PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF INDIGENOUS AND CROSSBRED DAIRY CATTLE IN MUZAFFARABAD, AZAD JAMMU AND KASHMIR

A Dissertation Submitted in Partial Fulfillment of the Requirements for the Degree of

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In

Animal Science

(Reproductive Physiology)

By

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بسم الله الرحمن الرحيم

In the Name of Allah,
Most Gracious, Most Merciful

Dedicated to my
Parents,
Adorable Wife
& Lovely Kids

CERTIFICATE

The Thesis titled "Productive and Reproductive Performance of indigenous and crossbred dairy cattle in Muzaffarabad Azad Jammu and Kashmir" submitted by **Mr. Muhammad Ijaz Khan** is accepted in its present form by the Department of Animal Sciences, Faculty of Biological Sciences, Quaid-i-Azam University, Islamabad as satisfying the thesis requirement for the degree of Doctor of Philosophy in Reproductive Physiology.

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Muhammad Ijaz K

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Abbreviations

ADB	Asian Development Bank
AFC	Age at first Calving
AI	Artificial Insemination
AJ&K	Azad Jammu and Kashmir
AM	Anti Meridian
BCS	Body Condition Score
BE	Breeding Efficiency
BQ	Black Quarter
Ca	Calcium
CI	Calving Interval
CP	Crude Protein
DM	Dry Matter
DP	Dry Period
FMD	Foot and Mouth Disease
GDP	Gross Domestic Product
HS	Hemorrhagic Septicemia
Kg	Kilogram
LDRC	Livestock Development Research Centre
Lit.	Liter
Ml	Milliliter
NS	Natural Service
P	Phosphorous
PL	Productive Life
PM	Past Meridian
SAP	South Asia Pacific
SP	Service Period
TD	Test Day
TDN	Total Digestible Nutrient
USA	United States of America
USDA	United State Department of Agriculture
VRI	Veterinary Research Institute
WMO	World Meteorological Organization

Abstract

The study was conducted at Livestock Development Research Centre Muzaffarabad, Azad Jammu and Kashmir. The primary objective of this study was to improve the milk production of indigenous cows along with other productive and reproductive traits by crossing with European breeds. The indigenous heifers were artificially inseminated with Jersey semen and F_1 crossbred were produced. The F_1 offspring were selfed to obtain the F_2 offspring and on the other hand the F_1 cows were crossed with Frisian bull to produce three-breed crossbred cows. The information regarding productive and reproductive traits of all the cows was studied. The number of cows for each group were 48 for indigenous, 32 for F_1 (Indigenous × Jersey) cross, 19 for F_2 ($F_1 \times F_1$) cross and 18 for F_1 × Frisian cross. Highly significant increase ($P < 0.0001$) in milk yield and birth weights of calves was observed in all the crossbred cows compared to indigenous cows. Highest milk yield per lactation (1411.0 ± 92.88 liters) and highest lactation length (354.5 ± 16.70 s) was observed in F_1 × Frisian cross whereas the highest 305day milk yield (1674.0 ± 47.58 liters) and daily average milk yield (5.07 ± 0.14 liters) was observed in F_1 (Indigenous × Jersey) cows. 305day milk yield did not differ significantly between F_2 (1295.0 ± 75.36 liters) and F_1 × Frisian (1355.0 ± 60.32 liters) cows. The sex ratio of male and female calves did not differ significantly among the all breed groups ($P > 0.05$). Similarly method of breeding did not affect the sex ratio of male and female calves. Mean age at first calving (AFC) reduced highly significantly ($P < 0.0001$) in all the crossbred cows (951.2 ± 37.35 s for F_1, 1086 ± 37.89 for F_2 and 952.1 ± 28.23 s for F_1 × Frisian) compared to indigenous (1861 ± 42.45 s) cows. Mean AFC of F_1 and F_1 × Frisian cows did not differ significantly ($P = 0.9869$). Mean dry period of F_1 (110.2 ± 4.78 s); F_2 (124.8 ± 10.14 s) and F_1 × Frisian (99.76 ± 6.67 s) cows decreased highly significantly ($P < 0.0001$) compared to indigenous cows (239.5 ±7.87 s). The dry period among the crossbred cows did not differ significantly ($P > 0.05$). The service period recorded in present study was 256.0 ± 8.67, 92.60 ± 5.04, 81.81 ± 11.19 and 266.7 ± 16.56 s for indigenous, F_1, F_2 and F_1 × Frisian cows respectively. The mean service period in F_1 and F_2 crossbred cows decreased highly significantly ($P < 0.0001$) compared to indigenous cows but no significant difference ($P = 0.5493$) was observed between the service period of indigenous and F_1 × Frisian cows. Mean calving interval of one year was observed in F_1 (368.8 ± 5.32 s) and F_2 (359.8 ± 11.68 s)

crossbred cows where as a calving interval of 518.6 ± 9.54 and 540.9 ± 22.39 s was observed in indigenous and F_1 × Frisian cows respectively. The mean calving interval decreased highly significantly in F_1 and F_2 cows compared to indigenous and F_1 × Frisian cows ($P < 0.0001$). Mean calving interval of indigenous and F_1 × Frisian cows did not differ significantly ($P = 0.2895$). High breeding efficiency was observed in F_1 (93.68 ± 1.85 %) and F_2 (93.71 ± 2.74 %) and it increased highly significantly ($P < 0.0001$) in F_1 and F_2 compared to indigenous cows (73.46 ± 2.50 %). The mean breeding efficiency of F_1 × Frisian (65.62 ± 3.05 %) did not differ significantly from that of indigenous cows ($P = 0.0870$). Within F_2 crossbred cows significant ($P < 0.05$) sires effects were observed on 305 milk yield, daily milk yield and service period while the birth weight, milk yield per lactation, lactation length, age at first calving, dry period and calving interval were not affected significantly ($P > 0.05$) by sire. The sire effects within F_1× Frisian crossbred cows were not observed ($P > 0.05$). Parity has significantly affected 305day milk yield in indigenous, F_1 and F_2 cows whereas parity did not significantly affected 305day milk yield in F_1 × Frisian cows ($P = 0.2472$). The 305day milk yield in indigenous cows decreased significantly ($P = 0.0063$) from parity one to parity five. 305day milk yield in F_1 and F_2 increased significantly ($P < 0.05$) towards 4^{th} and 5^{th} parity and decreased thereafter. The mean lactation length in indigenous cows decreased significantly from first to five parity ($P = 0.0024$). Parity did not affect significantly ($P > 0.05$) lactation length of crossbred cows in relation to parity. Season of calving significantly ($P < 0.05$) affected the 305day milk yield in indigenous and crossbred cows. In indigenous cows autumn calvers produced the highest 305day milk compared to spring, summer and winter calvers. In crossbred cows highest 305day milk yield was observed in winter calvers compared to spring, summer and autumn calvers. The lactation length was not affected significantly ($P > 0.05$) by the season of calving in nondescript and their crossbred. Year of calving had a significant ($P < 0.05$) effect on 305 milk yield and lactation length of nondescript indigenous cows. 305 milk yield and lactation length of all the crossbred groups was not affected significantly ($P > 0.05$) by the year of calving. Overall productive and reproductive performance of indigenous × Jersey (F_1) crossbred cows was found to be better compared to F_2 and F_1× Frisian crossbred cows. Thus upgrading of indigenous cows of AJ&K with exotic breed of Jersey is suggested in this study.

INTRODUCTION

Azad Jammu and Kashmir (AJ&K) lies between longitude of 73˚–75˚ and latitude of 33˚–36 ˚ and comprises an area of 5134 square miles. The topography of the area is mainly hilly and mountainous with valleys and stretches of plains. The climate is sub-tropical highland type with an average yearly rainfall of 1300 mm. The elevation from sea level ranges from 360 meters in the south to 6325 meters in the north. The snow line in the winter is around 1200 meters above sea level while in summer it rises to 3300 meters (Anonymous, 2006). Muzaffarabad is the capital of Azad Jammu and Kashmir. In Muzaffarabad mean minimum and maximum temperature in January and June is 3.2 ˚C, and 37.6 ˚C respectively (WMO 2007, 2008).

Daily minimum and maximum temperature and mean rainfall of Muzaffarabad are given below.

Table 1: Daily minimum and maximum mean temperature and mean total rainfall of Muzaffarabad city

Month	Mean Temperature C◦		Mean Total Rainfall (mm)
	Daily Minimum	Daily Maximum	
Jan	3.2	15.9	93.7
Feb	5.2	17.6	134.7
Mar	9.6	22.3	156.5
Apr	14.1	28.1	111.1
May	18.3	33.1	79.1
Jun	22.1	37.6	103.3
Jul	22.8	34.8	327.6
Aug	22.4	33.8	249.2
Sep	19.4	33.3	108
Oct	13.6	29.8	51
Nov	7.8	23.9	35.4
Dec	4	17.7	76.9

Source: World Weather Information Service (http://worldweather.wmo.int/047/c00901.htm)

The majority of the rural population depends on forestry, livestock and agriculture to eke-out its subsistence. Agriculture and livestock income ranges between 30–40 percent of the household earnings. Low agriculture productivity has very adversely affected the traditional lifestyle and average per capita income of the rural household (Anonymous, 2006). In Azad Jammu and Kashmir livestock is primarily raised in small herds and it does not exceed more than four animals. The animals are pre-dominantly reared on mixed system of feeding (grazing and stall feeding) and they are contributing about 62% in the GDP of Azad Jammu and Kashmir when compared with agriculture (Qureshi *et al.*, 2008). Although Pakistan contains handsome number of dairy breeds of cattle but these breeds are low performers in terms of milk production (Usman *et al.*, 2012). Although the Zebu cattle are more adapted to the local tropical environment, their capacity for milk production is usually low (Vaccaro *et al.*, 1977). Selection for high milk production within indigenous cattle would require a long-term genetic improvement program. However, in the highland areas of the tropics with an annual rainfall above 1000 mm, dairying is being carried out with relative success using imported and now adapted *Bos taurus* breeds, as well as their crosses with the Zebu (Katyega, 1988).

The indigenous cattle make 87 percent of total cattle population of Azad Jammu and Kashmir (Anonymous, 1996). The indigenous cattle are short structured and their live weight ranges from 175 to 225 kg with an average of 200 kg. These animals are dark grey in color with a light grey under belly and a dark face (Tanner, 1978). They have very little feed requirement for their maintenance, are resistant to diseases including ecto-parasites, very well adapted to graze on fragile and mountainous areas of the state, but their production potential is very low (Kuthu *et al.*, 2007). The reproductive performance of indigenous cattle have been extensively studied in Pakistan (Talbott *et al.*, 1997; Dahlin *et al.*, 1998; Khan *et al.*, 1999; Javed *et al.*, 2000), but all these studies have been carried out mostly in canal irrigated areas of Punjab and no report is available on the performance of indigenous cattle in hilly areas of Pakistan particularly Azad Jammu and Kashmir (Kuthu *et al.*, 2007).

The dairy industry in most parts of the world started with small-scale traditional cattle rearing in rural areas with the objective of producing milk to feed the family and neighbors (Bee *et al.*, 2006). *Bos taurus* breeds that are predominantly found in temperate countries have a high potential of milk production but they are not well adapted to tropical conditions because of their low heat tolerance and low disease resistance (Tadesse and Dessie, 2003). There is a constant trend towards increasing the productivity of indigenous cattle in the tropics through crossbreeding with improved *Bos taurus* breeds for nearly one century. The objective of dairy cattle crossbreeding is to create a mosaic of desirable traits having superior additive genetic merit of the temperate dairy breeds for milk production and reproduction and of the tropical breeds for adoptability to high temperature, tropical diseases and poor feed quality (Chaudhry *et al.*, 1992). A rapid genetic improvement of cattle for milk production in the tropics can often be made by the use of improved temperate breeds (Ageeb and Hayes, 2000). There has been considerable interest over the past several years by both researchers and dairy producers in the crossbreeding of dairy cows and the reasons for this interest include the potential for improving herd fertility and health through heterosis or hybrid vigor effects of crossbreeding (Weigel, 2007) and an emphasis on improving feed efficiency (Hutjens, 2005). The Holstein (high milk volume) and Jersey (high milk solids content) breeds are established as the predominant breeds in the United States, and thus have been included in many of the early crossbreeding programs on dairies (Anderson, 2007). Dairy development tends to be more strongly supported by the public sector in the countries that aim to use dairying to alleviate poverty and provide livelihood support in terms of income and employment generation to the millions of landless and smallholder dairy farmers. In part due to this support, milk production in South Asia Pacific (SAP) has increased steadily over the last decade. Bangladesh, India, Pakistan and Sri Lanka have realized annual growth of 1.5%, 4.1%, 4.9% and 0.6% respectively, in total national milk production from 1993 to 2003. Consumption of milk and dairy products has been expanding dramatically with income growth, population growth, urbanization and dietary changes (Beghin, 2005; Fuller *et al.*, 2005).

The national policy for cattle breeding was reported (Khan, 1994), which allows selective breeding for native breeds and up gradation of nondescript cattle through use of Friesian and Jersey semen in the plains irrigated and hilly rain fed areas, respectively. The policy emphasizes that the level of exotic inheritance should be maintained between 50 and 62.5 present. Emphasis was given in the national breeding policy on the up-gradation of local cattle through crossbreeding using semen from

Jersey and Friesian breeds. Jersey cattle is high potential breed of milk and is well adopted in rain-fed as well hilly areas. Because of its relatively small size the breed is suitable for hilly areas of the country (Suhail *et al.,* 2010).

In the tropics, and most developing countries, the productive and reproductive potentials of indigenous cattle are low compared to temperate breeds (Gwaza *et al.,* 2007). Hence several efforts to increase livestock production have been through breeding strategies and policies that encouraged the introduction and breeding of exotic temperate breeds (Stetshwaelo and Adebambo, 1992). The indigenous cattle in the tropics are known for their tolerance to hot environments but they generally exhibit low productive and reproductive performance (Ageeb and Hiller, 1991). Accurate evaluation of the reproductive efficiency of indigenous stocks and their crossbred in different production systems is essential for the development of appropriate breeding strategies (Negussie *et al.,* 1998). Low reproductive efficiency hinders genetic improvement efforts and causes direct economic loss (Mukasa-Mugerwa *et al.,* 1991). In many cases reproductive efficiency of cattle has been measured mainly by considering parameters such as age at puberty, age at first calving, days open, calving interval and number of services per conception (Alberro, 1983; Agyemang and Nkhonjera, 1990; Haile-Mariam *et al.,* 1993; Bekana, 1997; Negussie *et al.,* 1998; Shiferaw *et al.,* 2003; Masama *et al.,* 2003; Lyimo *et al.,* 2004). Reproductive efficiency of dairy cows is influenced by different factors including genetic, season, age, production system, nutrition, management, environment and disease (Alberro, 1983; Agyemang and Nkhonjera, 1990; Mukasa-Mugerwa *et al.,* 1991; Bekele *et al.,* 1991; Negussie *et al.,* 1998; Shiferaw *et al.,* 2003).

Crossbreeding has been adopted for the last few decades in Pakistan to increase the milk production of nondescript indigenous cattle. The Holstein Friesian (HF) is a renowned dairy cattle breed of the world hence the crossbreeding of local breeds with imported semen of Friesian is going on at the government farms as well as in the private sector (Shafiq *et al.,* 1993). Crossbreeding, as a system to develop new or as a part of an upgrading programme, is a widely used method of improving milk yield and profitability of native stock in many developing dairy production areas of the world (Chaudhry *et al.,* 1993). Introducing animals to a new environment will change their physiological functions causing changes in their productive and reproductive performance (Salah and Mogawer, 1990).

In AJ&K the environment is harsh and non-conducive for dairy animals due to lack of green fodder, water scarcity in many places throughout the summer, lack of knowledge among farmers about rearing of the animal and lack of artificial insemination facilities (Hussain *et al.*, 2006). Now a days the demand for crossbred animal is very high because of high milk production (Kabir and Islam, 2009). Cattle husbandry is one of the main areas of the animal breeding due to having great marketing impact on breeding stock with exporting sperm and live embryos. Although, the relative importance of the characters in cattle breeding programmes may change from country to country according to farmer and consumer requirements, milk yield traditionally has been the most important trait of dairy cattle selection programs in every country (Ulutas and Sezer, 2009).

Biologically potential for milk production depends on the age at puberty, early first calving, number of parity and shorter calving interval. However, the intensity of production traits differs according to the genotype of breeds and between parities (Djemali and Freeman, 1987; Rahman *et al.*, 1987). Crossbred cows attain sexual maturity at an early age compared to indigenous cows such as Red Sindhi and Sahiwal. Consequently, the crossbred cows produce more milk in third parity and indigenous cows in fourth parity (Khan *et al.*, 1989).

The productive and reproductive performance of indigenous crossbred cows with high yielding exotic breeds may differ among different geographical areas (Jahan *et al.*, 1990; Alam and Ghosh, 1994). However, the potential for milk production not only attributed with the genetic makeup of a cow, but also have an interaction with environment or variation of management could considerably limit the expected farm level production.

It is important for animal geneticists to identify and maintain economically profitable animal genotypes (and genes) and to integrate genotype interaction with on-farm production and environmental pressures that affect the genetic potential of dairy animals. Whereas in the developed countries there has been marked improvement in livestock production, in developing countries improvements in livestock production have generally been inadequate. One of the principal limiting factors has been the lack of genetically improved animals, a reflection of ineffective breeding programs, if any z(Njubi *et al.*, 2009). The better performance with regard to the reproductive and productive efficiency of the heifers and cows included age at first service and calving, period from parturition to the service, calving interval, gestation length, daily and total milk yield, and age and body weight of cow influence the onset of oestrus and the subsequent fertility after calving (Khan and Khatun, 1998). The productive performances of the crossbred cows may differ from that of the indigenous ones living in different geographical areas where harsh environmental condition exists (Alam *et al.*, 2001). The indigenous cattle in the tropics are known for their tolerance to hot environments but they generally exhibit low productive and reproductive performance (Ageeb and Hiller, 1991). Milk yield traditionally has been the most important trait of dairy cattle selection programs in every country (Ulutas and Sezer, 2009). However, selection for milk production alone can lead to deterioration in reproductive performance (Hermas *et al.*, 1987; Pryce *et al.*, 1999). Additionally, many secondary traits such as reproductive traits (Pryce, 1997) are also economically important for dairy enterprise.

1.1. Productive Traits

In the dairy industry, productive traits directly affect the profitability of the farm and these traits depend largely on the genetic potential of the dam and sire (Habib *et al.*, 2010).

In general, size of calf at birth has been of little concern to dairymen. It is only when calves are extremely large and cows have difficulty in calving, or when calves are born small and weak, that dairymen really become concerned about the birth weight of calf (Touchberry and Bereskin, 1966). Season of birth, sex and weight of calf, twining and parity of dam have been associated with calf mortality in early studies

(Martinez *et al.*, 1983; Erf *et al.*, 1990; Berger *et al.*, 1992; Meyer *et al.*, 2001; Berglund *et al.*, 2003). Jefrey and Berg (1972) stated that birth weight is important because cows heavier at birth tended to excel in both pre-weaning and post-weaning growth rates. A 1 kg increase in birth weight can result in an increase of 2.86 to 4.42 kg at 365 days of age (Jefrey and Berg, 1972). The rate of an animal's maturity for weight not only affects how soon an animal can be bred which has a positive correlation with age at first calving), but also affects certain dam-offspring relationships like dystocia (Brody, 1945). Body weight and growth are two factors that govern the onset of puberty and until heifers reach a particular weight, oestrus will not occur (Boyd, 1977). The weight at which oestrus is attained is positively correlated with birth weight (Jefrey *et al.,* 1971). Differences between birth weights of calves are also used as an indication of differences between them in vigor, potential growth rate and mature size (Shahzad *et al.,* 2010).

The most important role of livestock is the production of high quality animal protein for human consumption through the supply of milk and meat. Milk production is the most efficient process in converting plant material into a perfect food (Sandhu *et al.,* 2011). Milk constitutes an integral part of our daily diet necessary for nourishment and health development of the human being (Irshad *et al.,* 2011). The major objective of dairy cattle enterprises is to increase milk yield and obtain one calf in a year with regular intervals. Like other quantitative traits, milk yield is under the influence of environmental effects besides genotype (Topal *et al.,* 2010). For any genetic improvement program of farm animals, knowledge of genetic parameters is very important. For estimation of genetic parameters it is necessary to estimate the magnitude of various environmental factors influencing the traits under investigation (Javed *et al.,* 2007; Kuthu *et al.*, 2007).

Lactation milk yield is the most important trait of a dairy animal. Higher milk yield increases the profitability and decreases the rearing cost of dairy animals (Zafer *et al.*, 2008). Both breed and parity effects have been shown to exist on lactation curves (Wood, 1980; Collins-Lusweti, 1991; Friggens *et al.*, 1999; Rekaya *et al.*, 2001). In order to enhance productivity of a dairy animal, it is necessary to develop an understanding of the factors affecting its milk production (Afzal *et al.*, 2007).

305 day milk yield is a commonly used standard that represents milk yield of first 10 months (approximately) after the calving date. The reason for this standard is that for an ideal cow/buffalo to calve annually, if she is to be dried for two month (the dry period), she should be giving milk for the other 10 months. If such information is not available, the partial lactation milk yield is standardized by using some factors or equations to project milk yield to 305 days (Khan, 1997). Dairy cattle have traditionally been evaluated on the basis of 305 day lactation yield. A 305-day lactation yield is usually obtained from 7-10 test-day (TD) records taken at monthly intervals (Bilal *et al.*, 2008). The 305 day lactation have been a standard for comparison of dairy production records and serves as a raw material for evaluation of genetic merit of production traits of sires and cows (Famula and Van Vleck, 1981). Asian countries traditionally tend to express milk production based on yields at 305

days of lactation (Sane *et al.,* 1972; Mourad and Mohamed, 1995). Inclusion of incomplete lactation along with complete lactation helps to reduce the bias in ranking of bulls for breeding values. Early estimates of sire's breeding values by extending incomplete lactation can also help to reduce the generation interval. The projected records can also be used to estimate cow's producing abilities while their lactation are still in progress and facilitate the farmers for early culling decisions (Khan *et al.,* 2009). A standard lactation of 10 months is defined similar in cattle and buffalo (Khan, 1997) and procedures of estimating lactation milk yield are likely to be similar in both the species. Records shorter than the standard lactation should also be used to reduce the bias in estimating breeding values of sires due to differences in the culling rates among the progeny groups. Early estimates of sire's breeding values by extending lactation in progress can also help to reduce the generation interval as well as increase the intensity of selection. Furthermore, it helps in the allocation of resources such as feed supplies both for an individual cow or a herd (Khan *et al.,* 2005). Norman *et al.* (1985) showed that extending lactation yields to 305 days, even if a cow remained in the herd and discontinued lactation before 305 days, produced higher heritabilities and repeatabilities than if all records were not extended. This finding was the basis for crediting all cows with 305 days of yield in the United State genetic evaluation system. Traditionally, estimation of milk production is performed when cows are milked at regular intervals, such as 2 or 3 times daily, in conventional systems (Nielsen *et al.*, 2009).

Lactation length is the periods from calving till the animals dries. The term lactation number, on the other hand, is usually used to represent the order of a calving. The parity is synonym for lactation number (Khan, 1997). Duration of lactation length is the main criteria to declare any record complete or incomplete as information on reasons of drying is usually not available (Khan, 2009). Lactation length, which is one of the main factors affecting milk yield, itself is influenced by other factors (Bajwa *et al.*, 2004). The crossbreeding between exotic and native breeds tended to improve the lactation length. The Friesian sires appeared to cause longest lactation as compare to that of Jersey sires (Qureshi *et al.,* 2000). Profitable breeding could be improved by keeping lactation length, dry period and service period between optimal limits (Cilek and Tekin, 2005).

1.2. Reproductive Traits

Reproductive performance is one of the main factors affecting efficiency of dairy and beef herds (Diskin *et al.*, 2003). Improvement in cattle has focused on productive traits. However, reproductive regularity as an indicator of fertility dramatically affects cattle productivity (Gutierrez *et al.*, 2002). Reproductive performance has a large impact on the economy of dairy farms (Boichard 1990; Jalvingh *et al.*, 1993; Mourits *et al.*, 1997) and factors that affect reproductive performance of dairy cattle have been extensively documented (Lee *et al.*, 1989; Harman *et al.*, 1996a; Harman *et al.*, 1996b; Harman *et al.*, 1996c; Darwsash *et al.*, 1997).

There has been a growing concern about determination of sex ratio of calves born in dairy cattle (Yilmaz *et al.*, 2010). Determination of sex ratio with biotechnological applications such as super ovulation, in vitro fertilization, in vitro embryo production, embryo division, and embryo transfer has been of great importance in dairy industry (Kaygisiz *et. al.*, 2003). In long-term, profitability of milk production may be increased with increasing female calving ratio (Yilmaz *et al.*, 2010). Probability theory indicates that the secondary sex ratio, the ratio of male to female offspring at birth, should be 50:50 in respect of evolutionary equilibrium (Roche *et al.*, 2006). In non-human mammals, secondary sex ratio of newborn offspring was influenced by many factors such as litter size, maternal age, maternal parity, mother's milk yield, maternal stress, birth type, birth season and time of insemination, inbreeding levels, managerial conditions, and population demography (Demiral *et al.*, 2007). It was remarked that body condition scores had positive effect on secondary sex ratio (Roche *et al.*, 2006). Some authors also reported that breed, sire, season, parity, and year may be effective factors on sex ratio (Singh *et al.*, 2004; Kaygisiz and Vanli, 2008). Lari (2006) observed a significant effect of sex hormone levels of dam on sex ratio. It was also reported that there was a positive significant relationship between herd size and sex ratio (Farahvash *et al.*, 2008).

Age at first calving is the period between birth and first calving and influences both the productive and reproductive life of the female, directly through its effect on her lifetime calf crop and milk production and indirectly through its influence on the cost invested for up-bringing (Perera, 1996). Age at first calving has an important bearing on early economic return on total lifelong production (Mourad, 1997). Some fertility indicators such as calving interval (CI) or age at first calving (AFC) are obtained by recording organizations and used as indicators of fertility (Tonhati *et al.*, 2000; Van der Westhuizen *et al.*, 2000). As generally indicative to a better management index at farm level average age of first calving should be optimally around 2 years (Wiltbank, 1970; Sarder, 2001). Biologically potential for milk production depends on the age at puberty, early first calving, number of parity and shorter calving interval. However, the intensity of productive traits differs according to the genotype of breeds and between parities (Djemali and Freeman, 1987; Rahman *et al.*, 1987). Management of dairy replacement heifers is one of the most important factors affecting post-partum performances by determining body weight, and age at first calving (Simerl *et al.*, 1992; Pirlo *et al.*, 2000). Age at first calving (AFC) had also been identified as a significant factor affecting total cost of raising replacements in dairy cattle (Madani, 2008). Cows calving earlier produced more milk per day of herd life (Gardner *et al.*, 1977; Lin *et al.*, 1986; Nilforooshan and Edriss, 2004). Age at first calving may be delayed in dairy cattle by lack of accurate heat detection and timely insemination (Duguma *et al.*, 2012). A good dairy cow is expected to freshen each year and produce adequate amount of milk. This logically suggests that a cow must conceive within 90 days after parturition and should lactate for about 305 days. This leaves 8 week of dry period in which a cow can build up her body reserve for heavy drain of milk in ensuing lactation (Zaheer *et al.*, 1981). The optimal dry period length between lactation in dairy cows has been debated since the early 1800's (Dix Arnold and Becker, 1936). During this time, some English farmers believed that a 2-month dry period was optimal while others believed that a 2-week dry period was adequate. More than a century later during World War II, the 60 days dry period was adopted as the optimal dry period length for maximal milk yield and genetic progress during this time of food shortage (Knight, 1998). Since its adoption, the 60 days dry period has been maintained as the dry period length that best maintains the balance between lost milk income during the dry period and production levels achieved in the subsequent lactation. Currently, a majority of United State dairies manage for a 60 days or longer dry period (Anonymous, 2002). The dry period for years has been thought of as a time of rest that allows the mammary epithelial components to regress, proliferate, and differentiate with the ultimate goal of maximizing milk production during the subsequent lactation (Capuco *et al.,* 1997). There are many studies that have been designed to look at the impact of the dry period length on milk production (Annen *et* *al.,* 2004; Rastani *et al.,* 2005). Some other studies showed that cows with a short dry period during their second gestation produced 89.1% as much milk as cows with a 60-days dry period and that cows in their third or greater gestation produced 95.1% as much milk as cows with a 60-days dry period (Rastani and Grummer, 2006).

The service period is the interval from calving to the next conception. It has obvious economic importance because a longer service period increases the calving interval, resulting in a reduced life time production (Zafar *et al.,* 2008). The ideal service period for Zebu cattle is not apparent from the literature (Zafar *et al.,* 2008). General guidelines are available such as delaying service period until mobilization of body reserves ceases (Bourchier, 1981). As a rule of thumb a cow is preferably bred during third oestrus after calving in most dairy herds. With a lactation length of 300 days, this allows a rest of about 60-65 days prior to carrying another pregnancy. From a practical management point of view, a range of 60-90 days service period should be feasible (Zafar *et al.,* 2008). Brahmstaedt and Schonmuth (1983) suggested that service period in cattle should not be less than 40 days. Kale *et al.* (1982) showed that Red Sindhi cows conceiving after 106 days of calving had longer lactation versus those conceiving earlier.

The time interval between two calving is called the calving interval (Hinojosa *et al.,* 1980). It was generally accepted that a calving interval of 12 months or less is associated with optimal milk production in dairy cows (Wiliamson, 1981; Mackay, 1981). Although recent research indicated that optimal calving interval depends on many factors, including milk yield. Since getting pregnant reduce persistency, it is not profitable for high producing cows to get pregnant soon after calving (dev Vries, 2006). However, in the present study the indigenous cows and their crossbred are not the high milk producer and secondly the present study is an upgrading program for the nondescript indigenous cows, therefore along with increase milk yield numbers of calf is also of primary importance. Hence, a shorter calving interval is still desirable in this study. A number of studies have reported that when milk production is measured in terms of annual yield, maximum production is achieved with a calving interval of 12 months or less (Speicher and Meadows, 1967; Esslemont 1974; Britt 1974; Bar-Anan and Soller, 1979). Louca and Legates (1968) suggests that a 12 month calving interval is desirable for mature cows, while an interval of 13 months for first calf heifers maximizes their production due to their greater persistency of milk production. The length of the calving interval is effectively determined by the number of days from calving to conception, which is referred to as the open interval and which must average 85 days if a herd is to have an average calving interval of 12 months (Dohoo, 1983). The general practice in dairy herds with intensive milk production is to breed cows with the aim of establishing a CI of 12 months. This traditional breeding system, with 12 months CI, is based on the idea that the production economy benefits from an early conception (Holmann *et al.*, 1984; Strandberg and Oltenacu, 1989). In the 1960´s Speicher and Meadows (1967) reported that annual milk production was maximized with CI of 12 to 13 months and a CI of 13 months for primiparosus and of 12 months for multiparous cows was suggested by Louca and Legates (1968) for attaining maximum production. In 1969, Wood published a paper on the mathematical modeling of yield curves, and at this time the intensive concept of maximizing peak daily output and minimizing calving interval, was totally accepted. However, to achieve a 12 months CI, the insemination of the cow occurs at the peak of production. Consequently, the insemination takes place when the cows are most challenged metabolically (Harrison *et al.*, 1990). The average interval between two calving should ideally not exceed 13 to 14 months (Wiltbank 1970; Sarder 2001).

Reproductive performance in dairy cattle is of paramount importance. To maintain efficient production, it is necessary that cows reproduce regularly (Verley and Touchberry, 1961). It has been reported that lowered breeding efficiency may be associated with high production (Anonymous, 1940; Jones *et al.*, 1941; Lewis and Horwood, 1950) and contradictorily, that there is little relationship between production and breeding efficiency (Eckles, 1929; Boyd *et al.*, 1954; Carman, 1955; Touchberry *et al.*, 1959). The economic returns from dairy animals are not only based on milk production alone but also on their reproductive efficiency (Khan, 2002). Everett *et al.* (1966) reported that breeding efficiency and production were essentially interdependent. Reproductive efficiency is proposed as a measure of the net biological accomplishment of all reproductive activities and phenotypic expression of the interplay of genetic and environmental factors (McDowell, 1985). Indicators of reproductive efficiency are service period affecting in turn, the calving interval. However, the breeding efficiency in addition to accommodating the number of calving also takes care of age at first calving and total number of days from first to last lactation. Reproductive efficiency represents the overall performance of the herd with respect to age and reproductive traits (Suhail *et al.,* 2009). Heifers attaining mature body weight earlier, on the average would have smaller age at first calving and would be expected to calve more frequently than slow growing heifers (Syed *et al.,* 1994). Breeding efficiency, being a composite trait was estimated using various equations (Wilcox *et al*., 1957; Sharma *et al*., 1981). The age of dairy cows at first parturition and the lengths of her subsequent calving intervals are usually considered of primary importance in measuring breeding efficiency (Chapman and Casida, 1935). Low reproductive efficiency due either to delayed first service, missed estrus, or multiple services per conception continues to be a major problem in dairy herds. Insufficient reproductive performance results in excessively late age at first calving and long lactation. Both are costly to the dairy producers because of the veterinarian breeding expense, high reproductive replacement costs and fewer calves being born (Oudah *et al.,* 2001). Several reports have indicated that poor reproductive performance, manifested as prolonged calving intervals, can result in reduced milk yield and increased culling rates and replacement cost (Pryce, *et al.,* 2000; Kadarmideen *et al.,* 2003; Sewalem *et al.,* 2008).

1.3. Factors Influencing Productive and Reproductive Performance of Dairy Cows

The productive and reproductive traits in dairy animals are influenced by several genetic and environmental factors (Suhail *et al.,* 2010). The performance of animals depends not only on their genetic merits, but also on other factors such as nutrition, management, health, and environment. Many factors influence the reproductive performance of lactating dairy cows. Management factors such as accuracy of heat detection, use of proper inseminating techniques, proper semen handling, and appropriate herd health policies can directly influence the reproductive performance of a dairy herd. In addition other factors beyond the immediate control of management may impact fertility; these factors include milk production of the cow, age of the cow, and season of year (Hillers *et al*., 1984). A variety of environmental factors affect the onset of ovarian cycles in the postpartum period and the most important of these are suckling, milk yield, nutritional status, and season (Peters, 1984). Swensson *et al*. (1981) suggested that malnutrition, disease, milk let-down interference, weak heat symptoms, and inbreeding are factors that commonly result in very low fertility in unimproved breeds. Msangi *et al*. (2005) did a longitudinal study in Tanzania to examine factors influencing milk yield in small holder crossbred cows.

They investigated the effects of location (district), calving season, body condition score (BCS) at calving, calving year, herd size, source of labor (hired or family labor), calf-rearing method (bucket-fed or partial suckling), and parity number, and found that calving year, calf-rearing method and BCS significantly influenced the daily milk yield. Msangi *et al.* (2005) demonstrated that milk production was mainly influenced by BCS at calving, at which time the lactation milk yield increased quadratically from score 1 to 3; they concluded that BCS at calving may provide a simple single indicator of the nutritional status of a cow. In addition, Muraguri *et al.* (2004) from Kenya reported that commercial concentrate supplementary feeding of lactating small holder cows led to a significantly higher mean daily milk yield than that of non-supplemented ones throughout the year (18.6% higher annual milk off-take). With respect to effect of breed, it has been found that crossbreeding has improved the age at first calving and oestrus manifestation of crossbred cows, compared with the local ones, kept under equal and satisfactory feeding, management, and health-control regimes (Swensson *et al.*, 1981). However, a decline in both the productive and reproductive performance with increasing fractions of *Bos taurus* above the F_1 crosses was reported in medium-low-input production systems (Madalena *et al.*, 1990).

1.4. Objectives

The present study was conducted to investigate the productive and reproductive performance of nondescript indigenous cattle and their crossbred dairy cows in northern part of Azad Jammu and Kashmir. Before this no such study was carried out on crossbred cows maintained in hilly areas of AJK. One problem for crossbred animals in many environments is their inability to survive in the local environment therefore the present study has been conducted keeping in view the local need of the area. Hence the aim of present study was to access the adaptation of crossbred dairy cows in the sub tropical highland type climatic conditions of Azad Jammu and Kashmir. In this study our focal point was not to investigate the genetic makeup local cow, but we were concerned only to see the improvement in productive and reproductive performance with the aim to reduce their, age of first calving, calving interval, service period, dry period and to extend lactation length as well as 305 day milk yield and thus to get a more economic return from dairy farming.

However the specific objectives are as follows:

i) To know the productive performance using parameters such as birth weight, milk yield per lactation, 305 day milk yield, daily milk yield, lactation length, of indigenous cows and to compare them with their crossbred dairy cows.

ii) To know the reproductive performance using parameters such as sex ratio, age at first calving, service period, dry period, calving interval and breeding efficiency of indigenous cows and to compare them with their crossbred dairy cows.

iii) To find out the effect of parity on 305 day milk yield and lactation length of nondescript indigenous cows and their crossbred.

iv) To find out the effect of season and year of calving on 305 day milk yield and lactation length of nondescript indigenous cows and their crossbred.

v) To recommend farmers about the reproductive management practices for crossbred dairy cows to be applied at dairy farm.

The information generated from this study will provide a guideline for livestock farmers and other agencies who intend to improve the productivity of nondescript indigenous cattle by crossbreeding with high yielding European breeds of cattle.

MATERIALSAND METHODS

It is a retrospective study, carried out over a period from 1990–2010. The data regarding productive and reproductive records of 117 cows out of which 48 were indigenous, 32 were F_1 (Indigenous × Jersey), 19 were $F_1 \times F_1$ (F_2) and 18 were F_1 × Friesian cows. All the cows were maintained at Livestock Development Research Centre (LDRC) Muzaffarabad, Azad Jammu and Kashmir.

2.1. Brief History and Location of Farm

The LDRC was established by the Government of Azad Jammu and Kashmir in 1990. It is located at the bank of river Jhelum 6 kilometers away from the main city of Muzaffarabad which is the capital of Azad Jammu and Kashmir. The 66 indigenous heifers with mean body weight of 156.6 ± 3.25 Kg and mean age of 1589 ± 38.64 days were purchased from the different villages of district Muzaffarabad. Out of 66 indigenous cows 27 heifers were pregnant and 39 were non pregnant. Out of non pregnant heifers, 18 heifers did not conceive after repeated insemination at LDRC and were culled. Birth weights of calves from 27 pregnant heifers were recorded and then all of these indigenous calves were disposed off after weaning. The 48 (27 pregnant + 21 non pregnant) indigenous heifers were used as foundation cows for crossbreeding with exotic frozen thawed semen of Jersey by artificial insemination (AI) technique. Breeding of local cows continued from 1990 onward. First cross breeding was done by AI of indigenous cow with frozen thawed semen of Jersey on October 15, 1990. First crossbred offspring was produced on July 15, 1991. All those parameters recorded for the indigenous cows were also recorded for the crossbred cows.

2.2. Crossbreeding

In first cross F_1 offspring from crosses between indigenous and Jersey were produced. Calving of F_1 offspring occurred from July, 1991 to April, 1998. In second type of cross F_1 female were crossed with F_1 male, as a result of which $F_1 \times F_1$ (F_2) offspring were produced during the period of May, 1994 to April, 1999. In third type of cross the F_1 female were crossed with pure Friesian bull to produce 25 % indigenous + 25 % Jersey + 50 % Friesian offspring during May, 1994 to April, 1999.

All the indigenous cows were field born and the entire crossbred animals studied were farm born.

The detail of the breeding scheme used in this study is as follows:

1. Indigenous × Jersey

↓

F_1 (Indigenous 50 % + Jersey 50 %)

2. F_1 (Indigenous 50 % + Jersey 50 %) × F_1 (Indigenous 50 % + Jersey 50 %)

↓

F_2 (Indigenous 50 % + Jersey 50 %)

3. F_1 (Indigenous 50 % + Jersey 50 %) × Friesian

↓

Indigenous 25 % + Jersey 25 % + Friesian 50%

2.3. Artificial Insemination of Indigenous Heifers

The mature indigenous cows that showed the sign of heat were inseminated artificially by recto-vaginal method. The heat in cows was detected by personal observation and by teaser bull. The frozen semen of Jersey bull (Tregarden Ponsonby RR JENZL 84448) stored in liquid nitrogen at -196°C was used for artificial insemination. The artificial insemination (AI) gun was pre warmed by making it sure that the thaw bath was at 95°F. Straw of semen (0.5 ml with an average number of 20-40 million sperm per straw) was moved from the liquid nitrogen tank to the thaw bath as quickly as possible for 30 - 40 seconds at 95°F (37°C). Crimped end (opposite cotton plug) of the straw was clipped with scissors and straw was placed in a pre warmed AI gun. A sterile sheath over the gun and straw was placed. The cow to be inseminated was restrained and the insemination process was initiated by rectally palpating the cervix through the rectum and it was prepared to receive the insemination gun. A clean paper towel was used to wipe away any fecal material or mud from the external genitalia of the cow. The AI gun was placed into the vagina at a slight angle (30°) with the tip of the AI gun pointing upward to avoid the opening of the urethra. The AI gun was passed through the cervix and semen was deposited right at the tip of the cervical/uterine junction. After 60 days of insemination the pregnancy was confirmed by rectal palpation and non pregnant cows were inseminated again at the time of their estrous.

2.4. Natural Service

A young, fertile bull with good health, semen quality, libido and mating ability was used for natural service. The breeding soundness of bulls was evaluated after every six months to determine whether or not they maintain their reproductive soundness. Natural service was used in second type of crosses where F_1 female were crossed with F_1 male to obtained F_2 offspring and third type of crosses where F_1 female were crossed with pure Friesian bull to produce three breed crossbred cows. For the production of F_2 generation three Jersey crossbred bulls (farm born) were used and in third types of crosses two pure Friesian bulls (purchased from Military Farm Kheri Murat Pakistan) were used. All the 48 nondescript heifers used as foundation cows were field born and the detail of their sires was not available.

2.5. Housing Management and Feeding Practices

Housing

The cows were maintained in brick closed sheds with tail to tail system in double row. To provide the shade and protect animals from prevailing strong wind currents whether hot or cold the roofs of all the sheds are of asbestos sheets and have been constructed at a height of 12-14 feet above the floor level. The pitch of these roofs is at 12 degree to 18 degree with their horizontals. The eaves of the roofs are projected out at least 50 cm away from the walls and pillars. The roofs are supported on pillars which are built of cement mortar, and casted iron pipes. The milking cows, dry cows and young calves were kept in separate sheds. The breeding bulls were maintained in loose house having rough cement concrete floor to make comfortable housing with adequate arrangement of light and ventilation.

Cooling of Cows

During the summer months or hot climate the crossbred cows and breeding bulls were sprinkled with water to keep them cool. On days over 30°C the cows were brought into the open yard from the sheds and sprinkled with water for at least 2 hours. The simple water sprinklers system having four rows of water pipe each with five sprinklers across the yard at spacing of 4 meter and each row about 6 meter apart were used. The heights of sprinklers above cows were 3 meter at side of yard and 2.8 meter in the middle. The sprinklers were used to cool hot cows, with enough water to thoroughly soak the cows. The sprinklers created droplets that wet the cow's hair coat to the skin. The cows were brought back into the sheds where the fans were then used to force air over the cow's body causing evaporative cooling to take place on the skin and hair coat. Heat from the cow's body caused the moisture to evaporate.

Feeding Regime

All the animals were stall fed on farm raised green fodder and concentrates with adequate supply of fresh, clean and soft drinking water under the same managemental and environmental conditions. The ration was formulated to provide the recommended quantity of nutrients according to body weight and status of animals as given in Table 1. The composition of the feed varied according to the fodder crop available during the year. Elephant grass and maize were mainly fed during the months of May to October and from November to April green berseem and wheat straw were fed to these animals. Green fodder was chaffed and offered to these animals. Roughages comprised of wheat straw and stoves of maize. The concentrate mixture composed of wheat bran, oil seed cake (rape seed cake and cotton seed cake) and molasses. Lumps of common salts (sodium chloride) were placed in manger and cows were free to lick. The cows were milked manually twice a day at 5 a.m.in the morning and 5 p.m. in the evening.

As a general practice the calves were separated from mother after birth and milk was fed to calf by nipple bottle.

Table 2: Daily nutrient fed to cows per 500 kg body weight and according to their productive and reproductive status maintained at LDRC

Status	Total Dry Matter (Kg)	Type of Nutrients (Kg)			
		TDN	CP	Ca	P
Early Lactation	11.91	7.05	1.25	0.04	0.02
Lactating and Pregnant	11.41	6.27	0.99	0.03	0.02
Dry Non Pregnant	8.41	4.23	0.60	0.02	0.01
Pre Calving (60-90 days before calving)	10.32	5.59	0.88	0.03	0.02

DM = Dry Matter; TDN = Total Digestible Nutrient; CP = Crude Protein;
Ca = Calcium; P = Phosphorous; Kg = Kilogram.

2.6. Disease Management

Disease control was mainly prophylactic via the control of ecto- and endo-parasites after every three months interval. However, specific treatment was given whenever any disease occurrence was reported. Routine vaccinations were carried out for diseases such as Hemorrhagic Septicemia (HS) and Black Quarter (BQ) according to the schedule given in Table 3. All the vaccines were purchased from Veterinary Research Institute (VRI) Lahore, Pakistan.

Table 3: Vaccination schedule for the animals maintained at LDRC

Name of Disease	Name of Vaccine	Dose	Route	Month of Vaccination
Hemorrhagic Septicemia (HS)	HS Vaccine	5ml/270 Kg body weight	Subcutaneous injection	Twice in a year i)June ii)December
Black Quarter (BQ)	BQ Vaccine	3 ml/ 270 Kg body weight	Subcutaneous injection	Once in a year -April

2.7. Data Extraction and Analysis

Data for this study were obtained from the cows registers maintained at LDRC Muzaffarabad. Each record contained the following information: Animal's identification, date of birth, date of service, date of calving, date of drying, calf's birth weight, daily milk yield, monthly milk yield, lactation milk yield, and lactation length, date of culling or disposal and death of animals, parity, sire and dam number. Season effect was categorized into four seasons viz. Spring (Feb - Apr), Summer

(May - July), Autumn (Aug - Oct), Winter (Nov – Jan). Performance of indigenous cows was studied from September 1991-November, 99, performance of F_1 (indigenous × Jersey) was studied from July, 1991 – December, 2008, performance of F2 (F1×F1) was studied from May, 1994 – April 2008 and performance of F_1×Friesian cows was studied from February, 2000 – December 2010. Cows with abnormal and incomplete lactations records due to abortions, sickness were excluded from the present study.

2.8. Productive Traits

Following traits were studied in the present work.

Birth Weight of Male and Female Calves

Birth weights of the calves were taken within 12 hours after parturition using a stationary weighing bridge and recorded in kilograms.

Milk Yield

Milk yield per lactation

Milk produced during a given lactation length which terminated normally was considered as milk yield per lactation. The lactation affected by occurrence of any disease or resulting from premature death of calf were excluded from the study. The lactation of 56 days and longer duration were included in the analysis.

305 day milk yield

The equation developed by Khan (1997) was used to standardize the incomplete lactation on 305 day basis. The equation is given below.

$\hat{Y}305 = Yt + [\alpha+\beta Xi]\ (305-DIM)$

Where,

$\hat{Y}305$ = Predicted 305-day lactation milk yield

Yt = Known milk yield or milk yield available to date (up to the last test day)

α = Intercept for any lactation stage

β = Regression coefficient for any lactation stage

Xi = Milk yield (lit) on the last test day

DIM = Days in milk

Daily milk yield

Daily milk yield was calculated by dividing total milk yield per lactation by number of days a cow in milk during that lactation.

Lactation Length

Lactation length is the period (days) during which a cow remained in milk following calving. Lactation length was calculated as the difference between the date of calving and the date of drying normally in a given lactation.

2.9. Reproductive Traits

Sex Ratio

All the records of normal calving were recorded. Sex ratio was calculated as proportion of males against 100 female (100♀♀: −♂♂). Chi-square test was applied to test the significance of difference between male and female calf's numbers.

Age at First Calving

Age at first calving (AFC) of cows was calculated by the interval between the date of birth and the date of calving of a heifer following pregnancy of full term. AFC of indigenous cows that were purchased from the villages of district Muzaffarabad was calculated on the basis of their spoken date of birth interviewed by farmers at the time of their purchase.

Dry Period

Dry period of each cow was calculated by the difference between the date of drying and the date of subsequent normal calving.

Service Period

Service period of each cow was calculated by the difference between the date of calving and the date of subsequent fertile conception.

Calving Interval

Calving interval was calculated by the interval between the dates of two successive calving.

Breeding Efficiency

The breeding efficiency of each cow was calculated by using the following formula suggested by Wilcox *et al.* (1957).

$$\text{Breeding Efficiency (\%)} = \frac{365 \times (N-1)}{D} \times 100$$

Where N= Total number of parturition, D= Number of days from first to last parturition.

3.0. Statistical Analysis

Descriptive analysis was carried out to observe differences in mean of different variables. Student's t-test was applied for the comparison of means between two values and more than two values were compared by ANOVA. The effect of breed group and breeding method on calf sex ratio was analyzed by chi square test. Effect of parity and year of calving on 305 day milk yield and lactation length was calculated by applying regression analysis of variance. Graph Pad Prism 5 package was used for different statistical analysis.

RESULTS

Data regarding productive and reproductive traits was recorded for present study from Livestock Development Research Centre (LDRC) Muzaffarabad, Azad Jammu and Kashmir. This study is based on milk production records of 117 cows including 48 indigenous, 32 indigenous × Jersey (F_1), 19 F_1 × F_1 (F_2) and 18 F_1 × Friesian. Productive traits include birth weights of male and female calves, milk yield per lactation, 305 day milk yield, daily milk yield, and lactation length. Reproductive traits include sex ratio, age at first calving (AFC), dry period (DP), service period (SP), calving interval (CI) and breeding efficiency (BE).

3.1. Productive Traits

Measures of productive performance including birth weight of calf, milk yield (milk yield per lactation, 305 day milk yield and daily milk yield) and lactation length were analyzed in the present study.

Birth Weight of Calves

Mean birth weight of male and female calves in indigenous and crossbred cows is given in Table 4. Mean birth weight of male calves in indigenous cows was the lowest (14.36 ± 0.53 Kg) and the highest (22.85 ± 1.75 Kg) mean birth weight of male calves was observed in F_1 × Friesian. Similarly the mean birth weight of female calves in indigenous cows was the lowest (13.33 ± 0.49 Kg) and the highest (24.83 ± 1.10 Kg) mean birth weight of female calves was observed in F_1 × Friesian cross.

The result of two-way analysis of variance as (Table 5) indicated that the birth weight of calves was significantly ($P < 0.05$) affected by breed group whereas sex of the calves did not significantly ($P > 0.05$) affected the birth weight of calves in indigenous and crossbred calves.

The sire effect was also studied on birth weight of calves from F_2 and F_1 × Friesian crossbred cows. The result of two-way analysis of variance (Table 6) indicated that sire did not affect ($P > 0.05$) the birth weight of calves within F_2 crossbred calves in both male and female. The sire effect within F_1 × Friesian cows was analyzed by t-test between the two groups. Statistical analysis showed that birth weight of male calves from sire 1 and sire 2 did not differ significantly ($t_{(18)} = 2.027$; $P = 0.0578$). Similarly no significantly difference of birth weight was observed between female calves from sire 1 compare to sire 2 ($t_{(22)} = 0.5551$; $P = 0.5844$).

Table 4: Mean birth weight of male and female calves from indigenous and crossbred cows

Breed Groups		Birth Weight (Kg)	
		Male	**Female**
Indigenous		14.36 ± 0.53 (14)	13.33 ± 0.49 (12)
Indigenous × Jersey (F_1)		16.65 ± 0.28 (48)	15.85 ± 0.28 (49)
F_1 × F_1 (F_2)	Sire 1	21.70 ± 3.11 (10)	19.75 ± 2.25 (4)
	Sire 2	20.78 ± 1.34 (9)	19.69 ± 1.00 (13)
	Sire 3	23.80 ± 2.65 (5)	17.00 ± 2.27 (4)
	Overall	21.79 ± 1.45 (24)	19.19 ± 0.84 (21)
F_1 × Friesian	Sire 1	20.17 ± 1.120 12)	25.36 ± 1.413 (14)
	Sire 2	26.88 ± 3.734 (8)	24.10 ± 1.810 (10)
	Overall	22.85 ± $1.75^{ab***c**}$(20)	24.83 ± $1.10^{a***bc***}$(24)

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05^*$, $P \leq 0.01^{**}$, $P \leq 0.001^{***}$
Values in parenthesis ( ) = Number of calves

Table 5: Two-way ANOVA showing the effect of breed group on birth weight of male and female calves in indigenous and crossbred dairy calves

Source of Variation	Df	SS	MS	F	P value
Interaction	3	84.93	28.31	2.162	0.0938
Breed Group	3	2262	754.1	57.59	<0.0001
Sex	1	7.189	7.189	0.5490	0.4596
Residual	199	2606	13.10		

Table 6: Two-way ANOVA showing the sire effect on birth weight of male and female calves within F_1 crossbred calves

Source of Variation	Df	SS	MS	F	P value
Interaction	2	57.55	28.78	0.7910	0.4605
Sire	2	1.510	0.7549	0.02075	0.9795
Sex	1	98.00	98.00	2.694	0.1088
Residual	39	1419	36.38		

Milk Yield of Indigenous and Crossbred Dairy Cows

Milk yield is the most important trait of economic importance in dairy. Daily milk yield of indigenous and crossbred dairy cows was recorded. The following milk yield features were analyzed in detail.

Milk yield per lactation

Mean milk yield per lactation of indigenous and crossbred dairy cows is given in Table 7. The trait varied widely among different genetic groups. The productive performance of different groups of cows showed that the mean milk yield per lactation of indigenous cows was the lowest (286.0 ± 11.29 liters) and the highest (1411 ± 92.88 liters) mean milk yield per lactation was observed in F_1 × Friesian cows. Analysis of variance (Table 8) indicated that the mean milk yield per lactation increased highly significantly in F_1 ($P < 0.001$), F_2 ($P < 0.001$) and F_1 × Friesian ($P < 0.001$) cows compared to that of indigenous cows. Mean milk yield per lactation in F_1 hybrid cows was significantly higher compared to that of F_2 ($P < 0.05$) cows. Similarly mean milk yield per lactation in F_1 × Friesian cows was significantly higher compared to F_1 ($P < 0.05$) and F_2 ($P < 0.001$) cows.

Sire effect on mean milk yield per lactation within crossbred cows is given in Table 7. The present study revealed that within F_2 crossbred cows the mean highest milk yield per lactation was found for the daughters of sire 3 followed by the daughters of sire 2 and the lowest mean milk yield per lactation was observed for daughters of sire 1. One-way analysis of variance (Table 9) indicated that daughters of sire 3 produced significantly ($P < 0.05$) higher milk yield per lactation compared to the daughters of sire 1, however no significant difference was observed in milk yield per lactation among the daughters of sire 1 versus sire 2 and sire 2 versus sire 3.

No variations of milk yield per lactation within F_1 × Friesian crossbred cows were observed. The difference of milk yields per lactation between the two groups of F_1 × Friesian crossbred cows was analyzed by t-test. Mean milk yield per lactation from daughters of sire 1 did not differ significantly ($t_{(50)} = 0.3363$; $P = 0.7380$) from that of daughters of sire 2.

305 day milk yield

305 day milk yield the most commonly standard that is being used for the comparison of dairy production records showed variations among the different breed groups. Mean 305 day milk yield in indigenous and crossbred cows is given in Table 10. The lowest mean 305 day milk yield (561.0 ± 12.32 liters) was observed in indigenous cows and the highest (1674.0 ± 47.58 liters) was recorded in F_1 hybrid cows. Analysis of variance (Table 11) was applied which showed the mean 305 day milk yield increased highly significantly in F_1 ($P < 0.001$), F_2 ($P < 0.001$) and F_1 × Friesian ($P < 0.001$) cows compared to that of indigenous cows. Mean 305 day milk yield of F_1 hybrid cows was significantly higher compared to F_2 ($P < 0.001$) and F_1 × Friesian cows. However, no significant difference was observed in mean 305 day milk yield from F_2 and F_1 × Friesian cows ($P > 0.05$).

The sire effect on 305 day milk yield within F_2 and F_1 × Friesian crossbred cows is given in Table 10. In this study the highest 305 day milk yield was found for the daughters of sire 3 and the lowest was observed for the daughters of sire 1.

One-way analysis of variance (Table 12) indicated that daughters of sire 2 and sire 3 produced significantly ($P < 0.05$) higher milk yield per lactation compared to the daughters of sire 3, however no significant difference was observed in 305 day milk yield per lactation of the daughters of sire 2 compared to the daughters of sire 3.

No variations of 305 day milk yield were observed between daughters of sire 1 and sire 2 within F_1 × Friesian crossbred cows. The statistical analysis showed that the mean 305 day milk yield between two groups did not differ significantly ($t_{(50)} = 0.1897$; $P = 0.8503$).

Mean daily milk yield

Mean daily milk yield of indigenous and crossbred cows is given in Table 13. Mean daily milk yield of indigenous cows was the lowest (1.62 ± 0.03 liters) and the highest (5.08 ± 0.13 liters) was observed in F_1 hybrid cows. Statistical analysis of mean milk yield among different breed group was performed by analysis of variance (Table 14). Mean daily milk yield increased highly significantly in F_1 ($P < 0.001$), F_2 ($P < 0.001$) and F_1 × Friesian ($P < 0.001$) cows compared to that of indigenous cows. Mean daily milk yield of F_1 hybrid cows was significantly higher compared to F_2 ($P < 0.01$) and

F_1 × Friesian ($P < 0.0001$) cows. Mean daily milk yield of F_2 and F_1 × Friesian cows did not differ ($P > 0.05$).

Within F_2 crossbred cows the lowest mean daily milk yield was observed in daughters of sire 1 and the highest was found for daughters of sire 3. Although analysis of variance (Table 15) showed that significant ($P < 0.05$) difference of mean daily milk yield was observed in daughters of sire 1 compared to the daughters of sire 2 and sire 3. However, no significantly difference of mean daily milk yield was observed between daughters of sire 2 and sire 3.

Sire differences were no observed within F_1 × Friesian crossbred cows. The statistical analysis showed that the mean 305 day milk yield between two groups did not differ significantly ($t_{(50)} = 0.1283$; $P = 0.8984$).

Lactation Length

Mean lactation length of indigenous and crossbred dairy cattle is given in Table 16. Lactation length in different breeds groups varied significantly. Similar to milk yield per lactation, 305 day milk yield and mean daily milk yield, lactation length increased significantly in crossbred cows compared to nondescript indigenous cows. The shortest lactation was observed in nondescript indigenous cows (174.90 ± 5.92 days) and the longest lactation length (354.50 ± 16.70 days) was recorded for F_1 × Friesian cows. Analysis of variance indicated (Table 17) that the mean lactation length increased highly significantly in F_1 ($P < 0.001$), F_2 ($P < 0.001$) and F_1 × Friesian ($P < 0.001$) cows compared to that of indigenous cows. No significant difference was observed between mean lactation length of F_1 hybrid and F_2 hybrid cows ($P > 0.05$) while mean lactation length in F_1 × Friesian cows increased highly significantly compared to F_1 ($P < 0.001$) and F_2 hybrid ($P < 0.001$) cows.

The study of sire effect within F_2 crossbred cows indicated that there were no variations of lactation length among daughters of different sires. Analysis of variance (Table 18) indicated that the difference among different groups did not differ significantly ($P < 0.05$). Similarly the lactation length was not affected by sire within F_1 × Friesian crossbred cows $t_{(50)} = 0.2595$; $P = 0.7963$).

Table 7: Mean milk yield (liters) per lactation from indigenous and crossbred dairy cows

Breed Groups		Number of Cows	Milk yield per lactation	Range
Indigenous		48	286.0 ± 11.29 (149)	90.0 – 792.5
Indigenous × Jersey (F_1)		32	1228.0 ± 39.98^{a***} (151)	246.3 – 2784
$F_1 \times F_1$ (F_2)	Sire 1	09	694.2 ± 105.4 (14)	171.3 – 1491
	Sire 2	08	1085 ± 102.2 (21)	261.3 – 1791
	Sire 3	02	1346 ± 199.3 (9)	119.8 – 2416
	Overall	19	1014.0 ± 78.90^{a***b*}(44)	119.8 – 2416
F_1 × Friesian	Sire 1	11	1439 ± 129.6 (29)	346.5 – 3077
	Sire 2	07	1375 ± 134.8 (23)	375.5 – 2891
	Overall	18	1411.0 ± 92.88^{a***b*c**}(52)	346.5 – 3070

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of lactations

Table 8: One-way ANOVA showing the effect of breed group on milk yield per lactation from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	86300000	3	28770000	153.1	<0.0001
Within Breed Group	73670000	392	187900		
Total	160000000	395			

Table 9: One-way ANOVA showing the sire effect on milk yield per lactation within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	2527000	2	1263000	5.589	0.4201
Within Sire	9269000	41	226100		
Total	11800000	43			

Table 10: Mean 305 day milk yield (liters) from indigenous and crossbred dairy cows

Breed Groups		Number of Cows	305-Day Milk Yield	Range
Indigenous		48	561.0±12.32 (149)	155 –1340
Indigenous × Jersey (F_1)		32	1674.0±47.58[a***] (151)	615 – 3679
$F_1 \times F_1$ (F_2)	Sire 1	09	971.7±95.23 (14)	468 – 1556
	Sire 2	08	1409 ± 99.59 (21)	498 – 2215
	Sire 3	02	1530 ±193.6 (9)	510 – 2671
	Overall	19	1295.0±75.36[a***b***] (44)	468 – 2671
F_1 × Friesian	Sire 1	11	1366 ± 79.71 (29)	600 – 2170
	Sire 2	07	1342 ± 94.13 (23)	610 – 2447
	Overall	18	1355.0 ± 60.32 [a***b***] (52)	600 – 2447

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of lactations

Table 11: One-way ANOVA showing the effect of breed group on 305 day milk yield from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	96080000	3	32030000		P<0.0001
Within Breed Group	75020000	392	191400		167.4
Total	171100000	395			

Table 12: One-way ANOVA showing the sire effect on 305 day milk yield within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	2232000	2	1116000	5.375	0.0085
Within Sire	8514000	41	207700		
Total	10750000	43			

Table 13: Mean daily milk yield (liters) from indigenous and crossbred dairy cows

Breed Groups		Number of Cows	Daily average Milk Yield	Range
Indigenous		48	1.62±0.03 (149)	0.44 – 3.36
Indigenous × Jersey (F_1)		32	$5.08 \pm 0.14^{a***}$ (151)	1.96 – 9.88
$F_1 \times F_1$ (F_2)	Sire 1	09	3.10±0.29 (14)	1.60 – 5.00
	Sire 2	08	4.72±0.30 (21)	2.00 – 7.54
	Sire 3	02	4.88±0.68 (9)	1.00 – 8.60
	Overall	19	$4.24 \pm 0.25^{a***b**}$ (44)	1.00 – 8.60
F_1 × Friesian	Sire 1	11	4.117 ± 0.2866 (29)	1.58 – 8.25
	Sire 2	07	4.061 ± 0.3230 (23)	0.95 – 8.0
	Overall	18	$4.09 \pm 0.21^{a***b**}$ (52)	0.95 – 8.25

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of lactation

Table 14: One-way ANOVA showing the effect of breed group on daily average milk yield from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	944.6	3	314.9	179.0	P<0.0001
Within Breed Group	689.7	392	1.759		
Total	1634	395			

Table 15: One-way ANOVA showing the sire effect on 305 day milk yield within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	26.76	2	13.38	6.207	0.0044
Within Sire	88.40	41	2.156		
Total	115.2	43			

Table 16: Mean lactation length (days) of indigenous and crossbred dairy cows

Breed Groups		Number of Cows	Lactation Length	Range
Indigenous		48	174.90±5.92 (149)	77 – 556
Indigenous × Jersey (F_1)		32	244.10±5.83[a***](151)	56 – 472
$F_1 \times F_1$ (F_2)	Sire 1	09	222.6 ± 22.49 (14)	70 – 357
	Sire 2	08	222 ± 13.07 (21)	92 – 336
	Sire 3	02	264.4±20.57 (9)	120 – 319
	Overall	19	230.90±10.46[a***](44)	70 – 357
F_1 × Friesian	Sire 1	11	349.6 ± 23.30 (23)	147 – 507
	Sire 2	07	358.4 ± 23.89 (29)	89 – 602
	Overall	18	354.50±16.70[abc***](52)	89 – 602

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of lactations

Table 17: One-way ANOVA showing the effect of breed group on lactation length from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	1288000	3	429300	67.61	P<0.0001
Within Breed Group	2489000	392	6350		
Total	3777000	395			

Table 18: One-way ANOVA showing the sire effect on lactation length within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	12760	2	6381	1.347	0.2713
Within Sire	194300	41	4738		
Total	207000	43			

3.2. Reproductive Traits

In the present study six measures of reproductive performance were studied which included sex ratio, age at first calving, dry period, service period, calving interval and breeding efficiency.

Sex Ratio

Effect of breed group on calf sex ratio

The number of male, female calves and their sex ratio in indigenous and crossbred dairy cows is given in Table 19. A total of 259 (118 females, 141 males) births were studied, of which 27 (12 females, 15 males) were from indigenous, 123 (56 females, 67 males) from Indigenous × Jersey (F_1), 54 (26 females, 28 males) from $F_1 \times F_1$ (F_2) and 55 (24 females, 31 males) from F_1 × Friesian cows. Sex ratio of calves from indigenous, F_1, F_2 and F_1 × Friesian cows was 100♀♀:125♂♂, 100♀♀:120♂♂, 100♀♀:108♂♂ and 100♀♀:129♂♂ respectively. Chi-square test showed that male and female births were not significantly ($P > 0.050$) different from each other in all the breeds groups.

Effect of artificial insemination and natural service on calf sex ratio

Sex ratio of calves from artificially inseminated cows and calves obtained as a result of natural service (NS) from crossbred cows is given in Table 20. In artificially inseminated cows 123 births were recorded, of which 56 were females and 67 were males (100♀♀:125♂♂). Crossbred cows through natural service gave birth to 109 calves, of these 50 were females 59 were males (100♀♀:118♂♂). However, the difference between male and female births was not statistically different from zero ($P > 0.05$) in both artificially insemination and natural service.

Table 19: Number of female, male calves and their sex ratio in indigenous and crossbred dairy cows

Breed Groups	Number of Births	Female	Male	Sex Ratio	$X^2_{(1)}$	P
Indigenous	27	12	15	100♀♀:125.00♂♂	0.340	> 0.5
Indigenous × Jersey (F_1)	123	56	67	100♀♀:119.64♂♂	1.019	> 0.2
F_1 × F_1 (F_2)	54	26	28	100♀♀:107.69♂♂	0.074	> 0.5
F_1 × Friesian	55	24	31	100♀♀:129.17♂♂	0.445	> 0.5
Total	259	118	141			

Table 20 Number of female, male calves and their sex ratio in crossbred cows both, inseminated artificially and with natural service

Breeding Method	No. of births	Female	Male	Sex Ratio	$X^2_{(1)}$	P
Artificial Insemination	123	56	67	100♀♀:119.64♂♂	1.019	> 0.2
Natural Service	109	50	59	100♀♀:118.00♂♂	0.7431	> 0.2
Total	232	106	126			

Age at First Calving (AFC)

Mean age at first calving of indigenous and crossbred dairy cows is given in Table 21. Mean age at first calving was highest in nondescript indigenous cows (1861 ± 42.45 days) followed by F_1 × Friesian (1086 ±37.89) while lowest was found in F_1 and F_2 hybrid cows where it was 951.2±37.35 and 1086 ±37.89 days respectively. Analysis of variance (Table 22) showed that the mean age at first calving decreased highly significantly in F_1 ($P < 0.001$); F_2 ($P > 0.001$) and F_1 × Friesian ($P < 0.001$) cows compared to that of nondescript indigenous cows. Mean age at first calving of F_1 hybrid cows did not differ significantly ($P > 0.05$) compared to F_2 and F_1 × Friesian cows. Similarly the mean AFC of F_2 and F_1 × Friesian did not differ significantly ($P > 0.05$) from each other.

No sire effect was found on age at first calving within F_2 crossbred. Analysis of variance (Table 23) indicated that there were no variations of age at first calving among daughters of sire 1 sire 2 and sire 3 and the differences did not differ significantly ($P < 0.05$). Similar to F_1 crossbred cows age at first calving was not affected by sire within F_1 × Friesian crossbred cows $t_{(15)} = 0.3025$; $P = 0.7664$).

Dry Period (DP)

Mean dry period of indigenous and crossbred dairy cows is given in Table 24. Although, the dry period values in this study were too long in nondescript indigenous and crossbred cows compared to the ideal dry period in dairy cattle. However, crossbreeding of indigenous cows with exotic breeds decreased the dry period in crossbred cows. Mean dry period from F_1 × Friesian cows was shortest (99.76 ± 6.67 days) and the longest (239.5 ± 7.874 days) was recorded in indigenous cows. Analysis of variance showed (Table 25) that the mean dry period decreased highly significant in F_1 hybrid ($P < 0.001$); F_2 hybrid ($P < 0.001$) and F_1 × Friesian ($P < 0.001$) cows compared to that of indigenous cows.

There was no significant difference of mean dry period in F_1 cows compared to F_2 ($P > 0.05$) and F_1 × Friesian ($P > 0.05$) cows. Similarly dry period of F_2 and F_1 × Friesian cows did not differ significantly from each other ($P > 0.05$). One-way analysis of variance (Table 26) indicated that within F_2 the dry period found in daughters of sire 1, sire 2 and sire 3 did not differ significantly ($P > 0.05$).

No variations of dry period were observed between daughters of sire 1 and sire 2 within F_1 × Friesian crossbred cows. The statistical analysis showed that the values of dry periods did not differ significantly ($t_{(32)} = 0.4888$; $P = 0.6283$) between two sire groups.

Service Period (SP)

Mean service period of indigenous and crossbred dairy cows is given in Table (27). Analysis of variance (Table 28) indicated that the genetic group had a significant effect of service period. Mean service period of F_1 × Friesian cows was highest (266.7 ± 16.56 days) and the lowest (81.81 ± 11.19 days) mean service period was observed in $F_1 \times F_1$ (F_2) cows. Crossbreeding of indigenous cows with Jersey decreased the service period highly significantly in F_1 ($P < 0.001$) and F_2 ($P < 0.001$) hybrid cows compared to that of indigenous cows and service period of F_1 and F_2 did not differ significantly ($P > 0.05$) from each other. The mean service period of hybrid F_2 cows decreased significantly compared to that of F_1 × Friesian cows ($P < 0.001$). Crossing of F_1 female with Friesian bull increased the service period in F_1 × Friesian cows but it was significantly ($P > 0.05$) shorter than that of service period found in the non indigenous cows.

Sire had a significant effect on service period within F_2 crossbred cows (ANOVA Table 29). The daughters of sire 1 were found to have the longest service period (129.8±29.72 days) followed by daughters of sire 3 (93.14±16.31 days) and the shortest service period was observed in the daughters of sire 2 (59.0±13.43 days). The service period of the daughters of sire 1 was significantly ($P < 0.05$) longer compared to the daughters of sire 2 but not significantly ($P > 0.05$) longer compared to the daughters of sire 3. Similarly no significant ($P > 0.05$) difference was observed in service period of daughters of sire 2 and sire 3.

Sir did not have a significant effect on service period between daughters of sire 1 and sire 2 within F_1 × Friesian crossbred cows. The statistical analysis showed that the values of service periods did not differ significantly ($t_{(32)} = 1.167$; $P = 0.2518$) between two sire groups

Calving Interval (CI)

Mean calving interval of indigenous and crossbred dairy cows is given in Table 30. Mean calving interval of indigenous cows was longest (518.6 ± 9.543 days) and the shortest (359.8 ± 11.68 days) was observed in F_2 cows. Analysis of variance (Table 31) indicated that the crossbreeding of indigenous cows with Jersey decreased the calving interval highly significantly in F_1 ($P < 0.001$) and F_2 hybrid cows ($P < 0.001$) compared to that of indigenous cows. The mean calving interval of indigenous and F_1 × Friesian cows did not differ significantly ($P > 0.05$). Similarly the mean calving interval of F_1 hybrid did not differ significantly ($P > 0.05$) compared to F_2 hybrid cows. When F_1 hybrid cows were crossed with Friesian bull, then in F_1 × Friesian cows the calving interval increased significantly compared to that of F_1 ($P < 0.001$) and F_2 ($P < 0.001$) crossbred cows.

Sire did not have a significant ($P > 0.05$) effect on calving interval among daughters of different sires within F_2 crossbred cows (ANOVA Table 32). Similar to service period sire did not have a significant effect on calving interval between daughters of sire 1 and sire 2 within F_1 × Friesian crossbred cows. The statistical analysis showed that the values of service periods did not differ significantly ($t_{(32)} = 1.803$; $P = 0.0809$) between two sire groups

Breeding Efficiency (BE)

Mean breeding efficiency of indigenous and crossbred dairy cow is given in Table 33. Analysis of variance showed (Table 34) that the mean breeding efficiency increased significantly in F_1 ($P < 0.001$) and F_2 ($t_{(43)} = 3.635$; $P < 0.001$) hybrid cows compared to that of indigenous cows. Similarly crossing of F_1 females with Friesian bull decreased the breeding efficiency highly significantly in F_1 × Friesian cows compared to that of F_1 ($P < 0.001$) and F_2 ($P < 0.001$) hybrid cows. Mean breeding efficiency of F_1 and F_2 cows did not differ significantly from each other ($P > 0.05$). Statistically no significant difference of mean breeding efficiency was observed in F_1 × Friesian and indigenous cows ($P > 0.05$).

Table 21: Mean age (days) at first calving of indigenous and crossbred dairy cows

Breed Groups		Age at First Calving	Range
Indigenous		1861±42.45 (48)	1080 – 2543
Indigenous × Jersey (F_1)		951.2±37.35^{a***} (32)	712 – 1249
$F_1 \times F_1$ (F_2)	Sire 1	1024±69.38 (9)	736 – 1383
	Sire 2	1130±26.58 (8)	1073 – 1277
	Sire 3	1192±126 (2)	1066 – 1318
	Overall	1086 ±37.89^{a***} (19)	736 – 1383
F_1 × Friesian	Sire 1	965.2 ± 38.39 (11)	789 – 1137
	Sire 2	946.2 ± 47.61 (6)	798 – 1108
	Overall	952.1±28.23^{a***}(18)	789 – 1137

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of cows

Table 22: One-way ANOVA showing the effect of breed group on lactation length from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	21800000	3	7265000	132.8	P<0.0001
Within Breed Group	6184000	113	54730		
Total	27980000	116			

Table 23: One-way ANOVA showing the sire effect on lactation length within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	72980	2	36490	1.397	0.2759
Within Sire	417900	16	26120		
Total	490900	18			

Table 24: Mean dry period (days) of indigenous and crossbred cows

Breed Groups		Dry Periods	Range
Indigenous		239.5±7.87(102)	60 – 382
Indigenous × Jersey (F_1)		110.2±4.78^{a***} (121)	30 – 127
$F_1 \times F_1$ (F_2)	Sire 1	132.4±24.23 (5)	92 – 226
	Sire 2	84.71±9.22 (14)	31 – 164
	Sire 3	125.3±28.90 (7)	53 – 275
	Overall	104.8 ±10.72^{a***}(26)	31 – 275
F_1 × Friesian	Sire 1	106.4 ± 13.87 (18)	24 – 210
	Sire 2	97.50 ± 11.53 (16)	27– 220
	Overall	102.2±9.02^{a***} (34)	24 – 220

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of dry period

Table 25: One-way ANOVA showing the effect of breed group on dry period from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	1131000	3	377100	92.64	P<0.0001
Within Breed Group	1136000	279	4071		
Total	2267000	282			

Table 26: One-way ANOVA showing the sire effect on dry period within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	12390	2	6197	2.289	0.1240
Within Sire	62270	23	2707		
Total	74660	25			

Table 27: Mean service period (days) of indigenous and crossbred dairy cows

Breed Groups		Service Periods	Range
Indigenous		256.0±8.6 (102)	90 – 500
Indigenous × Jersey (F_1)		$92.60 \pm 5.04^{a***}$ (121)	40 – 306
$F_1 \times F_1$ (F_2)	Sire 1	129.8±29.72 (5)	53 – 207
	Sire 2	59.0±13.43 (14)	29 – 218
	Sire 3	93.14±16.31 (7)	39 – 160
	Overall	$81.81 \pm 11.19^{a***}$ (26)	42 – 218
F_1 × Friesian	Sire 1	284.8 ± 26.49 (18)	114 – 430
	Sire 2	246.3 ± 18.31 (16)	126 – 378
	Overall	$266.7 \pm 16.56^{bc***}$ (34)	114 – 430

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of service periods

Table 28: One-way ANOVA showing the effect of breed group on service period from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	1999000	3	666300	8190	P<0.0001
Within Breed Group	22700	279	81.36		
Total	2022000	282			

Table 29: One-way ANOVA showing the sire effect on service period within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	19700	2	9849	3.674	0.0412
Within Sire	61660	23	2681		
Total	81360	25			

Table 30: Mean calving interval (days) of indigenous and crossbred dairy cows

Breed Groups		Calving Interval	Range
Indigenous		518.6±9.54 (102)	360 – 736
Indigenous × Jersey (F_1)		368.8±5.32^{a***}(121)	320 – 596
F_1 × F_1 (F_2)	Sire 1	408.2±30.59 (5)	335 – 490
	Sire 2	336.6±13.85 (14)	301 – 498
	Sire 3	371.7±18.73 (7)	304 – 450
	Overall	359.8±11.68^{a***}(26)	301 – 498
F_1 × Friesian	Sire 1	577.7 ± 32.23 (18)	351 – 763
	Sire 2	499.4 ± 28.34 (16)	385 – 651
	Overall	540.9±22.39^{bc***} (34)	351 – 763

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of calving interval

Table 31: One-way ANOVA showing the effect of breed group on calving interval from indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	1755000	3	585000	81.62	P<0.0001
Within Breed Group	2000000	279	7167		
Total	3755000	282			

Table 32: One-way ANOVA showing the sire effect on calving interval within F_2 crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Sire	20260	2	10130	3.409	0.0505
Within Sire	68360	23	2972		
Total	88620	25			

Table 33: Mean breeding efficiency (%) of indigenous and crossbred cows

Breed Groups	Breeding Efficiency	Range
Indigenous	73.46±2.50 (37)	42.54 – 97.72
Indigenous × Jersey (F_1)	93.68±1.85[a***]	65.30 – 99.55
	(25)	
F_1 × F_1 (F_2)	93.71±2.74[a***]	78.49 – 99.55
	(8)	
F_1 × Friesian	65.62±3.05[bc***]	51.41 –88.72
	(14)	

Mean ± SE
a = Indigenous vs F_1, F_2 & F_1 × Friesian
b = F_1 vs F_2 and F_1 × Friesian
c = F_2 vs F_1 × Friesian
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of cows

Table 34: One-way ANOVA showing the effect of breed group on breeding efficiency of indigenous and crossbred dairy cows

Source of Variation	SS	Df	MS	F	P value
Between Breed Group	10660	3	3553	22.75	P<0.0001
Within Breed Group	12490	80	156.1		
Total	23150	83			

3.3. Effect of Parity, Season and Year of Calving on 305 Day Milk Yield in Indigenous and Crossbred Dairy Cows

In the present research work the effect of parity and season of calving was studied on 305 day milk yield of indigenous and crossbred cows.

Parity (Lactation Number)

In relation to parity 305 day milk yield of indigenous and crossbred dairy cows is given in Table 35. The 305 day milk yield varied in indigenous and crossbred cows in relation to parity. In indigenous cow milk yield data were available only for seven parities. Milk yield data for ten parities was available in F_1 hybrid cows. In $F_1 \times F_1$ (F_2) and F_1 × Friesian cow's milk yield data was available only for five parities. A valid comparison of effect of parity on standard 305 day milk yield in these four groups of cows could not be made. However, since in all the four cows group data of milk yield was available up to five parities for a pertinent comparison. In indigenous and F_1 × Friesian cows due to increase in parity number a decrease in mean 305 day milk yield was observed. It was a significant decrease in mean 305 day milk yield from parity one to parity five ($b = -37.41 \pm 5.427$; $F_{(1,3)} = 47.52$; $P = 0.0063$) in the case of indigenous cows. However, in F_1 × Friesian cows there was a non significant decrease in mean 305 day milk yield from parity one to parity five ($b = -35.40 \pm 24.70$; $F_{(1,3)} = 2.055$; $P = 0.2472$). On the other hand in $F_1 \times F_1$ (F_2) cows, there was increase in 305 day milk yield with the advance in the parity number. There was significant increase in 305 day milk yield in both the cases i.e., F_1 ($b = 195.8 \pm 43.83$; $F_{(1,3)} = 19.96$; $P = 0.0209$) and ($F_1 \times F_1$) F_2 hybrid cows ($b = 188.4 \pm 42.91$; $F_{(1,3)} = 19.28$; $P = 0.0219$). In F_1 hybrid milk data was available up to ten parities, decrease in milk yield was observed from parity 6 to parity 10. However, mean milk yield at parity ten is not significantly different compared to that in parity one ($t_{(32)} = 1.308$; $P = 0.2003$).

Table 35: Mean 305 day milk yield (liters) of indigenous and crossbred dairy cows according to parity

Parity	Indigenous	Indigenous × Jersey (F_1)	$F_1 \times F_1$ (F_2)	F_1 × Friesian
1	611.80±25.56 (48)	1298.0±91.38 (30)	1048.0±79.86 (18)	1448±74.85 (18)
2	589.10±24.04 (35)	1457.0±70.04 (27)	1168.0±103.3 (10)	1399±92.75 (14)
3	561.9±20.32 (26)	1829.0±89.86 (22)	1611.0±44.48 (7)	1222±87.86 (12)
4	526.8±24.06 (14)	1707.0±91.67 (19)	1722.0±39.96 (5)	1345±43.22 (4)
5	455.9±39.21 (10)	2152.0±142.1 (14)	1713.0 ± 100.8 (4)	1298±70.56 (4)
6	492.0±31.05 (9)	1923.0±169.8 (13)		
7	375.7±31.83 (7)	1834±76.76 (10)		
8		1631.0±149.3 (7)		
9		1694.0±153.0 (5)		
10		1648.0±267.1 (4)		
Overall	561.0±12.32	1674.0±47.58	1295.0±75.36	1355.0±60.32

Mean ± SE

Values in parenthesis ( ) = Number of lactations

Season of Calving

According to season of calving mean 305 day milk of indigenous and crossbred dairy cows is given in Table 36. In indigenous cows the highest mean 305 day milk yield was observed in cows that calved in autumn season (673.2±77.38 liters) whereas the lowest mean 305 day milk yield (513.0 ± 18.19 liters) was found in the cows that calved in summer season. Analysis of variance (Table 37) indicated that 305 day milk yield of indigenous cows that calved in summer was significantly higher ($P< 0.05$) compared to the cows that calved in autumn season but no significant difference was observed in cows that calved in summer compared to the cows that calved winter and springs season.

Analysis of variance (Table 38) indicated that in F_1 crossbred cows mean 305 day milk yield of cows calving in spring (1627±88.33liters) season did not differ significantly (P , 0.05) compared to that of summer season (1653 ± 85.90 liters), autumn season (1548 ± 95.14 liters) and winter season (1775 ± 74.34 liters). Mean 305 day milk yield of cows calving in summer season did not differ significantly ($P < 0.05$) compared to that of autumn and winter season. Similarly mean 305 day milk yield of cows calving in autumn did not differ significantly ($P < 0.05$) compared to that of winter season. Analysis of variance (Table 39) showed that similar to F_1 hybrid cows in $F_1 \times F_1$ (F_2) crossbred cows mean 305 day milk yield from cows calving in spring season (1184 ± 82.88 liters) did not differ significantly ($P < 0.05$) compared to the cows that calved in summer (1143 ± 78.98 liters), autumn season (1448 ± 42.63 liters) and winter season (1491 ± 95.32 liters). Similarly mean 305 day milk yield from cows calving in summer season did not differ significantly ($P < 0.05$) compared to the cows that calved in autumn and winter season. There was no significant ($P < 0.05$) difference of 305 day milk yield from $F_1 \times F_1$ (F_2) cows calving in autumn season compared to that of winter season.

The result of analysis of variance (Table 40) indicated that in F_1 × Friesian cows mean 305 day milk yield from cows calving in spring (1401 ± 69.70 liters) season did not differ significantly ($P < 0.05$) compared to that of cows calved in summer (1292 ± 74.28 liters), winter (1423 ± 90.53 liters) and autumn season (1010 ± 69.48 liters) . Mean 305 day milk yield from cows calving in summer season did not differ significantly ($P < 0.05$) compared to the cows calving in autumn and winter season.

Similarly mean 305 day milk yield from cows calving in autumn season did not differ significantly ($P < 0.05$) in cows that calved in winter season.

Year of Calving

In relation to calving year 305 day milk yield of indigenous and crossbred dairy cows is given in Table 41. The 305 day milk yield varied in indigenous and crossbred cows in relation to year of calving. In indigenous cows all the calving were found from 1990 to 1999. The maximum mean 305 day milk yield was recorded for 1990 (751.6 ± 118.0 liters) than there was a gradual decline over the year and the lowest mean 305 day milk yield was recorded in 1999 (402.5 ± 23.02). Regression analysis indicated that 305 day milk yield was affected by year and there was a significant ($b = -30.16 \pm 4.148$; $F_{(1, 8)} = 52.87$; $P < 0.0001$) decrease in 305 day milk yield from 1990 to 1999.

In F_1 hybrid cows calving were found to occur from 1993 to 2007. The lowest mean 305 day milk production was observed in 1993 (952.5 ± 217.5 liters) and the highest was observed in 2000 (2071 ± 159.6). Regression analysis indicated that 305 day milk was not significantly affected by year of calving in F_1 hybrid cows ($b = 26.79 \pm 16.89$; $F_{(1, 13)} = 2.517$; $P = 0.1367$). The calving were recorded from 1998 to 2006 for F_2 hybrid cows. Similar to F_1 hybrid cows regression analysis showed that year of calving did not affected the mean 305 day milk yield in F_2 hybrid cows ($b = 60.38 \pm 32.20$; $F_{(1, 7)} = 3.516$; $P = 0.1029$).

In F_1 × Friesian cows the calving were recorded for the period of 2002 to 2008. The highest mean 305 day milk yield was found in 2002 where it was 1710 ± 203.0 liters. Afterward a decline was observed in mean 305 day milk yield in relation to year and the lowest mean 305 day milk was recorded in 2008 (905.5 ± 77.30 liters). Regression analysis indicated that there was a significant decrease in mean 305 day milk yield from 2002 to 2008 ($b = -132.9 \pm 22.31$; $F_{(1, 5)} = 35.51$; $P = 0.0019$).

Table 36: Effect of season of calving on 305 day milk yield in Indigenous and crossbred dairy cows

Calving Season	Indigenous	Indigenous × Jersey (F_1)	$F_1 \times F_1$ (F_2)	F_1 × Friesian
Spring	572.6±14.90	1627±88.33	1184±82.88	1401±69.70
(Feb-Apr)	(66)	(46)	(20)	(17)
Summer	513.0±18.19 ^{a*}	1653±85.90	1143±78.98	1292±74.28
(May-August)	(37)	(15)	(7)	(5)
Autumn	673.2±77.38 ^{a*b**}	1548±95.14	1448±42.63	1010±69.48
(Sep-Oct)	(11)	(23)	(4)	(6)
Winter	550.9±23.23 ^{c*}	1775±74.34	1491±95.32	1423±90.53
(Nov-Jan)	(35)	(67)	(13)	(24)

Mean ± SE
a= Spring vs Summer, Autumn, Winter
b= Summer vs Autumn, Winter
c= Autumn vs winter
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of lactations

Table 37: One-way ANOVA showing the season effect on 305 day milk yield of nondescript indigenous cows

Source of Variation	SS	Df	MS	F	P value
Between Season	236100	3	78690	4.235	0.0007
Within Season	2694000	145	18580		
Total	2930000	148			

Table 38: One-way ANOVA showing the season effect on 305 day milk yield of Indigenous × Jersey (F_1) crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Season	1144000	3	381300	1.200	0.3120
Within Season	46720000	147	317800		
Total	47860000	150			

Table 39: One-way ANOVA showing the season effect on 305 day milk yield of $F_1 \times F_1$ (F_2) crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Season	1001000	3	333600	3.095	0.0375
Within Season	4311000	40	107800		
Total	5312000	43			

Table 40: One-way ANOVA showing the season effect on 305 day milk yield of F_1 × Friesian crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Seasons	880900	3	293600	2.310	0.0881
Within Seasons	6101000	48	127100		
Total	6982000	51			

Table 41: Effect of year of calving on 305 day milk yield (liters) in nondescript indigenous and crossbred dairy cows

Calving Year	Indigenous	Indigenous × Jersey (F_1)	$F_1 \times F_1$ (F_2)	F_1 × Friesian
1990	751.6 ± 118.0 (8)			
1991	599.7 ± 18.98 (22)			
1992	574.6 ± 27.73 (29)			
1993	575.9 ± 18.70 (25)	952.5 ± 217.5 (2)		
1994	563.0 ± 21.73 (12)	1362 ± 178.9 (6)		
1995	565.5 ± 42.15 (17)	1288 ± 120.9 (9)		
1996	510.7 ± 19.68 (15)	1461 ± 141.9 (15)		
1997	470.1 ± 50.48 (8)	1607 ± 70.65 (16)		
1998	439.9 ± 43.52 (8)	1776 ± 175.0 (19)	994.8 ± 209.0 (4)	
1999	402.5 ± 23.02 (5)	1701 ± 134.5 (18)	982.1 ± 207.0 (7)	
2000		2071 ± 159.6 (20)	1400 ± 161.6 (10)	
2001		1801 ± 120.4 (11)	1222 ± 176.1 (8)	
2002		1882 ± 157.5 (10)	1348 ± 340.5 (3)	1710 ± 203.0 (7)
2003		1751 ± 97.64 (5)	1539 ± 203.8 (3)	1472 ± 120.6 (4)
2004		1577 ± 149.5 (9)	1741 ± 194.8 (3)	1683 ± 155.6 (7)
2005		1345 ± 225.7 (5)	1707 ± 256.7 (3)	1363 ± 109.3 (7)
2006		1923 ± 465.1 (3)	1107 ± 166.4 (3)	1263 ± 85.70 (13)
2007		1330 ± 315.4 (3)		1028 ± 149.7 (7)
2008				905.5 ± 77.30 (7)
Overall	561.0±12.32	1674.0±47.58	1295.0±75.36	1355.0±60.32

Mean ± SE
Values in parenthesis ( ) = Number of lactations

3.4. Effect of parity, season and year of calving on lactation length of nondescript indigenous and crossbred dairy cows

The effect exerted by lactation number and season of calving on lactation length was studied in indigenous and crossbred cows.

Parity (Lactation Number)

According to parity mean lactation length of indigenous and crossbred dairy cows is given in Table 42. In indigenous cows the highest lactation length was recorded in parity first where it was 204.1 ± 11.74 days. There was a gradual decrease in lactation length with increase in parity and the lowest lactation length was observed in parity seventh where it was 132.0 ± 12.07 days. Regression analysis of variance showed a significant decrease in lactation length in indigenous cows from parity one to parity seven (b = -10.04 ± 1.770; $F_{(1, 5)}$ = 32.16; P = 0.0024).

In F_1 hybrid cows the highest lactation length was observed in parity fifth where it was 267.9 ± 10.95 days and the lowest lactation length was observed in parity tenth where it was 107.5 ± 10.31 days. Regression analysis of variance showed a non significant increase in lactation length from parity first to parity fifth (b = 0.9600 ± 5.085; $F_{(1, 3)}$ = 0.03565; P = 0.8623). After fifth parity lactation length decreased gradually and regression analysis of variance showed a non significant decrease in lactation length from parity fifth to parity tenth (b = -26.56 ± 11.60; $F_{(1, 3)}$ = 5.244; P = 0.1060). In $F_1 \times F_1$ (F_2) cows the highest lactation length was observed in fourth parity where it was 265.6 ± 13.70 days. Regression analysis of variance did not show an increase in lactation length from first to fourth parity (b = 0.4500 ± 13.99; $F_{(1, 2)}$ = 0.001035; P = 0.9773).

In F_1 × Friesian cows the highest lactation length was observed in parity first where it was 370.8±26.21 days and the lowest lactation length was observed in parity fifth where it was 279.8 ± 25.37 days. Regression analysis of variance showed a non significant decrease in lactation length from parity first to parity fifth (b = 14.88 ± 8.536; $F_{(1, 3)}$ = 3.038; P = 0.1797).

Table 42: Mean lactation length (days) of indigenous and crossbred dairy cows according to parity

Parity	Indigenous	Indigenous × Jersey (F_1)	$F_1 \times F_1$ (F_2)	Friesian × F_1
1	204.1±11.74 (48)	262.7±13.14 (30)	255.4±16.38 (18)	370.8±26.21 (18)
2	167.1±8.898 (35)	240±12.06 (27)	234±18.21 (10)	362.3±32.86 (14)
3	167.8±13.74 (26)	240.7±10.76 (22)	207.9±21.38 (7)	349.3±34.34 (12)
4	163.9±10.41 (14)	239.2±15.94 (19)	265.6±13.70 (5)	344.5±38.31 (4)
5	158.5±14.43 (10)	267.9±10.95 (14)	244.3±20.61 (4)	279.8±25.37 (4)
6	139.4±10.24 (9)	239.5±17.34 (13)		
7	132.0±12.07 (7)	219.0±19.73 (10)		
8		217.6±13.39 (7)		
9		217.4±11.49 (5)		
10		107.5±10.31 (4)		
Overall	174.90±5.92	244.10±5.83	230.90±10.46	354.50±16.70

Mean ± SE

Values in parenthesis ( ) = Number of lactations

Season of Calving

According to season of calving mean lactation length of indigenous and crossbred dairy cows is given in Table 43. In nondescript indigenous cows the mean lactation length was found to be shortest for cows that calved in summer (159 ± 9.09 days) and longest lactation length was observed in cows calved in winter season (199.0 ± 14.64 days). Analysis of variance (Table 44) showed that season of calving did not significantly ($P < 0.05$) affected the lactation in nondescript indigenous cows.

In F_1 crossbred cows mean lactation length of cows that calved in summer (233.5 ± 22.40 days) was shortest and the longest lactation length was recorded in cows calved in autumn season (267.1 ± 15.91 days). Analysis of variance (Table 45) indicated that the lactation length did not differ significantly ($P < 0.05$) among cows that calved during different season. In $F_1 \times F_1$ (F_2) crossbred cows the mean lactation length of cows that calved in summer (185.6 ± 29.11 days) was shortest and longest lactation length was recorded in winter calving (241.1 ± 21.99 days). Analysis of variance (Table 46) showed that similar to F_1 crossbred cows, the lactation length of F_2 crossbred cows that calved during different season did not differ significantly ($P < 0.05$).

In F_1 × Friesian cows the shortest lactation length was recorded in summer calving (258.8 ± 57.36 days) while the longest lactation length was observed in cows that calved during spring season (395.4 ± 38.69 days). Similar to the lactation length of nondescript indigenous and other two groups of crossbred cows the lactation length of F_1 × Friesian cows crossbred cows was not significantly ($P > 0.05$) affected by the season of calving (Table 47).

Year of Calving

In relation to calving year lactation length of indigenous and crossbred dairy cows is given in Table 48. The lactation length was found to be variable in indigenous and crossbred cows in relation to year of calving.

In indigenous cows all the calving were recorded from 1990 to 1999. The longest lactation length was observed in 1990 (242.4 ± 30.28 days) than there was a decline in lactation length over the year and the shortest was recorded in 1998 (127.5 ± 10.39 days). Regression analysis indicated that lactation length was affected by year and there was a significant (b = -9.716 ± 3.095; $F_{(1, 8)}$ = 9.85; P = 0.0138) decrease in lactation length of indigenous cows from 1990 to 1999.

In F_1 hybrid cows all the lactation lengths were from 1993 to 2007. Although a decline in lactation length was observed however, regression analysis indicated that lactation length in F_1 hybrid cows was not significantly affected by year of calving (b =-1.888 ± 2.110; $F_{(1, 13)}$ = 0.8008; P = 0.3860). The lactation lengths were recorded from 1998 to 2006 for F_2 hybrid cows. Similar to F_1 hybrid cows regression analysis showed that the decline in lactation length was not affected significantly by the year of calving in F_2 hybrid cows (b = -6.535 ± 5.605; $F_{(1, 7)}$ = 1.359; P = 0.2818).

In F_1 × Friesian cows the lactation lengths were recorded for the calving that were found to occur from 2002 to 2008. Regression analysis indicated that the year of calving did not affect the lactation length in F_1 × Friesian crossbred cows. The changes in lactation length in relation to year of calving from 2002 – 2008 were not significant (b = -8.936 ± 9.491; $F_{(1, 5)}$ = 0.8865; P = 0.3897).

Table 43: Effect of season of calving on lactation length of indigenous and crossbred dairy cows

Calving Season	Indigenous	Indigenous × Jersey (F_1)	$F_1 \times F_1$ (F_2)	F_1 × Friesian
Spring	173.0±10.14	255.3±10.42	228.8±14.53	395.4±38.69
(Feb-Apr)	(66)	(46)	(20)	(17)
Summer	159.8±9.09	233.5±22.40	185.6±29.11	258.8±57.36
(May-August)	(37)	(15)	(7)	(5)
Autumn	179.5±16.32	267.1±15.91	228.3±31.34	339.3±37.52
(Sep-Oct)	(11)	(23)	(4)	(6)
Winter	199.0±14.64^{b*}	233.8±8.44	241.1±21.99	358.7±21.66
(Nov-Jan)	(35)	(67)	(13)	(24)

Mean ± SE
a= Spring vs Summer, Autumn, Winter
b= Summer vs Autumn, Winter
c= Autumn vs winter
$P \leq 0.05$*, $P \leq 0.01$**, $P \leq 0.001$***
Values in parenthesis ( ) = Number of lactations

Table 44: One-way ANOVA showing the season effect on lactation length (days) of nondescript indigenous cows

Source of Variation	SS	Df	MS	F	P value
Between Season	28940	3	9647	1.674	0.1752
Within Season	835500	145	5762		
Total	864400	148			

Table 45: One-way ANOVA showing the season effect on lactation length (days) of Indigenous × Jersey (F_1) crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Season	26480	3	8826	1.678	0.1743
Within Season	773200	147	5260		
Total	799700	150			

Table 46: One-way ANOVA showing the season effect on lactation length (days) of $F_1 \times F_1$ (F_2) crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Season	14560	3	4852	0.9559	0.4229
Within Season	203000	40	5076		
Total	217600	43			

Table 47: One-way ANOVA showing the season effect lactation length (days) of $F_1 \times$ Friesian crossbred cows

Source of Variation	SS	Df	MS	F	P value
Between Season	75050	3	25020	1.551	0.2135
Within Season	774200	48	16130		
Total	849200	51			

Table 48: Effect of year of calving on lactation length (days) in nondescript indigenous and crossbred dairy cows

Calving Year	Indigenous	Indigenous × Jersey (F_1)	$F_1 \times F_1$ (F_2)	F_1 × Friesian
1990	242.4 ± 30.28 (8)			
1991	229.0 ± 18.54 (22)			
1992	164.3 ± 9.323 (29)			
1993	149.5 ± 4.986 (25)	317.5 ± 3.500 (2)		
1994	213.3 ± 35.22 (12)	230.2 ± 20.75 (6)		
1995	147.5 ± 10.59 (17)	292.9 ± 24.98 (9)		
1996	153.9 ± 9.480 (15)	239.6 ± 17.60 (15)		
1997	173.4 ± 29.57 (8)	273.2 ± 9.698 (16)		
1998	127.5 ± 10.39 (8)	209.7 ± 15.55 (19)	284.5 ± 21.72 (4)	
1999	144.0 ± 28.52 (5)	238.4 ± 15.12 (18)	265.3 ± 29.15 (7)	
2000		238.0 ± 15.03 (20)	224.0 ± 16.70 (10)	
2001		230.4 ± 22.04 (11)	172.5 ± 27.97 (8)	
2002		267.6 ± 15.62 (10)	246.7 ± 30.75 (3)	368.9 ± 24.81 (7)
2003		288.2 ± 32.44 (5)	260.0 ± 11.85 (3)	355.0 ± 24.83 (4)
2004		244.2 ± 30.56 (9)	287.3 ± 10.81 (3)	344.7 ± 46.70 (7)
2005		236.0 ± 59.11 (5)	220.3 ± 19.53 (3)	299.6 ± 53.85 (7)
2006		188.3 ± 62.28 (3)	166.7 ± 48.61 (3)	422.0 ± 28.47 (13)
2007		201.7 ± 66.17 (3)		345.3 ± 56.96 (7)
2008		317.5 ± 3.500 (2)		266.2 ± 77.30 (7)
Overall	174.90±5.92	244.10±5.83	230.90±10.46	354.50±16.70

Mean ± SE
Values in parenthesis ( ) = Number of lactation

DISCUSSION

4.1. Productive Traits

This study is based on productive and reproductive traits. Both the traits were studied in detail regarding indigenous cows and their crossbreeding with imported semen of Jersey (artificial insemination) and Friesian bull (natural service). Particular interest was to look at any improvement in the traits under study due to crossbreeding.

Birth Weight of Calves

Mammalian growth is influenced by the genes of the individual, environment provided by the dam during pregnancy, nutrition and other environmental factors (Albuquerque and Meyer, 2001).

In this study calves from indigenous cows were lighter than calves from that of Jersey cows. Das *et al.* (1984) also investigated that in male calves mean birth weight was 19.68 Kg and that of female calves was 18.19 Kg. Similarly Bhuyan and Mishra (1985) recorded mean birth weight of Jersey for male calves as 20.78 Kg and for female calves this was 19.68 Kg in India. Guaragria *et al.* (1990) recorded mean birth weight for male Friesian calves as 37.4 Kg and was 34.5 Kg for female calves in Brazil. In Ethiopia, Tadessi and Dessie (2003) recorded mean birth weight of Friesian male calves as 30.8 ± 1.45 Kg and in female calves 29 ± 1.25 Kg.

The indigenous cattle of Azad Jammu and Kashmir (AJ&K) are short structured with an average live weight of 200 kg (Kuthu *et al.*, 2007). The birth weights recorded for their calves in this study were 14.36 ± 0.53 Kg for males and 13.33 ± 0.49 Kg for female. The calves coming from Jersey and Friesian cows were heavier than calves from indigenous cows in present study. Indigenous cows are small in size. If they are crossed with Friesian as a result a heavier and large sized calf develops which small size cow cannot deliver and thus cow lead to dystocia. Hence the breeding program in present study was planned keeping in view the smaller size of indigenous heifers. Because of smaller size of calf from Jersey cows than that from Friesian cows, the indigenous heifers were inseminated with imported frozen thawed semen of Jersey in order to avoid dystocia this way. Then the F_1 cows were crossed with Friesian bull. Calves obtained as a result of these crosses were significantly heavier than those from indigenous cows ($P < 0.0001$).

The calves coming from F_1 cows crossed with Friesian bull were the heaviest in birth weight than those obtained from other crosses. Mondal *et al.* (2005) also obtained similar results when they crossed Bangladeshi cows with Holstein Friesian; Jersey; Sahiwal and Red Sindhi cows. In another type of crosses carried out in Bangladesh it was investigated that in a cross between Holstein Friesian × Deshi the calves thus produced were heavier than those obtained from cross between Jersey × Deshi (Nahar *et al.*, 1992). Ahunu and Grieve (1980) also found that crossbreeding of N'dama with Jersey and then crossing of their F_1 with Friesian resulted in greater mean birth weight in F_1× Friesian than in N'dama × Jersey (F_1) crossbred calves.

The birth weight of male and female calves did not differ significantly in indigenous cows. Whereas Shahzad *et al.* (2010) found that in Cholistani cows male calves had significantly higher birth weight than female. In present study F_1 hybrid male calves were heavier than female calves. The significant effect of sex on birth weight of F_1 hybrid calves in this study was similar to the observations of Zambrano *et al.* (2006) who investigated that male calves tend to be higher than female calves at birth in crossbred Holstein × Criollo Limonero cows in Venezuelan humid tropical forest zone. Different breeds indicate higher birth weight of male than female calves such as in Red Chittagong cattle (Habib *et al.,* 2009), in imported Holstein Friesian herds on zero grazing in the Western highland regions of Cameroon (Gwaza *et al.,* 2007) and in Holstein-Friesian Cattle at Quetta, Balochistan, Pakistan (Sandhu *et al.,* 2011).

In present study sex of calf did not show significant difference in birth weight of male and female calves in F_2 and F_1 × Friesian calves. Nevertheless, many researchers have reported significant effect of sex on birth weight in Holstein Friesian (Freitas *et al.*, 1987; Guaragna *et al.*, 1990). Effect of sex of calves on birth weight is attributed to longer gestation period of male calves or higher androgen concentration in foetuses (Manzi *et al.*, 2012).

Milk Yield

The milk production performance of indigenous cattle of Azad Jammu and Kashmir is very poor (Kuthu *et al.*, 2009). In this study 286 ± 129 liters milk yield per lactation was recorded in indigenous cows at Livestock Development Research Centre (LDRC) under subtropical environmental conditions of Muzaffarabad AJ&K. The crosses carried out at LDRC were intended to improve productive traits which include also milk yield per lactation. Indigenous cows were inseminated with imported frozen thawed semen of Jersey and then their F_1 offspring were crossed with Friesian bull to find if milk production potential of the exotic breeds will help in improving milk yield. In this study crossbred cows did show significant increase in milk yield per lactation compared to that of indigenous cows. Present crossbred cows coming from crosses indigenous × Jersey (F_1), $F_1 \times F_1$ (F_2) and F_1 × Friesian gave higher mean milk yield per lactation as against that of indigenous cows. In present study, compared to milk yield per lactation from indigenous cows (286 ± 129 liters), there was highly significant increase in mean milk yield per lactation in crossbred cows as was in indigenous × Jersey (F_1) (1228.0 ± 39.98 liters); $F_1 \times F_1$ (F_2) (1014.0 ± 78.90 liters) and F_1 × Friesian (1411.0 ± 92.88 liters). This indicated that the upgrading of non descript indigenous cows by crossing with *Bos Taurus* breeds enhanced the milk yield per lactation of crossbred. In these crosses the highest milk yield per lactation was observed in F_1 × Friesian cross. Jersey and Friesian breeds were used for crossbreeding, in this study, taking advantage of studies done by different investigators who showed quite high milk production by these two types of cows. Javed *et al.*, (2002) investigated per lactation milk yield of Jersey cow as 2274.65 ± 96.22 in Pakistan. Studies from other countries showed that lactation milk yield of Jersey cows was 4636 ± 25 Kg in USA (Campos *et al.*, 1994); 2798 ± 724 Kg in Brazil (Kemenes *et al.*, 1994) and 2480 ± 548 Kg in Australia (Cowan *et al.*, 1974). As regard the milk yield of Friesian cows in Pakistan it was 2418.3 ± 104.65 liters for 305-days (Hyder and Ullah, 2002); 3977.75 ± 37.20 liters per lactation (Sandhu *et al.*, 2011) and 3438 ± 887.19 kg per lactation (Usman *et al.*, 2012). The milk yield per lactation of Friesian reported in other countries as 4100 ± 692 Kg in Australia (Cowan *et al.*, 1974); 4791.21 ± 98.30 kg in Egypt (Badran and Shebl, 1991); 6693.63 Kg in USA (Dunklee *et al.*, 1994) and 3183 ± 111 Kg in Ethiopia (Tadesse and dessie, 2003).

Environment is very important for the maintenance of animals coming from different environmental conditions. Javed *et al*. (2002) indicated that animals of temperate origin maintained in tropical environment cannot perform similarly in both the environment. The European cattle breeds and their crosses with Zebu cattle in the tropics suffered from heavy losses which is an indication of their poor adoptability to the harsh environmental conditions of the tropics (Vaccaro, 1991). However, crossbreeding of Jersey breed of temperate origin with indigenous cows under the sub tropical environmental conditions of Muzaffarabad AJ&K in this study increased the milk yield in F_1 crossbred cows compared to the milk yield of indigenous cows. In other countries investigation were carried out about crossbreeding of their native cows with Jersey and Friesian breeds. In India Moulick *et al.* (1972) crossed Desi cows with Jersey and obtained as a result 1213 Kg milk yield per lactation in F_1 crossbred cows. Djoko *et al.* (2003) reported milk yield per lactation from a cross between White Fulani × Jersey as 1320 ± 170.9 Kg in western highlands of Cameroon. In Gambia in a cross of N'Dama × Jersey milk yield per lactation was 1051 ± 294 Kg (Diack *et al.,* 2005). Dutt *et al.* (1998) in a cross between F_1 of Hariana and Jersey with Friesian in India obtained milk yield per lactation as 2005 ± 87.0 Kg. Diack *et al.* (2005) observed milk yield per lactation as 1355 ± 347 Kg in a cross of N'Dama with Friesian. In a cross between Zebu cows and Friesian in Khartoum Ahmed *et al.* (2007) reported 2721.10 ± 87.36 kg milk per lactation.

The standard for comparison of dairy milk records is 305 day lactation yield and it serves as a raw material for evaluation of genetic merit of productive traits of sires and cows (Famula and Vleck, 1981). Milk yield is the most important trait in dairy cattle production and 305 day milk yield is often used in genetic evaluation of animals (Amasaib *et al.,* 2008). Although highest mean milk yield per lactation was observed in F_1 × Friesian cows however, when milk yield per lactation was standardized on 305 day basis then the highest was observed in F_1 hybrid cows. The increase in 305 day milk yield of indigenous cows of AJ&K in present study as a result of crossbreeding is much more than that of crossbreeding of Red Sihdhi and Dhani with Jersey and Friesian (Aslam *et al.,* 2002) and Sahiwal with Friesian (Chaudhry *et al.,* 1992). Crossbreeding of indigenous cows with Jersey increased the 305 day milk production by three-fold. This increase in milk production may be due to hybridization exhibited in the first crosses. However, the 305 day milk yield was not improved further by selfing of F_1 hybrid rather there was a decline. Inter *se* mating among the first generation crosses often gave the variable result (Dutt *et al.,* 1998). The decline in milk yield in F_2 in present study is in agreement with some other experiments in which a decline in milk yield was observed in second generation crossbred cows (Hayman 1974; Bhuvan-endran and Mahadevan, 1975; Bhatanagar *et al.*, 1981; Parmer *et al.*, 1986; Majid *et al.*, 1996). However, Hayman (1974) reported contradictory result from the crosses of Sahiwal × Jersey and Sindhi × Jersey F_2 over the F_1 in New South Wales, Australia. On the other hand, when F_1 cows were crossed with Friesian bull the 305 day milk yield did not improve any further.

Mean daily milk yield from indigenous cows in this study was 1.6 liters which is comparable to Indian Dehsi cattle (1.4 liters; Moulick *et al.* 1972) and Bangladeshi Deshi cattle (1.7 ± 0.6 litres; Alam *et al.*, 2008). In this study there was highly significant increase in daily milk yield as a result of crossbreeding with Jersey and Friesian. This indicates that Jersey and Friesian breeds have good genetic factors which to increase the daily milk production. In the present study crossbreeding of these types of crosses with indigenous cows must have transmitted to genetic factors which improved milk production in next generation. Highest daily average milk yield was observed in Indigenous × Jersey (F_1) cows but milk production decreased in F_2. This decrease in milk production in F_2 is may be due to segregation of genes. Majid *et al.* (1996) noticed a similar decline of cow's milk production in F_2 and F_3 as the generation number increased. Mean daily milk yield of F_1 × Friesian cross in this study was lower than the mean daily milk yield obtained from a similar cross of Hariana × Jersey (F_1) × Friesian (5.52 ± 0.23 Kg) in India (Dutt *et al.*,1998) and Desi × Friesian cross (6.3 ± 1.2 liters/ day) in Bangladesh (Alam *et al.*, 2008). Zebu × Friesian cows have been reported to produce daily average milk yield of 9.77 ± 0.30 kg in Khartoum (Ahmed *et al.*, 2007) this is higher than daily average milk produced by F_1 × Friesian cows in present study.

The results of milk production in present study indicated that the F_1 hybrid cows were the best for milk production among the studied crossbred cows. Often the primary objective of dairy farmers is to increase the milk production of their animals hence the result of milk yield obtained in F_1 as a result of crossbreeding of indigenous cows with Jersey will be very useful and adopting this practice will boost the productivity of indigenous cows in the Northern part of AJ&K which has almost the similar topography and environment. Although Friesian is high yielder than Jersey in term of milk production however, higher milk yield per lactation produced by F_1 × Friesian cows in this study was due to longer lactation length compared to F_1 and F_2 cows. Whereas 50 % Jersey inheritance cows resulted in higher 305 day milk yield and daily milk yield than 50 % Friesian inheritance cows. This may be attributed to the better adoptability of Jersey compared to Friesian to the local environmental conditions of Muzaffarabad, AJ&K.

Lactation Length

The present study revealed that lactation length of indigenous cows was shorter and as a result of crossbreeding, the lactation length increased significantly among crossbred cows. Mean lactation length of indigenous cows in this study is similar to lactation length of local cow (170.0 ± 22.36 days) of Bangladesh (Kabir and Islam, 2009) but on the other hand it was shorter than lactation length of Sahiwal cow (262 ± 1.04 days) maintained at the Livestock Experiment Station, Bahadurnagar, Okara, in Pakistan (Zafar *et al.,* 2008).

Lactation length of pure Jersey cows was 256.16 ± 82.72 days in Pakistan (Javed *et al.,* 2002); 314 ± 61 days in in Brazil (Kemenes *et al.,* 1994); 281.1 ± 5 days in India (Arora and Sharma, 1983) and 242 ± 40 days in Philippines (Hermosura and Mordeno, 1982). Crossbreeding of indigenous cow with Jersey increased the lactation length of indigenous cows in F_1 (244.1 ± 5.83). Similarly, crossbreeding in other studies like Moulick *et al.* (1972) reported lactation length of 288 ± 31days in Deshi × Jersey (F_1) in India. Nahar *et al.* (1992) observed lactation length of 304.4 ± 3.6 days for Deshi × Jersey (F_1) cows in Bangladesh. As a result of selfing of F_1 in this study the lactation decreased in F_2 (230.9 ± 10.46 days) compared to F_1 crossbred cows but this decrease was not significant.

The lactation length of Friesian cattle was 314.19 ± 0.91 days in Pakistan (Sandhu *et al.,* 2011); 315 ± 17.9 days in India (Perez and Ronda, 1983); 303.2 days in Iraq (Dabduab and Misra, 1988), and 318 days in Brazil (Freitas *et al.,* 1983).

In this study when F_1 crossbred cows were crossed with Friesian bull the lactation length increased in F_1 × Friesian crossbred cows (354.5 ± 16.70). Dutt *et al.* (1998) reported a lactation length as 333 ± 6.2 days in Harina × Jersry (F_1) × Friesian cross in India. Lactation length of 330.5 ± 3.6 days was also observed in Friesian × Deshi cows in Bangladesh (Nahar *et al.,* 1992).

The lactation length observed in F_1 × Friesian cross in this study was longer than Holstein Friesian cows (291.86 ± 6.55 days) maintained at Livestock Experiment Station Bhunkkey, Pakistan (Sattar *et al.,* 2005); indigenous × Friesian cross (262.0 ± 24.15) in Bangladesh (Rokonuzzaman *et al.,* 2009) and Zebu x Friesian cross (292.64 ± 08.28) in Khartoum (Ahmed *et al.,* 2007).

The variation of lactation length among Indigenous, Indigenous × Jersey (F_1), F_1 × F_1 (F_2) and F_1 × Friesian cows in present study could be due to union of different breeds.

Though the lactation length of F_1 × Friesian cows was longer than F_1 and F_2 crossbred cows but their daily milk yield and 305 day milk yield was lower. Conceicao *et al.* (1993) concluded that the lactation length did not affect significantly the milk yield in Holstein Friesian cows. This may indicates that the higher milk yield of F_1 and F_2 crossbred cows compared to F_1 × Friesian cows in this study may be primarily due to the variation in daily milk yield and not for the lactation length; Musa *et al.* (2005) indicated the same conclusion for Butana cattle in Sudan.

Effect of Sire

Among productive traits within F_2 crossbred cows, 305 day milk yield and daily average milk yield were significantly affected by sire but sire had non significant effect on birth and lactation length. Sire effect on milk yield are in agreement with Bahdauria *et al.* (2002) and Jadhav *et al.* (1994) who reported significant sire effects on milk yield on crossbred cows in India. Within F_1 × Friesian crossbred cows the sire had non significant effect on productive traits. The effect of sire on milk yield within F_2 crossbred cows indicated that sire selection may be used as useful tool for the improvement of this productive trait in Jersey crossbred cows.

4.2. Reproductive Traits

Reproductive performance is the trait of economic importance in dairy cattle, producing more female calves than male calves, will result in more economic return. Delayed first calving in dairy cattle is not economical in terms of milk production (Khan *et al.*, 1989). Service period and calving interval have a great economic importance on productive life and lifetime milk production of dairy cows (Rafique *et al.*, 1999). Hence important measures of reproductive performance studied are sex ratio, age at first calving, dry periods, service period, length of calving interval, and breeding efficiency.

Sex Ratio

In dairy generally, a farmer desires to have more female born in order to increase the profitability of milk production with increasing female calving ratio. In this study there is no significant increase in female calves both in indigenous cows as well as in crossbred cows. Sex ratio indicated a higher proportion of male calves in all types of crosses, but this was not significantly different from zero. Results reported by other investigators have also shown male calves were born in higher number than female calves. Rahman *et al.* (2002) found no significant difference of sex ratio of local and crossbred cows calved in different season in Dhaka, Bangladesh. Mukherjee *et al.* (2000) observed significantly higher frequency of male births than that of female births from Karan Swiss cows in India. Significantly higher frequency of male births have also been reported by Kaushik and Singhal (1982) among calves from Jersey x Hariana (F_1) × Holstein and Thanparker × Jersey (F_1) × Friesian (Tomar and Verma, 1988).

There is evidence from Irish farmers that natural breeding increases the probability of a female calf in dairy (Berry and Cromie, 2006). Khan *et al.* (2012) reported that male births were significantly higher as a result of artificial insemination compared to natural service but in present study no significant gender difference was observed from Indigenous × Jersey (F_1) calves because of artificial insemination.

In this study, calves outcome of natural service, due to F_2 and F_1 × Friesian crosses, male and female calf's ratio was not significantly different from zero. This is in contrast to Berry and Cromie (2006) view.

Age at First Calving (AFC)

Cow's productive life starts with first calving. An early age at first calving (AFC) decreases the generation interval. Early age at first calving results in more calves and milk during the life time of a cow. Therefore AFC is one of the most important economic traits of dairy cattle. Present study revealed that the mean AFC of indigenous cows (1861 ± 42.45 days) was higher than the mean AFC of local cows from some Asian countries such as in Deshi cattle (47 ± 7 months) of India (Moulick *et al.*, 1972); Deshi cattle (1365 ± 6.20) of West Bengal (Sarkar *et al.*, 2007); Gray cattle (1191 ± 19.7 days) of North Bengal (Al-Amin *et al.*, 2007) and indigenous cow of (40.48 ± 4.54 months) Bangladesh (Rokonuzzaman *et al.*, 2009). Mean AFC of indigenous cow in this study was also higher than the mean AFC of cows from African countries such as local cattle of Northern Ethiopia has an AFC of 3.41 ± 0.70 years (Weldeslasse *et al.*, 2012).

The AFC of Jersey cows in different countries was found to be 888.53 ± 15.97 days in Pakistan (Lateef *et al.*, 2008); 946 days in Russia (Denisova 1981); 956.24 ± 35.82 days in India (Matoch and Tomar, 1983) and 945.93 days in Nigeria (Adeneye, 1985). As a result of crossbreeding of indigenous cows with Jersey in this study the mean AFC in indigenous cows decreased significantly in crossbred cows. The lowest mean

AFC was observed in F_1 crossbred cows (951.2 ± 37.35 days) and it was comparable to that of Jersey cows (926.48 ± 10.29 days) studied by Sattar *et al.* (2004); lower than the mean AFC of imported Jersey cows (1010.73 ± 21.84 days) reported by Suhail *et al.* (2010) but higher than the mean AFC of farm born Jersey cows (888.53 ± 15.97) observed by Lateef *et al.* (2008) under subtropical conditions of Pakistan. Mean AFC of F_1 crossbred cows in present study was lower than the findings of Zaman *et al.* (1983) for F_1 (Jersey × Sahiwal) cows (793.7 ± 10.76 days) at Livestock Experiment Station Bahadurnagar, Pakistan and F_1 (Jersey × Dehsi) cows (1002.3 ± 49.4 days) in Bangladesh Agriculture University (Nahar *et al.*, 1992).

As a result of selfing of F_1 offspring mean AFC increased in F_2.This increase may be due to segregation of genetics factors. However, when F_1 crossbred cows were crossed with Friesian bull then in F_1 × Friesian cows the mean AFC became almost equal to that of F_1 crossbred cows.

Mean AFC of Holstein Friesian cows was 944.08 ± 12.71 days in Pakistan (Younas *et al.,* 2008); 927.81 ± 115.6 days in Chile (Perez *et al.*, 1985); 924.64 ± 15.21 days in Ghana (Gyawn *et al.,* 1988) and 888.14 in USA (Coleman and Dailey, 1985). Mean AFC in F_1 × Friesian cows in present study was comparable as indicated in farm born Holstein Friesian cows in Punjab (952.90 ± 15.14 days) (Lateef *et al.*, 2008); Holstein Friesian cows (987.87 ± 9.81 days) in Pakistan (Sattar *et al.,* 2005). Rokonuzzaman *et al. (*2009) recorded a mean AFC in Indigenous × Friesian cow (34.12 ± 3.78 months) in Bangladesh is also comparable to the findings of AFC in F_1 × Friesian cows in this study.

Mean AFC in Hariana × Jersry (F_1) × Friesian cows (1072 ± 23.7 days) indicated by Dutt *et al.* (1998) in India and in F_1 (Holstein Friesian × Dehsi) cows (1201.4 ± 29.6 days) at Bangladesh Agriculture University (Nahar *et al.*, 1992) was higher than mean AFC in F_1 × Friesian cows in present study but it was lower in Friesian × Non Descript cows (888.0 ± 21.47 days) in Pakistan (Zaman *et al.*, 1983. The present study suggests that calving at an early age could be induced in indigenous cattle through crossbreeding with exotic breed of Jersey and Friesian.

Dry Period

In dairy cows the dry period has been considered as a time of rest during which the mammary epithelial components regress, proliferate and differentiate with ultimate goal of maximizing milk yield during the subsequent lactation (Capuco *et al.,* 1997). Ulutaş and Sezer (2009) suggested a dry period in dairy cows between 45 and 60 days to be ready for the next lactation period and to provide the increased requirements of calf during the last months of the pregnancy.

Mean dry period of indigenous cows (239.5 ± 7.87 days) in this study was longer than mean dry period of Sahiwal cows (172 ± 1.44 days) at Livestock Experiment Station Bahadurnagar, Okara (Zafar *et al.,* 2008); indigenous cow (197.4 ± 52.28 days) of Bangladesh (Rokonuzzaman *et al.,* 2009) and Dehsi cattle (139 ± 80 days) of India (Moulick *et al.,* 1972). Mean dry period of indigenous cow in this study is comparable to mean dry period of Red Sindhi cattle as 230.5 ± 15.49 days (Aslam *et al.,* 2002) and 245.2 ± 11.9 days (Mustafa *et al.,* 2002).

Average dry period of Jersey cows was 169.26 ± 16.45 days in Pakistan (Suhail *et al.,* 2010); 111.84 ± 9.22 days in India (Sreemannarayana and Rao, 1993); 128 ± 88 days in Ethiopia (Tesfaye and Alemu, 1993) and 60 days in USA (Bertrand *et al.,* 1991).

As a result of crossbreeding of indigenous cows with Jersey the dry period decreased significantly in F_1 (110.2 ± 4.78 days) and F_2 (124.8 ± 10.14 days) cows. The dry period of F_1 and F_2 was shorter than the dry period of Jersey × Deshi (F_1) cows (130.9 ± 6.4 days); Red Sindhi × Dhanni × Friesian × Jersey crossbred cows (134.1 ± 35.90 days) under Barani conditions of Pakistan (Aslam *et al.,* 2002). The mean dry period of F_1 and F_2 cows in this study was shorter than the dry period of Jersey cows (169.26 ± 16.45 days) under subtropical conditions of Pakistan (Suhail *et al.,* 2010).

The dry period of Holstein Friesian cow was 59.15 ± 20.61days (Younas *et al.,* 2008); 100.26 ± 61.38 days (Usman *et al.,* 2012) in Pakistan. Whereas 95 days in India (Ganpule *et al.,* 1984); 98 days in Slovakia (Gabris *et al.,* 1978); and 62.2 days in USA (Coleman and Dailey, 1985). Crossing of F_1 cows with Friesian bull in this study further decreased the mean dry period in F_1 × Friesian cows (99.76 ± 6.67 days) and it was shorter than the dry period of Harina × Jersry (F_1) × Friesian cows (154 ± 14.2) in India (Dutt *et al.,* 1998); dry period of Holstein Friesian cows (224.99 ± 10.00 days) in Pakistan (Sattar *et al.,* 2005) and indigenous × Friesian cows in Bangladesh (134.8 ± 30.02 days) (Rokonuzzaman *et al.,* 2009). The dry of F_1 × Friesian was comparable to the dry period of Holstein Friesian cows (100.26 ± 61.38 days) under subtropical conditions of Pakistan (Usman *et al.,* 2012) and dry period of

50% Zebu × Friesian cows (86.61 ± 9.37 days) in Khartoum (Ahmed *et al.,* 2007). The longer dry period in indigenous and crossbred cows may be due to improper heat detection, faulty insemination and reproductive disorders.

Service Period

Days open or service period of 85 days are considered as standard values (McDowell, 1985; Radostits, 2001). Service period is a sole variable of calving interval. The main variation in calving interval is due to variation in service period. Long service period may be due to managemental problems associated with proper heat detection and timely insemination but it may also give some indication of reproductive system of cows.

The mean service period of indigenous cows (256.0 ± 8.67 days) in this study was higher than that of service period of Sahiwal cow (159 ± 1.56 days) observed by Zafar *et al.* (2008) at Livestock Experiment Station Bahadurnagar, Okara.

The mean service period of Jersey was 161.6 days in Brazil (Polastre *et al.,* 1983); 180.3 ± 18.3 days in India (Sadana and Basu, 1983) and 116 days in USA (Silva *et al.,* 1992). When indigenous cows were artificially inseminated with frozen thawed semen of Jersey then in F_1 (92.60 ± 5.04 days) and F_2 (81.81 ± 11.19 days) crossbred cows the service period decreased. The shorter service period is an indication of early resumption of ovarian activity after calving of these two crossbred cows group. The service period of F_1 and F_2 in present study was even less than the service period of Jersey cows (152.66 ± 4.85 days) under subtropical conditions of Punjab (Sattar *et al.,* 2004).

The mean service period of Holstein Friesian cows was 240 ± 9.61 days, (Younas *et al.*, 2008) in Pakistan, 117.25 days in Italy (Bagnato and Oltenacu, 1994); 97.41 ± 8.22 days in South Korea (Jo *et al.,* 1978) and 124 days in USA (Silva *et al.,* 1992). In this study when F_1 crossbred cows were crossed with Friesian bull then in F_1 × Friesian cows the mean service period increased (266.7 ± 16.56 days). The mean service period in F_1 × Friesian cows was longer than the service period of Harina × Jersey (F_1) × Friesian cows (195 ± 15.3 days) in India (Dutt *et al.,* 1998); Holstein-Friesian cows (129.95 ± 2.14) in Pakistan (Sandhu *et al.,* 2011). The mean service period of F_1 × Friesian crossbred cows was comparable to the mean service period in Holstein Friesian cows (222.22 ± 6.87days) in Pakistan (Sattar *et al.,* 2005). The variation in service period could be due to delayed conception which is affected by reproductive health, proper heat detection, timely insemination, quality of semen used for AI, skills of inseminator, parity number of cows and in case of natural service; the efficiency of breeding bull. The longer service period may reduce the number of lactations in the life span of cows which ultimately decreases the total milk yield and calves produce by a cow during her lifetime.

Calving Interval

The calving interval of a cow should ideally be one year long (Weldeslasse *et al.*, 2012). Calving interval plays an important role in life production and reproductive efficiency of dairy animals. Mean calving interval of indigenous cows (518.6 ± 9.54 days) in this study was longer than mean calving interval of Sahiwal cows (437 ± 1.46 days) (Zafar *et al.*, 2008); local cow of Bangladesh (415 ± 5.0 days) Al-Amin and Nahar (2007) but comparable to that of calving interval (521.6 ± 37.59) of Red Sindhi cows (Aslam *et al.*, 2002). The mean calving interval of indigenous cows in this study was shorter than that of local cattle of Northern Ethiopia (1.77 ± 0.52 years) (Weldeslasse *et al.*, 2012).

In present study as a result of crossbreeding of indigenous cows mean calving interval was one year in F_1 hybrid and $F_1 \times F_1$ (F_2) cows which is ideal calving interval. The calving interval of these two type of crossbred cows was even shorter than that of calving interval of Jersey cows 487.31 ± 19.08 days (Suhail *et al.*, 2010); 430.15 ± 4.87 days (Sattar *et al.*, 2004) in Pakistan, 387.8 in India (Rao *et al.*, 1997) and 389.32 days in USA (Bertrand *et al.*, 1991), but it was similar to the mean calving interval from crosses of Red Sindhi and Dhanni with Friesian and Jersey (416.9 ± 70.20 days; Aslam *et al.*, 2002).

The mean calving interval of Holstein Friesian cows was 505.02 ± 8.28 days in Pakistan (Sattar *et al.*, 2005); 486.2 days in Sudan (Ageeb and Hayes, 2000); 445 ± 90.8 days in Ethiopia (Tadesse *et al.*, 2010) and 414 in USA (Campos *et al.*, 1994). In this study when F_1 hybrid cows were crossed with Friesian bull the mean calving interval increased in F_1 × Friesian cows and it became nearly equal to the calving interval of indigenous cows. The mean calving interval of F_1 × Friesian crossbred cows was longer than the mean calving interval of Harina × Jersry (F_1) × Friesian cows (487 ± 15.4 days) in India (Dutt *et al.*, 1998). Although crossing of indigenous × Jersey (F_1 crossbred) cows with Friesian bull did not give the good results in term of service period that ultimately resulted in long calving interval. However, in present study the two crossbred cows group i.e., F_1 and F_2 cows produced one calf per year but it was not achieved in F_1 × Friesian crossbred cows due to long calving interval. F_1 × Friesian crossbred cows in this study showed longer calving interval while F_1 crossbred cows showed shorter calving interval. By choosing the Jersey semen for crossbreeding the farmers would be able to produce one calf per year and will also increase the milk yield.

Breeding Efficiency

In present study long service periods and subsequently long calving intervals of indigenous and F_1 × Friesian cows might have contributed to the low breeding efficiency. The long service period might be due to delayed resumption of ovarian activity after calving. The breeding efficiency varied among indigenous and crossbred cows in this study.

The breeding efficiency of indigenous cows (73.46 ± 2.50 %) in this study increased as a result of their crossbreeding with Jersey in F_1 and F_2 crossbred cows. The high breeding efficiency of F_1 (93.68 ± 1.85 %) and F_2 (93.71 ± 2.74 %) crossbred cows was due to their short service period and calving interval. Mean breeding efficiency of F_1 and F_1 × F_1 (F_2) was higher than that of breeding efficiency of Jersey cows in different countries as 87.01 ± 1.73 % in Pakistan (Lateef *et al.*, 2008) and in India it was 88.20 ± 0.55 % (Methekar *et al.*, 1992); 91.66 ± 1.25 % (Jain *et al.*, 1996) 83.98 ± 9.90 (Rao and Rao, 1996).

The breeding efficiency of Holstein Friesian cows was 73.12 ± 2.29 % (Lateef *et al.*, 2008) in Pakistan, 74.9 % in Sudan (Ageeb and Hayes, 2000); 84.4 % in Egypt (Sadek *et al.*, 1989); 82.61 % in Ethiopia (Tadesse and Hayes, 2003) and 87.28 % in USA (Wilcox *et al.*, 1957). In this study when F_1 crossbred cows were crossed with Friesian bull the breeding efficiency decreased in F_1 × Friesian crossbred cows (65.62 ± 3.05 %) compared to F_1 and F_2 crossbred cows. This decrease in breeding efficiency attributed to long service period and calving interval. The long service period of F_1 × Friesian cows might be due to the reason that the these cows did not resume the ovarian cycle at an early time after calving. The breeding efficiency of 50 % Friesian inheritance cows in this study was similar to that of 50 % Friesian inheritance cows (66.3 ± 0.49 %) in Ethiopia (Goshu, 2005).

The high breeding efficiency of Indigenous × Jersey (F_1) crossbred cows compared to F_1 × Friesian crossbred cows in present study is an indicative of better adaptation of Jersey crossbred cow to climatic conditions of Muzaffarabad, Azad Jammu and Kashmir.

Effect of Sire

Among reproductive traits within F_2 crossbred cows, age at first calving, dry period and calving interval were not affected by sire. Similarly in this study sire effects were not observed on reproductive traits within F_1 × Friesian crossbred cows. The non significant effect of sire on age at first calving was indicated by Khattab and Sultan (1990) and Oudah *et al.* (2008). Similarly Sohail *et al.* (2010) also reported no significant effect of sire on some of the reproductive traits such as age at first calving, calving interval and dry period in Jersey cattle under subtropical conditions of Pakistan. The reproductive traits among different breed groups in this study are not biased by sire effects.

4.3. Effect of Parity, Season and Year of Calving on 305 Day Milk Yield in Nondescript Indigenous and Crossbred Dairy Cows

Parity (Lactation Number)

In dairy cattle milk yield is the most important trait of economic importance and 305 day milk yield is used for the genetic evaluation of animals (Amasaib *et al.*, 2008). Various factors affect production during a lactation length of 305 days and consequently the shape of the lactation curve, such as sources of variation are the breed (Grossman *et al.*, 1986), fixed environmental factors (Ray *et al.*, 1992) and management practices (Tekerli *et al.*, 2000) and the calving year, calving season and parity (Hansen *et al.*, 2006).

The present study revealed that mean 305 day milk yield of indigenous and crossbred dairy cows was different in relation to parity number. In indigenous cows a gradual decrease in 305 day milk yield was observed from parity one to parity seven. Whereas other indigenous dairy breeds such as Sahiwal cows showed an increase in milk yield per lactation from parity first to parity six (Zafar *et al.*, 2008). Bajwa *et al.* (2004)

reported that in Sahiwal cow milk yield increased with increase in parity and maximum production was obtained around 4^{th} and 5^{th} parities, thereafter it decreased. Similarly Mustafa *et al.* (2002) found that in Red Sindhi cow the lactation milk yield increased gradually from first to third parity and remained almost constant in fourth parity and after that there was a declining trend from parity five to eight. In Red Chittagong cattle in Bangladesh, lactation milk yield reached a maximum at 5^{th} lactation and then declined (Habib *et al.*, 2010). Singh and Kumar (2007) studied that 305-days milk yield showed a gradual increase over the parities in Karan Fries cows in Karnal India. Parity number exerted a significant effect on 305 day milk yield in F_1 crossbred. The 305 day milk yield increased from first parity to fifth parity afterward there was a decreasing trend as the parity increased but this decrease was not significant. Similarly in $F_1 \times F_1$ (F_2) cows 305 day milk yield increased from one to fourth parity and remained almost constant in fifth parity. Similar finding were observed by Singh and Kumar (2007) for Karan Fries cows in Karnal, India.

Positive association of parity with 305 day milk yield in F_1 and F_2 cows in present work is similar to other studies and may be partly explained that high milk production capacity was due to the greater feed intake in older cows in later parities than young cows in starting parities (Gill *et al.*, 1970; Singh *et al.*, 1982). The gradual increase in milk yield in relation to the parities may be due to increase in the activity of alveolar epithelial cells. The decreasing of milk yield in older age of cows may be due to reason that in older age the milk production decreases due low turnover rate of secretary cell as rate of death of secretary cell is high compared to newly production of active secretary cell (Epaphras *et al.*, 2004).

In F_1 × Friesian cows there was a decline in 305 day milk yield in relation to parity (1^{st} to 5^{th}) but this decrease was not significant. Decreasing trend of 305 day milk yield in F_1 × Friesian cows is similar with finding of Zambrano *et al.* (2006) who observed a decreasing trend in 305 day milk yield in Holstein × Criollo (F_1) from parity one to parity five in Venezuelan humid tropical forest zone. Sandhu *et al.* (2011) studied that in Holstein-Friesian cows in Balochistan, the highest milk yield was achieved in third and the lowest was observed in sixth parity. In Holstein Friesian cows in Ethiopia the mean lactation milk yield increased from first to third parity then remain constant and after parity six a declining trend was observed. Decreasing trend of 305 day milk yield was observed in F_1 × Friesian cows compared to F_1 crossbred cows. These result indicated that such genetic combination are farmed which lead to parity wise increase in milk yield in F_1 hybrid and $F_1 \times F_1$ (F_2) cows. On the other hand in indigenous cows due to inbreeding decrease in milk yield with the advance in parity is expected. Also in F_1 × Friesian cows it appears that good genetic combination are not farmed that could result in increase in milk yield rather these lead to decrease in milk yield with the advance in parity.

Season and Year of Calving

Environmental effects on milk production of dairy cows due to photoperiod and temperature are generally small in temperate environments (Wood, 1970) but can be important in warmer subtropical areas (Abate *et al.*, 2010). Season of calving plays an important role in productive performance, as in high temperature due to increased intake of water feed intake is reduced which leads to decreased milk production. The present study revealed that 305 day milk yield of indigenous cows was significantly affected by season of calving. Similar findings were reported by Hossain *et al.* (2002) from crosses of Bangladeshi local cow with Sahiwal and Red Sindhi. In this study, indigenous cows produced the lowest mean 305 day milk yield in summer calving and the highest mean 305 day milk yield was observed in autumn calving.Whereas in case of crossbred cows season of calving has no significant effect on 305day milk yield in this study as reported by some other studies (Bhadauria and Katpatal, 2003). Holstein Friesian cattle face a challenge in tropical environment due to genotype by environment interactions which may lead to higher rates of involuntary culling (Amasaib *et al.*, 2008). All the crossbred cows in present study under subtropical environment behaved similarly under the influence of season of calving in the term of 305 day milk yield but behaved differently from that of indigenous cows. This may be due to breed and environment interaction. However, from this study it is indicated that overall milk production performance of crossbred cows was better among the cows that calved in winter. This may be attributed to the better environmental conditions and green fodder availability during the production period of cows.

The year of calving significantly affected the 305day milk yield in nondescript indigenous and F_1 × Friesian crossbred cows, which is in agreement with earlier studies (Bhat *et al.*, 1978; Dangi, 1979; Deshpande and Bond, 1982). However 305 day milk yield was not affected by year of calving in F_1 and F_2 crossbred cows. The significant effect of year of calving on 305 day milk yield of nondescript indigenous and F_1 × Friesian cows could be attributed to the changes in environmental conditions which occurred from one year to another.

4.4. Effect of Parity, Season and Year of Calving on Lactation Length of Nondescript Indigenous and Crossbred Dairy Cows

Parity (Lactation Number)

In present study a negative association between lactations length and order of parity was observed in indigenous cows. The lactation length decreased significantly from parity one to parity seven. A similar trend was observed in Sahiwal cow where a highest lactation length was observed for first parity (263 ± 8.8 days), while lowest for that of 4th parity (239 ± 5.8 days) (Bajwa *et al.,* 2004). *Zafar et al.* (2008) found that there was no increase in lactation length in Sahiwal cows from parity first to parity six. In Red Chittagong cattle in Bangladesh, no variation of lactation length was observed by lactation order (Habib *et al.,* 2010).

In F_1 hybrid, F_1 × F_1 (F_2) and F_1 × Friesian cows the parity did not show any effect on lactation length. Whereas Dhara *et al.* (2006) investigated that F_1 crossbred of Jersey × Hariana, Holstein Friesian × Hariana and Brown Swiss × Hariana cattle in West Bengal, the lactation length was longer in first parity compared to the second and third. The lactation length decreased with increasing lactation number from Holstein Friesian × Boran × Barca crosses in Ethiopia (Tadesse and Dessie, 2003).Whereas in Ayrshire x Boran (F_1) crosses in Tanzania lactation length was significantly increased in relation to parity Chenyambuga and Mseleko (2009). A non significant effect of parity on lactation length in Friesian cow was observed in Pakistan (Sattar *et al.,* 2004). In present study the lactation length did not show any increase from first to fifth parity in F_1 and F_1 × F_1 (F_2) crossbred cows but their 305 day milk yield of starting parities was lower than higher parities this might be because of smaller size of udder and nutrient requirement for growth of milking cows which had not grown well, thus reducing the milk yield in starting parities.

Season and Year of Calving

The present study revealed that the season of calving in indigenous, F_1 hybrid, F_1 × F_1 (F_2) and F_1 × Friesian cows had a non-significant effect on lactation length in this study. Similar to our study non-significant effects of season of calving on lactation length were observed by many other such as Bhat *et al.* (1980), Nagarcenkar and Rao

(1982), Rao *et al.* (1984), Dalal *et al.* (1993), Sreemannarayana and Rao (1995). Similar results were also reported on crossbred cows such as Chenyambuga and Mseleko (2009) investigated that in Ayrshire x Boran (F_1) crosses in Tanzania lactation length was not affected by season of calving. Lakshmi *et al.* (2009) studied that season of calving did not affect lactation length in Friesian × Sahiwal cows in India. Similarly lactation length was not affected by season of calving in Holstein Friesian × Boran × Barca crosses in Ethiopia (Tadesse and Dessie, 2003).

The lactation length in indigenous cows was affacted by year of calving. Year of calving also has significant effect on lactation length as reported by Shafiq, (1987) and Dangi, (1979). However, the lactation length from F_1, F_2 and F_1 × Friesian crossbred cows was not affected by the year of calving. This showed that the lactation length from all the crossbred cows behaved similarly in relation to year but behaved in a different way compared to the lactation length from that of indigenous cows. The non significant effects of year of calving on lactation length in crossbred cows are expected as a probable consequence of uniform feeding and management practices over the year.

4.5. Conclusion

- ✓ Crossbreeding of indigenous cows with exotic germplasm has improved the productive traits in crossbred cattle including birth weight, milk yield and lactation length.
- ✓ Similarly the reproductive traits have been improved by reducing the age at first calving, by shortening the dry period, service period and calving interval in crossbred cows. The crossbreeding also improved the breeding efficiency of cows.
- ✓ A decreasing trend in 305 day milk yield was observed in relation to parity number among indigenous and $F_1\times$ Friesian cows. On the other hand an increasing trend was observed in 305 day milk yield among F_1 and F_2 crossbred cows and maximum milk yield was obtained in fifth and fourth parity respectively.
- ✓ Although, in all groups of crossbred cows maximum 305 day milk yield was obtained in cows that calved in winter season. However, the season of calving has a significant effect on 305 day milk yield in indigenous cows and non significant effect on 305 day milk yield in crossbred cows.
- ✓ The lactation length was not affected by the season of calving in nondescript and their crossbred
- ✓ Year of calving had a significant effect on 305 day milk yield and lactation length of nondescript indigenous cows.
- ✓ 305 day milk yield and lactation length of all the crossbred groups was not affected by the year of calving.
- ✓ Within F_2 crossbred cows the sires effects were observed on 305 day milk yield, daily milk yield and service period while the birth weight, milk yield per lactation, lactation length, age at first calving, dry period and calving interval were not affected by sire.
- ✓ The sire effects within $F_1\times$ Friesian crossbred cows were not observed.
- ✓ Overall productive and reproductive performance of Indigenous × Jersey (F_1) crossbred cows was found best to be compared to other two groups of crossbred cows (F_2 and $F_1\times$ Friesian), thus their productive and reproductive performance was satisfactory.

4.6. Recommendations

- Crossbreeding is a good option to for the up gradation of nondescript indigenous cows not only in Azad Jammu and Kashmir but in other areas of Pakistan as well.
- Jersey breed is recommended for crossbreeding in hilly areas like that of Azad Jammu and Kashmir.
- Crossbred cows should be managed to calve better in late winter season as has been seen successful in climatic conditions of Muzaffarabad, Azad Jammu and Kashmir.
- It is suggested that seasonality may be considered for breeding purpose. This may vary from locality to locality accordingly; season may also be given preference when breeding programme is being planned.

4.7. Breeding Scheme/Policy

For the North Part of Azad Jammu and Kashmir the topography of which is mainly hilly and difficult terrain, under the practical conditions the simple crossbreeding strategy is being recommended. It should be based on continuous use of Jersey F_1 males on nondescript indigenous females and by time on crossbred females, in village herds. Maximum of 50% exotic genes should allow to be incorporated in the female stock.

The strategy should be based on two cornerstones:

1) A nucleus herd of selected animals of the pure nondescript indigenous cattle should be kept for continuous selection within the breed and for mating with exotic Jersey breed to produce F_1 males for distribution to village herds. To speed up the programme, F_1 females can be produced directly by using exotic semen in the village herds.
2) Crossbred female in the village herds should be bred to new F_1 males from the nucleus herd to produce the next generation of females

This strategy will result in the production of animals that on average contain 50% of the genes from the indigenous breed and 50% from the exotic breed.

As evaluation of performance of crossbred cattle with 62.5 % Jersey inheritance is under progress at LDRC, In future if a higher degree of upgrading is desired (60–

65%) then the nucleus herd should produce males that initially have 75% exotic genes, but later also F_1 males for rotational use.

A synthetic breed or population will be then underway. However, the degree of success will depend on the extent to which villagers will be involved in the design, implementation and review of stages of the performance and pedigree recording system.

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