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Culling pattern and effect of selection on milk production over the periods in Sahiwal cattle at an organised farm

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ABSTRACT

The investigation was carried out on 1,629 calving records of 462 Sahiwal cows calved between 1988 and 2013 at National Dairy Research Institute, Karnal, Haryana, India to study culling pattern as well as the effect of selection on milk production. Average culling and mortality rate per lactation of Sahiwal cows were 23.82 and 4.54%, respectively. The culling was found due to teat and udder problems (32.47%), followed by reproductive problems (22.73%) and low milk production (10.82%) in the herd. Most of the voluntary culling (based on the low milk yield) was observed during second and third lactations. Stage of lactation and milk yield had significant influence on culling during first lactation whereas, period had significant influence on culling during second lactation. Sahiwal cows yielding more than 8 kg of milk/day were less likely to cull and the probability of culling of cows increased after the completion of 360 days of first lactation. Most probable producing ability of per day milk yield [MPPA (PDMY)] was estimated for selected and culled cows. There is an intense need to minimize the involuntary culling of cows by providing better feeding and management so that more of cows can be saved in herd, which will in turn facilitate in increasing selection intensity and selection differential in the herd and ultimately help in faster genetic improvement of Sahiwal cows.

Key words: Culling, Milk production, Most probable producing ability, Sahiwal, Selection

In cattle breeding, selection is an important way to improve animal yield (Çilek and Tekin 2006). Small herd size is a major constraint in the process of genetic improvement of the breed, since it makes intense selection impracticable. The undesirable disposal of animals is one of the major reason which contributes to small herd size. A dairy cow leaves the herd mainly due to two reasons i.e. mortality and culling. Traditionally, culling is considered broadly into two categories i.e. voluntary culling and involuntary culling. Voluntary culling is culling of a cow due to low production irrespective of her health, where a healthy cow is replaced because her replacement is more productive (Smith *et al*. 2000, Hadley *et al*. 2006, Çilek and Tekin 2006). Whereas, involuntary culling is culling of a cow due to disease and/or low fertility or deformity regardless of her performance relative to her herd mates (Hadley *et al*. 2006). High voluntary cull rates would mean that high producing cows would remain in herd for many years and are indicative of good herd health. On the other hand, dairy producers need to focus on the causes of involuntary culling as excessive involuntary culling greatly hampers the profitability of dairy farming and are also indicative of poor herd health (Weigel *et al*. 2003, Pinedo *et al*. 2010, Smith *et al*. 2000).

Knowledge of various factors associated with involuntary culling of animals may help farm manager in making culling decisions and to formulate breeding and management strategies to reduce involuntary culling of animals and thereby making dairy farming more profitable especially in small herd size situations. Therefore, keeping in view the aforementioned things, the present study was conducted with the objective to quantify culling pattern and to assess the influence of various non-genetic factors on the incidence of culling during different lactations in Sahiwal cattle. Furthermore, most probable producing ability of per day milk yield [MPPA (PDMY)] of culled and selected cows on voluntary culling basis was estimated to assess the effect of selection on the milk production of the herd over the periods.

MATERIALS AND METHODS

Data structure and edits: The data for the present investigation were collected from the records of Sahiwal

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cattle maintained at NDRI, Karnal. Auction of animals is performed at the farm biannually and mostly during the months of March and September. Culling records are also being maintained at the farm. The information on animal numbers, milk yield at each lactation, date of calving, date of dry, date of disposal and reason of disposal of cows were recorded. Lactation records with missing parity number or calving date or milk yield, were excluded from the data set. And finally, the data on 1,629 calving records of 462 Sahiwal cows, sired by 60 sires, calved between 1988 and 2013 were utilized to analyse culling pattern in adult cows.

Traits of interest and explanatory variables: Culling rate in present study was defined as number of cows sold due to low milk production, reproductive problems, ill-health, old age and surplus as a percentage of total milking and dry cows present in the herd. Mortality rate was calculated separately as the number of cows died as a percentage of total milking and dry cows present in the herd.

Of the total lifetime milk yield (24,37,087.42 kg), around 80% was recorded upto 4 lactations (18,82,115.42 kg), so in the present study, productive herd life of Sahiwal cows was considered upto 4 lactations and analysis was conducted accordingly. The trait of interest (dependent variable) was culling during i^{th} lactation (i= 1 to 4). The explanatory variables were season of calving, period of calving, stage of lactation and per day milk yield, derived on the basis of information from last lactation immediately before culling. The months were grouped into four seasons based on climatic conditions as winter (December to March), summer (April to June), rainy (July to September) and autumn (October to November). Years were grouped in to period of calving as 1988–1992, 1993–1996, 1997–2000, 2001–2004, 2005–2008 and 2009–2013. Per day milk yield (kg/day) of cows was grouped as <2, 2–4, 4–6, 6–8 and >8. Stage of lactation (days) of cows was classified as <90, 90–180, 180–270, 270–360, and >360. Milk yield and stage of lactation groups were formed by using Sturges (1926) rule.

Most probable producing ability (Lush 1945) for per day milk yield [MPPA (PDMY)] of cows was calculated, while considering repeatability of milk yield as 0.4. Selection differential (SD) of MPPA (PDMY) was also calculated by using the following formula:

SD = MPPA (PDMY) of selected cows - MPPA (PDMY) of base population before selection.

Cows those stayed in herd for 4 or more lactations by avoiding voluntary culling for low milk yield were considered as selected.

Definition of culling pattern: Culling pattern in adult cows were coded as voluntary culling (low production and surplus) and involuntary culling (reproductive problems, teat and udder problems, poor health, leg problems, self-sucker, old age and miscellaneous causes). Miscellaneous causes of culling were tuberculosis, traumatic reticulo pericarditis, skin infection, tumorous growth on horn, one eye blind and rectal rupture.

Statistical analysis of data: Since the incidence of culling is binary trait, therefore, in the present study, data analysis were carried out by using Logistic regression model, a threshold trait model by using Statistics Analysis System (SAS version 9.3) programme. The following dichotomous logistic regression model was used:

$$\ln\left[\frac{p}{1-p}\right] = \beta_0 + \sum_{j=1}^{c} \beta_j X_j$$

$$\ln (p/1\text{-}p) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4$$

where, ln, natural logarithm; p, probability that the dependent variable (probability of culling during of i^{th} lactation, i = 1 to 4) equals a case; β_0, intercept from the linear regression equation (the value of the criterion when the predictor is equal to zero); $\beta_j X_j$ (j= 1 to 4), regression coefficient multiplied by some value of the predictor; X_1, Season of calving (4 subclasses); X_2, Period of calving (6 subclasses); X_3, Stage of lactation (5 subclasses) and X_4, Per day milk yield (5 subclasses).

RESULTS AND DISCUSSION

Culling pattern: Culling rate (%) in various lactations along with reasons is shown in Table 1. It revealed that out of 462 cows, 388 cows were culled and 74 cows died in the

Table 1. Lactation wise disposal pattern in Sahiwal cows

Culling pattern	Lactation					
	I	II	III	IV	V and above	Overall
	Number of cows available					
	462	376	277	191	323	462
Low milk yield (%)	2.81 (13)	3.99 (15)	4.69 (13)	2.62 (5)	1.24 (4)	10.82 (50)
Reproductive problems (%)	4.55 (21)	7.18 (27)	7.58 (21)	6.28 (12)	7.43 (24)	22.73 (105)
Teat and udder problems (%)	3.90 (18)	6.65 (25)	10.47 (29)	13.61 (26)	16.10 (52)	32.47 (150)
Poor health (%)	1.08 (5)	0.00 (0)	0.72 (2)	0.00 (0)	1.24 (4)	2.38 (11)
Leg problem (%)	0.65 (3)	1.33 (5)	1.08 (3)	3.14 (6)	3.72 (12)	6.28 (29)
Self sucker (%)	1.52 (7)	2.39 (9)	1.08 (3)	0.00 (0)	0.31 (1)	4.33 (20)
Old age (%)	0.00 (0)	0.00 (0)	0.00 (0)	0.00 (0)	1.86 (6)	1.30 (6)
Surplus (%)	0.22 (1)	0.53 (2)	0.00 (0)	0.52 (1)	0.31 (1)	1.08 (5)
Miscellaneous (%)	0.65 (3)	0.80 (3)	1.08 (3)	1.05 (2)	0.31 (1)	2.60 (12)
Total culling rate (%)	15.37 (71)	22.87 (86)	26.71 (74)	27.23 (52)	32.51 (105)	83.98 (388)
Total mortality rate (%)	3.25 (15)	3.46 (13)	4.33 (12)	5.42 (10)	7.43 (24)	16.02 (74)
Total disposal rate (%)	18.62 (86)	26.33 (99)	31.04 (86)	32.47 (62)	39.94 (129)	100 (462)

Figure in parenthesis indicates number of cows left the herd in particular lactation due to particular reason

herd. The culling rate varied from 15.37 to 32.51%, with an average being 23.82% per lactation. Mortality rate varied from 3.25% to 7.43%, with an average being 4.54% per lactation. The culling rates found in present study were optimal. Nearly similar estimates of average culling rate per lactation were also reported by Pinedo *et al*. (2010) in exotic dairy cattle. However, higher estimates were reported by Smith *et al*. (2000) and Hadley *et al*. (2006). Minimum culling rate was found during first lactation, then it has shown an increasing trend over the lactations, whereas trend for mortality over the lactations was inconsistent. Same trend of culling rate over the lactations was also reported by Hadley *et al*. (2006) and Pinedo *et al*. (2010). Major reasons of culling of cows were involuntary viz. teat and udder problems (32.47%), followed by reproductive problems (22.73%). Whereas, voluntary culling for low milk yield was only 10.82%. Pinedo *et al*. (2010) reported major reason of culling being reproductive problems, followed by injury or others, mastitis and low production. Higher rate of involuntary culling limits the scope of performing voluntary culling for low milk yield, as comparatively less number of cows remain in herd to perform voluntary culling. Results revealed that likelihood of culling of cows due to teat and udder problems, leg problems and poor health increased with the lactations. And likelihood of culling due to reproductive problems was more during second and onward lactations. However, likelihood of culling due to low milk yield was higher during second and third lactations.

Influence of non-genetic factors on culling rate in various lactations: The likelihood of culling of cows with respect to various non-genetic factors during first four lactations is presented in Table 2. It revealed that the stage of lactation and milk yield had significant (P<0.05) influence on likelihood of culling of cows during the first lactation, and period had significant (P<0.05) influence on likelihood of culling during the second lactation. Influence of the remaining factors was found to be non-significant (P>0.05) on likelihood of culling during various lactations. Ojango *et al*. (2005) reported significant influence of year-season, stage of lactation and milk yield on culling risk within first three lactations of cows.

Cows during 90 to 180 days of lactation and during 180 to 270 days of lactation had nearly equal likelihood (21%) of culling. Whereas, cows during 270–360 days of lactation had minimum likelihood (10.7%) of culling, revealing the normal range of lactation length in Sahiwal cattle. Ojango *et al*. (2005) also reported maximum likelihood of culling after 366 days of lactation.

Regarding the influence of milk yield, the likelihood of culling of cows decreased with the increase in milk yield. Cows yielding between 2 and 4 kg of milk/day had maximum likelihood of culling and this likelihood was 5.7 times greater than the likelihood of cows yielding more than 8 kg of milk/day being culled. The influence of milk yield was not significant on culling probabilities during second, third and fourth lactations. Ojango *et al*. (2005) also reported the same trend of likelihood of culling of cows during the first lactation with the level of milk yield.

Table 2. Lactation wise likelihood of culling of Sahiwal cows with respect to milk yield and various non-genetic factors

Explanatory variable	Lactation			
	I	II	III	IV
Season	NS	NS	NS	NS
Winter	2.353	0.779	0.870	1.356
Summer	1.655	0.756	0.738	1.083
Rainy	0.000	0.000	0.000	0.000
Autumn	1.000	1.000	1.000	1.000
Period	NS	S	NS	NS
1988-1992	5.717	8.987	10.750	>999.999
1993-1996	1.717	2.015	0.487	1.234
1997-2000	1.198	1.428	0.780	0.431
2001-2004	1.712	1.300	0.741	0.451
2005-2008	1.763	2.302	0.873	1.004
2009-2013	1.000	1.000	1.000	1.000
Stage of lactation (days)	S	NS	NS	NS
≥ 90	0.330	1.225	1.386	1.295
90-180	0.218	2.736	2.529	0.890
180-270	0.210	1.754	2.099	1.586
270-360	0.107	1.420	1.484	1.135
>360	1.000	1.000	1.000	1.000
Milk yield *(kg/day)*	S	NS	NS	NS
≤ 2	5.878	1.046	1.474	0.580
2-4	7.637	1.004	1.498	0.492
4-6	3.214	0.650	1.167	0.391
6-8	2.651	0.765	0.982	0.512
> 8	1.000	1.000	1.000	1.000

S, Significant (P<0.05); NS, non-significant (P>0.05).

Influence of period was significant (P<0.05) on the likelihood of culling of cows during the second lactation and culling showed a decreasing trend upto fourth period. Decrease in culling rate over the periods may be attributed to small herd size at the farm, therefore, culling policy was developed while aiming on maintaining herd size constant or increasing over the periods at the farm.

Effect of selection on milk production of Sahiwal cows over the periods: MPPA (PDMY) of selected and culled cows and selection differential over the periods are presented in Table 3. The results revealed that the overall MPPA (PDMY) of selected cows (stayed in herd for 4 or more lactations by avoiding voluntary culling for low milk yield) was 6.16 kg/day. Selection differential of MPPA (PDMY) revealed an overall decreasing trend over the periods. The decreasing trend of selection differential may be attributed to decrease in genetic variability among selected and culled cows and decrease in selection intensity of cows for milk production over the years due to small herd size. Therefore, there is an intense need for increasing genetic variability for producing ability, especially from the sire side, and increasing the selection intensity for milk production of cows. Besides taking care from breeding point of view, there is also need of providing better feeding and

Table 3. Selection differential (kg/day) of most probable producing ability of per day milk yield [MPPA (PDMY)] of Sahiwal cows over the periods

Period	MPPA (PDMY) of base population (before selection) (kg/day)	MPPA (PDMY) of selected cows (stayed in herd for 4 or more lactations) (kg/day)	Selection differential of MPPA (PDMY) (kg/day)
1988-1992	5.22 (26)	7.00 (1)	1.78
1993-1996	5.59 (48)	6.50 (16)	0.91
1997-2000	6.10 (48)	7.37 (20)	1.27
2001-2004	5.27 (97)	6.56 (39)	1.29
2005-2008	4.91 (121)	5.44 (40)	0.53
2009-2013	5.16 (122)	5.80 (47)	0.64
Overall	5.38 (462)	6.16 (163)	0.78

Figures in parenthesis are number of observations

Table 4. Average parity and most probable producing ability of per day milk yield [MPPA (PDMY)] of culled Sahiwal cows with different culling reasons

Culling reason	N	Parity at culling		MPPA (PDMY)	
		Mean**	SD	Mean**	SD
Voluntary culling	50	2.54^{a}	1.47	4.57^{a}	0.78
Reproductive problems	150	3.10^{b}	1.78	5.50^{b}	1.57
Teat and udder problems	150	3.96^{c}	2.21	5.00^{c}	1.58
Poor health	11	4.64^{abc}	4.48	4.45^{abc}	1.70
Leg problem	29	4.31^{c}	2.32	5.61^{bc}	1.53
Self sucker	20	1.95^{a}	1.00	4.65^{ac}	1.10
Old age	6	9.00^{d}	1.80	7.16^{d}	1.04
Surplus	5	2.80^{abc}	1.64	5.11^{abcd}	1.89
Miscellaneous	12	2.67^{ab}	1.50	5.70^{abcd}	2.14
Total	388	3.51	2.25	5.17	1.54

**Significant (P<0.01); ^{a,b,c,d}Means within each column not bearing a common superscript differ significantly at P<0.05

management practices at the farm. Trends over the period of MPPA (PDMY) of selected cows, disposed cows on involuntary disposal (mortality and involuntary culling) basis and culled cows on voluntary culling basis is depicted in Fig. 1. It revealed that most of the high producing cows left the herd because of involuntary disposal. It indicates the intense need of saving cows from involuntary disposal by providing better feeding and management practices, so that more number of high producing cows could be retained in the herd, and further facilitating in increasing the selection intensity for low milk yield or voluntary culling.

Average parity at culling and MPPA (PDMY) of culled cows for each culling reason are depicted in Table 4. Culling reasons were significantly (P<0.001) associated with the mean parity at culling and mean MPPA (PDMY) of culled cows. Mean culling age of cows was 3.51 lactations.

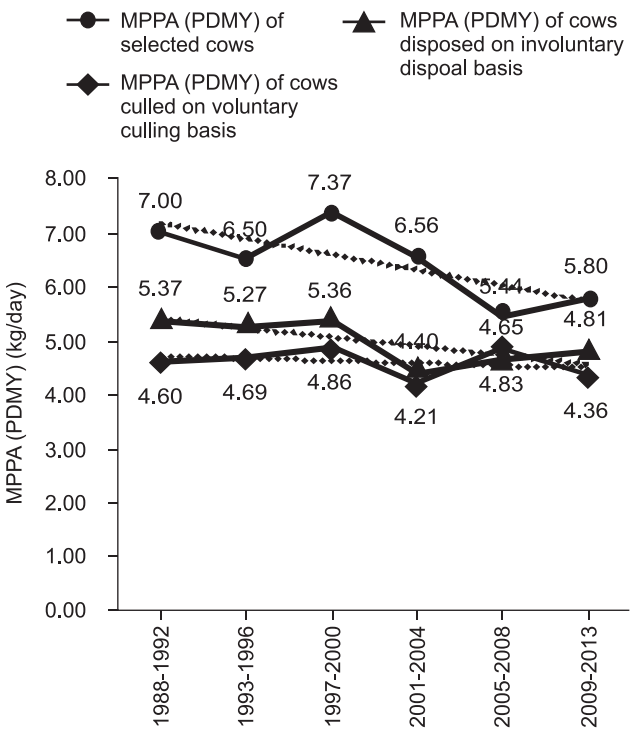

Fig. 1. Trends of most probable producing ability of per day milk yield [MPPA (PDMY)] of selected and culled cows over the periods.

Likelihood of culling of cows for low milk yield, self-sucker and surplus reasons was significantly (P<0.05) higher upto the first three lactations, whereas likelihood of culling for reproductive problems, teat and udder problems, poor health, leg problems and old age was significantly (P<0.05) higher after completing three lactations. Likelihood of culling of cows for old age was higher during 9th lactation. Mean MPPA (PDMY) of culled cows was 5.17 kg/day. Mean MPPA (PDMY) of cows culled for voluntary reason/ low milk yield (4.45 kg/day) was significantly (P<0.05) lower than the MPPA (PDMY) of cows culled for other reasons. Cows culled for involuntary reasons had significantly (P<0.05) higher MPPA (PDMY), which indicates that most of the high producing cows left the herd due to involuntary culling. Moreover, the likelihood of culling increased with the age of cows.

The results revealed that on an average 23.82% of cows were culled from the herd during each lactation. Major reasons of culling were teat and udder problems, followed by reproductive problems and low milk production. Stage of lactation and milk yield had significant (P<0.05) influence on likelihood of culling of cows during first lactation and period had significant (P<0.05) influence on culling during second lactation. The incidence of teat and udder problems, mastitis, reproductive problems and other involuntary culling reasons could be minimized by providing better feed and management, which would further facilitate in increasing selection intensity for voluntary culling, thereby improving the per cow productivity and profitability of dairy farming.

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