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Lactation Persistency and its Genetic Evaluation in Cattle—A Review

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Abstract

Lactation persistency, an economically important trait for dairy animal, can be defined as the capacity of a cow to continue milk production at a high level after the peak yield. High persistent cows are expected to have higher lactation production, longer productive life and considered as efficient producers. Moreover, lactation persistency has a great influence on the health, reproduction and feed costs of dairy cows. Different environmental factors viz., season of calving, period of calving, parity, genetic group, age of calving, lactation length, peak yield, were reported to have significant effect on the lactation persistency of dairy cattle. The heritability of lactation persistency varied according to the method of calculation of persistency and the method of heritability estimation. Low positive genetic correlation between persistency and milk yield indicated that selection for increased milk yield would slightly improve persistency. To ensure that cows persistent for milk production have good reproductive performance, it is important to study the relationship between persistency and reproductive traits. Various researchers have reported unfavorable relationship between persistency and reproductive traits.

Keywords: *Persistent, lactation, productivity, reproductive traits*

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INTRODUCTION

In any dairy enterprises, productivity is mainly dependent on lactational yield and reproductive performance of animal. Lactation persistency is generally considered as an economically important trait for dairy animal and it can be defined as the capacity of a cow to continue milk production at a high level after the peak yield [1]. Generally, the rate of milk secretion throughout the lactation period follows certain patterns which are called as the lactation curves. The lactation of animals may be divided into three phases: (i) Ascending phase: Calving to peak yield, (ii) Relatively constant phase: During peak of lactation, and (iii) Descending phase: Peak yield to end of lactation. More vividly, it is the descending phase that mainly describes the persistency of milk production. The rate of milk secretion is sustained by some cows for longer period during lactation and known as persistent producers while other goes dry or drop the yield within a few weeks and hence called as nonpersistent. In dairy industry, animals producing milk at a high level of persistency are considered economical as it will lead to reduction and stabilization of production cost and ultimately yield more profit. High persistent cows are expected to have higher lactation production, longer productive life and considered as efficient producers [2]. Animals having higher persistency index are good milk producer, which is recommended to be kept in the herd. Moreover, lactation persistency has a great influence on the health, reproduction and feed costs of dairy cows. The persistent cows may have fewer health and reproductive problems than cows that are less persistent. Persistent animals require less energy in early lactation, allowing greater utilization of cheap roughage [3]. Persistency therefore has a direct economic value. Reductions of feed (replacement of concentrates by roughages), health and reproductive costs are the major factors favoring more persistent cows [3]. Therefore, lactation persistency can be used as an important tool for selection and can be incorporated in any cattle breeding programme as the selection criteria.

METHODS OF ESTIMATION OF LACTATION PERSISTENCY

Measuring lactation persistency by one single term is difficult. Lactation persistency can be estimated in different ways according to the availability of information, data or records. Lactation persistency can be measured based on ratios of partial, total, or peak production, variation among successive yields and mathematical lactation curve models. Accordingly, considerable variations are observed in estimates of heritability, repeatability and the genetic correlations among various persistency indices of milk production as well as their correlations with milk yield, peak lactation and reproductive traits.

Ratio Method

Johansson and Hansson [4] divided milk yield into three parts as 1st 100 days milk yield, 2nd 100 days milk yield and 3rd 100 days milk yield to derive a simple measure of persistency indices P21, P31, P32 where P21 is the ratio of 2nd 100 days milk yield and 1st 100 days milk yield. Mean persistency index for P21 was estimated at 52.80 in Karan Fries cattle [5]. Rao and Sunderasan [6] estimated persistency indices (P_2) as ratio of 300 days yield to peak yield and obtained a least square mean of 174.79 [6]. Solkner and Fuchs [3] measured persistency as P_{TOMAX2} and P_{TOMAX3} and obtained the mean of 122.9±0.06 and 134.7±0.07, respectively. P_{TOMAX2} is the ratio of maximum test-day milk yield during first 200 days and mean test-day milk yield during this period in percent. Similarly ratio in percentage for milk yields during first 305-day milk yields was designated as P_{TOMAX3} [3].

Using Mahadevan (1951) method, mean of persistency (70th to 182nd days milk yield divided by 70 days milk yield) was estimated at 1.46±0.02 [5]. Mean persistency for P21, P31 and P32 was reported as 84.6±11.5%, 61.5±15.8% and 72.6±15.3%, respectively in Holstein Friesian (HF) cattle [7]. Persistency was estimated at 0.56±0.11 using Khmel'Nit ski (1947) method (Peak yield/ 305-days milk yield) in HF × Sahiwal [8].

Variation Among Successive Yields

Solkner and Fuchs [3] estimated persistency using standard deviations of test-day milk yields up to 200 (PSD2) and 305 (PSD3) days of lactation. They reported measures of mean persistency as 2.43±0.005 (PSD2) and 3.08±0.005 (PSD3), respectively [3]; while Atashi *et al.* [9] estimated PSD3 as 4.120±0.0079 in HF cattle. Yamazaki *et al.* [10] calculated persistency ranging from -10.9 to -6.3 as the difference between milk yields at 240 and 60 days in milk.

Mathematical Lactation Curve Model

In an early attempt to develop a mathematical model for lactation curve, Gaines [11] gave the model $y_t = Ae^{-Kt}$ where *y*, is the yield in month, *t*, and *A* and *K* are constants. *A* is the starting yield (when t = 0), and *K* is the rate of decline per month [11].

Vujicic and Bacic [12] modified the model provided by Gaines [11] and gave a new model $y_t = tn^{-a''}e^{-nt}$ where y, is the yield in the t^{th} period, and *n*, *a*, are parameters [12].

Wood [13] suggested a mathematical model for lactation curve $\mathbf{y_n = an^b e^{-cn}}$ where, y_n is the milk yield on day *n*, *a* is a scaling factor to represent yield at the beginning of lactation, and *b* and *c* are the factors associated with the inclining and declining slope of lactation curve. A typical lactation curves have positive *b* and *c*. Lactation curve with negative *b* and *c* are considered as atypical. This model can be solved by least squares analysis for multiple regressions after logarithmic transformation. Wood's persistency ranged from 6.70 to 72 on the basis of 305-day milk yield [13–15] and -0.49 to 142±3.8 on the basis of test-day milk yields [16, 17].

FACTORS AFFECTING THE LACTATION PERSISTENCY OF CATTLE

Different environmental factors *viz*., season of calving, period of calving, parity, genetic group, age of calving, lactation length, peak yield, significantly affected the lactation persistency of dairy cattle. Other factors like nutritional as well as nonnutritional factors also influence the lactation milk yield, which ultimately influence the peak yield and persistency of animals.

Effect of Sire

The random effect of sire had significant ($P<0.05$) influence on persistency indices of

milk production in Karan Fries, Jersey crossbred and Friesian cattle [5, 18, 19]. However, effect of sire on persistency was reported as nonsignificant in Red Sindhi and HF cattle [20, 21].

Effect of Season of Calving

Season is one of the most important factors affecting persistency. Several workers reported significant effect of season of calving on persistency of milk production in different breeds of cattle [5, 6, 18, 22–24]. In Karan Fries cattle highest persistency was observed in rainy calvers and lowest persistency in the winter calvers [5]. Holstein cows that calved in summer were more persistent as compared to those that calved in winter [23]. The effect of season of calving on persistency indices may be due the variation in temperature and rainfall which affects the comfort of the cows and fodder supply. Summer and autumn calvers were most persistent whereas spring and winter calvers were least persistent for P2, P3, and P4 methods in HF crossbred [24]. On the contrary, it was reported that season of calving had nonsignificant effect on persistency (Mahadevan method) of milk production in Phule Triveni cattle [25]. Nonsignificant results were also reported in Jersey x Hariana [26], Kenana × Friesian [27], Jersey [28] and HF [21].

Effect of Period of Calving

Period of calving was reported to have significant effect on persistency indices of milk production by Mahadevan method in HF, HF crossbred, Phule Triveni and HF cattle [24, 25, 28]. Effect of period of calving was significant on persistency indices P1 and P5 and highly significant ($P<0.01$) on P2 in Karan Fries cattle [5]. However, nonsignificant effects of period of calving on persistency of cattle were observed in Jersey and J x Hariana crossbred cattle [7, 26].

Effect of Parity of Animal

Several published reports showed that parity of cow had significant effect on lactation persistency in cattle [5–7, 22, 29]. It was observed that persistency decreased with increase in parity in HF of Morocco [30]. The effect of parity was highly significant ($P<0.01$) on all the measures (P1 to P5) of persistency indices (PIs) and significant differences existed between the persistency in first parity and other three parities for all the persistency indices (PIs) whereas, no statistically significant differences in persistency indices were observed between second, third and fourth parities [5]. First parity cows had highest persistency which decreased with increase in milk yield [7, 22]. Several workers reported that the highest persistency was observed in cow of first calvers as compared to the calvers of next lactations in different cattle breeds and its crosses [5, 6, 29]. The reason of cows of first calvers were more persistent may be explained as presence of more number of secretory cells in mammary gland, which maintain their secretory activity for a longer duration in first lactation as compared to subsequent lactations where although the amount of milk secretion by each secretory cell is increased but it fails to maintain their secretory activity for a longer duration and finally get sloughed off at early stage of lactation. On the contrary, few workers reported nonsignificant effects of parity on persistency of milk yield in different cattle breeds [25, 28].

Effect of Age Group of Animal at Calving

Significant effect of age at calving of animals on lactation persistency of dairy cattle has been reported by several researchers [19, 31]. Older cows were less persistent than the young ones [19]. This may be due to the fact that when the cow gets older it is expected to start its lactation at a higher level, but because the inhibiting effect of pregnancy occurs at about the same stage of lactation, the rate of decline becomes rapid in older cows. However, non-significant effect of age at calving on persistency of milk production was reported in Jersey crossbred and HF cattle [18, 30].

Effect of Farm

The effect of farm was highly significant ($P<0.01$) on 305 days milk yield and lactation persistency [19]. The persistency of lactation showed no significant difference between in-farm born and imported cattle of the same breed [23].

Effect of Exotic Inheritance Level

The level of exotic inheritance showed significant effect on lactation persistency of

cattle [6, 18]. Level of exotic inheritance had significant effect on lactation persistency in Rathi crossbred cattle [32]. In crossbred cattle of Sudan the percentage of total foreign blood significantly affected the lactation persistency of crossbred animals, the degree of persistency was significantly ($p<0.05$) higher for cows with 50% and 62.5% total foreign blood and those sired by Friesian bulls [17]. The average daughter milk yield expected at day 280 in lactation as compared to day 60 in lactation and evaluation of the sire's breeding value on lactation persistency was done by Canadian Dairy Network (1999, 2004) on different genetic group viz., Ayrshire, Brown Swiss, Canadienne, Guernsey, Holstein, jersey, and milking shorthorn and average lactation persistency were 56%, 69%, 52%, 64%, 66%, 67% and 59%, respectively. Persistency of milk yield varied with varying level of exotic inheritance of animals [18]. Level of exotic inheritance had significant ($p<0.05$) effect on lactation persistency in cattle and animals having a genetic combination of ½ Jersey X ½ Red Sindhi had higher persistency than animals of other genetic groups in Jersey crossbred cattle [18].

GENETIC CONTROL ON LACTATION PERSISTENCY

Estimates of genetic and phenotypic parameters of different component traits related to economic traits such as lactation, growth and reproduction traits are needed to develop a proper selection programme. In addition, these parameters are necessary for the prediction of a response to selection. An effective breeding plan can only be devised after through the knowledge has been obtained about the inheritance of economically important traits. Estimates of heritability and genetic and phenotypic correlation form the basis of such information.

Estimates of genetic parameters for lactation persistency have been reported in many published literatures [1–7]. Heritability estimated by Swalve and Gengler [33] ranged between 0.05 and 0.30. Lower estimates of h^2 of LP were reported at the range of 0.02–0.18 in different breeds of dairy cattle [5, 29, 34, 35]. However, medium-to-moderately high heritability estimates at the range of 0.17–0.21, 0.19–0.31 and 0.19–0.30 were also reported [3, 7, 36]. On the contrary, higher heritability estimates of 0.48 and 0.62 for LP were reported by few workers in Friesian cattle [37, 38]. Heritability estimates of three persistency indices by El-Awady [19] were 0.55, 0.67 and 0.39. Estimates of heritability by REML in random regression models using Legendre polynomials for persistence in milk, fat, and protein yields were 0.04–0.32, 0.00–0.23, and 0.00–0.27, respectively [39]. In Red Sindhi cattle, the estimate of heritability for persistency of lactation was low (0.08) [20]. The heritability estimates for lactation persistency index (P21) ranged from 0.01–0.17 by paternal half sib method [5, 22] and 0.01–0.55 by animal model [7, 19, 29] in different cattle breeds.

RELATIONSHIP BETWEEN LACTATION PERSISTENCY INDICES AND LACTATION TRAITS

Genetic correlation between persistency and 305-dMY was positive and ranged from 0.42 to 0.97 [9, 19, 34, 40]. Genetic correlation estimates between persistence and total 305-day milk, fat, and protein yields ranged from -0.38 to 0.54, from -0.39 to 0.97, and from -0.78 to 0.67, respectively in Holstein cows [39]. Genetic correlation between persistency and milk yield significantly depends on the lactation order and the measures of persistency used [41]. Lactation persistency were negatively correlated with peak yield for all milk traits ranging from -0.28 to -0.73 [5, 42]. Genetic and phenotypic correlations between persistency and peak yield were negative so higher peak yield of lactation indicates lower persistency and hence less milk production. Phenotypic correlations of persistency with milk yield were positive in five breeds namely Ayrshire, Brown Swiss, Guernsey, Jersey, and Milking Shorthorn cows [35]. Positive genetic correlation between persistency and milk yield indicated that selection for increased milk yield would slightly improve persistency [27, 43].

RELATIONSHIP BETWEEN PERSISTENCY INDICES AND REPRODUCTIVE TRAITS

The reproductive performance of a dairy herd has a significant effect on the profitability of that herd. But, continuous selection of high

yielding dairy cattle has caused reduction in reproductive performance. To ensure that cows persistent for milk production have good reproductive performance, it is important to study the relationship between persistency and reproductive traits. Common measures of (aspects of) reproductive performance are days to first service, days to conception, calving interval, services per conception, conception rate, estrus detection rate, and pregnancy rate. Muir *et al*., [43] estimated genetic correlations between persistency and reproductive traits which ranged from 0.17 to 0.43. Cows with higher lactation persistency had better reproductive performance [44]. On the contrary, Lean *et al.* [45] reported that cows with high persistency had lower reproductive performance. Phenotypic correlation between persistency and gestation period was negatively low (-0.036) [46]. Moderate negative genetic correlations existed between different persistency indices (P21, P31, P32, P4 and P5) and gestation length in Jersey crossbred cattle, which ranged between -0.46 to -0.68 and for phenotypic correlations, these values ranged from -0.01 to-0.05 [47]. Majority of the authors concluded that gestation has depressing effect on persistency [3, 47]. The reported correlation between persistency in first lactation and NRRH (Non-Return Rate as Heifer) was positive 0.16±0.13 and between persistency and NRRC (Non-Return Rate as Cow) was 0.32 [43]. Positive correlation (0.30±0.12) between persistency and NRR-56 indicated that cows which tended to conceive on first insemination also tended to have better persistency [48]. Persistency and conception rate (CR) was reported to be positively correlated as 0.42±0.07 [44]. On the contrary, negative genetic (-0.23 to -0.26) and phenotypic (-0.19 to -0.15) correlations between persistency and conception rate were also reported [10]. Antagonistic relationship existed between lactation persistency indices and conception rate both at genetic (r_g= - 0.11 to - 0.59) and phenotypic level (r_p = - 0.01 to - 0.10) in Jersey crossbred cattle [47]. Reported estimates of genetic correlation between persistency and calving interval (CI) ranged from 0.11 to 0.17 whereas phenotypic correlation was 0.23 [43, 49]. Similar positive correlations (0.131±0.052, 0.17±0.09, 0.36±0.09) were also reported by other researchers [26, 48, 50]. As expected, greater the persistency in first lactation longer was the calving interval from first to second calving. Longer CI is generally viewed as undesirable; therefore, genetically an antagonistic relationship existed between persistency and CI in first lactation. With increase in calving interval there were increase in persistency and estimated correlation between persistency and calving interval in Sahiwal × Brown Swiss crossbred cattle was 0.289 [51]. Positive r_g (0.28 to 0.88) and r_p (0.04 to 0.15) between different persistency indices and calving interval (CI) were reported in Jersey crossbred cattle [47]. On the contrary, negative correlations (-0.069) between persistency and CI was reported in Rathi breed of cattle [46].

CONCLUSIONS

Lactation persistency has been mostly defined in terms of milk yield although other parameters such as fat yield and protein are also important they were seldom considered. According to the literature, lactation persistency has been measured based on ratios of partial, total, or peak production, variation among successive yields and mathematical lactation curve models. Effect of various genetic and nongenetic factors *viz*., effect of sire, season of calving, period of calving, parity, genetic group, age of calving, lactation length, peak yield, etc. on lactation persistency are well reported in the literature. Means and heritability of persistency differed according to the method of estimation. Genetic correlation between persistency and milk yield significantly depends on the lactation order and the measures of persistency used. Persistency and peak yield were negatively correlated as reported by most of the researchers. Although scanty literature is available on the relationship between persistency and reproductive traits, majority of the researchers have reported unfavorable relationships between persistency and reproductive traits. Further studies on the relationship between persistency and reproductive traits should be done.

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