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FACTORS AFFECTING PERFORMANCE OF SAHIWAL CATTLE – A REVIEW

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ABSTRACT

Sahiwal cattle of Pakistan is one of the best zebu cattle breed that can potentially play the same role as Holstein for tropical environment. The environmental factors are generally influenced the Sahiwals' performance as well as other breeds. The performance traits reviewed were age at first calving, milk yield, lactation length, dry period, calving interval, and service period of Sahiwal cows. The average age at first calving among Pakistani Sahiwals ranged from 1242±6.7 to 1358±7.9 days. It was 1094 to 1263 days in Indian Sahiwals while Kenyan herd was reported to have 1293±9.3 days of age at first calving. Lactation milk yield have been reported 1474±15.4 kg to 2058.3±9.25 kg in 247 to 318 days longer lactations in Pakistani Sahiwals. Reports on dry period have a range of 148 to 245 days while the lactation milk production for Indian Sahiwals was almost in the same range 1455±10 to 2177.8±40.8 kg in 274±0.8 to 372±8 day long lactations. All the productive and reproductive traits were affected by herd, year, season of calving and parity. The phenotypic correlations among various performance traits have also been reported. Phenotypic deterioration in milk yield was noted over the years.

Key words: Sahiwal cattle, eenvironmental factors, phenotypic performance, milk yield

INTRODUCTION

Sahiwal is one of the fifteen documented cattle breeds of Pakistan that has gained international recognition. This breed is recognized as one of the best milch breeds in the tropics (Ilatsia *et al.*, 2011). Famous for its resistance to internal and external parasites and adequate milk production under subsistence production set up, it has been exported to other countries both for raising as purebred and for the production of synthetics. Examples of such synthetics are Australian-Friesian-Sahiwal, Australian Milking Zebu, Frieswal, Jamaica Hope, Karan Swiss, Mafriwal, Mpwapwa and Taurindicus etc.

In Pakistan the population of Sahiwal breed has been decreasing over the years due mainly to its crossing with exotics such as Friesian for dairy purposes. Livestock census published in 2006 (GOP, 2006) indicated that 1.4 million animals (6.8% of total cattle population) of this breed were available in Pakistan. Later, estimated population of breeding females of this breed was 9000-10500 heads (Payne and Hodges, 1997). The decline in Sahiwal cattle population was also reported by Ilatsia *et al*., (2007). Apart from these contradicting statistics, general consensus remains that population of Sahiwal cattle is decreasing mainly because of crossbreeding. Due to relatively small population size there is a threat of inbreeding in Pakistani Sahiwals which may further decline different production parameters (Iqbal *et al*., 2012).

The productivity of Sahiwal cattle has been reported to vary both across and within countries. Dahlin *et al*. (1998) reported total lactation yield of 1528 litres in a lactation length of 252 ± 82 days in Sahiwal cows at different Livestock Experiment Stations in Punjab. In a later study, Javed *et al*. (2000) reported that average lactation yield of 1862.4 ± 42 litres in a lactation length of 318 ± 3.24 days in Sahiwal cows at one of the main herds, Livestock Experiment Station Jahangirabad, Punjab. However, Rehman and Khan (2012) reported that in Sahiwal cattle the average lactation milk yield was 1552.1±12.15 kg in a lactation length of 235±1.4 days at 05 main Sahiwal herds of Punjab. Lactation performance of this breed in other countries has been reported to be in the range of 1474 to 1550 kg (Talbott *et al*., 1997; Dahlin *et al*., 1998; Bajwa *et al*., 2004; Rehman *et al*., 2006; Ilatsia *et al*., 2011). However, higher lactation milk yield of 2177.8 ± 40.8 litres with a lactation length of 294 ± 1.6 days was reported by Gaur and Raheja (1996). In other breeds like Cholistani cattle the total milk yields observed was 1235 litres (Farooq *et al*., 2010) and in Holstein cattle the average total milk yield observed was 2055 kg (Haile *et al*., 2009).

For traits other than lactation yield or duration, performance of Sahiwal has also been quite variable. The average age at first calving reported by Javed *et al*. (2000) was 1358 ± 7.9 days while Talbott *et al*. (1997) reported an average of 1339 ± 8.2 days for herd at Livestock Experiment Station, Bahadurnagar. In more recent study, Rehman *et al*. (2008) reported the overall age at first calving in Sahiwal cattle was 1390 ± 3.9 days

with a range of 1,327 to 1,510 days among 05 main herds of Punjab. A lower average of 1243±6.7 days was reported by Mohiuddin *et al*. (1994). For Kenyan Sahiwal age at first calving reported by Rege *et al*. (1992) was even lower (1218 ± 9.3 days). Reports from India has also been quite contradictory. Average age at first calving varied between 1195 (Kushwaha and Misra, 1969) and 1664 (Nandagawali *et al*., 1996) days. Differences in these studies may be more of environmental nature as opposed to genetics; sampling of population and data edits might have widened these ranges. For other reproductive traits, reports disagree even to a greater extent. The different environmental factors like herd, year and season of calving have also been studied in Sahiwal breed both for herds in Pakistan, India and Kenya (Gaur and Raheja 1996; Dahlin *et al*., 1998; Javed *et al*., 2000; Ilatsia *et al*; 2007; Raja and Narula 2007; Zafar *et al*., 2008; Monalisa *et al*., 2010) but the extent of effect on various performance traits have been quite variable.

Productive and Reproductive Performance: The Sahiwal cattle in their home tract (Punjab Province of Pakistan) have variable productivity reports. They have been reported to produce 1474±15.4 kg to 2217±10.48 kg of milk in 235 to 348 days longer lactations. Reports on dry period have a range of 148 to 245 days (Table 1). The largest data set contributing to these findings i.e. lactation performance of Sahiwal cattle, was that of Dahlin *et al*. (1998) who analyzed 11 Sahiwal herds in Pakistan for which 4069 cows contributed their lactation records. Later on, Rehman and Khan (2012) studied relatively smaller data sets in 05 Sahiwal hers while some others studied single herds containing little information except for Ahmad (1999) who included data from three herds.

The lactation milk production for Indian Sahiwals was almost in the same range 1455±10 to 2177.8±40.8 kg in 274±0.8 to 372±8 day long lactations (Table 1). The data sets belonging to various Indian Sahiwal herds also varied in number of cows (222-2163) contributing their lactations for analysis. Report on Kenyan Sahiwals (Rege *et al*. 1992; Ilatsia *et al*. 2007) also presented similar lactation average (1370 to 1666.4 kg). For other breeds like Red Sindhi, average lactation milk yield has been reported to range from 1531±34 kg (Ahmad, 1998) to 2019.2 kg (Wahid, 1962). For few herds in India, lactation milk yield in Red Sindhis have been reported to range 1050 to 1666 kg. Many of these reports did not provide statistics on lactation lengths or data edits and are thus difficult to be compared. Reports on Tharparkar are few and lactation average ranges from 1138 to 1410 kg. The Cholistani breed of Pakistan has an average of 1235 litres with 165 days lactation lengt. The Hariana breed from India may have similar average.

The age at first calving in Red Sindhi cattle of Pakistan was reported to be 1244 to 1347 days (Wahid, 1962; Ahmad, 1998). The trait was in the similar range for Indian Red Sindhis while in the other zebu breeds age at first calving ranged from 1346±26.6 to 1707±19.4 days.

Calving interval for Sahiwal cows in Pakistan was reported to be 429±1.9 to 480±1.4 days (Table 2). Range was even wider (388 to 498 days) for Indian Sahiwal herds. For Kenyan herd average of 426 to 468 days has been reported. In Red Sindhi cows, calving interval of 447 to 461 days has been reported while range is 437 to 546 days for Indian herds. Tharparkar, Hariana, Gir and Kankrej cattle breeds may have a comparable calving interval (Table 2).

The average service period has been reported to range 125±1.6 to 194±6.1 days in Pakistani Sahiwal cows and 73 to 294±1.6 days in Indian Sahiwals (Table 2). A higher range of 222 to 252 days has been reported in Tharparkar breed and almost a similar average (266 days) in Kankrej breed. Most of these reports indicated longer service period and calving intervals than commercial breeds. Age at first calving has also been quite high and dry periods longer. Most of these reports belong to cows on Government experiment

Environmental Factors Affecting Performance Traits

Milk Yield: Among the environmental factors, herd, year and season of calving are reported to affect milk yield. Among biological factors, parities (or age of the cow), lactation length, dry period and service period also influence lactation milk yield. The precise estimation of these effects help in improving managemental aspects of productivity as well as in more precise estimation of breeding values for genetic selection of animals.

Milk production of Sahiwal cattle in Pakistan has been reported to be influenced by herd, year and season of calving (Table 3). Indian studies have similar findings. The intensity of environmental influences on most of the traits vary among studies which may reflect the actual effect of some of these factors as well as sampling and modelling of various factors. Exclusion and inclusion of some factors also affect the variation explained by other factors being studied.

Many of the studies presented in Table 3 pertain to single herds yet, those involving multiple herds reported milk yield differences due to herds (Gandhi *et al*., 1995; Talbott *et al*., 1997; Dahlin *et al*., 1998; Ahmad, 1999; Rehman *et al*. 2006; Rehman and Khan, 2012). Year of calving represents managemental as well as environmental differences and has been found important in most of the studies on Sahiwal. Seasonal effects are important too (Yadav *et al*., 1992; Javed *et al*., 2000; Bajwa *et al*., 2004; Rehman *et al*. 2006; Zafar *et al*. 2008; Rehman and Khan, 2012). Parity has been reported to be an important variation source (Yadav *et al*., 1992; Talbott *et al*., 1997; Javed *et al*., 2000; Zafar *et al*. 2008; Rehman and Khan, 2012). Some workers studied actual age at calving instead of or in combination

with parity and found it to be important source of variation in lactation milk yield (Talbott *et al*., 1997; Ahmad, 1999) while others reported that parity may be important but age at calving may not be (Yadav *et al*., 1992). Lactation length is probably most important determinant of milk yield but as most of Sahiwal cows do not reach the standard of 10-months, lactations may not be adjusted to a base which is unrealistic for Sahiwal (Khan and Iqbal, 1999; Rehman and Khan, 2012). Reports on the effect of service period on lactation milk yield are few (Ahmad, 1972; Chopra *et al*., 1973; Garcha *et al*., 1989) and their findings do not agree. For other zebu breeds or their crossbreds, effects of various factors affecting milk yield vary substantially from each other.

Table 1. Average values for productive traits in different breeds of dairy cattle

Breed	Country	N[1]	MY[1] (kg)	LL[1] (days)	DP[1] (days)	References
Sahiwal	Pakistan	1776	1474.0±15.4	247	187±10.8	Talbott *et al*. (1997)
Sahiwal	Pakistan	4069	1528.3	252±82	-	Dahlin *et al*. (1998)
Sahiwal	Pakistan	2338	1762±12.51	281±1.1	148±2.1	Ahmad (1999)
Sahiwal	Pakistan	2532	1862.4±42.0	318±3.2	198±4.4	Javed *et al*. (2000)
Sahiwal	Pakistan	661	1475.0±25.3	248±2.6	-	Bajwa *et al*. (2004)
Sahiwal	Pakistan	3434	1547	268	-	Rehman *et al*. (2006)
Sahiwal	Pakistan	5697	1537±9.03	262±1.04	172 ± 3.70	Zafar *et al*. (2008)
Sahiwal	Pakistan	5897	1552.1±12.15	235±1.4	218±8.5	Rehman and Khan (2012)
Sahiwal	Pakistan	3054	2217±10.48	348±0.78	-	Khan *et al*. (2012)
Sahiwal	India	-	1866.0	-	-	Reddy & Nagarcenkar (1988b)
Sahiwal	India	1183	1455±10.0	274±0.8	148±1.8	Kimenye (1981)
Sahiwal	India	580	2083±33	336	140	Bhatnagar *et al*. (1983)
Sahiwal	India	222	1701.0±2.0	372±8	-	Yadav *et al*. (1995)
Sahiwal	India	2163	1659.9	278±3	-	Gandhi *et al*. (1995)
Sahiwal	India	1186	2177.8±40.8	294±1.6	127±5.8	Gaur and Raheja (1996)
Sahiwal	India	594	1721.3±36.5			Sentitula (2007)
Sahiwal	India	549	1894.1±47.7			Manoj (2009)
Sahiwal	India	676	1759.8±43.6			Raja (2010)
Sahiwal	India	713	1834.8±36.8			Monalisa *et al*. (2010)
Sahiwal	Kenya	-	1662.8	-	-	Rege *et al*. (1992)
Sahiwal	Kenya	6365	1370	278		Ilatsia *et al*. (2007)
Red Sindhi	Pakistan	-	2019.2	-	-	Wahid (1962)
Red Sindhi	Pakistan	-	1531.0±34.0	277	245	Ahmad (1998)
Red Sindhi	India	-	1666.4	-	-	Amble *et al*. (1967)
Red Sindhi	India	-	1316.8	-	-	Bhasin and Desai (1967)
Red Sindhi	India	102	1050.0	-	-	Johar and Taylor (1967a)
Tharparkar	Pakistan	218	1138.5±26.8	-	-	Ahmad *et al*. (1984)
Tharparkar	India	770	-	-	115	Vij *et al*. (1992)
Tharparkar	India	310	1410.3±23.8	-	-	Yadav *et al*. (1994a)
Cholistani	Pakistan	-	1235	165	155	Farooq *et al*. (2010)
Hariana	India	270	1429.0±16.0	532±5	-	Yadav *et al*. (1995)
Jenubi	Iraq	108	906.4±32.9	193±8.2	159±13.6	Maarof *et al*. (1987)

[1] N: number of cows, MY: milk yield LL: lactation length, DP: dry period,

The age at first calving among Pakistani Sahiwals ranged from 1242±6.7 to 1390±3.9 days. It was 1094 to 1281 days (Table 2) in Indian Sahiwals while Kenyan herd was reported to have 1218 to 1347 days of age at first calving.

Lactation Length: For lactation length, year and season of calving and parity (or calving age) have been reported to be important sources of variation (Table 4). The analyses of data on 23170 lactation records of 5897 Sahiwal cows maintained at five institutional herds in Pakistan reported that different herds, year and season of calving and parities affected lactation length significantly (Rehman and Khan, 2012), while the data on 9052 lactation records of 2163 Sahiwal cows maintained at five farms in India reported that different herds and parities affected lactation length significantly (Gandhi *et al*., 1995) but season did not have any effect. Data on 1186 records of Sahiwal cows, collected during 1951-73 had a significant effect of years on the lactation length (Gaur and Raheja, 1996). Similar findings were reported by Kathiravan *et al*. (2010) and Monalisa *et al*. (2010). Dahlin *et al*. (1998) analyzed data of 4069 Sahiwal cows maintained at 11 Government Livestock Farms in

Pakistan and reported that the first lactation length was affected significantly (P<0.01) by herd-year of calving while data from 588 lactation records of Hariana cows revealed a significant effect of period of calving on lactation length (Yadav and Rathi, 1992).

On the contrary, some studies reported a non-significant effect of year of calving and season of calving on lactation length in different breeds including Tharpakar (Ram *et al*., 1979; Ghandi *et al*., 1995). Similarly, season of calving effect was not important in Hariana, Tharparkar and Sahiwal breeds (Yadav and Rathi, 1992).

Table 2. Average values for reproductive traits in different breeds of dairy cattle

Breed	Country	N[1]	AFC[1] (days)	CI[1] (days)	SP[1] (days)	References
Sahiwal	Pakistan	2468	-	-	125±1.6	Shah and Shah (1983)
Sahiwal	Pakistan	6000	1345	456	172	Khan *et al*. (1992)
Sahiwal	Pakistan	1062	1242±6.7	-	-	Mohiuddin *et al*. (1994)
Sahiwal	Pakistan	489	1336	480±1.4	194±6.1	Talbott *et al*. (1997)
Sahiwal	Pakistan	4213	1345	465±2.1	-	Dahlin *et al*. (1998)
Sahiwal	Pakistan	910	1369±8.2	429±1.9	144±1.9	Ahmad (1999)
Sahiwal	Pakistan	2030	1358±7.9	468±4.3	186±4.8	Javed *et al*. (2000)
Sahiwal	Pakistan	5752	1390 ± 3.9	464±2.5	178±3.1	Rehman *et al*. (2008)
Sahiwal	Pakistan	4461	-	437±1.4	159±1.56	Zafar *et al*. (2008)
Sahiwal	Pakistan	5897	-	438±2.7	151±2.8	Rehman and Khan (2012)
Sahiwal	India	241	-	388	-	Singh and Dutt (1963)
Sahiwal	India	827	-	439	-	Kushwaha (1965)
Sahiwal	India	-	-	416	-	Johar and Taylor (1967b)
Sahiwal	India	-	-	479	-	Bhasin and Desai (1967)
Sahiwal	India	245	1195	498		Kushwaha and Misra (1969)
Sahiwal	India	-	1094	-	73	Bhatnagar *et al*. (1979)
Sahiwal	India	108	1263±4.7	454±2.8	170±3.4	Singh *et al*. (1990)
Sahiwal	India	222	-	493±4	-	Yadav *et al*. (1995)
Sahiwal	India	1186	-	445±5.9	294±1.6	Gaur and Raheja (1996)
Sahiwal	India	393	1104±23.8	-	-	Singh *et al.* (2005)
Sahiwal	India	574	1167±11.3	-	141.7±7.7	Kumar (2007)
Sahiwal	India	594	1152± 8.4	-	142.4±6.3	Sentitula (2007)
Sahiwal	India	901	1281±19.7	-	229±0.4	Kathiravan *et al*. (2009)
Sahiwal	India	842	1111± 9.98	-	134±5.34	Manoj (2009)
Sahiwal	India	961	1117±05.2	-	149.6±5.2	Raja (2010)
Sahiwal	Kenya	-	1218±9.3	426	-	Rege *et al*. (1992)
Sahiwal	Kenya	2894	1347	468		Ilatsia *et al*. (2007)
Red Sindhi	Pakistan	169	1347	515	236	Ahmad (1998)
Red Sindhi	Pakistan	-	1244	447	-	Wahid (1962)
Red Sindhi	India	216	1305	461	-	Venkayya & Anantakrishnan (1956)
Red Sindhi	India	-	1268	546	-	Amble *et al*. (1967)
Red Sindhi	India	-	-	437	-	Johar and Taylor (1967b)
Tharparkar	India	187	-	-	222	Kumar (1982a)
Tharparkar	India	117	1346±19.9	528±13.7	252±13.5	Panneerselvam *et al*. (1990)
Tharparkar	India	310	-	440±5.7	-	Yadav *et al*. (1994a)
Tharparkar	India	151	-	431±5.0	-	Yadav *et al*. (1995)
Hariana	India	-	1405±9.4	-	208±6.7	Arora and Sharma (1981)
Hariana	India	750		-	183	Kumar (1982a)
Hariana	India	270	-	415±4.0	-	Yadav *et al*. (1995)
Angole	India	306	-	498±4.3		Sharma (1981)
Gir	India	-	1346±26.6	-	274±21.8	Umrikar *et al*. (1990)
Gir	India	224	1707±19.4	-	-	Barwe *et al*. (1996)
Kankrej	India	1527	1623.68	553	266	Chaudhary *et al*. (1995)

[1] N: number of cows, AFC: age at first calving, CI: calving interval, SP: service period

Table 3. Environmental factors affecting milk yield

Breed	Level of statistical significance[1]							References
	H	Y	S	P	AC	LL	SP	
Sahiwal	-	-	-	-	ns	-	-	Ahmad *et al*. (1971)
Sahiwal	-	-	-	-	-	**	-	Ahmad (1972)
Sahiwal	-	*	*	*	-	-	-	Tahir *et al*. (1989)
Sahiwal	**	**	**	**	**	-	-	Talbott *et al*. (1997)
Sahiwal	**	**	ns	-	ns	-	-	Dahlin *et al*. (1998)
Sahiwal	**	**	**	**	**	-	-	Ahmad (1999)
Sahiwal	-	**	**	**	-	**	-	Javed *et al*. (2000)
Sahiwal	-	**	**	-	**	**	-	Bajwa *et al*. (2004)
Sahiwal	**	**	*	ns	-	-	-	Rehman *et al*. (2006)
Sahiwal	-	**	**	**	-	-	-	Zafar *et al*. (2008)
Sahiwal	**	**	**	**	-	**	-	Rehman and Khan (2012)
Sahiwal	-	-	ns	-	-	-	-	Saxena *et al*. (1972)
Sahiwal	-	-	-	-	-	-	ns	Chopra *et al*. (1973)
Sahiwal	-	-	*	ns	-	-	-	Deshmukh *et al*. (1973)
Sahiwal	-	-	*	-	-	-	-	Kimenye (1979)
Sahiwal	*	*	-	-	-	-	-	Chawla and Mishra (1982)
Sahiwal	-	-	-	-	*	-	ns	Shrivastava and Khan (1989)
Sahiwal	-	**	**	**	ns	-	-	Yadav *et al*. (1992)
Sahiwal	ns	*	*	-	-	*	-	Gandhi *et al*. (1995)
Sahiwal	-	*	ns	-	*	-	-	Manoj (2009)
Sahiwal	-	*	ns	-	ns	-	*	Raja (2010)
Sahiwal	-	*	ns	-	*	-	-	Monalisa *et al*. (2010)
Red Sindhi	-	-	-	-	-	*	-	Ahmad (1998)
Red Sindhi	-	-	-	-	-	-	*	Chopra *et al*. (1973)
Kankrej	-	ns	ns	-	ns	-	-	Bhambure and Dave (1989)
Karan Swiss	-	-	*	-	*	-	-	Kakran and Joshi (1990)
Guzera	-	**	**	-	-	-	-	Bastos and Pereira (1989)
Hariana	-	*	-	-	*	-	-	Dhaka *et al*. (2002)
HF X Sahiwal	*	*	-	-	-	-	-	Balwada and Balaine (1988)
HF X Sahiwal	*	*	-	-	*	-	*	Garcha *et al*. (1989)
Tharparkar	-	-	-	-	*	*	-	Bhat *et al*. (1980)
Tharparkar	-	-	-	*	*	-	-	Yadav *et al*. (1994)
Tharparkar	-	-	-	-	ns	-	-	Yadav *et al*. (1994a)

[1]*: significant (p<0.05), **: significant (p<0.01), ns: non-significant, H: herd, Y: year of calving, S: season of calving, P: parity, AC: age at calving, LL: lactation length, SP: service period

Age at First Calving: The effect of herd, year and season of birth on age at first calving in Sahiwal and other breeds of dairy cattle has been reported by many workers. Studies using multiple herd records of Sahiwal breed on age at first calving reported herd differences (Table 5).

Year of birth effect has been reported in all the studies (Table 5) while effect of season of birth varied among different reports. For Kenyan Sahiwal herd, Rege *et al.* (1992) also reported year of birth as important source of variation for age at first calving. The other breeds in the region exhibited variable influences of year and season (Table 5).

Dry Period: The dry period is another important trait studied by different workers. The environmental factors like herd, year and season of calving affect the trait. Differences due to parity also exist. (Table 6).

Rehman and Khan (2012) reported that herd, year of calving, season of calving, parity and milk yield significantly affect the dry period in Sahiwal cattle. Similar findings were reported by Rehman *et al*. (2006) except season of calving where non-significant difference was observed. For other studies on Sahiwal, Talbott *et al*. (1997), Ahmad (1999) and Javed *et al*. (2000) reported year and season of calving effects. Gaur and Raheja (1996) also had similar findings. Chawla and Mishra (1982) had contradictory results. Ahmad (1998) also did not find year and season differences for Red Sindhi breed. Parity differences in dry period were important in the studies of Talbott *et al*. (1997), Zafar *et al*. (2008) and

Ahmad (1999) while Javed *et al*. (2000) used age at calving but the effects were not important.

Table 4. Environmental factors affecting lactation length

Breed	Level of statistical significance[1]					References
	H	Y	S	P	AC	
Sahiwal	-	**	*	**	-	Talbott *et al*. (1997)
Sahiwal	**	**	**	-	ns	Dahlin *et al*. (1998)
Sahiwal	**	**	**	**	**	Ahmad (1999)
Sahiwal	-	**	**	**	-	Javed *et al*. (2000)
Sahiwal	-	**	**	-	**	Bajwa *et al*. (2004)
Sahiwal	ns	**	*	ns	-	Rehman *et al*. (2006)
Sahiwal	-	**	**	ns	-	Zafar *et al*. (2008)
Sahiwal	**	**	**	**	-	Rehman and Khan (2012)
Sahiwal	-	*	*	-	-	Sexena *et al*. (1972)
Sahiwal	-	*	-	-	-	Chawla and Mishra (1982)
Sahiwal	*	ns	ns	*	-	Gandhi *et al*. (1995)
Sahiwal	-	*	-	-	-	Gaur and Raheja (1996)
Sahiwal	-	*	*	-	-	Kathiravan *et al*. (2010)
Sahiwal	-	*	*	-	-	Monalisa *et al*. (2010)
Red Sindhi	-	*	*	-	-	Ahmad (1998)
Sahiwal, Hariana & Tharpakar	-	-	ns	-	-	Yadav *et al*. (1995)
Hariana	-	*	-	-	-	Yadav and Rathi (1992)
Tharparkar	-	ns	ns	*	-	Ram *et al*. (1979)
Jenubi	-	*	ns	-	-	Maarof *et al*. (1987)
Guzera	-	*	*	-	-	Bastos and Pereira (1989)

[1]*significant ($p<0.05$), **: significant ($p<0.01$), ns: non-significant, H: herd, Y: year of calving, S: season of calving, P: parity, AC: age at calving, SP: service period

Table 5. Environmental factors affecting age at first calving

Breed	Level of statistical significance[1]			References
	Herd	Year	Season	
Sahiwal	-	*	-	Khan *et al*. (1992)
Sahiwal	-	**	**	Talbott *et al*. (1997)
Sahiwal	**	**	Ns	Dahlin *et al*. (1998)
Sahiwal	**	**	**	Ahmad (1999)
Sahiwal	-	**	Ns	Javed *et al*. (2000)
Sahiwal	**	*	**	Rehman *et al*. (2008)
Sahiwal	-	*	-	Bhatnagar *et al*. (1979)
Sahiwal	-	*	*	Chawla and Mishra (1982)
Sahiwal	-	*	-	Singh *et al*. (1990)
Sahiwal	-	*	Ns	Singh *et al.* (2005)
Sahiwal	-	*	Ns	Kumar (2007)
Sahiwal	-	*	-	Sentitula (2007)
Sahiwal	-	*	Ns	Kathiravan *et al*. (2009)
Sahiwal	-	*	Ns	Manoj (2009)
Sahiwal	-	*	Ns	Raja (2010)
Sahiwal	-	*	Ns	Rege *et al*. (1992)
Red Sindhi	-	**	Ns	Mustafa *et al*. (2003)
Sahiwal × HF	-	*	-	Sharma *et al*. (1982)
Kankrej	-	-	Ns	Chaudhary *et al*. (1995a)
Gir	-	-	Ns	Barwe *et al*. (1996)
Hariana	-	*	*	Singh *et al*. (2002)

[1]*:significant ($p<0.05$), **: significant ($p<0.01$), ns: non-significant

Table 6. Environmental factors affecting dry period

Breed	Level of statistical significance[1]					References
	Herd	Year	Season	Parity	MY	
Sahiwal	-	**	**	**	**	Talbott *et al*. (1997)
Sahiwal	ns	**	**	**	-	Ahmad (1999)
Sahiwal	-	**	**	-	-	Javed *et al*. (2000)
Sahiwal	**	**	ns	**	-	Rehman *et al*. (2006)
Sahiwal	-	**	ns	**	-	Zafar *et al*. (2008)
Sahiwal	**	**	**	**	**	Rehman and Khan (2012)
Sahiwal	*	ns	ns	-	-	Chawla and Mishra (1982)
Sahiwal	-	**	*	ns	-	Gaur and Raheja (1996)
Hariana	-	-	*	ns	-	Balaine and Aggarwal, (1973)
HFXRed Sindhi	-	ns	ns	-	-	Buragohain and Sharma (1980)
Malvi	-	*	*	*	-	Singh *et al*. (1983)
HF×Sahiwal	ns	*	ns	*	-	Mudgal *et al*. (1986)
Butana	-	-	*	-	-	Khalafalla (1988)
Karen Fries	-	ns	ns	-	-	Singh and Tomar (1991)
Red Sindhi	-	ns	ns	-	-	Ahmad (1998)

[1*]significant ($p<0.05$), [**]: significant ($p<0.01$), ns: non-significant, [1]MY: milk yield

Calving Interval: Calving interval is very important in determining the lifetime performance of dairy cattle. The herd, year and season of calving differences have been reported (Table 7). Ahmad (1999) and Rehman and Khan (2012) reported that these factors were important for Sahiwal herds in Pakistan but Dahlin *et al*. (1998) did not find season of calving differences. Talbott *et al*. (1997) and Javed *et al*. (2000) used records from single herds and reported that year and season of calving affect calving interval. Parity differences were also important (Table 7). Zafar *et al*. (2008) reported differences in parity and year of calving for this trait in Sahiwal cattle. Study of Yadav *et al*. (1992) also found parity to be important variation source but year and season of calving differences were not important. Similarly, Parmar and Johar (1982) reported that neither year nor season of calving was important in calving interval of Tharparkar cows. While, year and season of calving were important factors for this trait in Red Sindhi cows in Pakistan (Mustafa *et al*. (2003). Parities also had similar means.

Table 7. Environmental factors affecting calving interval

Breed	Level of statistical significance[1]					References
	Herd	Year	Season	Parity	MY	
Sahiwal	-	**	*	**	**	Talbott *et al*. (1997)
Sahiwal	**	**	ns	-	-	Dahlin *et al*. (1998)
Sahiwal	**	**	**	**	-	Ahmad (1999)
Sahiwal	-	**	**	**	-	Javed *et al*. (2000)
Sahiwal	*	*	-	-	-	Rehman *et al*. (2008)
Sahiwal	-	**	ns	**	-	Zafar *et al*. (2008)
Sahiwal	**	**	**	**	**	Rehman and Khan (2012)
Sahiwal	-	ns	ns	**	-	Yadav *et al*. (1992)
Sahiwal	-	**	**	**	-	Gaur and Raheja (1996)
Tharparkar	-	*	*	*	-	Ram *et al*. (1979)
Tharparkar	-	ns	ns	ns	-	Parmar and Johar (1982)
Tharparkar	-	-	-	*	-	Yadav *et al*. (1994)
Gir	-	*	*	*	-	Leite *et al*. (1986)
Retinto	-	ns	*	ns	-	Lopez *et al*. (1988)
Hariana	-	*	-	*	-	Singh *et al*. (2002)
Red Sindhi	-	**	**	-	-	Mustafa *et al*. (2003)

[1*]significant ($p<0.05$), [**]: significant ($p<0.01$), ns: non-significant, MY: Milk yield

Service Period: The time to conception after calving, also referred as days open, plays important role in determining the reproductive efficiency of the cows. The environment responsible for modification of genetic expression has been widely studied in dairy breeds. The studies on Sahiwal cattle in Pakistan and other relevant work is reviewed to find variation sources (Table 8).

Of the 12 studies reviewed on Sahiwal, only three have reported across herd effects, others are based on single herd information. Year of calving is important variation source and so is season of calving except for some researchers (Gaur and Raheja, 1996; Zafar *et al*., 2008; Kathiravan *et al*., 2009; Manoj, 2009; Raja, 2010) where seasonal influences were not important. However, Rehman and Khan (2012) reported significant effect of herd, season and year of calving, milk yield and parity on service period. Similarly, multiple parity studies indicated that service period varied with parities. Talbott *et al*. (1997) reported that first calvers took 194 days to rebreed while multiple parity Sahiwals had average days open of 153 days. Similarly, Ahmad (1999) reported that service period for first, second and third parity Sahiwal cows average was 153, 136, and 118 days, respectively. Year and season effects have also been reported important for Red Sindhis but for crossbreds, results have been variable.

Table 8. Environnemental factors affecting service period

Breed	Level of statistical significance[1]					References
	Herd	Year	Season	Parity	MY	
Sahiwal	-	-	**	-	-	Shah and Shah (1983)
Sahiwal	-	**	**	**	**	Talbott *et al*. (1997)
Sahiwal	**	**	**	**	-	Ahmad (1999)
Sahiwal	-	**	**	-	-	Javed *et al*. (2000)
Sahiwal	*	*	*	-	-	Rehman *et al*. (2008)
Sahiwal	-	**	ns	**	-	Zafar *et al*. (2008)
Sahiwal	**	**	**	**	**	Rehman and Khan (2012)
Sahiwal	-	-	*	-	-	Tewari and Kushwaha (1982)
Sahiwal	-	*	ns	-	-	Gaur and Raheja (1996)
Sahiwal	-	ns	ns	-	-	Kathiravan *et al*. (2009)
Sahiwal	-	*	ns	-	-	Manoj (2009)
Sahiwal	-	*	ns	-	-	Raja (2010)
Red Sindhi	-	*	-	-	-	Ahmad (1998)
Red Sindhi	-	*	*	-	-	Mustafa *et al*. (2003)
HF × Sahiwal	ns	ns	ns	-	-	Dangi *et al*. (1980)
HF × Sahiwal	ns	*	*	*	-	Mudgal *et al*. (1986)
HF × Sahiwal	*	ns	ns	-	-	Deshpande *et al*. (1988)
HF × Sahiwal	-	**	**	*	-	Chaudhry *et al*. (1989)
Hariana	-	*	ns	*	-	Singh *et al*. (2002)
Kankrej	-	*	-	-	-	Gaur and Raheja (1996)

[1]*significant ($p<0.05$), **: significant ($p<0.01$), ns: non-significant, MY: milk yield

Conclusions: Sahiwal is one of the fifteen documented cattle breeds of Pakistan that has gained international recognition but the productivity of Sahiwal cattle has been reported to vary both across and within countries. The variations in performance traits may be more of environmental nature as opposed to genetics; sampling of population and data edits might have widened these ranges. For other reproductive traits, reports disagree even to a great extent. Parity, Herd, year and season of calving affected most of the performance traits in Sahiwal cows. Herd variations represent managemental differences for most of the traits. It was also noted that cows calving in winter season produced highest milk yield as compared to those calving in summer season due to more availability of fodder and comfortable temperature than in summer. The variations in lactation length were slight for herds as compared to season of calving. The age at first calving in Sahiwals and other cattle breeds was affected by herd, year and season of birth. However, most of the herd differences on age at first calving were reported by only those studies using multiple herd records of Sahiwal breed. Across herd variation in dry period was evident. The highest dry period was noted in winter calvers while the spring calvers had the lowest. The calving interval proved to be dependant in its expression on herd, year, season of calving and parity of cow. The service period was effected by herd, year, season and parity of cow with milk yield as covariable in some studies.

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