BODY WEIGHT AND ITS ASSOCIATION WITH AGE AT FIRST CALVING AND MILK PRODUCTION IN CROSSBRED CATTLE OF KERALA

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THESIS
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2000

DECLARATION

I hereby declare that this thesis entitled "**Body Weight and its Association With Age at First Calving and Milk Production in Crossbred Cattle of Kerala**" is a bonafide record of research work done by me during the course of research and that this thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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Certified that this thesis, entitled "**Body Weight and its Association With Age at First Calving and Milk Production in Crossbred Cattle of Kerala**" is a record of research work done independently by **Dr. Siddalingswamy Hiremath** under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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Siddalingswamy Hiremath

Dedicated to

My beloved

Parents and Sisters

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Introduction

1. INTRODUCTION

Tremendous progress has been made in increasing milk production in Kerala through programmes of crossbreeding of native cattle with exotic dairy breeds and adoption of artificial insemination. Milk production in the state has increased from 2.05 lakh tons in 1956 to 21.18 lakh tons in 1994-95 (Breeding Policy Report, Kerala state, 1998). The contribution of the Animal Husbandry to the state Gross Domestic Product (GDP) was 10.26 per cent against eight per cent in the national level (Dairy India, 1997). The contribution of Animal Husbandry to state GDP has increased from 5-9 per cent (1986-87) to 10.26per cent (1995-96), whereas from agriculture and allied sectors, it decreased from 29.1 per cent in 1986-87 to 25.5 per cent in 1995-96.

Initial attempts in crossbreeding of local cattle were in the form of pilot studies using Jersey (J) bulls in Kanjirapilly and Neyyitinkara area. Based on the encouraging results from these studies, it was decided to adopt crossbreeding of local cattle with Jersey bulls extensively through Intensive Cattle Development Projects started during 1960s. With the objective of producing a suitable breed for dual purpose (milk and meat), Indo-Swiss project (now known as Kerala Livestock Development Board i.e., KLDB) started functioning in 1963 at Mattupetty. Based on the results on Brown-Swiss (BS) crossbreds in their farm, Indo-Swiss project extended its activity, in mid 70s to the fields, viz., Idukki, Alleppey and Quilon districts and thus Brown Swiss breed was introduced into the local cattle. Later KLDB was entrusted with the supply of frozen semen of bulls (Brown Swiss, Jersey and their crossbreds) in the entire state. This led to the possibility of planning, formulating and implementing a suitable cattle-breeding policy for the entire state.

In the year 1983, Kerala Agricultural University conducted a research work on comparison of Jersey crossbreds and Brown Swiss crossbreds in the field. The results indicated that Jersey crossbreds were better suited for Kerala. Based on the results, use of pure Brown Swiss breed was excluded in the crossbreeding programme. The expert committee constituted by the Government of Kerala in 1979 under the chairmanship of Dr.R.M.Acharya, recommended the introduction of Holstein-Friesien (HF) crossbred bulls for further increasing milk yield of the existing crossbred population in the state.

Considering the above recommendations and results obtained from field studies on crossbreds, Kerala State approved a cattle-breeding policy for the state in 1994. It recommended the usage of crossbred bulls born to the dams having milk yield not less than the 3500 kgs in lactation, for insemination of crossbred cows. The exotic blood level is to be stabilized around 50 per cent and for crossing of local cattle purebred Jersey breed was suggested. As per the census (1996) 67.33 per cent of the cattle are crossbreds (Breeding Policy Report, Kerala state, 1998).

There exist a considerable genetic diversity within the species/strains with respect to production and adaptability characters. The age at first calving (AFC) and first lactation milk yield (FLMY) are the two important traits considered in the selection of the animals for augmenting economic returns from the dairy cattle. However, it is difficult to select the dairy cows prior to first calving and without assessing the milk production performance. This constraint increases the generation interval and lowers annual genetic gain. Hence it will be beneficial if some early expressing traits having strong genetic relationship with age at first calving and first lactation milk yield could be identified so that early selection can be done in dairy cattle.

Success of dairy farming depends to a very large extent upon rearing calves to breedable age. Body weights at earlier ages provide the measure of growth. These are the most important economic traits, which lay a foundation for adult performance and overall economy of dairy cattle. Under field conditions, studying growth is a difficult task and it is an established fact that growth is not uniform in different segments of growth period. But weighing of calves under field conditions often poses problems. In addition to selection at earlier ages, knowing the weight of the animals has many advantages as feeding can be more precise and many management decisions can be made more accurately. There are many reports indicating prediction of body weights using different body measurements. Taking measurements of animals at different stages can be easily practiced under field conditions. McDaniel and Legates (1965) have emphasized selection of dairy cattle on the basis of various body measurements of calves. General observation has shown that age at first calving and first lactation milk yield of cattle depend on the growth rate in the earlier ages. Information on the body measurements of calves under field conditions is available in the ICAR Field Progeny Testing Scheme.

The present study was planned to estimate the body weights of calves in the field at birth, three, six and twelve months of age and to assess association of these body weights with their age at first calving and first lactation milk yield using the data available in ICAR Field Progeny Testing (FPT) Scheme. The study is likely to provide clues on the possibility of using the initial body weights as indirect selection tool for increasing milk yield in dairy cattle and will help in formulating breeding strategies in Kerala.

Review of Literature

2. REVIEW OF LITERATURE

Growth is an essential and a peculiar characteristic of all living beings. It is a relatively irreversible time change in measured dimensions (Brody, 1945). Body weights are the measures of growth. Productivity in all classes of livestock has an inseparable and intimate associationship with body weights at different ages. Regardless of the definition, growth is an important economic trait and has been given high priority in breeding and improvement of domestic animals.

Literature on body weights at different ages, its relation with age at first calving (AFC) and first lactation milk yield (FLMY) are reviewed below.

2.1 Birth weight (BW0)

Birth weight is the first and foremost observable economic trait in the life of an animal, which determines the future prospective value of the animal through physical and functional development in the later parts of the life. The birth weight is a breed characteristic influenced by maternal environment through utilizing the uterine fluid to the maximum space available.

2.1.1 Means

Table 2.1 summarizes the birth weights in different Indian crossbreds. The table shows that Jersey (J) crossbreds have lower birth weight compared to Holstein-Friesian (HF) and Brown Swiss (BS) crosses. The birth weight ranged from 14.91 ± 0.27 kg for ¼ J x ¾ Local cattle of Kerala (Mathai *et al.*, 1978) to 29 kg for BS x Ongole (Prabhukumar *et al.*, 1991)

2.1.2 Factors affecting birth weight

a. *Season of Birth*

Most of the authors classified the year as winter, summer, autumn and rainy season. A few have classified it as dry and wet season. The effect of season was significant in Karan Swiss calves and calves with higher birth weight were born in winter (Mandal and Sachdeva, 1999). Such significant effect of season was also reported in HF x Bunaji cows (Malau – Aduli *et al.*, 1996), in Jersey x Red Sindhi (Narang *et al.*, 1994), in Karan Fries (Singh and

Table 2.1. Means and Standard errors of birth weight of important crossbreds of India

Crosses	Mean ± SE (kg)	Reference
JERSEY CROSSBREDS		
J x local cattle of Kerala	16.55± 0.18	Mathai *et al.* (1978)
¼ J x ¾ local cattle of Kerala	14.91± 0.27	-do-
¾ J x ¼ Local cattle of Kerala	18.71± 0.54	-do-
½ Sindhi x ¼ J ¼ Local cattle of Kerala	17.94 ± 0.66	-do-
J x Hariana	25.34	Srivastava *et al.* (1978)
J x Sahiwal	19.6 ± 0.4	Tahir *et al.* (1984)
Crossbreds of Kerala	24.44 ± 0.7	Nair *et al.* (1985)
J x Kankrej	22.35	Patel *et al.*(1985)
J x Gir	24.19 ± 0.25	Singh and Parekh (1986)
J x Red Khandari	20.73 ± 0.43	Dhumal *et al.*(1988)
J x Ongole	22.9	Prabhukumar *et al.*(1991)
J x Gir	19.39	Naikare *et al.*(1992)
J x Tharparkar	21.33 ± 0.42	Roy *et al.*(1996)
HF CROSSBREDS		
HF x Hariana	25.24	Srivastava *et al.*(1978)
HF x Kankrej	26.82	Patel *et al.*(1985)
Karan Fries	26.3 ± 0.27	Singh and Tomar (1988)
HF x Tharparkar	24.17 ± 0.2 22.64 ± 0.48	Pandit *et al.* (1989) Roy *et al.*(1996)
HF x Sahiwal	24.57 ± 0.18	Teotia *et al.*(1990)
F x Ongole	27.2	Prabhukumar *et al.*(1991)
Karan Fries	26.74 ± 0.43	Mandal and Sachdeva (1999)
BS CROSSBREDS		
BS x Hariana	21.27	Srivastava *et al.* (1978)
BS x Ongole	29.0	Prabhukumar *et al.*(1991)
BS x Local (Sunandini)	25.42 ± 2.47(Farm) 24.9 ± 0.91(Field)	Anthony and Thomas (1997)

Tomar, 1988), in Hariana cows with HF, Jersey and Brown Swiss inheritance (Srivastava *et al.,* 1986) and noted heavier calves in spring than summer, rainy and autumn seasons. Nair *et al.* (1985) observed that male calves born in dry season were heavier at birth than those born in the wet season. Mathai *et al.* (1978) noted the maximum birth weight in summer born calves and minimum in winter born calves. The difference in birth weight due to season was found statistically significant.

Some authors were of the different opinion that season of birth did not affect birth weight as reported in Tharparkar crosses with Jersey and HF (Roy *et al.*, 1996), in Gir crosses with J, HF and BS (Naikare *et al.,* 1992), in Red Khandari x Jersey crosses (Shelka *et al.*, 1992), in Hariana crosses with J, HF and BS (Nautiyal and Bhat, 1989), in non descript local cattle and its crosses with Jersey in Maharashtra (Dhumal *et al.*, 1988), in Jersey x Kankrej (Patel and Dave, 1987) and in HF x Sahiwal (Narayanaswamy *et al.*, 1984).

b. *Period/Year of Birth*

Significant contribution of period/year of birth on the birth weight has been reported in Karan Swiss calves (Mandal and

Sachdeva, 1999), in Gir crosses with J, HF and BS (Naikare *et al.*, 1992), in Red Khandari x Jersey crosses (Shelka *et al.*, 1992), in local and its crosses with Jersey in Maharashtra (Dhumal *et al.*, 1988), in Karan Fries (Singh and Tomar, 1988), in Tharparkar crosses with J and HF (Roy *et al.*, 1996) and in Hariana crosses with J, HF and BS (Nautiyal and Bhat, 1989).

Non-significant effect of year of birth on birth weight has also been recorded in HF x Bunaji crosses (Malau- Aduli *et al.*, 1996) and in Jersey x Kankrej calves (Patel and Dave, 1987).

c. *Farms /Centres*

The farm differences were nonsignificant at birth in HF x Sahiwal crossbreds (Narayanaswamy *et al.*, 1984). The significant influence of centres on body measurements of calves at birth under field conditions had been reported by Iype (1992).

d. *Sire*

The effect of sire on the birth weight of crossbred calves was reported nonsignificant by Nair *et al.* (1985), but

Rajgopalan and Francis (1976) reported that in crossbreds of Kerala, the sire had highly significant effect on birth weight. Such significant effect of sire also had been reported in HF x Sahiwal by Narayanaswamy *et al.* (1984), and on body measurements of calves under field conditions of Kerala by Iype (1992).

2.1.2 Heritability estimate

Birth weight is low to moderately heritable. The reports of heritability estimate of birth weight of some important crossbreds are presented in Table 2.2.

The heritability values of birth weight ranged between -0.01±0.22 (Shrivastava *et al.*, 1985) to 1.04±0.4 (Narang *et al.*, 1994).

2.2 Body weight at three months of age (BW3)

2.2.1 Means

Estimates of body weights at three months of age in different Indian crossbreds are presented in Table 2.3. The BW3 ranged from 34.57 ± 1.85 kg in HF x Tharparkar (Roy *et al.*, 1996) to 60.62 ± 0.82 kg in HF x Hariana (Bhat and Singh, 1978).

Table 2.2. Heritability estimates of birth weight in different cross breds of India

Crosses	Heritability	Reference
Crossbreds of Kerala	0.527±0.059	Rajgopalan and Francis (1976)
J x Hariana	0.13 ± 0.30	Shrivastava *et al.*(1985)
J x Gir	-0.05 ± 0.16	Shrivastava *et al.*(1985)
Crossbreds of Kerala	0.516	Nair *et al.*(1985)
J x Red Sindhi	1.04 ± 0.4	Narang *et al.* (1994)
F x Hariana	0.31 ± 0.25	Shrivastava *et al.*(1985)
F x Gir	0.34 ± 0.22	Shrivastava *et al.*(1985)
HF x Sahiwal	0.183 ± 0.039	Sharma and Singh (1987)
Karan Fries	0.1895 ± 0.12	Singh and Tomar (1988)
HF x Sahiwal	0.44 ± 0.13	Teotia *et al.* (1990)
HF halfbreds	0.145 ± 0.094	Rao and Nagarcenkar (1992)
BS x Hariana	-0.01±0.22	Shrivastava *et al.*(1985)
2 and 3 breed crosses of Gir, F, J	0.21	Saha and Parekh (1990)

Table 2.3. Mean and Standard errors of body weight at three months of age of different crossbreds in India

Crosses	Body weight (kg)	Reference
J x Hariana	46.92 ± 0.94	Bhat and Singh (1978)
J x Tharparkar	38.29 ± 0.68	Roy *et al.*(1996)
HF x Hariana	60.62 ± 0.82	Bhat and Singh (1978)
HF x Tharparkar	34.57 ± 1.85	Roy *et al.* (1996)
BS x Hariana	55.82 ± 0.88	Bhat and Singh (1978)
BS x Local (Sunandini)	58.95±3.20(Farm) 41.34±1.06(Field)	Anthony and Thomas (1997)

2.2.2 Factors affecting body weight at three months of age

a. *Season of Birth*

The significant influence of season of birth has been reported in Hariana crosses with J, HF and BS (Bhat and Singh, 1978) and in HF x Bunaji (Malau – Aduli *et al.*, 1996). No effect of season of calving was reported in Tharparkar crosses with J and HF (Roy *et al.*, 1996) and in HF x Deoni crosses (Kulkarni *et al.*, 1982).

b. *Period/Year of Birth*

The period/year of birth significantly influenced the weight at three months of age in HF x Tharparkar and Jersey x Tharparkar (Roy *et al.*, 1996), HF x Bunaji (Malau – Aduli *et al.*, 1996) and in Hariana crosses with J, HF and BS (Nautiyal and Bhat, 1989; Bhat and Singh, 1978).

c. *Farms /Centres*

The effect of farm on the measurements was highly significant in crossbred calves (HF x Sahiwal/Tharparkar) under field conditions (Reddy *et al.*, 1991).

d. Sire

Reddy ***et al.*** (1991) studied the growth of crossbred calves (HF x Sahiwal/Tharparkar) under field conditions and indicated a nonsignificant effect of sire.

2.2.3 Heritability estimate

The heritability of body weight at three months in HF x Deoni crossbreds has been reported to be 0.384±0.0052 (Kulkarni *et al.*, 1982) and 0.151±0.096 in Holstein half bred crosses (Rao and Nagarcenkar, 1992).

2.3 Body weight at six months of age (BW6)

2.3.1 Means

Body weight at six months of age in different Indian crossbreds is tabulated in Table 2.4. The BW6 ranged from 47.47 ± 2.42 kg in HF x Tharparkar (Roy *et al.*, 1996) to 118.65 ± 1.66 kg in HF x Sahiwal (Teotia *et al.*, 1990).

2.3.2 Factors affecting body weight at six months

a. *Season of Birth*

Season of birth is a significant source of variation in affecting weight at six months in HF x Bunaji calves (Malau – Aduli *et al.*, 1996). They had also observed that calves born during the dry season had highest weight. Bhat and Singh (1978) made similar observations in Hariana crosses (J, HF and BS). However non-significant influence of season of birth has been reported in HF x Tharparkar and Jersey x Tharparkar (Roy *et al.*, 1996), in Hariana crosses with J, HF and BS (Nautiyal and Bhat, 1989) and in HF x Sahiwal crosses (Narayanaswamy *et al.*, 1984).

b. *Period of birth / Year of Birth*

Period/Year of birth was significant source of variation in affecting weight at six months of age in Tharparkar crosses with J and HF (Roy *et al.*, 1996), in HF x Bunaji (Malau – Aduli *et al.*, 1996), in HF x Tharparkar/Sahiwal (Reddy *et al.*, 1991), in Hariana crosses with J, HF and BS (Nautiyal and Bhat, 1989;Bhat and Singh, 1978) and in Gir crosses with J and HF (Shrivastava and Katpatal, 1983).

c. Farms /centres

In HF x (Sahiwal / Tharparkar), Reddy *et al.* (1991) reported significant effect of farm. Similar findings were reported by Narayanaswamy *et al.* (1984) in HF x Sahiwal calves. Shrivastava and Katpatal (1983) also reported such significant impact of farm on this trait.

d. Sire

Narayanaswamy *et al.* (1984) reported non-significant effect of sire on body weight at six months in Friesian x Sahiwal crosses.

2.3.3 Heritability estimate

The heritability (h^2) estimate for body weights at six months in different crossbred calves reported are presented in Table 2.5. Body weights at six months are found to be low to moderately heritable. However, an estimate as high as 1.9 ±1.3 in Jersey x Hariana and as low as 0.03±0.31 in BS x Haryana has been reported by Shrivastava *et al.* (1985).

Table 2.4. Mean and standard errors of body weight at six months of age of different crossbreds in India

Crosses	Body weight (kg)	Reference
JERSEY CROSSES		
J x Kankrej	109.62	Patel *et al.* (1985)
J x Hariana	79.76±2.2	Shrivastava *et al.* (1985)
J x Gir	87.5±1.2	-do-
J x Tharparkar	58.41±0.99	Roy *et al.* (1996)
HF CROSSES		
HF x Hariana	95.39±1.7	Shrivastava *et al.* (1985)
F x Gir	98.23±1.1	-do-
HF x Sahiwal	118.65±1.66	Teotia *et al.* (1990)
HF x Sahiwal/ Tharparkar	106.3	Reddy *et al.*(1991)
HF x Tharparkar	47.47±2.42	Roy *et al.*(1996)
BS CROSSES		
BS x Hariana	80.9±2.2	Shrivastava *et al.* (1985)
BS x Local (Sunandini)	112.36±6.98(Farm) 74.28±4.11(Field)	Anthony and Thomas (1997)

Table 2.5. Heritability estimates of bodyweight at six months of age in different crossbreds of India

Crosses	Heritability	Reference
J x Hariana	1.9±1.3	Shrivastava *et al.* (1985)
J x Gir	0.24±0.23	-do-
HF x Hariana	0.08±0.35	Shrivastava *et al.* (1985)
F x Gir	0.24±0.20	-do-
HF x Sahiwal	0.29±0.09	Teotia *et al.* (1990)
HF crosses	0.376±0.145	Rao and Nagarcenkar (1992)
BS x Hariana	0.529±0.585	Bhat and Singh (1978)
BS x Hariana	0.03±0.31	Shrivastava *et al.* (1985)

2.4 Body weight at twelve months of age (BW12)

2.4.1 Means

Table 2.6 summarizes the body weight at twelve months of age in different crossbreds. The BW12 of crossbreds ranged from 110.76 ± 5.20 kg in HF x Tharparkar (Roy *et al.*, 1996) to 252.8 kg in HF x Kankrej (Patel *et al.*, 1985).

2.4.2 Factors affecting body weight at twelve months

a. Season of Birth

The effect of season of birth on body weight at twelve months age was found to be significant in HF x Sahiwal (Narayanaswamy *et al.* 1984). They reported that calves born in the summer season had significantly lower body weights than those born in winter or rainy season. Similar observation has been made in Gir crosses with J and HF (Shrivastava and Katpatal, 1983). However, reports were encountered suggesting that season of birth did not have much impact on body weight as in Tharparkar crosses with J and HF (Roy *et al.*, 1996) and Hariana crosses with J, HF and BS (Bhat and Singh, 1978).

b. Period of birth

The differences in body weight at twelve months due to effects of periods of birth were statistically significant in HF x Bunaji (Malau-Aduli *et al.*, 1996), in HF x Sahiwal (Narayanaswamy *et al.*, 1984) and in Gir crosses with J and HF (Shrivastava and Katpatal, 1983). On the contrary, no significant differences due to year of calving was reported by Bhat and Singh (1978) in Hariana crosses with J, HF and BS.

c. Farms / centres

Shrivastava and Katpatal (1983) studied the growth of Gir crossbreds (HF and J) in Rahuri and Jabalpur farms. Farm had significant effect on all body weights and indicated that the growth of Gir crosses was better at Rahuri farm than that of Jabalpur farm. The significant effects of farm are obviously due to differences in level of feeding, management and climatic conditions of the farms. Since the same standard technical programme on feeding and mangemental practices regulates both farms, agroclimatic conditions also might have played an important role in the higher growth rate of same crossbreds at Rahuri farm. Such significant influence has also been observed by Narayanaswamy *et al.* (1984) in HF x Sahiwal crosses.

d. Sire

Non-significant influence of sire was reported on body weight at twelve months by Narayanaswamy *et al.* (1984) in HF x Sahiwal.

2.4.3 Heritability estimate

The heritability estimates for body weight at twelve months in different crossbreds are listed in Table 2.7. The heritability estimate ranged from – 0.112 ± 0.387 in BS x Hariana (Bhat and Singh, 1978) to 0.66 ± 0.34 in F x Gir (Shrivastava *et al.*, 1985).

2.5 Age at first insemination (AFI)

Misotov and Konovalova (1994) indicated that intensive rearing of heifers and insemination at an early age (18 – 22 *vs.* 24 – 30 months) is beneficial for extending the productive life span.

Table 2.6. Means and Standard errors of body weights at twelve months of age of different crossbreds in India

Crosses	Body weight (Kg)	Reference
JERSEY CROSSES		
J x Kankrej	215.48	Patel *et al.* (1985)
J x Hariana	148.20± 3	Shrivastava *et al.* (1985)
J x Gir	165.69±2.8	-do-
J x Tharparkar	111.51±4.43	Roy *et al.*(1996)
HF CROSSES		
HF x Kankrej	252.8	Patel *et al.* (1985)
HF x Hariana	175.81±4.6	Shrivastava *et al.* (1985)
F x Gir	192.95±2.3	-do-
HF x Sahiwal	193.08±2.33	Teotia *et al.* (1990)
HF x Sahiwal/ Tharparkar	161.4	Reddy *et al.*(1991)
HF x Tharparkar	110.76±5.20	Roy *et al.*(1996)
BS CROSSES		
BS x Hariana	153.19±3.3	Shrivastava *et al.* (1985)

Table 2.7. Heritability estimates of body weight at twelve months of age in different crossbreds of India

Crosses	Heritability	Reference
J x Hariana	0.49±0.65	Shrivastava *et al.* (1985)
J x Gir	0.42±0.31	-do-
HF x Hariana	-0.40±0.24	Shrivastava *et al.* (1985)
F x Gir	0.66±0.34	-do-
HF x Sahiwal	0.41±0.12	Teotia *et al.*(1990)
BS x Hariana	-0.112±0.387	Bhat and Singh (1978)

2.5.1 Means

Reports on mean age at first insemination in crossbreds are tabulated in Table 2.8. The age at first insemination in crossbred cows ranged from 450 days (Blaho, 1987) to 769.8 days (Pyne *et al.*, 1987).

2.5.2 Factors affecting age at first insemination

Only a few references were available on the factors considered for the present analysis on AFI. The available references are reviewed below.

a. Season of birth

Pyne *et al.* (1987) observed nonsignificant effect of season of birth on age at first service in HF crossbreds. But in Jersey crossbreds, he observed that age at first service differed significantly for females born in the winter, summer and monsoon seasons (635.3, 714.9 and 662.1 days respectively).

b. Period of birth

No references were found on effect of period of birth on age at first insemination of crossbred cattle of India.

c. Farms / Centres

Reports with influence of farms/centres/locations on age at first insemination of Indian crossbreds were not available.

d. Sire

Anand and Balaine (1981) reported that there was a significant difference in reproductive performance (AFI) between J x Hariana cows sired by the progeny tested bulls from USA and by the bulls from Australia, the former being superior.

2.5.3 Heritability estimate

Heritability estimate for age at first insemination was 0.39 ± 0.16 in J x Hariana crosses (Anand and Balaine, 1981) and 0.14 in Holstein dairy cattle (Raheja *et al.*, 1987).

2.6 Age at first calving

A good dairy cow is one that delivers a calf at an early age and yields more milk during her lifetime. Early Age at First Calving (AFC) would result in higher genetic gain per unit time by decreasing the generation interval. Calving at an early age not only minimizes capital investment incurred on rearing of heifers to the stage of calving but also enables progeny testing programme to be completed in shortest possible time. Thus a cow calving at an early age gives more number of "calf crops" and lactations in her lifetime which inturn increase profitability of the dairy enterprise.

2.6.1 Means

The average age first calving reported in cattle of Kerala is listed in Table 2.9. The reports on AFC of nondescript cows of Kerala ranged from 38.5 to 49.7 months, for BS crosses it ranged from 31.8 to 46 months and for Jersey crossbreds it ranged from 41.0 to 51.0 months. Table 2.10 depicts the mean AFC of different crossbreds in other parts of country, and the reports do not suggest any special merit to any crossbreds among J, HF and BS crossbreds.

Table 2.8. Average age at first insemination of cattle

Crosses	Mean AFI (Days)	Reference
J x Hariana	670.8	Pyne *et al.*(1987)
HF x Hariana	769.8	-do-
Zebü x Chiana	738.3±3	Silva *et al.*(1986)
HF x Slovakian Pied	450	Blaho (1987)
Holstein	580	Raheja *et al.*(1987)

Table 2.9. Average age at first calving of nondescript and crossbred cattle of Kerala

Investigator	Quantity of Data	Avg. AFC months/days	Location
Non Descript cows			
Nair (1973)	32	38.5 ± 6.4	Indo-Swiss project
Patel *et al.* (1976)	-	49.7 – 58.1	Kerala
Bhat and Mukundan (1979)	-	38.5 – 58.7	Kerala
BS x ND cows			
Nair (1973)	22	34.5 ± 5.1	Indo-Swiss Project
Patel *et al.* (1976)	-	31.8	Local farms of Kerala in plains
-do-	-	33.5	Local farms of Kerala in high ranges.
Girija (1980)	64	43.2 ± 2.06	Farms under KAU
Chacko and George (1984)	-	1063 ± 156	Kerala
Iype *et al.* (1984)	352	44.8 ± 0.7	Field conditions of Kerala
Stephen *et al.* (1985b)	1258	46.0 ± 0.5	Field conditions of Kerala
J x ND cows			
Nair (1973)	28	1535.1 ± 56.22	District Livestock farm Kodapankunnu
Girija (1980)	281	40.2 ± 0.958	Farms under KAU
Stephen *et al.* (1985b)	35	41.1 ± 2.1	Field conditions of Kerala

Table 2.10. Average age and weight at first calving of Indian crossbreds

Crosses	AFC (months/days)	WFC (kg)	Reference
JERSEY CROSSES			
J x Kankrej	820.82±12.1 -	349.25±8 352.1±9.71	Mansuri (1989) Patel *et al.*(1989)
J x Sahiwal	31.0 ± 1.09	314.47±4.5	Singh *et al.*(1989)
J x Hariana	881.8	-	Chopra (1990)
J x Ongole	903	-	Prabhukumar *et al.* (1991)
J x Ongole	29.63±2.32	-	Rao *et al.* (1996)
HF CROSSES			
HF x Red Sindhi	871.3±17.4	356.4±6.9	D'Souza *et al.* (1979)
Karan Fries	32.46±0.26	-	Singh *et al.* (1988)
HF x Kankrej	880.2±14.2 -	420.5±16.3 421.73±7.4	Mansuri (1989) Patel *et al.*(1989)
HF x Sahiwal	34.24±1.25	401.47±5.4 238.9±2.1	Singh *et al.*(1989) Rana (1991)
HF x Hariana	932.6	-	Chopra (1990)
F x Ongole	1025	-	Prabhukumar *et al.* (1991)
HF x Sahiwal	965.26±14.5	-	Jadhav and Khan (1996)
Frieswal	940.2±14.6	-	Arora *et al.*(1996)
BS CROSSES			
BS x Hariana	1001.5	-	Chopra (1990)
Karan Swiss	1034	348	Kakran and Joshi (1990)
BS x Ongole	1030	-	Prabhukumar *et al.* (1991)

2.6.2 Factors affecting age at first calving

a. ***Season of birth***

The impact of season of birth was significant in Friesian x Sahiwal (Jadhav and Khan, 1996)

b. Period of birth

The significant influence of Period of birth has been reported in Friesian x Sahiwal crosses (Jadhav and Khan, 1996).

c. Farms /centres

Highly significant influence of farm on AFC in Friesian x Sahiwal has been observed by Jadhav and Khan (1996), Reddy and Basu (1985).

Hayatnagarkar *et al.* (1991) reported that locations contributed highly significantly towards variation in AFC in nondescripts crossed with J and HF.

AI centres affected AFC significantly. It accounted for 9.4 per cent of total variation (Mehra, 1983) in village crossbreds of Punjab.

d. Sire

Koul *et al.* (1985) made studies on AFC of halfbreds of Hariana with HF, BS and Jersey. It was found that sire effects on AFC were significant only in HF crosses but not in the other crosses. Significant effect of sire was also reported by Nobre *et al.* (1984) in HF crossbreds and by Naikare *et al.* (1994) in three breed Gir crosses.

2.6.3 Heritability estimate

AFC had low heritability in the literature consulted. Some have reported negative values indicating small genetic component or large error term. Heritability estimate reported in different crossbreds are presented in Table 2.11 and it ranged from 0.011 ± 0.0469 in HF x Sahiwal (Jadhav and Khan, 1996) to 0.58 ± 0.40 in HF x Kankrej (Mansuri, 1989).

2.7 Weight at first calving (WFC)

Body weight at first calving is an index of physical as well as physiological development of a female and plays a vital role in building their calves. Association of weight at first calving (WFC) with measures of subsequent productivity of dairy cows is of immense importance. The high cost of raising animals needs early identification of heifers with efficient production potential.

2.7.1 Means

The mean WFC of different crossbred cows are presented in Table 2.10. It ranged from 314.47 ± 4.5 kg in J x Sahiwal (Singh *et al.*, 1989) to 420.5 ± 16.3 kg in HF x Kankrej (Mansuri, 1989).

2.7.2 Factors affecting Weight at first calving

a. Season of Birth

No reports were found showing effect of season of birth on weight at first calving.

b. Period of Birth

Studies showing period of birth as one of the factors affecting WFC in crossbred cows could not be traced.

c. Farms / Centres

Under field progeny testing scheme in Kerala, the WFC of crossbred cows in different centres differed significantly. (Iype, 1992). Significant influence of farms on WFC was also observed by Dangi (1979) in Friesian x Sahiwal.

d. Sire

The WFC of crossbred cows born to different test bulls of field progeny testing scheme in Kerala were significantly different (Iype, 1992).

2.7.3 Heritability estimate

The heritability estimate of WFC of different crossbreds as reported are listed in Table 2.11. The estimate ranged from 0.027 ± 0.1989 in HF x Sahiwal (Tomar and Tomar, 1982) to 0.753 ± 0.334 (Naidu and Desai, 1970).

Table 2.11. Heritability estimates of age and weight at first calving of Indian crossbreds.

Age at First Calving		
Crosses	Heritability	Reference
J x Hariana	0.21±0.33	Koul *et al.* (1985)
J x Kankrej	0.23±0.36	Mansuri (1989)
F x Hariana	0.55±0.40	Koul *et al.*(1985)
Karan Fries	0.39±0.155	Singh *et al.* (1988)
HF x Kankrej	0.58±0.40	Mansuri (1989)
HF x Zebu crosses	0.111±0.087	Rao and Nagarcenkar (1992)
HF x Sahiwal	0.011±0.0469	Jadhav and Khan (1996)
BS x Hariana	0.11±0.25	Singh *et al.* (1990)
Weight at First Calving		
J x Hariana	0.42±0.19	Choudhuri *et al.*(1988)
HF x Sahiwal	0.753±0.334	Naidu and Desai (1970)
	0.027 ± 0.1989	Tomar and Tomar (1982)
HF halfbreds	0.078±0.112	Rao and Nagarcenkar (1992)

2.8 Milk yield

The milk yield is the most important economic trait in dairy cattle. As native breeds of cattle of India are very low milk yielders, exotic inheritance was introduced through massive crossbreeding programmes to enhance milk yield. The exotic inheritance was mainly from Jersey, Brown Swiss and Holstein Friesian.This resulted in various levels of exotic inheritance in native breeds.

In Kerala, Jersey bulls were used initially for crossbreeding local cattle. Subsequently Brown Swiss bulls were used and later Holstein bulls were also introduced (Iype *et al.,* 1993). This has resulted in a mosaic inheritance in the present cows.

2.8.1 Means

The average 305-day milk yield in crossbreds reported from Kerala and other parts of India are presented in Table 2.12 and 2.13 respectively. The milk yield of crossbreds in Kerala ranged from 1140 ± 46 kg (Nair, 1973) to 1905.7 kg (Radhika, 1997), whereas the milk yield of other Indian crossbreds ranged from 1091.12 ± 58.41 kg in J x Assam Local (Thakuria *et al.,* 1982) to 3758 kg in BS x Sahiwal (Chawla and Mishra, 1979).

Table 2.12. Average 305-days milk yield of crossbred cattle of Kerala

Breed groups	Average 305 day milk yield (litres)	References
½ J x ½ ND	1140±46	Nair(1973)
½ J x ½ ND	1359±57	Stephen *et al.* (1985a)
J x Local	1566.5±101.0	Iype *et al.* (1986)
½ BS x ½ ND	1492±20	Stephen *et al.* (1985a)
BS crosses	1445.5±0.374	Iype *et al.*(1985)
BS crosses	1476.8±114.2 1513.3±130.2	Thomas *et al.*(1987)
Cows with mosaic inheritance	1479.5±10.3	Iype *et al.*(1993)
Mosaic inheritance (on the basis of 3663 cows)	1517±12.5	Iype (1995)
Crossbred progenies born to test bulls of FPT scheme	1905.7	Radhika (1997)

Table 2.13. Average milk yield of crossbreds of India

Cross	Milk yield (in kg)	Reference
JERSEY CROSSES		
J x Gir	2713.0±225.5	Bhat (1977)
J x Red Sindhi	1501.7±82.3	-do-
J x Assam Local	1091.12±58.41	Thakuria *et al.*(1982)
J x Kankrej	2808.5±95.92	Patel *et al.*(1989)
J x Ongole	1688	Prabhukumar *et al.*(1991)
J x Hariana	1968.8	Chopra (1990)
J x Red Khandari	1189.5±176.11	Kulkarni *et al.*(1992)
J x Hallikar	1678-1779	Shettar and Govindaiah (1999)
HF CROSSES		
F x Gir	2254.5±97.5	Bhat (1977)
F x Tharparkar	2600.0±49.5	-do-
HF x Red Sindhi	2326.2±94.3	D'Souza *et al.*(1979)
HF x Kankrej	3869.5±158.19	Patel *et al.*(1989)
HF x Hariana	2647.3	Chopra (1990)
HF x Sahiwal	2309±90	Rana (1991)
F x Ongole	2070	Prabhukumar *et al.*(1991)
Frieswal	2712.3±76.6	Arora *et al.*(1996)
BS CROSSES		
BS x Local	2188.0±697	Bhat (1977)
BS x Sahiwal	3758	Chawla and Mishra (1979)
BS x Hariana	2187.7	Chopra (1990)
Karan Swiss	2768	Kakran and Joshi (1990)
BS x Ongole	1857	Prabhukumar *et al.*(1991)

The crossbreds of exotic milch breeds with the other Indian milch breeds were found to be performing better than the crossbreds of Kerala obviously due to the difference in the desi component

2.8.2 Factors affecting milk yield

a. Season of calving

Singh and Pandey (1970) observed that the cows calving in spring season were found to produce 3.7 per cent more milk than the average for the animals calving in other seasons. Shettar and Govindaiah (1999) studied the performance of crossbred cattle (J, HF or Danish Red crossed with Red Sindhi, Hallikar or Amrith mahal) and found that milk yield was lower in summer than in winter and monsoon seasons.

On the contrary, nonsignificant influence of season of calving has been reported by Stephen *et al.* (1985a) in crossbreds of Kerala (i.e., J & BS crosses with local cattle).

b. Period/year of calving

The significant effect of period of calving was reported in HF x Sahiwal (Jadhav *et al.*, 1991), in HF x Deoni and Jersey x Deoni (Thalkari *et al.*, 1995) and in Jersey, HF or Danish Red crossed with Red Sindhi, Hallikar or Amrit mahal (Shettar and Govindaiah , 1999).

c. Farm / Centres

The studies made by Chacko *et al.* (1984) and Thomas *et al.* (1987) under field conditions (Mavelikkara and Kattapana) of Kerala had observed significant influence of AI centres on milk yield. Iype *et al.* (1993) who conducted study in farmers' herds in Thrissur area also reported significant influence of centres on milk yield. The significant influence of farm on milk yield had been reported by Iype *et al.* (1986) in crossbreds of Kerala and by Jadhav *et al.* (1991) in HF x Sahiwal and in Deoni crossbreds (with J and HF) by Thalkari *et al.* (1995).

d. Age group

Significant effect of AFC on milk yield was reported by Stephen *et al.* (1985a) in Jersey and Brown-Swiss crosses and

Thomas et al. (1987) in BS crosses under field conditions of Kerala, Turkmut and Kumuk (1994) in Holstein-Friesian, Garcha and Dev (1994) in HF crossbreds. On the contrary, Varade and Ali (1998) in Jersey crossbreds and Sreemannarayana and Rao (1994) in Jersey cows (Andhra Pradesh) reported nonsignificant influence of AFC on milk yield.

e. Sire

Vij and Basu (1986) observed that the effect of breed of sire was not significant for milk production traits and they have opined that, it is probably not the breed, but the sires that are important in causing the differences among the crossbred progeny.

Herbert and Bhatnagar (1989) evaluated production traits of Karan Swiss cows. Result indicated that 305 days yield was influenced by sire.

Touchberry and Balaine (1990) studied the effect of sire (Holstein and Guernsey) on milk yield, fat, SNF etc. It was observed that the sire effect was significant for milk yield in the second lactation but not in the first lactation.

Pereira *et al.* (1994) reported significant effect of sire on milk yield in Caracu cattle.

Radhika (1997) studied the milk yield of progenies born to test bulls of FPT scheme under field conditions of Kerala and observed nonsignificant influence of sire on milk yield.

2.8.3 Heritability estimate

Reports on the heritability estimate of milk yield are low to medium in crossbreds. In HF x Sahiwal, the heritability estimate reported for milk yield were 0.068 ± 0.172 (Naidu and Desai, 1970), 0.482 ± 0.203 (Rao and Nagarcenkar, 1981), 0.54 ± 0.20 (Tomar and Tomar, 1982), 0.22 ± 0.02 (Teotia *et al.*, 1990) and 0.025 (Sachdeva and Gurnani, 1995) whereas in crossbreds of Kerala, Radhika (1997) reported an estimate of 0.169 ± 0.240.

2.9 Correlation estimates

2.9.1 Between body weights

In Sahiwal x Friesian, Sharma (1977) reported positive genetic and phenotypic correlation of birth weight and weight at one year, between weight at six months and weight at one year.

Table 2.14 and 2.15 shows the genetic and phenotypic correlation estimates among body weights reported by different authors.

Rao and Nagarcenkar (1981) concluded that the phenotypic correlation of birth weight with body weights at later ages were positive but low indicating that birth weight could not be used as a guide to the future body weights in crossbred cattle. The phenotypic correlation between body weights from 3 to 24 months were highly significant while the genetic correlation ranged from 0.421 and >1.They have inferred that the increased growth potential of crossbred calf was probably not expressed at birth but only at later ages.

Jogi and Parekh (1982) made studies on birth weight, weight at 3,6,9,12 and 15 months in HF halfbreds (with Gir and Tharparkar) and observed that the genetic correlation of birth weight with weight at 3 and 6 months were close to zero (-0.0036 and 0.0431) and estimates were higher among weights at later ages. But the genetic correlations among body weights at later ages were higher and significant.

Table 2.14. Genetic correlation between body weights at different ages

	BW0	BW3	BW6	BW12	Reference
BW0	1	-0.0036±0.29	0.0431±0.28	0.58±0.06	(A)
		0.746±0.215	0.766±0.146	0.745±0.159	(B)
		-	-0.15±0.01	0.51±0.02	(C)
BW3		1	0.8±0.06	0.83±0.09	(A)
			0.616±0.283	0.769±0.173	(B)
			-	-	(C)
BW6			1	0.99±0.004	(A)
				0.757±0.14	(B)
				0.74±0.07	(C)
BW12				1	

(A) Jogi and Parekh (1982)

(B) Rao and Nagarcenkar (1981)

(C) Teotia *et al.* (1990)

Table 2.15. Phenotypic correlation between body weights at different ages

	BW0	BW3	BW6	BW12	Reference
BW0	1	0.61	0.40	0.31	(A)
		-	-	-	(B)
		0.12±0.08	0.97±0.08	0.35±0.06	(C)
BW3		1	0.7	0.49	(A)
			0.1	0.742	(B)
			0.88±0.01	0.6±0.04	(C)
BW6			1	0.58	(A)
				0.094	(B)
				0.5±0.04	(C)
BW12				1	

(A) Malau Aduli *et al.*(1996)

(B) Sharma and Singh (1987)

(C) Jogi and Parekh (1982)

In genetic studies made by Teotia *et al.* (1990) on growth and milk production in HF x Sahiwal crosses, it was revealed that the correlations among the 6 monthly body weights from birth to 24 months of age were positive and significant, except the genetic correlation of birth weight with 6 months weight which was negative. The correlation between body weights at two successive stages was larger than the stages much wider apart. It was explained this could be due to the carry over effects of one stage to its successive stage and the role of environment over a period of time gap.

Malau – Aduli *et al.* (1996) studied the growth of Friesian x Bunaji crosses. The phenotypic correlation among body weights at birth, 3,6,9 and 12 months of age were all positive and highly significant ranging from 0.30 to 0.79. There was high correlation of 0.70 between body weight at 3 and 6 months, of 0.74 between 6 and 9 months, of 0.79 between 9 and 12 months. Based on these results, they have opined that selection for yearling body weight can be done early on the basis of weights of heifers at 3 and 6 months of age.

2.9.2 Body weights at different ages with AFC & FLMY

Significant negative genetic and phenotypic correlations were found between birth weight and AFC, between weight at 6 months and AFC and between weight at one year and AFC in Sahiwal x Friesian crosses (Sharma, 1977).

The genetic and phenotypic correlation estimates reported by different authors for body weights with AFC and with FLMY are summarized in Table 2.16 and 2.17, respectively.

The relationship between birth weight and AFC was not significant and was negative (Rao and Nagarcenkar, 1981). But negative and highly significant values were reported by Jadhav and Khan (1996) in F x Sahiwal and Singh *et al.* (1988) in Karan Fries. Positive and nonsignificant correlation between birth weight and AFC was reported by Hayatnagarkar *et al.* (1991). Rao and Nagarcenkar (1981) noted the phenotypic correlation of body weights at earlier ages with AFC as negative and significant statistically. These correlations were high from 6 months of age indicating that the physiological age of maturity was attained at an earlier age in animals growing at a faster rate. The genetic correlation was also negative and high.

D' Souza *et al.* (1979) reported positive phenotypic correlation between AFC and WFC in F x Red Sindhi.

Arora and Desai (1979) reported that WFC was genetically correlated with AFC (-0.85 and –0.47) in F x Sahiwal with less than or equal to 50 per cent and more than or equal to 50 per cent Friesian breeding respectively.

The positive and significant correlation between AFC and WFC was observed in HF x Sahiwal by Rao and Nagarcenkar (1981) and Singh *et al.* (1990). Similar observations were made in HF x Kankrej and J x Kankrej by Mansuri (1989) and in Hariana x Friesian by Pandey *et al.* (1985), in Hariana x Jersey by Koul *et al.* (1985).

Yadav and Balaine (1984) made studies in Hariana crosses (HF, BS and J) and observed that correlation between WFC and AFC was significant only for Hariana x J.

Teotia *et al.* (1990) reported that the phenotypic correlations of 300 days milk yield with early six monthly body weights from birth to twenty four months of age were all positive and significant except the correlation with birth weight which was negative and non significant. The genetic correlation of 300-day milk yield with body weight at birth, 6 and 12 months were negative and significant. In HF x Sahiwal, Rao and Nagarcenkar (1981) observed positive and significant correlation between body weight at earlier ages and first lactation production except in case of birth weight and weight at three months. The genetic correlation ranged from 0.549 to >1 in ¾ Friesian crosses while they had high standard errors in ½ Friesian crosses.

The phenotypic correlation between first lactation milk yield with WFC was positive and significant in F x Sahiwal (Dangi, 1979) and 0.694 in F x Red Sindhi by D' Souza *et al.* (1979). The phenotypic correlations between WFC and FLMY were 0.010 ± 0.006, 0.06 ± 0.08, 0.27 ±0.03 and 0.28 ± 0.03 for Sahiwal, BS x

Sahiwal, HF x Sahiwal and Sahiwal x (HF x Sahiwal), respectively (Chawla and Mishra, 1979).

Tomar and Tomar (1982) reported that WFC had low as well as no significant genetic and phenotypic correlation with the FLMY.

Yadav and Balaine (1984) made studies in crosses of Hariana with HF, BS and J and observed that lactation milk yield was not significantly correlated with WFC in any breed group.

Koul *et al.* (1985) made studies on AFC and its relation with WFC and milk yield in crossbred cattle. Significant correlation between WFC and FLMY in Hariana x Friesian and Hariana x Brown Swiss were observed.

The significant and positive correlation between WFC and FLMY in both Holstein x Kankrej and Jersey x Kankrej breed groups respectively were observed in the studies made by Mansuri (1989). These reports on the correlation of body weights at different ages with FLMY are contradictory and do not suggest any definite trend.

Table 2.16. Genetic (r_g) and Phenotypic (r_p) correlation between body weights at different ages with age at first calving

	AFC		Reference
	r_g	r_p	
BW0	-0.945 ± 0.056	-0.028	Rao and Nagarcenkar (1981)
	-	0.65 ± 0.05	Singh *et al.*(1988)
	-	0.019	Hayatnagarkar *et al.*(1991)
	0.34 ± 0.18	-	Narang *et al.*(1994)
	-0.38 ± 0.14	-0.14 ± 0.03	Jadhav and Khan (1996)
BW3	-0.572 ± 0.321	-0.172	Rao and Nagarcenkar (1981)
BW6	-0.551 ± 0.347	-0.223	-do-
BW12	<-1	-0.272	-do-
WFC	-	0.267	D' Souza *et al.*(1979)
	-0.85 -0.47	- -	Arora and Desai (1979)
	- -	0.39 0.67	Mansuri (1989)
	- -	0.65 0.37	Koul *et al.*(1985)
	-	0.65	Pandey *et al.*(1985)

Table 2.17. Genetic and Phenotypic correlation between body weights at different ages with Milk Yield

	Milk yield		Reference
	r_g	r_p	
BW0	0.313±0.33	0.070	(a)
	-0.52±0.02	-0.01±0.07	(b)
BW3	-0.306±0.478	0.076	(a)
	-	-	(b)
BW6	0.271±0.294	0.176	(a)
	-0.72±0.02	0.15±0.07	(b)
BW12	0.189±0.302	0.172	(a)
	-0.65±0.02	0.23±0.06	(b)
WFC	-	0.694	D'Souza *et al.*(1979)
	0.94±1.4	0.104±0.174	Tomar and Tomar (1982)
	-	0.38 0.45	Koul *et al.*(1985)
	-	0.78 0.55	Mansuri (1989)
	0.613±0.182	0.303±0.041	Singh *et al.*(1990)

a) Rao and Nagarcenkar, (1981)
b) Teotia *et al.*(1990)

Materials and Methods

3. MATERIALS AND METHODS

Data for the study of "Body weight and its association with Age at First calving and Milk production in crossbred cattle of Kerala" were taken from the records of ICAR Field Progeny Testing Scheme pertaining to the period 1993 – 2000. Progeny Testing Scheme started in 1986 as Ad-hoc scheme on Progeny testing of crossbred bulls in rural areas in collaboration with Department of Animal Husbandry, Kerala Livestock Development Board and the People Dairy Development Project (NGO). The main objective of this project was to develop a system of milk recording for progeny testing of crossbred bulls. In 1992, the scheme titled "Progeny testing procedures in crossbred cattle using information from both large and small herds" was started as a continuation of the scheme. In April 1994, Kerala Agricultural University (KAU) was recognized as one of the field progeny-testing (FPT) unit with others viz., Punjab Agricultural University (PAU) and BAIF in the country by the ICAR. All the three FPTs were brought under the control of Project Directorate on Cattle, located at Meerut. This programme envisaged the progeny testing of 30 HF crossbred bulls (50-75 per cent) at national level. Improvement of the genetic potential and milk production of the crossbred cattle became the prime objective with the transformation of the scheme to FPT under Project Directorate on Cattle.

The test bulls used in the scheme were of HF crossbred bulls selected on the basis of pedigree. They were from dams with not less than 4500-kg milk per lactation and the bull's sires were superior proven bulls with much higher genetic worth. The bulls were test inseminated in crossbred cows of farmers in the field through fourteen (14) artificial insemination centres of the State Department of Animal Husbandry in Thrissur district near KAU. The semen of these superior bulls is being used in Cattle Breeding Farm (CBF), Thumburmuzhy from 1991 onwards, and at University Livestock Farm (ULF), Mannuthy from 1993 onwards. The Livestock Research Station (LRS), Thiruvazhamkunnu used semen of the scheme during 1991-93 period. Before the introduction of HF crossbred bulls, most of the animals in the field were of Jersey crossbreds. Therefore the progenies born under the scheme have mosaic type of inheritance from desi, Jersey and HF. Female progenies of these bulls belonging to the farmers in the field area and in the farms were identified by ear tagging. In farms, all the animals were maintained under standard management conditions, i.e, they were given green fodder and concentrates throughout the year. In the field, 50 per cent of the farmers had only one cow and percentage of the farmers who own cattle had less than 10 cents of land (Annual Progress Report, 1999). The green fodder was given only during rainy season. Paddy straw was the main roughage during other months of year. Milk recording was done both in morning and evening at monthly intervals. First recording is done around 20 days of calving. The farmer does not practice weaning. After morning milking, calf is allowed to be with mother for about one hour generally. In the university farms, weaning is practiced and milk recording is done daily in the morning and evening. The 305 days milk yield was estimated from these records as the yield of milk (litres) from the date of calving to 305 days. Some cows voluntarily dried before 305 days. Therefore their yields upto the date of drying were taken as standard lactation yields. When records were missing or incomplete, due to sale of animals, the prediction formula (Iype, 1992) was used to calculate the total 305-day yield.

For the present study, the progenies born to the four batches of bulls since 1993 were included. Under the scheme, the body growth of female calves was monitored by recording the following measurements up to one year of age.

1. Body Measurements at birth, three, six and twelve months of age and at calving

   a) Body length (cm): From the point of shoulder to the tip of pin bone.
   b) Chest girth (cm): Measured around the chest behind the elbow joint.
   c) Height at withers (cm): Measured immediately behind the hump to the ground.

Besides body measurements, the following observations recorded in the scheme were also utilized in the study.

1.Date of first insemination

2.Date of first calving

3.Milk Yield at monthly intervals

To estimate the body weights from the body measurements at different ages, the formula given by Anthony (1994) and Minnesota formula are used in the farm born animals. The test showed that Minnesota formula was nearer to the actuals. Hence in the present study, Minnesota formula given by Johnson

(1940) was used for predicting body weight. The same is given below.

$$W = \frac{LG^2}{300}$$

Where,

W= Weight in pounds

L = Body length in inches

G = Chest girth in inches

The following non-genetic factors were considered for analyzing their effect on body weights, age at first insemination (AFI), AFC, and WFC and the data was classified accordingly. Milk Yield for 305-days lactation was estimated from the ten monthly recordings.

1. Season of birth: The whole year was divided into two seasons as done by Stephen *et al.* (1985a).

a) Dry Season: This includes the months from November to April.

b) Rainy Season: This includes the months from May to October.

2. Period of birth: The whole duration from 1993 – 2000 was classified into four periods and each period consisted of two years.

1993 - 1994 - Period 1

1995 - 1996 - Period 2

1997 - 1998 - Period 3

1999 - 2000 - Period 4

3. Centres: The progenies born in the field artificial insemination centres (14) and three university farms were included for the present study.

To study the effect of non-genetic factors such as centre, Season of Birth (SOB) and Period of Birth (POB) the following model was used.

$$Y_{ijkl} = \mu + S_i + P_j + C_k + e_{ijkl}$$

Where,

Y_{ijkl} = The observation on the l^{th} individual born in i^{th} season, j^{th} period and k^{th} centre

μ = Overall mean when equal subclass members exist

S_i = Effect of i^{th} season of birth

P_j = Effect of j^{th} period of birth

C_k =Effect of k^{th} centre

e_{ijkl} = Random error associated with Y_{ijkl} which is assumed to be normally and independently distributed with zero mean and variance $\sigma_e{}^2$

For Milk Yield, the data were classified as follows-

1. **Seasons of calving:** Seasons of calving were defined by dividing year into dry and rainy seasons as above.
2. **Period of calving:** Different periods of calving were made by grouping the years as follows-

1995 – 1996 = Period 1

1997 – 1998 = Period 2

1999 – 2000 = Period 3

3. **Centre:** The progenies calved in the field artificial insemination centres (14) and three university farms were included for the present study.

4. Age Group: The progenies were grouped into four age groups based on their age at first calving

Less than 2 ½ years	–	age group 1
2 ½ – 3 years	–	age group 2
3 – 3 ½ years	–	age group 3
Above 3 ½ years	–	age group 4

To study the effect of non-genetic factors on milk yield, the model used was

$$Y_{ijklm} = \mu + S_i + P_j + C_k + A_l + e_{ijklm}$$

Where,

Y_{ijklm} = The observation on the m^{th} cow calved in i^{th} season, j^{th} period and k^{th} centre of l^{th} age group.

μ = Overall mean when equal subclass members exist

S_i = Effect of i^{th} season of calving

P_j = Effect of j^{th} period of calving

C_k = Effect of k^{th} centre

A_l = Effect of l^{th} age group

e_{ijklm} = Random error associated with Y_{ijklm} which is assumed to be normally and independently distributed with zero mean and variance $\sigma_e^{\ 2}$

Least squares analysis of variance was employed to study the effect of seasons, periods, centres and age groups on the different traits using the above model. The standard programme LSML (Harvey, 1986) was used for computation.

3.1 Sire effect and heritability

The data were adjusted for significant non-genetic factors and then effect of sire and heritability was estimated by paternal half sib method using the following model (Becker, 1975). The minimum number of progeny per sire was three.

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

Where,

Y_{ij} = Observation of j^{th} progeny of i^{th} sire

μ = Overall mean

S_i = Effect of i^{th} sire assumed to be random with mean zero and variance σe^2

e_{ij} = Random error of each observation.

Anova Table

Source	DF	MSS	EMS
Between Sires	S-1	MS_s	$\sigma_e^2 + k\,\sigma_s^2$
Progeny within sire	N-S	MS_e	σ_e^2

Where,

$k = 1/S\text{-}1 \ (N - \sum n_i^{\,2}/N)$

k = average number of progenies per sire

S = number of sires

$\sum n_i$ = number of progenies within i^{th} sire

N = total number of progenies

σ_s^2 = Sire component of variance

σ_e^2 = Variance among progeny within sire

$$\sigma_s^2 = \frac{MS_s - MS_e}{k}$$

t = Intraclass correlation between half sibs

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

Heritability (h^2) = 4t

The standard error of heritability was estimated by the following formula

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

3.2 Correlation

3.2.1 Estimation of genetic correlation

Genetic correlations (r_g) between body weights at different ages and between body weights and AFC and between body weights and FLMY were estimated using the model similar to that by the method of analysis of co-variance of data on half sib described under heritability.

k, $\sigma_{s(x)}^2$, $\sigma_{s(y)}^2$ were estimated as in the case of heritability where x and y were the two characters considered.

The ANACOVA between X and Y is as given below.

Source	DF	MCP	EMCP
Sire	S–1	MCP_s	$Cov_w + kCov_s$
Progeny within sire	N – S	MCP_w	Cov_w

$$Cov_w = MCP_w$$

$$COV_s = \frac{MCP_s - MCP_w}{k}$$

$$r_{g(xy)} = \frac{Cov_s}{\sigma_{s(x)}^{\ 2} \cdot \sigma_{s(y)}^{\ 2}}$$

3.2.2 Estimation of phenotypic correlation

The Phenotypic correlations between body weights at different ages and with AFC and FLMY were calculated by the formula described by Becker (1975).

$$r_{p(xy)} = \frac{Cov_w + Cov_s}{(\sigma_{w(x)} + \sigma_{s(x)})\,(\sigma_{w(y)} + \sigma_{s(y)})}$$

Results

4. RESULTS

4.1 Birth weight

4.1.1 Means

Least squares analysis of variance for birth weight is presented in Table 4.1. Least squares means for birth weight according to Centre, Period of Birth (POB) and Season of Birth (SOB) are presented in Table 4.2 and the over all mean (μ) birth weight was 26.0 ± 0.38 kg.

4.1.2 Factors affecting birth weight

a. Season of Birth (SOB)

Effect of SOB was observed to be non-significant on birth weight.

b. Period of Birth (POB)

POB had significant ($P \leq 0.05$) effect on birth weight. The averages were 25.8 ± 0.41 kg, 27.2 ± 0.42 kg, 25.0 ± 0.60 kg and 26.0 ± 0.73 kg for the periods 1993-94, 1995-96, 1997-98 and 1999-2000 respectively.

Table 4.1 Least squares analysis of variance for effect of non-genetic factors on body weights at different ages of crossbred calves in Kerala

Source	Mean squares							
	DF	BW0	DF	BW3	DF	BW6	DF	BW12
Season	1	5.42	1	94.54	1	1702.53*	1	151.29
Period	3	110.70*	3	305.36*	2	802.56	3	1525.56*
Centre	10	144.67*	11	472.08*	11	778.78*	10	1395.17*
Error	545	18.71	398	72.74	323	303.05	195	440.31

* P≤0.05

Table 4.2 Least squares means and standard errors for the factors affecting body weights (kg) at birth and three months of age of crossbred calves in Kerala

FACTORS	BW0	BW3
	M+SE	M+SE
μ	26.0±0.38 (560)	48.7±1.26 (414)
Season		
Dry	26.1±0.42 (287)	49.2±1.32 (212)
Rainy	25.9±0.44 (273)	48.1±1.36 (202)
Period		
1993-94	25.8±0.41 (196)	49.5±1.29 (234)
1995-96	27.2±0.42 (210)	47.6±1.36 (142)
1997-98	25.0±0.60 (97)	38.3±4.06 (5)
1999-2000	26.0±0.73 (57)	59.28±5.17 (33)

Cont......

Centre		
Parappur	24.3±0.90 (25)	50.73±2.63 (20)
R.V.Puram	25.5±1.33 (11)	57.1±3.05 (11)
Chettupuzha	-	49.7±3.73 (7)
Cherpu	22.8±0.73 (40)	50.6±2.53 (25)
Chirakkakode	24.0±1.27 (12)	51.8±5.28 (3)
Karuvannur	28.1±2.18 (4)	49.0±2.86 (15)
Kunnathangady	26.1±1.65 (7)	49.1±2.37 (33)
Kannara	29.1±1:11 (17)	53.5±2.00 (74)
Moorkanikkara	27.7±0.61 (63)	52.1±1.99 (126)
ULF, Mannuthy	25.9±0.40 (120)	46.0±5.38 (11)
CBF,Thumburmuzhy	27.8±0.32 (180)	41.0±4.80 (22)
LRS, Thiruvazhamkunnu	24.6±0.55 (81)	43.3±2.03 (67)

BW0(kg): Mean = 26.55 Error standard deviation = 4.32
CV = 16.29 R Squared = 0.140 R= 0.374
BW3(kg): Mean = 50.38 Error standard deviation = 8.52
CV = 16.93 R Squared = 0.163 R = 0.404
Note - Values in parentheses are the number of observations

c. Centre

Effect of centre was significant ($P \leq 0.05$) on birth weight. The lowest mean was for Cherpu centre (22.8 ± 0.73 kg) and the highest mean was for Kannara centre (29.1 ± 1.11 kg).

d. Sire

The least squares analysis of variance for effect of sire on birth weight (adjusted for significant non-genetic factors) is presented in Table 4.3. Sire wise means for birth weight are presented in Table 4.4. The over all mean birth weight was 25.9 ± 0.23 kg. Effect of sire was found to be significant ($P \leq 0.05$) on birth weight. The progenies of Heera had the highest birth weight (30.0 ± 0.98 kg).

4.1.3 Heritability estimate

Estimates of heritability at different ages are given in Table 4.5. BW0 was found to be lowly heritable (0.12 ± 0.027).

Table 4.3. Least squares analysis of variance for effect of sire on body weights upto one year of age of crossbred calves in Kerala

Trait		DF	MSS
BW0	Sire	37	26.729053*
	Error	515	18.463213
BW3	Sire	28	262.9681*
	Error	374	66.470383
BW6	Sire	25	433.798908
	Error	302	296.604910
BW12	Sire	19	1370.954876*
	Error	190	423.333986

* $P \leq 0.05$

Table 4.4. Sire wise mean and standard error for body weights (kg) at different ages of crossbred calves in Kerala

	BW0	BW3	BW6	BW12
	M±SE	M±SE	M±SE	M±SE
μ	25.9±0.23 (553)	50.3±0.52 (403)	77.7±1.17 (328)	137.8±1.55 (210)
SIRE				
Admiral	26.0±0.71 (36)	50.2±1.35 (36)	77.2±3.19 (29)	120.2±4.99 (17)
Dany	24.6±1.10 (15)	44.3±2.88 (8)	72.7±4.44 (15)	140.8±5.31 (15)
Dara	24.4±1.10 (15)	54.1±2.71 (9)	90.5±7.03 (6)	158.0±6.85 (9)
Dayal	25.9±0.93 (21)	53.0±1.87 (19)	87.3±4.3 (16)	132.4±6.85 (9)
Dilbagh	24.2±2.14 (4)	-	-	-
Dilwar	25.0±0.91 (22)	46.3±1.87 (19)	78.5±3.95 (19)	124.9±6.20 (11)
Gopal	26.3±0.79 (29)	52.1±1.59 (26)	81.3±4.3 (16)	142.3±4.99 (17)
Gorakh	24.8±1.07 (16)	45.6±1.59 (26)	76.8±3.67 (22)	133.5±4.72 (19)
Hemanth	25.0±1.29 (11)	48.8±2.10 (15)	80.4±5.19 (11)	-

Cont......

Horror	25.4±0.71 (36)	50.0±1.27 (41)	81.5±3.44 (25)	122.9±5.31 (15)
Ideal	27.1±1.24 (12)	45.6±1.82 (20)	75.4±3.85 (20)	130.5±4.99 (17)
Darbara	27.3±1.01 (18)	46.5±1.97 (17)	75.3±5.74 (9)	136.4±7.77 (7)
David	25.5±1.07 (16)	48.5±2.45 (11)	82.4±7.70 (5)	156.2±6.50 (10)
Deepak	26.2±1.01 (18)	50.1±1.73 (22)	80.2±4.97 (12)	150.1±8.40 (6)
Dinesh	25.6±1.07 (16)	50.1±2.26 (13)	73.4±5.19 (11)	145.6±6.50 (10)
Dinkar	25.4±0.82 (27)	48.9±2.10 (15)	75.7±4.17 (17)	145.0±6.20 (11)
Don	26.6±1.07 (16)	47.5±2.71 (9)	79.7±5.74 (9)	137.0±7.77 (7)
Dost	26.0±1.35 (10)	54.0±3.64 (5)	68.2±6.50 (7)	124.8±8.39 (6)
Haleem	26.7±0.77 (31)	49.4±3.08 (7)	82.7±6.50 (7)	-
Hameed	25.6±0.85 (25)	44.3±2.45 (11)	72.8±4.05 (18)	145.3±7.27 (8)
Heera	30.0±0.98 (19)	47.6±2.17 (14)	83.8±4.30 (16)	154.6±8.39 (6)
Husmukh	27.5±0.87 (24)	44.2±1.77 (21)	74.3±4.05 (18)	136.7±8.39 (6)
Diwana	27.0±1.35 (10)	45.0±4.70 (3)	-	-
Gajraj	28.9±1.24 (12)	42.1±2.88 (8)	54.8±7.70 (5)	-
Kala	22.8±1.92 (5)	-		-
Mahan	27.6±1.75 (6)	-	-	-
Majnu	21.6±2.48 (3)	-		-
Swaraj	29.0±1.92 (5)	-	-	-

Cont……

Tony	24.2±2.14 (4)	-		-
Dharma	25.7±0.98 (19)	-	-	-
Devendra	23.5±1.62 (7)	50.2±4.07 (4)	98.0±9.94 (3)	118.0±10.28 (4)
Anthony	26.6±1.92 (5)	-	71.33±9.9 (3)	-
Balawan	26.0±1.29 (11)	62.7±2.71 (9)	67.16±7.08 (6)	-
Bharat	25.4±1.62 (7)	56.6±4.70 (3)	-	-
Jani	24.7±2.14 (4)	52.5±4.07 (4)	-	-
Puran	25.4±1.35 (10)	68.4±3.64 (5)	-	-
Debu	29.0±2.14 (4)	60.3±4.70 (3)	78.0±9.94 (3)	-
Deva	26.2±2.14 (4)	-	-	-

Note - Values in parentheses are the number of observations

Table 4.5. Heritability estimates of body weights upto one year of age

TRAIT	h^2
BW0	0.12±0.027
BW3	0.71±0.16
BW6	0.14±0.038
BW12	0.70±0.18

Photographs showing crossbred calves at birth and three months of age born to HF crossbred test bull of FPT Scheme

4.2 Body weight at three months of age (BW3)

4.2.1 Means

Least squares analysis of variance for non-genetic factors affecting BW3 is presented in Table 4.1. Table 4.2 shows the Least squares means for BW3 according to Centre, POB and SOB. The overall mean body weight at three months of age was 48.7 ± 1.26 kg.

4.2.2 Factors affecting body weight at three months of age

a. Season of Birth

Non-significant influence of SOB was observed on BW3 in the present study.

b. Period of Birth

POB was having significant influence ($P \leq 0.05$) on BW3. Highest Least squares mean was for calves born in the period 1999-00 (59.2 ± 5.17 kg) and lowest was for calves born in the period 1997-98 (38.3 ± 4.06 kg).

c. Centre

Effect of centre ($P \leq 0.05$) was found to be significant on BW3.The centre-wise average body weight at three months ranged from 41.0 ± 4.8 kg (CBF, Thumburmuzhy) to 57.1 ± 3.05 kg (R.V.Puram).

d. Sire

Sire was found to have significant influence on body weight at three months of age (Table 4.3). Table 4.4 shows the mean body weight at three months of age according to sire. The average BW3 was 50.3 ± 0.52 kg. The Puran recorded the highest average (68.4 ± 3.64 kg).

4.2.3 Heritability estimate

BW3 was found to have high heritability (0.71 ± 0.16).

4.3 Body weight at six months of age (BW6)

4.3.1 Means

Least squares analysis of variance and least squares means according to different non-genetic factors of BW6 are presented in Table 4.1 and Table 4.6, respectively. The overall mean body weight at six months of age was 74.1 ± 2.81 kg.

4.3.2 Factors affecting body weight at six months of age

a. Season of Birth

Significant ($P \leq 0.05$) influence of season of birth on weight at six months of age has been noticed after least squares analysis. The least squares mean body weight at six months of those born during dry season was 76.6 ±.2.97 kg and of those born during rainy season was 71.6 ± 3.04 kg.

b. Period of Birth

Period of birth was not having significant effect on BW6.

c. Centre

Effect of centre on BW6 was significant ($P \leq 0.05$). The Arattupuzha centre had the lowest mean weight at six months of age (62.6 ± 8.42 kg) and the CBF, Thumburmuzhy was having the calves with highest weight at six months of age (88.9 ± 9.69 kg).

d. Sire

Least squares analysis of variance for effect of sire on body weight at six months of age is presented in Table 4.3. Sire was not having any influence on the trait. Least squares means of body weight at six months of age for different sires is presented in Table 4.4. The overall mean was 77.7 ± 1.17 kg. The progenies of the sire Devendra recorded the highest mean (98.0 ± 9.94 kg).

4.3.3 Heritability estimate

The heritability estimate of BW6 was found to be low (0.14 ± 0.038).

Photographs showing crossbred calves at six and twelve months of age born to HF crossbred test bull of FPT Scheme

4.4 Body weight at twelve months of age

4.4.1 Means

Least squares analysis of variance and least squares means and standard errors according to different factors are detailed in Table 4.1 and Table 4.6, respectively. The overall mean body weight at twelve months of age was 151.0 ± 7.74 kg.

4.4.2 Factors affecting body weight at twelve months of age

a. Season of Birth

Season of birth had no significant influence on BW12.

b. Period of Birth

Significant influence of POB was observed on BW12. The calves born during 1997-98 period had the highest body weight at twelve months (169.1 ± 20.08 kg) and those calves born during 1993-94 period had the lowest body weight at twelve months (130.4 ± 4.52 kg).

Table 4.6. Least squares means and standard errors for factors affecting body weights (kg) at six and twelve months of age of crossbred calves in Kerala

Factors	BW6	BW12
	M±SE	M±SE
μ	74.1±2.81 (338)	151.0±7.74 (210)
Season		
Dry	76.6±2.97 (185)	151.9±8.03 (90)
Rainy	71.6±3.04 (153)	150.0±7.76 (120)
Period		
1993-94	80.5±2.61 (292)	130.4 ± 4.52 (125)
1995-96	75.5±2.86 (123)	141.9 ± 5.53 (70)
1997 – 98	-	169.1 ± 20.08 (10)
1999-2000	66.3±11.16 (23)	162.5 ± 19.75 (5)
Centre		
Parappur	72.1±5.45 (28)	149.3 ± 11.92 (46)
R.V.Puram	67.0±5.51 (27)	145.2 ± 12.11 (23)
Arattupuzha	62.6±8.42 (6)	149.1 ± 18.65 (2)

Cont……

Chettupuzha	63.7±7.63 (8)	159.2 ± 14.82 (5)
Cherpu	68.7±5.20 (38)	146.0 ± 12.75 (14)
Chirakkakode	70.5±9.74 (4)	-
Karuvannur	72.4±6.15 (17)	163.9±12.45 (16)
Kunnathangady	81.1±5.85 (22)	150.8±12.71 (13)
Kannara	82.2±5.07 (48)	167.7±13.11 (10)
Moorkanikkara	73.9±4.53 (114)	166.0±11.55 (65)
ULF,Mannuthy	85.6±9.96 (5)	131.7±14.5 (8)
CBF, Thumburmuzhy	88.9±9.69 (18)	131.6±11.31 (8)

BW6 (kg): Mean = 78.56 Error standard deviation = 17.40

CV = 22.16 R Squared = 0.104 R= 0.322

BW12(kg): Mean = 140.53 Error standard deviation = 20.98

CV = 14.93 R Squared = 0.158 R= 0.397

Note - Values in parentheses are the number of observations

c. Centre

Effect of centre was significant ($P \leq 0.05$) on BW12. CBF, Thumburmuzhy had the calves with lowest mean of 131.6 ± 11.31 kg and Kannara had the calves with highest mean of 167.7 ± 13.11 kg at twelve month of age.

d. Sire

Effect of sire was significant on BW12 (Table 4.3). The mean BW12 was 137.8 ± 1.55 kg. The Table 4.4 shows the means according to sire. The progenies born to sire Dara were having the highest BW12 (158.0 ± 6.85 kg).

4.4.3 Heritability estimate

High heritability (0.70 ± 0.18) was observed for BW12.

4.5 Age at first insemination (AFI)

4.5.1 Means

Least squares analysis of variance and least squares means and standard errors according to different nongenetic factors considered for the study are presented in Table 4.7 and Table 4.8 respectively. The overall average age at first insemination of progenies was 689.3 ± 22.9 days.

Fig. 4.1. Average body weights at different stages of crossbred cattle of Kerala

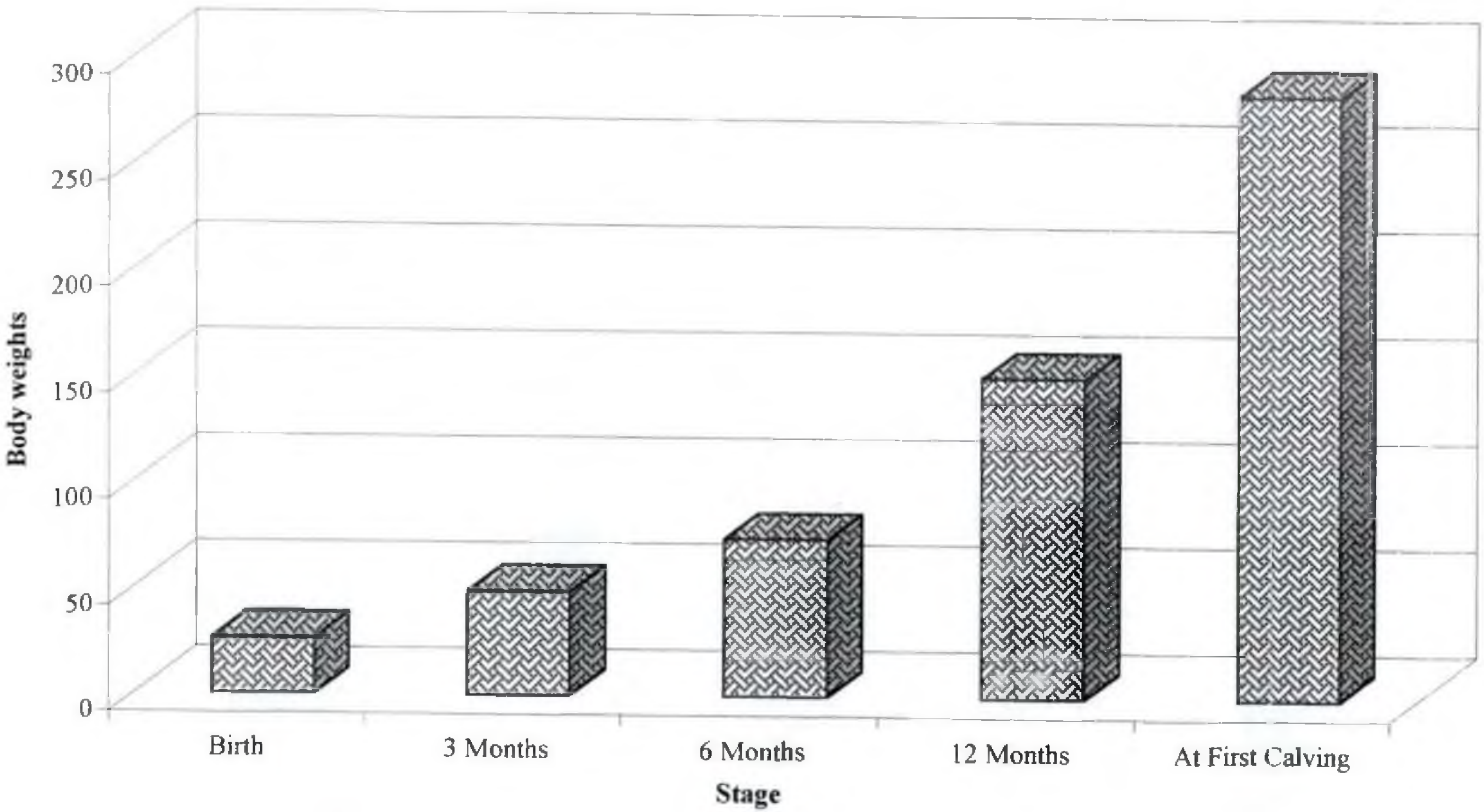

Table 4.7. Least squares analysis of variance for effect of non-enetic factors on AFI, AFC and WFC of crossbred cattle in Kerala

Source	Mean squares					
	DF	AFI	DF	AFC	DF	WFC
Season	1	72656.60	1	16970.27	1	9.27
Period	2	328654.79*	2	749094.56*	2	5528.73
Centre	8	73478.45*	13	160382.24*	9	4178.51
Error	225	35158.16	443	45394.48	132	2306.88

*P ≤ 0.05

Table 4.8. Least squares means and standard errors for the factors affecting AFI, AFC and WFC of crossbred cattle in Kerala

Factors	AFI(days)	AFC(days)	WFC(kgs)
	M+SE	M+SE	M+SE
μ	689.3±22.9 (237)	1013.6±21.74 (460)	284.9±7.71 (145)
Season			
Dry	671.3±26.34 (115)	1019.8±24.01 (215)	285.1±8.95 (71)
Rainy	707.4±25.86 (122)	1007.3±24.03 (245)	284.6±8.49 (74)
Period			
1993-94	776.9±19.99 (134)	1126.4±15.90 (263)	282.4±8.11 (69)
1995-96	652.4±25.48 (86)	1013.9±17.97 (270)	299.2±7.99 (64)
1997-98	638.7±51.3 (13)	900.4±56.86 (17)	273.0±17.8 (12)
1999-2000	-	-	-

Cont......

Centre			
Parappur	672.6±42.89 (25)	921.4±41.6 (35)	286.1±12.22 (26)
R.V.Puram	-	933.0±38.01 (43)	298.4±35.12 (2)
Arattupuzha	-	913.3±78.69 (8)	-
Chettupuzha	679.5±86.9 (5)	1084.2±48.27 (23)	296.2±17.65 (9)
Cherpu	-	1023.5±46.62 (25)	199.3±34.73 (2)
Chirakkakode	755.0±66.1 (9)	952.7±70.72 (10)	296.4±19.37 (7)
Kanimangalam	721.4±57.2 (12)	1073.5±49.19 (22)	318.7±13.41 (16)
Karuvannur	573.9±66.8 (9)	914.84±37.37 (45)	302.0±12.30 (21)
Kunnathangady	-	1032.9±46.90 (25)	-
Kannara	-	1103.5±83.15 (7)	-
Moorkanikkara	639.1±38.23 (33)	1033.5±31.50 (74)	293.8±11.73 (24)
ULF, Mannuthy	663.8±27.1 (53)	1018.1±30.76 (53)	285.6±12.65 (16)
CBF, Thumburmuzhy	741.3±28.1 (50)	1136.3±32.07 (49)	276.2±10.87 (26)
LRS, Thiruvazhamkunnu	757.6±34.78 (41)	1049.5±38.85 (41)	-

AFI(days): Mean = 730.21 Error standard deviation = 187.50
CV = 25.68 R Squared = 0.147 R= 0.383

AFC(days): Mean = 1075.73 Error standard deviation = 213.05
CV = 19.81 R Squared = 0.135 R= 0.367

WFC(kg): Mean = 295.97 Error standard deviation = 48.03
CV = 16.23 R Squared = 0.147 R= 0.384

Note - Values in parentheses are the number of observations

4.5.2 Factors affecting age at first insemination

a. Season of Birth

SOB was not having significant influence on AFI.

b. Period of Birth

Significant influence of POB was observed on AFI. The average AFI of those born during periods 1993-94, 1995-96 and 1997 – 98 were 776.9 ± 19.9 days, 652.4 ± 25.48 days and 638.7 ± 51.34 days, respectively.

c. Centre

Centre was found to have significant influence on AFI. Least squares analysis has shown that AFI was found to be more for heifers at Chirakkakode centre (755.0 ± 66.15 days) and it was lowest for heifers at Karuvannur (573.9 ± 66.83 days) centre.

d. Sire

Sire was found to have significant influence on age at first insemination (Table 4.9). Table 4.10 shows the sire-wise mean age at first insemination of crossbred heifers.

Table 4.9. Least squares analysis of variance for effect of sire on AFI, AFC, WFC and FLMY of crossbred cattle in Kerala

Trait		DF	MSS
AFI	Sire	22	67614.089394*
	Error	201	35479.480532
AFC	Sire	24	88586.389512*
	Error	425	46178.212383
WFC	Sire	18	3007.442027
	Error	109	2551.284516
FLMY	Sire	24	139067.200902
	Error	416	198019.768433

*P ≤ 0.05

Table 4.10. Sire wise mean and standard error for AFI, AFC, WFC and FLMY of crossbred cattle in Kerala

	AFI (days)	AFC(days)	WFC(Kg)	FLMY (litres)
	M±SE	M±SE	M±SE	M±SE
μ	741.4±15.52 (224)	1070.6±12.28 (450)	297.6±4.67 (128)	1912.0±25.51 (441)
Sire				
Admiral	722.4±45.68 (17)	1089.1±37.98 (32)	283.2±17.85 (8)	1896.7±82.63 (29)
Dany	800.7±50.34 (14)	1092.9±40.61 (28)	266.0±15.22 (11)	1823.2±84.09 (28)
Dara	870.7±108.74 (3)	1091.5±75.97 (8)	-	2071.8±157.32 (8)
Dayal	866.1±54.37 (12)	1150.0±48.05 (20)	338.3 ± 0.62 (6)	1865.7±99.50 (20)
Dilwar	732.2±62.78 (9)	1146.6±44.80 (23)	309.3±16.83 (9)	2072.2±94.87 (22)
Gopal	832.7±48.63 (15)	1155.5±39.23 (30)	310.4±22.58 (5)	1967.9±82.63 (29)
Gorakh	781.5±62.78 (9)	1135.3±49.30 (19)	279.0±0.20 (6)	1966.8±102.08 (19)
Hemanth	794.5±94.17 (4)	1164.8±64.79 (11)	268.8±22.58 (5)	2082.2±134.17 (11)

Cont……

Horror	709.4±32.30 (34)	1061.7±31.34 (47)	295.0±16.83 (9)	1961.6±64.90 (47)
Ideal	760.7±56.79 (11)	1148.1±38.59 (31)	288.2 ± 22.58 (5)	1889.6±79.92 (31)
Darbara	788.8±71.19 (7)	1026.5±55.48 (15)	339.5±19.09(7)	1803.4±114.89 (15)
David	-	1116.1±75.97 (8)	-	1875.5±157.32 (8)
Deepak	639.1±59.56 (10)	984.1±53.72 (16)	-	1879.0±111.24 (16)
Dinesh	843.3±108.75 (3)	1228.0±75.97 (8)	-	1791.8±157.32 (8)
Dinkar	650.7±66.59 (8)	986.9±52.11 (17)	289.1±20.62 (6)	1850.6±107.92 (17)
Don	730.8±84.23 (5)	1107.2±57.43 (14)	309.0±19.09 (7)	1901.6±118.92 (14)
Dost	694.7±108.74 (3)	1043.5±75.97 (8)	297.7±29.16 (3)	1796.6±157.32 (8)
Haleem	622.0±47.08 (16)	1006.2±41.35 (27)	309.0±16.83 (3)	1768.9±88.99 (25)
Hameed	751.7±59.56 (10)	940.9±57.43 (14)	293.8±20.62 (6)	1994.4±118.92 (14)
Heera	751.6±84.23 (5)	1008.2±52.11 (17)	326.0±22.58 (5)	1926.3±107.92 (17)
Husmukh	546.7±48.63 (15)	995.7±38.59 (31)	289.5±16.83 (9)	1894.7±82.63 (29)
Diwana	685.1±71.19 (7)	1022.2±81.22 (7)	290.0±19.09 (7)	2039.8±168.19 (7)
Gajraj	739.7±108.74 (3)	1010.6±96.10 (5)	-	1942.2±199.0 (5)
Mahan	-	916.5±107.44 (4)	-	2030.7±222.49 (4)
Devendra	737.7±94.17 (4)	1137.0±67.95 (10)	273.4±22.58(5)	1707.3±140.71 (10)

Note - Values in parentheses are the number of observations

4.5.3 Heritability estimate

Table 4.13 shows the heritability estimates of AFI, AFC, WFC and FLMY. Age at first insemination was found to be moderately heritable (0.35 ± 0.09).

4.6 Age at first calving (AFC)

4.6.1 Means

The details of least squares analysis of variance and least squares averages of AFC according to different non-genetic factors are depicted in Table 4.7 and 4.8, respectively. The overall average age at first calving of progenies of test bulls was 1013.6 ± 21.74 days.

4.6.2 Factors affecting age at first calving

a. Season of Birth

Season of birth was not having significant influence on AFC.

b. Period of Birth

Effect of POB was significant on AFC ($P \leq 0.05$). The mean AFC of heifers born during periods 1993 - 94, 1995 - 96 and 1997 – 98 were 1126.4 ± 15.90 days, 1013.9 ± 17.97 days and 900.4 ± 56.86 days, respectively.

c. Centre

Least squares analysis of variance revealed significant influence ($P \leq 0.05$) of centre on AFC. The averages ranged from 913.3 ± 78.69 days for Arattupuzha centre to 1136.3 ± 32.07 days for CBF, Thumburmuzhy.

d. Sire

The sire was found to have significant ($P \leq 0.05$) effect on AFC. The Table 4.9 shows the least squares analysis of variance for effect of sire on AFC and the least squares means according to sires are presented in Table 4.10. The progenies born to sire Mahan were having lowest average AFC (916.5 ± 107.44 days).

4.6.3 Heritability estimate

Low estimate of heritability (0.2 ± 0.05) was observed for age at first calving (Table 4.13).

4.7 Weight at first calving

4.7.1 Means

The details of least squares analysis of variance and least squares means according to centre, POB and SOB are presented in Table 4.7 and 4.8. The overall mean weight at first calving of crossbred cows under study was 284.9 ± 7.71 kg.

4.7.2 Factors affecting weight at first calving

a. Season of Birth

Season of birth had no significant influence on WFC.

b. Period of Birth

Influence of POB was not significant on WFC.

c. Centre

The centre was found to have nonsignificant influence ($P \leq 0.05$) on WFC.

d. Sire

Sire was not having significant effect on WFC. The Table 4.9 and 4.10 shows the least squares analysis of variance for effect of sire and the means according to sires, respectively. The progenies of sire Darbara had the highest mean WFC (339.5 ± 19.09 kg).

4.7.3 Heritability estimate

Weight at first calving was having low heritability (0.10 ± 0.03).

4.8 First lactation milk yield (FLMY)

4.8.1 Means

Results of least squares analysis and least squares means according to different non-genetic factors for first lactation milk yield are shown in Table 4.11 and 4.12. The overall mean first lactation milk yield of crossbred cows born to the test bulls of FPT scheme was found to be 1958.5 ± 30.74 litres.

Photograph showing a first lactation daughter from HF crossbred test bull of FPT Scheme

Table 4.11. Least squares analysis of variance for effect of non-genetic factors on first lactation milk yield of crossbred cattle of Kerala

Source	DF	Mean squares
Season of calving	1	10929.82
Period of calving	2	905703.30*
Centre	13	1098314.19*
Age group	3	313117.79
Error	431	199939.83

* $P \leq 0.05$

Table 4.12. Least squares means and standard errors for the factors affecting first lactation milk yield of crossbred cattle in Kerala

Factors	FLMY(litres)
	M+SE
μ	1958.5±30.74 (451)
Season of calving	
Dry	1953.4±37.34 (232)
Rainy	1963.5±37.74 (219)
Period of calving	
1995-96	1958.2±55.58 (93)
1997-98	1868.5±31.91 (284)
1999-2000	2048.6±61.71 (74)
Centre	
Parappur	1711.1±79.45 (35)
R.V.Puram	2190.3±71.22 (43)
Arattupuzha	1559.3±161.12 (8)
Chettupuzha	1829.5±97.56 (22)

Cont......

Cherpu	1981.8±92.05 (25)
Chirakkakode	2639.0±154.73 (9)
Kanimangalam	1833.29±96.15 (22)
Karuvannur	1902.7±70.42 (45)
Kunnathangady	2009.1±90.65 (25)
Kannara	1951.7±172.03 (7)
Moorkanikkara	1854.0±54.94 (74)
ULF,Mannuthy	2200.6±67.3 (51)
CBF,Thumburmuzhy	1885.0±69.91 (45)
LRS, Thiruvazhamkunnu	1871.3±74.86 (40)
Age group	
Upto 2 ½ years	1952.7±48.45 (116)
2 ½ – 3 years	2012.5±46.05 (137)
3 – 3 ½ years	1890.3±47.21 (118)
Above 3 ½ years	1978.3±57.9 (80)

FLMY (litres): Mean = 1907.71 Error standard deviation = 447.14
CV= 23.44 R Squared = 0.178 R = 0.422
Note -Values in parentheses are the number of observations

Table 4.13. Heritability estimates of AFI, AFC, WFC and FLMY

AFI	0.35±0.09
AFC	0.20±0.05
WFC	0.10±0.03
FLMY	-0.069±0.05

4.8.2 Factors affecting first lactation milk yield

a. Season of Calving

Influence of season of calving was not significant on FLMY.

b. Period of calving

POC had significant influence on FLMY. Those calved in 1999-2000 had the highest average FLMY (2048.6 ± 61.71 litres) and those calved in the 1997-98 had lowest average FLMY (1868.5 ± 31.91 litres).

c. Centre

Effect of centre was significant ($P \leq 0.05$) on FLMY. The milk yield varied from 1559.3 ± 161.12 litres (Arattupuzha) to 2639.0 ± 154.73 litres (Chirakkakode).

d. Age group

Age group was found to have no significant influence on FLMY.

e. Sire

The effect of sire was not significant on FLMY. The Table 4.9 and 4.10 shows the least squares analysis of variance and the averages of FLMY according to sires, respectively. The highest mean FLMY among different sires was for sire Hemanth (2082.2 ± 134.17 litres) and the lowest was for sire Devendra (1707.3 ± 140.17 litres).

4.8.3 Heritability estimate

Heritability estimate of milk yield was -0.069 ± 0.05 (Table 4.13).

4.9 Correlation estimates

The genetic and phenotypic correlations among body weights at different ages and those with AFC and FLMY are presented in Table 4.14 and 4.15, respectively.

4.9.1 Among body weights

The genetic correlation of BW0 with BW3 was positive but very low and nonsignificant (0.066), with BW6 it was high (0.97), positive and significant ($P \leq 0.05$), whereas with BW12, it was negative (-0.68), significant ($P \leq 0.05$). The low, positive and significant ($P \leq 0.05$) phenotypic correlation was seen between BW0 and BW3 (0.32) and also between BW0 and BW6 (0.20), whereas between BW3 and BW12, the phenotypic correlation was moderate (0.41), positive and nonsignificant.

4.9.2 Body weights at different ages with AFC and FLMY

The genetic correlation of BW0, WFC with AFC couldn't be computed due to negative genetic variance. The phenotypic correlation between BW0 and AFC was low and nonsignificant (0.002), whereas it was negative and nonsignificant between BW3 and AFC (-0.002). The BW6 and AFC were positively correlated genetically (0.32), but phenotypic correlation was negative and not significant (-0.007). The negative and nonsignificant genetic and phenotypic correlation was observed between BW12 and AFC (Table 4.15).

Table 4.14. Correlation among body weights

	BW0	BW3	BW6	BW12
BW0	1	0.066	0.97	-0.68*
BW3	0.32*	1	-0.19	0.54*
BW6	0.20*	-0.35*	1	-
BW12	0.27	0.41*	0.47*	1

Note- Figures above and below the diagonal indicate genetic and phenotypic correlation respectively.
*$P \leq 0.05$

Table 4.15. Genetic and Phenotypic correlation of body weights at different ages with AFC and FLMY

Body weights	AFC		FLMY	
	r_g	r_p	r_g	r_p
BW0	-	0.002	-0.038	-0.19
BW3	>1	-0.002	-	0.004
BW6	0.32	-0.007	0.46*	0.009
BW12	-0.62	-0.14	>1	0.047
WFC	-	-0.21	0.27*	0.15

*$P \leq 0.05$

The BW0 and FLMY were negatively correlated both genetically and phenotypically but were not significant. The genetic correlation between BW3 and FLMY couldn't be computed due to negative genetic variance, whereas the phenotypic correlation was low and nonsignificant (Table 4.15). The genetic correlation between BW6 and FLMY (0.46) was significant but the phenotypic correlation was low and nonsignificant (0.009). The genetic correlation between BW12 and FLMY was observed to be beyond the positive limit but the phenotypic correlation was low and nonsignificant (0.047). The genetic correlation between WFC and FLMY (0.27) was low but significant whereas the phenotypic correlation was low and nonsignificant (0.15).

Discussion

5. DISCUSSION

The work was conducted as a part of the ICAR Field Progeny Testing (FPT) Scheme, which envisaged the progeny testing of HF crossbred bulls selected at national level. Milk yield is a complex character observed at a later age. Hence selection for milk yield based on highly heritable and early observable characters that are closely associated with the milk yield will definitely be advantageous. Knowledge of heritability and association of characters is therefore, very relevant in any animal breeding programme. The above mentioned information is available under farm conditions but under field conditions, it is meagre in India. Therefore an attempt was made to study heritability and correlation among growth traits and milk production in crossbreds under field conditions which may aid in selection for higher milk production in crossbreds. To estimate and to interpret the effect of various nongenetic factors on different traits, the least squares analysis of variance (Harvey, 1986) was carried out on pooled data. The adjusted data was used to estimate heritability and correlation among different traits.

The growth is usually measured in terms of body weights. However for want of weighing facilities, the body weight of animals under field conditions is predicted from the measurement of girth, height and length at various intervals. In the present study the body measurements of crossbred calves in different centres of FPT area were recorded and used for predicting body weights.

5.1 Birth Weight (BW0)

5.1.1 Means

The overall average birth weight in crossbred calves under the present study was 26.0 ± 0.38 kg (Table 4.2). This is in close proximity with the reports of Mandal and Sachdeva (1999) in Karan Swiss, Singh and Tomar (1988) in Karan Fries, Patel *et al.* (1985) in HF x Kankrej, Srivastava *et al.* (1978) in HF x Hariana. Further, the present estimate excelled the means given by Nair *et al.* (1985) in crossbred calves of Kerala, Mathai *et al.* (1978) in Jersey (J) x local at different levels of exotic inheritance, Anthony and Thomas (1997) in BS x Local crossbred calves under field conditions of Kerala. The higher estimate in the present study compared to the estimates reported earlier from Kerala could be due to the introduction of HF inheritance. The present estimate is higher than the estimates given by Tahir et *al.* (1984) in J x Sahiwal, Srivastava *et al.* (1978) in J x Hariana and BS x Hariana, Naikare *et al.* (1992) in J x Gir. But it was lower than the estimates reported by Prabhukumar *et al.* (1991) in Friesian (F) x Ongole and BS x Ongole. The variations observed in mean birth weight among different breed crosses may be attributed to breed variation.

5.1.2 Factors affecting birth weight

a. Season of birth

The effect of season of birth on birth weight was non-significant. This finding concurs with the reports of Dhumal *et al.* (1988) in non-descript cattle and its crosses with J in Maharashtra, Roy *et al.* (1996) in Tharparkar crosses of J and HF, Naikare *et al.* (1992) in Gir crosses with J, HF and BS, Shelka *et al.* (1992) in Red Khandari crosses with J, Narayanaswamy *et al.* (1984) in HF x Sahiwal.

This finding doesn't match with the observations made in crossbred calves of Kerala by Nair *et al.* (1985) and Mathai *et al.* (1978), in Karan Swiss calves (Mandal and Sachdeva, 1999), in

Karan Fries (Singh and Tomar, 1988), in Hariana calves with HF, BS and J inheritance (Srivastava *et al.* 1986).

The present observation indicates absence of much variation in the management of dams in the two seasons and thereby birth weight remains unaffected.

b. Period of birth

On least squares analysis, it was found that periods of birth were having significant ($P \leq 0.05$) influence on birth weight. Similar observation was noticed by Mandal and Sachdeva (1999) in Karan Swiss, Singh and Tomar (1988) in Karan Fries, Naikare *et al.* (1992) in J x Gir, Dhumal *et al.* (1988) in J x Nondescript cows of Maharashtra, Roy *et al.* (1996) in Tharparkar crossed with J and HF. However, the present finding disagrees with the observations made in HF x Bunaji cows by Malau – Aduli *et al.* (1996) and in J x Kankrej (Patel and Dave, 1987).

The birth weight of calves varied from 25.0 ± 0.60 kg (1997-98) to 27.2 ± 0.42 kg (1995-96). The difference in birth weight of calves observed over periods could be due to difference in the environment.

c. Centre

The variation of birth weight of crossbred calves ranged from 22.8 ± 0.73 kg for Cherpu centre to 29.1± 1.11 kg for Kannara centre. The effect of centre was found to be significant ($P \leq 0.05$) on birth weight. Iype (1992) had observed similar findings with regard to the body measurements of calves at birth. But, Narayanaswamy *et al.* (1984) reported nonsignificant effect of centre on birth weight.

This variation can be attributed to prevalence of different management, nutritional practices among farmers' herds in different locations considered for the study.

d. Sire

Significant ($P \leq 0.05$) influence of sire was observed on birth weight (Table 4.3). Thus sires are an important source of variation influencing the body weight at birth. This observation is in agreement with reports of Rajgopalan and Francis (1978) in crossbred calves of Kerala and Narayanaswamy *et al.* (1984) in HF x Sahiwal. Iype (1992) had reported that the body measurements of calves at birth of different sires were significant. However, the present result is not in conformity with the observation of nonsignificant effect of sire made by Nair *et al.* (1985) in crossbred calves of Kerala.

5.1.3 Heritability estimate

The heritability estimate of birth weight was 0.12 ± 0.027. This estimate is close to the estimate (0.13 ± 0.3) given by Shrivastava *et al.* (1985) in J x Hariana and to the estimate (0.14 ± 0.094) given by Rao and Nagarcenkar (1992) in HF halfbreds. The present finding was higher than those reports of -0.05 ± 0.16 in J x Gir and -0.01 ± 0.22 in BS x Hariana by Shrivastava *et al.* (1985), While it was found to be lower than those estimates of 0.516 and 0.527 ± 0.009 in crossbreds of Kerala by Nair *et al.* (1985) and Rajgopalan and Francis (1976), respectively. It was also lower than the estimates given by Narang *et al.* (1994) in J x Red Sindhi, Teotia *et al.* (1990) in HF x Sahiwal, Singh and Tomar (1988) and Saha and Parekh (1990) in two and three breed crosses of

Gir, F and J. The present estimate was very low indicating that the trait is largely under the control of non-genetic factors.

5.2 Body weight at three months of age (BW3)

5.2.1 Means

The overall average of body weight at three months of age of crossbred progenies born to test bulls was 48.7 ± 1.26 kg (Table 4.2). This is 87.3 per cent more than the birth weight. The present estimate is comparable to estimate reported in J x Hariana by Bhat and Singh (1978), but it was lower than the reports of Anthony and Thomas (1997) under farm conditions of Kerala, Bhat and Singh (1978) in BS x Hariana and HF x Hariana. The present finding was much higher than the report of Anthony and Thomas (1997) for BS crossbreds (41.34 ± 1.06 kg) under field conditions of Kerala.

As stated earlier for birth weight, the variation in body weight at three months of age among breed crosses can be attributed to breed variation.

5.2.2 Factors affecting body weight at three months of age

a. Season of birth

Effect of season of birth was not significant on BW3. This finding concurs with the observation made by Roy *et al.* (1996) in crosses of Tharparkar with J and HF and Kulkarni *et al.* (1982) in HF x Deoni crosses. On the other hand, significant influence of season of birth had been reported in Hariana crosses (Bhat and Singh, 1978) and HF x Bunaji (Malau-Aduli *et al.*, 1996). These differences in the observations could be due to location, management and weather conditions prevailing apart from the genetic architecture of the animals involved in the crossbreeding.

The effect of SOB was not significant on birth weight also in this study. Hence similar influence of SOB on BW3 could be expected.

b. Period of birth

The period-wise body weight at three months of age varied from 59.28 ± 5.17 kg (1999-2000) to 38.3 ± 4.06 kg (1997-98). Period of birth had significant ($P \leq 0.05$) influence on body weight at three months of age. This result is in conformity with the reports of Roy *et al.* (1996) in Tharparkar crosses with J and HF, Malau-Aduli *et al.* (1996) in HF x Bunaji, Nautiyal and Bhat (1989) in Hariana crosses with J, HF and BS. Wide variation can be seen among body weight at three months in different periods considered for the study. This variation can be attributed to prevalence of wide range of management, nutritional practices and climatic conditions in the location of the study.

c. Centre

The centre-wise mean body weight at three months of age ranged from 41.0 ± 4.80 kg to 57.1 ± 3.05 kg in different centres. Significant ($P \leq 0.05$) effect of centres was observed on least squares analysis. This is in agreement with Reddy *et al.* (1991). This can be attributed to difference in the managemental and nutritional practices in different locations of the study. Literature reporting the influence of centre/farm on body weight under Indian conditions was not available.

d. Sire

The sire wise mean BW3 ranged from 42.1 ± 2.88 kg (Gajraj) to 68.4 ± 3.64 kg (Puran). The differences among sires was significant (Table 4.3) on BW3. This result is not in agreement with the observation made by Reddy *et al.* (1991) under field conditions. Narayanaswamy *et al.* (1984) observed that the variation seen due to sire was not more than two per cent and sires were not an important source of variation in promoting growth of animals. Unlike birth weight, reports on weight at three months of calves and at higher ages of calves under Indian conditions are scanty.

5.2.3 Heritability estimate

In the present study, the heritability estimate of body weight at three months of age was 0.71 ± 0.16. This estimate is quite higher than the estimates reported earlier by Kulkarni *et al.* (1982) in HF x Deoni crosses and by Rao and Nagarcenkar (1992) in Holstein halfbreds.

The high heritability estimate indicates that it is under the high influence of genetic factors, which could be exploited through selection of calves for higher body weight at three months of age.

5.3 Body weight at six months of age (BW6)

5.3.1 Means

The overall average of body weight at six months was 74.1 ± 2.81kg (Table 4.6). This estimate is close to that given by Anthony and Thomas (1997) under field conditions of Kerala. The present finding excelled the averages given by Roy *et al.* (1996) in J x Tharparkar and HF x Tharparkar. But the present estimate was much lower than the means given by Patel *et al.* (1985) in J x Kankrej, Shrivastava *et al.* (1985) in J x Gir, F x Gir, HF x Hariana and BS x Hariana, Reddy *et al.* (1991) in HF x Sahiwal/ Tharparkar, Teotia *et al.* (1990) in HF x Sahiwal.

The variations observed in mean body weight at six months among different breed crosses may be attributed to breed variation.

5.3.2 Factors affecting body weight at six months

a. Season of birth

On least squares analysis, it was observed that the season of birth was a significant ($P \leq 0.05$) source of variation in affecting body weight. Those born in dry seasons were having higher weight at six months of age. It is quite likely that the calves born during dry season might be in the succeeding rainy season when they reach the stage of consuming roughage and therefore would be able to consume enough green fodder. Malau-Aduli *et al.* (1996) in HF x Bunaji crosses, Bhat and Singh (1978) in Hariana crosses (J, HF and BS) attributed similar reasoning. Nevertheless, the nonsignificant influence of season of birth was noticed by Roy *et al.* (1996) in HF x Tharparkar and J x Tharparkar, Nautiyal and Bhat (1989) in Hariana crosses with J, HF and BS and Narayanaswamy *et al.* (1984) in HF x Sahiwal crosses.

b. Period of birth

Unlike the observation at birth and three months body weight, influence of period of birth on six months body weight was not significant. The present finding is not in agreement with the reports of Roy *et al.* (1996) in Tharparkar crosses with J and HF, Malau – Aduli *et al.* (1996) in HF x Bunaji, Reddy *et al.* (1991) in HF x Tharparkar/Sahiwal, Nautiyal and Bhat (1989) in Hariana crosses with J, HF and BS and Shrivastava and Katpatal (1983) in Gir crosses (J and HF).

c. Centre

The average body weight at six months ranged from 62.6 ± 8.42 kg (Arattupuzha) to 88.9 ± 9.69 kg (CBF, Thumburmuzhy). Centre effect was significant ($p \leq 0.05$) on BW6. Similar finding has been observed in HF x Sahiwal/ Tharparkar (Reddy *et al.*, 1991), in HF x Sahiwal (Narayanaswamy *et al.*, 1984). The possible reason for significant influence of farm/centre on the trait is due to difference in the managemental and nutritional practices in different locations of the study.

d. Sire

Sire effect was not significant on BW6 (Table 4.4). The present finding is in agreement with the report of Narayanaswamy *et al.* (1984) in HF x Sahiwal crosses.

Six months body weight was found to have highest variability (22.16 per cent) compared to other body weights under field conditions. The period of 3-6 months of age is a crucial period when the calves are generally weaned and they start taking roughages and concentrates. At this stage, variance from the environmental source is relatively more resulting in masking of sire variances.

5.3.3 Heritability estimate

In the present study, the heritability estimate of BW6 was 0.14 ± 0.038. The present estimate was low indicating that the variance of the trait is largely due to non-genetic factors.

The heritability estimate is quite higher than the estimate reported in HF x Hariana and BS x Hariana but lower than that of J x Hariana (Shrivastava *et al.*, 1985), in HF crosses (Rao and Nagarcenkar, 1992), HF x Sahiwal (Teotia *et al.*, 1990), in F x Gir and J x Gir (Shrivastava *et al.*, 1985) and in BS x Hariana (Bhat and Singh, 1978).

5.4 Body weight at twelve months (BW12)

54.1 Means

The average body weight at twelve months age was 151.0 ± 7.74 kg (Table 4.6). Reports on the body weights of crossbred calves under the field and farm conditions of Kerala were not available for making comparisons. This present average is in close proximity with the means given by Shrivastava *et al.* (1985) in J x Hariana and BS x Hariana. Mean values lower than the present estimate in J x Tharparkar and HF x Tharparkar was reported by Roy *et al.* (1996). The present estimate was much lower than the mean reported by Patel *et al.* (1985) in J x Kankrej and HF x Kankrej, Shrivastava *et al.* (1985) in J x Gir, HF x Hariana and HF x Gir. Reddy *et al.* (1991) in HF x Sahiwal/Tharparkar and Teotia *et al.* (1990) in HF x Sahiwal.

The variation in body weight at twelve months of age among breed crosses can be attributed to breed variation.

5.4.2 Factors affecting BW12

a. Season of birth

Influence of season of birth on BW12 was not significant. The present findings show that season of birth had significant effect only on BW6 and not before and after it. This observation concurs with the observation made in HF x Sahiwal crosses by Narayanaswamy *et al.* (1984) and in Gir crosses with J and HF by Shrivastava and Katpatal (1983), but does not match with the reports of Roy *et al.* (1996) in Tharparkar crosses (J and HF) and Bhat and Singh (1978) in Hariana crosses with J, HF and BS.

b. Period of birth

The calves born during the period 1993-94 had the lowest mean (130.4 ± 4.52 kg) and those born during the period 1997-98 had the highest mean (169.1 ± 20.08 kg). The differences in BW12 due to effects of periods of birth were statistically significant ($P \leq 0.05$). This is in conformity with the reports of Malau – Aduli *et al.* (1996) in HF x Bunaji, Narayanaswamy *et al.* (1984) in HF x Sahiwal crosses and Shrivastava and Katpatal (1983) in Gir crosses with J and HF and different from the reports of Bhat and Singh (1978) in Hariana crosses with J, HF and BS.

This shows the prevalence of different management and nutritional practices over different periods considered for the study.

c. Centre

The mean ranged from 131.6 ± 11.31 kg to 167.7 ± 13.11 kg for different centres. Effect of centre was significant ($P \leq 0.05$) on BW12. This is in agreement with the studies made on farmbred calves by Shrivastava and Katpatal (1983) and Narayanaswamy *et al.*, (1984) in HF x Sahiwal.

This variation can be attributed to prevalence of different management, nutritional practices among farmers' herds in different locations considered for the study.

d. Sire

Sire was a significant ($P \leq 0.05$) source of variation for BW12 (Table 4.6). This is not in agreement with the observation of nonsignificant influence of sire made by Narayanaswamy *et al.* (1984) in HF x Sahiwal. The present study indicates the significant sire effect on body weights at all ages except at six months of age.

5.4.3 Heritability estimate

In the present study, the BW12 was found to be highly heritable (0.70 ± 0.018). This is in close proximity to the estimate in F x Gir (0.66 ± 0.34) given by Shrivastava *et al.* (1985). Much lower estimates compared to the present estimate were reported by Shrivastava *et al.* (1985) in J x Hariana, J x Gir and HF x Hariana, by Teotia *et al.* (1990) in HF x Sahiwal, by Bhat and Singh (1978) in BS x Hariana.

This present high estimate indicated that BW12 could be exploited through selection of individuals.

Conceptually, it might reveal that, though body weights at different ages are probably controlled by same set of genes, their expression appears to be modified with advance of age as reflected in differential magnitude of heritability.

5.5 Age at First Insemination (AFI)

5.5.1 Means

The mean AFI of crossbred progenies born to test bulls was 689.3 ± 22.9 days (Table 4.8). This is in close proximity with the report of Pyne *et al*, (1987) in J x Hariana. The present finding is quite higher than the estimates given by Raheja *et al.* (1987) in Holsteins, Blaho (1987) in HF x Slovakian Pied cows. However, Pyne *et al.* (1987) and Silva *et al.*(1986) reported estimates higher than the present finding in HF x Hariana and Zebu x Chiana cows respectively.

The above reports were based on only farmbred cows, whereas in the present study data from both farm and field were included.

5.5.2 Factors affecting AFI

a. Season of birth

SOB was not having significant influence on AFI and possibly the season at which the heifers attain puberty are more important than their SOB. The present finding is in accordance with the reports of Anand and Balaine (1981) in J x Hariana and Pyne *et al.* (1987) in HF crossbreds. However, Pyne *et al.*(1987) observed significant influence of SOB on AFI in Jersey crossbreds.

b. Period of birth

The significant ($P \leq 0.05$) influence of POB was observed on AFI. AFI showed decreasing trend over the periods. No references were available for making comparison with the present finding.

c. Centre

The centre-wise mean AFI of crossbred heifers ranged from 573.9 ± 66.83 days (Karuvannur) to 755.0 ± 66.15 days (Chirakkakode). Centre was a significant ($P \leq 0.05$) source of variation for AFI. This shows the existence of different management in different centres. No references are available for making comparison with the present finding.

d. Sire

The sire-wise means ranged from 546.7 ± 48.63 days (Husmukh) to 870.7 ± 108.74 days (Dara). Sire was found to be significantly influencing the AFI (Table 4.9). This finding is in conformity with Anand and Balaine (1981) in J x Hariana cows.

5.5.3 Heritability estimate

In the present study, the heritability estimate of AFI was moderately high (0.35 ± 0.09) indicating the scope for improving this trait. Such similar estimates were reported by Anand and Balaine (1981) in Hariana crosses with J and HF, by Raheja *et al.* (1988) in Holstein dairy cattle.

5.6 Age at first calving (AFC)

5.6.1 Means

The overall least squares means (Table 4.8) of AFC observed was 1013.6 ± 21.74 days (33.8 months). The present finding is in line with the results of Nair (1973) and Patel *et al.* (1976) in crossbred cattle of Kerala (34.5 ± 5.1 and 31.8 months), Prabhukumar *et al.* (1991) in F x Ongole and BS x Ongole, Singh *et al.* (1988) in Karan Fries and Kakran and Joshi (1990) in Karan Swiss.

The estimates lower than the present average were reported in J x Ongole by Rao *et al.* (1996) and by Prabhukumar *et al.* (1991), in J x Hariana and HF x Hariana by Chopra (1990), in J x Kankrej by Mansuri (1989), in Frieswal by Arora *et al.* (1996), in HF x Red Sindhi by D' Souza *et al.* (1979) and in HF x Sahiwal by Jadhav and Khan (1996).

Higher estimates compared to the present average were also reported in BS x nondescript cattle of farms under KAU (43.2 ± 2.06 months) by Girija (1980), Stephen *et al.* (1985b) in J x Nondescript cows (41.1 ± 2.1 months) and BS x Nondescript cows (46.0 ± 0.5 months) and Iype *et al.* (1984) in BS crossbreds (44.8 ± 0.7 months) under field conditions of Kerala.

5.6.2 Factors affecting Age at first calving

a. Season of birth

As in the case of AFI, the effect of season of birth was not significant on the AFC. As stated earlier in AFI, the season at which animals attain puberty may be more important than season of birth for AFC. On the contrary, there were reports, which do not match with the present result as in F x Sahiwal crosses (Jadhav and Khan, 1996),

b. Period of birth

The AFC over different periods ranged from 900.4 ± 56.86 days (1997-98) to 1126.4 ± 15.90 days (1993-94). The declining trend in AFC was noticed over different periods as in the case of AFI. The estimate of 900 days in the last period is likely to have a bias due to low number of observations (17). But the first and second period comparison shows a definite improvement. The period of birth contributed significantly ($P \leq 0.05$) towards the variation in AFC. Similar reports were made in HF x Sahiwal crosses (Jadhav and Khan, 1996). The reason for significant influence of period of birth can be attributed to variation in management and climatic conditions in different periods. Suitable environment and improved management probably could lower AFC.

c. Centre

Significant ($P \leq 0.05$) variation has been observed in different centres and this indicates difference in management in different centres. Mehra (1983) and Hayatnagarkar *et al.* (1991) made similar observations under field conditions of Punjab and Maharashtra, respectively. Among farms, CBF, Thumburmuzhy had higher AFC and many field centres had lower AFCs than the farms. Jadhav and Khan (1996) and Reddy and Basu (1985) in F x Sahiwal observed significant influence of farms on AFC.

d. Sire

The AFC of crossbred cows varied from 916.5 ± 107.44 days (Mahan) to 1228.0 ± 75.97 days (Dinesh). Effect of sire was significant ($P \leq 0.05$) on AFC (Table 4.9). This is in conformity with result of Nobre *et al.* (1984) in HF crossbreds, Naikare *et al.* (1992) in three breed Gir crosses and Koul *et al.* (1985) in HF x Hariana, but different from the observation made by him in BS x Hariana and J x Hariana.

5.6.3 Heritability estimate

The heritability estimate of AFC observed in the present study was 0.20 ± 0.05. This is in close proximity with the reports of Mansuri (1989) in J x Kankrej, Koul *et al.* (1985) in J x Hariana. The estimates lower than the present estimate were reported by Jadhav and Khan (1996) in HF x Sahiwal, Rao and Nagarcenkar (1992) and Singh *et al.* (1990) in BS x Hariana. Higher estimates of heritability compared to present one were indicated by Mansuri (1989) in HF x Kankrej, Koul *et al.* (1985) in F x Hariana, Singh *et al.* (1988) in Karan Fries.

Low heritability for AFC indicates less additive genetic variance and more of environmental influence. Better management can lower the AFC further and thus increase the productive life. As the location of study was from different centres, where herd size was very small and different managemental and nutritional practices were existing, more environmental influences are expected.

5.7 Weight at first calving (WFC)

5.7.1 Means

The overall mean of WFC was 284.9 ± 7.71 kg (Table 4.8). This estimate is quite less than the means reported earlier by Mansuri (1989) in J x Kankrej and HF x Kankrej, Kakran and Joshi (1990) in Karan Swiss, Singh *et al.* (1987) and Rana (1991) in HF x Sahiwal and D'Souza *et al.* (1979) in HF x Red Sindhi.

The present estimate would appear low for crossbred cows compared to those in the other regions of India, but the local cattle of Kerala are very small and weighing less than 150 kg. When Jersey bulls were used for crossbreeding in this area, the weight was only 252 kg (Iype, 1992). The present estimate is higher than this estimate, which could be attributed to use of HF crossbred test bulls with high genetic potential.

5.7.2 Factors affecting WFC

a. Season of birth

Season of birth was not an important factor in causing variations in WFC. This shows that effect of season at an earlier age is not an important for WFC, which is expressed at later age. No reports were found indicating influence of season of birth on WFC for making comparisons.

b. Period of birth

Period of birth was not significant on WFC. There were no reports with influence of period of birth on WFC for comparing the present finding.

c. Centre

The centre-wise averages ranged from 199.3 ± 34.73 kg (Cherpu) to 318.7 ± 13.41 kg (Kanimangalam). Effect of centre was not significant in causing differences in WFC. This is not in agreement with Iype (1992) who observed significant influence of centres on WFC of crossbred cattle under field conditions of Kerala. Dangi (1979) reported significant influence of farms on WFC.

It could be noticed that the effect of period and centre, which were significant on AFI and AFC, was not significant on WFC. When the heifers become pregnant, the farmers start feeding them liberally. This practice probably reduces the differences in WFC due to different seasons/periods/centres of birth.

d. Sire

Sire was not having any significant influence on WFC (Table 4.9). But the number of observations on WFC per sire were less compared to other body weights studied and therefore definite conclusions on this cannot be made at present. Earlier Iype (1992) had observed significant effect of sire on WFC of progenies born to the Jersey bulls under field conditions of Kerala.

5.7.3 Heritability estimate

In the present study, WFC was found to be a lowly heritable character (Table 4.13). This low value could be due to the less number of observations per sire. Rao and Nagarcenkar (1992) and Tomar and Tomar (1982) also observed such low heritability in HF halfbreds. However, the present finding is not in line with Naidu and Desai (1970) and Choudhuri *et al.* (1988).

5.8 First Lactation Milk Yield (FLMY)

5.8.1 Means

The overall mean FLMY of progenies born to test bulls under ICAR FPT Scheme was 1958.5 ± 30.74 litres (Table 4.12).

Earlier Radhika (1997) reported the FLMY of progenies of 10 sires of the scheme to be 1905.7 litres. The present estimate is quite higher than the averages given for crossbreds of Kerala by Nair (1973), Stephen *et al.* (1985a) and Iype *et al.* (1986) in J x Nondescript cattle, Stephen *et al.* (1985a) in ½ BS x ½ Nondescript cattle, Iype *et al.* (1985), Thomas *et al.* (1987) in BS crosses, Iype *et al.* (1993) and Iype (1995) in crossbred cows of Kerala. The present higher estimate shows that introduction of HF inheritance into the already existing crossbred population increases the milk production potential. The present estimate is lower than those estimates reported earlier for crossbreds in other parts of India involving HF inheritance, as in Frieswal (Arora *et al.*, 1996), F x Ongole (Prabhukumar *et al.*, 1991), HF x Hariana (Chopra, 1990), HF x Kankrej (Patel *et al.*, 1989), HF x Red Sindhi (D'Souza *et al.*, 1979), F x Gir and F x Tharparkar (Bhat, 1977).

The higher estimates in those crossbreds might be due to the difference in the indigenous breed involved, high quality of roughage available in those areas. The hot and humid climate in Kerala also might be affecting the crossbred cows adversely. More over there is always a scarcity of good green grass in Kerala.

5.8.2 Factors affecting FLMY

a. Season of calving

Influence of season of calving was not significant on FLMY. This result is in line with Stephen *et al.* (1985a) in crossbreds of Kerala. But it is in disagreement with Singh and Pandey (1970) and Vij and Basu (1986). Disagreement was with North Indian studies and the reason may be that the seasons are not very clear-cut in Kerala, like in other places.

The lack of influence of season of calving on milk yield in the present study can be attributed to systems of management. When greens are scarce, additional concentrates are given to compensate, probably resulting in a nonsignificant seasonal variation.

b. Period of calving

Period of calving was having significant ($P \leq 0.05$) influence on milk yield. This concurs with the observation made by Jadhav *et al.* (1991) in HF x Sahiwal, Thalkari *et al.* (1995) in HF x Deoni, J x Deoni and by Shettar and Govindaiah (1999) in J, HF and Danish Red crossed with Red Sindhi, Hallikar or Amrith Mahal. The mean in the last period being the highest (2048.6 ± 61.71 litres) shows that the improvement in the management practices over the period of time.

c. Centre

Centre was a significant ($P \leq 0.05$) source of variation for FLMY. Chirakkakode recorded the highest 305 days milk yield of 2639.0 ± 154.73 litres and Arattupuzha the lowest (1559.3 ± 161.12 litres). ULF, Mannuthy had the next best average of 2200.6 ± 67.3 litres. This farm already had animals with good genetic potential and the daughters born out of these dams and sires under good management conditions, showed high level of milk production, thus proving the superiority of sires. Other than Chirakkakode, R.V.Puram and Kunnathangady centres recorded the milk yield >2000 litres. The closeness to Thrissur town offers these centres better marketing facilities for milk and in this area animals are generally managed better. In other centres like Arattupuzha, Parappur where the milk yield is low, the farmers are considering cow as an integral part of agriculture through their contribution of manure and milk is not the important consideration as in centres near town. Iype *et al.* (1993) and Radhika (1997) also recorded higher milk yield in R.V.Puram and the same reason of closeness to town has been quoted. Chirakkakode centre was added recently to the scheme area.

The significant influence of centre on milk yield in the present study concurs with the findings of Chacko *et al.* (1984) and Thomas *et al.* (1987) who conducted the study at Mavelikkara and Kattapana and also with the report of Iype *et al.* (1993) who conducted study in farmers' herds at Thrissur area. Jadhav *et al.* (1991) in HF x Sahiwal and Thalkari *et al.*(1995) in J x Deoni and HF x Deoni crosses reported significant farm differences.

d. Age group

To study the influence of age at first calving on milk yield, the animals were grouped into four classes, viz., Less than 2 ½ years, 2 ½ - 3 years, 3 – 3 ½ years and above 3 ½ years.

Analysis of variance showed that the effect of AFC on FLMY was not significant in the present study. This is in conformity with Varade and Ali (1998) in Jersey crossbreds (Gaolao, Tharparkar x J) and by Sreemannaarayana and Rao (1994) in Jersey cows (Andhra Pradesh). The present finding is in disagreement with the reports of Garcha and Dev (1994) in HF crossbreds and Turkmut and Kumuk (1994) in Holstein-Friesian and Stephen *et al.* (1985a) and Thomas *et al.*(1987) in crossbreds of Kerala under field conditions.

e. Sire

The sires wise mean first lactation milk yield of the daughter cows is given in Table 4.10. The average milk yield of progenies of different test bulls varied from 1707.3 ± 140.71 litres (Devendra) to 2082.2 ± 134.17 litres (Hemanth). However, the analysis of variance revealed that effect of sire was not significant on FLMY (Table 4.9). This is in accordance with Radhika (1997) in crossbred cows under field progeny testing scheme in Kerala, Touchberry and Balaine (1990) but not in conformity with Pereira *et al.* (1994), Vij and Basu (1986) and Herbert and Bhatnagar (1989).

For the present study, the sires with minimum three progenies were included and there was wide disparity in the number of progenies per sire. Thus sampling error might have caused the non-significant effect of sire. Therefore at present it has to be concluded that the differences in the breeding value of bulls used in the scheme are not significant.

5.8.3 Heritability estimate

The heritability estimate for milk yield in the present study was found to be -0.069 ± 0.05. This is not in agreement with Rao and Nagarcenkar (1992), Teotia *et al.* (1990), Tomar and Tomar (1982) in HF crosses and Radhika (1997) in crossbreds of Kerala. However, Naidu and Desai (1970) and Sachdeva and Gurnani (1995) reported very low estimate.

Low estimate of heritability for milk yield under field conditions is expected. Wide fluctuations in the management of cows in field, difference in the purpose to which animals are kept, disparity in the land holding, difference in the availability of green grass etc. increases the environmental variances and thereby reducing the ratio of genetic variance to total phenotypic variance.

5.9 Correlation estimates

5.9.1 Among body weights

The genetic correlation between BW0 and BW3 was negligible but BW0 showed a very high positive, significant correlation (0.97) with BW6. But, the genetic correlation between the BW0 and BW12 was negative (Table 4.14). The phenotypic correlation of birth weight with body weights at 3, 6 and 12 months were positive but low (Table 4.14).

Rao and Nagarcenkar (1981) reported similar results in HF x Sahiwal and concluded that BW0 could not be used as a guide to the future body weights in crossbred cattle. The present finding also agrees with Jogi and Parekh (1982) who observed correlation values close to zero. But the phenotypic correlation estimates of present study disagree with those (0.3 to 0.79) of Malau – Aduli *et al.* (1996) in HF x Bunaji crosses.

The BW3 did not have a strong correlation both genetically and phenotypically with BW6 but showed a moderately high correlation (0.54) with BW12. Both genetic and phenotypic correlation estimates of the present study were not similar to the estimates given by Rao and Nagarcenkar (1981), Jogi and Parekh (1982) and Malau – Aduli *et al.* (1996).

The present study also showed that BW6 had no genetic correlation with BW12 though the phenotypic correlation was positive, medium and significant (0.47). Malau- Aduli *et al.* (1996) and Jogi and Parekh (1982) also gave such moderate estimates. But Sharma and Singh (1987) reported very low phenotypic correlation (0.094) between BW6 and BW12.

In general, this study did not show any definite trend in the association among body weights.

5.9.2 Body weights with AFC and FLMY

The phenotypic and genetic correlation of body weights did not show any definite association with AFC (Table 4.15). The low and positive correlation between BW0 and AFC of the present study agrees with Hayatnagarkar *et al.* (1991) who made studies under field conditions of Maharashtra, but negative correlation was reported by Rao and Nagarcenkar (1981), Jadhav and Khan (1991) and Singh *et al.* (1988). In the present study, the phenotypic correlation between body weights at earlier ages with AFC was low and negative. Similar trend was also observed by Rao and Nagarcenkar (1981).

The main objective of the present study was to examine whether there exists any association between FLMY and body weights at birth, three, six and twelve months. The results (Table 4.15) showed that the phenotypic correlations between FLMY and body weights were absent or negligible. The birth weight and BW3 did not have any genetic association with FLMY. Rao and Nagarcenkar (1981) also observed similar trend. However, BW6 registered strong, positive and significant genetic correlation (0.46) with first lactation milk yield. The genetic correlation between BW12 and FLMY was beyond the positive limit indicating a strong association. This doesn't agree with Teotia *et al.* (1990) who reported negative and nonsignificant association. The genetic correlation of WFC with FLMY was however low showing body weight at calving is not a good indicator for milk yield. The genetic correlation (0.27) between WFC and FLMY recorded in this study is not in line with Singh *et al.* (1990), Tomar and Tomar (1982) who reported higher values. However, the phenotypic correlation between WFC and FLMY of present study is in conformity with lower estimates given by Singh *et al.* (1990), Tomar and Tomar (1982), Koul *et al.* (1985) but disagrees with D'Souza *et al.* (1979) and Mansuri (1989) who recorded higher estimates.

In the present study, no definite trend was observed in the association among body weights and between body weights and AFC. However, the genetic correlation (0.46) between BW6 and FLMY and high positive genetic correlation (>1) between BW12 and FLMY indicate strong genetic association of BW6 and BW12 with FLMY and their relationship can be used advantageously for selection of heifers for milk production under field conditions.

Summary

6. SUMMARY

1. A study was made to assess association of body weights at birth, three, six and twelve months of age and at calving with age at first calving (AFC) and first lactation milk yield (FLMY). The aim of the present study was to detect the possibility of using the initial body weights as indirect selection tool for increasing milk yield in dairy cattle. Data for the present study was taken from the records of ICAR FPT Scheme for the period 1993 – 2000. The progenies considered for the present study were born to HF crossbred bulls with exotic inheritance ranging from 50-75 per cent.

2. Body weights i.e., at birth (BW0), three (BW3), Six (BW6), twelve (BW12) and at calving (WFC) were predicted from body measurements (Body length and Chest girth) using the Minnesota formula given by Johnson (1940).

3. The 305-days milk yield was estimated from monthly recordings. First recording starting within 20 days of calving extending to a period of 10 months.

4. Least Squares technique (Harvey, 1986) was employed to estimate the effects of season of birth (SOB), Period of birth (POB) and centre on body weights at different ages, Age at first insemination (AFI) and AFC. For milk yield, the influence of season of calving (SOC), Period of calving (POC), centre and age group were studied. The data adjusted for significant nongenetic factors were used to study the influence of sire on all these traits and for estimating heritability and correlation among body weights and between body weights and AFC and FLMY.

5. The SOB was found to have significant effect ($P \leq 0.05$) only on BW6, whereas the influence of POB was significant ($P \leq 0.05$) on BW0, BW3 and BW12 but not on BW6. Centre had significant ($P \leq 0.05$) influence on BW0, BW3, BW6 and BW12.

6. The least squares average body weights of crossbred calves at birth, 3, 6 and 12 months of age were 26.0 ± 0.38 kg, 48.7 ± 1.26 kg, 74.1 ± 2.81 kg and 151.0 ± 7.74 kg respectively.

7. SOB did not exert any significant effect on AFI, AFC and WFC. The significant ($P \leq 0.05$) influence of POB and centre was observed on AFI and AFC but not on WFC.

8. The mean AFI, AFC and WFC of crossbred cows born to test bulls of FPT Scheme were 689.3 ± 22.9 days, 1013.6 ± 21.74 days and 284.9 ± 7.71 kg respectively.

9. The overall mean FLMY of crossbred cows born to test bulls of FPT Scheme was 1958.5 ± 30.74 litres. Influence of POC and centre were found to be significant ($P \leq 0.05$) but SOC and age group did not have any effect on FLMY.

10. The influence of sire was significant ($P \leq 0.05$) on BW0, BW3, BW12, AFI and AFC but not on BW6, WFC and FLMY.

11. Heritability estimates of different traits under study were estimated by paternal half sib method. The heritability estimates were 0.12 ± 0.027, 0.71 ± 0.16, 0.14 ± 0.038 and 0.70 ± 0.18 for BW0, BW3, BW6 and BW12 respectively. The heritability estimates of AFI, AFC and WFC were 0.35 ± 0.09, 0.20 ± 0.05 and 0.10 ± 0.03 respectively. The heritability estimate of FLMY was -0.069 ± 0.05.

12. Definite trend was not observed in the association among body weights and between body weights and AFC. However, the genetic correlation (0.46) between BW6 and FLMY and high positive genetic correlation (>1) between BW12 and FLMY indicates strong genetic association of BW6 and BW12 with FLMY and their relationship can be used advantageously for selection of heifers for milk production under field conditions.

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BODY WEIGHT AND ITS ASSOCIATION WITH AGE AT FIRST CALVING AND MILK PRODUCTION IN CROSSBRED CATTLE OF KERALA

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ABSTRACT OF A THESIS
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ABSTRACT

The present study was undertaken with a view of estimating body weights of crossbred calves in the field conditions of Kerala at birth, three, six and twelve months of age and to find association of these body weights with age at first calving and first lactation milk yield.

The data for the present study were taken from the records of ICAR Field Progeny Testing Scheme of Centre for Advanced Studies in Animal Genetics and Breeding, Kerala Agricultural University. The data were of the 1993-2000 period. Body weights at birth, 3, 6, 12 months and at calving were predicted from body measurements using Minnesota formula given by Johnson,(1940).

The data were analyzed using least squares analysis of variance to study the effects of non-genetic factors on different traits under study. The data adjusted for significant non-genetic factors were used to study the effect of sire and for estimating heritability and correlation among body weights and between body weights and

age at first calving and between body weights and first lactation milk yield.

The overall average body weights of crossbred calves at birth, 3, 6 and 12 months of age were 26.0 ± 0.38 kg, 48.7 ± 1.26 kg, 74.1 ± 2.81 kg and 151.0 ± 7.74 kg, respectively.

Least squares analysis of variance has shown that the effect of season of birth was significant ($P \leq 0.05$) only on body weight at six months of age. The influence of period of birth was significant for all body weights upto one year age except for body weight at six months of age. Centre was a significant source of variation for all body weights upto one year age,

The mean Age at First Insemination, Age at first calving and Weight at first calving of crossbred cattle were 689.3 ± 22.9 days, 1013.6 ± 21.74 days and 284.9 ± 7.71 kg respectively.

The season of birth did not affect age at first insemination, age at first calving and weight at first calving. The significant ($P \leq 0.05$) influence of period of birth and centre were observed on age at first insemination and age at first calving only but not on weight at first calving.

The effect of period of calving and centre on first lactation milk yield was significant whereas the effect of season of calving and age at first calving did not affect first lactation milk yield. The average first lactation milk yield of crossbred cows was 1958.5 ± 30.74 litres.

The sire wise means of body weight at six months of age, weight at first calving and first lactation milk yield did not differ significantly but sire effect was significant ($P \leq 0.05$) in all the other traits.

Heritability estimates were calculated by paternal half sib method for different traits under study. The low heritability estimate was obtained for birth weight, body weight at six months of age, age at first calving and weight at first calving. But the heritability estimates of body weight at three months of age and body weight at twelve months of age were high. Age at first insemination was moderately heritable. The heritability estimate of first lactation milk yield was –0.069 ± 0.05.

Association among body weights and that between body weights and age at first calving followed no definite trend. However, the genetic correlation (0.46) between body weight at six months and first lactation milk yield and high, positive (>1) genetic correlation between body weight at twelve months and first lactation milk yield indicates strong genetic association of body weight at six months and body weight at twelve months with first lactation milk yield and their relationship can be used advantageously for selection of heifers for milk production under field conditions.