STUDIES ON PERSISTENCY OF MILK YIELD IN CROSSBRED CATTLE OF DIFFERENT LEVELS OF EXOTIC INHERITANCE

Thesis

Submitted to the Guru Angad Dev Veterinary and Animal Sciences University in partial fulfillment of the requirement for the degree of

MASTER OF VETERINARY SCIENCE
in
ANIMAL GENETICS AND BREEDING
(Minor Subject: Animal Biotechnology)

By

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(L-2014-V-01-M)

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CERTIFICATE – I

This is to certify that the thesis entitled, **"Studies on Persistency of Milk Yield in Crossbred Cattle of Different Levels of Exotic Inheritance"** submitted for the degree of **Master of Veterinary Science,** in the subject of **Animal Genetics & Breeding** (Minor Subject: **Animal Biotechnology**) of the Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, is a bonafide research work carried out by **Nisha Sharma (L-2014-V-01-M)** under my supervision and that no part of this thesis has been submitted for any other degree.

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

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CERTIFICATE - II

This is to certify that the thesis entitled, **"Studies on Persistency of Milk Yield in Crossbred Cattle of Different Levels of Exotic Inheritance"** submitted by **Nisha Sharma (L-2014-V-01-M)** to the Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, in partial fulfillment of the requirements for the degree of **Master of Veterinary Science** in the subject of **Animal Genetics and Breeding** (Minor Subject: **Animal Biotechnology**) has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with an external examiner.

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ABSTRACT

The present study was undertaken to study the effect of various genetic and non genetic factors on persistency of milk production and to identify the most appropriate persistency method that fits best in our environment. In the present study effect of different non-genetic factors viz. year, season, level of production, days to attain peak yield and animal genetic group based on the level of exotic inheritance on persistency of milk yield in crossbred cattle were studied. The 686 first lactation daily milk yield records of crossbred cattle that were maintained at GADVASU dairy farm over a period of 25 years from 1991-2015 were utilized to calculate persistency coefficients by four methods Ludwick and Peterson method (P1), Mahadevan method (P2), Ratio method(P3) and Prasad et al method (P4). Overall least squares means for persistency by Ludwick and Peterson method (P1), Mahadevan method (P2), Ratio method(P3) and Prasad et al method (P4) were 0.896± 0.096, 1.385±0.224, 187.207± 26.398 and 0.621±0.098 respectively. Effect of animal genetic group on all four Methods was non-significant. Period of calving had significant ($P<0.01$) effect on persistency of milk yield (P2, P3 and P4 method). Effect of level of production on all four Methods was significant ($P<0.05$). The effect of season of calving on persistency of milk yield was found to be significant in all estimates obtained by four methods. Summer and Autumn calvers were most persistent whereas spring and winter calvers were least persistent for (P2, P3 and P4 method). The medium producer cows (2861.45-4033.88 kg) were most persistent and low producer cows (<2861.45) were least persistent for P1, P2, P3 and P4 method. The persistency of milk yield was significantly ($P<0.05$) affected by days to attain peak yield in P1 and P2 methods. Maximum persistency was obtained in animals attaining peak at 41-57 days of lactation and minimum in < 41 days for Mahadevan method and Ratio method. Highest heritability of persistency and minimum value of standard error was estimated as 0.275±0.11 for Mahadevan method followed by Prasad method (0.197±0.10) by half sib correlation method. Maximum coefficient of variation which indicates available variability was estimated as 20.788 for persistency by Mahadevan method followed by 18.969 for Prasad method. Highest correlation was also observed between P1 and P3 method by Spearman and Pearson's correlation for least squares breeding value of the sires. On the basis of heritability, standard error of heritability and coefficient of variation, it was concluded that Mahadevan method followed by Prasad method suits best to our environment for animals in first lactation as well as they can be utilized for effective selection for higher persistency in crossbred animals of Punjab.

Keywords: Persistency, Daily milk yield, Pearson Correlation, Spearman correlation and Heritability

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Signature of Major Advisor **Signature of the student**

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LIST OF ABBREVIATIONS

An No	:	Animal number
GG	:	Genetic Group
ANOVA	:	Analysis of Variance
DAPY	:	Days to attain peak yield
DMY	:	Days milk yield
ISRDD	:	Intrasire Regression of Daughter on Dam Method
LL	:	Lactation length
LL	:	Lactation length
LMY	:	Lactation milk yield
ML	:	Maximum likelihood
MVQUE	:	Minimum Variance Quadratic Unbiased Estimation
P1	:	Ludwick and Peterson method of persistency
P2	:	Mahadevan method of persistency
P3	:	Ratio method of persistency
P4	:	Prasad method of persistency
PIs	:	Persistency indices
PY	:	Peak yield
REML	:	Restricted maximum likelihood

CHAPTER – I

INTRODUCTION

Crossbred cattle hold a key position in the growth of dairy sector in India as crossbred cattle though merely 13.26 % of the total bovine population of India, yet they contribute 24.46 % of the total milk yield by bovines. In the state of Punjab, where dairy farming is more developed, the wide acceptance of crossbred cattle is evident from the fact that 85.06 % of total cattle in Punjab are crossbreds (Basic Animal Husbandry Statistics, 2015). Persistency of lactation is the ability of animal to continue producing milk at a high level after reaching the peak of lactation. The main aim of the animal breeder is to enhance genetic improvement in important economic traits.

Mathematically, persistency is the average percentage or degree of decrease in production each month to that of previous month. Improved persistency of lactation can contribute to reduce the cost of the production system because lactation persistency is associated with feeding and health costs, reproductive performance and resistance of disease and return from milk (Dekkers *et al* 1998). Over a period of time, economic benefits of persistency can be enhanced by selecting the animals which were persistent during their lactation. Excistence of variation in persistency shows that a better breeding stratergy could accrue, maximum results if persistency is one of criteria of selection. The success of dairy industry is much dependent on the level of production and reproductive traits of the animals. The main income for most dairy farmers is based on milk, fat and protein yields of their crossbred cows. Studies revealed that milk yield in a lactation depends mainly on persistency, peak yield and lactation length. More persistent animals produce relatively higher milk and therefore, They have longer productive life (Narain *et al* 1981) and (Ramachandraiah *et al* 1990).

According to Wood (1967) persistency is, “the extent to which peak yield is maintained”. According to Jamrozik *et al* (1998) persistency of lactation is the ability of animal to continue producing milk at a high level after reaching the peak of her lactation. The peak yield is maintained for a shorter duration and thereafter, it declines progressively till the milk secretion ceases.

Studies revealed that milk yield in dairy cattle increases rapidly from calving to peak period of yield in a few weeks, there after it gradually decreases until milking is no longer practical (Leon-Velard *et al* 1995). Selection for total milk yield and persistency concurrently would contribute to higher lactation. Persistency of milk is always considered to have more advantages for selection. Solkner and Fuchs (1987) found that more persistent cows have lesser feed intake cost and contribute to more economic returns from animal by increasing the lactation milk yield, resulting in increased profitability. Low individual persistency of milk yield is governed by certain genetic and non-genetic factors.

Milk production is not uniform throughout the lactation period. It is a common that milk yield displays a definite trend throughout the lactation. The daily milk yield rises to a maximum point (peak yield) in a few weeks after calving, thereafter stabilises for some period (persistency) and then decreases gradually till the milk secretion stops. More persistent animals have been reported to have higher lactation milk yields as reported by Ludwick and Peterson (1943), Mahadeven (1951) and Saxena and Kumar (1960). A persistency measure that is independent of yield will therefore allow more efficient selection for total yield and persistency simultaneously (Muir *et al* 2004). Persistency in lactation is directly related with economical aspects of dairying, since its improvement can contribute to reduction of production costs. Genetic and environmental factors contribute towards differences in persistency, peak yield, days to reach peak yield, lactation length and lactation yield among animals. Relative importance of these factors is important in optimizing selection criteria.

Therefore, keeping in view the importance of persistency of milk yield of crossbred cattle *vis a vis* improved lactation yield, the present study was conducted with the following objectives:

1. To study the effects of genetic and non- genetic factors on persistency of milk yield.
2. To identify the most appropriate persistency method that fits best in our environment.

CHAPTER – II

REVIEW OF LITERATURE

The knowledge of persistency of lactation yield is very important for managing dairy farm profitability by decreasing input cost and increasing the lactation milk yield. An insite review pertaining to genetic studies on production efficiency attributes in Crossbred cattle (HF x Sahiwal) is done which includes the following parameters:

2.1 Persistency

It can be defined as the ability of animal to maintain milk production at a high level after peak production or usually refers to the rate of decline in daily yield after peak of lactation (Togashi and Lin 2004). A more persistent animal has more productive life and hence more milk yield so high persistency is necessary to maintain high level of production. Economically milk production depends mainly on peak yield and persistency of milk production. Milk production starts at a relatively high rate and the amount secreted continues to increase for about 3-6 weeks. After a peak is attained, milk production gradually declines. The increase in milk yield in early lactation may be attributed to an increase in the secretion rate per cell, which is partially associated with increased milk flow through the mammary gland. On the other hand, the decrease in milk yield after peak production is associated with a die-off of secretory cells as well as hormonal changes.

The method ratios including the method of percentage yields and weighted average ratios seems to be widely accepted as a measure of persistency by various workers as Ludwick and Peterson (1943) and Mahadeven (1951) However, the periods of lactation chosen to define ratios differ widely with different workers and there seem to be no agreement as to which periods of lactation should be considered for defining these ratios.

Dhaka *et al* (1994) measured the persistency of lactation milk yield by three methods. The methods were: P_1 (Ludwick and Peterson 1943), P_2 (Mahadeven 1951),

P_3 (Ratio method=Lactation milk yield/peak yield). The overall averages for P_1, P_2 and P_3 were 0.90, 1.19 and 187.14 per cent, respectively.

Shaflq *et al* (1994) estimated least square means persistency of first lactation by Mahadeven (1951) method from 257 Sahiwal cows. The estimates were l.61 ± 0.04 (1.33 ± 0.19 to 2.00 ± 0.13) based on data on progeny of 15 sires.

Zakariyya *et al* (1995) and Ahmad *et al* (2003) estimated persistency of milk yield by Ludwick and Peterson (1943) method and it was 91.31 ± 0.55 kg for 437 lactation records and 90.5±0.01 respectively.

Dekkers *et al* (1998) suggested the following criteria in selecting a better measure of persistency. The measure of persistency must be uncorrelated with 305 days yield. The measure of persistency must have substantial genetic variance which contribute to economic factors also.

Grossman *et al* (1999) categorized persistency measures in literature into three groups: 1. Measures expressed as a ratio of yields 2. Measures derived from variation of test day yields and 3. Measures constructed of parameter estimates from lactation curves.

Belayneh *et al* (2001) observed significant effect of level of exotic inheritance on days to attain peak yield, 300 days milk yield, lactation yield, annual milk yield. The effect of level of exotic inheritance was significant for all the traits studied except for lactation length and peak yield.

Tekerli *et al* (2001) analyzed the lactation for estimation of persistency by three ratio methods: P_1 the ratio of 305-day yield to maximum daily yield; P_2 the coefficient of variation (%) among daily yields in successive days and P_3, the average of proportions of each month's milk yield to preceding month's milk yield after the peak is attained. The average mean of P_1, P_2, and P_3 were 120.56 ± 1.72, 34.99± 1.07% and 85.22 ± 0.92% respectively.

Kaya *et al* (2003) found that effects of sire, calving season, and calving year on measures of persistency and milk yield traits were significant. First lactations were

more persistent than later lactations. Generally, autumn- calvers were most persistent and spring- calvers were least persistent.

Muir *et al* (2004) estimated the genetic relationships between lactation persistency and reproductive performance in first lactation. Reproductive traits of heifer had low genetic correlation, whereas reproductive traits of cows were moderately correlated. Young heifers than conceived first tended were more persistent in first lactation.

Kumar and Singh (2006) studied effects of genetic and non -genetic factors on persistency of crossbred cattle and reported that rainy calvers were most persistent whereas the winter calvers were least persistent and correlation between peak yield and lactation milk yield (0.61) was positive and highly significant ($P < 0.01$). There was significant and negative correlation of peak yield with all the persistency indices across all the four parities.

Cobuci *et al* (2007) observed that the rank correlation estimates for persistency of lactation and 305 days milk yield were practically the same for sire and cows, and ranged from -0.45 to 0.69. The estimated breeding values for milk yield during lactation for sires producing daughters with superior 305 days milk yield indicate genetic differences between sires regarding their ability to transmit desirable persistency of lactation traits. This suggests that selection for total lactation milk yield does not identify sires or cows that are genetically superior in regard to persistency of lactation. Genetic evaluation for persistency of lactation is important for improving the efficiency of the milk production capacity of Holstein cows.

Das *et al* (2007) reported the least squares means of persistency of milk yield in the first lactation and overall lactations were 96.99 ± 0.53 and 97.40 ± 0.28 percent, respectively.

Swalve *et al* (2011) estimated the genetic correlations between milk yield and persistency to be favourable for selection on yield for the two ratios ($r_g = 0.50/ -0.50$) and correlations among criteria of persistency were favourable. No apparent

differences existed between using 305-days milk yield (DMY) records or test-day records.

Dongre *et al* (2011) observed that milk production during the entire lactation is a continuous physiological function which describes the rate of milk secretion with advancement in lactation. The biometrical properties of lactation are different in different genetic groups even if the environmental and managerial factors are constant.

Wondifraw *et al* (2013) reported that the least squares mean of lactation milk yield, 305DMY, lactation length (LL), and milk yield per day of lactation length were 1661.35±15.17, 1707.25±13.25, 296.80±2.29 and 5.65±0.04 kg, respectively. Milk production was depressed for cows calving in summer. First lactation cows had lowest milk production, and highest production occurred in 5th parity.

Yamazaki *et al* (2014) found antagonistic genetic correlations between reproductive traits and persistency, which ranged from -0.17 to -0.39. Therefore, when selecting dairy cows to increase lactation persistency, female fertility indicators have to be included in the genetic evaluation to reduce undesirable effects on fertility. Genetic relationships among reproductive traits in cows, 305-day milk yield, and persistency were constant over the first three lactations.

Patond *et al* (2014b) observed the least square means for persistency of milk yield in Jersey cattle were, 12.99±0.40, 0.88±0.009 and 67.83±0.73 by Method I (Mahadevan,1951), Method II (Ludwick and Peterson, 1943) and Method III (McDowell *et al.*, 1961), respectively. Effect of period of calving had significant ($P<0.01$) on persistency of milk yield (Method II and Method III). Effect of season of calving on all three methods had non-significant.

Bhuktar *et al* (2014) reported that overall least squares means of lactation milk yield, peak milk yield, days to reach peak milk yield, lactation period and dry period were 358.31±27.18, 3.14±0.18, 44.81 ±2.52, 213.90 ±13.74 and 211.93± 26.23. Period of calving had significant effect on lactation milk yield, peak milk yield and

dry period, whereas non-significant effect on days to reach peak milk yield and lactation period. Season of calving had non- significant effect on production traits.

Anarase *et al* (2015) observed significant effect of period of calving (P≤.01) on peak milk yield, persistency of milk production, lactation milk yield and lactation length. Season of calving significantly (P≤.01) influenced lactation length. There was significant correlation between peak milk yield (0.356) and days to attain peak yield (-0.553).

Garudkar *et al* (2015) observed least-squares mean of lactation milk yield, 300 days milk yield, lactation length and persistency were 3424.12±103.86 kg, 3005.66 ± 80.04 kg, 389.72±8.14 days and 11.00±0.71 respectively. Garudkar (2015) estimated least square means persistency by Mahadeven (1951) method from 194 Phule Triveni synthetic cows.

Shingare *et al* (2015) found Least squares means for persistency of milk yield in Deoni cattle by Mahadevan method was 2.98±0.20. The significant effect of period of calving was recorded on 305 DMY, LL, Peak yield (PY) and Days to attain peak yield (DAPY) and non-significant effect was recorded on persistency of milk yield and lactation milk yield. The non-significant effect of season of calving & lactation order was recorded on persistency of milk yield & all milk production traits. Moderately high heritability were observed for persistency of milk yield (0.36 ± 0.23) and LL (0.25 ± 0.23).

Japheth *et al* (2015) observed significant effect of season of calving and period of calving (P<0.05) on 305 days or less milk yield. While season of calving was significant (P<0.01) on total milk yield and milk yield per day of lactation length. Effect of period of calving was also significant (P<0.01) on age at first calving, 305DMY, total milk yield, lactation length, milk yield per day of lactation length and milk yield per day of calving interval.

Patel *et al* (2015) analyzed persistency of milk production in Holstein Friesian cattle up to 42nd week of lactation and the overall persistency (%) for weekly milk production in first lactation was 84.45%.

Kaushal *et al* (2016) observed first lactation records of 351 Sahiwal cows to estimate the persistency by Rao and Sundaresan method. The average persistency of milk yield estimated by Rao and Sundaresan method was 194±1.10.

2.2 Environmental and physiological factors affecting persistency

Persistency of lactation yield has been studied by several workers. Mahadeven (1951) concluded that major part of variation in persistency was of non-genetic origin and it could be improved by proper managerial and feeding practices. Garcha and Tiwana (1980) also studied various factors affecting the persistency of milk yield and concluded that effect of period of calving on persistency was significant.

Alrawi and Alani (1981) reported that origin of bulls had non- significant effect on total milk yield and persistency in friesian cows. Maarof and Tahir (1988) stated that persistency was not affected by sire in friesian cows. Pathak *et al* (1980) and Ibeawuchi (1988) reported significant effect of sire on persistency. Chaudhary *et al* (2000) found the significant effects of season of calving, parity and lactation length on the persistency. Tekerli *et al* (2001) concluded that various environmental factors such as period, season, parity, age significantly affected the persistency of lactation yield.

Persistency of milk yield is influenced by various factors such as inheritance, period, season and parity as reported by various workers (Kumar *et al* (1979), Rao and Sundaresan (1979, 1981), Cady *et al* (1983), Khan and Johar (1985), Parkash *et al* (1989), Kandasamy *et al* (1993) and Dhaka and Chaudhary (1994).

2.2.1 Effect of period of calving

Balaine *et al* (1969) analysed first lactation milk yield in Hariana cattle and observed that period of calving significantly affected persistency, peak yield, lactation length and yield. Persistency was also significantly affected by season of calving. Peak yield and lactation length were genetically positively correlated with lactation yield. Peak yield and persistency were negatively associated both phenotypically and genetically. Peak yield had a low correlation with lactation length, however these correlations were not statistically significant.

Bhat *et al* (1982) observed that the year of calving significantly affected the persistency of lactation measured by Ludwick and Peterson, Mahadevan and Ratio methods.

Non-significant effect of period of calving on persistency was reported by Koley *et al* (1979) in Hariana crosses**,** Gupta and Johar (1982) in Tharparkar cattle. However, Shaflq *et al* (1994) observed that persistency of milk yield was not affected by year of calving in Sahiwal cattle.

Singh and Khanna (2000) reported that the persistency indices measured by Ludwick and Peterson method was significantly affected by period of calving in crossbred cows.

Ahmad *et al* **(**2003) found that the year of calving had a significant ($P<0.01$) effect on persistency of lactation. Kumar and Singh (2006) reported significant ($P<0.05$) effect of year of calving on persistency.

Das *et al* (2007) found that effect of period of calving on persistency of milk yield in the first lactation was not statistically significant.

Garudkar *et al* (2015) found that the period of calving had a significant ($P<0.01$) effect on persistency of milk yield.

Shingare *et al* (2015) found that effect of period of calving had non-significant effect on persistency of milk yield estimated by Mahadevan method.

2.2.2 Effect of season of calving

Rao and Sundaresan (1982) in Holstein-Friesian x Sahiwal crossbred cows observed that season of calving had significant effect on persistency. They reported that the monsoon calvers (July-Sept) those started their lactations at a relatively lower level had the highest persistency indicating the influence of succeeding seasons (winter) which were congenital in climate and fodder availability.

Ibeawuchi *et al* (1988) found that season of calving had a significant ($p<0.05$) effect on persistency of lactation of Friesian x White Fulani cattle.

Prasad *et al* (1999) in crossbred cattle found that summer and monsoon calvers were more persisteant than winter calvers.

Significant effect of season of calving on persistency of milk yield was reported by Pathak *et al* (1980), Khan and Johar (1985), Maarof and Tahir (1988) in Friesian cows of Iraq. Whereas, non-significant effect of season of calving on persistency of milk yield was reported by Koley *et al* (1979) in Hariana crosses and Gupta and Johar, (1982) in Tharparkar cattle.

Belayneh and Hedge (2001) found that effect of season was highly significant ($P<0.01$) for days to reach peak yield whereas no significant effect on lactation length, 300 days milk yield and peak yield. The first calvers had higher persistency, longer lactation length and longer period (days) to reach peak yield year of calving had significant effect in all traits ($P<0.01$). There was no significant effect of season of calving on lactation length, lactation yield annual milk yield, 300 days milk yield and peak yield.

Kumar and Singh (2006) reported that the rainy calvers were most persistent whereas the winter calvers were least persistent for milk yield and the effect of season was highly significant on persistency.

Das *et al* (2007) reported that effect of season of calving was significant ($P< 0.01$) on the persistency of milk yield in overall lactations.

Abate *et al* (2010) reported that effect of season of calving had no significant effect on the milk yield per lactation, lactation length, peak yield, and persistency index whereas, the year of calving had no significant effect on only the lactation curve parameters. Persistency correlated negatively with the lactation period, peak yield. The study concluded that these crossbred (Kenana × Friesian) cows have moderately repeatable milk persistency.

Hamdi *et al* (2012) observed that least squares mean was higher for autumn calvers (307.6±4.57 days) as compared to spring calvers (296.7±3.99 days). Although, summer and winter calvers have similar lactation length (301.4±4.12 and 303.7±4.28 days) but winter calvers have the highest milk yield (5827±63.17 kg).

Hussain *et al* (2014) reported that effect of season of calving had no significant on first lactation production and reproduction traits whereas the effect of period of calving was found to be significant on first lactation production and reproduction traits.

Bahashwan and Alfadli (2014) observed significant effect of season of calving ($P < 0.05$) on daily milk yield and the highest means were found in autumn and summer with 7.55 ± 0.27 and 7.18 ±0.61 kg/day, respectively.

Shingare *et al* (2015) observed that Season of calving had non-significant effect on the persistency and lactation traits. Cows calved in summer season had the higher persistency than rainy and winter calvers. Persistency of milk yield was highest in summer season (S1) followed by rainy (S2) and winter (S3).

2.2.3 Effect of genetic groups

Ludwick *et al* (1943) postulated that major portion of variation in persistency was of genetic origin controlling the development and rate of function of endocrine glands.

Rao and Sundaresan (1982) in Holstein Friesian x Sahiwal observed the highest persistency in half bred cattle followed by 5/8 and 3/4 bred using ratio method.

Bhutia and Pandey (1989) reported that genetic groups affected persistency of lactation significantly by ratio method. The 5/8 Holstein Friesian had the highest persistency followed by ½ and ¾ Holstein Friesian.

Shubha Lakshmi *et al* (2009) studies revealed that cows with Holstein inheritance of 5/8 and above had higher yields than cows of lower genetic grades ($P \leq 0.01$).

Saha *et al* (2010) studies revealed that the crossbred cattle with >62.5% exotic inheritance were found to be superior with respect to reproduction traits, while maximum milk yield was observed for the animals with exotic inheritance > 50 to 62.5%.

2.2.4 Days to attain peak yield (DAPY)

It is defined as the period from the calving to the date when maximum milk yield is attained.

Kundu *et al* (2003) found period of calving had significant (P <0.01) influence on PY, DAPY, total yield up to peak but rate of increase up to peak yield did not influence significantly by period of calving.

Bee *et al* (2006) found that daily milk yield was affected by *Bos taurus* inheritance (P<0.05). The cows with 75% *Bos taurus* inheritance produced more milk than the other *Bos taurus* levels and this was followed by the 62% *Bos taurus*. Dairy cattle farmers who practice zero grazing should be advised to keep crossbred animals of the intermediate exotic blood (62.5-75%) for good production performances.

Taher *et al* (2012) evaluated effect of some non-genetic factors (season of calving, year of calving) on peak milk yield and days to attain peak yield .The least-squares means for peak milk yield and days to attain peak yield were :14.252± 4.763 kg and 47.528 ± 24.121 days. Peak milk yield was significantly influenced by year of calving.

Patond *et al* (2014a) found overall least square means for peak yield and days to attain peak yield in Jersey cattle were, 13.10±0.37 kg and 21.41±0.46 days, respectively. Significant (P<0.01) effect of period of calving on peak yield was observed in Jersey cattle, whereas the effect of period of calving on days to attain peak yield was non-significant. The effect of season of calving was non-significant for peak yield. The effect of lactation order on peak yield and days to attain peak yield was non-significant in the present study.

2.2.5 Level of milk Production

Kumar and Singh (2006) revealed that the level of milk production had highly significant (P<0.01) effect on persistency measured by Ratio (Rao and Sundaresan) method and Prasad method. There was no any significant effect of level of production on Mahadevan method. The high producer cows were most persistent for Ratio and Prasad method with their means being 214.50±2.44 and 0.71±0.00 respectively. The low producer cows were least persistent for Ratio and Prasad method with their means being 192.81±2.64 and 0.65±0.00 respectively.

Table 1: Average number of days to attain peak yield (DAPY) in Buffalo and Jersey cattle

Mean ± S.E.(Days)	Number of observations	References	Year
48.26±1.63	863	Garcha and Tiwana	1980
50.40±0.97	1250	Vij and Tiwana	1987
52.50±0.00	45	Govindaiah and Rai	1987
58.30±5.50	-	Neog *et al*	1993
32.00±1.00	369	Rao and Rao	1996
62.64±0.00	502	Chhikara *et al*	1998
45.47±1.32	311	Kundu *et al*	2003

2.3 Genetic and phenotypic correlation of persistency of milk yield with peak milk yield, 305-days milk yield, total lactation yield.

Mahadevan (1951) found a positive relationship between persistency and total milk yield. Malhotra *et al* (1984) and Dhaka *et al* (1998) observed high positive correlations of persistency of the first lactation with lactation milk yield. However Balaine *et al* (1969) found that persistency was phentoypically correlated positively with lactation yield while with peak yield were negatively associated both phentoypically and genetically.

Madsen *et al* (1975) used five measures of persistency of milk yield by using 598 first lactation records and 354 records of all parities from Red Danish cows. Correlations between persistency, expressed as the absolute decrease of yield, and maximum daily yield were -0·46 to -0·52 (phenotypic) and -0·22 (genetic). Correlations between the measure of persistency and 305-day yield were 0·12 to 0·45 (phenotypic) and 0·45 to 0·69 (genetic).

Khan *et al* (1980) reported the persistency index was significantly correlated with milk yield (0.29) and duration of lactation (0.34). Leukkunen (1985) estimated for genetic correlation between persistency and milk yield are 0 to 0.17 in the first and

0.45 to 0.55 in the second lactation. Shaflq *et al* (1994) the phenotypic correlation between total milk yield and persistency was 0.305.

Gengler *et al* (1995) reported genotypic and phenotypic correlation between persistency and 305 days lactation was positive. The phenotypic correlation ranged from 0.26 to 0.88 between all measures of persistencies.

The genetic correlation estimated by Jamrozik *et al* (1998) between level of production and persistency of production were –0.10, 0.01 and –0.00 for milk for the first, second and third lactation respectively.

Dhaka *et al* (1998) has reported correlation range between persistency and lactation milk yield was 0.14 (0.07 to 0.53, depending on the, method of calculating persistency). However, the correlation with peak yield was negative (-0.13) in Murrah buffaloes.

Ahmad *et al* (2003) reported persistency of lactation had a positive and significant ($P<0.01$) correlation with lactation yield (0.17) and lactation length (0.28) and correlation of persistency of lactation with service period was 0.20 ($P<0.01$), suggesting that better persistent cows tended to have longer service period.

Das *et al* (2007) concluded that persistency of milk yield in the first lactation was found to have a positive correlation with lactation milk yield, peak yield and days to attain peak yield.

2.4 Heritability

Heritability helps to determine which selection method is suitable for the improvement of yield. Heritability value for persistency of lactation yield was found between 0.01 (Balaine *et al* 1969) and > 0.30 (Smith and Legates 1962) with most values around 0.10. The higher heritabilities were reported by Madsen (1975) in Danish cows (0.40 to 0.57).

Shanks *et al* **(**1981) reported heritability for persistency was 0.02 but Batra *et al* (1987) reported heritability for persistency was 0.21. Gengler *et al* (1995) worked on 31482 first lactation records and calculated various persistencies and reported that heritabilities of several persistency measures were above 0.10 while Gengler (1995b)

reported 0.14. Chaudhry *et al* (2000) concluded that persistency was 9% (0.091±. 0.043) heritable.

Leukkunen (1985) measured persistency by four ways, one of them based on an exponential function. Heritability estimates varied from 0.08 to 0.11 for heifer persistency and from 0.18 to 0.21 for second lactation persistency.

The persistency heritability in the temperate zone in Dutch HF cows was estimated by Van der Linde *et al* (2000) as 0.13, Muir *et al* (2004) also reported heritability for persistency to be 0.18 in Canadian HF.

Jakobsen *et al* (2002) compared 5 measures of persistency derived from parameters of lactation curves using random regression test-day models. Heritabilities ranged from 0.09 to 0.24 for persistency of milk yield.

The dataset consisted of 87,942 and 50,469 cows with milk yield records in the first and second parity, respectively studied by Haile-Mariam *et al* (2003) and the heritability estimates for persistency of milk yield were 0.09 and 0.11 in the first and second parity, respectively.

Kitpipit *et al* (2004) reported the heritability estimates for persistency measures and found that the values ranged from 0.01 to 0.03 for 2,308 lactation records of Holstein cows.

Geetha *et al* (2006) found that the heritabilities of test day milk yield varied from 0.33 to 0.58 in different test days. Kumar and Singh (2006) reported the heritability estimates for persistency as very low (0.01 to 0.17) with high standard errors. However, Cole and Vanraden (2006) obtained heritability estimate for persistency of milk as 0.10.

Weller *et al* (2006) calculated the heritability of persistency of milk yield to be 0.17 (0.16 to 0.27) from first through third parity, and then it declined through fifth parity in Israeli HF cows.

Atashi *et al* (2006) studied data set comprising of 36487 first lactation yield records on Holstein dairy cattle of Iran and found out heritabilities based on the univariate models varing from 0.0469 to 0.0819 for persistency criteria.

Balaine *et al* (1969) estimated heritability of milk yield as 0.40 in Hariana cattle, 0.28 in Ayrshire cattle by Leukkunen (1985), 0.30 for Japanese Holstein cows by Suzuki and Van (1994), 0.123 ± 0.132 for Sahiwal cows by Shaflq *et al* (1994) and 0.65 for Brown Swiss, 0.20 for Holstein by Klopcic *et al* (1997) for all lactations, 0.471 ± 0.224 for Hariana cattle by Pandey *et al* (2001), 0.404 for cattle by Deb *et al* (2008)**,** 0.20 for HF x Sahiwal cattle by Shubha Lakshmi *et al* (2009), 0.24 for Iranian Brown Swiss crossbred dairy cattle by Gorbani *et al* (2011).

2.5 Heritability estimates of persistency

The review on heritability estimates by paternal half sib correlation method and Intrasire regression of daughter on dam method for different measures of persistency is given in the following table.

Perusal of the Table 2 indicated that the estimates of heritability for different measures of persistency ranged between 0.12 and 0.41 for Sahiwal, Red sindhi and Brown Swiss x Sahiwal crosses by intrasire regression of daughter on dam method. Furthermore, estimates of heritability by paternal half sib correlation method ranged between zero and 0.33 for different breeds of cattle and buffaloes. The heritability estimates of persistency indices in most of the cases were low to medium but with high standard errors making these estimates unreliable. It seems that persistency is more influenced by environmental variation than genetic causes of variation.

Shanks *et al* (1982) estimated the heritabilities in various parity and find out that the heritability of mature-equivalent milk production declined as lactation number increased: 0.27 ± 0.02 in first, 0.21 ± .02 in second, 0.16 ± 0.02 in third, and 0.15 ± 0.02 in fourth lactation

Haile-Mariam *et al* (2003) estimated the highest heritability (0.32) for mean milk yield in the first parity.

Cilek and Sahin (2009) worked on 2653 lactation records and estimated heritability of milk yield for first, second and all lactations were as 0.47±0.12, 0.38±0.04 and 0.30 ± 0.06, respectively.

Table 2: Heritability estimates of different measures of persistency

Method	Breed	Estimate	Measure of persistency indices	Reference
Paternal half sib correlation	Holstein cattle	0.21±0.17	Ludwick and Peterson	Dutt and Saxena 1966
ISRDD	Sahiwal	0.41±0.18	Mahadevan	Sharma and Bhatnagar,1974
ISRDD	Red sindhi	0.12±0.32	Mahadevan	Sharma and Bhatnagar,1974
ISRDD	B x S crossbreds	0.37±0.18	Mahadevan	Sharma and Bhatnagar,1974
Paternal half sib correlation	Tharparkar	0.33±0.18	Ludwick and Peterson	Gupta and Johar,1983
Paternal half sib correlation	Murrah buffalo	0.25±0.17	Ludwick and Peterson	Dhaka *et al*, 1994
Paternal half sib correlation	Sahiwal	-0.29±0.32	Ludwick and Peterson	Dhaka *et al* (1994)
Paternal half sib correlation	Buffalo	-0.919±0.11	Ludwick and Peterson	Narain *et al* (1981)
Paternal half sib correlation	Murrah buffalo	-0.111±0.07	Ludwick and Peterson	Khan and Johar (1985)
Paternal half sib correlation	Hariana cattle	-0.004±0.05	Ludwick and Peterson	Gill (1969)

CHAPTER – III

MATERIALS AND METHODS

3.1 Source of data

The data pertaining to ancestory, production and reproduction for the present investigation were collected from the history-cum-pedigree sheets, daily milking register, calving register, peak yield register, drying register, production and reproduction records maintained at the Dairy farm of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana. The data with respect to required traits were collected over a period of 25 years i.e. from 1991 to 2015. The 686 lactation records of first lactations were used in the present study.

3.2 Animals under study

The data of crossbred cattle Holstein Friesian x Sahiwal maintained at GADVASU Dairy Farm was used for analysis. Cattle with abnormal or conditions such as abortion or premature birth, still birth, sickness, culling or death before completion of lactation period were excluded from the study. For first lactation 305 days milk yield only those crossbred cattle were considered which produced milk for at least 200 days**.**

3.3 Management and Feeding of herd

At the Dairy Farm of GADVASU, the animals were kept in loose housing system having some covered area. The animals were having free access to feed and water. The following groups of animals were housed separately:

1. Suckling calves
2. Breeding heifers
3. Pregnant heifers
4. Dry cows
5. Cows in milk

The calves were weaned immediately after birth and fed on colostrum for the first four days. Whole milk from fifth day onward to sixteen week of age was given.

The green fodder and calf starter consisting of grains, cakes, brans (rice/wheat), bypass protein and mineral mixture were offered from one month of age onward. The calves were kept in individual calf pens, usually upto four month of age, and were provided adequate protection from adverse weather conditions.

The animals were kept in groups in loose housing system and male calves were housed separately. Heat detection in animals at the farm was done by parading the vasectomised bull and through the signs exhibited by the animals in the heat. Artificial insemination was the sole procedure followed for breeding. The advanced pregnant animals were segregated to the calving pens at least six weeks before the expected date of calving. The freshly calved cattle were kept in calving line for one week, after which the animals with normal calving are shifted to the milking herd. The buffaloes were hand/machine milked twice daily. The milk yield is weighed at each milking and recorded separately for each cattle. Following feeds/fodders/roughages/Silage were fed to the animals according to seasonal availability:

1. Berseem
2. Oats
3. Jowar
4. Bajra
5. Maize
6. Makchari
7. Wheat straw

Out of the above-mentioned feeds, Berseem and oats were fed to animals during the rabi season and jowar, bajra, makchari and maize during kharif season given as green fodder and wheat straw was given as dry fodder. During kharif season, silage is prepared from jowar, bajra and maize and oats in rabi season was fed to animals in the periods of lean fodder production. Maintenance ration was fed to the animals in the morning hours once in a day while the production ration to the milking crossbred cattle was fed at the time of milking. Balanced concentrate ration was fed to the animals.

3.4 Recording of Data

The records were collected on the cattle herd covering a period from 1991 to 2015. Whole of the data recording was done by dividing it into two parts and following observations in each part were recorded on crossbred cattle:

The data pertaining to animal number, dam number and sire number were collected from the history sheets.

3.4.1 Production

1. 305 day milk yield	MY
2. Lactation milk yield	LY
3. Peak yield	PY
4. Lactation length	LL

The data pertaining to date of birth, date of calving, Daily milk yield (morning and evening), Post peak period(days), Pre-peak period(days), Post-peak milk production (kg) and Pre-peak production (kg) were collected from the birth registers, milking registers, history sheets and computer database maintained at the dairy farm of the GADVASU, Ludhiana.

3.5 Classification of data

3.5.1 Division of year into different season

The years of calving were classified into four different seasons as shown in Table 3.

Table 3: Division of year into different season

Season	Month	Code
Winter	December to February	1
Spring	March to May	2
Summer	June to August	3
Autumn	September to November	4

3.5.2 Grouping of calving year into periods

The data spread over 25 years was divided into five periods of calving. Year to year variation within period was assumed to be non-significant. So the whole calving years from 1991 to 2015 were divided into 5 periods as shown below:

Table 4: Division of year of calving into periods

Sr No.	Years	Code
1	1991-1995	1
2	1996-2000	2
3	2001-2005	3
4	2006-2010	4
5	2011-2015	5

Table 5: Division of animals into different genetic groups

Level of Exotic inheritance	Code
<75%	1
=75%	2
>75≤87.5%	3
>87.5%	4

Table 6: Grouping of days to attain peak yield into Days

Days to attain peak yield	Code
<41	1
41-57	2
>57	3

Table 7: Grouping of level of production

Level of production	Code
<2861.45	1
2861.45-4033.88	2
>4033.88	3

3.6 Persistency

The persistency was calculated by a method developed by following methods:

3.6.1 Ludwick and Peterson (1943):

According to this method, the persistency is defined as the summation of consecutive ratios, obtained by comparing production of each individual sub division of lactation period with the preceding period. This method was developed by Ludwick and Peterson (1943) and was used by Gupta and Johar (1982) in Tharparkar, Sharma and Bhatnagar (1974) in Red Sindhi and Sahiwal, Roy and Katpatal (1987) in Jersey cattle, Gawari *et al* (1999) in triple crossbred cattle, Singh *et al* (1999) in crossbred cattle, Kumar and Singh (2006) in Karan Fries cattle, Patond *et al* (2014b) in Jersey cattle to measure the persistency index.

$$\boldsymbol{P_1 = \frac{X_2}{X_1} \times K1 + \frac{X_3}{X_2} \times K2 + \frac{X_4}{X_3} \times K3}$$

Where

X_1 = milk yield during second and third month.

X_2 = milk yield during fourth and fifth month

X_3 = milk yield during sixth and seventh month

X_4 = milk yield during eighth and ninth month

.

$$K1 = \frac{X2/X1}{\left(\frac{X2}{X1}\right) + \left(\frac{X3}{X2}\right) + \left(\frac{X4}{X3}\right)}$$

$$K2 = \frac{X3/X2}{\left(\frac{X2}{X1}\right) + \left(\frac{X3}{X2}\right) + \left(\frac{X4}{X3}\right)}$$

$$K3 = \frac{X4/X3}{\left(\frac{X2}{X1}\right) + \left(\frac{X3}{X2}\right) + \left(\frac{X4}{X3}\right)}$$

K_1, K_2 and K_3 represent the weights derived from the combination of ratios viz; X2/X1, X3/X2 and X4/X3 respectively.

The milk yield during first month is eliminated to avoid bias due to fluctuation in time to reach peak milk production.

3.6.2 Mahadevan's method (1951):

According to this method, the persistency is defined as the ratio of milk yield following the attainment of maximum yield (26 weeks of lactation) to the initial yield (10 weeks of lactation) and is given as under:

$$= \frac{\text{Milk yield in first 26 weeks of lactation} - \text{Milk yield in first 10 weeks of lactation}}{\text{Milk yield in first 10 weeks of lactation}}$$

Where

A: is lactation milk yield in first 26 weeks of lactation

B: is lactation milk yield in first 10 weeks of lactation

This method was developed by Mahadevan (1951) and was used by Rao *et al* (1970) and Gill (1969) in Hariana cattle for computation of persistency.

3.6.3 Ratio Method (Rao and Sundaresan, 1982):

According to this method, the persistency is defined as the ratio of lactational milk yield to peak yield.

$$\text{Persistency (P3)} = \frac{\text{Lactation milk yield}}{\text{Peak yield}}$$

Rao (1977) advocated this method and was used by Rao and Sundaresan (1982) in Friesian x Sahiwal crossbred cows, Bhutia and Pandey (1989) in different grades of Friesian cows and Kumar and Singh (2006) in Karan Fries cattle for assessing persistency of milk yield.

3.6.4 Prasad *et al*'s Method (1999):

This method was proposed by Prasad *et al* (1999) in crossbred cattle and area of lactation curve was taken into account for measuring the persistency of milk production.

$$\text{Persistency (P4)} = \frac{\text{Milk production during post peak period}}{\text{Peak yield x Post peak period}}$$

$$\text{Persistency (P4)} = \frac{\text{Average milk production during post peak period}}{\text{Peak yield}}$$

3.7 Statistical analysis

The data on milk yield and persistency for the present study pertained to animals which calved during different years, seasons and had different levels of exotic inheritance. The effect of various factors viz. year, season, genetic group, days to attain peak yield and level of production was studied on persistency of milk yield and milk production traits to evaluate relative contribution of each factor.

3.7.1 Statistical model

Data was analyzed by the SAS 9.3 using Least squares analysis as described by Harvey (1987) to study the effects of various genetic and non -genetic factors on different traits by using the following model;

$$Y_{ijklmno} = \mu + B_i + S_j + Y_k + L_l + DPY_m + GG_n + e_{ijklmno}$$

Where:

$Y_{ijklmno}$ = Persistency index of n^{th} cow, sired by i^{th} bull, k^{th} season, i^{th} year, m^{th} level of production, n^{th} days to reach peak yield

μ is the population mean

B_i is the random effect of i^{th} sire

S_j is the fixed effect of j^{th} season

Y_k is the fixed effect of k^{th} year

L_l is the fixed effect of l^{th} level of production

DPY_m is the fixed effect of m^{th} days to reach peak yield

GG_n is fixed effect of n^{th} level of genetic group (level of exotic inheritance)

$e_{ijklmno}$ is the random error, assumed to be NID $(0, \sigma_e^2)$

3.7.2 Evaluation of sire

Least square method

The least square means of sire were estimated by adjusting the data for significant effects of non-genetic factors. Breeding values of bulls was analyzed by the SAS 9.3 using Least squares analysis as described by Harvey (1987).

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

Where,

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

μ = population mean

S_i = least square mean of i^{th} sire

e_{ij} = random error, assumed to be NID $(0, \sigma_e^2)$

Breeding value was calculated for the bulls using following equation

$$I = \frac{2nh^2}{4 + (n-1)h^2}\ (Si)$$

3.8 Box and plots

In descriptive statistics, a boxplot is a convenient way of graphically depicting groups of numerical data through their quartiles. Box plots may also have lines extending vertically from the boxes (*whiskers*) indicating variability outside the upper and lower quartiles, hence the terms box and whisker plot and box and whisker diagram. Box plots are non-parametric. They display variation in samples of a statistical population without making any assumptions of the underlying statistical distribution. The spacings between the different parts of the box indicate the degree of dispersion (spread) and skewness in the data, and show outliers.

In addition to the points themselves, they allow one to visually estimate various L-estimators, notably the interquartile range, midhinge, range, mid-range, and trimean. Box plots can be drawn either horizontally or vertically.

3.9 Correlation analysis

3.9.1 Karl Pearson coefficient of correlation

To measure the degree of linear relationship between two variables, a British biometerician, Karl Pearson, developed a formula called correlation coefficient. It is numerical measure of linear relationship and is defined below:

If (X_i, Y_i); i=1,2,…….n is a Bivariate data then Karl Pearsons

Correlation coefficient $r_{(X, Y)}$ is given as

$$r_{(x,y)} = \frac{Cov(x, y)}{\sigma_x \sigma_y}$$

3.9.2 Spearman Rank correlation

In statistics, Spearman's rank correlation coefficient is a non-parametric measure of rank correlation (statistical dependence between the ranking of two variables). It assesses how well the relationship between two variables can be described using amonotonic function.

The Spearman correlation between two variables is equal to the Pearson correlation between the rank values of those two variables; while Pearson's correlation assesses linear relationships, Spearman's correlation assesses monotonic relationships (whether linear or not). If there are no repeated data values, a perfect Spearman correlation of +1 or −1 occurs when each of the variables is a perfect monotone function of the other.

The correlation between the rankings of the sire based on their breeding values estimated by using Spearman rank correlation as:

$$r_s = 1 - \frac{6\sum di^2}{n(n^2 - 1)}$$

Where,

$r_{(s)}$ = Spearman rank correlation

n = Number of sires under observation

d_i = Difference between the ranking of sire by two methods

3.10 Heritability of persistency of milk production

The heritability of persistency indices of milk yield was estimated by half sib correlation method.

The heritability of persistency indices was calculated by REML, MVQUE and ML methods/softwares as follows:

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

Where,

Y_{ij} = Persistency index of j^{th}cow born to i^{th} sire

μ = population mean

S_i = Sires assumed to be random with NID $(0, б_e^2)$

e_{ij} = random error, assumed to be NID$(0, б_e^2)$

Table 8: Analysis of variance for estimation of heritability

Source	DF	Sum of square	Mean squares	Expected mean squares
Between sires	S-1	SS_S	MS_S	$\sigma_e^2 + K\sigma_s^2$
Within sires	N-S	SS_E	MS_E	σ_e^2
Total	N-1			

K= Average number of progenies per sire

$$K = \frac{1}{S - 1}\left(N - \frac{\sum_{i=1} n_i^2}{N} \right)$$

Where:

S = Number of sires

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

N = Number of observations

Sire component of variance was calculated as:

$$\sigma_S^2 = \frac{MS_S - MS_E}{K}$$

Where,

σ^2_s = Sire component of variance

σ^2_e = Random error

Intra-class correlation (t) among half sibs:

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

$$h^2 = 4t$$

Standard error of heritability was computed by using the formula given by Swiger *et al* (1964):

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

Where:

N = Total number of observations

S = Total number of sires

t = Intraclass correlation among paternal half sibs

K = Average number of progeny per sire

3.11 Restricted maximum likelihood (REML) and Maximum likelihood (ML) method and Minimum Variance Quadratic Unbiased Estimation (MVQUE) method

The least squares method minimizes the error variance whereas the maximum likelihood method (chance) estimates the parameters by maximizing the logarithm of the likelihood function. The likelihood function is the likelihood of simultaneous occurrence of observation and is generally the product of the density function of observations (variables). However, the maximum likelihood (ML) estimates are biased because no account is taken of the degree of freedom in estimating the variance components. The maximum likelihood method was improved by a method known as restricted maximum likelihood (REML) which take care of bias in estimates as well as avoid negative estimates of component of

variance. The variance components by REML are based on residuals calculated after fitting by ordinary least squares from the fixed effects part of the model. This maximizes a marginal likelihood function. This is also called as the residual maximum likelihood or marginal maximum likelihood.

Initial interest in ML, to estimate both genetic parameters and fixed effects, was stimulated by concern about bias due to selection. Restricted Maximum Likelihood is a ML method that accounts for the loss of degrees of freedom due to fitting fixed effects.

Residual maximum likelihood estimation (REML) is often preferred to maximum likelihood estimation as a method of estimating covariance parameters in linear models because it takes account of the loss of degrees of freedom in estimating the mean and produces unbiased estimating equations for the variance parameters. MVQUE is a variation of the Restricted Maximum Likelihood estimation technique and it was chosen because there is no weighting of the random effects, so an iterative solution for estimating their variance components is not required. Like correlation, the basic goal of variance component estimation is to assess the population covariation between random factors and a dependent variable. The advantage of MVQUE is that it is not limited to linear relationships between random factors and dependent variables.

CHAPTER – IV

RESULTS AND DISCUSSION

The data used in present study pertained to crossbred cattle (HF x Sahiwal) maintained at Guru Angad Dev Veterinary and Animal Sciences University (GADVASU) dairy farm. The investigation was aimed to study the effects of genetic and non-genetic factors on persistency of milk yield and to identify the most appropriate persistency method that fits best in our environment. In the present study effect of different non-genetic factors viz. sire, year, season, level of production, days to attain peak yield and genetic group (GG) based on the level of exotic inheritance on persistency of milk yield in crossbred cattle were studied. The 686 first lactation daily milk yield records of crossbred cattle that were maintained at GADVASU dairy farm over a period of 25 years from 1991-2015 were utilized to calculate persistency coefficients by four methods Ludwick and Peterson method (P1), Mahadevan method (P2), Ratio method(P3) and Prasad *et al's* method (P4).

4.1. Standardization of data

Cattle with abnormal conditions such as abortion or premature birth, still birth, sickness, culling or death before completion of lactation period were excluded from the study. For first lactation 305 days milk yield, only those crossbred cattle were considered which produced milk for at least 200 days as per Table 9.

Table 9: Animals excluded from study

Sr. No.	Reason for exclusion	No. of Animals
N1	<200 day lactation length	6
N2	Abnormal lactation curve	9
N3	Abnormal milk yield records	4
X	Animals included in study (1991 - 2015)	705- (19) = 686

4.2 Estimation of persistency indices by different methods

The overall least squares mean of persistencies calculated by different methods as Ludwick and Peterson (1943), Mahadeven (1951), Ratio (Rao and

Sundaresan , 1982) and Prasad *et al* (1999) method were 0.896± 0.096, 1.385±0.224, 187.207± 26.398 and 0.621±0.098, respectively. The least square means for persistency of milk yield in HF x Sahiwal cattle are presented in Table 10.

Table 10: Least squares mean along with standard errors of persistency indices

Measure of persistency	Mean ±SE
P_1	0.896± 0.096
P_2	1.385±0.224
P_3	187.207± 26.398
P_4	0. 621±0.098

4.2.1 Persistency of milk yield:

Method 1 (Ludwick and Peterson, 1943): The estimated value of persistency of milk yield in present study was 0.896± 0.096 (Table 10). Similar results were reported by Roy and Katpatal (1987) in Jersey cattle and Kumar and Singh (2006) in Karan Fries cattle possibly due to similar exotic extent of Holstein Friesian in indigenous breeds. However, Sharma and Bhatnagar (1974) in Red Sindhi and Sahiwal, Gupta and Johar (1982) in Tharparkar, Gawari (1999) in triple crossbred cattle. The lower values of persistency were observed because study was conducted on pure indigenous breeds of cattle or may be due to differences in managemental practices/environmental conditions. Mean values of persistency by Ludwick and Peterson method were reported to be as 0.91 ± 0.55, 0.90±0.01, 0.86±0.01 and 0.88±0.009 by Zakariyya *et al* (1995), Ahmad *et al* (2003) Kumar and Singh (2006), Patond *et al* (2014b) in Nili-ravi buffaloes, Holstein cows, Karan Fries and Jersey cattle, respectively.

Method 2 (Mahadevan Method, 1951): The estimated value of persistency of milk yield in present study was 1.385±0.224 (Table 10). Higher values of persistency were reported by Shaflq *et al* (1994) in Sahiwal cows in Pakistan. It may be due to different selection strategies. The mean value of persistency by Mahadevan method was 1.48±0.07, 1.40±0.02, 11±0.71, 2.98±0.20 by Shaflq *et al* (1994) in Sahiwal cows, Kumar and Singh (2006) in Karan Fries cattle, Garudkar (2015) in Phule Triveni Synthetic cows and Shingare (2015) in Deoni cattle.

Method 3 (Ratio Method – Rao and Sundaresan, 1982) : The estimated value of persistency of milk yield in present study was 187.207± 26.398 (Table 10).The mean value of persistency by ratio method was obtained as 174.79, 185.14, 187.14 ± 1.70 and 201.65±1.42 by Rao and Sundaresan (1982), Bhutia and Pandey (1989), Dhaka and Chaudhary (1994), Kumar and Singh (2006) in Friesian x Sahiwal crossbred cows, dairy cattle, Murrah buffaloes and Karan Fries cattle respectively. Lower values of persistency were reported by Rao and Sundaresan in Friesian x Sahiwal crossbred cows because of different environmental practices. Similar results were reported by Bhutia and Pandey (1989) in dairy cattle due to similar exotic extent of Holstein Friesian in indigenous breeds.

Method 4 (Prasad *et al*, 1999): The estimated value of persistency of milk yield in present study was 0.621±0.098 (Table 10). The mean value of persistency by Prasad method was obtained as 0.68±0.01 by Kumar and Singh (2006) in Karan Fries cattle. Higher values may be due to similar exotic extent of Holstein Friesian in indigenous breeds.

4.3 Descriptive statistics for 305- days milk yield and days to attain peak yield

The descriptive statistics for 305 days milk yield and days to attain peak yield are presented in Table 11. Both the traits were characterized by high coefficients of variation.

Table 11: Descriptive statistics for 305 days milk yield and days to attain peak milk yield

Parameter	305 days milk yield (Kg)	Days to attain peak yield
Mean	3447	48.69
Standard error	44.8	0.640
Median	3316.6	45
Standard deviation	1172.428	16.78
Sample variance	1374589.3	281.64
Range	6097	167
Minimum	795	13
Maximum	6892	180
Coefficient of variation (%)	34.0	34.46

4.4 Descriptive statistics for unadjusted coefficients of persistency

Descriptive statistics based on a total 686 records for persistency coefficients obtained by different methods of persistency measurement were obtained and are presented in Table 12. . However due to large differences in their mean and range, they are not suitable measure for comparison of persistency indices. So, coefficient of variation is better suited for comparing variability between different persistency coefficients. Highest coefficient of variation was observed in P2 method (20.8) followed by P4 (18.9), P3 (17.6) and P1 (12.7) methods in that order. Mean ± SE values was observed as 0.89±0.004, 1.38 ± 0.01, 187.2 ± 1.25 and 0.621 ± 0.004 for P1, P2, P3 and P4 method.

Table 12: Descriptive statistics for different uncorrected coefficients of persistency under study

Parameter	P1	P2	P3	P4
Mean	0.8967	1.3856	187.207	0.621
Standard error	0.0043	0.010	1.2582	0.0045
Median	0.9019	1.369	187.63	0.6160
Standard deviation	0.1134	0.288	32.954	0.1179
Sample variance	0.0128	0.082	1085.99	0.0139
Range	1.0888	2.0582	188.44	0.6154
Minimum	0.4660	0.534	79.39	0.2912
Maximum	1.5549	2.5924	267.84	0.9066
Coefficient of variation (%)	12.7	20.8	17.6	18.9

4.5 ANOVA for different measures of persistency indices

All four persistency coefficients was analyzed for effect of period of caving, season of calving, level of production, genetic group and days to attain peak yield.

4.5.1 Non-genetic factors affecting coefficient of persistency by Ludwick and Peterson Method

Effect of season of calving, level of production and days to attain peak yield was significant on the persistency obtained by Ludwick and Peterson method. Analysis of variance was conducted to examine the effect of non-genetic factors on persistency. The ANOVA for Ludwick and Peterson method is given in Table 13.

Table 13: ANOVA table for non-genetic factors affecting coefficient of persistency by Ludwick and Peterson Method

Source	DF	Sum of Square	Mean Square	F value	P value
Period	4	0.0273	0.0068	0.73	0.5693
Season	3	2.1069	0.7023*	75.26	<.0001
Level of production	2	0.0960	0.0480**	5.15	0.0060
Genetic group	3	0.0606	0.0202	2.17	0.0905
Days to attain peak yield	2	0.0637	0.0318**	3.42	0.0334

Values carrying * and ** are significant at 0.05 and 0.01, levels of probability respectively

4.5.2 Non-genetic factors affecting coefficient of persistency by Mahadevan Method

Effect of period of calving, season of calving, level of production and days to attain peak yield was significant on the persistency obtained by Mahadevan method. Analysis of variance was conducted to examine the effect of non-genetic factors on persistency. The ANOVA for Mahadevan method is given in Table 14.

Table 14: ANOVA table for non-genetic factors affecting coefficient of persistency by Mahadevan Method

Source	DF	Sum of Square	Mean Square	F value	p>F
Period	4	1.335	0.3338**	6.64	<.0001
Season	3	10.470	3.490**	69.47	<.0001
Level of production	2	0.701	0.3508**	6.98	0.0010
Genetic group	3	0.3911	0.1303	2.60	0.0516
Days to attain peak yield	2	2.7331	1.3665	27.20	<.0001

Values carrying * and ** are significant at 0.05 and 0.01, levels of probability respectively

Effect of period of calving, season of calving, level of production and days to attain peak yield was significant on the persistency obtained by Mahadevan method. Analysis of variance was conducted to examine the effect of non-genetic factors on persistency. The ANOVA for Mahadevan method is given in Table 14.

4.5.3 Non- genetic factors affecting coefficient of persistency by Ratio Method

Effect of period of calving, season of calving and level of production was significant on the persistency obtained by Ratio method. Analysis of variance was conducted to examine the effect of non-genetic factors on persistency. The ANOVA for Ratio method is given in Table 15.

Table 15: ANOVA table for non-genetic factors affecting coefficient of persistency by Ratio Method

Source	DF	Sum of Square	Mean Square	F value	p>F
Period	4	12511.53	3127.88**	4.49	0.0014
Season	3	109287.61	36429.20**	52.27	<.0001
Level of production	2	71937.82	35968.91**	51.61	<.0001
Genetic group	3	4128.44	1376.14	1.97	0.1164
Days to attain peak yield	2	853.53	426.76	0.61	0.5424

Values bearing * and ** are significant at 0.05 and 0.01, levels of probability respectively

4.5.4 Non- genetic factors affecting coefficient of persistency by Prasad *et al* Method

Effect of Period of calving, Season of calving and Level of production was significant on the persistency obtained by Prasad *et al* method. Analysis of variance was conducted to examine the effect of non-genetic factors on persistency. The ANOVA for Prasad *et al* method is given in Table 16.

Table 16: ANOVA table for non-genetic factors affecting coefficient of persistency by Prasad *et al* Method

Source	DF	Sum of Square	Mean Square	F value	p>F
Period	4	0.30825	0.0770**	7.93	<.0001
Season	3	1.4504	0.4834**	49.74	<.0001
Level of production	2	0.2963	0.1481**	15.24	<.0001
Genetic group	3	0.040	0.0133	1.38	0.2492
Days to attain peak yield	2	0.0072	0.0036	0.38	0.6872

Values bearing * and ** are significant at 0.05 and 0.01, levels of probability respectively

4.6 Factors affecting persistency

The least squares means for persistency of milk yield for different genetic and non-genetic factors were shown in Table 17 (sire) and Table 18 (Genetic group, level of production, seasons, period and days to attain peak yield) respectively.

4.6.1 Effect of sires on persistency indices

The effect of sire on persistency indices P2 and P4 was highly significant (P<0.05). It reflected that these persistency indices could be partially genetic in origin. The effect of sire on persistency indices P1 and P3 was not significant (P<0.05). So, these methods were not suited for estimation of genetic components of persistency in the herd under study

Table 17: Effect of sires on persistency indices

Persistency coefficients	Sum of square	Mean square	F value	P value
P1	1.029	0.0123	1.03	0.4083
P2	6.789	0.081**	1.59	0.0012
P3	65745.65	792.11	1.12	0.2336
P4	1.185	0.0142**	1.43	0.0107

Values bearing * and ** are significant at 0.05 and 0.01, levels of probability respectively

4.7 Effect of genetic group, level of production

4.7.1 Effect of genetic group

Ludwick and Peterson method (P1): The persistency of milk yield was not (P<0.05) affected by genetic group. Maximum persistency (0.9150±.018) was obtained in fourth genetic group (>87.5%) and minimum (0.8908±.005) in second genetic group (=75%). The persistency of milk yield was non- significantly (P<0.05) affected by genetic group by Ludwick and Peterson method because most of animals included in our study at the GADVASU farm have exotic inheritance of 75% or >75%.

Mahadevan method (P2): The persistency of milk yield was not (P<0.05) affected by genetic group. Maximum persistency (1.5129±.035) was obtained in first genetic group (<75%) and minimum (1.3671±.041) in fourth genetic group (>87.5%). The persistency of milk yield was non- significantly (P<0.05) affected by genetic group by Mahadevan method because there is no much change in performance of animals when exotic inheritance of animals is >75% or >87.5%.

Ratio method (P3): The persistency of milk yield was not (P<0.05) affected by genetic group. Maximum persistency (197.547±4.194) was obtained in first genetic group (<75) and minimum (181.822±4.945) in fourth genetic group (>87.5%).

Prasad *et al* method (P4): The persistency of milk yield was not (P<0.05) affected by genetic group. Maximum persistency (.6557±.016) was obtained in first genetic group (<75%) and minimum (.6084±.018) in fourth genetic group (>87.5%).

4.7.2 Effect of level of production

Ludwick and Peterson method (P1): The persistency of milk yield was significantly (P<0.05) affected by level of production. Maximum persistency (0.9245^{b}±.008) was obtained in second level of production group (2861.45-4033.88) and minimum (0.8867^{a}±.009) in first level of production group (<2861.45)

Mahadevan method (P2): The persistency of milk yield was significantly (P<0.05) affected by level of production. Maximum persistency (1.4893^{b}±.019) was obtained in second level of production group (2861.45-4033.88) and minimum (1.3843^{a}±.022) in first level of production group (<2861.45). Non-significant effect of level of production was observed by Kumar and Singh (2006) in Karan Fries cattle.

Ratio method (P3): The persistency of milk yield was significantly (P<0.05) affected by level of production (Table 18). Maximum persistency (203.886^{b}±2.320) was obtained in second level of production group (2861.45-4033.88) and minimum (171.810^{a}±2.589) in first level of production group (<2861.45). Significant effect of Level of production was observed by Kumar and Singh (2006) in Karan Fries cattle.

Prasad method (P4): The persistency of milk yield was significantly (P<0.05) affected by level of production. Maximum persistency (0.6633^{b}±.008) was obtained in second level of production group (2861.45-4033.88) and minimum (0.5970^{a}±.009) in first level of production group (<2861.45). Significant effect of level of production was observed by Kumar and Singh (2006) in Karan Fries cattle.

4.7.3 Effect of season of calving:

Ludwick and Peterson method (P1): The persistency was higher for crossbred cattle calving during spring (March to May) and summer season (June to August) and low for those calving in the autumn (September to November) and winter (December to February). Similar Significant effect of season of calving was observed by Pradhan and Dave (1973), Yadav *et al* (1992), Rao and Sundaresan (1982), Prasad *et al* (1999) and Kumar and Singh (2006).

In contrary non-significant effect of season of calving were reported by Koley *et al* (1979) in Jersey x Hariana, Roy and Katpatal (1987) in Jersey cattle and Patond *et al* (2014b) in Jersey cattle.

Mahadevan method (P2): The persistency was higher for crossbred cattle calving during summer and autumn season and low for those calving in the spring and winter. Similar significant effect of season of calving on persistency has also been reported by Pradhan and Dave (1973), Yadav *et al* (1992), Rao and Sundaresan (1982), Prasad *et al* (1999), Kumar and Singh (2006) and Garudkar *et al* (2015). In contrary non-significant effect of season of calving were reported by Koley *et al* (1979) in Jersey x Hariana, Roy and Katpatal (1987) in Jersey cattle and Patond *et al* (2014b) in Jersey cattle.

Ratio method (P3): The persistency was higher for crossbred cattle calving during summer and autumn and low for those calving in the spring and winter. Similar significant effect of season of calving on persistency has also been reported by Pradhan and Dave (1973), Yadav *et al* (1992), Rao and Sundaresan (1982), Prasad *et al* (1999) and Kumar and Singh (2006)

Prasad *et al* method (P4): The persistency was higher for crossbred cattle calving during summer and autumn season and low for those calving in the spring and winter. The season of calving had highly significant (P<0.05) on all the four measures for persistency indices. Our results were in agreement with Mahadevan (1951), Madsen (1975), Rao and Sundaresan (1982), Dhaka *et al* (1994), and Prasad *et al* (1999) for different breeds of cattle and crossbred cattle.

The cause for higher persistency in rainy calvers seems to be continuous availability of green fodder and conductive weather conditions for longer duration during pre-peak and post peak periods. However in winter calvers there is sharp decline in milk production during post peak period due to higher temperature of ensuing summer months. Thus it appears that it is not merely calving the season of calving but also the supply of nutritive diet through availability of green fodders at different stages of lactation which makes the cow persistent.

4.7.4 Effect of period of calving

Ludwick and Peterson method (P1): The persistency of milk yield was non-significantly (P<0.05) affected by period of calving. Maximum persistency (0.9212±.010) was obtained in fourth period (2006-2010) and minimum (0.8976±.010) in first period (1991-1995). In contrary, significant effect of period of calving on persistency has been reported by Shah *et al* (1983) in HF crossbred and Patond *et al* (2014b) in Jersey cattle.

Mahadevan method (P2): The persistency of milk yield was significantly (P<0.05) affected by period of calving. Maximum persistency (1.5269^{b}±.025) was obtained in fourth period (2006-2010) and minimum (1.3561^{a}±.024) in first period (1991-1995).

Similar significant effect of period of calving on persistency has also been reported by Garudkar *et al* (2015), Komatular *et al.* (2010), Wondifraw *et al.* (2013), Dhumal *et al.* (1993) and Kaya and Kaya (2003). In contrary, non-significant effect of period of calving on persistency has been reported by Kumar and Singh (2006) in Karan Fries cattle. In contrary, non-significant effect of period of calving on persistency has been reported by Patond *et al* (2014b) in Jersey cattle. The significant effect of period of calving could be due to change in climate, feeding, management and genetic constituent of the herd over the years (periods).

Ratio method (P3): The persistency of milk yield was significantly (P<0.05) affected by period of calving. Maximum persistency (199.463^{b}±2.991) was obtained

in fourth period (2006-2010) and minimum (183.298^{a}±2.825) in first period (1991-1995). In contrary, non-significant effect of period of calving on persistency has been reported by Kumar and Singh (2006) in Karan Fries cattle.

Prasad *et al* method (P4): The persistency of milk yield was significantly (P<0.05) affected by period of calving. Maximum persistency (0.6842^{c}±.011) was obtained in fourth period (1995-2000) and minimum (0.5969^{a}±.010) in first period (1991-1995). Similar significant effect of period of calving on persistency has also been reported by Kumar and Singh (2006) in Karan Fries cattle.

Effect of period of calving was significant for P2, P3 and P4 whereas non-significant for P1. However higher persistency was obtained for P1, P2, P3 and P4 between 2006-2010. Also significant differences was obtained for P2 and P3 between 1991-1995 and 2006-2010.

4.7.5 Effect of days to attain peak yield

Ludwick and Peterson method (P1): The persistency of milk yield was significantly (P<0.05) affected by days to attain peak yield (Table 18). Maximum persistency (0.9178^{b}±.008) was obtained in <41 days and minimum (0.8952^{a}±.008) in >57 days.

Mahadevan's method (P2): The persistency of milk yield was significantly (P<0.05) affected by days to attain peak yield (Table 21). Maximum persistency (1.5286^{b}±.020) was obtained in 41-57 days and minimum (1.3644^{a}±.018) in < 41 days.

Ratio method (P3): The persistency of milk yield was significantly (P<0.05) affected by days to attain peak yield (Table 18). Maximum persistency (191.053±2.385) was obtained in 41-57 days and minimum (188.098±2.138) in <41 days. The persistency of milk yield was significantly (P<0.05) affected by days to attain peak yield (Table 21). Maximum persistency (0.6366±.008) was obtained in 41-57 days and minimum (0.6280±.008) in >57 days.

Prasad *et al* method (P4): Effect of days to attain peak yield was significant for P1 and P2 whereas non-significant for P3 and P4. Also significant differences was obtained for P1 between <41 and >57 days and for P2 between <41 and 41-57 days. However higher persistency was obtained for P2 between 41-57 days.

Table 18: Genetic group-wise, level of Production-wise (μ± ½ σ), season-wise, period-wise and days to attain peak yield-wise least squares means and their standard errors for different measures of PIs

Factor	No of observations	P_1	P_2	P_3	P_4
Overall mean	686	0.896±0.096	1.385±0.224	187.207±26.398	0.621±0.098
Genetic group					
<75%	47	0.9069±.015	1.5129±.035	197.547±4.194	0.6557±.016
=75%	408	0.8908±.005	1.4273±.014	189.559±1.615	0.6316±.006
>75≤87.5%	198	0.9148±.007	1.4198±.017	188.857±2.046	0.6341±.008
>87.5%	33	0.9150±.018	1.3671±.041	181.822±4.945	0.6084±.018
Level of Production					
<2861.45	228	0.8867^{a}±.009	1.3843^{a}±.022	171.810^{a}±2.589	0.5970^{a}±.009
2861.45-4033.88	210	0.9245^{ab}±.008	1.4893^{b}±.019	203.886^{b}±2.320	0.6633^{b}±.008
>4033.88	248	0.9094^{b}±.008	1.4218^{a}±.019	192.642^{c}±2.263	0.6373^{c}±.008
Season of calving					
Winter	182	0.8217^{a}±.008	1.3306^{a}±.020	170.690^{a}±2.419	0.5710^{a}±.009
Spring	199	0.9262^{b}±.008	1.2908^{a}±.019	185.725^{b}±2.306	0.6056^{b}±.008
Summer	154	0.9770^{c}±.009	1.4967^{b}±.021	205.220^{c}±2.572	0.6915^{c}±.009
Autumn	151	0.9028^{b}±.009	1.6093^{c}±.021	196.153^{d}±2.516	0.6619^{c}±.009
Period of calving					
1991-1995	169	0.8976±.010	1.3561^{a}±.024	183.298^{a}±2.825	0.5969^{a}±.010
1996-2000	190	0.9037±.009	1.3650^{a}±.022	188.738^{ab}±2.575	0.6133^{a}±.009
2001-2005	134	0.9096±.009	1.4415^{b}±.023	185.794^{a}±2.732	0.6330^{b}±.010
2006-2010	106	0.9212±.010	1.5269^{b}±.025	199.463^{b}±2.991	0.6842^{c}±.011
2011-2015	87	0.9027±.013	1.4696^{b}±.032	189.939^{ab}±3.799	0.6352^{ab}±.014
Days to attain peak yield					
<41	264	0.9178^{b}±.008	1.3644^{a}±.018	188.098±2.138	0.6329±.007
41-57	181	0.9079^{ab}±.009	1.5286^{b}±.020	191.053±2.385	0.6366±.008
>57	241	0.8952^{a}±.008	1.4025^{a}±.018	189.189±2.192	0.6280±.008

Means bearing different superscript within a column differ significantly.

4.8 Descriptive statistics for different corrected coefficients of persistency under study

Descriptive statistics of total 686 records for persistency coefficients was observed for each of P1, P2, P3 and P4 method. Table 19 depicts the descriptive statistics for different uncorrected coefficients of persistency. Mean ± SE values was observed as 0.901±0.004, 1.44 ± 0.009, 191.1 ± 1.02 and 0.64 ± 0.004 for P1,However due to large differences in their mean and range, not suitable measure for comparison. So, coefficient of variation is better suited for comparing variability between different persistency coefficients. Highest coefficient of variation was observed in P2 method (16.3) followed by P4 (15.9), P3 (14.0) and P1 (12.2) method. P2, P3 and P4 method. All the distribution curves after correction were more or less normally distributed as shown in Figures 1, 2, 3 and 4 for P1, P2, P3 and P4

Table 19: Descriptive statistics for different adjusted coefficients of persistency under study

Parameter	P1	P2	P3	P4
Mean	0.901	1.441	191.1	0.641
Standard error	0.004	0.009	1.023	0.004
Median	0.903	1.447	192.1	0.645
Standard deviation	0.11	0.235	26.8	0.102
Sample variance	0.012	0.055	718.4	0.011
Range	1.066	1.763	152	0.694
Minimum	0.479	0.56	110.4	0.326
Maximum	1.545	2.323	262.4	1.02
Coefficient of variation (%)	12.2	16.3	14.0	15.9

4.9 Box and Plots for different measures of persistency

Box and plots are graphical representation of the sample parameters for both the measures of central tendency and dispersion. Box and Plots for different measures of persistency are given in Table 20 and depicted in Figure 5**.** As is evident in the box and plots , the P2 measure had higher variability and maximum number of outliers while P3 had minimum number of outliers. However, due to

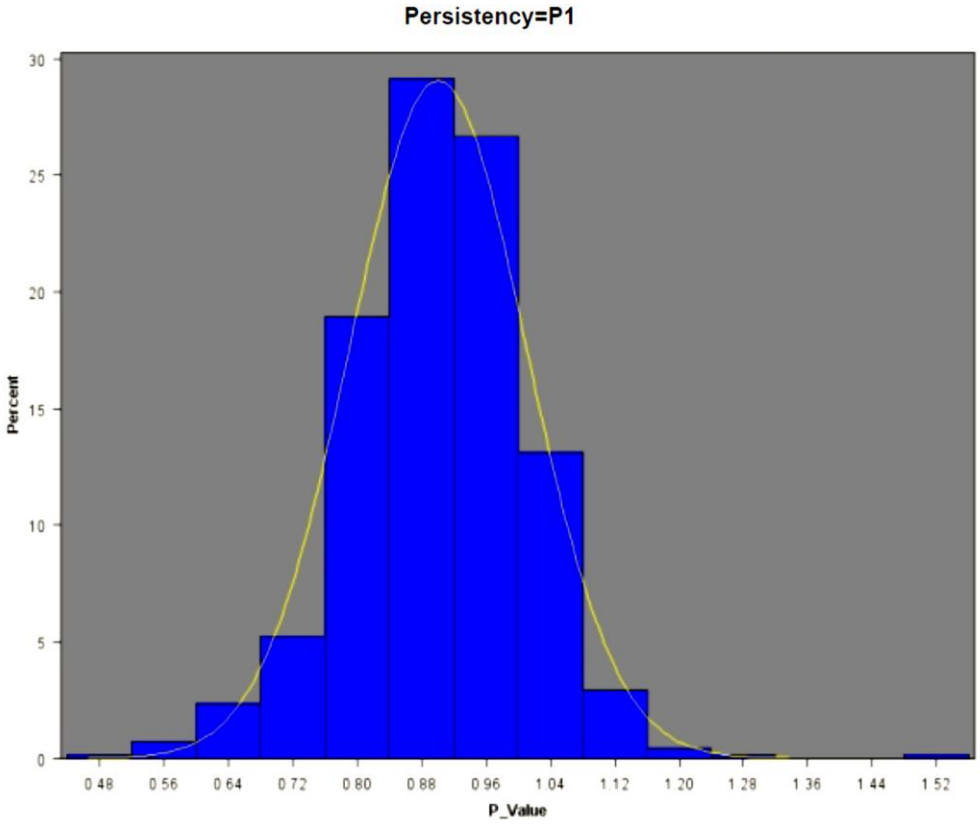

Figure 1: Checking normality for Ludwick and Peterson Method

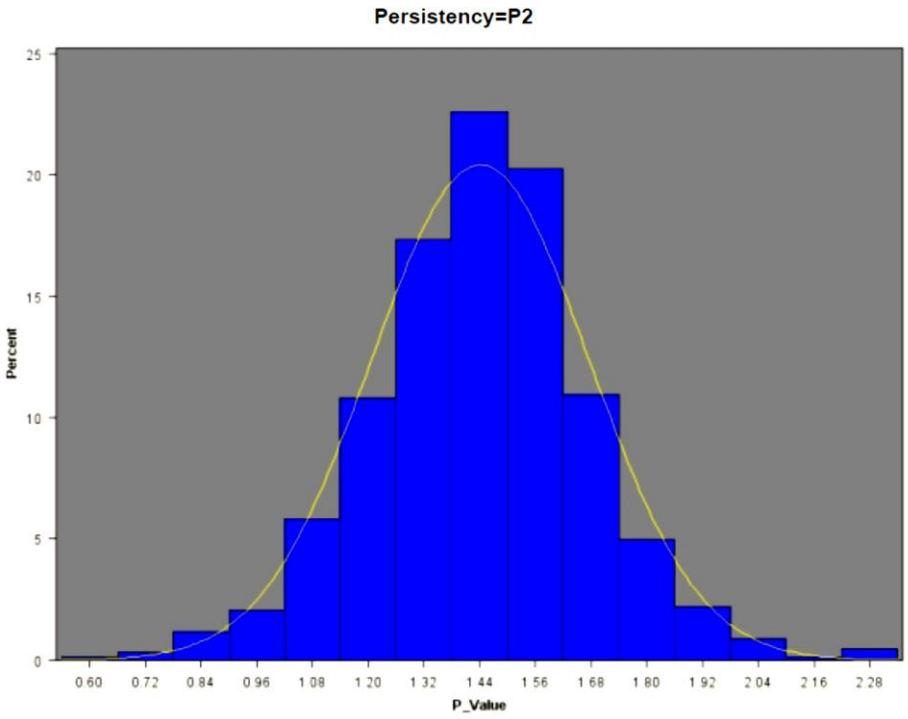

Figure 2: Checking normality for Mahadevan Method

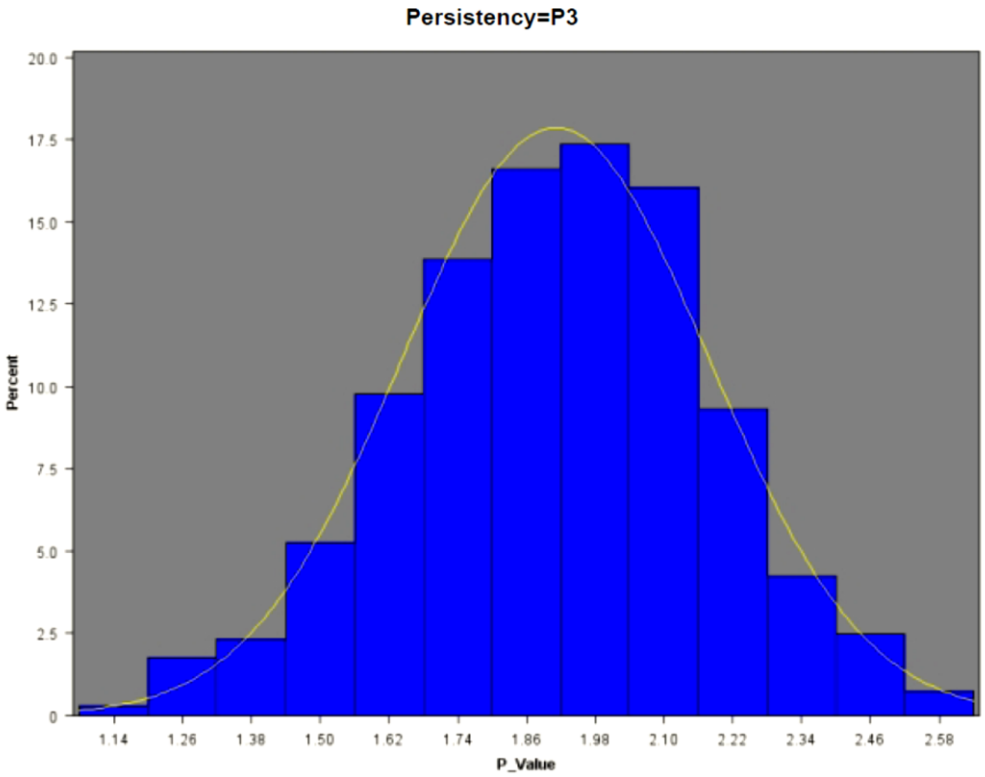

Figure 3: Checking normality for Ratio Method

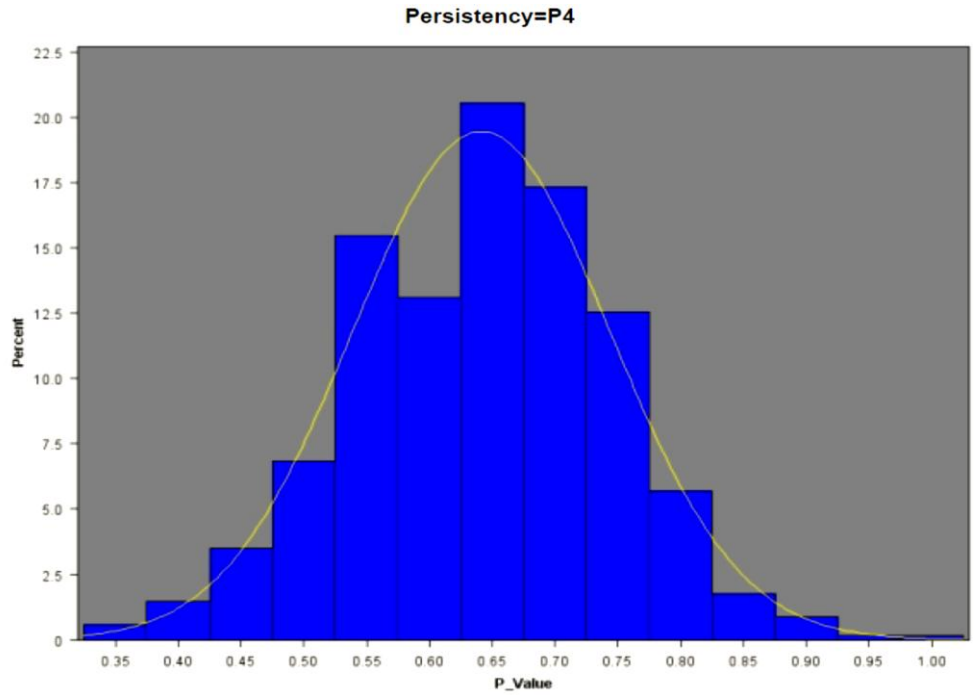

Figure 4: Checking normality for Prasad *et al* method

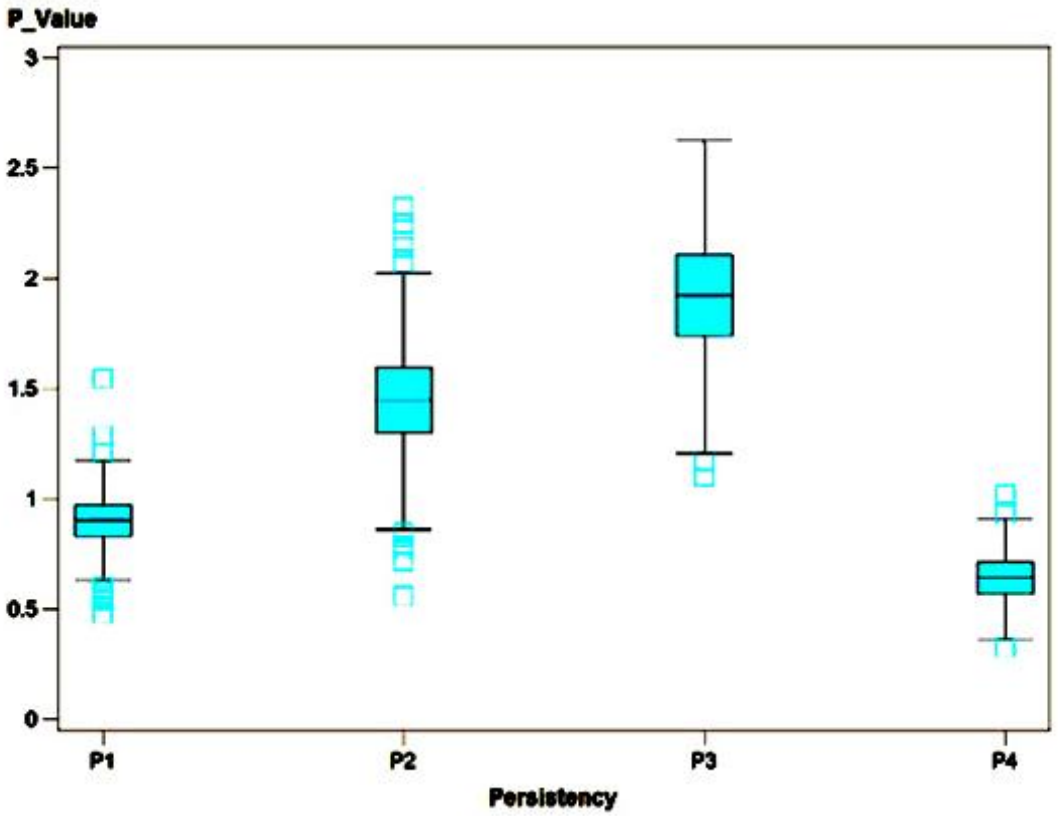

Fig. 5: Box and plots for different measures of persistency

differences in the calculation procedures of persistency coefficients they cannot be appropriately compared.

Table 20: Box and Plots for different measures of persistency

Labels	P1	P2	P3	P4
Min	0.478	0.560	1.103	0.326
Q_1	0.831	1.298	1.740	0.568
Median	0.902	1.446	1.921	0.645
Q_3	0.971	1.593	2.105	0.711
Max	1.544	2.323	2.624	1.020
IQR	0.139	0.295	0.365	0.143
Upper Outliers	3	6	0	2
Lower Outliers	7	7	2	1
For the Box (IQR and Median)				
Q2-Q1	0.071	0.148	0.180	0.076
Q3-Q2	0.068	0.147	0.184	0.06
For the Whiskers				
Q_3+1.5*IQR	1.180	2.037	2.653	0.926
Q_1-1.5*IQR	0.622	0.854	1.193	0.353
Upper Whisker	1.180	2.037	2.624	0.926
Lower Whisker	0.622	0.854	1.193	0.353
W_{upper}-Q_3	0.209	0.443	0.518	0.214
Q_1-W_{lower}				
For the Outliers				
Max	1.544	2.323		1.020
Min	0.478	0.560	1.1037	0.326

4.10 Heritability estimates of persistency indices

The heritability estimates of different measures of persistency indices were estimated by paternal half sib correlation method. The records of only those sires were taken which had at least two progeny. Accordingly, the records of 686 half sibs sired by 83 sires were analyzed for heritability estimation.

The heritability was estimated for data adjusted for significant effect of non-genetic factors viz. seasons, years, level of production, genetic group and days to attain peak yield. The heritability estimates of various measure of persistency index are given in Table 21.

Table 21: Heritability estimation by ANOVA, REML, MIVQUE and Maximum Likelihood method

Method of persistency measurements	ANOVA			REML		
	Sire variance component	Error variance component	Heritability	Sire variance component	Error variance component	Heritability
P1	0.00001	0.012	0.006±0.08	0.0001	0.011	0.053±0.087
P2	0.003	0.051	0.275±0.11	0.0029	0.052	0.214±0.10
P3	10.178	708.36	0.056 ±0.08	3.401	715.03	0.018±0.08
P4	0.0005	0.009	0.197±0.10	0.0005	0.010	0.194±0.10
	Maximum Likelihood			MIVQUE		
P1	0.0001	0.011	0.065±0.08	0.0001	0.011	0.047±0.08
P2	0.0018	0.053	0.132±0.09	0.0028	0.052	0.203±0.10
P3	2.956	715.46	0.016±0.08	2.128	715.19	0.011±0.08
P4	0.0004	0.010	0.169±0.10	0.0004	0.010	0.186±0.10

The estimate of heritability was highest (0.275±0.11) for persistency measured by Mahadevan's method (P2) followed by Prasad *et al* method (P4). The lowest value of heritability estimate was .006±0.08 for the persistency measure P1 (ANOVA). In Mahadevan's method, more heritability and least standard error was observed followed by Prasad *et al* method. So, Mahadevan method is suitable for selection of dairy animals.

In general, the heritability estimates of persistency indices were very low and had high standard errors for Ratio and Ludwick and Peterson method thus making the estimates not reliable based on the earlier reports and our findings, it was

inferred that persistency indices were not influenced by genetic effect of sire component.

4.11 Breeding values of sires for different coefficients of persistency indices

Breeding values of sires were estimated using least squares means of persistency values using the prropriate value of heritability.

4.12 Descriptive statistics for breeding values of sires

Descriptive statistics of total 84 sires was observed for each of P1, P2, P3 and P4 method. For P1, P2, P3 and P4, breeding value range from 0.002-0.08, 0.015-0.0297, 0.037-0.8607 and 0.022-0.05 respectively. For P1, highest breeding value was estimated for sire HRS238M whereas lowest breeding value was observed for HFC1050. For P2 , highest breeding value was estimated for sire HRS172M whereas lowest breeding value was observed for HFC1050. For P3, highest breeding value was estimated for sire HRS238M whereas lowest breeding value was observed for HFC1050. For P4, highest breeding value was estimated for sire FCB523M whereas lowest breeding value was observed for HFC1050M. Mean ± SE values was observed as 0.021 ± 0.001, 0.026 ± 0.0003, 0.286 ± 0.019 and 0.043 ± 0.0007 for P1, P2, P3 and P4 method. Table 22 depicts the descriptive statistics for breeding values of sires.

Table 22: Descriptive statistics for breeding values of sires

Parameter	**P1**	**P2**	**P3**	**P4**
Mean	0.021	0.026	0.286	0.043
Standard error	0.0017	0.00037	0.019	0.0007
Median	0.018	0.028	0.248	0.04
Standard deviation	0.015	0.003	0.174	0.0072
Range	0.08	0.014	0.03	0.029
Minimum	0.002	0.015	0.037	0.022
Maximum	0.08	0.0297	0.8607	0.0515
Coefficient of variation	71.4	11.5	60.8	16.7

4.13 Correlation analysis

4.13.1 Pearson correlation coefficients between persistency coefficients using breeding values of the 84 sires.

Pearson correlation coefficients among persistency values obtained for four different methods are presented in Table 23. The inter-relationship between the estimates of breeding values of sires for different persistency coefficients obtained by four different methods was evaluated by Pearson correlation coefficients using SAS 9.3. Highest correlation was also observed between P1 and P3 (0.989**) method by Pearson correlation for least squares breeding value of the sires. Positive correlation was observed for all four persistencies methods whereas lowest correlation was observed between P1 and P2 methods (0.663**).

Table 23: Pearson's correlation coefficients between breeding values of the sires for persistency coefficients (N=84)

	P1	P2	P3	P4
P1		0.663**	0.989**	0.793**
P2	0.663**		0.723**	0.979**
P3	0.989**	0.723**		0.843**
P4	0.793**	0.979**	0.843**	

* and ** refer to significance at P>0.05 and P>0.01, respectively.

4.13.2 Spearman Correlation Coefficients between breeding values of the sires for persistency coefficients (N=84)

Spearman correlation coefficients among persistency values obtained for four different methods are presented in Table 24. The inter-relationship between ranks for breeding values of sires for different persistency coefficients obtained by four different methods was evaluated by Pearson correlation coefficients using SAS 9.3. Highest correlation was also observed between P1 and P3 method (0.992**) by Spearman correlation for least squares breeding value of the sires. Positive correlation was observed for all four persistencies methods whereas lowest correlation (0.914**) was observed between P1 and P2 methods.

Table 24: Spearman Correlation Coefficients between breeding values of the sires for persistency coefficients (N=84)

	P1	P2	P3	P4
P1		0.914**	0.992**	0.989**
P2	0.914**		0.908**	0.943**
P3	0.992**	0.908**		0.985**
P4	0.989**	0.943**	0.985**	

* and ** refer to significance at P>0.05 and P>0.01, respectively.

CHAPTER – V

SUMMARY AND CONCLUSIONS

The present investigation was undertaken with the following objectives:

1. To study the effects of genetic and non-genetic factors on persistency of milk yield.
2. To identify the most appropriate persistency method that fits best in our environment.

The data pertaining to ancestory and production performance were collected over a period of 25 years i.e. 1991 to 2015 from the history-cum-pedigree sheets, daily milking register, calving register, drying register, production and reproduction records maintained at the dairy farm of Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana of crossbred cattle (HF x Sahiwal).

Performance records of 686 crossbred animals pertaining to the herd of GADVASU were utilized for the present investigation. Performance records on production traits 305-day milk yield (305 MY), complete lactation milk yield (LMY), which spanned over a period of twenty five years (1991-2015). Records with the history of abnormal lactation (less than 200 days), abortion, premature birth and incomplete lactation due to death or disposal were excluded from the analysis.

The data were divided into five periods of five year duration each viz. 1991-1995, 1996-2000, 2001-2005, 2006-2010 and 2011-2015. Each year was divided into four seasons viz. winter, spring, summer, rainy of three month duration each. The level of production was divided into three classes viz low producers (< 2861.45), medium producers (2861.45 - 4033.88) and high producers (>4033.88) based on 305 days milk yield. Animal were grouped on the basis of exotic inheritance into four groups viz <75%, =75%, >75≤87.5% and >87.5%. Days to attain peak yield was divided into three phases viz upto 41 days, 41-57 days and more than 57 days.

The persistency indices were estimated by four different methods viz. Ludwick and Peterson, 1943 (P1), Mahadevan (P2), Ratio (P3) and Prasad, 1999 S(P4). The overall least square means for P1, P2, P3 and P4 were 0.896± 0.096, 1.385±0.224, 187.207± 26.398 and 0.621±0.098 respectively.

Season, period, days to attain peak yield, level of production and genetic group were considered as fixed effect for examining their effects on the traits under study. Data were analyzed by the SAS 9.3 using Least squares analysis as described by Harvey (1987) to study the effects of various genetic and non- genetic factors. The genetic group had non - significant effect on all the four persistency indices because most of animals in the herd had exotic inheritance of 75% or more than 75%. Period of calving had significant influence on all traits. Period had more effect on persistency of milk yield as it spanned over twenty five years. During such a long time span management practices including nutrition regime change. Additionally, genetic structure of the population also undergoes change due to selection and introduction of outside animals.

The season had highly significant effect on all four measures of persistency indices. The calvers were more persistent during summer and autumn whereas spring and winter calvers were least persistent for P2, P3 and P4 method. There was significant difference between the summer and spring calvers for all persistency indices. However, there was no significant difference between persistency indices of summer and autumn calver measured by P4 method.

The level of milk production had highly significant ($P<0.05$) effect on persistency measured by Ratio method (P3) and Prasad method (P4). The medium producer cows (2861.45-4033.88) were most persistent as observed for P3 and P4 with their least square means being 203.886±2.320 and 0.6633±.008 respectively. The low producer cows (<2861.45) were least persistent for P3 and P4 with their least square means 171.810±2.589 and 0.5970±.009 respectively. The persistency value of persistency 0.896 indicates that milk yield was maintained at the level of 89.6 after attainment of the peak yield or 89.60 % obtained in the next month that of previous month. The persistency of milk yield was significantly ($P<0.05$) affected by days to attain peak yield. Maximum persistency was obtained in 41-57 days and minimum in < 41 days for Mahadevan method and Ratio method. Effect of sires was significant ($P < 0.05$) on P2 and P4 method. It reflected that these persistency indices could be partially genetic in origin. Highest coefficient of variation was found in Mahadevan's method (20.788) followed by Prasad method (18.969) which indicates genetic variability. Highest correlation was also observed between P1and P3 method by Spearman (0.992) and Pearson correlation (0.989) for least squares breeding

value of the sires. The heritability of persistency indices of milk yield was estimated by paternal half sib correlation method, REML, ML and MVQUE method. The maximum heritability of persistency was estimated as 0.275 by Mahadevan method followed by Prasad *et al* method. In general, the heritability estimates of persistency indices were very low and had high standard errors for Ratio and Ludwick and Peterson method thus making the estimates not reliable. Based on the earlier reports and our findings, it was inferred that persistency indices were not influenced by genetic effect of sire component.

Based on the overall results of the present study the following conclusions have been drawn.

- Genetic group exerted non- significant influence on all traits.
- Persistency is low heritable trait.
- The persistency of milk yield was significantly ($P<0.05$) affected by days to attain peak yield. Maximum persistency was obtained in 41-57 days for Mahadevan method, Ratio and Prasad method.
- Effect of season was significant. Summer and Spring calvers were more persistent than autumn and winter calvers.
- Effect of period was significant. Herd management needs to improve
- Effect of level of production was significant. Medium producer cows were more persistent than high and low producers.
- Effect of sire was significant on P2 and P4 method.
- On the basis of heritability, standard error of heritability and coefficient of variation, it was concluded that Mahadevan's method followed by Prasad method suits best to our environment for animals in first lactation. It can be utilized for effective selection for higher persistency in crossbred animals of Punjab.

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