Karan Fries cattle.

Table 2.27: Heritability estimate of Service Period in Karan Fries cattle

Heritability ± SE	Reference
0.04 ±0.13	Singh and Tomar (1991)
0.04 ±0.06	Sahana (1996)
0.05 ± 0.14	Panja (1997)
0.16 ± 0.75	Saha (2001)
0.18 ± 0.08	Dash (2014)

2.3.1.2.4 Pregnancy Rate (PR)

Heritability estimates of pregnancy rate were reported to be ranging between 0.01 (Dash, 2014) to 0.05 (Kuhn *et al*., 2014), indicating low heritability of the trait in HF and HF crossbred. The heritability estimates of the pregnancy rate in HF and HF crossbred are summarized in the Table 2.28.

Table 2.28: Heritability estimate of pregnancy rate in Holstein Friesian and Karan Fries cattle

Breed	Heritability ± SE	Reference
HF	0.04	Van Raden *et al*. (2004)
HF	0.05	Kuhn *et al*. (2004)
KF	0.01 ± 0.02	Dash (2014)

2.3.1.3. Heritability estimate of longevity

Tsuruta *et al*. (2005) reported heritability estimate of herd life as 0.09, Dash (2014) reported that the heritability estimate of longevity in KF cattle is 0.03 ± 0.06

2.3.2 Genetic and Phenotypic correlation between production and reproduction traits in HF and KFcattle

2.3.2.1 Genetic correlations between milk production and reproduction traits in HF and crossbred cattle

Genetic correlation between production and reproduction traits is summarized in the Table 2.29. Genetic correlation between milk production and age at first calving ranged from -0567 (Singh *et al*., 1998) to 0.540 (Ojango and Pollot, 2001). Genetic correlation among milk production and calving to first insemination was 0.30 (Zink *et al*., 2012).

Table 2.29: Genetic correlations between milk production and reproduction traits in HF and KF cattle

Breed	Trait	Correlation	Reference
KF	AFC	0.296 ± 0.230	Kakran (1987)
KF	AFC	-0.567±0.231	Singh *et al* (1988)
HF	AFC	0.290±0.580	Jain *et al* (1995)
KF	AFC	0.2 15±0.479	Panja (1997)
HF	AFC	0.540±0 .120	Ojango and Pollot (2001)
KF	SP	0.289±0 .991	Singh and Tomar (1991)
HF	SP	-0.072±0.857	Jain *et al* (1995)
KF	SP	> l	Panja (1997)
HF	SP	-0.279	Lee *et al*. (1997)
HF	SP	0.390 ± 0.070	Zink *et al. (*2012)
HF	CFI	0.300 ± 0.060	Zink *et al. (* 2012)

2.3.2.2 Phenotypic correlation between milk production and reproduction traits in HF and crossbred cattle

The phenotypic correlation between milk and reproduction traits is summarized in the Table 2.30. Phenotypic correlation between milk production and age at first calving in Karan Fries cattle ranged from -0.523 (Kumar, 1992) to 0.211 (Panja, 1997). Phenotypic correlation between milk production and service period ranged from -0.057 (Panja, 1997) to 0.152 (Sivakumar, 1998). Further, phenotypic correlation between milk production and calving to first insemination were reported to vary from 0.039 (Sewalem *et al*., 2008) to 0.130 (Sun *et al*, 2010).

Table 2.30: Phenotypic correlation between milk and reproduction traits in HF and crossbred cattle

Breed	Trait	Correlation	Reference
KF	AFC	-0.011± 0.048	Singh *et al*. (1988)
KF	AFC	-0.523 ± 0.179	Kumar (1992)
KF	AFC	0.146 ± 0.040	Bhattacharya (1996)
KF	AFC	0.2 11 ± 0.060	Panja (1997)
KF	AFC	-0.200	Ojango and Pollot (2001)
KF	AFC	0. 130 ± 0. 120	Nehra (2011)
KF	SP	0.083 ± 0.06	Singh and Tomar (1991)
HF crossbred	SP	0.033	Jain *et al*. (1995)
KF	SP	0.13 ± 0.04	Bhattacharya (1996)
KF	SP	-0.057 ± 0.065	Panja (1997)
KF	SP	0. 152	Sivakumar (1998)
HF	CFI	0.039	Sewalem *et al.* (2008)
HF	CFI	0. 130	Sun *et al.* (2010)

2.4 Selection criteria based on production and reproduction traits and longevity

2.4.1 Trends in milk yield and reproduction

Profitability of dairy farm can be assured by ensuring high milk productivity of animal. Genetic selection for increased milk production has been most proven and consistent way to achieve this goal (Hansen *et al*., 1983). Despite having diverse production systems, genetic selection criteria and climatic conditions in all the major dairying countries, selection of dairy cattle for high milk production was found to be accompanied by reduction in reproductive performance (Royal *et al*., 2000 and Roxstrom *et al*., 2001) and reduced health performance (Pryce *et al*., 1998).

Improving reproduction performance (Kragelund *et al*., 1979 and Strandberg and Oltencau, 1989) and health traits (Jones *et al*., 1994) are equally important in minimizing cost and maximizing the net returns of an individual dairy farmer in addition to milk production. Realizing this fact after years of continuous selection for milk production alone, emphasis has now been shifted to give weightage to functional traits associated with improved health and fertility adding up to production traits (Miglior *et al*., 2005). Janson and Andreasson (1981) and Kragelund *et al*. (1979) have suggested that deterioration of fertility might be prevented though consideration of various indices of fertility in making selection decisions.

2.5 Selection Indices

Selection index is one of the multi-trait criteria of selection for females having optimum combination of production and reproduction traits for simultaneous improvement in more than one trait in cattle and buffaloes (Kaushik and Khanna, 2003). Selection index is a function of economics of a herd as well as prevailing genetic status pertaining to relevant traits (Mrode, 1995). Further, selection index maximised the probability of correctly ranking animals on their true breeding values, maximises genetic progress through selection and minimises the mean square difference between true breeding value and the index. Selection indices increase the possibility of simultaneous improvement of negatively correlated traits and maximize the income through genetic improvement in dairy animals.

Hazel and Lush (1942) compared relative efficiency of different selection methods and indicated that multi trait index selection is most effective than others when several traits were involved. Hazel (1943) outlined the method for constructing selection indices. He calculated three different indices for swine and presented in detail the genetic basis and also gave a detailed method for computing the efficiency of index. Tabler and Touchberry (1955) constructed five selection indices with various combinations of milk production, fat percentage and type classification for selection of Jersey cows for genetic improvement of milk and fat production. Tallis (1962) extended the method of Kempthorne and Nordskog (1959) of restricted selection index to the case of selection for optimum genotype. Henderson (1984) suggested the construction of sub-indices when variable economic weighting happened for various traits. Selection indexes from USDA included yield traits beginning in 1971, productive life and somatic cell score beginning in 1994, conformation traits in 2000, and cow fertility and calving ease in 2003 (Van Raden *et al.,* 2004).

2.5.1 Methodology

The selection index was first applied by Smith (1936) in plant breeding for multiple traits selection, using Fisher's notion of discriminant function. This was later modified by Hazel and Lush (1942) and Hazel (1943) for its application in animal breeding. Hazel and Lush (1942), compared the effectiveness of selection induces with independent culling level and tandem method and showed its superiority over the later two. The superiority of the index increased as the number of traits with equal relative values increased.

Searle (1965) studied the efficiency of the indirect selection in relation to direct selection of a trait. He reported that (a) the selection for the basic trait on the basis of an alternative trait was preferable if the coefficient of genetic correlation between the alternative trait and basic trait was more than the coefficient of correlation between the phenotypic and genotypic values of the basic traits, (b) the selection of a basic trait would be preferable only when the heritability value of the alternative trait exceeded the heritability value of the basic trait, and (c) combining an alternative trait or trait along with the basic trait in a selection index would always be better than using basic trait or the alternative trait alone.

Lush elaborated certain aspects of selection index for increasing the rate of improvement and making selection more effective. He indicated that characters which might have negative genetic correlations between them, when included in the selection index improved the general efficiency of the index.

2.5.2 Total Performance Index (TPI)

Theory of selection index was extended by Young and Tallis (1961) to yield "Performance index" for the life time production and reproduction traits in animals. Total performance index (TPI) is a selection index used to rank animals and assist dairy producers in identifying superior animals with a combination of high production, conformation, desirable health and fertility. For example, daughters pregnancy rate (DPR) was added to TPI in 2003 (Van Raden *et al.,* 2004). TPI formula was developed by Holstein Association United States of America for Holstein cows with 42% weightage to production traits, 33% to health and fertility and remaining 25% to body conformation traits. The TPI is comprised of 12 traits that have proven to be economically significant for enhancing profitability and overall quality of Holstein breed. The developed TPI is being used as the standard in ranking worldwide Holstein genetics, guiding genetic progress of the Holstein breed. In TPI, weightage is given to major categories of traits i.e. Production, Reproduction (Fertility), Health and Conformation of animals. Selecting animals based on TPI helps in sustaining the performance of Holstein breed.

Cunningham and Taubert (2009) reported that an index with only yield traits gives an economic gain of 0.2%, an index with yield and functional type traits had an improvement of 3.4% in economic gain, and an index with yield, functional, type, health, and fertility traits improved the gain by 4.4% in cattle.

TPI formula:

$$\left[\frac{27(PTAP)}{19} + \frac{16(PTAF)}{22.5} + \frac{3(FE)}{44} + \frac{8(PTAT)}{0.73} - \frac{1(DF)}{1} + \frac{11(UDC)}{0.8} + \frac{6(FLC)}{0.85} + \frac{7(PL)}{1.51} - \frac{5(SCS)}{0.12} + \frac{13(FI)}{1.25} - \frac{2(DCE)}{1} - \frac{1(DSB)}{0.9}\right] 3.9 + 2187$$

**The value 2187 adjusts for our periodic base change, allowing TPI values to be comparable across time (Formula last updated December 2014)*

Where, PTAP = PTA Protein; PTAF = PTA Fat; FE = Feed Efficiency; PTAT = PTA Type; DF = STA Dairy Form; UDC = Udder Composite; FLC = Feet & Legs Composite; PL = Productive Life; SCS = PTA Somatic Cell Score; FI= Fertility Index; DCE= PTA Daughter Calving Ease; DSB = PTA Daughter Still-birth

The Udder Composite is computed as the total of the STAs of seven udder traits

UDC = [(UD x .35) + (FU x .16) + (UH x .16) + (UW x .12) + (UC x .09) + (TP x .05) - (RP x .07)] + 0.15

UD: Udder Depth; FU: Fore Udder Attachment; UH: Rear Udder Height; UW: Rear Udder Width; UC: Udder Cleft; TP: Front Teat Placement; RP: Rear Teat Placement

Weighting of Major Categories in TPI

Production	46%
Health & Fertility	28%
Conformation	26%

Table 2.31: Indexes developed by different countries for weightage of different traits

Country	Indexs' Name	Relative emphasis (%)		
		Production	Durability	Health and Reproduction
Denmark	S-Index	34	29	37
Great Britain	TOP	50	42	08
France	ISU	50	25	25
Germany	RZG	50	40	10
Switzerland	ISEL	53	31	16
United States	TPI	54	41	5
United States	Net Merit	55	25	20
Canada	LPI	57	38	5
The Netherlands	DPS	58	26	16
Italy	PFT	59	31	10
Spain	ICO	59	38	3
New Zealand	BW	66	24	10
Australia	APR	67	17	17
Ireland	EBI	69	23	8
Japan	NTP	75	25	-
Great Britain	PLI	75	20	5
Israel	PD01	80	-	20

2.5.3 Estimation of economic and relative economic values of traits

Relative emphasis for a trait was defined by Van Raden (2002) as the economic values times' standard deviation divided by the sum of the absolute values of these products multiplied by 100. Miglor *et al*. (2005) used a similar definition, but dividing instead of multiplying economic values by standard deviations. An economic value is the profit change when a given trait changes by one unit keeping all other traits in index as same. Normative approach or expenditure-income method is mainly used for the construction of selection indices in animal breeding (Mulder *et al*., 2011).

2.6 Genetic persistency of milk production

Persistency of milk production is the ability of the animal to maintain milk production at a high level after peak production (Jamrozik *et al*., 1998). Persistent cows are more desirable because they are more efficient in roughage usage, suffer less metabolic stress due to high peak yield, and thus are more disease resistant and may need less expenditure to maintain their health and reproductive performance (Zimmermann and Sommer, 1973 and Solkner and Fuchs, 1987). A good persistency measure should be independent of level of production (Gengler, 1996). Dekkers (1997) reported that cows with greater persistency were more profitable than cows with average persistency. Jensen (2001) quoted that persistency of milk production and disease resistance was genetically correlated. Therefore, a flatter lactation curve without a decrease in the total production may be desirable from an economic as well as a physiological point of view (Jakobsen *et al*., 2002). Differences in persistency of milk production, if not properly accounted, reduce the accuracy of genetic evaluations of dairy animals (Jamrozik *et al*., 1998).

Swalve and Gengler (1999) measured the persistency derived from random regression models (RRM) using test day yields. The persistency measures from RRM estimates the shape of the genetic lactation curve (Swalve, 2000) for every animal by fitting the curve through the test day yields individually for each lactation, with a simultaneous correction for other fixed and random effects on phenotypic performance. A measure of persistency based on the shape of the lactation curve after peak seems to be a natural way of describing potential to maintain the level of milk production (Jamrozik *et al*., 1998).

The graphical representation of estimated daily breeding values for milk yield against time gives a ‘genetic curve’ (Strabel *et al*., 2001). Since RRM allows estimation of the shape of genetic lactation curve for individual cow, they provide additional information on the estimated breeding values for persistency compared to analyses on the basis of 305 day yields (Jamrozik *et al*., 1997).

In random regression test day models the genetic variance and ‘genetic yields’ for each single day of lactation can be estimated and used to define suitable criteria of persistency (Swalve, 2000). Jamrozik *et al*. (1998) defined genetic persistency as the slope of the animals’ lactation curve between days in milk 60 and 280. An animal is said to be more persistent when this value was smaller than on average and vice-versa.

Similar method was used for estimating genetic persistency of Canadian Holstein cows (Jamrozik *et al*., 1998), Dutch Holstein cows (Van der Linde, 2000), Holstein Friesian bulls (Pool and Meuwissen, 2001) and Polish Black and White cattle (Strabel *et al*., 2001).

Cows with high persistency tend to produce less milk than expected at the beginning of lactation and more than expected at the end (Cole and VanRaden, 2006). It is required to improve the lactation milk yield and persistency simultaneously as it is undesirable to improve one trait at the expense of the other (Togashi and Lin, 2003). Togashi and Lin (2004) reported that selection based on lactation estimated breeding value for milk yield increased the lactation milk yield at the expense of persistency. However, low correlation estimates were reported between genetic persistency and yield of milk production in Police Black and White cattle (Strabel *et al*., 2001 and Strabel and Jamrozik, 2006) and Dutch Holstein cattle (Van der Linde, 2000) thus allowing for independent selection for both the traits. The heritability estimates of genetic persistency of milk production reported in different breeds of cattle have been shown in Table no 2.32. The values ranged from 0.11 to 0.39 over three lactations. Jamrozik *et al*. (1998) evaluated genetic persistencies of Holstein Friesian cattle and concluded that persistency of milk yield is moderately heritable and unrelated to 305 day milk production, thus allowing for efficient selection for the shape of the lactation curve. Different lactations have genetically different persistencies (Jamrozik *et al*., 1998 and Van der Linde, 2000). Gengler (1996) reported that persistency of milk production decreased with an increase in parity. Hence, persistency in different lactations should be considered as separate traits and combined later into one overall persistency index (Jamrozik *et al*., 1998).

The correlation estimates between persistency of milk production among first three lactations as reported by various authors have been presented in the Table no. 2.33. Higher correlations between persistencies of second and third lactations than the correlation between first and other lactations were reported in cattle by Jamrozik *et al*. (1998), Kistemaker (2003), Roos *et al*. (2004) and Strabel and Jamrozik (2006).

Different measures for estimating persistency of milk production are currently in use worldwide. In Canada, genetic persistency for milk yield is estimated as the daily breeding value for milk yield on day 280 minus the daily breeding value for milk yield on day 60 (Kistemaker, 2003). In Finland, persistency for milk yield is calculated as deviation of average estimated breeding value for milk yield between days in milk 101 and 300 from the estimated breeding value for milk yield on day 100 (Kistemaker, 2003). The genetic persistency for milk yield is calculated in The Netherlands as the deviation of average estimated breeding value for milk yield between days in milk 61 and 305 from the estimated breeding value for milk yield on day 60 (Roos *et al*., 2001).

Table 2.32: Heritability of genetic persistency of milk production in cattle

Breed	Lactation	h^2 value	Reference
Canadian Holstein	1	0.34	Jamrozik *et al*. (1997)
Canadian Holstein	1	0.30	Jamrozik *et al*. (1998)
	2	0.37	
	3	0.39	
Dutch Holstein	1	0.15	Van Der Linde *et al*. (2000)
Polish Black and White cattle	1	0.17	Strabel *et al*. (2001)
Danish Holstein	1	0.14	Jakobsen *et al*. (2002)
Holstein Friesian	1	0.25	Roos *et al*. (2004)
	2	0.33	
	3	0.36	
Polish Black and White cattle	1	0.11	Strabel and Jamrozik (2006)
	2	0.16	
	3	0.18	

Table 2.33: Correlation between genetic persistency of milk production among lactations in cattle

Breed	Between Lactation			Reference
	1 & 2	2 & 3	1 & 3	
Canadian Holstein	0.37	0.60	0.31	Jamrozik *et al*. (1998)
Canadian Holstein	0.69	0.86	0.54	Kistemaker (2003)
Canadian Holstein	0.68	0.87	0.53	Kistemaker (2003)
Canadian Holstein	0.60	0.83	0.45	Kistemaker (2003)
Holstein Friesian	0.58	0.81	0.57	Roos *et al*. (2004)
Polish Black and White cattle	0.59	0.65	0.50	Strabel and Jamrozik (2006)

2.7 Expected genetic gain in first lactation 305 - day milk yield

Rendel and Robertson (1950) developed a measure of genetic change by measuring the genetic superiority and generation interval from four paths of parent to offspring viz., bulls to breed bulls (BB), bulls to breed cows (BC), cows to breed bulls (CB) and cows to breed cows (CC). They found genetic gain of 15.45 kg milk per year in a closed herd of Ayrshire cattle which was equivalent to 0.7% of herd average of 2107 kg.

Rendel and Robertson (1950) obtained the expected genetic gain of 34.9 kg/year based on average selection differential and average generation interval, which was much lower than the potential rate of 96 kg per year. This was due to larger generation interval and smaller selection differential. Selection for traits other than milk production may also be the reason of lower genetic gain.

Amble *et al*. (1958) estimated annual expected genetic gain in Red Sindhi following method described by Rendal and Robertson and obtained as 1.2% of average first lactation yield. Acharya and Lush (1968) estimated genetic change from direct selection in closed Hariana herd at Hisar over the period of 16 year as 2.5% of the herd average. Nicholas (1979) reported expected annual genetic gain of 0.71% above the herd mean (2135 kg) in crossbred cattle at Altinova State Farm of Kenya.

Sigurdsson *et al.* (2011) reported expected annual genetic gain of 305 DMY as 33 kg/year in Icelandic dairy cattle maintained at Agricultural University of Iceland, Hvanneyri, Indonesia. Yaegboobi *et al*. (2011) estimated genetic gain of 305 days milk yield of first lactation in HF dairy cattle of West Province of lran. The estimated genetic changes in 305 days milk yield over the period of 1999 to 2006 were 1.02 - 1.18%/year (26.8 - 31.0 kg per year). Effa *et al*. (2011) estimated the genetic gain of 305 days milk yield in crossbred dairy cows maintained at Holetta Agricultural Research Center, Ethiopia as -1.84%/ year over the herd average.

Gama *et al*. (2013) estimated the expected genetic gain by direct selection of 305DMY in Brazilian Gyr cattle as 19.26 kg/year. Santos *et al*. (2013) reported expected genetic gain by direct selection of 305 DMY in Guzerat cows as 137.6 kg/year. Rahayu *et al*. (2015) estimated genetic gain of 305 DMY in Baturraden Indonesian dairy cattle maintained at Baturraden Dairy Cattle Breeding and Forage Centre, Indonesia as 38.20 kg per generation and annual genetic gain as 9.76 kg per year. Khan *et al*. (2016)

calculated expected annual genetic gain of 305 DMY in Pabna breed of cattle of Bangladesh under progeny testing scheme and parent average testing scheme as 13.5 kg/year and 15.3 kg/year respectively. Ruiz *et al*. (2016) estimated the expected annual genetic gain of 305 DMY in HF cows maintained at different states of USA as109 kg/year.

2.8 Sustainability

To maintain sustainability in farm incomes, farmers need to optimize the balance between maximum production while minimizing costs of production. Reduced profitability is associated with health and fertility costs of the dairy herd, which are also leading causes of involuntary culling. Reducing disease incidence in dairy cattle is not only of economic importance to dairy industries worldwide but essential in accounting for the societal and environmental considerations, such as concerns over animal welfare and carbon emissions. Although, health traits tend to have low heritability implying slow genetic gain, the gain achieved year on year would be positive and cumulative.

For many years, selection indices for dairy cows worldwide have focused on increasing milk production because of consumer demands and the impact of production on farm profit margin. This was extremely successful through genetic selection together with improvements in nutrition and management. However, inefficiencies exist because increased production has led to negative effects on health, reproduction and longevity (Oltenacu and Broom, 2010), which directly influence costs of production. Thus, selection indices have evolved more recently focusing on a broader and more balanced breeding goal to include functional traits (Miglior *et al*., 2005), such as fertility, health and longevity, with the realization that these traits have both economic and socio-economic impact through improving animal welfare and sustainability of dairy production.

CHAPTER –3

Materials & Methods

MATERIALS AND METHODS

3.1 General appraisal of data

The present investigation was carried out on Karan Fries cattle maintained at ICAR-National Dairy Research Institute, Karnal, Haryana. The data used in the study were collected from history-cum pedigree sheets/registers, calving reports, health and general treatment register, reproduction records and milk constituents registers maintained at Animal Genetics and Breeding Division, Livestock Production and Management Section and Artificial Breeding Research Centre (ABRC). A total of 3165 lactation records of 965 cows sired by 159 sires were utilized. The data were extended over a period of twenty four years from the years 1993 to 2016. The cows completing a minimum of one lactation were considered in this study.

3.2 Location and Climate of the Livestock Research Centre

Livestock Research Centre (LRC), ICAR-NDRI, Karnal is situated in Trans-Gangetic plain, in eastern zone of Haryana, at an altitude of 250 meters above mean sea level on 29º 43’ N latitude and 72º 59’ E longitudes and receives a mean annual rainfall ranging from 500 to 1000 mm. The normal rainy days are more than thirty in a year and more than 70% of rain is received during July to September. Intensity of monsoon rainfall varies from 20 to 30 mm per day and in winter; cyclonic rainfall varies from 8 to 14 mm per day. The climate of the farm is subtropical in nature. The minimum temperature falls near to freezing point in winter months, whereas, maximum temperature goes up to around 45ºC in summer. Relative humidity ranges from 41% to 85%. Thus, it is obvious that KF cattle maintained at LRC experienced a period of extreme climatic condition.

3.3 Breeding and Management Practices

3.3.1 Breeding management

Artificial insemination is practiced in cows after proper detection of estrous. Initially young male calves born to elite dams are raised in the LRC. Thereafter, young males are selected for inclusion in the set of progeny testing on the basis of their expected predicted difference (EPD), growth, health, libido, semen quality and freezability of semen. A set of around 8 bulls are mated during a period of about 2 years to have at least 8-10 daughters per bull for their evaluation. The heifers were culled on the basis of their body confirmation, health condition and age at sexual maturity. Further, heifers that were unable to conceived within 40 months of age and cows with expected producing ability (EPA) of less than 1550 kg are also culled from the herd. Cows in elite group were mated to top ranking bulls and their male progenies were reared as future young sires. The number of elite cows ranged from 40 to 75. The rest of the breedable population of about 200 female acted as a test population.

3.3.2 Feeding Management Practices

The nutritional requirements are met through a standardized balanced ration of green fodder, dry fodder and concentrates feed. The calves are weaned at birth and fed colostrums of its own dam for 4-5 days and later on whole milk upto 30 days. 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. An additional concentrate of 1-1.5 kg is made available to pregnant heifers/cows after 7 months of pregnancy. A let down ration of 0.25 kg of concentrate is also provided at the time of milking and additional concentrates is also provided to meet out the requirements of high milk producers (more than 8 kg / day). For adult heifers and cows, green fodder and other roughages are provided *ad libitum*. All the cows are exclusively stall fed in open paddocks at the NDRI farm.

3.3.3 Housing Management Practices

Animals are housed under loose housing system. Separate sheds are provided for each category (young, dry, lactating and down calvers) of cows. The young stock are housed according to age groups i.e. cows from birth to six months, six months to two and half years and heifers from two and half years to conception were kept in different sheds. The calves are kept in covered calf pens up to 6 months of age and thereafter in loose housing system.

3.3.4 Milking Management Practices

Milk recordings of the cows started from sixth day onwards after calving till the date of drying and are milked twice a day. Both the systems of milking, (machine and hand milking) are practiced depending upon yield of cows and adaptation by individual cow to machine milking.

3.3.5 Health Care

Animals falling sick are routinely spotted and treated in sick line or in shed, depending upon the severity of health disorder. Records on health status of the animal are maintained at Animal Health Complex and ABRC. Standard prophylactic measures are followed as a routine to all categories of animals. All the cows are managed under high levels of sanitary conditions and provided with adequate veterinary care at the research centre.

3.3.6 Culling

Standard culling procedures are followed and those animals with poor growth, congenital defects, low production, breeding problems and poor health are identified and culled periodically.

3.4 DATA DESCRIPTION

A total of 3165 lactation records on 965 Karan Fries cows sired by 159 bulls maintained at National Dairy Research Institute pertaining to the period between 1993 to 2016, were utilized for the present study.

3.4.1 Information recorded and compiled

The data were recorded on production, reproduction and functional traits from history-cum pedigree sheets/registers, calving reports, maintained at data record room of Animal Genetics and Breeding Division, health and general treatment register, maintained at health complex of Livestock Production and Management Section, milk constituents registers maintained at Livestock Production and Management Section and reproduction records, maintained at Artificial Breeding Research Center (ABRC) and LRC and milk constituents registers maintained at Livestock Production and Management Section. Following information was collected for the purpose of analysis:

1. Animal number
2. Date of birth
3. Sire number
4. Dam number
5. Date of calving
6. Date of successful service
7. Dates of testing milk composition

8. Lactation number
9. Date of drying off
10. Records on calving traits, udder and reproductive disorders
11. Name of disease or disorder
12. Number of days under treatment
13. Milk yield during treatment

3.4.2 Traits under study

The information on the following traits related to production, reproduction, functional traits and longevity were considered for the study:

3.4.2.1 Production traits

1. 305-Days or less milk yield (kg)
2. Total milk yield (kg)
3. Lactation length (days)
4. Peak yield (kg)
5. Monthly test day milk yield (kg)

3.4.2.2 Reproduction traits

1. Date of first service
2. Date of successful service
3. Number of service per conception

3.4.2.3 Functional traits

3.4.2.3.1 Health traits:

I. Udder health: Clinical mastitis; Flakes (mild), Blood-in-milk (severe), Teat block (Chronic)
II. Uterine health: Uterine infection: Endometritis, Metritis, Pyometra
III. Ovarian health: Cystic ovaries disease (COD)
IV. Post calving uterine health: Retention of foetal membrane

3.4.2.3.2 Female fertility: Repeat breeding, Anoestrus

3.4.2.3.3 Calving traits: Dystocia, Stillbirth, Abortion, Premature birth

3.4.2.2 Production traits generated

I. Milk yield per day of 305 days or less lactation length (kg)

II. Milk yield per day of calving interval (kg)

III. Days to attain peak yield (days)

IV. Productive life

3.4.2.3 Reproduction traits

I. Age at first calving (months)

II. Calving to first insemination (days)

III. Pregnancy Rate (%)

IV. Calving Interval (days)

V. Service period (days)

3.4.2.4 Longevity (Herd life)

It was calculated as the period from date of birth to date of disposal or death, expressed in days

3.4.3 Recording of data

First report of a particular disease identified by veterinarian was considered irrespective of its progression to another disease condition in later stage of life. Further, same disease occurring more than once during a lactation was considered to be one incidence for the analysis. Clinical presence or absence of a specific disease generates discrete data with a binomial distribution. Udder health for cows was evaluated on the basis of symptoms of clinical mastitis recorded at Animal Health Complex. Clinical signs of mastitis include swelling and pain in udder, fever, abnormal milk appearance (milk clot, yellow milk, and thick/thin milk), altered milk composition and reduced milk yield (Harmon 1994). Flakes, blood in milk and teat block were the symptoms of mastitis and represented mild, severe and chronic form of mastitis. Uterine, ovarian and female fertility health was judged on the basis of clinical diagnosis of disorders that occurred after one month of calving. The clinical cases of metritis, endometritis, pyometra, cystic ovary, repeat breeding and anoestrous were diagnosed and recorded by ABRC. These health traits were used as indictor traits for evaluation of uterine, ovarian and female fertility health status. Post calving uterine health was evaluated on basis of clinical symptoms of retained placenta. Incidence of retained placenta was recorded from the health register maintained at Animal Health Complex. Incidence of dystocia, still birth, abortion and pre mature birth were recorded from calving records and health register maintained at Animal Genetics and Breeding Division and Animal Health Complex, respectively.

3.4.4 Classification of Data

Data on production, reproduction and functional traits were classified according to season of calving, period of calving, parity order, genetic group and age at first calving group.

3.4.4.1 Season of calving

The prevailing climatic conditions in Karnal region were considered as the basis of grouping the total duration of a year into four seasons (winter, summer, rainy and autumn), and followed by coding of the respective seasons as detailed in the Table 3.1.

Table 3.1 Classification of season of calving

Duration	Code	Season of calving
April to June	1	Summer
July to August	2	Rainy
September to November	3	Autumn
December to March	4	Winter

3.4.4.2 Parity

Analysis of the effect of parity on performance was done after classifying and coding of the data. Parity order was recorded upto the last lactation in the available production and reproduction sheets. But in this study, fifth parity and above were grouped together due to less number of animals above fifth parity.

3.4.4.3 Period

The data utilized for this study were spread over a period of 24 years (1993 to 2016). Since the modifications of management practices in the farm occurred over different years, the resulting cumulative effect of such practices over a period of five to six years may be significant on any trait. Therefore, to study this effect, the period of calving were classified into different groups as follows:

Table 3.2 Classification of Period:

Period of calving	Code
1993-95	1
1996-98	2
1999-01	3
2002-04	4
2005-07	5
2008-10	6
2011-13	7
2014-16	8

3.4.4.4 Genetic Groups

To study the effect of genetic group the classification was done on the basis inheritance level of Holstein Friesian blood in Karan Fries cows. The classification has been detailed in the Table 3.3.

Table 3.3 Classification of Genetic Groups

Genetic Group	Sire breed	Dam breed	Code
Group I (F1 crosses)	Holstein Friesian	Zebu breed (Tharparkar)	**1**
Group II (interbred)	Karan Fries	Karan Fries	**2**
Group III (Higher crosses)	Holstein Friesian	Karan Fries	**3**

3.4.4.5 Age at First Calving groups

The age at first calving was categorized in age at first calving (AFC) groups, after analyzing distribution of AFC in the population. Classification of data on age at first calving was into different groups was based Sturge's formula (1926):

$$\mathbf{C = R/ [1 + 3.322log_{10}\mathit{N}]}$$

Where,

$1 + 3.322 \log10N$ = number of classes

N = number of observations

R = range (maximum – minimum observation)

C = width of each class

AFC Group (days)	Code
<921	1
922-1112	2
1113-1302	3
>1303	4

3.5 Statistical Analysis

The statistical analysis was carried out as per the objectives of the study as follows:

3.5.1 Measures of Central Tendency and Dispersion of traits

Descriptive analysis like mean, standard error and coefficients of variation of production, reproduction and longevity were carried out using standard statistical procedures (Snedecor and Cochran, 1967).

3.5.2 Effect of genetic factors on production and reproduction traits

To overcome the non-orthogonality of data due to unequal and disproportionate sub-class frequencies, least-squares analysis was applied to identify the significance of important genetic and non-genetic factors as suggested by Harvey (1990). The following model was considered with the assumptions that the different components being fitted into the model are linear, independent and additive.

$$\mathbf{Y_{ijklmno} = \mu + S_i + P_j + (Pa)_k + (AG)_l + GG_m + b(X_n - \bar{X})_n + e_{ijklmno}}$$

Where,

$Y_{ijklmno}$ = Observation of O^{th} animal calved in i^{th} season, j^{th} period, k^{th} parity, having l^{th} age group at first calving and m^{th} genetic group

μ	=	Overall mean
S_i	=	Effect of i^{th} season of calving
P_j	=	Effect of j^{th} period
Pa_k	=	Effect of k^{th} parity
AG_l	=	Effect of l^{th} age group in first calving
GG_m	=	Effect of m^{th} genetic group
$b(X_n-\overline{X})_n$	=	Effect of covariables e.g. DIM, SP
$e_{ijklmno}$	=	random error associated with each observation assumed to be NID $(0, \sigma_e^2)$

The effect of parity was not considered for first lactation traits.

3.5.3 Functional/Indicator traits

Incidence is the number of new cases of the disease within a specified period of time. Normally, incidence is measured on a relative scale (Woodward, 1999).

$$\textbf{Incidence rate for the lactation or calving} = \frac{\text{Number of new cases of disease in the lactation}}{\text{Number of animals in the lactation}}$$

The incidence of various indicator traits was calculated in terms of proportion for season, period, parity and genetic group in lactation. It was calculated by taking the proportion of animals affected from indicator traits in the lactation or calving.

3.5.4 Effect of genetic and non-genetic factors on functional traits

The influence of various non-genetic factors i.e., season, period, parity of calving and genetic group of Karan Fries on functional traits were tested by Chi- Squares method (Snedecor and Cochran, 1994)

$$\textbf{Chi-square} = \frac{\Sigma(O-E)^2}{E}$$

Where,

O	=	Observed frequencies
E	=	Expected frequencies

Expected frequencies were calculated as follows:-

$$\mathbf{E_{ij} = (R_{i}.)(C._{j})/GT}$$

Where,

Eij	=	Expected frequency belong to i^{th} row and j^{th} column
Ri.	=	i^{th} row total
Cj.	=	j^{th} column total
GT	=	Grand total

3.5.5 Analysis of functional traits using logistic regression approach

It is very difficult to identify genetic and non-genetic factors influencing various functional traits in dairy animals using conventional analysis wherein normality of residual error is assumed. Under such conditions of binary or discontinuous nature of response variable, logistic regression can facilitate effectively in exploring the relationship between the dependent and explanatory variables as well as for predicting the response. Logistic regression method works with odds instead of proportion of data. The odds are simple the ratio of the proportion for the two possible mutually exclusive outcomes. If p is the proportion for one outcome, then (1-p) is the proportion for the second mutually exclusive outcome;

ODDS = p/ (1-p)

The logistic regression model relates the log of the odds to the explanatory variable in the form of a linear function as:

$$\text{Log}\,[p_i/\,1\text{-}p_i] = \beta_0 + \beta_1 X_i$$

$$1/p = [1+ \exp^{(\beta_0+\beta 1Xi)}]/ \exp^{(\beta_0+\beta 1Xi)}$$

$$p = \exp^{(\beta_0+\beta 1Xi)}/ [1+ \exp^{(\beta_0+\beta 1Xi)}]$$

$$= 1/ [1+ \exp^{(\beta_0+\beta 1Xi)}]$$

$$= 1/[1+ \exp^{-(Zi)}]$$

Z_i ranges from $^-\infty$ to $^+\infty$ and P_i ranges between 0 and 1. P_i is non-linearly related to Z_i thus satisfying the two conditions required for a probability model.

The following dichotomous logistic regression model in SAS 9.3 version was used:

$$\mathbf{ln\ [P / (1\text{-}P)] = \beta_\circ + \sum \beta_i X_j}$$

Where,

P = Probability of incidence

β□ = The intercept from the linear regression equation

β_i = Partial regression coefficient

3.5.5.1 Information criteria in logistic regression

Akaike (1974) introduced the concept of information criteria as a tool for optimal model selection. Schwarz (1978) developed a model selection criterion that was derived from a Bayesian modification of the AIC criterion. In case of logistic regression approach in the present study Akaike Information Criterion (AIC) and Schwarz Criterion (SC) was used to assess the fitness of the model.

Akaike Information Criterion (AIC)

AIC = -2 Log L+ 2[(k-1) + s]

K = the number of levels of the dependent variable

S = number of predictors in the model

L = the maximized value of the likelihood function for the estimated model

Schwarz criterion

SC = -2 Log L + [(k-1) +s] * log ($\sum f_i$)

Where, f_i's: frequency values of the i^{th} observation

AIC and **SC** penalizes for the number of predictors in the model

3.5.5.2 Likelihood Ratio (LR) Chi-Square test

Likelihood Ratio Chi-Square statistic was calculated with the following equation:

LR Chi-Square statistic = -2Log L_0 – 2 Log L

Where, L_0 refers to the Intercept only model and L to the fitted model i.e., Intercept and covariates model.

In case of Multiple Logistic Regression more than one continuous/discrete explanatory variable could be used to predict the categorical response variable. The explanatory variables were selected using the all possible regression and backward elimination methods and Chi-square statistic $-2(\text{Log } L_0 - \text{Log } L_1)$ was calculated at each step to assess the inclusion or exclusion of explanatory variables.

3.5.6 Estimation of Heritability

The heritability was estimated for reproduction and production traits by paternal half sib correlation method (Becker, 1975). Records on cows belonging to group G2 (interbred) were used to estimate the genetic parameter for production and reproduction and functional traits. The sires having minimum of three numbers of progeny were considered to estimate the heritability.

3.5.6.1 Production and reproduction efficiency traits

The heritability for first lactation production and reproduction efficiency traits was estimated by paternal half sib correlation method (Becker, 1975). The below model were used for the purpose:

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

Where,

Y_{ij} = Record on j^{th} daughter of ith sire

μ = population mean

S_i = Effect of i^{th} sire

e_{ij} = Random error associated with Y_{ij} NID $(0,\sigma^2)$

The analysis of variance for estimating the heritability was carried out as given in the following table.

Analysis of variance for estimation of heritability

Source of variation	df	Sum of Squares	Mean of Squares	Expected mean squares
Between sire	s-1	B.S.S	M.Ss	$\sigma^2 e + k\,\sigma^2 s$
Within sires	N-s	W.S.S.	M.Sw	$\sigma^2 e$

Where,

S	=	Number of sires
N	=	Total number of daughters
n_i	=	Number of daughters of i^{th} sire

The sire component of variance:

$$\sigma^2 s = [MSs - MSe] / k$$

$$t \text{ (intra class correlation)} = \frac{\sigma^2 s}{\sigma^2 s + \sigma^2 e}$$

$$h^2 = 4t$$

The standard error of heritability was estimated by using the following formula as given by Swiger *et al*. (1964):

$$\textbf{S.E. (h2)} = 4 \sqrt{\frac{[2 (N - 1) (1 - t) 2 \{1 + (K-1) t\} 2]}{[K2 (N - S) (S - 1)]}}$$

Where

S	=	Number of sires
N	=	Total number of daughters
t	=	Intra class correlation
k	=	Average number of progeny per sire

3.5.6.2 Effect of functional traits on performance

Effect of functional traits on production and reproduction performance was studied by least squares technique (Harvey, 1975) using the following model:

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

Data on lactation records of all animals including those suffering from lactation and reproduction disorders were considered to examine the effect of lactation disorders and cumulative days of mastitis on production and reproduction performance.

Where,

Y_{ij} = Milk yield of cattle suffered from i^{th} disease

μ = population mean

d_i = Effect of ith category of functional trait status

e_{ij} = Random error associated with Y_{ij} NID $(0,\sigma^2_e)$

3.6 Assessing the importance of production, reproduction and health in selection of Karan Fries cows

The primary goal of animal breeder is to maximize the rate of genetic improvement through proper selection as well as improving several important traits simultaneously. Study aimed at selecting animals that have not only good production or performance, but also have good health and reproduction. The method to optimize selection on multiple traits was based on the selection index principle. The purpose of the selection index method is to combine information from different sources such that an optimal selection criterion is achieved. So, development of selection index would be helpful tool to select the animals based on best combination of traits where traits were assigned with the weightage.

To achieve the objective related to sustainability, data were analyzed to estimate the 'genetic persistency' for the genetic evaluation of animals. So, test day milk yield traits were analyzed using random regression model for assessing the genetic persistency of animals. Estimation of genetic persistency based on test day breeding values estimated using Random Regression Model not only improves the accuracy of genetic evaluations, but also provides a potential for evaluating genetic persistency and in a dairy animal context, a better understanding of the genetics of lactation.

3.6.1 Construction of Total Performance Index (TPI)

Total performance index (TPI) is a selection index, was developed for ranking of Karan Fries cattle and assisting in identifying superior animals with a combination of high production, reproduction and longevity.

For constructing Total Performance Indices (TPI), genetic and phenotypic parameters (h^2, σ^2_G, σ^2_P, $Cov._G$, $Cov._P$), for all traits was estimated. The relative economic value of different traits was also estimated.

3.6.1.1 Phenotypic and genotypic variance and covariance of traits

Variance and covariance components of the traits were estimated from mixed model analysis. The phenotypic and genotypic variances and co-variances between different traits were set in a matrix form for the solution of the set of regression coefficients. The diagonal elements were the phenotypic/genetic variances and off diagonal elements will be phenotypic/ genetic co-variances of traits.

The inverse of phenotypic variance co-variance matrix for each combination of the traits was multiplied with the corresponding genotypic variance co-variance matrix. The product matrix was then finally multiplied with the column vector of relative economic values of the same traits to obtain the desired solution for weightage coefficients of the traits in the index.

3.6.1.2 Relative economic values of traits

Economic values of the trait are the cost of production per unit of the trait. In the present study, relative economic values was calculated on basis of expenditure involved for the different categories of animals for last five years as suggested by Chakravarty *et al*. (1991). Following major items of expenditure were considered to estimate the relative economic values for different traits selected for incorporation in the index.

1. Feed and fodder cost/animal/day
2. Treatment charges/animal/day
3. Labour charges/animal/day
4. AI charges/animal/day

Income from dung, urine, calf sale, depreciation of fixed expenditure etc., was not considered while calculating the relative economic value of the trait.

To calculate the cost of rearing of one animal per day, animals were categorized into different age groups (0-3 months, >3-6 months, >6-12 months, >1-2 year, >2 year, dry stock and lactating animals). Economic value of milk yield is the cost of production per kg of milk during different months of year. From this the average cost of 1 Kg of milk was estimated. Further in order to bring about similarity among different traits, the economic value of a standard unit of each trait was considered. Finally, keeping the economic value of milk as unity (one), relative economic values of other traits were estimated with proper sign assigned to each of the relative economic values of the traits.

3.6.1.3 Construction of selection index

Hazel (1943) defined index as:

$$I = b_1X_1 + b_2X_2 + \dots + b_nX_n$$

Where, X_i represents the phenotypic performance of i^{th} trait which influence the objective of selection and b_i represents the partial regression coefficients (weightage coefficients for different traits), estimated for increasing the correlation between index and breeding value.

The weighting coefficients for each trait was determined from the simultaneous equations, represented in matrix form as follows:

$$\mathbf{P\ b = G\ a}$$

and, $$\mathbf{b = P^{-1}\ G\ a}$$

Where,

P = Phenotypic variance-covariance matrix of traits

G = Genotypic variance-covariance matrix of traits

b = Column vector of regression coefficients of traits

a = Row vector of relative economic values of traits

3.6.1.4 Accuracy of selection index

In order to determine the accuracy (R_{IH}) of each selection index, the correlation between the aggregate genotype and index was computed using the following formula:

$$R_{IH} = \frac{\sigma_I}{\sigma_H} = \sqrt{\frac{b'Pb}{a'Ga}}$$

Where,

σ_I = Standard deviation of Index (I)

σ_H = Standard deviation of aggregate genetic merit (H)

Based on highest R_{IH} value best three traits selection indices were developed for sustainable selection in relation to production, reprroduction and longevity of Karan Fries cattle.

3.6.1.5 Relative emphasis of traits

Depending on the number of traits, various indices were constructed along with the accuracy of each index (R_{IH}). Based on R_{IH} the best indices were identified.

The relative emphasis was given for production, reproduction traits and longevity involved in the best indices using weightage factor of each trait and the sum of weightage factors of set to 100%

3.6.1.6 Robustness of selection index

The developed index is often found unstable due to changes in the cost of production of the trait in a particular farm, different locations and over the time. Therefore, the problem of stability of Total Performance Index (TPI) against the changing economic values defined as the robustness of selection index was judged by increasing the relative economic values of the traits by 25% and 50% (Chakravarty *et al*. 1991) in each Index. The index coefficients (b_i) and the accuracy of indices were studied with the change in relative economic values of the traits for the adoption of the developed total performance index over a period of time.

3.7 Estimation of genetic gain per generation and per year

Genetic gain was assessed for important production traits. The genetic gain due to selection per generation (ΔG) is a function of the selection intensity (i), phenotypic standard deviation (σ_p) and heritability of trait (h^2) and it was calculated using the formula given below:

$$\Delta G = I \times \sigma_p \times h^2$$

Where,

I = intensity of selection

σ_p = phenotypic standard deviation

h^2 = heritability of the trait

To calculate genetic gain per year, the genetic gain per generation was divided by generation interval which was generated by taking the average age of sire and dam when their first progeny was born in the herd. This method was been given by Rendel and Robertson (1950). This was used to measure genetic change by measuring the genetic superiority and generation interval from paths of parents to offspring.

$$\Delta G \text{ per year} = \frac{GSC + GSB + GDC + GDB}{LSC + LSB + LDC + LDB}$$

Where,

G_{SC} = Genetic gain per generation along sire to cow path

G_{SB} = Genetic gain per generation along sire to bull path

G_{DC} = Genetic gain per generation along dam to cow path

G_{DB} = Genetic gain along dam to bull path

L_{SC} = Average age of sires when their daughters are born which enter the herd

L_{SB} = Average age of sires when their sons (bulls) are born and are used as breeding bulls

L_{DC} = Average age of dams when their daughters are born which enter the herd

L_{DB} = Average age of dams when their sons (bulls) are born and used as breeding bulls

The expected genetic gain from different paths was calculated as follows.

$$\mathbf{G = i \cdot r_{IA} \cdot \sigma_A}$$

Where,

i = Intensity of selection

r_{IA} = Accuracy of selection

σ_A = Additive genetic standard deviation, which will be same for all four paths

For SB (sire to bulls) & SC (sire to cows) paths

$$r_{IA} = \frac{1}{2}\sqrt{\frac{nh^2}{1+(n-1)\,0.25\,h^2}}$$

For DB (dam to bulls path)

$$r_{IA} = \sqrt{\frac{nh^2}{1+(n-1)\,r}}$$

For DC (dam to cows) path

r_{IA} = h

Where,

n is number of records and r is repeatability

For the SC and SB paths the value of 'n' was calculated by averaging the number of normal daughter and sons born, sired by the breeding bulls used over the years in the farm. Similarly for the DC and DB paths the value of 'n' was calculated by averaging the number of normal daughter and sons born from the lactating cows used over the years in the farm.

3.8 Genetic Persistency

Persistency of milk production is the ability to maintain milk production at a high level after peak production. Jamrozik *et al*. (1998) defined genetic persistency as the slope of the animals' lactation curve between days in milk 60 and 280 in cattle. Generally, the lactation length and days to attain peak yield vary from lactation to lactation. So, different methods were used for estimating the genetic persistency of milk production of Karan Fries cattle.

Genetic Persistency Method 1 (GPM 1):

This method estimated the genetic persistency as the deviation between the breeding values on days in milk corresponding to average lactation length in a lactation and on days in milk corresponding to average days to attain peak milk yield in different lactations.

Genetic Persistency Method 2 (GPM 2):

This method estimated the genetic persistency as the deviation between the breeding values on days in milk i.e. average lactation length of all lactations and average days to attain peak milk yield of all lactations.

Both methods were used on the estimated breeding values using Legendre polynomial function under Random Regression Model to estimate genetic persistency of milk production.

3.9 Formulation of sustainable breeding strategies

3.9.1 Breeding strategy for genetic improvement of lactation milk yield in Karan Fries cattle

Under the existing breeding strategy at ICAR-NDRI, Karnal, Karan Fries animals are selected for milk production under progeny testing programme. Bulls are selected on the basis of first lactation records of their daughters and no importance is being imparted to the functional traits. It is important to select the daughters on the basis of a best combination of traits for developing sustainable strategy as production and reproduction performance are negatively correlated.

In the present study, the best combination of important traits was estimated. Based on these traits the genetic gain was calculated. Since the proportion of animals to be selected as parent for next generation varies from herd to herd or even within the single herd over generations, there is a need to put selection pressure so that an optimum level for selection of animals can be fixed which will provide the maximum genetic gain. Therefore, genetic gain was assessed considering different levels of selection intensity of females (90 %, 80 %, 70 %, and 60 % of animals being selected) and the gain was compared with the gain to be obtained under the existing selection strategy.

3.9.2 Breeding strategy for genetic improvement of productivity in Karan Fries cattle

Sustainable performance of Karan Fries animals was also assessed based on their productivity and the corresponding reproductive performance. Karan Fries animals were classified on the basis of their productivity as low (<8 kg/day WA), medium (9-12 kg/day WA) and high (>12kg/day WA) and under different intensities of selection (90 %, 80 %, 70 %, and 60 % of animals being selected). Genetic gain was assessed for each category and was compared with the gain to be obtained under existing selection strategy.

The present study finally formulated the combination of traits for selection of Karan Fries animals giving due weightage to important production reproduction traits along with longevity and the level of optimum selection intensities for obtaining the maximum genetic gain of different traits in a sustainable manner.

CHAPTER –4

Results & Discussion

RESULTS AND DISCUSSION

The data on production, reproduction and functional traits were analyzed for developing Multi-trait Selection Strategy in Karan Fries cattle. The results of the present investigation are discussed under the following subheadings:

4.1 Incidence of indicators for functional traits

4.2 Logistic regression analysis to identify influence of genetic and non-genetic factors on various functional traits

4.3 Production and reproduction performance traits in Karan Fries cattle

4.4 Non-genetic factors affecting production and reproduction traits in Karan Fries cattle

4.5 Genetic and phenotypic parameters of performance traits

4.6 Development of selection criteria based on production and reproduction traits and longevity in Karan Fries cattle

4.7 Genetic persistency of milk yield in Karan Fries cattle

4.8: Estimation of expected genetic gain (ΔG)

4.9: Breeding strategy for production and reproduction trait in Karan Fries cattle

4.1 INCIDENCE OF THE INDICATORS OF FUNCTIONAL TRAITS

The incidence of indicators of functional traits in relation to various genetic and non-genetic factors and the results of chi-squares analysis showing the effect of various genetic and non-genetic factors on indicator traits have been depicted in Tables 4.1 - 4.8. Incidence of the indicators of functional traits was measured in terms of proportion.

4.1.1 Incidence of udder health indicator traits (Clinical mastitis- flakes, blood-in milk and teat block)

The incidence of clinical mastitis including the symptoms like flakes (mild form), blood - in - milk (severe) and teat block (chronic) in relation to various genetic and non-genetic factors have been presented in Table 4.1 whereas the results of Chi-Squares analysis showing the effect of various genetic and non-genetic factors on these traits have been shown in Table 4.2.

The overall incidence of clinical mastitis was found to be 0.41 out of 3165 calvings. The proportion of flakes symptoms in milk was 0.33. Whereas those of blood in milk and teat block were recorded as 0.06 and 0.02, respectively. Almost similar values of incidence were reported by Mukherjee *et al*. (1993) for clinical mastitis and blood in milk, Chand and Behra (1993) and Sharma (2010) for clinical mastitis in Karan Fries cattle. Jadhav *et al*. (1995) estimated the proportion of incidence of clinical mastitis as 0.31 in Holstein-Sahiwal cross. On the other hand, lower incidence of clinical mastitis and higher incidence of teat block was reported for Karan Fries cattle by Satyapal (2003) and Mukherjee *et al*.(1993)

A lower estimate of incidence of clinical mastitis was reported in Haryana cattle (Kaushik and Khanna, 2004) and buffalo (Sharma, 2000; Shinde *et al*. 2001; Taraphder, 2002). Whereas, higher incidence of teat block was observed in Murrah buffalo by Taraphder (2002). From this, it could be inferred that Karan Fries cattle were more susceptible to udder health disorder as compared to indigenous cattle and buffalo. While low incidence of chronic form of clinical mastitis (teat block) in the present study could be due to better udder health management during disease period.

Season

The incidence of clinical mastitis was found to be the highest in those calved during rainy season (0.55) than those calved during summer (0.35), winter (0.47) and autumn (0.26) season. The incidence was also higher for the symptoms of flakes (0.46), blood in milk (0.04) and teat block (0.02) in rainy season (Table 4.1). Subjecting the data to statistical analysis, it was found that season of calving had highly significant ($P<0.01$) effect on the incidence of clinical mastitis including all the symptoms of lactation disorder (Table 4.2).

Non-significant effect of season of calving on incidence of mastitis has been reported in Karan Fries cows (Mukherjee, 1989; Satyapal, 2003; Sharma, 2010) and Hariana cattle (Kaushik and Khanna, 2004). However, Mukherjee (1989) reported that incidence of blood in milk and teat block was significantly lower during winter season of calving in Karan Fries cattle.

Significant effect of season of calving on clinical mastitis was reported in cross bred cows by Singh (1979), Chand and Behra (1993), Jadhav *et al*. (1995) and Kulkarni *et al*., (2002). The lowest incidence of clinical mastitis was observed in winter and the highest incidence was observed in rainy season of calving in Murrah buffaloes (Taraphder, 2002)

Period

The incidence of clinical mastitis varied from 0.49 to 0.12 in different periods and lowest incidence (0.12) was observed in the period of 1993-1995. It also showed lowest incidence (0.07) during same period for the symptoms of flakes and no case of teat block was found in the same period. Incidence of blood in milk was minimum (0.02) during 2014-2016. No particular trend of incidence of clinical mastitis was observed over the periods.

Chi-squares analysis (Table.4.2) indicated that the period of calving had highly significant effect on clinical mastitis and overall symptoms (flakes, blood in milk and teat block).

Significant effect of period of calving on incidence of blood in milk and teat block and non-significant effect on clinical mastitis in Karan Fries cattle was earlier reported by Mukherjee (1989) and Satyapal (2003). Sharma (2010) reported significant effect on clinical mastitis and flakes, and non-significant effect on blood in milk and teat block. Taraphder (2002) reported non-significant effect on incidence of clinical mastitis and teat block and significant effect on blood in milk in Murrah buffaloes.

Parity

The incidence of clinical mastitis showed a consistent increasing trend up to fifth parity. The incidence was observed to be the highest in fifth (0.83) and the lowest in first parity (0.21). Flakes also showed the trend similar to that of the mastitis. Blood in milk and teat block did not show any particular trend of incidence (Table 4.1- 4.2.) Similarly, Mukherjee (1989) and Sharma (2010) reported that the incidence of mastitis, blood in milk and teat block significantly increased, as the animal grew older. Chand and Behra (1993) reported that incidence of mastitis increased with the increased parity. Singh (1979) and Jadhav *et al*. (1995) reported significant effect of parity in Holstein Friesian crossbreds. Kaushik and Khanna (2004) also reported significant effect of parity on incidence of mastitis in Haryana cattle.

Taraphder (2002) reported significant effect of season of calving on incidence of clinical mastitis and showed an increasing trend over the parities in Murrah buffaloes. While, non-significant differences among the parities were recorded for incidence of clinical mastitis in Karan Fries cattle by Satyapal (2003).

The higher incidence of mastitis in later parities in comparison to first parity might be due to long time exposure of streak canal to pathogenic organism. The canal acts as a barrier to infection and effectiveness of streak canal as barrier to infection decreased with the increase in parity order (Schalm *et al*., 1971) and another reason might be negative energy balance due to increased of milk yield with the increase in parity order.

Genetic Group

The incidence of clinical mastitis was almost similar in different genetic groups. The higher incidence was observed in higher crosses (0.41) than those of interbred (0.39) and F1 crosses (0.40) for clinical mastitis (Table4.1). However, statistical analysis failed to show any significant effect of genetic groups on clinical mastitis including the flakes, blood in milk and teat block (Table4.2).

Table 4.1: Incidence of udder health indicator traits in relation to different genetic and non-genetic factors

Effect	Calving	Udder health indicator traits			
		Flakes	Blood in milk	Teat Block	Clinical mastitis
Overall	3165	0.33 (1034)	0.06 (195)	0.02 (64)	0.41 (1293)
Season					
Summer	727	0.30 (218)	0.04 (26)	0.02 (14)	0.35 (258)
Rainy	521	0.46 (241)	0.06 (33)	0.02 (11)	0.55 (285)
Autumn	722	0.21 (155)	0.03 (24)	0.01 (9)	0.26 (188)
Winter	1195	0.35 (420)	0.09 (112)	0.03 (30)	0.47 (562)
Period					
1993-95	123	0.07 (9)	0.05 (6)	0	0.12 (15)
1996-98	513	0.33 (169)	0.07 (35)	0.02 (10)	0.42 (214)
1999-01	544	0.24 (133)	0.06 (30)	0.01 (3)	0.31 (166)
2002-04	572	0.40 (227)	0.06 (35)	0.01 (5)	0.47 (267)
2005-07	650	0.42 (272)	0.06 (38)	0.02 (11)	0.49 (321)
2008-10	311	0.34 (105)	0.06 (19)	0.04 (13)	0.44 (137)
2011-13	275	0.27 (75)	0.10 (28)	0.07 (18)	0.44 (121)
2014-16	177	0.25 (44)	0.02 (4)	0.02 (4)	0.29 (52)

Parity					
1	1219	0.12 (144)	0.07 (88)	0.02 (29)	0.21 (261)
2	809	0.37 (300)	0.02 (20)	0.01 (10)	0.41 (330)
3	488	0.40 (196)	0.09 (43)	0.02 (12)	0.51 (251)
4	276	0.41 (113)	0.08 (23)	0.03 (7)	0.52 (143)
5	373	0.75 (281)	0.06 (21)	0.02 (6)	0.83 (308)
Genetic Group					
1	342	0.32 (108)	0.07 (24)	0.02 (8)	0.40 (140)
2	2634	0.33 (865)	0.06 (160)	0.02 (50)	0.39 (1075)
3	189	0.32 (61)	0.06 (11)	0.03 (6)	0.41 (78)

Jadhav *et al*. (1995) reported significant effect of genetic group on the incidence of mammary disorders. It was the lowest in ¼ and the highest in 7/8 (high) grades. They also reported that higher level of inheritance showed increased incidence of mastitis in Holstein Frisian crossbred. Sharma (2010) also reported no significant effect of genetic group on the incidence of clinical mastitis.

Table 4.2: Chi-square value for lactation disorders in Karan Fries cows

Effect	df	Pearson chi-square value			
		Flakes	Blood in milk	Teat Block	Clinical Mastitis
Season	3	90.62**	39.79**	3.69	65.089**
Period	7	99.07**	23.90**	48.41**	110.05**
Parity	4	85.44**	29.77**	4.47	101.06**
Genetic group	2	0.23	0. 50	1.64	0.613

**Significant (p<0.05); **Significant (p<0.01)*

4.1.2 Incidence of ovarian and uterine health indicators (Cystic Ovary Disease, metritis, pyometra and endometritis)

The incidence and the results of Chi-square analysis for uterine and ovarian disorders viz. cystic ovary disease (COD), metritis, pyometra and endometritis in relation to various genetic and non-genetic factors have been depicted in Table 4.3- 4.4.

4.1.2.1 Ovarian health indicator trait -Cystic Ovary Disease (COD)

The number of calvings affected with cystic ovary disease was 653 out of 3165 calvings and the incidence of the disease was found to be 0.21. Incidence of COD was influenced by all non-genetic factors. Similar incidence of cystic ovary disease in German Holstein cows was reported as 0.21 and 0.26 by Petersen *et al*. (2002). Opsomer and Kruif (2009) reviewed incidence of COD in different cattle breeds and reported that incidence of disease varied from 0.06 to 0.30 in dairy cattle. However, the lower estimates of incidence of COD incidence were also reported by various workers in their studies on Holstein cattle (Uribe *et al*., 1995; Van Dorp *et al*., 1998; Hooijer *et al*.,2001).

Season

Karan Fries cows calved in autumn season had significantly lower ($P<0.05$) incidence (0.15) than summer (0.17), and winter (0.22) season calvers. Higher incidence of COD in rainy season (0.31) of calving may be due to high humidity thereby indicating the need of amelioration of stress due to inclement weather condition during these months for improving overall reproductive efficiency of Karan Fries cows.

Period

Incidence of the disease was higher (0.39) in the period of 2005-07 than the periods of 2002-04 (0.30) and 2008-2010 (0.17). The results indicated that incidence showed an decreasing trend over the period from 2005- 2016. Decrease in incidence of COD over periods may be due to better management practices or positive energy balance by better feeding management

Parity

The incidence of COD was significantly ($P<0.01$) higher in pluriparous cows (0.24 in second parity, 0.29 in third parity, 0.31 in fourth parityand 0.39 in fifth parity) than primiparous cows (0.07). Higher Incidence of COD in pluriparous cows could be attributed to higher risk of increased uterine infections over successive calvings, which act as a predisposing factor for the disease in pluriparous cows compared to primiparous cows.

Genetic group

The present study revealed that genetic groups had non-significant effect on cystic ovary disease in Karan Fries cows (Table 4.3 - 4.4). F1 crosses showed lower

Incidence (0.19) of COD as compared to Interbred group (0.21) and higher crosses (0.23). Overall the results indicated that the cows in the interbred and higher crosses were more susceptible to COD, whereas F1 cows might be better adapted to the tropical environment.

4.1.2.2 Uterine health indicator traits- Uterine Infection (Endometritis, Metritis and Pyometra)

The results obtained from the present study indicated that the incidence of uterine infection was 0.18 comprising the incidence of endometritis (0.03), metritis (0.12) and pyometra (0.03) in 3165 calvings (Tables 4.3 - 4.4). Similar incidence of endometritis was recorded as 0.03 for Karan Fries cows by Balasundaram (2008). However, higher incidence was reported (0.14 - 0.39) by Mukherjee *et al*. (1993); Satyapal (2003); Balasundaram (2008) for metritis, pyometra (0.02) by Balasundaram (2008) in Karan fries cows and endometritis (0.17) by Franz *et al*.(1988) in German Black Pied cows.

Season

The incidence of uterine infection was found to be highest among those calved during rainy season (0.32) than those calved during autumn (0.14), summer (0.17) and winter season (0.16).The trend similar to that of uterine infection was observed for endometritis and metritis. Statistical analysis revealed highly significant effect of season on endometritis, metritis, pyometra and uterine infection (Tables 4.3- 4.4).

Similarly, effect of season of calving on incidence of metritis was reported in crossbred cattle by Singh *et al*. (1997), Pandey and Tomar (1994), Petersen *et al*. (2002), Satyapal (2003), Kaushik and Khanna (2004) and Zwald *et al*. (2004). However, contrasting with the findings of Mukherjee (1989) Balasundaram (2008) and Sharma (2010), who reported that metritis, pyometra and uterine infection were not affected by season of calving in Karan Fries cattle.

Period

The period of calving had highly significant ($P<0.01$) effect on the incidence of uterine infection. Lower incidence was estimated during the period (2008-10) as 0.08 for uterine infection comprising 0.02 for endometritis, 0.04 for metritis and 0.02 for pyometra. Not a particular trend was found over the period on incidence of uterine infection

The results were similar to those of Satyapal (2003) and Sharma (2010) who observed significant effect of period on incidence of metritis in Karan Fries cows. Contrary to the present findings, Balasundaram (2008) reported that period of calving had no significant effect on metritis and endometritis and had significant effect on pyometra.

The variation in incidence of uterine infection over period may not only be caused by annual random changes of the climatic factors but also include management changes.

Parity

The incidence of uterine infection was significantly ($P<0.05$) lower in (0.13) primiparous cows than pluriparous cows. Similar incidence was observed for endometritis (0.02), metritis (0.09) and pyometra (0.02) in Karan Fries cows. Mukherjee (1989), Satyapal (2003) and Sharma (2010) reported that metritis was significantly affected by parity and the disease was less prevalent during first lactation and more in later parities in Karan Fries cows However, non significant effect of parity on uterine disorders was reported by Kaikini *et al*. (1983) and Chourewar *et al*. (2002) in different crossbreds and Balasundaram (2008) in Karan Fries cattle. Higher incidence in pluriparous cows could be attributed to the high risk of infection during later calvings.

Genetic Group

Statistical analysis showed that the effect of genetic group was significant ($P<0.001$) only for pyometra and non-significant for endometritis and metritis (Tables 4.3- 4.4) .The incidence of uterine infection was lower in interbred group as compared to F1 and higher crosses. Incidence of uterine infection was 0.17 in interbred group comprising of 0.03 for endometritis, 0.12 for metritis and 0.02 for pyometra. Pandit *et al*. (1981) and Deshmukh and Kaikini (1999) reported that halfbreeds (F1) were less susceptible to reproductive disorders as compared to ¾ breeds, while non-significant effect of genetic group on metritis was observed by Chourewar *et al*. (2002) and Balasundaram (2008) in Karan Fries. Lower incidence of uterine infection in interbred group may be due to better adaptability for tropical environment than that of F1 and higher crosses.

Table 4.3: Incidence of ovarian and uterine health indicator traits in relation to different genetic and non-genetic factors

Effect	Calvings	Ovarian and uterine health indicator traits				
		Cystic Ovary	Endometritis	Metritis	Pyometra	Uterine infection
Overall	3165	0.21 (653)	0.03 (102)	0.12 (402)	0.03 (87)	0.18 (591)
Season						
Summer	727	0.17 (121)	0.03 (21)	0.117 (85)	0.02 (14)	0.167 (120)
Rainy	521	0.31 (160)	0.07 (39)	0.18 (97)	0.07 (34)	0.32 (170)
Autumn	722	0.15 (108)	0.01 (9)	0.09 (69)	0.04 (28)	0.14 (106)
Winter	1195	0.22 (264)	0.03 (33)	0.12 (151)	0.01 (11)	0.16(195)
Period						
1993-95	123	0.02 (3)	0.01 (1)	0.04 (6)	0.04 (5)	0.09 (12)
1996-98	513	0.08 (43)	0.01 (5)	0.17 (88)	0.02 (11)	0.2 (104)
1999-01	544	0.16 (89)	0.01 (4)	0.16 (87)	0.01 (8)	0.18 (99)
2002-04	572	0.30 (169)	0.001 (1)	0.14 (80)	0.01 (6)	0.151 (87)
2005-07	650	0.39 (251)	0.03 (20)	0.16 (107)	0.01 (8)	0.2 (135)
2008-10	311	0.17 (54)	0.02 (6)	0.04 (15)	0.02 (5)	0.08 (26)
2011-13	275	0.12 (34)	0.11 (29)	0.04 (12)	0.11 (30)	0.26 (71)
2014-16	177	0.06 (10)	0.20 (36)	0.04 (7)	0.08(14)	0.32 (57)
Parity						
1	1219	0.07 (82)	0.02 (26)	0.09 (117)	0.02 (27)	0.13(170)
2	809	0.24 (198)	0.03 (24)	0.15 (122)	0.02 (17)	0.2 (163)
3	488	0.29 (140)	0.05 (26)	0.13 (67)	0.06 (30)	0.24 (23)
4	276	0.31 (86)	0.04 (11)	0.15 (42)	0.04 (10)	0.23 (73)
5	373	0.39 (147)	0.04 (15)	0.14 (54)	0.01 (3)	0.19 (72)
Genetic Group						
1	342	0.19 (66)	0.02 (7)	0.12 (41)	0.07 (27)	0.21 (75)
2	2634	0.21 (544)	0.03 (89)	0.12 (336)	0.02 (56)	0.17 (481)
3	189	0.23 (43)	0.03 (6)	0.13 (25)	0.02 (4)	0.18 (35)

Table 4.4: Chi-square values for ovarian and uterine disorders in Karan Fries cows

Effect	df	Pearson chi-square value			
		Cystic ovary	Metritis	Endometritis	Pyometra
Season	3	55.12**	23.56**	40.47**	53.09**
Period	7	271.83**	77.28**	255.45**	70.07**
Parity	4	250.32**	17.82**	13.02**	16.46*
Genetic group	2	0.89	0.21	1.72	16.78**

**Significant (p<0.05); **Significant (p<0.01)*

4.1.3 Incidence of fertility and post calving uterine health indicators (Repeat breeding, anoestrous and Retention of placenta (ROP)

The incidence and results of Chi-square analysis for fertility and post calving uterine disorders in relation to various genetic and non-genetic factors have been depicted in Tables 4.5 - 4.6.

4.1.3.1 Incidence of fertility health indicator traits - Repeat breeding and anoestrous

The present study on fertility health indicator traits showed the proportion of incidence as 0.06 for repeat breeding and 0.22 for anoestrous. The season period and parity of calving had highly significant (P<0.01) effect on those indicator traits while genetic group showed non-significant effect in statistical analysis

Almost significant incidence of anoestrous was reported in Karan Fries by Balasundaram (2008) and Sharma (2010) and in crossbred cattle by Sharma and Luktuke, (1983). Perusal of literature revealed that incidence of repeat breeding ranged from 0.07 to 0.28 in crossbreds (Kaikini *et al*, 1983; Chourewar *et al.*, 2002; Kulkarni *et al.*, 2002; Selvaraj *et al.* 2003). Urade (2001) reported that the overall incidence of repeat breeding was 8.08 percent in crossbred cows.

Season

The present findings (Tables 4.5- 4.6) indicated that the incidence of repeat breeding and anoestrous was significantly (P<0.01) affected by season. The incidence of fertility disorders was lowest in the autumn season calvers as compared to others. It was 0.05 for repeat breeding and 0.17 for anoestrous in autumn season. Chourewar *et al*. (2002) found that season of calving had significant effect on incidence of repeat breeding in cross bred cows. Similarly, Balasundaram (2008) and Sharma (2010) reported significant effect of season on the incidence of repeat breeder and anoestrous in Karan Fries cows.

Period

The period of calving had highly significant ($P<0.01$) effect on repeat breeding and anoestrous. Incidence of repeat breeding increased from duration 1993-2007. The incidence of anoestrous was found to be highest (0.36) in the period of 2002-04 and lowest (0.07) in 1993-95. However, Balasundaram (2008) reported non-significant effect of period on repeat breeding and anoestrus.

Parity

The results obtained from the present study (Tables 4.5-4.6) showed that lower estimates of incidence was observed in primiparous cows (0.17 and 0.05) for anoestrous and repeat breeding than in pluriparous cows (0.22-0.28 and 0.051-0.08). No particular trend was observed over the parities. Similar to the present findings, significant difference and increasing trend over the parities was observed for anoestrus in Friesian×Haryana cows by Sharma and Luktuke (1983). Chourewar *et al*. (2002) reported non-significant effect of parity on repeat breeding in crossbred cow. Balasundaram (2008) reported non-significant effect of parity on repeat breeding and anoestrus in Karan Fries cattle.

Genetic Group

Subjecting the data to statistical analysis revealed that genetic groups had no significant effect on the incidence of fertility disorders. Similarly, Balasundaram (2008) and Sharma (2010) observed non-significant differences in the incidence of anoestrous and repeat breeding for different genetic groups of Karan Fries cattle. Whereas, Kulkarni *et al*., (2002) and Selvaraj *et al*. (2003) reported significant differences among genetic groups for incidence of repeat breeding in cows.

4.1.3.2 Incidence of post-calving uterine health indicator traits- Retention of placenta (ROP)

The number of parturitions with retention of placenta (ROP) was 584 out of 3165 calvings which showed the proportion of 0.18 in Karan Fries cows (Table 4.5 and 4.6). An incidence 0.27 and 0.25 for retained placenta was reported in crossbreds (Mahrotra and Dey, 1998; Satyapal, 2003; Balasundaram *et al*., 2011a) and Karan Fries (Sharma, 2010) respectively. Whereas lower (0.15) incidence of retention of placenta was observed in Karan Fries cattle by Mukherjee (1989)

Season

The proportion of incidence of retention of placenta (ROP) varied from 0.13 to 0.23 in the herd for different seasons. Estimates of incidence was lower in autumn (0.13) season and higher in rainy (0.23) season. Statistically, incidence of ROP differ significantly (P<0.001) across the different seasons of calving.

Similarly other reports showed that season of calving had significant difference on the incidence of retained placenta in crossbred and Karan Fries cows (Pandit *et al*., 1981; Saini *et al*., 1988; Mukherjee, 1989; Singh *et al*., 1997 and Satyapal, 2003). Whereas Balasundaram *et al*. (20011a) and Sharma (2010) reported non-significant effect of season of calving on incidence of retention of placenta in Karan Fries cattle. Satyapal (2003) found that summer season of calving had higher incidence of retained placenta in Karan Fries cows.

Period

The incidence of retention of placenta was highest (0.25) in the period of 1996-2001 whereas it was 0.18 and 0.14 during the periods of 2002-08 and 2014-16, respectively. It showed almost decreasing trend over the period. Further, statistical analysis revealed highly significant effect (P<0.01) of period of calving. Similarly Mukherjee (1989), Balasundaram *et al*. (20011a) and Sharma (2010) had also reported that period of calving significantly affected the incidence of retained placenta in Karan Fries cows. In conformity with the present findings, a decreasing trend of incidence over the period was observed by Balasundaram (2008). However, an increasing trend was reported by Mukherjee (1989) in Karan Fries cattle.

Parity

The present results revealed the lowest incidence (0.13) of retention of placenta in primiparous cows. Whereas pluriparous cows showed, the incidence proportion as 0.21 in second parity, 0.20 in third parity, 0.25 in fourth parity and 0.23 in fifth parities. Differences in the incidence proportion of ROP across the parities were found to be highly significant (P<0.01). Similarly, various authors reported that parity of calving significantly affected the incidence of retained placenta in crossbred cows and its incidence was lesser during early lactation and more in later lactations (Pandit *et al*.,1981; Saini *et al*.,1988; Mukherjee,1989; Satyapal, 2003; Sharma, 2010).Kaikini *et al*. (1983) and Balasundaram *et al*. (2011a) found that the effect of parity was not significant for incidence of retained placenta in different cross bred cattle.

Genetic group

However, the statistical analysis showed that the genetic group did not significantly influence the incidence of ROP. The incidence of ROP was lower (0.16) in F1 and higher crosses as compared to (0.19) interbred cows. The present results were in conformity with the findings of Chourewar *et al*. (2002) and Balasundaram *et al*. (20011a) who reported non-significant effect of genetic group on incidence of retention of placenta in crossbred and Karan Fries cows.

Table 4.5: Incidence of fertility and post calving uterine health indicators in relation to different genetic and non-genetic factors

Effect	Calving	Fertility and post calving uterine health indicators		
		RB	AN	ROP
Overall	3165	0.06 (185)	0.22 (699)	0.18 (584)
Season				
Summer	727	0.06 (41)	0.21 (153)	0.15 (110)
Rainy	521	0.09 (48)	0.31 (163)	0.23 (118)
Autumn	722	0.05 (35)	0.17 (126)	0.13 (96)
Winter	1195	0.05 (61)	0.22 (257)	0.22 (260)

Period				
1993-95	123	0.02 (3)	0.07 (9)	0.10 (12)
1996-98	513	0.03 (14)	0.14 (70)	0.25 (126)
1999-01	544	0.05 (29)	0.22 (122)	0.25 (135)
2002-04	572	0.09 (51)	0.36 (207)	0.18 (101)
2005-07	650	0.09 (59)	0.19 (125)	0.18 (119)
2008-10	311	0.03 (10)	0.16 (50)	0.13 (41)
2011-13	275	0.02 (5)	0.32 (89)	0.09 (25)
2014-16	177	0.08 (14)	0.15 (27)	0.14 (25)
Parity				
1	1219	0.05 (61)	0.17 (211)	0.13 (164)
2	809	0.06 (50)	0.28 (224)	0.21 (167)
3	488	0.07 (33)	0.23 (113)	0.20 (99)
4	276	0.08 (23)	0.25 (69)	0.25 (70)
5	373	0.05 (18)	0.22 (82)	0.23 (84)
Genetic Group				
1	342	0.06 (19)	0.22 (76)	0.16 (56)
2	2634	0.06 (154)	0.22 (582)	0.19 (498)
3	189	0.06 (12)	0.22 (41)	0.16 (30)

Table 4.6: Chi-square value for fertility and post calving disorders in Karan Fries cows

Effect	df	Pearson chi-square value		
		Repeat Breeding	Anestrous	Retention of Placenta
Season	3	13.29**	35.33**	32.86**
Period	7	47.42**	134.27**	57.75**
Parity	4	15.51**	32.61**	34.03**
Genetic group	2	0.14	0.02	2.17

**Significant (p<0.05); **Significant (p<0.01)*

4.1.4 Incidence of calving health indicators: - Dystocia (calving ease), still birth, abortion and premature birth

The incidence of calving health indicator traits comprising dystocia, still birth, abortion and premature birth in relation to various genetic and non-genetic factors have been presented in Table 4.7.

The results of chi-squares analysis showing the effect of various genetic and non-genetic factors on these traits have been presented in Tables 4.7- 4.8. The average incidence of calving problems traits was found to be 0.12 comprising of 0.06 for abortion, 0.006 for premature birth, 0.02 for still-birth and 0.03 for dystocia among 3165 calving.

The frequency of calving disorder is usually small, around 0.03-0.05 in Holstein cows (Luo *et al*., 2002). The average incidence of calving disorders ranged from 0.02 to 0.03 for dystocia, 0.02 to 0.04 for still birth, 0.04 to 0.07 for abortion and 0.01 to 0.015 for premature birth in Karan Fries cows (Mukherjee, 1989; Satyapal, 2003 and Balasundaram *et al*. (2011b); Sharma, 2010).Taraphder (2002) reported that incidence of calving abnormality was 0.13 in Murrah buffaloes comprising of the incidence of dystocia (0.02), stillbirth (0.02), abortion (0.06) and premature birth (0.02).

Season

The incidence of calving traits was found to be lowest among those calved during autumn season (0.10) than those calved during winter (0.13), summer (0.13) and rainy season (0.11). The highest incidence of indicator traits was found to be in winter season for dystocia (0.05) and still-birth (0.03), in autumn season (0.009) for premature birth and in summer and rainy (0.08) season for abortion, whereas the lowest incidence was found to be in autumn, (0.01) for dystocia, in rainy, autumn and summer season (0.02) for sill-birth, in summer season for premature birth (0.001) and in autumn and winter (0.05) for abortion. It was further observed that the season of calving had statistically significant ($P<0.01$) effect on incidence of abortion and dystocia and non-significant for premature birth and still birth

Table 4.7: Incidence of calving health indicators in relation to different genetic and non-genetic factors

Effect	Calving	Calving health indicators				
		Dystocia	Stillbirth	Premature birth	Abortion	Calving abnormality
Overall	3165	0.03 (90)	0.02 (77)	0.006 (20)	0.06 (196)	0.12 (383)
Season						
Summer	727	0.03 (19)	0.02 (18)	0.004 (3)	0.08 (56)	0.13 (96)
Rainy	521	0.02 (11)	0.02 (10)	0.008 (4)	0.08 (43)	0.13 (68)
Autumn	722	0.01 (6)	0.02 (17)	0.009 (7)	0.05 (33)	0.09 (630
Winter	1195	0.05 (54)	0.03 (32)	0.005 (6)	0.05 (64)	0.13 (156)
Period						
1993-95	123	0	0.01 (1)	0.008 (1)	0.05 (6)	0.07 (8)
1996-98	513	0.03 (13)	0.03 (16)	0.01 (9)	0.06 (29)	0.13 (67)
1999-01	544	0.06 (30)	0.01 (5)	0.007 (4)	0.05 (26)	0.12 (65)
2002-04	572	0.03 (16)	0.03 (19)	0.003 (2)	0.06 (36)	0.13 (73)
2005-07	650	0.03 (18)	0.03 (19)	0.003 (2)	0.09 (57)	0.15 (96)
2008-10	311	0.01 (4)	0.03 (8)	0	0.03 (10)	0.07 (22)
2011-13	275	0.02 (5)	0.03 (8)	0	0.06 (17)	0.11 (30)
2014-16	177	0.02 (4)	0.01 (1)	0	0.08 (15)	0.11 (20)
Parity						
1	1219	0.03 (40)	0.03 (34)	0.003 (4)	0.05 (56)	0.11 (134)
2	809	0.02 (19)	0.02 (15)	0.01 (12)	0.08 (70)	0.14 (116)
3	488	0.02 (12)	0.02 (10)	0.004 (2)	0.06 (30)	0.11 (54)
4	276	0.02 (5)	0.04 (10)	0.004 (1)	0.07 (18)	0.12 (34)
5	373	0.03 (14)	0.02 (8)	0.003 (1)	0.06 (22)	0.12 (45)
Genetic Group						
1	342	0.03 (11)	0.03 (10)	0.006 (2)	0.07 (25)	0.14 (48)
2	2634	0.03 (74)	0.02 (61)	0.006 (16)	0.06 (161)	0.12 (312)
3	189	0.03 (5)	0.03 (6)	0.01 (2)	0.05 (10)	0.12 (23)

Table 4.8: Chi-square value for calving disorders in Karan Fries cows

Effect	df	Pearson chi-square value				
		Abortion	Dystocia	Still birth	Premature birth	Calving abnormalities
Season	3	11.37**	23.87**	0.91	2.34	9.62*
Period	7	16.26*	21.84**	15.44*	15.13*	15.46*
Parity	4	1.275	4.0	3.87	12.62**	1.20
Genetic group	2	1.03	0.21	0.94	0.58	1.28

*- Significant (P<0.05); **-Significant (P<0.01)

Tomar and Verma (1988) observed that the season of calving did not statistically influence dystocia, stillbirth, abortion and premature birth in Friesian crossbreds. Similar effect of season of calving on calving abnormality was reported by Vaccaro and Vaccaro (1981) in Friesian crossbreds. Mukherjee *et al*. (1993), Satyapal (2003) and Balasundaram *et al*. (2011b) and Sharma (2010) also found that season of calving had no significant effect on dystocia in Karan Fries cows. Satyapal (2003) and Balasundaram *et al*. (2011b) could not observe any significant influence of season of calving on incidence of stillbirth in Karan Fries cows. Similarly, Balasundaram *et al*. (2011b) reported that season had non-significant effect on incidence of abortion in Karan Fries cows. Contrarily, Mukherjee *et al*. (1993) and Satyapal (2003) reported that season of calving had significant effect on abortion. Incidence of abortion and stillbirth was low during winter and high during summer season (Mukherjee *et al*., 1993).

Period

The present findings (Tables 4.7-4.8) indicated that the lowest incidence (0.06) of calving health traits was observed during the period of 1993-95 and the highest incidence (0.15) was found during the period of 2005-07. It was further observed that the incidence of dystocia varied from 0.0 (1993-95) to 0.01(2008-10) in different period. The value of still birth ranged from 0.02 during 2011-13 to 0.6 during the period 1999-01 Incidence of other calving health indicators varied from 0.00 (Period 2008-16) to 0.01 (Period 1996-98) for premature birth; from 0.03 (2008-10) to 0.09 (2005-07) for abortion, respectively. Chi-square analysis showed that the effect of period was significant (P<0.05) for premature birth abortion stillbirth and, overall calving ease. Whereas, it was highly significant (P<0.01) for dystocia.

Balasundaram *et al*. (2011b) and Sharma (2010) found that period had no significant effect on abortion and stillbirth in Karan Fries cows. Satyapal (2003) also observed non-significant effect of period of calving on incidence of stillbirth but significant effect on abortion in Karan Fries cows. However, Tomar and Verma (1988) reported significant effect of period of calving on dystocia, stillbirth, abortion and premature birth in Friesian crossbred.

Parity

The incidence of calving health traits varied from 0.11 to 0.14 across different parities of KF cows. Highest incidence was observed in second (0.14) for dystocia, in fifth parity (0.037) for still-birth, in second parity for premature birth (0.01) and abortion (0.081). There was no specific trend in incidence of calving disorders across the different parities. The Chi squares analysis has indicated that the effect of parity was not significant for all calving health (dystocia, still birth and abortion) traits but highly significant for premature birth.

Prabhu and Chatterjee (1970) and Vaccaro and Vaccaro (1981) Balasundaram *et al*. (2011b) and Sharma (2010) could not found significant effect of parity on calving disorders in Holstein crossbred cows. Satyapal (2003) observed non-significant effect of parity on incidence of stillbirth in Karan Fries cows. Contrarily, Mukherjee *et al*. (1993) reported that parity had significant effect on calving abortion and dystocia in Karan Fries cows.

Genetic group

The present results (Tables 4.7-4.8) revealed that F1 crosses had higher incidence (0.14) of calving health indicators as compared to those of Interbred group (0.12) and higher crosses (0.12). Statistically, the calving health traits were not significantly affected by genetic groups. The estimates of incidence of dystocia, still-birth, premature-birth and abortion were found to be 0.03, 0.02, 0.006 and 0.06, respectively in interbred group of Karan Fries cows.

Tomar and Verma (1988) reported that the frequency of abnormal calvings did not differ significantly among different genetic groups produced from mating in various combinations of Holstein×Sahiwal and Holstein×Tharparkar animals at NDRI, Karnal.

Similarly, Balasundaram *et al*. (2011b) and Sharma (2010) found that genetic group had no significant effect on the incidence of dystocia, stillbirth and abortion in Karan Fries cattle. Pandey and Desai (1972) observed lowest incidence of abortion in half grades (6.82%) than 5/8 grades (7.89%) and grades (7.61%) of Frisian ×Sahiwal.

4.2 Logistic regression analysis to identify the influence of genetic and non-genetic factors on various functional traits

For the analysis of binary or discontinuous nature of response variable, a multiple logistic regression model was used to explore the relationship between the dependent and explanatory variables as well as for predicting the response.

Logistic regressions work with odds rather than proportions. The odds are the ratio of the proportion for the two possible mutually exclusive outcomes. If p is the proportion for one outcome, then (1-p) is the proportion for the second mutually exclusive outcome.

To study the incidence of functional traits, logistic regression analysis was used to assess the influence of various genetic and non-genetic factors.

4.2.1 Effect of various non-genetic factors on incidence of udder health indicator traits in terms of ODDS values

The multiple logistic regression results revealed that the incidence of flakes were higher in rainy season, while incidence of blood in milk and teat block was found maximum in winter season. The multiple logistic regression analysis also revealed higher ODDS ratio in favour of normal udder health in animals calved during autumn season (table 4.9-4.10)

Periods: The incidence of normal udder health varied from 3.503 to 0.492, >999.99 to 0.188 and >999.99 to 0.340 with respect to flakes, blood in milk and teat block in different periods, lowest incidence for normal udder health (0.492) was observed in the period of 2005-07 so incidence of flakes were maximum in these period, and over the periods from 2005-2016 significantly ($P<0.01$) decreasing trend of incidence was observed for flakes and increasing trend of incidence was observed for blood and milk and teat block.

Table 4.9 Effect of various non-genetic factors on incidence of udder health indicator traits in terms of ODDS values

Effect	Udder health indicator traits			
	Calving	**Flakes**	**Blood in milk**	**Teat block**
Season	Summer	1.320	2.904	1.375
	Rainy	0.686	1.473	1.196
	Autumn	2.271	2.907	1.198
	winter	1.00	1.00	1.00
Period	1993-95	3.503	>999.99	>999.99
	1996-98	0.680	0.230	1.400
	1999-01	1.222	0.362	5.613
	2002-04	0.544	0.322	3.335
	2005-07	0.492	0.336	1.541
	2008-10	0.604	0.320	0.553
	2011-13	0.997	0.188	0.340
	2014-16	1.00	1.00	1.00
Parity	1	2.095	0.757	1.576
	2	0.996	2.446	2.696
	3	0.851	0.652	1.04
	4	0.798	0.658	0.924
	5	1.00	1.00	1.00
Genetic group	1	1.033	0.877	1.66
	2	0.913	1.036	2.05
	3	1.00	1.00	1.00
Stage of Lactation	1	1.624	0.878	1.672
	2	1.268	0.758	2.413
	3	1.00	1.00	1.00

Parity: The incidence of normal udder health varied from 2.095 to 0.798, 2.446 to 0.652 and 2.696 to 0.924 with respect to flakes, blood in milk and teat block among different parities of KF cows. Lowest incidence was observed for normal udder health in third (0.0851) and fourth parity (0.798) it showed that maximum incidence were found in third and fourth parity, incidence blood in milk and teat block were also found maximum in third and fourth parity.

Genetic group: The incidence of normal udder health in different genetic groups varied from 1.033 to 0.41, 1.036 to 0.877 and 2.05 to 1.00 with respect to flakes, blood in milk and teat block. The lowest proportion of normal udder health (0.913) was observed in interbreeds than those of F1 crosses (1.033) and higher crosses (1.00) for flakes, Thus maximum incidence of flakes were observed in interbreeds. Highest proportion of Blood in milk were found in F1 crosses while teat block found maximum in higher crosses (Table 4.9). However, statistical analysis failed to show any significant effect of genetic groups on the flakes, blood in milk and teat block

Stages of lactation: The incidence of normal udder health in different stages of lactation varied from 1.62 to 1.00, 1.00 to 0.758 and 2.413 to 1.00 with respect to flakes, blood in milk and teat block. However the effect of lactation was not found to be statistically significant on odd ratio for blood in milk and teat block

The Wald chi-square estimates for different non-genetic factors indicated highly significant ($P<0.01$) influence of season of calving and parity on incidence of flakes and blood in milk. The effect of period was also highly significant ($P<0.01$) on incidence of flakes and teat block and significant effect ($P<0.05$) on incidence of blood in milk. Stage of lactation had highly significant ($p<0.01$) effect on incidence of flakes only and was non-significant for incidence of blood in milk and teat block Genetic group had no significant effect on incidence of udder health traits (table 4.10)

Table 4.10 Wald Chi-square value for udder health indicators in KF cattle

Effect	df	Wald chi-square value		
		Flakes	**Blood in milk**	**Teat block**
Season	3	92.00**	36.35**	3.34
Period	7	86.49**	14.51*	36.78**
Parity	4	65.15**	26.96**	5.55
Genetic group	2	1.12	0.52	2.70
Stage of lactation	2	11.07**	1.06	2.24

**Significant (p<0.05); **Significant (p<0.01)*

4.2.2 Effect of various non-genetic factors on incidence of ovarian and uterine health indicator traits in terms of ODDS values

The multiple logistic regression results revealed that the incidence of cystic ovary, metritis, endometritis and pyometra were highest in rainy season. It also showed a higher ODDS ratio in favour of normal ovarian and uterine health in animals calved during autumn season (Table 4.11-4.12).

Periods: The incidence of normal ovarian and uterine health varied from 1.34 to 0.086,1.00 to 0.200, >999.99 to 1.00 and 8.285 to 1.00 with respect to cystic ovary, metritis, endometritis and pyometra in different periods. Incidence of cystic ovary were found to be maximum in period from 2005 to 2007. Incidence of endometritis and pyometra was highest from period 2014 - 2016 and Incidence of metritis was highest from period 1996-1998. Over the periods from 1996 - 2005 an increasing trend of incidence was observed for cystic ovary. There was decreasing trend of incidence observed for cystic ovary and metritis from period 2008 – 2016.

Parity: The incidence of normal ovarian and uterine health varied from 7.483 to 1.00, 0.839 to 1.00, 4.344 to 1.00 and 0.556 to 1.00 with respect to cystic ovary, metritis, endometritis and pyometra in different parities. The lowest incidence was observed for first parity while highest incidence was observed for cystic ovary in third, fourth and fifth parity, for metritis in second parity, for endometritis in fifth parity and for pyometra highest incidence was found in fourth parity. Overall the results showed an increasing trend in these disorders with the increasing parity order.

Genetic group: In case of cystic ovary, metritis, endometritis and pyometra, the incidence were lowest in higher crosses (1.00), interbreeds (0.986), higher cross (1.00) and F1 cross (0.525) respectively. Thus maximum incidence of cystic ovary and endometritis was found in higher crosses, metritis in interbreeds and pyometra in F1 cross.

Stage of lactation: Incidence of cystic ovary and pyometra was found maximum in second stage of lactation, metritis had maximum incidence in first stage of lactation and incidence of endometritis was observed maximum in first stage of lactation (Table 4.11).

The Wald chi-square estimates for different non-genetic factors indicated highly significant ($P<0.01$) influence of season and period of calving on all ovarian and uterine health traits (cystic ovary, metritis, endometritis and pyometra) as shown in Table 4.12.

Parity also had highly significant (P<0.01) influence on the incidence of cystic ovary, metritis and endometritis. Genetic group had highly significant effect (P<0.01) only for pyometra. Stage of lactation was significantly (P<0.05) influence only on endometritis, whereas effect of stage of lactation for other ovarian and uterine health indicator traits was observed non-significant (Table 4.12).

Table 4.11: Effect of various non-genetic factors on incidence of ovarian and uterine health indicator traits in terms of ODDS values

Effect	Calving	Ovarian and uterine health indicator traits			
		Cystic ovary	Metritis	Endometritis	Pyometra
Season	Summer	1.592	1.106	0.904	0.457
	Rainy	0.791	0.663	0.304	0.110
	Autumn	2.07	1.440	2.456	0.375
	Winter	1.00	1.00	1.00	1.00
Period	1993-95	1.342	0.682	<999.99	1.510
	1996-98	0.649	0.200	31.05	3.453
	1999-01	0.375	0.222	58.07	5.987
	2002-04	0.144	0.250	264.95	7.712
	2005-07	0.086	0.204	12.80	8.285
	2008-10	0.203	0.767	16.28	6.145
	2011-13	0.454	0.927	2.64	1.253
	2014-16	1.00	1.00	1.00	1.00
Parity	1	7.483	1.402	4.344	0.349
	2	1.396	0.839	2.919	0.556
	3	1.007	0.938	1.794	0.318
	4	1.062	0.862	1.830	0.278
	5	1.00	1.00	1.00	1.00
Genetic group	1	1.273	1.118	2.009	0.525
	2	1.054	0.986	1.282	1.26
	3	1.00	1.00	1.00	1.00
Stage of Lactation	1	1.02	0.698	2.075	0.405
	2	0.778	0.819	3.852	0.307
	3	1.00	1.00	1.00	1.00

Table 4.12: Wald Chi-square values for ovarian and uterine health indicator traits in KF cattle

Effect	df	Wald chi-square value			
		Cystic ovary	Metritis	Endometritis	Pyometra
Season	3	51.15**	21.10**	36.37**	45.59**
Period	7	215.55**	62.33**	133.3**	44.77**
Parity	4	158.5**	12.16**	12.51**	6.45
Genetic group	2	1.5	0.48	1.56	8.34**
Stage of lactation	2	1.6	4.30	7.52*	0.40

**Significant (p<0.05); **Significant (p<0.01)*

4.2.3 Effect of various non-genetic factors on incidence of fertility and post calving uterine health indicators in terms of ODDS values

The multiple logistic regression results revealed that the incidence of repeat breeding, anestrous and retention of placenta was highest in rainy season. It also revealed higher ODDS ratio in favour of normal fertility and post calving uterine health in animals calved during autumn season as shown in Table 4.13 below.

Period: The incidence of normal fertility and post calving uterine health varied from 5.086 to 1.00, 2.004 to 0.301 and 1.709 to 0.523 with respect to repeat breeding, anestrous and retention of placenta in different periods. Incidence of repeat breeding and anestrous were found to be maximum in period from 2002 to 2004 and incidence of retention of placenta was highest from period 1996 to 1998.

Parity: Parity significantly influenced the incidence of repeat breeding, anestrous and retention of placenta and highest incidence of repeat breeding and anestrous was observed in second parity, while fourth parity has highest incidence of retention of placenta

Genetic group and stage of lactation: Genetic group and stage of lactation had no significant effect on fertility and post calving uterine health traits.

The Wald chi-square estimates for different non-genetic factors indicated highly significant (P<0.01) influence of parity and period of calving in all fertility and post calving uterine health traits (Repeat breeding, anestrous and retention of placenta) as shown in Table 4.14. Season of calving has significant (P<0.05) effect on repeat breeding and highly significant (P<0.01) effect on anestrous and retention of placenta.

Table 4.13: Effect of various non-genetic factors on incidence of fertility and post calving uterine health indicators in terms of ODDS values

Effect	Calving	Fertility and post calving uterine health indicators		
		Repeat breeding	Anestrous	Retention of Placenta
Season	Summer	0.900	1.037	1.572
	Rainy	0.563	0.614	1.016
	Autumn	1.145	1.324	1.945
	Winter	1.00	1.00	1.00
Period	1993-95	2621	2.004	1.309
	1996-98	2.834	1.134	0.523
	1999-01	1.400	0.610	0.557
	2002-04	0.773	0.301	0.809
	2005-07	0.847	0.765	0.733
	2008-10	2.534	0.949	0.961
	2011-13	5.086	0.395	1.709
	2014-16	1.00	1.00	1.00
Parity	1	0.678	0.933	2.125
	2	0.385	0.541	1.186
	3	0.486	0.755	1.128
	4	0.427	0.691	0.847
	5	1.00	1.00	1.00
Genetic group	1	1.147	0.99	0.963
	2	1.053	0.96	0.786
	3	1.00	1.00	1.00
Stage of Lactation	1	0.823	0.98	0.731
	2	0.910	1.07	0.983
	3	1.00	1.00	1.00

Table 4.14: Wald Chi-square values for fertility and post calving disorder in KF cattle

Effect	df	Wald chi-sq values		
		Repeat Breeding	Anestrous	Retention of Placenta
Season	3	11.28*	31.69**	33.58**
Period	7	41.68**	123.74**	39.45**
Parity	4	15.65**	27.5**	31.27**
Genetic group	2	0.156	0.08	2.77
Stage of lactation	2	0.576	0.17	3.83

**Significant (p<0.05); **Significant (p<0.01)*

4.2.4 Effect of various non-genetic factors on incidence of calving health indicators in terms of ODDS values

The multiple logistic regression results revealed that the incidence of dystocia and still birth were highest in winter season, premature birth incidence was found maximum in autumn season whereas incidence of abortion was found to be maximum in rainy season (table 4.15- 4.16).

Period: The incidence of normal calving health varied from 2.834 to 0.990, >999.99 to 0.330, >999.99 to 0.151 and 1.00 to <0.001 with respect to abortion, dystocia, still birth and premature birth in different periods. In case of incidence of abortion and dystocia an increasing trend was observed from period 2008 to 2016 and not a particular trend was observed on incidence of still birth. There was no cases of premature birth from period 1993–2008 and from 2011-2016 incidence was observed in decreasing trend.

Parity: No particular trend was observed for calving health traits (abortion, dystocia and still birth) in different parities only premature birth was significantly influenced with highest incidence in second parity.

Genetic groups: The incidence of normal calving health varied from 0.700 to 1.00, 0.794 to 1.00, 1.00 to 1.438 and 2.37 to 1.00 with respect to abortion, dystocia, still birth and premature birth in different genetic groups. Incidence of abortion and dystocia was observed maximum in F1 cross, Whereas incidence of still birth and premature birth was observed maximum in higher cross

The Wald chi-square estimates for different non-genetic factors indicated significant (p<0.05) influence of season on abortion and highly significant (P<0.01) on dystocia. Period has highly significant (P<0.01) effect on abortion and significant (P<0.05) influence on dystocia. Effect of parity was observed significant (P<0.05) only for on premature birth (Table 4.16).

Table 4.15: Effect of various non-genetic factors on incidence of calving health indicators in terms of ODDS Values

Effect	Calvings	Calving health indicators			
		Abortion	Dystocia	Still birth	Premature birth
Season	Summer	0.713	1.741	1.096	1.371
	Rainy	0.655	2.275	1.426	0.702
	Autumn	1.192	5.439	1.093	0.568
	Winter	1.00	1.00	1.00	1.00
Period	1993-95	2.141	>999.99	>999.99	<0.001
	1996-98	2.017	0.803	0.153	<0.001
	1999-01	2.340	0.330	0.575	<0.001
	2002-04	1.572	0.754	0.151	<0.001
	2005-07	0.990	0.707	0.173	<0.001
	2008-10	2.834	1.760	0.201	<0.001
	2011-13	1.455	1.205	0.177	0.930
	2014-16	1.00	1.00	1.00	1.00
Parity	1	1.625	0.793	0.715	1.282
	2	1.095	1.240	1.141	0.256
	3	1.096	1.330	1.024	0.782
	4	0.918	2.087	0.531	0.810
	5	1.00	1.00	1.00	1.00
Genetic group	1	0.700	0.794	1.103	2.37
	2	0.831	0.953	1.438	2.24
	3	1.00	1.00	1.00	1.00

Table 4.16: Chi-square value for calving health indicators in Karan Fries cows

Effect	df	Wald chi-square value			
		Abortion	Dystocia	Still birth	Premature birth
Season	3	9.24*	19.85**	0.9168	1.93
Period	7	21.18**	18.06*	10.6	4.8
Parity	4	0.9	5.01	4.5	9.21*
Genetic group	2	5.5	0.32	1.12	1.10

*Significant (p<0.05); **Significant (p<0.01)

4.3 Performance of production and reproduction traits in Karan Fries cattle

Means, standard errors and coefficients of variation of various first lactation traits in Karan Fries cattle were calculated and the results are discussed under the following headings. The results are summarized and presented in table 4.17.

Table 4.17: Means, standard error (SE) and coefficient of variation (CV) of first lactation and production and reproduction traits

Traits	No. of observation	Mean ± S.E (kg)	C.V. (%)
FL305DMY (Kg)	960	3164.87 31.52	30.8
FLTMY (Kg)	953	3832.36 50.17	40.4
FLL (days)	960	343.14 3.42	30.9
WA (Kg)	956	10.89 0.09	25.8
MY/FCI (Kg)	760	8.95 0.10	30.4
AFC (days)	960	1045.60 4.58	13.5
CFI (days)	508	104.01 2.74	59.5
FSP (days)	533	170.39 3.74	50.7
PR (%)	485	36.62 1.28	77.3
Herd life (days)	960	1773.55 19.38	33.8

4.3.1. Production traits

4.3.1.1. First lactation 305-days or less milk yield (FL305DMY)

Mean 305 days or less mild yield of Karan Fries cattle was estimated as 3164.87 ± 31.52 Kg with coefficient of variation as 30.8% during first lactation (Table 4.17). Previous reports showed that average first lactation 305 days or less lactation milk yield ranged between 2470 ± 20 (Saha, 2001) and 3562 ± 27 (Rashia, 2010) and present study also showed the results within the reported range. Present results of first lactation 305-days or less milk yield in KF cattle were more or less similar to the reports by Nehra (2011), Divya (2012) and Dash (2014).

4.3.1.2 First lactation total milk yield (FLTMY)

Means first lactation total milk yield in Karan Fries cattle was estimated as 3832.36 ± 50.17 Kg with coefficient of variation of 40.4% (Table 4.17). Available literature showed that average first lactation total milk yield in KF cattle ranged between 2823 (Saha, 2001) to 3908 Kg (Sinha, 1999). Observed in first lactation total milk yield values reported earlier.

4.3.1.3 First lactation length (FLL)

Average first lactation length in Karan Fries cattle was obtained as 343.14 ± 3.42 days with a coefficient of variation of 30.9% (Table 4.17). Perusal of literature revealed that average first lactation length in KF cattle ranged from 315.25 days (Saha, 2001) to 359.92 (Nehra, 2011).

4.3.1.4 First lactation 305 days or less wet average (WA)

Average first lactation 305 day or less wet average in Karan Fries cattle was estimated as 10.89 ± 0.09 Kg with a coefficient of variation of 25.8% (Table 4.17). The present observations were nearly in agreement with previous reports by Dash (2014), where, it was observed as 11.3 ± 0.05 Kg in Karan Fries cattle.

4.3.1.5 Milk yield per day of first calving interval (MY/FCI)

Average milk yield per day of first calving interval was obtained as 8.95 ± 0.10 kg with a coefficient of variation of 30.4 % (Table 4.17). The average 305 milk yield per day of first calving interval in the present study was in accordance with the values earlier reported which ranged from 5.44 Kg (Nehra, 2011) to 9.58 kg (Dash, 2014), which were in the result of present study.

4.3.2 Reproduction traits

4.3.2.1 Age at first calving (AFC)

Mean age at first calving was observed to be 1045.60 ± 4.58 days with a coefficient of variation of 13.5 % in Karan Fries cattle (Table 4.17). Among the available literature, average age at first calving (days) ranged from 850 days (Nagarcenkar and Rao, 1982) to 1023 days (Divya, 2012). The mean values obtained in the present study was in close conformity to the results obtained by Divya (2012).

4.3.2.2 Calving to first insemination (CFI)

Mean calving to first insemination in Karan Fries cattle was estimated as 104.01 ± 2.74 days with a coefficient of variation of 59.5% in the present study (Table 4.17). The results are similar to those of Dash (2014) and Divya (2012) in Karan Fries cows.

4.3.2.3 First service period (FSP)

Mean first service period in Karan Fries cattle was obtained as 170.39 ± 3.74 days with a coefficient of variation of 50.7% (Table 4.17). Average first service period were less than 142.90 ± 10.82 days as reported earlier by many workers (Singh and Tomar, 1991; Singh, 1995: Sahana, 1996; Panja, 1997; Sinha, 1999; Saha, 2001; Singh *et al*., 2001; Divya, 2012 and Dash, 2014) in Karan Fries cattle. However, in the present study, higher value of first service period was observed in comparison to previous reports. Though Rathee (2015) have reported higher mean first service period of 153 ± 3.79 days and 164.51 ± 164.51 ± 2.51 days, respectively in KF cattle.

4.3.2.4 Pregnancy rate (PR)

Average pregnancy rate of Karan Fries cattle was obtained as 36.62 with a coefficient of variation of 77.3 % (Table 4.17). Although, average pregnancy rate was observed previously as 41% (Divya, 2012) and 33 % (Dash, 2014). Reported voluntary waiting period and mean of overall lactation was in the calculation for the pregnancy rate (Dash, 2014).

4.3.3 Herd life

Longevity of animal was considered as the period from date of birth to date drying off in different lactations (up to sixth lactation). Average longevity of Karan Fries cattle was observed as 1773.55 days with coefficient of variation of 33.80% (Table 4.17). Results were in conformity to the available previous reports, where, longevity ranged between 1048 days (Singh and Tomar, 1991) to 2974 days (Sharma, 2010) in Karan Fries cattle.

Table 4.18: Least square means and standard errors of first lactation production traits in Karan Fries cattle

Effects	FL305DMY (Kg)	FLTMY (Kg)	FLL (days)	WA (Kg)	MY/FCI (Kg)
Overall (μ)	3164.87 ± 31.52	3832.87 ± 50.17	343.14 ± 3.42	10.89 ± 0.09	9.30 ± 0.15
Period of calving					
1	3010.20 ± 58.39	3519.51 ± 134.39	321.47 ± 10.46	10.18 ±0.22	8.27 ± 0.29
2	2687.7 ± 31.7	3134.04 ± 119.08	314.55 ± 9.9	9.34 ± 0.19	7.56 ± 0.29
3	2886.04 ± 82.01	3288.04 ± 111.25	351.50 ± 9.66	9.44 ± 0.24	7.72 ± 0.24
4	3104.62 ± 8.02	3834.25 ± 119.29	341.8 ± 9.21	10.60 ± 0.22	9.39 ± 0.24
5	3104.62 ± 8.02	3834 ± 119.24	341.8	10.60 ± 0.22	9.39 ± 0.24
6	3469.93 ± 76.61	4145.08 ± 128.18	351.77 ± 7.24	11.80 ± 0.22	9.84 ± 0.23
7	3634.79 ± 69.51	4438.03 ± 124.19	363.15 ± 8.32	12.41 ± 0.20	9.94 ± 0.23
8	3061.98 ± 115.29	3636.25 ± 192.50	338.58 ± 14.58	10.79 ± 0.38	7.31 ± 0.43
Season of calving					
1	3076.90 ± 61.85	3809.36 ±101.64	314.96 ± 6.91	10.57 ± 0.16	8.81 ± 0.18
2	3158.61 ± 86.53	3849.36 ± 130.79	328.32 ± 8.44	10.68 ± 0.24	8.89 ± 0.18
3	3262.14 ± 75.52	3764.16 ± 112.70	359.95 ± 17.54	11.31 ± 0.22	9.28 ± 0.23
4	3258.14 ± 82.52	3874.64 ± 77.97	344.48 ± 5.41	10.98 ± 5.41	8.90 ± 0.16

Genetic group					
1(HF x TP)	3753.91 ± 14	4425.12 ± 21	366.10 ± 12.4	12.91± 0.39	109 ± 0.39
2(KF x KF)	3091.35 ± 31.8	3748.98 ± 52.04	341.04 ± 3.62	10.64 ± 0.09	8.69 ± 0.48
3(HF x KF)	3775.3 ± 17.6	4513.12 ± 12.2	353.13 ± 17.4	12.50 ± 0.44	10.7 ± 0.62
Age groups (days)					
<921	3083.23 ± 76.39	3767.16 ± 118.19	367.15 ± 7.91	10.69 ± 0.28	8.96 ± 0.21
922-1112	3189.24 ± 49.33	3881.1.9 ± 70.85	344.61 ± 4.83	10.93 ± 0.12	9.11 ± 0.14
1113-1463	3197.49 ± 66.77	3778.25 ± 103.49	338.50 ± 6.96	10.91 ± 0.19	8.83 ± 0.21
>1463	3100.41 ± 178.65	3100.57 ± 107.21	330.83 ± 12.35	10.86 ± 0.32	8.35 ± 0.36

Table 4.19: ANOVA (M.S. values) of first lactation production traits in KF cattle

Source of variation	FL305DMY (Kg)	FLTMY (Kg)	FLL (days)	WA(Kg)	MY/FCI (Kg)
Sire	1262236.15 (159)	3045806.6**(158)	11396.01(158)	9.7**(158)	1.5**(158)
Season of calving	212207.02 (3)	1920234 (3)	26166.01 (3)	5.4 (3)	4.04 (3)
Period of calving	128281.91*(7)	1659442.43 (7)	5543.34 (7)	14.4** (7)	5. (7)
Age group	540623.74 (3)	948411.20 (3)	1491.82 (3)	3.49 (3)	2.081 (3)
Genetic group	544758.87* (2)	2513868.06 (2)	5127.14 (2)	13.68* (2)	9.7 (2)
Error	705408.96 (739)	1956214.73.(733)	1090.24 (744)	5.59 (743)	5.64(546)

Figures in parentheses represent number of degrees of freedom
**Significant (p<0.05); **Significant (p<0.01)*

4.4 Non-genetic factors affecting production and reproduction traits in Karan Fries cattle

4.4.1 Production traits

4.4.1.1 First lactation 305-days or less milk yield (FL305DMY)

Least-squares means and analysis of variance for first lactation 305-days or less milk yield in Karan Fries cattle are presented in Tables 4.18 and 4.19. Overall least-squares mean for first lactation 305 days or less milk yield in Karan Fries cattle was 3164.87 ± 31.52 Kg. First lactation 305 days or less milk yield in Karan Fries cattle was not significantly affected by the season of calving (Table 4.19). Similar non-significant results were reported earlier by Panja (1997), Sivakumar (1998), Rashia (2010), Nehra (2011), Divya (2012) and Dash (2014), On contrary, Sinha (1999), Sahana (1996), Saha (2001), Singh and Gurnani (2004) and Kokate (2009) had reported a significant effect of season of calving on first lactation 305-days or less milk yield in KF cattle.

Period of calving and genetic group had significant effect ($P<0.05$) on first lactation 305 days or less milk yield in Karan Fries cattle. Similar results were reported by Sahana (1996), Sivakumar (1998), Saha (2001), Singh *et al*. (2006) and Kokate (2009), where they have found significant effect of period of calving on FL305 DMY while, some researches were not able to establish any significant influence of the period of calving on the same trait (Panja, 1997; Sinha, 1999; Singh and Gurnani, 2004; Nehra, 2011 and Divya, 2012).

Age at first calving had no significant effect on the first lactation 305 days or less milk yield in Karan Fries cattle. Divya (2012) and Dash (2014), had also reported non-significant influence of AFC on FL305 DMY in KF cattle. On the contrary, Sahana (1996) had reported a significant effect of AFC on first lactation 305 days or less milk yield (Table 4.19).

4.4.1.2 First lactation total milk yield (FLTMY)

Least squares means and analysis of variance of first lactation total milk in Karan Fries cattle are presented in Tables 4.17 and 4.18. First lactation total milk yield in KF cattle was not significantly influenced by the season of calving (Table 4.19). Similarly, Singh (1995, Panja, (1997) and Nehra (2011) had found no significant influence of season of calving on first lactation total milk yield in KF cattle. However, Singh and Tomar (1991), Sivakumar (1998) and Dash (2014) reported significant effect of the season of calving on first lactation total milk yield in KF cattle.

There was no significant effect of the period of calving and genetic group on first lactation total milk yield in KF cattle. Similarly, Singh, 1995, Panja (1997), Sinha (1999), Sahana and Gurnani (2000), Saha (2001) and Nehra (2011) also observed non-significant association. On the contrary, Singh and Tomar (1991), Singh *et al*. (1993) and Dash (2014) reported significant effect of the period of calving on the first lactation total milk yield in KF cattle.

Likewise, there was no significant effect of the age at first calving and genetic group on the first lactation total milk yield in KF cattle (Table 4.19). The results were similar to the observations made by Singh (1995), Panja (1997) and Nehra (2011). However, Sahana and Gurnani (2000) and Saha (2001) had found significant effect of age at first calving on the first lactation total milk yield in KF cattle.

4.4.1.3 First lactation length (FLL)

Overall least- square means of first lactation length was 343.14 ± 3.42 days in Karan Fries cattle (Table 4.17). The season of calving had no significant influence on first lactation length (Table 4.19), which is in agreement with previous reports (Saha, 2001 and Sharma, 2010). While, reports of significant influence was also available although (Singh, 1995; Sahana, 1996; Panja, 1997; Sahana and Gurnani, 2000 and Dash, 2014) in Karan Fries cattle.

First lactation length of Karan Fries cattle was not significantly influenced by the period of calving (Table 4.19). The results are in conformity to the reports of Sinha (1999), Saha (2001) and Sharma (2010) who also could not establish any significant influence of period of calving on first lactation length. Although, previously reports on significant effect of period of calving on first lactation length was observed (Singh, 1995; Sahana, 1996; Panja, 1997; Sivakumar, 1998; Nehra, 2011; and Dash, 2014).

Perusal of results (Table 4.19) showed that age at first calving and genetic group has no significant effect on the first lactation length. The results were similar to the observations made by Panja (1997), Sinha (1999), Saha (2001) and Nehra (2011). While, Singh (1995), Sahana (1996), Sivakumar (1998), Sahana and Gurnani (2000) had reported significant effect of age of first calving on the first lactation length in KF cattle.

4.4.1.4 First lactation 305 days or less wet average (WA)

Least squares mean of first lactation wet average in KF cattle was estimated as 10.89 ± 0.09Kg (Table 4.17). Season of calving had no significant effect on the first lactation 305 days or less wet average in Karan Fries cattle (Table 4.19). Dash (2014) had reported a significant influence of season of calving on the first lactation 305 days or less wet average in Karan Fries cattle. Similarly, period of calving (P<0.01) and genetic group (P<0.05) had significantly influence on first lactation wet average in KF cattle (Table 4.19). The results of present study were similar to the report of Dash (2014). However, effect of age at first calving had no significant on the first lactation 305 days or less wet average in Karan Fries cattle, which was in agreement with the findings of Dash (2014) in Karan Fries cattle.

4.4.1.5 Milk yield per day of first calving interval (MY / FCI)

Least squares mean of milk yield per day of first calving interval was 8.95 ± 0.10 Kg in Karan Fries cattle (Table 4.17). Saha *et al.* (2010) had reported least squares mean of milk yield per day of first calving interval in KF cattle as 7.88 ± 0.28 Kg which was almost similar to the present result. Results of Nehra, (2011) were towards the lower side (5.44 Kg), while that of Dash (2014) were towards the higher range (9.58 ± 0.04 Kg) of the present result. Milk yield per day of first calving interval was not significantly influenced by the season of calving and period of calving (Table 4.19) which was in agreement with the reports of Saha (2010) and Dash (2014) in Karan Fries cattle. However, Milk yield per day of first calving interval was found to be significantly influenced by the season of calving (Nehra, 2011) and period of calving (Dash, 2014) in KF cattle.

4.4.2 Reproduction traits

4.4.2.1 Calving to first insemination (CFI)

Least-squares mean and analysis of variance for calving to first insemination in Karan Fries cattle are presented in Table 4.20 and 4.21. Least-square mean for calving to first insemination is 104.01 ± 2.74 days in KF cattle. Present study could not found significant effect of season of calving on calving to first insemination in Karan Fries cattle. The present results were in conformity with the findings of Tadesse *et at*. (2010), Divya (2012) and Dash (2014) where they also could not find any significant influence of season of calving on CFI. However, significant effect of season of calving on calving to first insemination was observed by Sattar *et al*. (2006), Asimwe and Kifaro (2007), Hammound *et al*. (2010) and Potgieter (2012). Period of calving had no significant effect on calving to first insemination in Karan Fries cattle, which were also reported by Divya (2012) in KF cattle. Although, Asimwe and Kiraro (2007), Tadesse *et al*. (2010), Hammound *et al*. (2010), Potgieter (2012) and Dash (2014) had reported significantly influence of period of calving on CFI. Similarly, age at first calving and genetic group had no significant effect on the calving to first insemination in Karan Fries cattle (Table 4.21).

4.4.2.2 First service period (FSP)

Overall least-squares means of first service period in Karan Fries cattle was 170.39 ± 3.74 days (Table 4.20). Season of calving had significant effect on the first service period ($P<0.05$) (Table 4.21) which was in confirmation to the reports of Sahana (1996), Panja (1997), Saha (2001) and Dash (2014). On the contrary, Singh (1995), Sharma (2010) and Divya (2012) reported no significant effect of season of calving on the first service period. First service period was not significantly influenced by period of calving and age at first calving in Karan Fries cattle, which was in agreement with the reports of Singh (1995), Saha (2001) and Sharma (2010). However, earlier reports had indicated a significant effect of period of calving on first service period (Sahana, 1996; Panja, 1997; Divya, 2012 and Dash, 2014).

4.4.2.3 Pregnancy rate (PR)

Least-squares means of first lactation pregnancy rate in KF cattle was estimated as 36.62 ± 1.28 (Table 4.20). Present study showed that season of calving had a highly significant ($P< 0.01$) effect on the first lactation pregnancy rate (Table 4.21). In a study, Ono *et al*. (2016) also found significant influence of season on pregnancy rate. Although, Divya (2012) had reported that seasons have no significant effect on pregnancy rates of Karan Fries cows. No significant effect of period of calving and age group on the first lactation pregnancy rates in Karan Fries cattle was observed. Similar opinion was expressed by Divya (2012), although, Dash (2014) reported a significant effect of the period of calving on first lactation pregnancy rates in KF cattle.

4.4.4 Stayability (Herd life)

Overall least-squares mean of longevity in Karan Fires cattle was obtained as 1773.55 ± 19.38 days (Table 4.20). Season of calving was found to have no significant effect on the longevity in Karan Fries cattle (Table 4.21). Similarly, Singh *et al*. (2002) reported non-significant effect of seasons of calving on longevity. Periods of calving was found to have a significant effect on the longevity ($P<0.05$). On the contrary, Singh *et al*. (2002) reported non-significant effect of period of calving on longevity. Age at first calving and genetic group was found to have significant ($P<0.01$) influence on the longevity in Karan Fries cattle, which were in agreement with reports of Dash (2014).

Table 4.20: Least square means and standard errors of first lactation reproduction traits and longevity in Karan Fries cattle

Effects	CFI (days)	FSP (days)	PR (%)	LNG (days)
Overall (µ)	104.01 ± 2.74	170.39 ± 3.74	36.63 ± 1.28	1773.51 ± 19.38
Period of calving				
1	107.72 ± 8.88	165.63 ± 11.90	34.99 ± 3.27	1852.01 ± 70.57
2	93.43 ± 5.65	171.94 ± 10.95	39.35 ± 3.56	1805.13 ± 67.62
3	91.23 ± 5.39	166.46 ± 9.79	31.68 ± 3.12	1830.08 ± 8.56
4	104.47 ± 5.95	162.78 ± 8.63	40.79 ± 3.54	1768.55 ± 47.31
5	115.10 ± 6.25	168.22 ± 8.08	35.97 ± 2.81	1781 ± 45.96
6	110.33 ± 8.95	181.97 ± 9.22	36.14 ± 5.57	1790.28 ± 39.38
7	104.50 ± 5.23	186.5 ± 16.49	36.14 ± 5.57	1705.78 ± 48.20
8	98.91 ± 6.86	148.26 ± 18.4	37.47 ± 8.42	1503.39 ± 28.32
Season of calving				
1	111.17 5.91	179.16 ± 7.22	37.26 ± 2.65	1792.55 ± 40.40
2	107.34 8.03	163.57 ± 9.27	33.36 ± 3.24	1702.89 ± 43.06
3	93.71 5.51	159.9 ± 9.09	42.35 ± 3.09	1731.69 ± 44.75
4	103.16 ± 4.08	171.73 ± 5.85	34.46 ± 1.88	1802.84 ± 29.84
Genetic group				
1 (HF x TP)	128.19 0.19	163.54 ± 15.4	40.19 ± 4.49	1836.63 ± 10.5
2 (KF x KF)	102.65 2.87	170.05 ± 3.9	36.44 ± 1.39	1750.39 ± 19.6
3 (HF x KF)	103.19 76.96	178.48 ± 15.02	34.4 ± 5.05	1754.73 ± 95.8
Age groups (days)				
<921	108.99 ± 6.04	173.23 ± 8.06	32.74 ± 2.39	1816.70 ± 5.91
922-1112	104.07 ± 3.38	168.69 ± 5.54	39.82 ± 2.01	1684.16 ± 25.11
1113-1463	97.93 ± 6.03	174.44 ± 7.86	36.23 ± 2076	1854.39 ± 38.8
>1463 days	102.56 ± 9.76	158.69 ± 11.9	2939 ± 2.91	1892 ± 4.93

Table 4.21: ANOVA (M.S. values) of first lactation reproduction traits in KF cattle

Source of variation	CFI (days)	FSP (days)	PR (%)	LNG (days)
Sire	4025.21*(105)	6300.76(130)	760.74 (130)	421768.60**(156)
Season of calving	6564.98 (3)	2736.43 (3)	1138.32** (3)	45636.55(3)
Period of calving	6013.03 (7)	10254.8 (7)	1228.89 (7)	100472.21 (7)
Age group	4296.11 (3)	2179.13 (3)	2058.49(3)	2088942** (3)
Genetic group	2667.11 (2)	3592.76 (2)	63.98 (2)	435785.89**(2)
Error	3603.66 (359)	8047.75 (362)	832.61 (318)	319228.02 (754)

Figures in parentheses represent number of degrees of freedom
**Significant ($p<0.05$); **Significant ($p<0.01$)*

4.5 Genetic and phenotypic parameters

4.5.1 Heritability of production and reproduction traits, longevity and test day milk yield in Karan Fries cattle

Heritability estimates of production and reproduction traits and longevity are summarized in the Table 4.22.

Table 4.22: Heritability estimates of Production and reproduction traits and longevity in KF cattle

Traits	Heritability (h^2 ± S.E)
FL305DMY	0.37 ± 0.08
FLTMY	0.29 ± 0.10
FLL	0.17 ± 0.09
WA	0.44 ± 0.11
MY/CI	0.15 ± 0.11
AFC	0.39 ± 0.09
CFI	0.24 ± 0.22
FSP	0.16 ± 0.12
PR	0.08 ± 0.13
LNG	0.11 ± 0.08

4.5.1.1 Heritability estimates of production traits

4.5.1.1.1 First lactation 305-days or less milk yield (FL305DMY)

Heritability estimates of first lactation 305-days or less milk yield in Karan Fries cattle was obtained as 0.37 ± 0.08 revealing that the FL305DMY is moderately heritable in Karan Fries cattle. The moderate heritability estimate, indicated that a selection can be exercised on this trait through scientific breeding programmes. The results were similar to the observations made by pervious authors, who reported a low to moderate heritability estimates for first lactation 305-days or less milk yield in Karan Fries cattle (Singh, 1995 Sahana, 1996 Sahana, 1996; Panja 1997; Sivakumar, 1998; Sahana and Gurnani, 2000; Saha 2001; Rashia, 2010; Nehra *et al*. 2012 and Dash 2014).

4.5.1.1.2 First lactation total milk yield (FLTMY)

Heritability estimate of first lactation total milk yield in Karan Fries cattle was 0.29 ± 0.19, which indicated a moderate heritability for the trait. Similar results were obtained perviously by various workers (Dash, 2014; Panja, 1997; Saha, 2001 and Nehra *et al*., 2012), where they had reported h^2 ranging from 0.24 to 0.41.

4.5.1.1.3 First lactation length (FLL)

Heritability estimates of first lactation length in Karan Fries cattle was 0.17 ± 0.09. Panja (1997) reported heritability equal to 0.09 in Karan Fries cattle, while, Saha (2001) had reported a slightly higher heritability estimate (h^2 = 0.21) of the trait.

4.5.1.1.4 First lactation 305 days or less wet average (WA)

Heritability estimates of first lactation 305 days or less wet average was obtained as 0.44 ± 0.01 indicating moderate heritability of the trait. The result was almost in conformity to the findings of Dash (2014), who reported heritability estimates of wet average as 0.40 in KF cows.

4.5.1.1.5 Milk yield per day of first calving interval (MY/ FCI)

Heritability estimate of milk yield per day of first calving interval was estimated as 0.15 ± 0.11 in Karan Fries cattle. Other researchers had also reported a moderate heritability estimates in the range of 0.38 ± 0.10 (Hayatnagarkar *et al*., 1990) to 0.42 ± 0.10 (Dash, 2014) in HF crossbred animals.

4.5.1.2 Heritability estimates of reproduction traits

4.5.1.2.1 Age at first calving (AFC)

Heritability estimate of age at first calving was estimated as 0.39 ± 0.09. The result was in conformity to the previous researches indicating inheritance of age at first calving as highly heritable (Panja, 1997; Nehra, 2011; Divya, 2012 and Dash, 2014).

4.5.1.2.2 Calving to first insemination (CFI)

Heritability estimate of calving to first insemination was 0.24 ± 0.22. Previous researchers had reported very low heritability estimates ranging from 0.02 ± 0.008 (Berry *et al*., 2003) to 0.13 ± 0.02 (Haile Mariam *et al*., 2003) in HF cattle, while, Divya (2012) and Dash (2014) had reported low heritability values of 0.016 ± 0.124 ad 0.06 ± 0.04 respectively, in KF cattle.

4.5.1.2.3. First service period (FSP)

First service period of Karan Fries cattle had low heritability of 0.16 ± 0.12 that was similar to the findings of Singh and Tomar (1991), Sahana (1996) and Panja (1997). Previous reports showed that heritability values ranges from 0.04 (Singh and Tomar, 1991) to 0.18 (Dash, 2014) in Karan Fries cattle.

4.5.1.2.4 Pregnancy rate (PR)

Heritability estimate of pregnancy rate was estimates as 0.08 ± 0.13, indicating low heritability estimates of the trait. Heritability estimates of pregnancy rate was reported to be in the range of 0.01 (Dash, 2014) to 0.09 (Kuhn *et al*., 2004), in HF and HF crossbreds. Thus the result was in conformity to the previous reports.

4.5.1.3 Heritability estimates of longevity

Longevity was found to have a low heritability of 0.11 ± 0.08. However Tsuruta et *al*. (2005) reported heritability of longevity in conformity to the previous reports by considering different number of lactations in HF.

4.5.1.4 Parity wise (up to sixth) heritability estimates of test day milk yield using Random Regression Model in Karan Fries cattle

Parity wise test day milk yield data of Karan Fries were analyzed using Random Regression Model (Wilminks' function 1987). Test day of Karan Fries cattle were not fixed at regular intervals as milk constituents were tested as different intervals for different animals. Parity wise average number of days in milk in different test days as observed in milk in different test days as observed is presented in Table 4.23

Table 4.23 Parity wise average number of days in milk in different test days

Test day (TD)	Parity					
	1st	2nd	3rd	4th	5th	6th
1	12	10	10	10	11	10
2	38	36	36	35	45	38
3	66	65	64	65	72	71
4	96	97	97	94	98	102
5	127	125	141	125	126	130
6	156	156	206	166	159	138
7	186	188	127	186	189	189
8	217	219	222	228	220	222
9	247	247	253	246	251	232
10	277	275	284	273	283	282
11	305	305	305	305	305	305

Parity wise heritability (h^2) and permanent environment effect (c^2) for different test day milk yield in Karan Fries cattle is shown in the Table 2.24. Heritability estimates for different test days in first parity were found to range from 0.16 to 0.25; however, the range of permanent environment effect (c^2) was much wider i.e., 0.21 to 0.45. Permanent environment effect was found to be very high in 5th parity and lowest in 6th parity. Heritability estimate for various test days in second parity were high whereas, for second parity it was low to moderate and for parity fourth it was estimates as moderate heritability.

Literature was not available for parity wise heritability of test day milk yield upto sixth lactation in Karan Fries cattle. However, Togashi and Lin (2003), found average of heritability estimate of 0.40, 0.54 and 0.46 in Japanese Holstein cows for first , .second and third lactations respectively. Similar to the present findings, they observed that daily heritability across lactation was larger in the second parity than in third lactation because third parity had larger residual and permanent environmental variances than second parity.

Table 4.24: Parity wise heritability of different test day milk yields in Karan Fries cattle

TD	Parity wise heritability of different test day milk yield in Karan Fries cattle											
	1st		2nd		3rd		4th		5th		6th	
	h^2	c^2	h^2	c^2	h^2	c^2	h^2	c^2	h^2	c^2	h^2	c^2
1	0.24	0.30	0.51	0.25	0.16	0.57	0.25	0.52	0.09	0.72	0.76	0.03
2	0.25	0.26	0.55	0.20	0.17	0.51	0.27	0.46	0.10	0.69	0.76	0.05
3	0.25	0.23	0.58	0.15	0.18	0.46	0.30	0.40	0.11	0.66	0.75	0.08
4	0.25	0.21	0.60	0.11	0.19	0.41	0.32	0.34	0.11	0.63	0.73	0.11
5	0.25	0.21	0.61	0.08	0.20	0.38	0.34	0.30	0.11	0.60	0.71	0.14
6	0.24	0.22	0.61	0.08	0.20	0.36	0.35	0.28	0.12	0.58	0.70	0.17
7	0.22	0.25	0.59	0.09	0.19	0.38	0.35	0.28	0.12	0.57	0.67	0.20
8	0.21	0.30	0.56	0.13	0.17	0.42	0.33	0.31	0.11	0.56	0.65	0.23
9	0.19	0.35	0.52	0.18	0.15	0.47	0.31	0.36	0.11	0.57	0.63	0.26
10	0.18	0.40	0.48	0.24	0.13	0.53	0.28	0.42	0.10	0.59	0.61	0.29
11	0.16	0.45	0.43	0.31	0.12	0.59	0.24	0.48	0.09	0.62	0.60	0.32

4.5.2 Genetic and Phenotypic correlation

4.5.2.1 Genetic and Phenotypic correlation between production traits

Genetic and phenotypic correlations between production traits in Karan Fries cattle have been summarized (Table 4.25). Results showed that genetic correlation of FL305DMY with FLTMY, FLL, WA and MY/FCI were 0.84, 0.30, 0.99 and 0.70 respectively. The results indicated a high positive correlation of FL305DMY with other first lactation production traits in Karan Fries cattle. Similarly, FLTMY was also positively correlated with FLL (0.35), WA (0.87) and MY/FCI (0.45). Genetic correlations of FLL and MY/FCI with WA were 0.09 and 0.70 respectively, while, FLL was negatively correlated with MY/FCI (-0.29).

Phenotypic correlations of FL305 DMY with FLTMY, FLL, WA and MY/FCI were 0.83, 0.44, 0.91 and 0.70 respectively, which indicated a positive phenotypic correlation between production traits. FLTMY was positively correlated with FLL (0.46) and WA (0.70), while, negatively correlated with MY/FCI (-0.01). FLL was positively correlated with WA (0.26) and MY/FCI (0.10). Phenotypic correlation of MY/FCl with WA was 0.70 indicating a positive correlation among the traits.

Table 4.25: Genetic (above diagonal) and phenotypic (below diagonal) correlation among first lactation production traits in Karana Fries cattle

	FL305DMY	FLTMY	FLL	WA	MY/CI
FL305DMY		0.84	0.30	0.99	0.70
FLTMY	0.83		0.35	0.87	0.45
FLL	0.44	0.46		0.09	-0.19
WA	0.91	0.70	0.26		0.70
MY/CI	0.70	0.01	0.10	0.70	

4.5.2.2 Genetic and Phenotypic correlation between reproduction traits and herd life (longevity)

Genetic and phenotypic correlations among reproduction traits and herd life in Karan Fries cattle are summarized (Table 4.26). Genetic correlation of CFI with FSP and longevity were high (0.55) and medium (0.35), respectively, while, genetic correlations of CFI with PR were found negatively correlated (-0.30). The genetic correlations of FSP and PR with LNG were found 0.55 and -0.04, respectively. Phenotypic correlations of CFI with FSP was found medium and positively correlated (0.53), while, that with PR (-0.40) and longevity (0.10) were found less and positively correlated. Pregnancy rates were negatively correlated with FSP (-0.70) and LNG (-0.20). In case of FSP and LNG, there was very low positive correlation (0.23).

Table 4.26: Genetic (above diagonal) and phenotypic (below diagonal) correlations of first lactation reproduction traits and longevity in Karan Fries cattle

	CFI	FSP	PR	LNG
CFI		0.55	-0.30	0.35
FSP	0.53		-0.05	0.55
PR	-0.40	-0.70		-0.0.4
LNG	0.10	0.23	-0.20	

4.5.2.3 Genetic and Phenotypic correlations among production, reproduction traits and Longevity

Genetic and phenotypic correlation among production, reproduction traits and longevity are presented in the Table 4.27. Genetic correlations of FL305DMY with CFI, FSP were 0.09 and 0.11 whereas, with PR and LNG the values were -0.05 and -0.05, respectively. First lactation 305 day or less wet average (WA) had moderate to high positive genetic correlation with CFI (0.26), FSP (0.20) and LNG (0.80), while, negative correlation with PR (-0.18). First lactation 305 day milk yield had low positive phenotypic correlation with CFI (0.15), FSP (0.09) and LNG (0.24) and negatively correlated with pregnancy rate (-0.10). The WA had low positive genetic correlation with FSP (0.04), CFI (0.10) and LNG (0.19) and negative correlation with PR (-0.003).

Table 4.27: Genetic and Phenotypic correlation among production reproduction traits and Longevity

Traits		Genetic correlation	Phenotypic correlation
FL305DMY	CFI	0.09	0.15
FL305DMY	FSP	0.11	0.09
FL305DMY	PR	-0.51	-0.10
FL305DMY	LNG	0.05	0.24
WA	CFI	0.26	0.10
WA	FSP	0.20	0.04
WA	PR	-0.18	-0.003
WA	LNG	0.60	0.19

4.6 Development of selection criteria based on production and reproduction traits and longevity in Karan Fries cattle

There is need of estimating economic values, relative economic values, genetic and phenotypic variances and co-variances of trait for developing selection criteria based on production and reproduction traits and longevity in Karan Fries cattle.

4.6.1 Estimation of economic values of traits

Economic value of the trait was computed as the cost of production per unit of the trait. Estimation of economic values was done using the income-expenditure method. Due to variation in the cost of inputs in different seasons, average expenditure involved in different seasons was considered for the calculation of economic values. Major items of expenditure considered to estimate the relative economic values for different traits selected for incorporation in the index were feed and fodder cost, treatment charges, labour charges and AI charges. Animals were divided into different categories (0-3 months, >3-6 months, >6-12 months and >1 year) according to the feeding schedule and cost of feed/day/animal was calculated for each category based on average of last five years. Total expenditure involved on feed and fodder for 0-3 months, >3-6 months, >6-12 months and >1 year per animal per day is presented in the Tables 4.28- 4.31.

Table 4.28: Total feed and fodder expenditure per day for Karan Fries calf during 0-3 months

Age of calf(days)	Feed components	Requirements (kg/day)	Expenditure /animal/day (Rs)	Total expenditure/ anima/day (Rs)
0-5	Milk	2.6	45.5	45
6-36	Milk	3.6	63	63
>36- 60	Milk	2.6	45.5	51
	Calf starter	250 gram	5.5	
61-90	Milk	3.6	63	74
	Calf starter	500 gram	11	
Average cost/day (Rs.)				58.25

Table 4.29: Total feed and fodder expenditure per day for Karan Fries calf during 3-6 months

Year/Season	Summer	Rainy	Autumn	Winter
2012	19.99	16.71	17.53	21.60
2013	30.57	29.55	29.44	22.46
2014	30.09	33.28	33.64	25.02
2015	31.95	36.17	31.34	39.42
2016	30.39	32.90	28.16	30.67
Season wise average cost (Rs.)	28.60	29.44	28.02	28.83
Overall average cost/day (Rs.)	29.97			

Table 4.30: Total feed and fodder expenditure per day for Karan Fries calf during 6-12 months

Year/Season	Summer	Rainy	Autumn	Winter
2012	40.77	40.46	41.86	45.90
2013	50.47	41.54	46.26	51.78
2014	38.68	50.41	48.33	47.84
2015	51.05	45.75	47.12	57.02
2016	53.01	50.86	46.07	48.59
Season wise average cost (Rs)	46.80	45.80	45.92	49.03
Overall average cost/day (Rs)	46.89			

Table 4.31: Total feed and fodder expenditure per day for adult Karan Fries cattle in different seasons of different year

Year/Season	Summer	Rainy	Autumn	Winter
2012	118.827	152.204	77.864	82.995
2013	86.631	160.468	116.829	92.738
2014	127.984	171.851	101.574	88.270
2015	116.442	103.738	99.772	96.693
2016	180.281	176.299	91.977	89.215
Season wise average cost (Rs)	126.033	152.912	97.603	89.982
Overall average cost/day (Rs)	116.633			

Calves of 0-6 months suffer mostly from diseases like Enteritis, Coccidiosis, Pneumonia, Theleria, Lameness, Joint ill and Naval ill. Therefore, average cost/day/calf was found to be Rs.24.7 at NDRI herd. The details of diseases wise average treatment cost/day/calf during 0-6 months is presented in Table 4.32.

Table 4.32: Disease wise average treatment cost per day per Karan Fries calf during 0-6 months

Disease	Average cost/day/calf (Rs.)
Enteritis and bloody diarrhoea	19.3
Eye infection and temperature	3.75
Other diseases (Theleria, Lameness, Joint ill, Naval ill, Pneumonia, Theleria)	1.62
Total cost/day/calf	24.7

Adult Karan Fries cattle suffer more from different reproductive, fertility and udder disorders (ROP, Anestrous, Prolapse, Metritis, Pyometra, Cystic ovary, Repeat breeding and Mastitis). Expenditure on treatment of these diseases along with lameness and general cases were considered for estimation of average cost/day/adult Karan Fries animal is presented in Table 4.33.

Table 4.33: Disease wise average treatment cost per day per adult Karan Fries cow

Disease	**Average cost/case**
Mastitis	3.38
ROP	0.79
Prolapse	0.10
Pyometra	1.18
Metritis	29.85
Cystic ovary	2.31
Anestrous	22.65
Repeat breeding	1.34
Lameness	0.33
General	7.61
Total cost/day/adult cattle	69.44

As per norms of NDRI herd, one labour allotted to look after 25 calves and in case of large animals one labour was allotted to maintain 10 adult animals. There was variation in labour charges over last five years. Thus, average labour/cost/day/animal was also considered for estimating the economic values of the traits. Labour charges/day/small animal and adult animal were found to be Rs. 9.28 and Rs. 23.21 (Table 4.34 and 4.35)

Table 4.34: Total labour expenditure per day for Karan Fries cattle up to one year in different years

Year	Per day labour cost	Per day/animal cost
2012	200.00	8.00
2013	200.00	8.00
2014	223.00	8.93
2015	223.00	8.93
2016	314.00	12.56
Average cost (Rs.)	**232.13**	**9.28**

Table 4.35: Total labour expenditure per day for Karan Fries cattle in different years

Year	Per day labour cost	Per day/animal cost
2012	200.00	20.00
2013	200.00	20.00
2014	223.00	22.00
2015	223.00	22.00
2016	314.00	31.40
Average cost (Rs.)	**232.13**	**23.21**

In present study, cost of semen straw used for artificial insemination (AI) was also considered in estimating economic values of a trait. However, charges of AI technician were not considered. Average number of services per conception up to sixth parity was observed as 1.89. Thus, about two inseminations per animal were needed for successful pregnancy. Cost of Karan Fries semen straw available at ABRC, NDRI is Rs 20/straw. Hence, overall expenditure of Rs 40/animal was considered for estimating economic values in the study.

Average expenditure/animal/day considering major items of expenditure (feed and fodder cost, treatment charges, labour charges and AI charges) is presented in below (Table 4.36)

Table 4.36: Average expenditure/animal/day for different input components in KF cattle

Components		Total expenditure/ animal/day (Rs)	Average expenditure/ animal/day (Rs)
Feed & Fodder	Season	126.033	116.633
	Winter	152.912	
	Summer	97.603	
	Rainy	89.982	
	Autumn	116.633	
Labour	1 labor/10 animals (Rs 232.13/day)	23.2	23.2
Treatment	Reproduction, Fertility, Mastitis, General		69.44/case
A.I.	2 services/conception	Rs. 20/service	0.14
Total			**209.425**

Average first lactation 305 days or less milk yield, first lactation length and first lactation wet average in Karan Fries cattle were estimated as 3164.87 Kg, 343 days and 10.89 Kg respectively. Total expenditure/day/animal during that period was Rs. 209.4. Economic value of FL305 DMY and WA is the cost of production of 1Kg milk. The cost per Kg milk yield was derived as Rs. 17.5 for Karan Fries cattle.

Economic value of pregnancy rate (PR) is the cost of production of 1% PR in Karan Fries cattle. Average first lactation pregnancy rate of Karan Fries cattle was estimated as 36.63%. Total expenditure per cycle (21 days) per animal was estimated as Rs. 4397.9 and cost of 1% PR was estimated as Rs. 145.53.

Economic value of calving to first insemination is cost of maintenance of 1 day CFI. Average CFI in Karan Fries cattle was estimated as 104 days. Total expenditure per animal for the trait was Rs. 20736.4 and cost of one day of CFI was Rs. 209.42

For estimating economic value of longevity, cost of rearing animals upto age at first calving was initially estimated. It is because cost per day per animal was different up to one year of age and for adult animal due to different feeding schedule of each category. Average longevity of Karan Fries cattle was estimated as 1773.51 days. Total cost for longevity was calculated as Rs. 374826.3 and total expenditure/animal/day for longevity was estimated as Rs 186.4.

4.6.2 Estimation of relative economic values of traits

Keeping the economic value of milk production (305DMY and WA) as unity (one), relative economic values of other traits were estimated with proper sign assigned to each of the relative economic values of different traits. Relative economic values for different traits in Karan Fries cattle are presented (Table 4.37)

Table 4.37: Relative economic values for different traits in Karan Fries cattle

Trait	Total cost/ animal for the trait (Rs.)	Cost/unit	REV (a)
305DMY (Kg)	57370.3	17.5	1
WA (Kg)	57370.3	17.5	1
CFI (days)	20736.4	209.452	-11.9
PR (%)	4397.9	145.53	8.31
Longevity (days)	374826.3	186.4	10.65

4.6.3 Construction of Selection Index

4.6.3.1 Phenotypic and genotypic variance and covariance of traits

Phenotypic and genotypic variances and co-variances among different traits used for the construction of selection index were estimated and presented (Table 4.38 and 4.39).

4.6.3.2 Index coefficients and accuracy of indices

Total four indices were constructed incorporating three traits giving due weightage to important production (FL305DMY & WA) and reproduction traits (CFI, FSP & PR) along with longevity (LNG). The weightage factors for each index are presented in Table 4.38.

In order to determine accuracy of each Selection Index (SI), correlation between aggregate genotype and index (R_{IH}) was computed. The accuracies of the developed indices are also presented in Table 4.40

Table 4.38: Genetic and phenotypic variances of first lactation traits used for developing the selection index

	I_1	V_G	V_P	I_2	V_G	V_P
Traits	**WA**	53.49	478.33	**WA**	13.57	487.521
	PR	23.59	861.338	**CFI**	192.73	3185.27
	LNG	1650.22	23449.9	**LNG**	1193.4	20076.5

	I_3	V_G	V_P	I_4	V_G	V_P
Trait	**305DMY**	59115.2	416780	**305DMY**	45525.5	575264
	PR	1.127	423.654	**SP**	307.08	14982.4
	LNG	4717.9	21322.7	**LNG**	829.9	33560.9

Table 4.39 Genetic and phenotypic covariances of first lactation traits used for developing the selection index

	I_1	COV_G	COV_P	I_2	COV_G	COV_P
Traits	**WA & PR**	-6.696	-18.62	**WA & CFI**	-18.58	126.61
	WA& LNG	147.55	615.289	**WA& LNG**	104.336	685.31
	PR & LNG	-53.32	-1590.39	**CFI & LNG**	-74.76	350.63

	I_3	COV_G	COV_P	I_4	COV_G	COV_P
Traits	**305 DMY & PR**	-277.3	-1882.2	**305 DMY & SP**	9470.83	9740.83
	305 DMY & LNG	9485.29	25115.9	**305DMY& LNG**	-2345.63	6028.51
	PR & LNG	-109.64	-911.43	**SP & LNG**	683.27	2705.45

Table 4.40: Selection Index coefficients and accuracy of different selection indices

Index	Traits	Index Coefficients			R_{IH} (%)
		b_1	b_2	b_3	
I_1	**WA, PR, LNG**	2.354	0.977	0.737	29.7
I_2	**WA, CFI, LNG**	2.222	1.129	0.591	36.3
I_3	**FL305DMY, SP, LNG**	0.023	0.267	0.074	32.3
I_4	**FL305DMY, PR, LNG**	0.235	3.285	2.611	49.1

4.6.3.3 Relative emphasis of traits

Relative emphasis was derived for production, reproduction traits and longevity involved in the indices using weightage factor of each trait and sum of weightage factors set to 100%. Identification of importance of traits for sustainability of performance was estimated and presented (4.41). Among the four indices, combination of WA, CFI and LNG was found to be the best with 56%, 28% and 15% weightage respectively (Fig 4.1) and having 36.3% accuracy. The relative emphasis of the traits in all four selected indices is illustrated in the Figure 4.1.

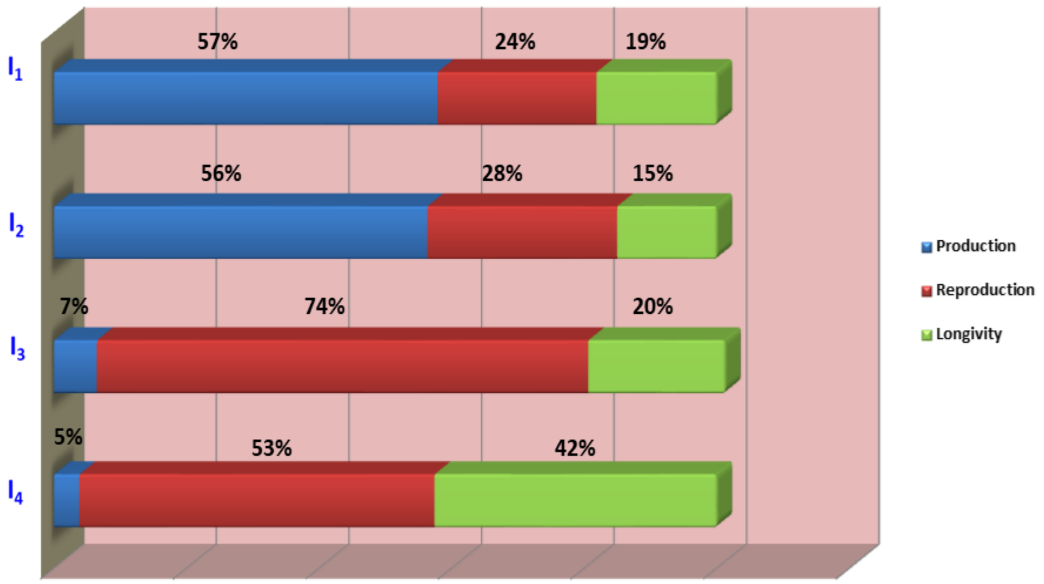
In the present study, health data made continuous by estimating days suffered from a particular disease in order to include health of animals in the total performance indices. Days suffered from commonly affected diseases like mastitis and reproductive disorder (pyometra and endometritis) were estimated and excluded from the longevity of animals and the combination of wet average, calving to first insemination and longevity was still found to be the best as compared to other combinations of traits.

Table 4.41: Identification of importance of traits for sustainability of performance

Index	Traits	Relative weightage		
		Production (%)	**Reproduction (%)**	**Longevity**
I1	**WA, PR & LNG**	57	24	19
!2	**WA, CFI & LNG**	56	28	15
I3	**305DMY, SP &LNG**	7	74	20
I4	**305DMY, PR &LNG**	5	53	42

Figure: 4.1 Importance of traits in Karan Fries cattle

I_1 : WA, PR & LNG
I_2 : WA, CFI & LNG
I_3 : 305DMY, SP & LNG
I_4 : 305DMY, PR & LNG



4.6.4 Robustness of Selection Index

The cost of production of the traits in a particular farm or in different locations varies over a period of time. Thus the developed indices were analyzed for stability by increasing the relative economic values of traits by 25 % and 50 % (Table 4.42).

Table 4.42: Relative economic values of traits after increasing it by 25% and 50%

Traits	REV (a)	REV+25%	REV+50%
FL305DMY (Kg)	1	1.25	1.50
WA (Kg)	1	1.25	1.50
CFI (days)	-11.9	-14.87	-17.85
PR (%)	8.31	10.37	12.45
LNG (days)	10.65	13.25	15.9

With 25% and 50% increase in REV, accuracies of the developed indices remained constant although there was a slight changes in the index coefficients (Table 4.43). After increasing relative economic value by 25% and 50 %, slight changes were found in accuracy of selection indices I_2 and I_3 whereas, accuracies of selection index I_1 and I_4 remained constant. This indicates robustness of developed selection indices. The present observations were similar to the reports of Chakravarty *et al.* (1991) and Valsalan (2012), who reported that an increase or decrease in economic values of traits even upto 25% and 50% caused no major change in the index coefficients and accuracy of indices.

Table 4.43: Robustness of selection index after increasing relative economic values of traits by 25% and 50%

Index	Traits	Actual Weightage (%)	R_{IH} (%)	Weightage REV+25%	R_{IH} (%)	Weightage REV+50%	R_{IH} (%)
I_1	WA	57	29	57	29	57	29
	PR	24		24		24	
	LONG	19		19		19	
I_2	WA	56	36	54	34	60	34
	CFI	28		19		11	
	LONG	15		27		28	
I_3	FL305DMY	7	32	3	32	1	30
	SP	74		62		64	
	LONG	20		35		35	
I_4	FL305DMY	5	49	5	49	5	49
	PR	53		53		53	
	LONG	42		42		42	

4.7 Genetic persistency of milk yield in Karan Fries cattle

Persistency of milk production is ability of animal to maintain milk production at a high level after peak production (Jamorzik *et al.,* 1998). Genetic persistency of milk yield was estimated upto sixth lactation by two different methods in the present study for assessing sustainable performance of Karan Fries cattle. Although, Karan Fries cattle may be persistent for more lactation but it was considered upto sixth lactation. Reason were majority of animals disposed of after sixth parities and in the present study only 6.2% Karan fries animals remained up to sixth lactations.

4.7.1 Genetic persistency using method I

Method I involved average days to attain peak yield and average lactation length. Parity wise average days to attain peak yield (DPY) and average lactation length (LL) in Karan Fries cattle is presented in the Table 4.44

Table 4.44 Parity wise average days to attain peak yield and lactation length in Karan Fries cattle

Parity	N	Average DPY	Average LL
1^{st}	847	39.2	360
2^{nd}	527	35	336
3^{rd}	303	36	376
4^{th}	167	36.7	327
5^{th}	71	36.8	321
6^{th}	51	35.5	343

Breeding values for each test day were estimated using Random Regression model in Method I. The genetic persistency was estimated as the summation of the deviation of estimated breeding value on days to attain peak yield (TD3) from estimated breeding value on each test day after days to attain peak yield. The estimated genetic persistency for KF cattle on test day breeding values for milk yield using method I in different days in milk (DIM) is presented in Table 4.45

Table 4.45: Parity wise estimated genetic persistency in Karan Fries cattle based on test day breeding values using Method I

Parity		TD4	TD5	TD6	TD7	TD8	TD9	TD10	TD11
1	N	847	847	847	847	847	847	847	847
	Mean	**-0.02**	**-0.04**	**-0.06**	**-0.09**	**-0.11**	**-0.13**	**-0.16**	**-0.18**
	S.D.	0.63	1.27	1.9	2.5	3.1	3.8	4.46	5.09
	Minimum	-1.8	-3.6	-5.5	-7.3	-9.2	-11.0	-12.9	-14.6
	Maximum	2.24	4.49	6.74	8.9	11.2	13.4	15.7	17.9
2	N	527	527	527	527	527	527	527	527
	Mean	**0.09**	**0.23**	**0.32**	**0.64**	**1.00**	**2.9**	**3.00**	**3.65**
	S.D.	0.15	0.17	0.19	0.22	0.26	0.29	0.31	0.33
	Minimum	-0.03	-0.06	-0.08	-0.10	-0.14	-0.17	-0.19	-0.20
	Maximum	0.05	0.06	0.07	0.12	0.16	0.20	0.22	0.25
3	N	303	303	303	303	303	303	303	303
	Mean	**0.02**	**0.05**	**0.08**	**0.14**	**0.16**	**0.20**	**0.23**	**0.26**
	S.D.	0.67	1.3	0.02	3.3	4.7	5.5	6.5	8.2
	Minimum	-2.4	-4.9	-7.37	-12.2	-16.5	-17.2	-19.6	-20.02
	Maximum	1.9	3.8	5.83	9.73	11.2	13.6	15.5	17.2

4	N	167	167	167	167	167	167	167	167
	Mean	**0.01**	**0.02**	**0.05**	**0.07**	**0.10**	**0.15**	**0.18**	**0.20**
	S.D.	0.22	0.37	070	0.08	1.4	2.24	2.62	2.9
	Minimum	-0.7	-0.8	-1.6	-2.4	-3.29	-4.94	5.75	-6.5
	Maximum	1.10	1.2	2.43	3.6	4.86	7.29	8.51	9.72
5	N	71	71	71	71	71	71	71	71
	Mean	**-0.0001**	**-0.0003**	**-0.0005**	**-0.0006**	**-0.0008**	**-0.0009**	**-0.001**	**0.0013**
	S.D.	0.01	0.02	0.03	0.05	0.06	0.07	0.09	0.10
	Minimum	-0.04	-0.08	-0.12	-0.17	-0.20	-0.25	-0.30	-0.34
	Maximum	0.02	0.04	0.06	0.08	0.10	0.12	0.14	0.16
6	N	51	51	51	51	51	51	51	51
	Mean	**0.01**	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.08**
	S.D.	0.10	0.21	0.43	0.43	0.50	0.64	0.75	0.86
	Minimum	-0.24	-0.48	-0.9	-0.9	-1.21	-1.46	-1.7	-1.95
	Maximum	0.34	0.80	1.36	1.36	1.70	2.04	2.38	2.72
Average persistency		0.10	0.27	0.42	0.80	1.20	2.41	3.25	4.01

Parity wise mean genetic persistency was found to be positive in all the parities except first and fifth parity by Method I. However, negative values of genetic persistency in first and fifth parity may be due to large influence of environment during these parities. Further overall genetic persistency upto sixth lactation was estimated by taking the average of mean persistency of same test day in all parity and it was found to be positive in Karan Fries cattle. An increasing trend in the values of genetic persistency was observed with increase in the days in milk (DIM).

4.7.2. Genetic persistency using Method-II in Karan Fries cattle

In Method II, genetic persistency was estimated as the additional yield (gained or lost) from average days to attain peak yield to estimated breeding values for milk yield on different days after days to attain peak yield relative to an average cattle having the same yield on days to attain peak yield. The estimated genetic persistency for Karan Fries cattle based on test day breeding values for milk yield using Method II in different days on milk (DIM) (Table 4.46). Similar to the Method-I, lactation wise mean genetic persistency using Method-II was found to be positive except second and third lactation. Overall average genetic persistency of same test day in all lactation up to sixth lactation was found to be positive.

The positive correlation has been reported between lactation (Balaine, 1970 and Dhaka *et al*., 1994). Whereas, phenotypic correlation between persistency and peak yield in most of the studied was found to be negatively associated (Bhutia and Pandey, 1989) in indigenous breed of cattle and crossbreds.

Table 4.46: Parity wise estimated genetic persistency in Karan Fries cattle based on test day breeding values using Method II

Parity		TD4	TD5	TD6	TD7	TD8	TD9	TD10	TD11
1	N	847	847	847	847	847	847	847	847
	Mean	**0.02**	**0.04**	**0.09**	**-0.12**	**0.35**	**0.72**	**1.44**	**2.885**
	S.D.	0.90	1.8	3.61	0.05	13.5	27.9	55.89	111.7
	Minimum	-3.15	-6.35	-12.56	-20.18	-46.9	-97.02	-193.9	-257.3
	Maximum	3.03	6.11	12.09	0.22	15.18	93.36	186.6	373.33
2	N	527	527	527	527	527	527	527	527
	Mean	**-0.007**	**-0.02**	**0.05**	**-0.08**	**-0.092**	**0.14**	**-0.18**	**-0.20**
	S.D.	0.30	0.72	2.5	3.8	6.04	5.7	6.4	7.9
	Minimum	-0.80	-1.4	-6.19	-7.1	-11.20	-15.3	-14.32	-20
	Maximum	1.42	3.62	8.5	8.5	15.88	18.07	18.20	25.8
3	N	303	303	303	303	303	303	303	303
	Mean	**-0.018**	**-0.03**	**-0.07**	**-0.12**	**-0.27**	**-0.5**	**-1.10**	**-2.21**
	S.D.	0.76	0.14	3.05	5.32	11.3	22.6	45.3	90.6
	Minimum	-1.9	-3.78	-7.6	-13.96	-28.4	-56.8	-113.7	-224
	Maximum	2.00	3.97	8.0	14.0	30.0	59.3	118	237

4	N	167	167	167	167	167	167	167	167
	Mean	**0.01**	**0.02**	**0.04**	**0.08**	**0.17**	**0.34**	**0.70**	**0.70**
	S.D.	1.15	2.29	4.5	9.1	18.3	36.6	73.2	73.20
	Minimum	-3.28	-6.5	-13.03	-26.04	-52.0	-104.0	-205	-208
	Maximum	2.9	5.8	11.6	23.2	46.5	93.1	186	187
5	N	71	71	71	71	71	71	71	71
	Mean	**0.01**	**0.03**	**0.07**	**0.14**	**0.29**	**0.5**	**1.18**	**2.36**
	S.D.	0.3	0.5	1.16	2.31	4.6	9.2	18.4	36.9
	Minimum	-0.5	-1.00	-1.98	-3.95	-7.89	-15.7	-31.5	-63.01
	Maximum	0.8	1.6	3.2	6.35	12.6	25.2	50.5	101.07
6	N	51	51	51	51	51	51	51	51
	Mean	**0.31**	**0.62**	**1.27**	**2.55**	**5.11**	**6.01**	**7.23**	**8.2**
	S.D.	2.96	6.04	12.1	24.4	49.1	52.2	60.01	68.3
	Minimum	-6.74	-13.7	-27	-55.7	-111	-123	-140	-152.5
	Maximum	9.40	19.1	38	77.6	155.6	160	175	188.6
Average persistency		**0.325**	**0.66**	**1.45**	**2.45**	**5.55**	**7.21**	**9.27**	**11.73**

4.8: Estimation of expected genetic gain (ΔG)

Selection in a dairy herd is primarily aimed at improving milk productivity. Therefore, genetic gain in Karan Fries herd was estimated on the basis of 305 days lactation yield by different methods to evaluate the net effect of selection in retrospect. The expected gain per generation as well as per year as a result of selection of Karan Fries cattle was assessed for first lactation as well as all lactation (Upto 6th parity) using production (FL305DMY and WA) and reproduction (CFI) by three different methods. Method I involved h^2 and selection differential; Method II was based on the proportion of animals selected (p), phenotypic standard deviation (σ_p) and h^2 of the trait, while method III was direct selection method (path wise) used for estimation of genetic gain. The phenotypic standard deviation used for FL305DMY, WA and CFI were 1070.69 Kg, 2.99 Kg and 56.19 days and heritability estimate for corresponding traits were 0.37, 0.44 and 0.24, respectively. The overall means for 305 days milk, wet average and calving to first insemination were 3164.87 kg, 1089 kg and 104 days, respectively in Karan Fries cattle.

4.8.1: Estimation of expected genetic gain by different methods for first lactation, production and reproduction traits

Expected genetic gain (ΔG) per generation and per year for first lactation, production and reproduction traits as estimated by Method I, Method II is presented in Table 4.47.

Table 4.47: Expected genetic gain of first lactation, production and reproduction traits in Karan Fries cattle

Traits	Method I			Method II		
	ΔG/gen	ΔG/year	% of OA	ΔG/gen	ΔG/year	% of OA
FL305DMY (Kg)	100.8	20.00	0.6	170.2	33.7	1.02
CFI (days)	2.1	0.41	0.3	8.89	1.76	1.48
WA (Kg)	0.56	0.11	0.9	0.72	0.14	1.16

Method I ($\Delta G = h^2$ SD/GI); Method II ($\Delta G = i\sigma p h^2$ /GI); p= 75%, i= 0.43, GI= 5.04 years

Expected genetic gain for first lactation 305DMY, WA and CFI was found to be 20.00 kg/year, 0.41 kg/year and 0.11 days/year which were 0.6, 0.41 and 0.9 % of overall average respectively.

Method II estimated expected genetic gain as 33.7 kg/year, 1.76 kg/year and 0.14 days/year which was 1.02, 1.48 and 1.16 % overall average for 305 DMY, WA and CFI respectively.

Theoretically expected genetic gain obtained by Method I and Method II has to be same but practically it was found different which could be due to the reason that assumptions of normal distribution curve in Method II required for intensity of selection and phenotypic standard deviation were not fulfilled due to small data size.

Expected genetic gain by direct selection (Method III) for 305DMY, wet average and calving to first insemination was found to be 50.33 kg/year 0.18 kg/year and 2.6 days/year (Table 4.48 - Table 4.50).

Yaegboobi *et al*. (2011) estimated the genetic gain of 305 days milk yield of first lactation 26.8-33.0 kg/year in HF dairy cattle which was similar to the estimates obtained by Method I and Method II. Effa *et al*. (2011) estimated genetic gain of 305 days milk yield as 1.84 percent/year over the herd average in HF crossbred dairy cows which was similar to the estimates obtained by Method II.

Table 4.48: Expected genetic gain in 305days milk yield by Direct Method (method III) in Karan Fries

Path	i	N	r	σ_A	L	ΔG (Kg)
Sire to Bull : G_{SB}	1.27	13	0.75	396.15	5.3	377.33
Sire to Cow : G_{SC}	1.27	12	0.74	396.15	7.07	372.30
Dam to Bull : G_{DB}	1.17	3	0.70	396.15	6.93	324.44
Dam to Cow : G_{DC}	0.20	3	0.61	396.15	3	48.33
ΔG per Generation					**22.3**	**1122.4**
ΔG per year					**50.33 kg**	
% of O. A.					**1.5%**	

Table 4.49: Expected genetic gain in wet average by Direct Method (method III) in Karan Fries

Path	I	N	r	σ_A	L	ΔG (Kg)
Sire to Bull : G_{SB}	1.27	13	0.75	1.196	5.3	1.14
Sire to Cow : G_{SC}	1.27	12	0.74	1.196	7.07	1.12
Dam to Bull : G_{SB}	1.17	3	0.70	1.196	6.93	0.98
Dam to Cow : G_{DC}	0.20	3	0.61	1.196	03	0.15
				ΔG per Generation	**22.3**	**3.39**
				ΔG per year	**0.18**	
				% of O. A.	**1.5%**	

Table 4.50: Expected genetic gain in calving to first insemination by Direct Method (method III) in Karan Fries

Path	I	N	r	σ_A	L	ΔG (Kg)
Sire to Bull : G_{SB}	1.27	13	0.75	20.68	5.3	19.7
Sire to Cow : G_{SC}	1.27	12	0.74	20.68	7.07	19.4
Dam to Bull : G_{SB}	1.17	3	0.70	20.68	6.93	16.9
Dam to Cow : G_{DC}	0.20	3	0.61	20.68	03	2.52
				ΔG/Generation	**22.3**	**58.52**
				ΔG/year	**2.6 days/year**	
				% of O. A.	**2.4%**	

4.8.2. Relative efficiency of different methods used for estimating expected genetic gain in KF cattle

Three methods were applied for estimation and comparison of expected genetic gain and relative efficiency in KF cattle (Table 4.51). Expected genetic gain/year for first lactation 305 days milk yield was observed as 20.0, 33.7 and 50.33 kg/year by Method I, II and III respectively. The relative efficiency of methods viz., II over I, III over I and III over II were observed as 40.65, 60.20 and 33.04% respectively. Expected genetic gain/year for wet average using Methods I, II and III was found as 0.10, 0.14 and 0.18 kg/year. So, from the above findings it could be conferred that method II is 28.6% more efficient than Method I and Method III was 44.44% more efficient than Method II. Expected genetic gain/year for calving to first insemination was observed as 0.41, 0.90 and 2.6 days/year by three methods and relative efficiencies of Methods viz., Method II over I, Method III over II and Method III over II were observed 61.66, 81.20 and 58.90% respectively.

Table 4.51: Relative efficiency (%) of different methods for estimating expected genetic gain in KF cattle

Traits	Expected ΔG/year			Superiority in efficiency (%)		
	Method I	Method II	Method III	II over I	III over I	III over II
FL305DMY(Kg)	20.00	33.7	50.33	40.65	60.20	33.04
WA (Kg)	0.10	0.14	0.18	28.6	44.44	22.22
CFI (days)	0.41	0.90	2.6	61.66	81.20	58.90

Expected genetic gain per generation as well as per year for first lactation production and reproduction traits was found to be better by using method II considering intensity of selection and phenotypic standard deviation of the traits in KF cattle, Whereas, efficiency of Method III was found best over other two methods for estimating expected genetic gain in KF cattle. There were no previous reports on relative efficiency of three different methods for estimating expected genetic gain in KF cattle.

4.9: Breeding strategy for production and reproduction trait in Karan Fries cattle

Expected genetic gain was assessed for first lactation 305 days milk yield (305DMy), wet average (WA) and calving to first insemination (CFI) by simulating different parameters involved in Method I, II and III respectively, in order to identify the optimum level of intensity of selection (i) and generation interval (GI) for an organized herd so that maximum genetic gain can be obtained

4.9.1: Expected genetic gain by Method I on simulation

Here generation interval was decreased and also increased for estimation of expected genetic gain. Expected genetic gain obtained in different traits on decreasing (4 years) and increasing (6 years) as compared to the existing one (5.04) is presented in the Table 4.52

Table 4.52: Expected genetic gain of production and reproduction traits on simulating generation interval by Method I

Trait	ΔG/gen	GI	ΔG/year	% of O.A.
305 DMY	61.01	4	25.20	0.77
		5.04	20.00	0.61
		6	16.80	0.51
WA	0.24	4	0.14	1.17
		5.04	0.11	0.93
		6	0.09	0.78
CFI	2.11	4	0.53	0.44
		5.04	0.42	0.35
		6	0.35	0.30

It was observed that expected genetic gain increased by about 26%, 26% and 25.9 % for FL305DMY, WA and CFI with the reduction of generation interval from 5.04 to 4 years, whereas, expected genetic gain decreased by 15.94%, 16% and 15.9% with increase in generation interval from 5.04 to 6 years by Method I

4.9.2: Expected genetic gain by Method II on simulation

In Method II, selection intensity and generation interval both were simulated simultaneously. Expected genetic gain of first lactation 305 days milk yield, wet average and calving to first insemination on simulating I and GI by Method II is presented in Table 4.53-4.55.

Table 4.53: Expected genetic gain of first lactation 305 days milk yield (FL305DMY) on simulating intensity of selection and generation interval by Method II

P (%)	i	GI	ΔG/generation	ΔG/year	% of O.A. average
60	0.64	4	253.38	63.34	1.93 (+88%)
65	0.57		225.66	56.42	1.72
70	0.5		197.95	49.49	1.51 (46%)
75	0.43		170.24	42.56	1.30 (44%)
80	0.35		138.57	34.64	1.06
85	0.28		110.85	27.71	0.84
90	0.2		79.18	19.80	0.60
60	0.64	5.04	253.38	50.27	1.53
65	0.57		225.66	44.77	1.36
70	0.5		197.95	39.28	1.20
75	0.43		170.24	33.78	1.03
80	0.35		138.57	27.49	0.84
85	0.28		110.85	21.99	0.67
90	0.2		79.18	15.71	0.48
60	0.64	6	253.38	42.23	1.29
65	0.57		225.66	37.61	1.15
70	0.5		197.95	32.99	1.00 (-2%)
75	0.43		170.24	28.37	0.86 (-16%)
80	0.35		138.57	23.09	0.70
85	0.28		110.85	18.48	0.56
90	0.2		79.18	13.20	0.26

σ_p=1070.67; h^2=0.37;O.A.3164.87kg

According to Table 4.53, it is evident that with increases in selection intensity (p=90% to 60%) and reduction in generation interval by 4 years, annual ΔG for first lactation 305 days milk yield were increased from 19.80 to 63.34 kg/year. Similarly, with I (p= 60% to 90%) and considering GI (5.04 years), expected genetic gain was increased from 15.71 to 50.27. However, with increase in generation interval (GI=6 years) and I (p=60% to 90%), expected genetic gain per year increased only from 13.20 to 42.23 kg/year. For an organized herd, with increase in intensity of selection (p= 75% to 70%) and reduction of GI from 5.04 to 4 years, expected ΔG for 305 DMY was increased between 44 to 46 %, whereas, with increase in selection intensity (p= 75% to 70%) and increase of GI from 5.04 to 6 years, expected genetic gain were varied between -2 to -16% in Karan Fries cattle. With the increase in i (p= 60% to 90%) and reduction of GI upto 4 years, ΔG/year for wet average increased from 0.07 to 0.19 kg/year by Method II. Similarly, with intensity of selection (p= 60 to 90%) and considering GI as 5.04 years, expected genetic gain/year increased from 0.05 to 0.17 kg/year.

For an organized herd, with the increase in intensity of selection (p= 70 to 75%) and reduction in generation interval from 5.04 to 4 years, expected genetic gain for wet average was increased between 26 to 46%, whereas, with increases of intensity of selection (p= 70% to 75%) and increase generation interval from 5.04 to 6 years, expected genetic gain were varied between -2 to -16% in Karan Fries cattle.

On the perusal of Table 4.55 it is evident that with the increased in intensity of selection (p= 60% to 90%) and reduced generation interval by 4 years, ΔG/year for calving to first insemination was decreased from 3.37 to 1.03 days/year by Method II. Similarly, with increase of intensity of selection (p= 60% to 90%) and considering generation interval 5.04 years, expected ΔG/year decreased from 2.62 to 0.82 days/year but with increase in intensity of selection (p= 60% to 90%) and increase of generation interval upto 6 years, expected ΔG/year decreased 2.20 to 0.69 days/year.

Table 4.54: Expected genetic gain of wet average (WA) on simulating I and GI by Method II

P (%)	i	GI	ΔG/generation	ΔG/year	% of O.A. average
60	0.64	4	0.77	0.19	1.59 (+86%)
65	0.57		0.75	0.19	1.56
70	0.5		0.66	0.16	1.37 (46%)
75	0.43		0.57	0.14	1.18 (26%)
80	0.35		0.46	0.12	0.96
85	0.28		0.37	0.09	0.77
90	0.2		0.26	0.07	0.55
60	0.64	5.04	0.84	0.17	1.39
65	0.57		0.75	0.15	1.24
70	0.5		0.66	0.13	1.09
75	0.43		0.57	0.11	0.94
80	0.35		0.46	0.09	0.76
85	0.28		0.37	0.07	0.61
90	0.2		0.26	0.05	0.44
60	0.64	6	0.84	0.14	1.17
65	0.57		0.75	0.12	1.04
70	0.5		0.66	0.11	0.91 (-2%)
75	0.43		0.57	0.09	0.79 (-16%)
80	0.35		0.46	0.08	0.64
85	0.28		0.37	0.06	0.51
90	0.2		0.26	0.04	0.37

σ_p=2.99 Kg; h^2=0.44;O.A.10.89 kg/day

Table 4.55: Expected genetic gain of calving to first insemination (CFI) on simulating I and GI by Method II

P (%)	i	GI	ΔG/generation	ΔG/year	% of O.A. average
60	0.64	4	13.22	3.31	2.78 (+88%)
65	0.57		11.78	2.94	2.47
70	0.5		10.33	2.58	2.17 (+46%)
75	0.43		8.89	2.22	1.87 (+44%)
80	0.35		7.23	1.81	1.52
85	0.28		5.79	1.45	1.22
90	0.2		4.13	1.03	0.87
60	0.64	5.04	13.22	2.62	2.21
65	0.57		11.78	2.34	1.96
70	0.5		10.33	2.05	1.72
75	0.43		8.89	1.76	1.48
80	0.35		7.23	1.44	1.21
85	0.28		5.79	1.15	0.96
90	0.2		4.13	0.82	0.69
60	0.64	6	13.22	2.20	1.85
65	0.57		11.78	1.96	1.65
70	0.5		10.33	1.72	1.45 (-2%)
75	0.43		8.89	1.48	1.24 (-16%)
80	0.35		7.23	1.21	1.01
85	0.28		5.79	0.96	0.81
90	0.2		4.13	0.69	0.58

σ_p= 56.19 days; h^2=0.24;O.A.104.01days

4.9.3 Expected genetic gain by Method III on simulation

Method III involved increasing and decreasing number of progenies/sire for assessing expected genetic gain and accuracy. Expected genetic gain estimated for FL305DMY, WA and CFI on simulating ‘n’ is presented in Table 4.56- 4.58.

With increasing and decreasing number of progenies/sire by 50% from the existing number of progenies (13), expected genetic gain in first lactation 305 days milk yield were found to be increased by 7.86% and decrease by 15.89%. Almost similar trend in results was observed on increasing and decreasing number of progenies/sire in case of wet average and calving to first insemination

Table 4.56: Expected genetic gain in 305 days milk yield by direct selection method on changing number of progenies in Karan Fries cattle

Path	i	n	r	σ_A	ΔG(kg)	L	ΔG/gen	ΔG/year	% of O. A.
Sire to Bull : G_{SB}	1.27	6	.62	396.15	311.92	5.3	944.05	42.33	1.28
Sire to Cow : G_{SC}	1.27	5	.58	396.15	291.80	7.07			
Dam to Bull : G_{SB}	1.17	4	.63	396.15	292	6.93			
Dam to Cow : G_{DC}	.20	4	.61	396.15	48.33	3			
Sire to Bull : G_{SB}	1.27	13	.75	396.15	377.33	5.3	**1122.4**	**50.33**	**1.53**
Sire to Cow : G_{SC}	1.27	12	.74	396.15	372.3	7.07			
Dam to Bull : G_{SB}	1.17	3	.70	396.15	324.44	6.93			
Dam to Cow : G_{DC}	.20	3	.61	396.15	48.33	3			
Sire to Bull : G_{SB}	1.27	18	.81	396.15	407.5	5.3	1210.7	54.29	1.65
Sire to Cow : G_{SC}	1.27	17	.79	396.15	397.45	7.07			
Dam to Bull : G_{SB}	1.17	5	.77	396.15	356.89	6.93			
Dam to Cow : G_{DC}	.20	5	.61	396.15	48.33	3			

Table 4.57: Expected genetic gain in wet average by direct selection method on changing number of progenies in Karan Fries cattle

Path	i	n	r	σ_A	ΔG(kg)	L	ΔG/gen	ΔG/year	% of O. A.
Sire to Bull : G_{SB}	1.27	6	.62	1.44	1.13	5.3	3.42	0.15	1.25
Sire to Cow : G_{SC}	1.27	5	.58	1.44	1.06	7.07			
Dam to Bull : G_{SB}	1.17	4	.63	1.44	1.06	6.93			
Dam to Cow : G_{DC}	.20	4	.61	1.44	0.17	3			
Sire to Bull : G_{SB}	1.27	13	.75	1.44	1.37	5.3	**4.06**	**0.18**	**1.50**
Sire to Cow : G_{SC}	1.27	12	.74	1.44	1.35	7.07			
Dam to Bull : G_{SB}	1.17	3	.70	1.44	1.17	6.93			
Dam to Cow : G_{DC}	.20	3	.61	1.44	0.17	3			
Sire to Bull : G_{SB}	1.27	18	.81	1.44	1.48	5.3	4.38	0.20	1.66
Sire to Cow : G_{SC}	1.27	17	.79	1.44	1.44	7.07			
Dam to Bull : G_{SB}	1.17	5	.77	1.44	1.29	6.93			
Dam to Cow : G_{DC}	.20	5	.61	1.44	0.17	3			

Table 4.58: Expected genetic gain in calving to first insemination by direct selection method within change in number of progenies in Karan Fries cattle

Path	i	n	r	σ_A	ΔG(kg)	L	ΔG/gen	ΔG/year	% of O. A.
Sire to Bull : G_{SB}	1.27	6	.62	17.22	13.55	5.3	41.02	1.84	1.55
Sire to Cow : G_{SC}	1.27	5	.58	17.22	12.68	7.07			
Dam to Bull : G_{SB}	1.17	4	.63	17.22	12.69	6.93			
Dam to Cow : G_{DC}	.20	4	.61	17.22	2.10	3			
Sire to Bull : G_{SB}	1.27	13	.75	17.22	16.40	5.3	48.78	2.19	1.84
Sire to Cow : G_{SC}	1.27	12	.74	17.22	16.18	7.07			
Dam to Bull : G_{SB}	1.17	3	.70	17.22	14.10	6.93			
Dam to Cow : G_{DC}	.20	3	.61	17.22	2.10	3			
Sire to Bull : G_{SB}	1.27	18	.81	17.22	17.71	5.3	52.58	2.36	1.9
Sire to Cow : G_{SC}	1.27	17	.79	17.22	17.27	7.07			
Dam to Bull : G_{SB}	1.17	5	.77	17.22	15.5	6.93			
Dam to Cow : G_{DC}	.20	5	.61	17.22	2.10	3			

4.9.4: Breeding strategy for genetic improvement of productivity in Karan Fries cattle

In organized herd of NDRI, Karan Fries cattle were maintained with having different productivity levels. Similarly, farmers also rear animals of different productivity levels depending upon the resources and strength available. Therefore, in the present study, an attempt was made to assess expected genetic gain in different productivity groups using different selection intensities along with existing generation interval (5.04 years) in Karan Fries cattle. Karan Fries animals were further classified into low (< 8Kg), medium (8-12 Kg) and high (>12 Kg) high productivity groups based on first lactation records. Expected genetic gain was assessed in different level of selection intensities (60%, 70%, 80% and 90%). Genetic gain at different productivity levels and selection intensities are presented in Table 4.59 and Figure 4.2 and 4.3.

Table 4.59: Genetic gain at different productivity levels and selection intensities

productivity	Proportion of animals selected	ΔG/gen (g)	ΔG/year (g)
Low (< 8Kg)	60%	256	50.79
Medium (8-12 Kg)	60%	335	66.46
High (>12 Kg)	60%	384	76.19
Low (< 8Kg)	70%	200	39.68
Medium (8-11 Kg)	70%	262	51.98
High (>11 Kg)	70%	300	59.52
Low (< 8Kg)	80%	140	27.7
Medium (8-12 Kg)	80%	183	36.30
High (>12 Kg)	80%	210	41.66
Low (< 8Kg)	90%	80	15.87
Medium (9-12 Kg)	90%	104.8	20.7
High (>12 Kg)	90%	120	23.8

The results indicated that at higher selection intensities, when proportion of animals selected were less, a higher genetic gain was obtained. For example, when 90%, 80%, 70% and 60% of low productivity animals were selected, obtained expected genetic gain per generation in daily milk yield were 80g, 140g, 200g and 256g respectively (Table 4.59). Hence, there was an increment in genetic gain of daily milk yield across generations when proportion of animals selected was decreased from 90%, 80%, 70% and 60%.

In an organized herd we can reduce the proportion of selected animals upto 70% maximally because generally less number of animals are disposed off voluntarily based on expected producing ability (EPA). Major proportion of animals is disposed off due to involuntary reasons like reproductive problems, mastitis etc. Among low milk productivity group, when proportion selected was reduced from 90% to 70%, expected genetic gain per year in daily milk yield increased from 15.87 to 39.68 grams/year (Fig 4.3.) Medium and high milk productivity groups revealed an increase from 20.7 to 57.98 and 23.8 to 59.52 grams/year on reducing the selected animals proportion from 90% to 70% increment. In commercial herd proportion of animal selected can be reduced up to 60% for obtaining more profit. On decreasing the proportion of animas selected from 90% to 60% in high productivity group the expected genetic gain increased from 23.8 to 76.19 grams/year.

Fig 4.2: Expected genetic gain per generation in daily milk yield at different productivity and selection intensities in Karan Fries cattle

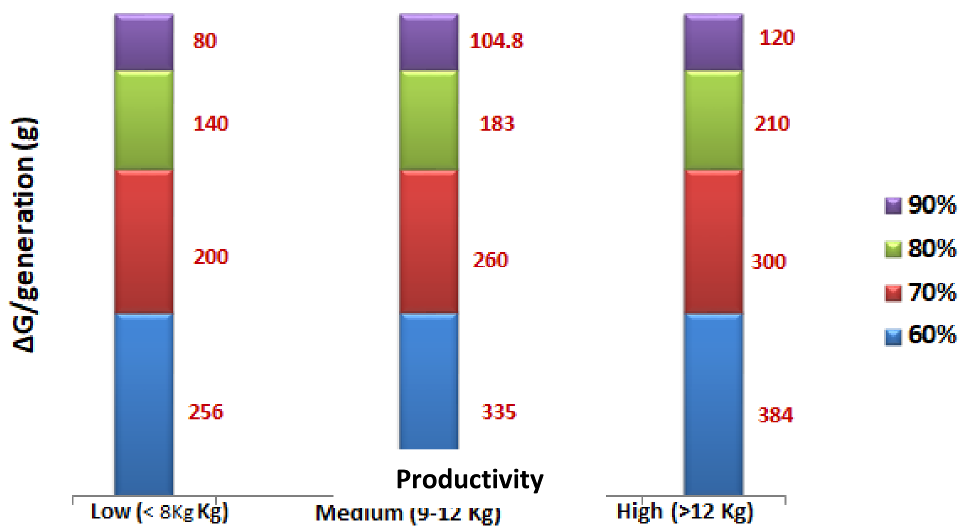
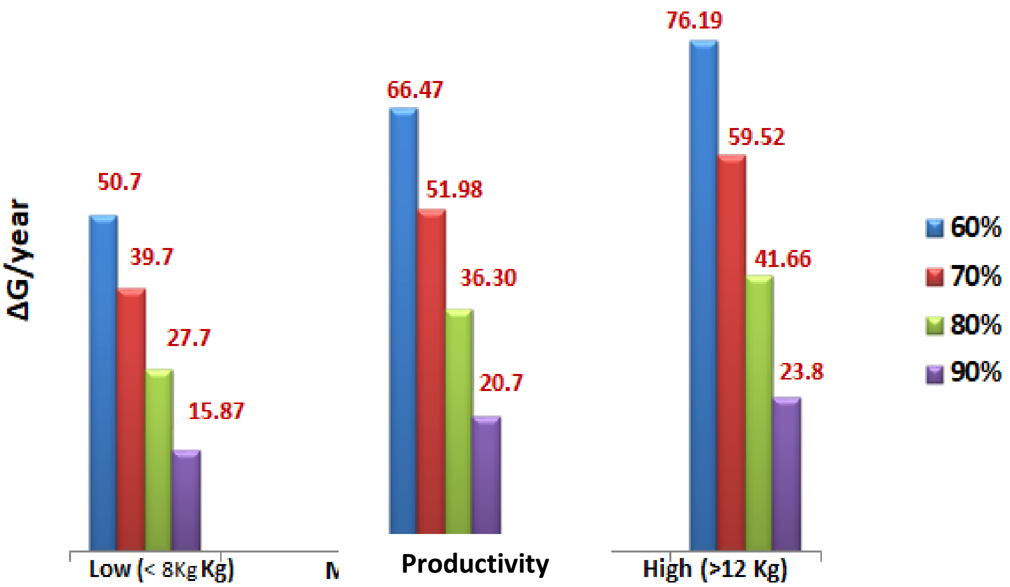


Fig 4.3: Expected genetic gain per year in daily milk yield at different productivity and selection intensities in Karan Fries cattle



A higher change in expected ΔG/year from low milk productivity group to medium productivity group was noticed but there was very less improvement in expected genetic gain from medium to high productivity group at different levels of selection intensities. The expected genetic gain in low, medium and high milk productivity group was 50.79, 66.46 and 76.19 grams/year respectively at 60% selection intensity. There was 15.6 grams/year more expected gain in medium productivity group as compare to low productivity group and 9.7 grams/year more expected gain in high productivity group as compare to medium productivity group. In a study, Meera (2017) reported expected genetic gain in daily milk yield as 127.4, 145.4 and 343.3 grams/generation in low, medium and high milk productivity groups at 70% selection intensity in Karan Fries cattle which were slightly on the little lower side of the findings of the present study.

CHAPTER –5

Summary and Conclusions

SUMMARY AND CONCLUSIONS

The present study was carried out on production, reproduction, longevity and functional traits of Karan Fries (Holstein Friesian crossbred) cattle maintained at Livestock Research Centre, ICAR-NDRI, Karnal. The data comprised of 3165 calving records spread over a period of 24 years from 1993 to 2016.

Data were standardized, normalized and were classified in to different seasons, periods and age groups, for assessing the effect of different non genetic factors on production reproduction and herd life traits data were analyzed using least-squares technique. Effect of both random (Sire) and fixed (seasons, periods and age groups) was explored using mixed model. Genetic parameter like heritability, genetic correlation and genetic persistency were estimated.

Major groups of functional traits viz., udder, ovarian, uterine, female fertility, post calving uterine and calving health were evaluated using various potential indicator traits. Lactation and reproduction disorders comprised of indicators viz., clinical mastitis, flakes, blood-in-milk and teat block for udder health; uterine infection, endometritis, metritis and pyometra for uterine health; cystic ovaries disease (COD) for ovarian health; retained placenta for post calving uterine health; repeat breeding and anoestrus for female fertility health; dystocia, stillbirth, abortion and premature birth for calving health.

Data were analyzed to estimate incidence (proportion) of functional traits in relation to various genetic and non-genetic factors. The data were subjected to chi-squares test and logistic regression approach to examine effect of various genetic and non-genetic factors on functional traits. The overall incidence of clinical mastitis was 0.41 comprising of flakes (0.33), blood-in -milk (0.06) and teat block (0.02) for lactation disorders. Statistical analysis showed that period had significant effect ($P< 0.01$) on all lactation disorders and season and period revealed significant effect ($P<0.01$) on flakes, blood-in -milk and clinical mastitis. The overall incidence of the COD disease was 0.21 and was significantly ($P<0.01$) influenced by season, period and parity. Lowest incidence was found in F1 cross (0.19) as compared to Interbred (0.21) and higher crosses (0.23). Overall the results indicated that the pluriparous and rainy season calvers were more susceptible to COD, whereas the interbred cows might be better adapted to the tropical environment. High humidity and uterine infections over successive calvings could be attributed to act as a predisposing factor for the higher risk of increased incidence for COD. Incidence of uterine infection was 0.18 comprising of the incidence of endometritis (0.03), metritis (0.12) and pyometra (0.03). The season of calving, period of calving and parity had significant effect on the incidence of metritis, endometritis and pyometra, the incidence of pyometra was also significantly ($P<0.05$) affected by genetic group. Lower incidence of uterine disorders was observed in primiparous cows and not a particular trend found over the period in uterine disorders.

Fertility health indicator traits showed the proportion of incidence as 0.06 for repeat breeding and 0.22 for anoestrous. The period, season and parity of calving had significant effect ($P<0.01$) on fertility health traits. Repeat breeding and anoestrous showed an increasing trend up to middle period then decreased in later period. A lower estimate of incidence was found in primiparous cows for anoestrous and repeat breeding. Overall incidence of retained placenta was measured as 0.18 and differences in incidence during the season, period and parities were found to be statistically significant ($P<0.001$). A decreasing trend over the period (up to 2013) was observed. The lowest incidence (0.13) of retention of placenta was also observed in 1st parity and highest (0.25) in 4th parity cows.

The average incidence of calving traits was found to be 0.12 comprising of 0.08 for abortion, 0.006 for premature birth, 0.02 for still-birth and 0.03 for dystocia. Significant difference in incidence was observed during the period for all calving abnormality. Season had Significant effect for abortion and dystocia but there was no specific trend across the period.

Average 305 DMY was found 3164.87 kg in Karan Fries cattle. Milk yield increased up to 3rd lactation and declined in subsequent lactation. Highest wet average was found to be 13.77kg/day in 3rd parity. Average age at first calving was found to be1045.60 days. Average Calving to first insemination was found 104.01 days, average longevity (herd life) of first lactation animal that is animal completed first lactation stayed in the herd up to 1756.17 to 1792.93 days. The overall least squares means for first lactation production traits viz., 305 days milk yield (305DMY), total milk yield (TMY), lactation length (LL), wet average (WA), Milk yield per day of calving interval

(MY/FCI) were estimated as 3164.87 ± 31.52 kg, 3832.87 ± 50.17 kg, 343.14 ± 3.42 days, 10.89 ± 0.09 kg/day and 9.30 ± 0.15 kg/day. The overall least squares means for first lactation reproductive traits first service period (FSP), calving to first insemination (CFI), service period (SP), pregnancy rate (PR) were estimated as 170.39 ± 3.74 days, 104.01 ± 2.74 days, 36.63 ± 1.26 days and for longevity (herd life) it was 1773.51 ±19.38 days.

The lactation milk yield found to be lowest in 1st parity and increased up to 3rd parity. It may be due to the reason that large body size and increased development of udder tissue leads to more milk production than cows of first parity. Milk yield was also lowest in first lactation because the feed provided to heifer was also directed to growth further with the increase in parity and age, milk yield declined due to decline in body condition and degeneration of body system over the recurrent pregnancies. The least squares means for total milk yield was found to be highest in 3rd parity decline in 4th and 5th parity but increased in 6th parity, the reason for more milk in 6th parity may be either due to less influence of environment during 6th lactation or may be less number of observation in 6th parity. Moreover no significant difference observed in 4th, 5th and 6th parity milk yield

Sire had significant effect ($P<0.01$) on first lactation total milk yield, wet average and milk yield per day of calving interval. The first lactation 305-days or less milk yield was significantly ($P<0.05$) affected by period of calving and genetic group, maximum FL305DMY was recorded (3775.3 ± 17.6 kg) for high Holstein crosses (GG3), while season of calving and age group had no significant effect on first lactation 305-days. The first lactation total milk yield, lactation length and milk yield per day of calving interval was not significantly influenced by the season of calving, period of calving, age group and genetic group. Wet average was significantly ($P<0.01$) influenced by period of calving and genetic group also had significant ($P<0.05$) effect on WA, in which F1 crosses had maximum (12.9 kg/day) wet average.

Sire had significant ($p<0.05$) effect on calving to first insemination and has highly significant ($p<0.01$) effect on longevity. The present study showed that the season of calving, period of calving, age group and genetic group had no significant effect on calving to first insemination. Service period was significantly ($P<0.05$) influenced by season of calving where maximum service period (179.16 days) was observed during summer season and lowest (159.9 days) during autumn season, while no significant effect was observed for period of calving, genetic group and age group. Season of calving had a significant (P< 0.01) effect on pregnancy rate, maximum pregnancy rate (42.35 %) observed during autumn season and lowest (33.36 %) during rainy season, no significant effect of period of calving, age group and genetic group was observed. Longevity (herd life) was significantly (P< 0.01) affected by age group and genetic group, maximum longevity (1836.63 days) was estimated for F1 crosses and no significant difference between interbred and higher crosses, while it was not affected by season and period of calving in Karan Fries cattle.

Heritability estimate for different traits was found to be low-medium. The overall least square means for FL305DMY, FLTMY, LL, WA, MY/CI, AFC, CFI, FSP, PR and longevity were estimated as 0.37± 0.08, 0.29 ± 0.10, 0.17± 0.09, 0.44 ± 0.11, 0.15 ± 0.11, 0.39 ± 0.09, 0.24 ± 0.22, 0.16 ± 0.12, 0.08 ± 0.13 and 0.11 ± 0.08 respectively. The moderate estimates of heritability indicated the scope of genetic improvement through selective breeding for milk production.

Total performance index (TPI) was developed using three trait combinations including production (305DMY, WA), reproduction (CFI, SP) and longevity traits and the accuracy (R_{IH}) of each selection index was judged. Relative importance was computed for production, reproduction and longevity traits involved in the best indices. Developed indices were explored for robustness by increasing relative economic value of traits by 25% and 50%. Data on health traits like mastitis and other reproductive disorder were used by excluding the days suffered from the longevity of the animal and best performance index was identified, importance of trait was also compared for relative weightage and the importance of traits was remained same as earlier.

Among the indices developed the performance index with a combination of wet average, calving to first insemination and longevity (WA, CFI & Longevity) was found to be the best index with 36.3% accuracy, giving 57.6 %, 28.6 % & 14.9 % weightage to production reproduction and longevity for selection of Karan Fries cattle. Developed indices were assessed for robustness by increasing the relative economic value 25% and 50% little changes were found in accuracy of selection indices. The performance index with combination WA, CFI & Longevity was found to be best index and giving same weightage to the traits even on excluding days suffered from longevity.

Lactation wise genetic persistency was estimated by two different methods using Random Regression model (RRM). Similar trend of genetic persistency was observed by both the methods. The parity wise mean genetic persistency was found to be positive in all the parities except first and fifth parity (by Method-I) and second and third lactation (by Method-II) the negative values of genetic persistency may be due to large influence of environment during these parities. Although the overall average genetic persistency of same test day in each lactation up to sixth lactation was found to be positive and sustainable by both methods

Expected genetic gain (ΔG) of 305 days milk yield (DMY), wet average (WA) and calving to first insemination (CFI) was estimated using three different methods. Expected genetic gain was also estimated using different combination of selection intensities (i) and generation interval (GI). Path wise expected genetic gain was assessed using different number of progenies/sire and dam and was compared to the expected genetic gain obtained under existing selection strategy.

Expected genetic gain /year for first lactation 305 days milk yield was observed as 20.00, 33.7 and 50.33 kg/year by Method I ($\Delta G = h^2 SD/GI$), II ($\Delta G = i\sigma ph^2 /GI$) and III (direct selection method) respectively. The relative efficiency of methods viz., II over I, III over I and III over II were observed as 40.65, 60.20 and 33.04% efficient respectively. The expected genetic gain/year for wet average using Methods I, II and III was found as 0.10, 0.14 and 0.18 kg/year, it was observed that method II was 28.6 % more efficient than Method I and Method III was 44.44% more efficient than Method II. The The expected genetic gain/year for calving to first insemination was observed as 0.41, 0.90 and 2.6 days/year by Methods I, II and III and relative efficiencies of Methods viz., Method II over I, Method III over II and Method III over II were observed 61.66, 81.20 and 58.90 % efficient. Expected genetic gain per generation as well as per year for first lactation production and reproduction traits was found to be better by using method II considering intensity of selection and phenotypic standard deviation of the traits, Whereas the efficiency of Method III was found best over other two methods for estimating expected genetic gain in KF cattle.

Expected genetic gain was also assessed for first lactation 305DMY, WA and CFI by simulating different parameter involved in Method I, II and III respectively. In Method I GI was decreased and also increased for estimation of ΔG .It was observed that expected genetic gain increased by about 26%, 26% and 25.9 % for FL305DMY, WA and CFI with the reduction of generation interval from 5.04 to 4 years, whereas the expected genetic gain decreased by 15.94%, 16% and 15.9% with increase in generation interval from 5.04 to 6 years by Method I. On increasing intensity of selection (p = 75 to 70) and reduction of GI from 5.04 to 4 years the expected ΔG for 305DMY and CFI increased between 44 to 46% and for WA increased between 26 to 46%, whereas increase of GI from 5.04 to 6 years the expected ΔG varied between -2 to -16 % in Karan Fries cattle.

In method III, the expected ΔG and the accuracy was assessed by increasing and decreasing the number of progenies/sire. On increasing and decreasing the number of progenies/sire by 50% from the existing number of progenies (13), the expected genetic gain in first lactation 305 days milk yield increased by 7.86 % and decrease by 15.89% respectively. Almost similar trend was observed on increasing and decreasing number of progenies/sire in case of wet average and calving to first insemination. With the increase of intensity of selection (p = 75 to 70) and reduction in GI from 5.04 to 4 years the expected ΔG for 305DMY increased between 44 to 46 % , whereas with the increase of selection intensity (p = 75 to 70) and increase GI from 5.04 to 6 years the expected genetic gain varied between -2 to -16 % in Karan Fries cattle.

In organized herd, Karan Fries animals are maintained having different productivity levels. Therefore in the present study an attempt was been made to assess the expected genetic gain in different productivity groups using different selection intensities along with existing generation interval (5.04 years) The cows were classified into low (< 8Kg/day WA) medium (8-12 Kg/day WA) and high (>12 Kg/day WA) productivity groups based on first lactation records. The expected genetic gain was assessed in different selection intensities (60%, 70%, 80% and 90%) of female. A more change in expected ΔG/year from low milk productivity group to medium productivity group was noticed but there was relatively less improvement in expected genetic gain from medium to high productivity group at different levels of selection intensities. The expected genetic gain in low, medium and high milk productivity group was 50.79, 66.46 and 76.19 grams/year respectively at 60% selection intensity. There was 15.6 grams/year more expected gain in medium productivity group as compared to low productivity group and 9.7 grams/year more expected gain in high productivity group as compare to medium productivity group

Recommendation

- In an organized herd Karan Fries animals selection criterion where is 57.6%, 28.6% and 14.9% weightage are given to wet average, calving to first insemination and Longevity would result in better sustainability
- The generation interval and intensity of selection should be less than 5 years and 70-75% respectively or achieving more genetic gain/year in an organized herd.

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