Estimation of Genetic Parameters for Persistency of Lactation in Sahiwal Dairy Cattle

Ali Zurwan[1,*], Muhammad Moaeen-ud-Din[2], Ghulam Bilal[2], Zia-ur-Rehman[1,2] and Muhammad Sajjad Khan[1]

[1]*Institute of Animal Sciences, Faculty of Animal Husbandry, University of Agriculture, Faisalabad-38040, Pakistan*

[2]*Laboratories of Animal Breeding and Genetics, Faculty of Veterinary and Animal Sciences, PMAS Arid Agriculture University, Rawalpindi, 46300, Pakistan*

A B S T R A C T

The main objective of the present study was to estimate the persistency of lactation in Sahiwal cows using different persistency indices and to estimate heritability of persistency. Data on 808 Sahiwal cows maintained at the Livestock Experiment Station (LES), Jahangirabad, District Khanewal were used for the present study. Persistency of lactation was determined using five indices *viz*. Wood, Johnson and Hansen, Mahadevan, Ludwick and Petersen and Gajbhiye and Tripathi. Statistical model included fixed effects of period and season of calving and parity and random factors of animal. Indices values for Wood, Johnson and Hansen, Mahadevan, Ludwick and Petersen and Gajbhiye and Tripathi were 138.66, 75.68, 243.65, 85.84 and 275.41, respectively. Moreover, our results indicated that all indices were significantly affected by period and season of calving and lactation number except that Wood index that did not vary with seasons. Heritability estimates of various indices were low and ranged from 0.004 to 0.067 indicating very lower genetic control. This is the first study to show genetic of persistency of lactation. Although results may be validated using more data and more accurately recorded pedigree for several generations however, this is really useful firsthand information.

INTRODUCTION

Sahiwal cattle of Pakistan are the best zebu dairy breed in the tropics. They are well known for disease resistance and heat tolerance and exhibit adequate performance at low quality roughages (Leroy and Marchot, 1987). The population of Sahiwal cattle in the country is nearly 2.75 million (GoP, 2006). Yet, the productivity is low, genetic progress is nearly zero based on studies conducted in the institutional herds and population was threatened by flood of cross breeding few years back (Javed, 1999). Keeping in view that scenario, conservation and development efforts in respect of Sahiwal cattle breed were initiated in the province of Punjab. One result of this endowment was the establishment of a Research Centre for Conservation of Sahiwal Cattle in 2004. The mandate of RCCSC was to initiate performance recording at farmer level to widen the genetic base and help to initiate scientific genetic selection so that the breed can be conserved.

There are previous studies on various genetic aspects of Sahiwal cattle *i.e.* seasonality of breeding and calving

(Khan *et al.*, 2009). However, one of the important aspects of productivity for any lactating cow is maintenance of peak yield for a longer period after first few weeks of calving. Generally, milk yield in cows increases until first 45-90 days after parturition, gets stable for a few weeks and declines thereafter until the end of lactation. This trend of milk yield during the lactation is called lactation curve (Rakes *et al.*, 1963). Lactation curve passes through different phases, one of which is persistency. Persistency may be defined in many ways like the number of days during which the level of constant yield is maintained (Grossman *et al.*, 1999), the degree to which milk yield in early lactation is maintained (Mahadevan, 1951), the extent at which peak yield is maintained (Wood, 1967) or the ability to maintain a more or less constant yield during the lactation (Gengler, 1996). A cow with a flatter lactation curve, therefore, is considered to be more persistent than a cow with the same total yield but with a curve that decreases rapidly after the peak (Grossman *et al.*, 1999). The heritability and repeatability of persistency of lactation was measured to be low (0.08) and medium (0.21), respectively in *Bos indicus* (Pereira *et al.*, 2015).

From genetic stand point, if the trait has an adequate genetic control, bulls may be selected to produce next generation having genetic ability to maintain high milk

yield for a longer period in any lactation. In this scenario the present study was, therefore, designed to estimate the persistency of lactation in farm recorded Sahiwal cows and to determine the genetic control of persistency.

MATERIALS AND METHODS

A total of 3829 lactation records of 808 Sahiwal cows with lactation length of at least 60 days, from 1984 to 2005 were used for the present study. Cows were maintained at the Livestock Experiment Station (LES), Jahangirabad (District Khanewal). Weekly milk yield and pedigree records of Sahiwal cows calved between 1984 and 2005 were collected from the milk record, disposal and birth registers. Information on reason of drying was collected from registers for dry animals. History sheets were also used to match the cumulative yields of these animals. The data were grouped in four periods of calving and four seasons of calving. The lactations were grouped in 10 groups with four weeks in each group. Seasons of calving were defined as winter (December to February), spring (March to May), summer (June to August) and autumn (September to December).

The lactations of 28 weeks or above were included in analyses which were 53.51 percent of the total number of lactations. About 43.92 percent of the lactations used in the analysis were of 5th parity. However, out of total records, 15.08 percent fell in 44th week of lactations. Among the all records used for analysis, 29.86 percent were from 2001-05 and 31.47 percent were from winter season.

To measure the effect of lactation length on persistency, a persistency index was calculated using the formula of (Johansson and Hanssen, 1941) where persistency was defined as the ratio of milk yield in second 100 days of lactation to the milk yield in first 100 days.

(i) Johnson and Hansen's Persistency Index formula as modified by Chaudhry *et al*. (2000):

$$Persistency\ (\%) = \frac{100 * (\text{Milk yield in 28 weeks} - \text{Milk yield in first 14 weeks})}{\text{Milk yield in first 14 weeks}}$$

Other measures of persistency were estimated by using the formulae of Ludwick and Peterson (1943) and modification suggested by Gajbhiye and Tripathi (1992), Mahadevan (1951) and Wood (1967). The formulae are as follows:

(ii) Ludwick and Petersen's Persistency Index:

$$P = \frac{\frac{X_2(n)}{X_1} + \frac{X_3(n-1)}{X_2} + \frac{X_4(n-2)}{X_3} + \dots \frac{X_n(n-(n-2))}{X_{n-1}}}{N(n-1) - \frac{[(n-1)(n-2)]}{2}}$$

Where P is the persistency of lactation, X (with the aid of subscript) designates the production of any particularly period after attaining the peak yield and "n" is the number of divisions into which the lactation is divided after attaining the peak yield. The lactations were grouped in 10 groups of same number of weeks in milk in each group: Group 1 (Weeks 8-11); Group 2 (Weeks 12-15); Group 3 (Weeks 16-19); Group 4 (Weeks 20-23); Group 5 (Weeks 24-27); Group 6 (Weeks 28-31); Group 7 (Weeks 32-35); Group 8 (Weeks 36-39); Group 9 (Weeks 40-43); Group 10 (Weeks ≥44).

(iii) Mahadevan's Persistency Index:

$$P = \frac{A - B}{A}$$

Where P is the persistency of lactation, A is the milk yield during the first 180 days and B is the initial milk yield during the first 10 weeks of lactation.

(iv) Wood's Persistency Index:

In the Wood's (1967) model, the persistency value (S) based on monthly test-day records of milk was obtained using the following formula:

$$S = -(b + 1)log_e(c)$$

Where *b* and *c* are factors associated with the inclining and declining slope of the lactation curves, respectively. For the estimation of genetic parameters of persistency of lactation following animal model was used:

$$Y_{ijkl} = \mu + P_i + S_j + L_k + A_l + e_{ijkl}$$

Where Y_{ijkl} is the persistency of lactation index value for l^{th} cow in her k^{th} lactation, j^{th} period of calving, i^{th} season of calving; μ is overall population mean, P_i is the fixed effect of period of calving; S_j is the fixed effect of season of calving; L_k is the fixed effect of lactation number or parity; A_l is the random additive genetic effect of the animal and e_{ijkl} is the random residual associated with each observation.

Data analysis

For data entry and exploratory data analysis, MS Excel® (2003) was used. To explore the fixed effects on persistency, (SAS Institute, 2008) was used while Wombat (Meyer, 2007) was used to calculate heritability of persistency.

RESULTS

Milk yield among different lactation lengths
Data on milk production of Sahiwal cows maintained

at LES Jahangirabad, Khanewal, which calved during 1985 to 2005, were collected. Nearly 3829 lactation records were recorded excluding the shorter lactations (less than 8 weeks). Actual milk yields for lactations of different durations are presented in Table I. Out of 3829 lactations, only 15% had a standard lactation length (around 300 days) indicating that about 85% of the lactations were shorter than 40 weeks. The data suggests that 60% of the lactations were shorter than six months. Overall average lactation milk yield was 1318 kg with a standard deviation of 715 kg. Very short lactations (8-11 weeks) had average yield of 384 kg as compared to an average of 2276 kg when lactation length was 44 weeks.

Table I.- Milk yield (Mean±SD) for different lactation length groups of Sahiwal Cows.

Lactation length (weeks)	Mean milk yield (Kg)±SD	n	Percentage
8-11	384.56±179.95	494	12.90
12-24	751.65±243.46	681	17.79
25-32	1208.33±357.91	1125	29.38
33-40	1752.54±446.40	944	24.65
41-44	2276.30±572.38	585	15.28
Total	1318.16±715.07	3829	100

Persistency indices by parity

The basic statistics of various persistencies of lactation indices calculated by different methods is given in the Table II. Higher values of CV for JOH and MAH indices (>26%) indicate greater variation among the

studied population for persistency of lactation suggesting greater chances for improvement. The TRI and LUD1 indices displayed modest values of CV (between 14 and 20%) followed by WI and LUD2 indices. The effects of fixed factors on various persistent indices are given in Table III. Values of persistency index using Wood formula were similar among all seasons (P<0.05), whereas effect of season of calving was significant (P<0.01) for all other indices.

Table III.- Factors affecting different persistency of lactation indices.

Item	WI	JOH	MAH	LUD	TRI
Season of calving	1.68	5.23**	4.59**	6.05**	5.19**
Period of calving	19.16**	22.54**	6.17**	24.19**	4.56**
Parity	15.54**	17.47**	9.98**	14.23**	6.64**

**Probability values show difference (p<0.01). *Probability values show difference (p<0.05). For abbreviations, see Table II.

Environmental factors affecting persistency of lactation

The least square means were highest in first parity and lowest in fifth parity for all indices (except TRI). All the indices had lowest values in fifth parity except TRI which had lower value in first parity cows and higher values in fifth parity. The least square means were high for TRI in all periods of calving and seasons of calving as compared to other indices. The means were low for LUD in all periods of calving and seasons of calving. The highest value (277.70 kg) of TRI was in 2001-05 and low (262.37 kg) in 1996-00. The highest value (275.23 kg) of TRI is in summer season and lower (257.39 kg) in autumn season.

Table II.- Persistency indices (Mean±SD) of lactation in Sahiwal cows by parity.

Parity	N	WI±SD	JOH±SD	MAH±SD	LUD±SD	TRI±SD
1	317	143.44±13.47	81.17±22.09	267.09±76.96	90.83±13.23	259.01±53.31
2	279	141.13±13.18	79.68±19.85	252.83±62.32	87.95±12.04	264.89±49.50
3	296	137.48±11.35	73.62±18.87	239.01±63.09	84.58±11.14	279.30q±48.71
4	257	137.72±11.48	75.48±21.16	237.39±65.52	84.64±12.51	283.29±52.77
5	900	136.87±11.69	73.25±19.59	235.21±59.81	84.18±11.74	280.93±53.41
Total	2049	138.66±12.36	75.68±20.36	243.36±65.25	85.84±12.28	275.41±52.85
Min		96.59	15.83	98.55	53.66	99.55
Max		214.35	242.86	757.14	159.73	537.04
CV		8.91	26.90	26.81	14.30	19.19

WI, Wood's index (gamma function), Wood (1967); JOH, Johnson and Hansen (1941); MAH, Mahadevan (1951); LUD, Ludwick and Petersen (1943); TRI, Gajbhiye and Tripathy (1992).

Estimates of variance components and heritability

The estimates of additive, environmental and phenotypic variances and heritability of different persistency indices are given in Table IV. Highest heritability (h^2) estimate were observed in (0.067) for WI and lowest (0.004) for TRI.

Nonetheless, present study, for the first time, reported heritability estimates for persistency of lactation in Sahiwal cows suggesting lower genetic control. The results imply that persistency of lactation is likely to improve less through genetic selection and various environmental factors including feed and other management may be improved to get an improvement in this valuable trait in Sahiwal cattle. A validation of the results from the present study using larger data set and more precisely recorded pedigree is suggested before implementing results of the present study.

Table IV.- Estimates of variance components and heritability for different persistency of lactation indices.

Item	WI	JOH	MAH	LUD	TRI
Additive genetic variance	9.27	3.53	54.49	1.32	9.76
Residual variance	130.36	349.32	4202.40	130.89	2667.41
Phenotypic variance	139.63	352.86	4256.89	132.21	2677.17
Heritability estimate	0.067	0.01	0.013	0.01	0.004

For abbreviations, see Table II.

DISCUSSION

Milk yield among different lactation lengths

The average milk yield in the current study was similar to the earlier recent studies on Sahiwal cattle in Pakistan (Bilal *et al.*, 2008; Khan *et al.*, 2008). Iqbal (1996) reported a higher average of 1971±473 kg for this station when lactations were required to be of 308 days in length. Later on, Dahlin (1998) reported average yield of 1477 kg for an average lactation length of 256 days in 11 institutional herds in Pakistan including the LES Bahadurnagar. Only first three lactations were used in this study and there was no minimum for the lactation length to be included. Average lactation length was 282, 280-308 days in another study (Iqbal, 1996). The earlier report for LES Bahadurnagar, Okara included 1474±648 kg for an average lactation length of 240 days (Talbott, 1994). Population averages for other farms varied. Javed (1999) reported average lactation milk yield of 1980±927 kg for LES Jahangirabad.

Persistency indices by parity

The studies on Sahiwal cattle in other countries also vary in reporting the average milk yield in the breed. Gandhi *et al.* (1995) reported an average milk yield of 1660 kg for Sahiwal cows (n= 9052) in India with an average lactation length of 278 days. Rege *et al.* (1992) in a study on Sahiwal cows (n=2015) in Kenya, reported an average milk yield of 1662 kg. The other dairy breeds to which milk yield of Sahiwal can be compared are Red Sindhi, Cholistani and Tharparkar in Pakistan. Very limited studies are available on these breeds. Ashfaq (2000) studied the data of Cholistani cows kept at Government Livestock Farm, Jogait Peer (District Bahawalpur) during 1985-99 and reported an average first lactation milk yield of 1249±464 kg (n=96) while overall milk yield was 1233±400 kg (n=946) for a lactation length of 20066 days. Mustafa *et al.* (2002) reported average milk yield of 1531 kg for Red Sindhi cows at an institutional herd in Balochistan. For Tharparkar cows, average lactation milk yield has been reported as 1138 kg (Ahmad *et al.*, 1984).

Environmental factors affecting persistency of lactation

The period of calving affected all the indices significantly (P<0.01) which is in agreement with Ahmad *et al.* (2003). The values of all indices varied by parity (P<0.01). Similar finding were observed by other researchers (Dedkova and Nemcova, 2003).

Estimates of variance components and heritability

The lowest h^2 estimate was shown by JOH and LUD (0.01). The heritability estimate of WI were almost similar to Atashi *et al.* (2006) where h^2 ranged from 0.047 to 0.082, 0.09 to 0.11 in the study of Haile-Mariam *et al.* (2003), 0.08±0.02 in study of Leukkunen (1985) and 0.07 in the study of Lahiri *et al.* (1981). All heritability estimates of different indices reported in the present study were lower than the earlier reports 0.11 to 0.27 (Cobuci *et al.*, 2004); 0.18, (Muir *et al.*, 2004) and 0.17 (Jamrozik *et al.*, 1997). The differences between parameter estimates reported in the present study and other studies could be due to different sampling population, different statistical models used and breed differences *etc*.

CONCLUSIONS

Lactation length determines the shape of lactation curve as shorter lactations were atypical as compared to complete and longer lactations. The genetic control of persistency is very less in the study however the genetic control can be better estimated by recording accurate measurements of reason of shorter lactations and precise pedigree recording and the further research is needed to

explore the exact cause of greater environmental variation and low heritability of persistency. Average milk yield in Sahiwal cows is 1318.16±715.07 kg per lactation and the genetic control (h^2) of milk yield was very low which is due to missing pedigree information and uncontrolled environmental variation. Milk yield is affected by season of calving, period of calving, cow and parity. Heritability of the persistency of lactation in Sahiwal cows is very low; nonetheless, we have provided first report on persistency of lactation in Sahiwal cattle and it may provide the grounds for further research in this area.

ACKNOWLEDGEMENT

Statement of conflict of interest
Authors have declared no conflict of interest.

REFERENCES

Ahmad, M., Ahmad, M. and Naz, N.A., 2003. Environmental and genetic factors affecting first lactation milk yield, peak milk yield and persistency of lactation in Nili-Ravi buffaloes. *Pakistan J. Vet. Res*., **1**: 20-24.

Ahmad, Z., Ahmad, M.D. and Ghaffar, A., 1984. Studies on the factors affecting milk yield in Tharparkar cows. *Pakistan J. agric. Sci.,* **21**: 198-207.

Ashfaq, F., 2000. *Genetic and phenotypic parameters for some performance traits of Cholistani cattle*. Univ. of Agriculture, Faisalabad, Pakistan.

Atashi, H., Shahrbabak, M. and Abdolmohammadi, A., 2006. Study of some suggested measures of milk yield, persistency and their relationships. *Int. J. Agric. Biol.,* **8**: 387-390.

Bilal, G., Khan, M.S., Bajwa, I.R. and Shafiq M., 2008. Genetic control of test-day milk yield in Sahiwal cattle. *Pakistan Vet. J*., **28**: 21-24.

Chaudhry, H.Z., Khan, M.S., Mohiuddin, G. and Mustafa, M.I., 2000. Persistency of Lactation in Nili-Ravi Buffaloes. *Int. J. agric. Biol*., **2**: 207.

Cobuci, J.A., Euclydes, R.F., Costa, C.N., Lopes, P.S., Torres, R.A. and Pereira, C.S., 2004. Analysis of persistency in the lactation of Holstein cows using test-day yield and random regression model. *Rev. Bras. Zootec.,* **33**: 546-554. https://doi.org/10.1590/S1516-35982004000300004

Dahlin, A., 1998. *Genetic studies on Sahiwal cattle in Pakistan*. Swedish University of Agricultural Sciences, Uppsala, Sweden.

Dedkova, L. and Nemcova, E., 2003. Factors affecting the shape of lactation curves of Holstein cows in the Czech Republic. *Czech J. Anim. Sci*., **48**: 395-402.

Gajbhiye, P.U. and Tripathi, V.N., 1992. Factors affecting persistency of first lactation in Murrah buffaloes. *Buffalo Bull.,* **2:** 109-116.

Gandhi, R.S., Gurnani, M. and Singh, A., 1995. Influence of non genetic factors on some of the economic traits in Sahiwal cattle. *Indian J. Dairy Sci.,* **48**: 605-606.

Gengler, N., 1996. Persistency of lactation yields: A review. *Interbull Bull.,* **12**: 87-96.

Govt. of Pakistan, 2006. *Livestock census*. Agricultural Census Organization, Statistics Division, Lahore.

Grossman, M., Hartz, S.M. and Koops, W.J., 1999. Persistency of lactation yield: a novel approach. *J. Dairy Sci*., **82**: 2192-2197. https://doi.org/10.3168/jds.S0022-0302(99)75464-0

Haile-Mariam, M., Bowman, P.J. and Goddard, M.E., 2003. Genetic and environmental relationship among calving interval, survival, persistency of milk yield and somatic cell count in dairy cattle. *Livest. Prod. Sci*., **80**: 189-200. https://doi.org/10.1016/S0301-6226(02)00188-4

Iqbal, J., 1996. *Sire evaluation on partial lactation records in Sahiwal cattle and Nili-Ravi buffaloes*. Animal Breeding and Genetics, University of Agriculture, Faisalabad.

Jamrozik, J., Schaeffer, L.R. and Dekkers, J.C.M., 1997. Genetic Evaluation of dairy cattle using test day yields and random regression model. *J. Dairy Sci*., **80**: 1217-1226. https://doi.org/10.3168/jds.S0022-0302(97)76210-6

Javed, K., 1999. *Genetic and phenotypic aspects of some performance traits in the purebred herd of Sahiwal cattle in Pakistan*. Animal Breeding and Genetics. University of Agriculture, Faisalabad.

Johansson, I. and Hanssen, A., 1941. *Causes of variation in milk and butterfat yield of dairy cows*. Stockholm.

Khan, M.S., Bilal, G., Bajwa, I.R., Rehman, Z. and Ahmad, S., 2008. Estimation of breeding values of Sahiwal cattle using test day milk yields. *Pakistan Vet. J.*, **28**: 131-135.

Khan, M.S., Hassan, F., Rehman, M.S., Ahmed S. and Rehman, Z., 2009. Days open and seasonality of calving in buffaloes and cattle in Pakistan. *Pakistan J. of Zool.,* **9**: 195-199.

Kheirabadi, K., Rashidi, A., Alijani, S. and Imumorin,

I., 2014. Modeling lactation curves and estimation of genetic parameters in Holstein cows using multiple-trait random regression models. *Anim. Sci. J.*, **85**: 925-934. https://doi.org/10.1111/asj.12185

Lahiri, S.S., Patro, B.N., Pani, S.N. and Dhar, N.L., 1981. Inheritance of breeding efficiency and persistency of lactation in a Hariana herd. *Indian J. Anim. Sci*. **51**: 596-598.

Leroy, P. and Marchot, P., 1987. The resistance to dermatophilosis of Dinka cattle breed, Dinka crossbred and Boran, Friesian, Jersey, Sahiwal crossbreds. *Annls. Vet. Res*., **18**: 107-109.

Leukkunen, A., 1985. Genetic parameters for the persistency of milk yield in the Finnish Ayrshire cattle. *J. Anim Breed. Genet.*, **102**: 117–124. https://doi.org/10.1111/j.1439-0388.1985.tb00679.x

Ludwick, T.M. and Peterson, W.R., 1943. A measurement of persistency of lactation in dairy cattle. *J. Dairy Sci*., **26**: 439-445. https://doi.org/10.3168/jds.S0022-0302(43)92740-7

Mahadevan, P., 1951. The effect of environment and heredity on lactation. II. Persistency of lactation. *J. agric Sci*., **41**: 89-93. https://doi.org/10.1017/S0021859600058573

Meyer, K., 2007. WOMBAT-A tool for mixed model analyses in quantitative genetics by restricted maximum likelihood (REML). *J. Zhejiang Univ. Sci*. B, **8**: 815-821. https://doi.org/10.1631/jzus.2007.B0815

Muir, B.L., Fatehi, J. and Schaeffer, L.R., 2004. Genetic relationships between persistency and reproductive performance in first-lactation Canadian holsteins. *J. Dairy Sci*., **87**: 3029-3037. https://doi.org/10.3168/jds.S0022-0302(04)73435-9

Mustafa, M.I., Latif, M., Bashir, M.K. and Ahmad, M., 2002. Productive and reproductive performance of Red Sindhi cattle under hot humid environment of Balochistan province of Pakistan. *Pakistan Vet. J*., **22**: 151-157.

Pereira, R.J., Ayres, D.R., El Faro, L., Vercesi Filho, A.E., Verneque Rda, S. and de Albuquerque, L.G., 2015. A new way to measure milk yield persistency: a genetic point of view with application to Gyr (*Bos indicus*) cattle. *J. Dairy Res*., **82**: 385-390. https://doi.org/10.1017/S0022029915000448

Rakes, J.M., Stallcup, O.T. and Gifford, W., 1963. *Persistency and the lactation curve of dairy cows*, Agricultural Experiment Station, Division of Agriculture, University of Arkansas, Fayetteville, Ark.

Rege, J.E.O., Lomole, M.A. and Wakhungu, J.W., 1992. An evaluation of a long-term breeding programme in a closed Sahiwal herd in Kenya: I. Effects of non-genetic factors on performance and genetic parameter estimates. *J. Anim Breed. Genet*., **109**: 364-373. https://doi.org/10.1111/j.1439-0388.1992.tb00416.x

SAS Institute, I., 2008. *SAS/STAT 9.2 user's guide*. SAS Institute, Inc., Cary, NC.

Talbott, C.W., 1994. *Potential to increase milk production in tropical countries*. North Carolina State University.

Wood, P.D.P., 1967. Algebraic model of the lactation curve in cattle. *Nature*, **216**: 164-165. https://doi.org/10.1038/216164a0