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Influence of non-genetic factors on milk yield traits in Sahiwal cows

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Abstract

The present investigation aimed to determine the magnitude of non-genetic factors affecting the milk production traits of Indian dairy cattle, Sahiwal. The cattle were raised and maintained at Livestock research Farm of National Dairy Research Institute, Karnal, Haryana, India. The data representing 342 records of Sahiwal cows for first lactation 305 days milk yield and 212 cows records for lifetime milk yield over a period of 11 years (2006-2017) was collected. The Least square procedures of Harvey using season, parity and stage of lactation as the fixed effects were utilized for the analysis. The year was classified into four major seasons while the parity was grouped into five parities and the period of calving was divided into four classes. The overall least squares mean for first lactation 305 days milk yield and lifetime milk yield were found to be 2028.98 ± 13.32 kgs and 6775.92 ± 686.14 kgs respectively. 305-days milk yield was found to be significantly ($p<0.05$) affected by parity while Lifetime milk production was significantly ($p<0.05$) influenced by parity and season of calving. Results indicate that considerable variation exists for different milk production traits within the resource population. The above factors need to be included in genetic analysis while evaluating dairy animals and be used as a management tool, to improve selection criteria by accounting for non-genetic factors.

Keywords: parity, season of calving, period of calving, 305-d milk yield, lifetime milk yield, Sahiwal

1. Introduction

Sahiwal breed of cattle is the dominant milch breed having Indian origin with its native tract in North-Western region (Punjab region alongside Indian–Pakistan border) but a much broader breeding tract in the country [1, 2]. It is famous for higher milk production, remarkable power of endurance for hot climate of subtropics, comparatively resistant to diseases and low maintenance cost [3]. Cattle have deep body, loose skin, short legs, stumpy horns and a broad head with pale red to dark brown body colour [4]. It has gained international recognition which is evident from its eight synthetics (Australian Friesian-Sahiwal, Australian Milking Zebu, Frieswal, Jamaica Hope, Karan Swiss, Mafriwal, Mpwapwa and Taurindicus) produced for tropical/subtropical conditions [5]. Sahiwal cows, despite being genetically superior, has limited production, especially in smallholder management systems. Milk productivity in the country remains one of the lowest as compared to many leading countries of the world [6]. In modern dairying, the cow is under extreme pressure for high milk production and for maintaining her body to withstand the environmental stress for longer period of time [7]. Economic success of dairy farming is mainly affected by the milk production of cows. Out of enormous number of economic and functional traits, milk yield of cow is still a trait of primary importance [8]. It is the most crucial economic trait determining the economic returns to the dairy farmers [9]. Lifetime production is the key factor of milk production economic efficiency. 305 day's milk yield is also an important basis for the selection and elimination of cows during the production process and also for individual genetic evaluation which is defined as a cow's milk yield from day 1 to day 305 of the lactation period [10]. Every month, or every second month, test-day milkings are being carried out, which are the base or calculating 305-day lactation milk yield [11]. The yields of farm animals are the result of the combined effects of genotype and environmental conditions. The production performance is affected by various factors due to complex interactions between the animal and the environment with its different factors [12]. Genetic factors cause variations between individual animals within and between breeds. Environmental factors can be classified as factors with immeasurable effects (infectious diseases, parasitic infestations, etc.) and measurable effects (calving year, season, and age; number of lactations; body weight etc.) [13] The measurable effects can be determined and used in the management of the farm [14]. These effects influencing milk production traits have been previously studied in Jersey crossbred cattle and Murrah buffaloes by [15-17] respectively. Variation in protein and lactose content of milk have also been noticed because of different managemental practices as well as environmental factor [18]. Environmental variance, embracing all variation of non-genetic origin, is a source of error that reduces precision in genetic studies and tends to obscure the animal's true genetic ability. Estimation of systematic environmental sources of variation can help in developing models to predict future genetic abilities of the animals [19]. Therefore, adjusting records for environmental effects is essential for improving the selection procedures and defining appropriate breeding strategies [20]. A study on the non-genetic factors affecting milk production traits in Sahiwal cattle is therefore justifiable.

2. Material and Method

2.1. Subject and location of study: Data on cattle maintained at Livestock Research Centre, ICAR-National Dairy Research Institute, Karnal, India were used for study. Location of farm is between 29° 42'N latitude and 72° 54'E longitude at an altitude of 250 m above the mean sea level (MSL). Subtropical climate prevails with temperature ranging between 45 °C to 2 °C. The annual rainfall is 760 to 960 mm and relative humidity ranges from 40 to 85%. All nutrient requirements of lactating animals were fulfilled according to recommendations of ICAR (2012).

2.2. Source of information and data: Data of productive traits 305-d MY, LTMY was collected from the daily milk yield record registers of Livestock Record Unit, AG&B, NDRI, Karnal, India. 342 performance records of first 305-d MY of Sahiwal cows and 212 records of lifetime milk yield for over a period of 11 years (2006-2017) was collected. The total milk production upto 4th parity was regarded as lifetime milk production. Lifetime milk yield was considered for only those animals which has completed the 4th parity as after 4th parity milk production generally starts to decline.

2.3. Analysis: Least square analysis of variance using Harvey, (1990) (LSMLMW PC-2 VERSION) [21] was used to determine the effects of Season of calving, period of calving and parity. Year was classified into four major seasons, viz. S (1) winter (December - March), S (2) summer (April - June), S (3) rainy (July - September) and S (4) autumn (October - November) depending on prevalent meteorological factors as recorded in CSSRI, Karnal [22]. According to the parity order, cows were grouped from Group 1 to Group 5 where group 5 included cows in 5th and above parities. According to Period of calving, three classes were made, P1 (2006- 2009), P2 (2010-2013) and P3 (2014-2017). Duncan's Multiple Range Test (DMRT) was employed to test and locate means that were significantly differed among subclasses. The following statistical model was employed to analyse the data.

$$Y_{ijkl} = \mu + L_i + P_j + S_k + e_{ijkl},$$

where,

Y_{ijkl} = l^{th} Observation of cow in i^{th} lactation, j^{th} period of calving and k^{th} season of calving

μ = Overall mean

L_i = Fixed effect of i^{th} lactation (i= 1 to 5)

P_j = Fixed effect of j^{th} period of calving (j =1 to 3)

S_k = Fixed effect of k^{th} season of calving (l = 1 to 4)

e_{ijkl} = Random error NID (0, σ2e)

3. Result and Discussion

The production performance of the cows is affected by the various factors. Additive genetic variation and non- genetic variation, both play a major role, outcome of which is observed as the high or low milk yield of the animal. The heritability of the production traits is generally medium to low signifying the role played by non-genetic variation. The actual production records are delusional as they are swayed by the influence of the non-genetic factors. So, the analysis of the production records with the non-genetic factors is obligatory before the genetic evaluation of the dairy animals. The 305-day milk yield is an important basis for the selection and elimination of cows during the production process and for individual genetic evaluation [23]. It is still the current basis for the genetic evaluations of dairy cattle and the information is used by producers to make their management and breeding decisions [24]. Furthermore, Lifetime milk production has its own importance, higher lifetime milk production means that fewer cows are needed for the same scope of milk production on farms. Longer productive life ensures more lactations with higher milk production [25]. Longer life, higher milk production and more calves are characteristics of cows with good body composition [26]. It is required to know the significance of environmental impact on the results of the production traits of high-yielding cows in order to include it in the model. Considering the importance of each non-genetic factor, the unbiased assessment to evaluate the results as accurate as possible has been made in the study.

The overall least-squares mean for 305-d MY and LTMY were observed to be 2028.98 ± 13.32 kg and 6775.92 ± 686.14 kg in respectively resource Sahiwal cattle population. Similar findings were obtained by [27] while the estimates were higher for the Holstein cows as observed by [13]. The least squares mean of LTMY and 305-d MY as affected by different factors are presented in Table 1. 305-d MY was significantly ($p<0.05$) affected by parity and by stage of lactation similar to previous reports by [28, 29]. LTMY was significantly ($p<0.05$) affected by parity and season of calving.

Table 1: Least square means and standard errors for 305 days milk yield and lifetime milk yield on lactation, parity and season of calving.

Source of variation	Code	305 days milk yield		Lifetime milk yield	
Overall mean	μ	342	2028.98±13.32	212	6775.92±686.14
Period of calving					
1	P_1 (2006- 2009)	102	2052.47±22.21	56	6860.78±1403.18
2	P_2 (2010-2013)	153	2688.05±24.56	98	8448.86±1135.13
3	P_3(2014-2017)	87	1727.56±33.21	58	7100.19±1007.31
Parity					
1	L_1	35	1364.58^a±28.88	45	7437.32^b±1511.16
2	L_2	47	1597.23^b±22.67	42	5490.55^b±841.44
3	L_3	58	1833.39^{ab}±18.35	37	7708.05^b±1640.00
4	L_4	103	2767.79^c±23.42	52	8293.16^b±1675.93
5	L_5	99	2581.91^c±26.40	36	4950.54^a±1251.63
Season of calving					
1	S_1 (winter)	103	2109.10±23.52	85	5795.10^b±974.46
2	S_2 (summer)	64	1723.71±22.21	47	5111.89^a±1486.04
3	S_3 (rainy)	79	2027.92±19.74	39	9930.48^c±1536.00
4	S_4 (autumn)	96	2255.19±24.11b	41	6266.22^b±879.87

Note: Means with different letter (a, b, c) indicates significant difference (*p<0.05*).

The variation in MY observed in different parities indicates differences in management practices and also, the physiology of lactation i.e. given set of genes and their reaction with the environment. 305-d MY was the lowest in 1st parity and was found highest in 4th parity, declining thereafter similar to findings of [30] in Murrah buffaloes. An earlier report by [31] showed that cows of the same age but different parity had different production, and those differences were particularly evident for the 1st and 2nd parity. Average 305-d MY of 1st and 2nd parity was statistically different from each other; however, no statistical difference was seen between milk yield of 4th parity and above. The results can be explained with the perspective held by [32] who stated that cows in their 1st parity had significantly lower 305-dMY ($p<0.01$) than those cows in higher parities due to the fact that first lactation cows have lower energy balance for growth and lactation as they cannot consume adequate energy in diet and the peak yield was reported at 3rd parity and later declined which might be due to degeneration of secretory tissue of mammary gland with advancement of age. [33] also found that least squares mean of milk yield across parities increased with order of lactation and maximum production was obtained around 4th parity, there after a declining trend was noticed similar to this study findings [34]. had the findings that milk yield was lower in the 1st parity than other parities that tended to increase until the 5th parity and then decreased [35] . reported that mean 305-d MY increased with parity, which is consistent with present reports [36]. found that milk production was significantly lower in the 1st lactation than the yield in the 2nd, 3rd and 4th lactation [37, 38]. observed that production of cow reached the peak around 5th parity when an animal was 7-8 years old and gained the adult body size. LTMY was found to be highest in 4th parity and lowest in 5th parity in the present investigation. This is in agreement with the findings above which is obvious as 305-d MY is one of the main factors setting LTMY. So, the trend of both these traits is similarly affected by parity variation. Upto 4th parity, the average LTMY was similar, however, significantly different from 5th and higher parities. This happens due to increase in body weight combined with advancing age, full development of secretory tissues of udder occurs and the animal is able to exhibit its maximum genetic potential. Results coincide with [28] who reported that total milk yield of buffaloes increased from 1st to 4th parities and declined thereafter [39]. also observed higher milk yield in 4th and onward parities in Deoni cows. The effect of period of calving was not significant on any of the traits. This indicated that not much change has been made in the way of handling and controlling the managemental factors over the years.

Effect of season of calving on LTMY was statistically significant and non-significant on 305-d MY. The seasonal variations did not show any significant effect on 305-d MY, may be because the Sahiwal cows are well adapted to the climate and conditions of the region and are not influenced by any kind of seasonal stress. On the contrary, LTMY is affected by seasonal changes, acknowledgement of which can be to other miscellaneous factors not considered in this study. Cows calved in rainy season had the highest LTMY while those that calved in summers had the lowest. The reason for this might be the abundant availability of fodder during this season and also, the optimum temperature range favouring the animal to yield its best. However, different views have been reported by different researchers. The study by [30, 33] showed that winter calvers produced higher quantity of milk in all parities compared to those calved in other seasons [36]. had a different view that animals calving in spring showed the highest and those calving in summer showed the lowest milk yield. The milk yield did not differ between the autumn, winter and summer calvers.

Conclusion

It is concluded that correction of data for the effect of parity and season of calving is mandatory to increase the accuracy of estimated genetic potential, to avoid misleading conclusions when evaluating animals and to make decisions on proper culling. The results can be used as a management tool, to improve selection criteria by accounting for non-genetic factors.

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Conflict of Interest

The authors have declared no conflict of interests exist.

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