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RESEARCH ARTICLE

Environmental Factors Affecting Performance Traits of Sahiwal Cattle in Pakistan

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ABSTRACT

Data on 23925 lactations of 5897 Sahiwal cows in five Government herds of Punjab (Pakistan) viz. Livestock Experiment Station (LES) Allahdad, LES Bahadurnagar, LES Fazalpur, LES Jahangirabad and LES Khizerabad (1964-2004) were collected to document the behavior of various productive and reproductive traits of Sahiwal cows with respect to herd, year and season of calving and parity. A linear model was used to determine the effects of various environmental factors on performance traits. The 305-day milk yield, total milk yield, lactation length, dry period, calving interval and service period averaged 1530.5±12.36 kg, 1552.1±12.15 kg, 235±1.4 days, 218±2.1 days, 438±2.7 days and 151±2.8 days, respectively. All the productive and reproductive traits were affected (P<0.01) by herd, year, season of calving and parity. Lactation length was important covariable for yield traits while yield was important for dry period, service period and calving interval. Maximum yield was recorded for 5th parity cows. Calving interval differed by two months among herds. Cows calving in most frequent calving season (winter) produced more milk than summer calvers (1608.6±12.91 kg vs 1474.1±13.63 kg). The phenotypic trends for 305-day milk yield, total milk yield, lactation length, dry period, calving interval and service period were -1.33 kg, -0.21 kg, -1.27 days, +1.52 days, +0.32 days and +0.59 days, respectively. Lactation length (244.5 days) was used as covariable. Improvement in feeding and breeding management and culling on productivity may improve the performance of Sahiwal cows.

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INTRODUCTION

Sahiwal cattle of Pakistan are an important national genetic resource. Well known for its abilities to produce and reproduce adequately under tropical conditions has attracted various countries to produce synthetics and upgrading their local breeds (Dahlin *et al*., 1998; Ilatsia *et al.*, 2012). In its home tract, there is not just population decline (Ilatsia *et al*., 2007), but performance has also been reported to decrease (Rehman *et al*., 2008). Popularity of Sahiwal x Friesian F1 crossbreds has a constant pressure on the declining population. Its ranking by FAO as high priority cattle breed for conservation and development necessitates studies on the breed to access the status of its performance for lifetime traits.

Estimation of systematic environmental sources of variation such as age, herd, year and season of calving on performance traits can help in developing models to predict future genetic abilities of the animals. Most of the studies on Sahiwal breed were based on small data sets restricted to a specific herd and thus differed significantly in establishing performance pattern of the breed for traits of economic importance (Bajwa *et al*., 2004; Leclerc *et al*., 2008). A comprehensive attempt to establish performance pattern of the breed (Dahlin *et al*., 1998) was restricted to first three lactations for cows completing their performance in 1985. Lactation milk yield, for example has been reported to vary from 1474 L (Talbott *et al*., 1997) to 1862 liters (Javed *et al*., 2000), lactation length from 239 (Talbott *et al*., 1997) to 318 days (Javed *et al*., 2000) and calving interval from 465±2.1 (Dahlin *et al*., 1998) to 480±1.4 days (Talbott *et al*., 1997) for Sahiwal herds in Pakistan. For Sahiwal herds in India and Kenya, performance reports vary even to a greater extent. Systematic environmental factors have also been studied in Sahiwal breed both for herds in Pakistan, India and Kenya (Gaur and Raheja 1996; Javed *et al*., 2000; Raja and Narula 2007; Zafar *et al*., 2008; Monalisa *et al*., 2010)

but the extent of effect on various performance traits has been quite variable. In Cholistani cattle, the low productive performance was observed while it was at par with those of Sahiwal cattle (Farooq *et al*., 2010). Ilatsia *et al.* (2012) also observed the productive and reproductive performance of local Sahiwal cattle to optimize the breeding strategies in Kenya. Strandberg *et al*. (2009) observed genotype by environment interaction for various fertility traits in UK dairy cattle.

The objective of the present study aimed at establishing the productive and reproductive performance of Sahiwal cattle in Pakistan and to document the behavior of various performance traits with respect to herd, year, season of calving and parity.

MATERIALS AND METHODS

Source of Data: Data on performance traits of Sahiwal cattle from five recorded herds i.e. Livestock Experiment Station (LES) Allahdad, LES Bahadurnagar, LES Fazalpur, LES Jahangirabad and LES Khizerabad were collected for this project. The performance traits examined were 305-d milk yield, total milk yield, lactation length, dry period, calving interval and service period of Sahiwal cows.

The data on the various performance traits were analyzed to evaluate the magnitude of various environmental sources of variation. Incomplete lactations for any recorded reason or lactations ending with abortion or other anomaly were not utilized. Lactation records of less than 60 days were not considered in the analysis. In order to eliminate the effect of short dry period on subsequent production, a dry period of less than 30 days were omitted. The records of cows which had aborted or missed a year due to sickness or other reasons were eliminated. Lactation numbers more than 10 were converted into 10. Initially 23925 lactation records of 5897 cows sired by 300 males were available. The structure of data left at the end of the various edits is summarized in Table 1.

The year was divided into winter (December to February), Spring (March to May), Summer (June to August) and Autumn (September to November) seasons. Herd by year interactions and year by seasons could not be fitted because some of the years were not common in herds. Apart from these cross-classified effects, lactation length was fitted as covariable for 305-d and total milk yield while 305-d milk yield was fitted as covariable for dry period, service period and calving interval. Coefficient of determination (R^2) was generated for all the analyses. Multiple means comparisons were done by Duncan's multiple range tests. Statistical Package for Social Sciences (SPSS, 2004) was used for these analyses.

Following model was used to evaluate the effect of various environmental factors on performance traits.

$$Y_{ijklm} = \mu + H_i + Y_j + S_k + P_l + b\,(LL_{ijklm}) + e_{ijklm}$$

Where,

μ = population mean of a particular trait (e.g, 305-day milk yield)

Y_{ijklm} = individual measurement on the trait

H_i = Effect of i^{th} herd (I = 1 to 5)

Y_j = the effect of j^{th} year of calving (j = 1 to 41)

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

P_l = effect of lth parity (l= 1 to 10)

$b(LL_{ijklm})$ = linear regression of LL (lactation length) on the trait

e_{ijklm} = the random error associated with each observation assuming zero mean & normal distribution.

RESULTS AND DISCUSSION

305-day milk yield: The average 305-d milk yield in the present study was 1530.5±12.36 kg. It was highest (1608.6±12.91 kg) in cows calved during winter and lowest (1474.1±13.63 kg) in summer calvers (Table 3). The across herd performance also varied as cows from LES Allahdad performed comparatively better (1757.8±15.22 kg). The phenotypic trend in the 305-day milk yield over the years was -1.33 kg (Fig.1). Across parities, peak was attained in the 5^{th} parity and declined thereafter (Table 3). The average 305-d milk yield was similar to previous studies (Bajwa *et al*. 2004; Rehman *et al*., 2008; Ilatsia *et al*., 2012) on Sahiwal cattle. Yet, higher averages 1862.4 to 2083 kg have also been reported (Dongre *et al*., 2011). In Holstein cattle the average 305-d milk yield observed was 1776 kg (Haile *et al*., 2009).

Total milk yield: The average total lactation milk yield was 1552.1±12.15 kg. The milk yield across herds was variable (Table 3). It was sensitive to seasonal variation ($P<0.01$). The phenotypic trend in the trait was similar to 305-d milk yield except that rate of decline was -0.21 kg per year (Fig.1) as compared to -1.33 kg for 305-d milk yield. Highest milk yield (1607.6±14.57 kg) was attained in the 5^{th} parity and winter calvers produced (1629±12.70 kg) better than the cows calving in other seasons (Table 3).

The previously reported almost same lactation milk yield (1474 to 1550 kg) was also confirmed by the findings of present study (Talbott *et al*., 1997; Dahlin *et al*., 1998; Bajwa *et al*., 2004; Ilatsia *et al*., 2012). In Cholistani cattle the total milk yield observed was 1235 litres (Farooq *et al*., 2010). In Holstein cattle the average total milk yield observed was 2055 kg (Haile *et al*., 2009).

However, the higher estimates of milk yield (1662 to 2178 kg) were also reported by Gaur and Raheja (1996) and Javed *et al*. (2000). As lactation length in the present study was much below the standard 305-days, both 305-d yield and total lactation milk yield were expected to behave similarly.

Lactation length: On an average the cows produced milk for 235±1.4 days (Table 3). The differences in lactation length were subtle for herds as compared to season of calving. Highest (254±2.5 days) and lowest (197±2.6 days) lactation length was observed for LES Allahdad and LES Fazilpur, respectively (Table 3). The lactation length ranged from 226±2.2 days in autumn to 238±2.1 days in spring calvers (Table 3). The trait deteriorated over the years at the rate of 1.3 days (Fig.1).

The parity of cow did influence the lactation length ($P<0.01$). The first five parity cows were having an increasing phenotypic trend in lactation length (2.2 days/lactation). The cows in later parities were having

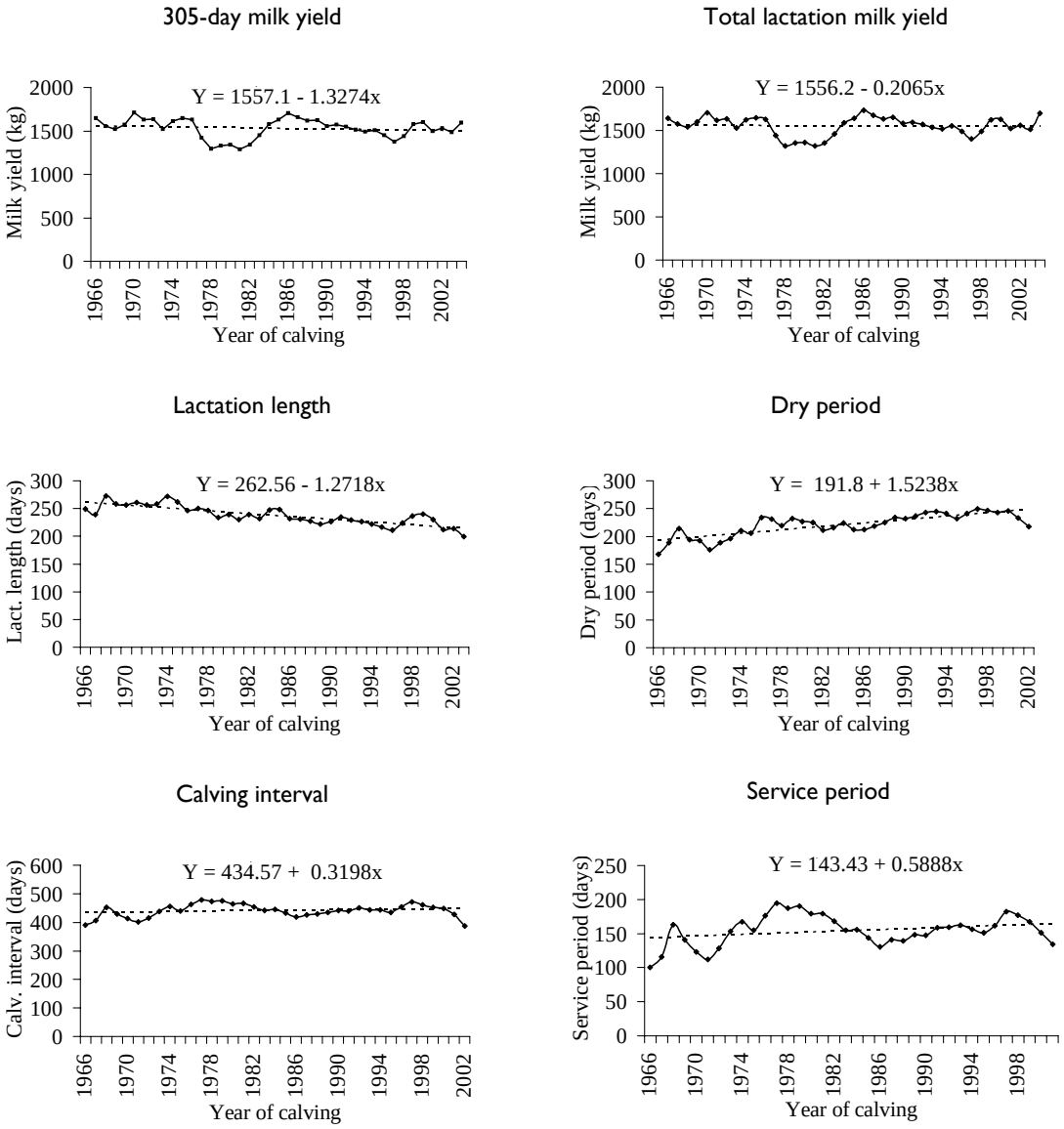

Fig. 1: Phenotypic trends in performance traits of Sahiwal cattle

Table 1: Percent records removed after applying the edit criteria on all the traits under study

Sr. No.	Traits	Total records	Acceptable range	Records		
				Utilized	Removed	%
1	305-day milk yield (kg)	23637	≥1 kg/day of LL	22970	667	2.8
2	Total milk yield (kg)	23764	≥1 kg/day of LL	23049	715	3.0
3	Lactation length (days)	23925	≥ 60	23170	755	3.0
4	Dry period (days)	18817	≥ 30 to ≤ 730	18188	629	3.3
5	Calving interval (days)	19003	≥ 300 to ≤ 900	18540	473	2.4
6	Service period (days)	18215	≥ 30 to ≤ 600	17674	541	2.9

LL: Lactation length

Table 2: Environmental factors affecting performance traits of Sahiwal cattle

Sources of Variation	305-d MY (kg)		Total MY (kg)	Lactation Length (d)			Dry period (d)	Calving Interval (d)	Service period (d)
	df	F-ratio	F-ratio	df	F-ratio	df	F-ratio	F-ratio	F-ratio
Herd	4	407.5**	323.5**	4	326.5**	4	345.9**	161.5**	139.2**
Year	38	42.1**	40.3**	38	28.2**	37	10.2**	13.8**	14.6**
Season	3	130.4**	130.8**	3	27.2**	3	6.5**	8.7**	17.3**
Parity	9	106.7**	97.6**	9	14.0**	9	10.6**	29.3**	26.7**
Lact. length	1	22758.2**	29219.3**	-	-	-	-	-	-
305-d MY	-	-	-	-	-	1	1171.2**	382.0**	381.5**
Error	22911	-	-	22913	-	18577	-	-	-
R^2	93.0	93.0	93.6		93.0		78.0	94.0	71.0

**: Significant (P<0.01), ns: non significant, MY: milk yield, R^2: coefficient of determination (%)

305-d MY (kg) = -25 + 6.24 lactation length (days); Total MY (kg) = -173 + 6.95 lactation length (days)

Table 3: Least square means for performance traits in Sahiwal cattle

Sources of Variation	305-d MY (kg)		Total lact. MY (kg)		Lactation Length (d)		Dry Period (d)		Calving Interva (d)	Service Period (d)
	n	Mean±SE	Mean±SE	n	Mean±SE	n	Mean±SE	Mean±SE	Mean±SE
Herd										
LES Allahdad	2180	1757.8±15.22^{d}	1754.2±14.98^{e}	2180	254±2.5^{e}	1777	182±3.4^{a}	404±3.7^{a}	121±3.7^{a}
LES Bahadurnagar	7975	1425.4±12.81^{c}	1463.8±12.60^{d}	7975	253±2.1^{d}	6384	167±2.3^{a}	421±2.9^{a}	139±2.9^{a}
LES Fazilpur	1552	1307.5±16.31^{a}	1350.9±16.04^{a}	1552	197±2.6^{a}	1051	279±4.2^{d}	439±4.1^{b}	137±5.0^{a}
LES Jehangirabad	7593	1539.2±12.76^{b}	1560.8±12.56^{b}	7594	223±2.1^{b}	6448	217±2.3^{b}	446±2.8^{c}	160±2.8^{b}
LES Khizerabad	3667	1622.7±14.20^{c}	1630.8±13.96^{c}	3667	236±2.3^{c}	2972	246±3.0^{c}	482±3.4^{d}	196±3.4^{c}
Season										
Winter	8161	1608.6±12.91^{c}	1629.7±12.70^{c}	8161	233±2.1^{c}	6681	222±2.4^{a}	435±2.9^{ab}	144±3.0^{a}
Spring	6321	1491.6±13.20^{ab}	1515.6±12.98^{b}	6322	238±2.1^{c}	5028	219±2.5^{b}	445±3.0^{c}	158±3.1^{c}
Summer	4443	1474.1±13.63^{a}	1495.8±13.41^{a}	4443	234±2.2^{b}	3618	211±2.7^{a}	439±3.2^{b}	154±3.2^{b}
Autumn	4042	1547.8±13.75^{b}	1567.0±13.52^{b}	4042	226±2.2^{a}	3305	221±2.7^{ab}	435±3.2^{a}	147±3.3^{a}
Parity										
1st	5495	1348.7±12.87^{b}	1380.1±12.65^{b}	5495	231±2.1^{ef}	4812	235±2.2^{d}	468±2.8^{b}	178±2.9^{b}
2nd	4468	1495.9±13.27^{d}	1520.7±13.04^{d}	4469	237±2.1^{f}	3779	223±2.4^{ab}	445±3.0^{a}	158±3.0^{a}
3rd	3564	1568.0±13.67^{ef}	1577.9±13.44^{f}	3564	241±2.2^{f}	2952	215±2.6^{a}	436±3.1^{a}	147±3.2^{a}
4th	2851	1563.1±14.15^{def}	1582.7±13.92^{ef}	2851	239±2.3^{ef}	2279	214±2.9^{a}	437±3.3^{a}	150±3.4^{a}
5th	2205	1591.8±14.82^{f}	1607.6±14.57^{f}	2205	241±2.4^{ef}	1719	213±3.2^{a}	434±3.5^{a}	146±3.6^{a}
6th	1618	1572.6±15.82^{de}	1590.3±15.56^{de}	1618	236±2.6^{de}	1257	210±3.7^{a}	428±3.9^{a}	140±4.0^{a}
7th	1174	1584.5±17.14^{d}	1600.2±16.86^{d}	1174	233±2.8^{cd}	855	224±4.3^{bc}	440±4.5^{a}	151±4.5^{a}
8th	769	1557.4±19.39^{c}	1579.6±19.07^{c}	769	231±3.1^{c}	505	213±5.4^{ab}	432±5.5^{a}	143±5.6^{a}
9th	437	1554.8±23.60^{b}	1578.5±23.21^{b}	437	226±3.8^{b}	277	215±7.2^{bc}	429±7.1^{a}	143±7.2^{a}
10th	386	1478.4±24.76^{a}	1503.1±24.35^{a}	386	213±4.0^{a}	197	218±8.5^{bc}	437±8.2^{a}	150±8.4^{a}
Overall	22967	1530.5±12.36	1552.1±12.15	22968	235±1.4	18632	218±2.1	438±2.7	151±2.8

MY: milk yield, n: number of observations, d: days, SE: standard error

^{abc} Means with the different superscripts within column in a parameter are significantly different (P<0.05).

decreasing phenotypic trend in lactation lengths (-0.8 day/lactation). The shortest length of lactation was observed in the tenth parity (213±4.0 days).

The same range of lactation length (239-268 days) in Sahiwal cows has previously been reported (Rehman *et al*., 2006; Ilatsia *et al*., 2012). In Cholistani cattle the lactation length observed was 165 days (Farooq *et al*., 2010).

Dry period: The dry period averaged 218±8.5 days (Table 3). Across herd variation was apparent. LES Bahadurnagar had the minimum dry period of 167±2.3 days. It was closely followed by LES Allahdad (182±3.4 days). LES Jahangirabad, LES Khizerabad and LES Fazilpur averaged 217±2.3, 246±3.0 and 279±4.2 days, respectively. The winter calvers had the highest average (222±2.4 days) while spring calvers had the lowest average (211±2.7 days). The trait decreased with the advancing parity. First calvers had average dry period of 235±2.2 days. The phenotypic trend in dry period was increasing i.e. 1.5 days per year (Fig. 1). The effect of 305-d milk yield was also an important modifying factor in the length of dry period. The high producers had shorter than average dry period (-0.06±0.001 day decrease/kg milk).

Long dry period has already been reported in Sahiwal cattle (Talbott *et al*., 1997; Rehman *et al*., 2006). In Cholistani cattle the dry period observed was 155 days (Farooq *et al*., 2010).

Calving interval: The average calving interval in the present investigation was 438±2.7 days (Table 3). The trait proved to be dependant in its expression on herd, year, season of calving and parity of cow (P<0.01). The calving interval of cows calving during spring was the longest (445.5±3.0 days) and it was the shortest (435±3.2 days) in autumn calvers (Table 3). The management groups (herds) caused the most of variation in the trait. The LES Khizerabad Sahiwals had the longest (482±3.4 days) calving interval while cows from LES Allahdad had the shortest (404±3.7 days) calving interval. The parity of cow also influenced the length of interval between two calvings (P<0.01). The first lactation cows exhibited longer calving intervals (468±2.8 days) while the cows in 6th parity were having somewhat shorter (428±3.9 days) calving interval which again increased in subsequent lactations. There was a slight increasing trend (0.32 days/year) in calving interval of cows calving in different years (Fig. 1).

A reduction in calving interval is desirable to produce more number of calves ultimately improving overall productivity (Dahlin *et al*., 1998). The longer calving interval (428-506 days) in Sahiwal cows have been reported earlier (Javed *et al*., 2000).

Service period: The average service period in Sahiwal cows was 151±2.8 days (Table 2). The trait was analysed with fixed effects of herd, year, season and parity of cow with 305-d milk yield as covariable. The trait was effected by all the factors included in the model (P<0.01). The seasonal variation in response was evident from the results i.e. cows calving during winter were having comparatively shorter service period (144±3.0 days) than those calving in other seasons (Table 3). There was a lot of fluctuation in the service period among cows calving during different years (Fig. 1).

Herd with maximum service period (LES Khizerabad) and minimum service period (LES Allahdad) differed by 75 days. The 305-d milk yield affected the trait. High producer cows had longer service period and consequently longer calving interval. Yet, Talbott *et al*. (1997) had reported similar averages for service period in Sahiwal cows. In Cholistani cattle, the service period observed was 121 days (Farooq *et al*., 2010).

Conclusions: The performance traits in Sahiwal cows were affected by year and season of calving. Herd differences which represent management differences affected all the traits. Cows calving in winter season

produced highest milk yield (1630 kg) as compared to those calving in summer season (1496 kg) due to more availability of fodder than in summer. The differences in lactation length were subtle for herds as compared to season of calving. Across herd variation in dry period was apparent. The dry period in winter calvers was the highest (222±2.4 days) while spring calvers had the lowest (211±2.7 days). The calving interval proved to be dependant in its expression on herd, year, season of calving and parity of cow ($P<0.01$). The service period was effected by herd, year, season and parity of cow with 305-d milk yield as covariable ($P<0.01$).The phenotypic trend for various productive and reproductive traits were deteriorated over the years and needs serious efforts to revive the economic viability of the breed. There is a lot of variation within herd which promises for scope in the productivity of this important national resource.

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