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Abnormal Lactation Lengths and its Consequences on Performance of Crossbred Cattle

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ABSTRACT

Background: The study was conducted to unravel the consequences of abnormal lactation lengths (Extremely short, short, prolong and extremely prolong lactation length) on production and reproduction traits of crossbred cattle (Red Dane × Sahiwal × Holstein Friesian), which otherwise remains unutilized in routine breeding data analysis owing to normalization and standardization of lactation lengths.

Methods: The performance data of 2541 lactations of 1001 crossbred cattle, sired by 146 bulls over a period of 30 years maintained at the Livestock Farms of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana were used for this study. The data on production and reproduction traits were analysed using general linear model procedures based on extremely short (<102 days), short (102-179 days), prolong (483-560 days) and extremely prolong (≥ 560 days) lactation lengths on the basis of mean lactation length and its standard deviation.

Result: Result indicated that the alteration of lactation lengths affected all important performance traits of crossbred cattle in contemporary as well as in next lactation. The values of 305 days milk yield, lactation milk yield, average fat (%), 305 days fat yield and lactation fat yield of contemporary lactation cycle were higher (P≤0.05) for the extremely prolong lactation length and reduced for shorter lactations. Similar trend was seen for next lactation cycle of the animal having abnormal lactation length in previous lactation cycle for all traits except calf birth weight, whereas days to reach peak yield and fat yield traits were not significantly affected by lactation length classes. The preferred lactation length for crossbred cattle for optimum performance was concluded as 180 to 483 days ranging one standard deviation from mean lactation length, covering more than 72% of population; however, it needs further studies to break it into groups in terms of productive life and economical merits. Farmers should avoid breeding of animal having extremely short and short lactation lengths, as their production and reproductive traits are lower in successive production cycle.

Key words: Crossbred cattle, Performance traits, Prolong lactation, Short lactation.

INTRODUCTION

The success of dairy sector depends on maintenance of production cycle for regular production of milk. The major determinant of production cycle is calving interval, which can be bifurcated into lactation length and dry period. Lactation length has been given enormous importance as it indicates the duration of animal in milk and amount of milk produced by animal during a production cycle that reflects the foremost economic produce for dairy sector. For dairy animals, the proposed length of an ideal production cycle is 365 days, of which accepted standard lactation length is 305 days and dry period is 60 days. This 12 month production cycle has been considered “Ideal” for cattle since long.

A large portion of the variability in milk yield is explained by lactation length (Bhat and Patro, 1978). The duration of lactation influences the milk yield, larger the length, more will be the milk yield but at the same time higher lactation length leads to increased calving interval, adversely affecting the breeding efficiency and the milk production per day (Gahlot *et al.*, 1993). The length of lactation depends upon genetic makeup of animal along with many environmental factors like season of calving, period of calving, type of calving, management of farm, quantity and quality of feed and fodders offered, disease conditions and more such factors may also influence the lactation length of the dairy animals.

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The lactation length in numerous animals can be observed to abnormally deviate from normal, which is termed as short lactation and prolong lactation. In general, short lactation occurs when length of lactation cycle is far less than the normally occurring 305 days. It can be further

classified into two types *i.e.* Short Lactation (SL) and Extremely Short Lactation (ESL). Prolong lactation which is also called as extended lactation, occurs when the lactation length is way more than 305 days. It can be further classified into two types *i.e.* Prolong Lactation (PL) and Extremely Prolong Lactation (EPL), the definition criteria of which may vary between species and breeds.

Among Sahiwal cattle, only 32.48% of total lactation records fell in the range of 251-350 days of lactation length, while more than three-fourth (76%) of total observations failed to reach the standard level of 305 milking days (Narwaria *et al.* 2015). Vaccaro *et al*. (1999) and Canaza - Cayo *et al*. (2016) reported fewer incidences of short lactations upto 100 days as 3.8- 4% and 2.5%, respectively whereas Facó *et al.* (2009) reported a higher incidence of shorter than 120 days as 13.6% of lactations among dairy cattle.

Lactation length in high-producing cattle has increased over the last decade (VanRaden, 2005; Steri *et al*. 2010) and presently in many countries cattle have lactations extended beyond 305 days (Vargas *et al*. 2000) mostly due to strong positive genetic correlation between lactation length and milk yield (Aisbett, 1984) and continual selection for improving milk productivity. A trend of increasing interest in extended lactations for dairy cattle has been reported (Knight, 2005), particularly as high producing cattle in intensively managed herds appear to suffer more from health and fertility problems than do lower producing cattle (Lucy, 2001; Windig *et al.* 2006). Recent studies show that over 55% of US Holstein cattle exhibited lactations beyond 305 days and their productive life diminishes gradually on prolongation of lactation as extended lactation (Tsuruta *et al.* 2005; VanRaden *et al.* 2006).

These abnormal lactation lengths have major impact on the production as well as reproductive traits of the animal. Grossman *et al.* (1988) highlighted that lactation length has a significant effect on estimates of milk yield traits *viz.* initial yield, peak yield, 305 days yield, time of peak and persistency. Hossein-Zadeh (2013) reported longer calving interval (CI) for longer lactation length which is due to the positive correlation between milk yield and CI, implying that animals that produce more milk have longer calving intervals. De Vries (2006) reported that cattle with longer lactations may be able to produce the same amount of lifetime milk while incurring risks associated with difficult calving and postpartum metabolic diseases less often and it may be profitable to breed some cattle later in lactation than is needed to maintain a 365-d calving interval. The objective of our study, therefore, were to identify consequences of abnormal lactation length on production and reproduction traits in crossbred cattle.

MATERIALS AND METHODS

Location of the study

The experiment was conducted at the Livestock Farms of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana located at an altitude of 250 meters above the sea level, in the indo-gigantic alluvial plains at 29°C 42′N and latitude 72°C 54′E longitude. The climate is subtropical in nature with temperature usually ranging between 2°C in winter and 45°C in summer respectively. The area receives an annual rainfall of 760 - 960 mm and relative humidity 41-85%.

Parameters studied

The records were collected on the crossbred cattle (Red Dane × Sahiwal × Holstein Friesian), herd covering a period from 1990 to 2019. The data pertaining to identification of animal and pedigree were collected from the history sheets and data related to production and reproduction of the animal were collected and utilized for this study. Animals with completed lactation till drying were included in the study, excluding animals those died/ sold/ transferred mid lactation.

Lactation length was classified into five groups (Extremely short, short, normal, prolong and extremely prolong) using mean and standard deviation. Effect of lactation length classes were explored on 305 days or less milk yield (hereafter called as 305 days milk yield), lactation milk yield, average fat (%), 305 days fat yield and lactation fat yield for contemporary lactation to the traits, whereas service period, peak yield, days to reach peak yield, weight at calving and calf birth weight were additionally considered for next lactation cycle.

Effects of season, period, age at first calving and parity were included as non-genetic factors. Each year was divided into four seasons, *viz*. winter (December-February), summer (March-May), rainy (June-August) and autumn (September-November) of calving according to the prevalent geo-climatic conditions. The complete duration under investigation from 1990 to 2019 was divided into six periods of calving of five years each. The age at first calving (AFC) was divided to three groups with mean and standard deviations. Each of the First, second and third parity was considered a separate parity group whereas fourth and fifth parities were clubbed as one and parities beyond fifth parity were considered as one group.

Statistical analysis

The data were subjected to general linear model procedures using SAS software package, version 9.3 for the effects of extremely short lactation length, short lactation length, normal lactation length, prolong lactation length and extremely prolong lactation on production traits of contemporary lactation cycle after correcting for non-genetic factors using following model:

$$Y_{jklmn}+P_j+SC_K+Pa_i+Ag_m+e_{jklmn}$$

Where

Y_{jklmn} = Observation of n^{th} animal.
P_j = Effect of j^{th} period of calving on n^{th} animal.
SC_k = Effect of k^{th} season of calving on n^{th} animal.
Pa_l = Effect of l^{th} parity on n^{th} animal.
Ag_m = Effect of m^{th} age group on n^{th} animal.
e_{jklmn} = Residual term, NID ~ (0, σ^2_e).

The significant findings of non-genetic factors were corrected for using least squares constants in the traits. The effects of extremely short lactation length, short lactation length, normal lactation length, prolong lactation length and extremely prolong lactation were explored on the corrected traits using following model:

$$Y'_{in} = LL_i + e_{in}$$

Where

Y'_{in} = Corrected observation of n^{th} animal.

LL_i = Effect of i^{th} lactation length category.

e_{in} = Residual term, NID ~ (0, σ^2_e).

RESULTS AND DISCUSSION

A total of 72.64% of data fell in normal range of standard deviation of -1 SD to 1 SD which forms 1832 of lactation records out of 2541 records. Around 5.67% and 7.36% of data fall in -1.5 SD to -1 S.D and 1SD to 1.5 SD which forms short lactation length and prolong lactation length class respectively. Nearly 8.86% and 6.02% of lactation length records comes in -1.5 SD to > -2 SD and 1.5 SD to > 2 SD which forms extremely short lactation length and extremely prolong lactation lengths class (Table 1). Out of total lactation records, only 36.60% were within the range of 251-350 days which is still higher than reported 32.48% lactations in Sahiwal (Narwaria *et al.* 2015) and 17.87% lactations were beyond 450 days of lactation length which were lower than 30.45% reported by Mellado *et al.* (2016) in Holstein cattle respectively.

Effects on contemporary lactation traits

The effect of lactation length classes were estimated on 305 days milk yield, lactation milk yield, average fat percentage, 305 days fat yield and lactation fat yield of contemporary lactation *i.e.* the lactation in which abnormal lactation was observed (Table 2). The least squares ANOVA revealed that 305 days milk yield, Lactation milk yield, average fat percentage, 305 days fat yield and lactation fat yield of contemporary lactation were significantly affected by lactation length (P<0.0001).

305 days milk yield

The least squares mean for 305 days milk yield was significantly higher in the animal having extremely prolong lactation length followed by normal lactation length then by short lactation length and then by extremely short lactation length (P≤0.05). There was no significant difference in the least squares mean for 305 days milk yield of animal having prolong and extremely prolong lactation length. The least squares mean for 305 days milk yield was lowest in the animal having extremely short lactation length as compared to animal having short, normal, prolong and extremely prolong lactation length (Table 3). The findings can be supported by reports of Lakshmi (2009), Kathiravan (2009) and Ambhore *et al.* (2017) where first lactation 305 days milk yield trait was positively correlated with first lactation length at genetic level in Crossbred cattle.

Lactation milk yield

Lactation milk yield was highest in the animal having extremely prolong lactation length (7781.556±117.956) followed by prolong, normal and short lactations respectively and smallest in extremely short lactation length (442.956±94.934). The Lactation milk yield for every lactation length classes differed to other significantly (P≤0.05) as shown in Table 3. The findings indicate similar consequences to the reports of highly positive genetic correlation of lactation milk yield with lactation length as 0.93±0.02 (Vercesi *et al.*, 2006) and 0.79±0.15 (Lakshmi *et al.,* 2009) in crossbred cattle.

Fat yield traits

The least squares mean for average fat percentage was significantly lower in the animal having extremely short lactation length as compared to animal any other lactation length. There was no significant difference in the least

Table 1: Classification of lactation length on basis of frequency of different class.

Category	Standard deviation from mean	Range (in days)	No. of lactations	Percentage (%)
Extremely short lactation	≤ Mean-1.5 SD	<102	225	8.86
Short lactation	> Mean-1.5 SD to ≤ Mean-1 SD	102-179	144	5.67
Normal lactation	Mean ±1 SD	180-483	1832	72.64
Prolong lactation	> Mean +1 SD to ≤ Mean +1.5 SD	484-560	187	7.36
Extremely prolong lactation	> Mean +1.5 SD	>560	153	6.02
Total	2541	100		

Table 2: ANOVA for effect of lactation length classes on traits of contemporary lactation .

Traits	DF	Type III SS	Mean squares	F value	Pr > F
305 days milk yield (kg)	4	3136733454	784183364	635.35	<.0001
Lactation milk yield (kg)	4	6601483888	1650370972	826.00	<.0001
Average fat (%)	4	504.916305	126.229076	78.08	<.0001
305 days fat yield (kg)	4	3148505.346	787126.337	286.57	<.0001
Lactation fat yield (kg)	4	6189294.519	1547323.630	233.46	<.0001

squares mean for average fat percentage of animal having any lactation length (Table 3).

The least squares mean for 305 days fat yield was significantly higher in the animals having prolong and extremely prolong lactation length, followed by normal and then by short and smallest in extremely short lactation length (P≤0.05) while there was no significant difference in the least squares mean for 305 days fat yield in prolong and extremely prolong lactation length.

Lactation fat yield was significantly (P≤0.05) higher in the animals with extremely prolong lactation, sequentially followed by prolong and normal lactation length. While there was no significant difference between short and extremely short lactation length, their least squares mean for lactation fat yield of were significantly lower than other lactation length classes (Table 3).

Effects on next lactation traits

The effect of preceding lactation length in the next lactation cycle of the animal were estimated on service period, peak yield, days to reach peak yield, 305 days milk yield, lactation milk yield, average fat percentage, 305 days fat yield, lactation fat yield, weight at calving and calf birth weight of next lactation cycle. The least squares ANOVA revealed that service period, peak yield, weight at calving (Pd≤0.0001), lactation milk yield (P≤0.0005), 305 days milk yield (P≤0.005) and calf birth weight (P≤0.05) of next lactation cycle was significantly affected by lactation length in the previous cycle whereas days to reach peak yield and fat yield traits (average fat percentage, 305 days fat yield and lactation fat yield) were not affected by previous lactation lengths (Table 4). The results here forth were scarcely discussed due to scanty comparable reports.

Service period

The least squares mean for service period of next lactation cycle of animal having extremely prolong lactation length was highest followed by service period for animals having prolong lactation length in the previous lactation cycle. While the service period of animal having normal, short and extremely short lactation length in the previous lactation cycle were significantly smaller (P≤0.05) than other two, there was no significant difference among them (Table 5).

Peak yield

Peak yield of next lactation cycle of animals having prolong lactation length (23.861±0.648) was significantly higher than animal having normal and extremely short lactation length (P≤0.05). There was no significant difference for peak yield of next lactation cycle of short and extremely prolong lactation length with any other in the previous lactation cycle (Table 5). Further the peak yield of short lactation exhibited smaller least squares mean accompanied by a larger

Table 3: Least squares means of contemporary lactation traits for lactation length classes.

Factor effect	305 Day milk yield	Lactation milk yield	Average fat percentage	305 days fat yield	Lactation fat yield
ESLL (<102 days)	431.327^{d}±74.614	442.956^{e}±94.934	1.817^{b}±0.085	8.659^{d}±3.520	19.495^{d}±5.468
SLL (102-179 days)	1575.145^{c}±94.831	1597.565^{d}±120.656	3.285^{a}±0.109	41.359^{c}±4.474	42.246^{d}±6.949
NLL (180-483 days)	3821.525^{b}±31.078	4184.500^{c}±39.542	3.404^{a}±0.036	117.456^{b}±1.466	131.038^{c}±2.277
PLL (484 - 560 days)	4505.679^{a}±83.113	6270.157^{b}±105.747	3.462^{a}±0.095	134.390^{a}±3.921	198.238^{b}±6.090
EPLL (>560 days)	4658.651^{a}±92.709	7781.556^{a}±117.956	3.224^{a}±0.106	134.038^{a}±4.373	236.583^{a}±6.794

Values with different superscript (a, b, c…) within a trait differ significantly (P≤0.05). ESLL: Extremely short lactation length, SLL: Short lactation length, NLL: Normal lactation length, PLL: Prolong lactation length, EPLL: Extremely prolong lactation length.

Table 4: ANOVA for effect of lactation length classes on traits of next lactation.

Traits	DF	Type III SS	Mean squares	F value	Pr > F
Service period	4	12186356.64	3046589.16	295.98	<.0001
Peak yield	4	1614.12856	403.53214	6.94	<.0001
Days to reach peak yield	4	748.42659	187.10665	0.20	0.9366
305 days milk yield	4	45002415.0	11250603.8	3.91	0.0037
Lactation milk yield	4	98901191.7	24725297.9	5.01	0.0005
Average fat percentage	4	8.9268607	2.2317152	1.17	0.3235
305 days fat yield	4	39834.445	9958.611	2.20	0.0668
Lactation fat yield	4	89536.868	22384.217	2.16	0.0709
Weight at calving	4	112290.142	28072.535	8.64	<.0001
Calf birth weight	4	392.913398	98.228349	3.30	0.0107

Table 5: Least squares means of production traits of next cycle for lactation length classes.

Lactation length (Previous cycle)	Service period	Peak yield	Days to reach peak yield	305 days milk yield	Lactation milk yield	Average fat percent	305 days fat yield	Lactation fat yield	Weight at calving	Calf birth weight
ESLL	147.862^{c}	16.201^{b}	39.277	2660.294^{ab}	2983.800^{ab}	3.140	83.475	101.744	495.493^{ab}	26.442^{b}
(<102 days)	±30.696	±2.307	±9.179	±513.403	±672.045	±0.418	±20.353	±30.778	±17.252	±1.653
SLL	158.718^{c}	17.133^{ab}	49.548	2158.715^{ab}	2310.236^{ab}	4.530	47.858	55.524	460.789^{ab}	37.368^{a}
(102-179 days)	±58.759	±4.417	±17.570	±982.766	±1286.441	±0.801	±38.961	±58.916	±33.024	±3.163
NLL	156.017^{c}	20.784^{b}	41.702	3336.818^{b}	3799.663^{b}	3.251	101.096	119.644	472.020^{b}	29.671^{ab}
(180-483 days)	±3.334	±0.251	±0.997	±55.759	±72.988	±0.045	±2.211	±3.343	±1.903	±0.193
PLL	335.410^{b}	23.861^{a}	40.990	3840.686^{a}	4505.860^{a}	3.130	115.179	139.848	485.438^{ab}	30.440^{ab}
(484 - 560 days)	±8.627	±0.648	±2.580	±144.288	±188.873	±0.118	±5.720	±8.650	±4.921	±0.485
EPLL	481.837^{a}	22.037^{ab}	43.861	3530.797^{ab}	4332.282^{ab}	3.087	106.313	136.636	505.502^{a}	30.386^{ab}
(>560 days)	±10.680	±0.803	±3.194	±178.630	±233.827	±0.146	±7.082	±10.709	±6.097	±0.636

Values with different superscripts (a, b, c...) within a trait differ significantly ($P \leq 0.05$). ESLL: Extremely short lactation length, SLL: Short lactation length, NLL: Normal lactation length, PLL: Prolong lactation length, EPLL: Extremely prolong lactation length.

standard error (17.133±4.417), indicating wider within group variation.

305 days milk yield

The mean 305 days milk yield of next lactation cycle of animal having prolong lactation length (3840.686±144.288) was significantly higher than that of normal lactation length (3336.818±55.759) in the previous lactation cycle, indicating a slightly prolong lactation being better in lactation milk yield but without such benefits in extremely prolong lactations. There was no significant difference among any other lactation length groups. Similar to peak yield short lactation exhibited smaller least squares mean accompanied by a large standard error (2158.715±982.766), indicating wider within group variation (Table 5).

Lactation milk yield

Similar to 305 days milk yield, lactation milk yield (LMY) of next lactation cycle of animal having prolong lactation length (4505.860±188.873) was significantly higher ($P \leq 0.05$) than normal lactation length (3799.663±72.988). However, there was no significant difference in the least squares mean for lactation milk yield of next lactation cycle among extremely short, short, prolong and extremely prolong lactation lengths. Yet again the short lactation had numerically smallest least squares mean for LMY coupled with a fairly large standard error, showing wider variations within the group (Table 5).

Weight at calving

The least squares mean for weight at calving in next lactation cycle of extremely prolong lactation length (505.502±6.097) was significantly higher than that of normal lactation length (472.020±1.903) in the in previous lactation cycle ($P \leq 0.05$).There was no significant difference among rest of the groups for weight at calving in next lactation cycle. The weight at calving of next calving for short and extremely short lactation lengths were accompanied by large standard errors (Table 5).

Calf birth weight

The least squares mean for calf birth weight in next calving of animal having short lactation length was significantly higher ($P \leq 0.05$) than extremely short lactation length in the previous lactation cycle. There was no significant difference in the least squares mean for calf birth weight for any other class of lactation length (Table 5).

CONCLUSION

The deviant lactation lengths as extremely short, short, prolong and extremely prolong lactations affect not only the performances of contemporary lactation traits as 305 days milk yield, lactation milk yield, average fat percentage, 305 days fat yield and lactation fat yield; it also affected next lactation traits like service period, peak yield, 305 days milk yield, lactation milk yield, weight at calving and calf birth weight. The values of traits of contemporary lactation cycle were higher for the prolong lactation length and lower for

extremely short/short lactation length, while extremely prolong lactation mostly did not show substantial superiority over prolong lactation. Similar trend was seen for next lactation cycle of the animal having abnormal lactation length in previous lactation cycle except calf birth weight. The performance of short lactation animals however had a substantial variation for next lactation traits exhibiting that a good proportion of animals recovered from short lactation in next cycle. Present study suggested that the alteration of lactation lengths affected all important traits of crossbred cattle in contemporary as well as next lactation and thus may be given importance for efficient dairy management.

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Disclosure statement

The authors declare that there is no potential conflict of interest in whatsoever form associated to this article.

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