Indian Journal of Animal Sciences **91** (2): 121–127, February 2021/Article
https://doi.org/10.56093/ijans.v91i2.113819

Sire evaluation and effect of various factors on growth performance in males of Tharparkar and Karan fries cattle

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Received: 16 September 2020; Accepted: 18 January 2021

ABSTRACT

The current study was undertaken with the objective of sire evaluation as well as studying the effect of genetic and non-genetic factors on growth performance in males of Tharparkar and Karan Fries Cattle. Data on body weights of Tharparkar and Karan Fries males born during the period 1994–2012 at ICAR-NDRI, Karnal, were utilized. The overall least squares means of birth weight and weights at one-month interval up to 12 months of age were 26.92±0.24, 35.55±0.22, 45.04±0.28, 57.56±0.40, 70.02±0.51, 82.62±0.66, 95.18±0.80, 105.11±1.55, 108.19±1.15, 114.20±1.15, 120.11±1.09, 130.35±1.11 and 136.91±4.13 kg respectively, in KF males. In TP males, least square means for birth and one-month were 21.34±0.77 and 25.63±0.67 kg, respectively. Effect of month and period of birth was highly significant on all traits except 1 month and 12-months for the former effect. The effects of genetic group and parity were mostly significant on body weights in KF males. Regression on birth weight was highly significant for all the weight traits. Effect of sire and birth-month was highly significant on all traits except one-month weight in KF. In Tharparkar, effect of season was highly significant on birth weight. Growth curves were linear, and deviations of average body weekly weight showed more divergence with increasing age. Growth rates from birth to three-months age in KF and TP males were 320 g/day and 226 g/day. Effect of non-genetic factors indicated the need of further improvement in feeding and management practices for augmenting growth, i.e. body weights especially in calves born to primiparous dams.

Keywords: Breeding values, Cattle, Genetic factors, Growth band, Growth curve, Growth rate

Cattle is one of the most important domestic animal species of India and it contributes significantly to the rich biodiversity of cattle genetic resources the current population being 192 million (Anonymous, 2019). Therefore, genetic improvement of cattle has always been a priority in all national livestock policies. Despite multiple efforts, the non-availability of genetically proven male germplasm has been a serious bottleneck (Rashid *et al.* 2019) especially for sustaining any cattle breeding program. This has created a need to create nucleus herds of high genetic merit cattle for production and dissemination of quality germplasm to meet the requirement of pure as well as cross bred bulls. The emphasis on dairy traits has somewhat diminished the importance of growth traits which are also considerably important in any breeding program. The National Dairy Institute of India maintains of the elite germplasm of the Tharparker breed. Also, a composite breed, Karan Fries was developed in the 1970's at the Institute, by crossing Tharparkar with Holstein Friesian with an exotic inheritance level of around 62.5% (Gurnani *et al.* 1986). This germplasm is now being used around the Country for genetic improvement of livestock. Considering the importance of these two breeds and their utility, a sound breeding program needs to be in place (Cilek and Tekin 2005). Growth traits are crucial in cattle breeding and therefore are useful to know the empirical relationships of these measures of growth rate in the population. Similar studies for understanding the correlation of growth rates with body weights for various breeds have been done (Simm 1998, Bakir *et al.* 2004, Kuralkar *et al.* 2005, Akpa *et al.* 2007, Madhuri *et al.* 2007, Kumar 2011 and Mishra *et al.*2017). However, it is necessary to perform such studies on every breeding farm from time to time to access their status, thus facilitating good breeding decisions (Gupta *et al.* 2019). Growth curves and growth bands are useful aids in making efficient decision for selection of the animals at different ages. Therefore, the current study was undertaken with the objective of sire evaluation as well as studying the effect of genetic and non-genetic factors on growth performance in males of Tharparkar and Karan Fries Cattle.

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MATERIALS AND METHODS

Data collection: Data on body weights of male calves of KF (2047 head) and TP (130 head) born from year 1994–2012, were collected from NDRI, Karnal. Animal number, date of birth, sire and dam number, stage of lactation, sire and dam breed, birth weight (kg), weekly weights up to 26 weeks of age (kg), body weights at one-month interval of age (kg) up to disposal, were recorded for the study.

Farm location and practices: The National Dairy Research Institute (NDRI) livestock Farm is located at 250 meters above the sea level on 29°42′ N latitude and 72°02′ E longitude. The climate is subtropical. Calves were weaned at birth and both sexes were reared together till 6 months after which male calves were disposed except those calves from high yielding dams with good pedigree records were maintained as future bulls. Colostrum was fed for the first five days. The calves were fed with mixture of skim milk and whole milk up to four months and skim milk up to six months of age. Concentrate, mineral mixtures and roughages were also provided to calves from one month of age.

Standardization and classification of data: The data were suitably classified according to different seasons, periods, genetic groups, parity (Primiparous and Pleuriparous) to observe the effect of different genetic and non-genetic factors on the traits under study. A year was divided into twelve classes based on the month of birth of calves. Due to limited data size in TP year was divided into four seasons (winter, summer, rainy and autumn). The sire-period confounding was avoided by classifying periods while avoiding overlapping of sires. The data were also classified into 6 periods of 3 years each. The last was of 4 years in KF. For the genetic group, classification was done on the basis of level of Holstein (HF) inheritance of Karan Fries males. HF (sire) × TP (dam) was classified into F_1 group, KF (sire) × KF (dam) into Interbred group (50–62.5% HF) and HF (sire) × KF (dam) into the Higher crosses group (≥ 75% HF)

Measures of central tendency and dispersion: The mean, standard error, standard deviation and coefficients of variation of all traits were estimated by using standard statistical procedures. The data of all traits were normalized using mean and standard deviation of the traits.

Least squares analysis: The effect of genetic and non-genetic factors on growth traits was studied by least squares analysis of variance for unequal and non-orthogonal data using the technique described by Harvey (1987). The statistical models used for different traits are given here.

For birth weight of KF and TP:

$$Y_{ijklm} = \mu + S_i + P_j + G_k{}^* + PA_l + e_{ijklm} \text{(* Excluded for TP)}$$

where, Y_{ijklm}, birth weight of m^{th} calf born in i^{th} season/ month, j^{th} period, k^{th} genetic group and l^{th} parity; μ, overall population mean; S_i, fixed effect of i^{th} season; P_j, fixed effect of j^{th} period; G_k, fixed effect of k^{th} genetic group; PA_l, Fixed effect of l^{th} parity; e_{ijklm}, random error, assumed to be independently and normally distributed with mean zero and constant variance, i.e. NID (0, σ^2_e).

For other body weights of KF and TP:

$$Y_{ijklm} = \mu + S_i + P_j + G_k{}^* + PA_l + b_{yz}(Z_{ijklm} - Z) + e_{ijklm} \text{ (* Excluded for TP).}$$

where, Y_{ijklm}, birth weight of m^{th} calf born in i^{th} season, j^{th} period, k^{th} genetic group and l^{th} lactation; μ, overall population mean; S_i, Fixed effect of i^{th} season; P_j, fixed effect of j^{th} period; G_k, fixed effect of k^{th} genetic group; PA_l, fixed effect of l^{th} parity; Z_{ijk}, birth weight to be taken as a co-variable with other body weights; Z, average birth weight of the herd, b_{yz}, regression of body weight under study on birth weight; e_{ijklm}, random error, assumed to be independently and normally distributed with mean zero and constant variance, i.e. NID (0, σ^2_e).

Sire was included in above described two fixed models to study effect of sire on the birth and other body weights. Sire was taken as random effect while season, period, genetic group and parity were taken as fixed effect on the traits under study.

Duncan's multiple range test as modified by Kramer (1957), was used for testing the differences among least squares means (using the inverse coefficient matrix).

Best Linear Unbiased Prediction (*BLUP*): The breeding value of sires were estimated by using BLUP method which is currently in vogue the world over for breeding value estimation (Hamadani *et al.* 2019). The following general model was used: Y = Xb + Zu + e. Where, Y is the vector of observations for traits under study, b is the vector of observations of unknown fixed effects (periods, seasons, age), u is the vector of observations of unknown random effects (sires). X and Z are the incidence matrices pertaining for fixed and random effect. e is the residual effect with assumptions that,

$E(Y) = X\mathbf{b}$; $E(\mathbf{u}) = 0$; $E(\mathbf{e}) = 0$ and $Var(u) = \mathbf{G}\,\sigma^2_s$;

$Var(e) = \mathbf{I}\,\sigma^2_e$

The mixed model equation is

$$\begin{pmatrix} (X'R^{-1}X) & (XR^{-1}Z) \\ (Z'R^{-1}X) & (ZR^{-1}Z+G^{-1}) \end{pmatrix} \begin{pmatrix} b \\ u \end{pmatrix} = \begin{pmatrix} (X'R^{-1}Y) \\ (X'R^{-1}Y) \end{pmatrix}$$

By solving the mixed model equations, the BLUP breeding values of the random effects (animal and sire) was obtained (Henderson *et al.* 1973).

Rank correlations: The correlations between the ranking of the sires based on their breeding values estimated by the above methods was tested by using Spearman's rank correlation.

$$r_{(s)} = 1 - \frac{6\sum d_i^2}{n(n^2-1)}$$

where, r is the rank correlation coefficient, n is the no. of sires under evaluation; di is the difference of rank between paired items under two methods. The significant of rank correlation was be tested by t-test with n-2 (d.f.) as given below:

$$\mathbf{t = r\sqrt{\frac{n-2}{1-r2}}} \quad t = r\sqrt{\frac{n-2}{1-r^2}}$$

Growth curves and growth bands: The linear growth function was considered for construction of growth curves up to 25 weeks of age:

$$Y = a + bX$$

where, Y, body weight (kg); X, age; a, intercept value; b, regression coefficient. The growth curves were prepared by plotting average weekly body weights (from birth to 25 weeks) against age (in weeks), for KF and TP calves.

Growth bands were prepared by plotting weekly mean body weights plus or minus two standard deviations (Mean ± 2 SD) against age with the upper limit equal to $W_i + 2\ Sw_i$ and the lower limit equal to $W_i - 2\ Sw_i$. Where, W_i is the average body weight at i^{th} age, Sw_i is the standard deviation of the body weight at i^{th} age. The upper and lower limits plotted against age and the band between the curve of the upper limits and curve of the lower limits constituted the growth band.

RESULTS AND DISCUSSION

Descriptive statistics: The descriptive Statistics of data are shown in Tables 1 and 2 respectively. The coefficient of variation associated revealed that sufficient variability existed in growth traits of KF and TP males under study. Highest CVs was observed for 17-month body weight (21.06%) for Karan Fries and 6 month body weight (26.25) for TP. The mean birth weight was 28.43±0.12 kg with coefficient of variation (CV %) 19.21% in KF. In TP, the average birth weight was 21.46±0.12 kg and the coefficient of variation (CV %) of this trait was 12.91%. The mean body weights along with standard error (SE) at 3 months interval from birth to 24 months of age were 57.67±0.37, 92.29±0.80, 111.68±1.24, 127.88±1.72, 150.41±3.47, 187.93±6.99, 236.05±7.98, 276.90±7.32 kg in KF. Whereas mean weights at 3 and 6 months were 41.58±1.04 and 62.38±2.46 kg respectively in TP males.

Table 1. Least squares means of birth and 1-month weight in TP

Trait	Birth weight		1 month	
	N	Mean±SE (kg)	N	Mean±SE (kg)
Overall	129	21.34±0.77	102	25.63±0.67
Season				
Dec. to Mar.	39	22.69^a±0.82	30	28.15±0.84
Apr. to Jun	39	20.71^b±0.84	31	27.24±0.82
Jul. to Sep.	34	20.47^b±0.85	50	26.53±0.92
Oct. to Nov.	17	21.50^a±0.96	16	28.59±1.02
Periods				
1994–1995	11	19.80±1.65	9	25.49±2.32
2000–2005	14	23.10±1.14	9	28.06±1.38
2006–2007	40	21.32±0.96	29	29.89±1.07
2008–2009	30	21.65±1.04	24	28.23±1.23
2010–2012	34	20.84±1.13	31	26.47±1.36
Parity				
Primiparous	45	20.94±0.83	35	26.81±0.82
Pleuriparous	84	21.74±0.77	67	28.44±0.69

N, No. of observations. Means with same superscript did not differ significantly.

Least squares analysis of variance for body weights: The overall least squares means for various body weights of TP (Table 1) and KF (Table 2 and Table 3). Similar estimates for birth weight and 6 month body weight by Madhuri *et al.* (2007) in crossbred cattle and Kumar (2011) in KF. The estimate was higher than the estimates of birth weights and 6 month body weight in KF reported by most of the workers in different breeds of cattle (Roy *et al.* 1996; Khan *et al.* 1999; Manoj, 2010). However, the estimate was lower for birth weight in TP than estimates reported by other workers (Bakir *et al.* 2004) in Karan Swiss (KS) and HF. For TP, similar estimates of least squares mean for birth weight were reported by Roy *et al.* (1996) in TP crossbred and Khan *et al.* (1999) in Sahiwal. The estimate of birth weight in TP was higher than the estimates reported by most of the workers in different breeds of cattle (Manoj, 2010). However, the present estimate of birth weight in TP was lower than values reported by other workers (Bakir *et al.* 2004, Madhuri *et al.* 2007).

Effects of genetic and non-genetic factors: Least squares analysis of variance (Mean squares only) for birth weight and different body weights in KF and TP are given in Tables 1 and 2 respectively. The influences of month of birth, period, genetic group and parity were highly significant ($P < 0.01$) on birth weight of KF while in TP; only effect of season was very significant ($P < 0.01$) for birth weight. Bakir *et al.* (2004) reported significant influence of season on birth weight in Sahiwal calves. On the contrary, the non-significant influence of season on birth weight were observed by various researchers (Roy *et al.*1996, Khan *et al.* 1999, Madhuri *et al.* 2007, Manoj 2010, Kumar 2011 and Verma *et al.* 2019) in different breeds of cattle.

The effect of period and genetic group were highly significant ($P < 0.01$) on 1 month body weight of KF while month of birth and parity had non-significant effect on this trait. In TP effect of season, period and parity were not significant on 1 month body weight. The effect of month of birth and period were significant ($P < 0.05$) and highly significant ($P < 0.01$) respectively, on 2 month body weight of KF. The influence of period of birth was highly significant ($P < 0.01$) on 2 month body weight in KF calves. The effect of month of birth and period were highly significant on 3 month body weight of KF. The influence of period of birth was highly significant ($P < 0.01$) on 3 month body weight in KF calves. The effect of month of birth and period were highly significant ($P < 0.01$) on 4 month body weight of KF. The effect of month of birth, period and parity were highly significant ($P < 0.01$) on 5 month body weight of KF. The effect of month of birth, period, genetic group and parity were highly significant on 6 month body weight of KF. Madhuri *et al.* (2007), Manoj (2010) and Kumar (2011) also observed the significant effect of season on 6 month body weight in different breeds of cattle. On contrary, Roy *et al.* (1996) in TP crossbred did not observe any significant

Table 2. Least squares means of birth, 1, 2, 3, 4, 5, 6 months weight in KF

Trait	Birth weight		1 month		2 month		3 month		4 month		5 month		6 month	
	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)
Overall	2046	26.92±0.24	1426	35.55±0.22	1189	45.04±0.28	1028	57.56±0.40	880	70.02±0.51	721	82.62±0.66	503	95.18±0.80
Month of birth														
January	189	28.33^{ab}±0.43	150	35.42±0.37	107	44.36^{ab}±0.74	80	54.45^{f}±1.20	75	67.02^{d}±1.48	69	78.80^{c}±1.81	53	87.94^{fg}±2.17
February	200	28.39^{ab}±0.41	109	34.25±0.42	68	41.76^{b}±0.92	62	54.19^{f}±1.34	58	67.24^{d}±1.64	54	77.47^{c}±1.99	42	86.08^{g}±2.39
March	229	29.03^{a}±0.40	134	35.85±0.39	125	45.38^{a}±0.69	117	56.85^{cdef}±1.00	108	67.89^{cd}±1.23	96	79.46^{c}±1.53	73	89.44^{efg}±1.86
April	201	28.34^{ab}±0.42	163	35.91±0.36	154	45.19^{a}±0.62	149	57.06^{bcdef}±0.88	142	68.06^{cd}±1.07	122	78.63^{c}±1.34	59	89.99^{efg}±2.09
May	145	26.60^{bc}±0.47	104	36.01±0.43	95	44.64^{a}±0.78	89	55.87^{def}±1.13	73	67.09^{d}±1.49	35	81.35^{bc}±2.49	28	94.80^{def}±2.94
June	150	26.45^{bc}±0.47	110	35.71±0.42	104	44.52^{a}±0.75	85	54.72^{ef}±1.15	47	66.30^{d}±1.84	40	79.28^{c}±2.34	36	95.33^{de}±2.67
July	182	25.67^{c}±0.44	140	35.47±0.38	89	44.58^{a}±0.81	51	58.42^{abcd}±1.49	50	72.33^{b}±1.80	47	86.94^{a}±2.17	36	104.72^{ab}±2.66
August	155	26.02^{c}±0.47	76	35.36±0.51	43	45.86^{a}±1.17	42	58.78^{abcd}±1.66	40	71.50^{bc}±2.05	38	87.08^{a}±2.50	21	110.83^{a}±3.58
September	135	26.07^{c}±0.50	78	35.76±0.49	76	47.02^{a}±0.87	72	61.59^{a}±1.25	70	75.21^{ab}±1.50	61	89.42^{a}±1.88	46	102.74^{bc}±2.30
October	158	25.55^{c}±0.47	133	35.70±0.41	122	45.81^{a}±0.70	114	60.22^{abc}±1.00	97	72.55^{b}±1.29	76	85.55^{ab}±1.70	38	96.13^{cde}±2.56
November	135	25.55^{c}±0.49	104	35.66±0.44	98	46.16^{a}±0.77	89	60.44^{ab}±1.12	68	77.01^{a}±1.52	37	88.52^{a}±2.42	31	97.84^{bcd}±2.79
December	167	26.99^{bc}±0.45	125	35.53±0.41	108	45.18^{a}±0.73	78	58.14^{abcde}±1.20	52	68.02^{cd}±1.73	46	78.91^{c}±2.16	40	86.34^{g}±2.48
Periods														
1994–1996	332	28.12^{a}±0.36	107	33.63^{d}±0.45	90	42.58^{b}±0.81	68	56.98^{b}±1.29	59	71.80^{a}±1.66	46	87.23^{a}±2.24	35	110.76^{a}±2.99
1997–1999	312	27.06^{ab}±0.38	230	34.61^{cd}±0.34	182	43.01^{b}±0.58	150	53.90^{c}±0.89	126	66.22^{b}±1.16	108	80.28^{b}±1.48	75	102.40^{b}±2.03
2000–2002	337	26.66^{b}±0.35	251	35.41^{bc}±0.31	215	43.95^{b}±0.53	182	55.25^{bc}±0.80	156	67.54^{b}±1.02	127	80.12^{b}±1.33	88	93.11^{c}±1.78
2003–2005	349	26.60^{b}±0.34	256	36.02^{ab}±0.30	203	46.70^{a}±0.54	174	60.69^{a}±0.82	131	73.53^{a}±1.12	104	88.12^{a}±1.48	80	105.18^{ab}±1.81
2006–2008	324	26.64^{b}±0.35	267	36.91^{a}±0.31	231	47.20^{a}±0.52	208	60.87^{a}±0.75	185	73.71^{a}±0.94	154	84.68^{a}±1.22	119	96.56^{c}±1.50
2009–2012	392	26.43^{b}±0.35	315	36.76^{a}±0.31	268	46.79^{a}±0.50	246	57.67^{b}±0.73	223	67.88^{b}±0.96	182	75.28^{c}±1.37	106	63.09^{d}±3.08
Genetic group														
F_1	119	23.57^{c}±0.49	87	35.78^{a}±0.45	84	45.04±0.52	79	57.45±0.63	75	69.66±0.71	71	81.76±0.83	67	92.36^{b}±0.93
Interbred	1800	28.00^{b}±0.13	1230	34.87^{b}±0.13	1000	44.80±0.26	853	57.34±0.39	715	69.78±0.50	567	82.30±0.65	370	93.78^{b}±0.78
Higher crosses	127	29.18^{a}±0.48	109	36.02^{a}±0.40	105	45.27±0.51	96	57.88±0.64	90	70.61±0.74	83	83.80±0.90	66	99.40^{a}±1.12
Parity														
Primiparous	588	25.84^{b}±0.32	384	35.44±0.29	288	45.02±0.35	246	57.49±0.46	199	69.79±0.56	135	81.92^{b}±0.70	87	91.48^{b}±0.85
Pleuriparous	1458	28.00^{a}±0.23	1042	35.67±0.20	901	45.05^{a}±0.29	782	57.63±0.42	681	70.25±0.54	586	83.32^{a}±0.71	416	98.88^{a}±0.96

Table 3. Least squares means of 7, 8, 9, 10, 11 and 12 months weight in KF

Trait	7 month		8 month		9 month		10 month		11 month		12 month	
	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)	N	Mean±SE (kg)
Overall	395	105.11±1.55	275	108.19±1.15	226	114.20±1.15	181	120.11±1.09	144	130.35±1.11	115	136.91±4.13
Month of birth												
January	43	99.33^{c}±2.83	24	101.36^{b}±3.23	20	108.69^{cd}±3.43	16	115.43^{bc}±3.43	16	127.76^{bced}±3.08	13	131.19±6.12
February	35	99.02^{c}±3.08	26	106.71b^{cd}±.12	21	113.56b^{cd}±3.31	19	120.86^{bc}±3.07	13	131.78^{bc}±3.28	12	134.25±5.84
March	51	100.03^{c}±2.66	27	100.68^{b}±3.09	19	108.90^{cd}±3.51	16	113.58^{bc}±3.38	11	131.85^{bc}±3.64	9	134.69±6.97
April	52	105.07^{c}±2.56	34	108.31b^{cd}±.77	25	108.83$^{cd±}$3.05	20	115.74^{bc}±2.99	15	121.95^{cde}±3.03	10	139.59±6.36
May	28	104.31^{bc}±.38	22	104.53^{cd}±3.38	21	111.09^{cd}±3.34	18	117.74^{bc}±3.20	16	130.80^{bcd}±3.08	11	127.12±6.51
June	34	99.91^{c}±3.06	23	107.90^{bcd}±.28	19	114.96^{bcd}±3.49	12	119.88^{bc}±3.85	10	130.46^{bcde}±3.66	8	135.97±6.95
July	26	112.11^{ab}±.46	21	115.96^{ab}±3.47	14	123.27^{ab}±4.06	12	124.86^{abc}±3.91	8	134.21^{b}±4.28	6	146.53±8.03
August	17	116.96^{a}±4.23	14	123.40^{a}±4.26	9	128.90^{a}±5.04	6	134.96^{a}±5.52	4	148.32^{a}±5.74	3	150.31±10.39
September	25	109.41^{ab}±.62	18	110.56^{bcd}±3.71	17	118.66^{abc}±3.66	16	123.36^{bc}±3.33	13	135.62^{b}±3.19	11	139.19±6.51
October	25	109.23^{ab}±.61	16	105.03^{bcd}±3.91	16	108.63^{cd}±3.76	12	116.87^{bc}±3.84	10	118.95^{e}±3.66	8	132.39±7.22
November	29	110.97^{ab}±.37	26	114.03^{abc}±3.15	23	119.42^{abc}±3.23	15	125.51^{ab}±3.51	11	132.08^{bc}±3.58	10	138.64±6.67
December	30	94.95^{c}±3.34	24	99.88^{d}±3.29	22	105.52^{d}±3.34	19	112.51^{c}±3.20	17	120.48^{de}±3.01	14	133.08±6.42
Periods												
1994-1996	24	106.57^{ab}±.65	21	111.70^{ab}±.47	17	125.46^{a}±3.77	15	139.48^{a}±3.61	10	164.07^{a}±4.10	1	154.02^{a}±17.21
1997-1999	64	109.83^{a}±2.60	42	108.67^{bc}±.56	36	111.23^{d}±2.64	31	116.38^{c}±2.49	28	128.45^{c}±2.30	25	133.60^{cd}±4.78
2000-2002	77	100.06^{bc}±.29	57	102.84^{cd}±.18	43	106.54^{b}±2.41	32	111.71^{e}±2.51	27	121.10^{d}±2.41	22	120.43^{e}±4.56
2003-2005	67	112.31^{a}±2.27	41	117.34^{a}±2.52	36	123.24^{a}±2.56	26	129.60^{b}±2.67	15	143.85^{b}±3.16	12	145.14^{ab}±5.36
2006-2008	84	105.94^{ab}±.24	52	111.30^{ab}±.26	42	120.21^{a}±2.42	35	126.16^{b}±2.38	28	135.21^{c}±2.41	21	139.83^{bc}±4.92
2009–2012	79	95.92^{c}±2.39	62	97.33^{d}±2.24	52	98.54^{c}±2.44	42	97.32^{d}±2.80	36	89.43^{e}±3.61	34	128.47^{de}±4.02
Genetic group												
F_1	61	105.81^{a}±2.59	41	107.98±1.74	34	113.23^{b}±1.54	28	118.59^{b}±1.38	21	127.04^{b}±1.27	15	138.66±6.47
Interbred	285	101.77^{b}±1.37	200	106.64±1.19	166	112.92^{a}±1.18	132	118.45^{b}±1.13	106	127.51^{b}±1.11	85	131.77±3.77
Higher crosses	49	107.74^{a}±2.71	34	109.96±1.83	26	116.46^{a}±1.67	21	123.28^{a}±1.49	17	136.52^{a}±1.53	15	140.30±5.82
Parity												
Primiparous	63	107.26^{a}±2.49	40	107.04±1.53	34	112.09^{b}±1.40	25	116.81^{b}±1.29	20	124.36^{b}±1.22	14	136.45±5.82
Pleuriparous	332	102.95^{b}±1.19	235	109.35±1.13	192	116.31^{a}±1.18	156	123.40^{a}±1.16	124	136.34^{a}±1.34	101	137.38±3.59

effect of season on the body weight of calves at 6 month of age. Roy *et al.* (1996), Madhuri *et al.* (2007), Manoj (2010) and Kumar (2011) also observed significant effect of period on 6-month body weight.

The effect of month of birth, period and parity were highly significant ($P < 0.01$) and genetic group was significant ($P < 0.05$) on 7 month body weight of KF. The effect of month of birth and period were highly significant ($P < 0.01$) on 8 month body weight of KF. The effect of month of birth, period and parity were highly significant ($P < 0.01$) and genetic group was significant ($P < 0.05$) on 9 month body weight of KF. The effect of month of birth, period, genetic group and parity were highly significant ($P < 0.01$) on 10 month body weight of KF. The effect of month of birth, period, genetic group and parity were highly significant ($P < 0.01$) on 11 month body weight of KF. The effect of period was highly significant ($P < 0.01$) on 12 month body weight of KF.

Growth curves and growth bands: The growth curve was linear in nature in both breeds of calves (Figs 1 and 2). Similar observations were reported by Manoj (2010) in Sahiwal and Kumar (2011) in KF cattle. The growth curve as described indicates the average body weight at different ages. It would be normally expected that, at a given age, 50% of the animals would have body weight above the growth curve and 50% of the animals would have below

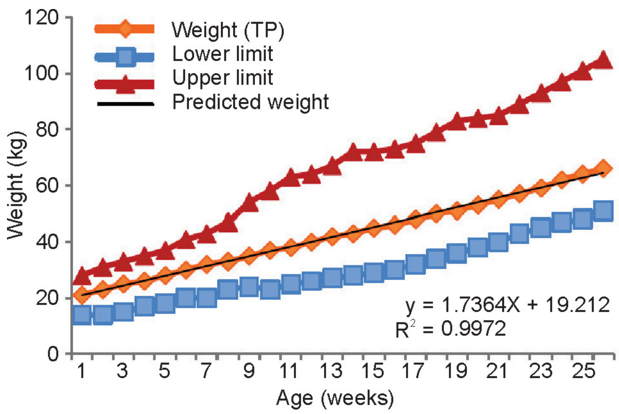

Fig. 1. Growth curve and band of KF male calves.

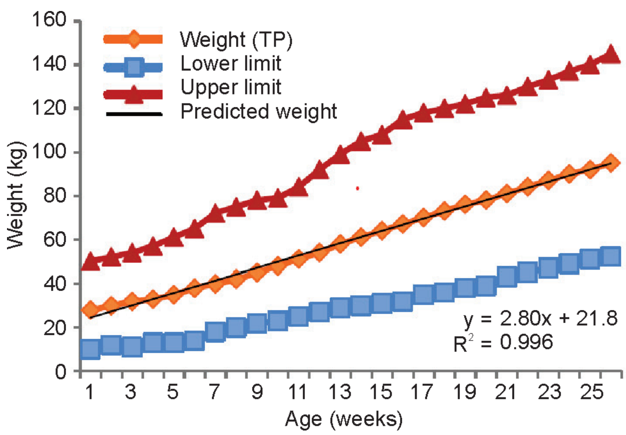

Fig.2 Growth curve and band of TP male calves.

the growth curve. The growth curve reveals little about the fact whether a given animal is 'over weight' or 'under weight' at a given age. Therefore, 95% confidence intervals of the body weight at various ages ranging from birth to 25 weeks at weekly intervals were computed separately for KF and TP calves. The band between the upper limit and lower limits of the curve constituted the growth band. These growth bands for KF and TP calves are depicted in Figs 1 and 2, respectively.

The widening of growth band during later ages is due to generally observed higher variance in body weight with the increase in age. Similar shape of growth bands was also reported by Manoj (2010) in Sahiwal and Kumar (2011) in KF cattle, respectively. This increase in variance with age could be due to large role of environment causing larger animal to animal differences in body weights with the advancement of age.

Growth rates: Average daily weight gain from birth to 3 months was 320 g/day in KF calves and 226 g/day in TP calves. The average daily weight gain in KF and TP calves was 368 g/day and 237 g/day respectively, from 3 months to 6 month.

Manoj (2010) reported that in Sahiwal, average daily weight gain from birth to six months was 339.11 g/day in female calves and 333.50 g/day in male calves. The average daily weight gain in Sahiwal cattle was 298.35 g/day from six months to age at first calving. Manoj (2010) observed maximum growth rate was observed between twelve and eighteen months of age (363.32 g/day) and minimum growth was observed between thirty months to age at first calving (238.74 g/day). Kumar (2011) reported average daily weight gain from birth to six months was 358.48 g/day in female calves and 463.57 g/day in male calves of KF.

Sire evaluation for birth weight and other body weights: The overall breeding value was 28.09±0.19 and 21.42±0.85 kg for birth weight of KF and TP respectively. The overall breeding values for body weight of KF calves from 1 to 6 months were 34.94±0.20, 44.58±0.36, 56.98±0.58, 69.53±0.74, 82.68±1.03 and 94.69±1.39 respectively at one-month interval up to 6M body weight. The highest breeding values for body weights of KF from birth weight to 6 months were 37.40±0.79, 47.01±1.39, 61.56±2.44, 73.89±2.82, 87.93±3.73 and 101.26±3.76 respectively. Correlation among breeding values in KF revealed that breeding value of birth weight with different body weights were low, whereas genetic correlations among these traits were all favourable the correlation was medium to high as the age increased (Table 4). Olsen *et al.* (2020) reported body weight and daily weight gain to be favourable too.

Sires were ranked for growth traits on the basis of EBV, estimated by BLUP and comparison of the rankings was done on the basis spearman's rank correlation estimate. The ranking of bulls varied greatly among different body weights and low correlations exists between traits. For 1M, 2M, 3M, 4M, 5M, 6M these were –0.03, 0.03, 0.06, 0.03, –0.06, –0.05 respectively.

Table 4. Correlation among breeding value in KF

Trait	Birth weight	1M	2M	3M	4M	5M	6M
BW	1.00						
1M	0.01	1.00					
2M	0.04	0.74	1.00				
3M	0.05	0.47	0.80	1.00			
4M	0.03	0.36	0.66	0.88	1.00		
5M	-0.06	0.25	0.55	0.71	0.87	1.00	
6M	-0.06	0.09	0.37	0.56	0.66	0.82	1.00

Effect of non-genetic factors indicated the need of further improvement in feeding and management practices for augmenting growth, i.e. body weights especially in calves born to primiparous dams. The growth bands were developed which could be used for proper screening of underweight and overweight calves and can serve as selection criterion for growth in calves.

REFERENCES

Ahmad T, Magotra A, Mohsin M and Hamadani A. 2020. Cytogenetic screening of Karan fries and Tharparkar males for selection of Elites at an early age. *International Journal of Livestock Research* **10**(5): 62–70.

Akpa G N, Galadima M A, Adeyinka A I, Aduli A E O and Abdu S B. 2007. Measures of daily gain in Friesian–Bunaji crossbred heifers and their relationship with first lactation milk yield, *International Journal of Dairy Science* **2**(4): 380–86.

Bakir G, Kaygisiz A and Ulker H. 2004. Estimates of genetic and phenotypic parameters for birth weight in Holstein Friesian cattle. *Pakistan Journal of Biological Sciences* **7**(7): 1221–24.

Cilek S and Tekin M E. 2005. The environmental factors affecting milk yield and fertility traits of Simmental cattle raised at the Kazova state farm and phenotypic correlations between these traits. *Turkish Journal of Veterinary and Animal Sciences* **29**(4): 987–93.

Gupta J P, Prajapati B M, Choudhari J D, Pandey D P, Panchasara H H and Prajapati K B. 2019. Impact of environment trend in relation to genotypic and phenotypic trend on traits of economic interest in Kankrej cattle. *Indian Journal of Animal Sciences* **89**(11): 1255–61.

Gurnani M, Sethi R K and Nagarcenkar R.1986. Development of Karan Fries cattle at NDRI, Karnal. *Dairy information Bulletin III* **9**: 1–2

Hamadani A, Ganai N A, Khan N N, Shanaz S and Ahmad T. 2019. Estimation of genetic, heritability, and phenotypic trends for weight and wool traits in Rambouillet sheep. *Small Ruminant Research*. doi:10.1016/j.smallrumres.2019.06.024.

Harvey R. 1987. Least squares analysis of data with unequal sub-class numbers. ARS H-4, USDA, Washington DC, USA.

Henderson C R. 1973. *Selection index and expected genetic advance*. Statistical Genetics and Plant Breeding. NAS-NRC. 982.

Khan U N, Dahlin A, Zafar A H, Saleem M, Chaudhry M A and Philipsson J. 1999. Sahiwal cattle in Pakistan: Genetic and environmental causes of variation in body weight and reproduction and their relationship to milk production. *Animal Science* **68**(1): 97–108.

Kramer C R. 1957. Extension of multiple range tests to group correlated means. *Biometrics* **13**: 13–18.

Kumar P. 2011. 'Developing Multiple-trait prediction models using growth and performance traits in Karan Fries cattle'. MVSc Thesis, NDRI, Deemed University, Karnal, India.

Kuralkar S V, Ali S Z, Takarkhede R C and Sahatpure S K. 2005. Genetic analysis on birth weight in crossbred calves. *Journal of Bombay Veterinary College* **13**: 78–80.

Madhuri S B, Suman C L and Pandey H S. 2007. Growth performance of three-breed crosses of Holstein Friesian, Brown swiss and Hariana cattle. *Indian Journal of Animal Research* **41**(4): 244–49.

Manoj M. 2010. 'Evolving multi-trait selection criteria using body weights and first lactation traits in Sahiwal cattle'. MVSc Thesis, NDRI, Deemed University, Karnal, India.

Mishra G, Siddiqui M F, Ingle V S and Meel M S. 2017. Studies on production performance of Tharparkar cattle at organized farm. *International Journal of Livestock Research* **7**(1): 54–62.

Olsen H, Heringstad B and Klemetsdal G. 2020. Genetic correlations between body weight, daily weight gain, and semen characteristic traits in young Norwegian Red bulls. *Journal of Dairy Science* **103**: 6311–17.

Rashid S A, Tomar A K S, Verma M R and Bharti P K. 2019. Effect of skin and coat characteristics on growth and milk production traits in Tharparkar cattle. *Indian Journal of Animal Sciences* **89**(11): 1251–54.

Roy P K, Pal P K and Basu S B. 1996. Studies on body weights up to one year of age in Jersey × Tharparkar and Holstein-Friesian × Tharparkar crossbred. *Indian Veterinary Journal* **73**(3): 288–90.

Simm G. 1998. *Genetic Improvement of Cattle and Sheep*. Farming Press Miller Freeman. Ipswich. UK.

Van De Stroet D L, Calderón Díaz J A, Stalder K J, Heinrichs A J and Dechow C D. 2016. Association of calf growth traits with production characteristics in dairy cattle. *Journal of Dairy Science* **99**(10): 8347–55.

Verma U, Kumar S, Yousuf S, Ghosh A and Aswal A. 2019. Genetic evaluation of Red sindhi cattle: Heritability, genetic and phenotypic correlation estimates. *International Journal of Livestock Research* **8**(2): 210–16.