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Effect of genetic and non-genetic factors on semen production performance of Karan Fries and Tharparkar breeding bulls

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ABSTRACT

The present study was conducted at Artificial Breeding Research Centre, to ascertain the influence of genetic (3 genetic groups of Holstein Friesian and Tharparkar crosses and pure Tharparkar) and non genetic (Periods i.e.,1997–2000, 2001–2004, 2005–2008 and 2009–2012; seasons i.e., winter, summer, autumn and rainy; age group i.e., <2 yrs, >2–2.5 yrs, >2.5–3 yrs and >3 yrs) factors on semen production performance of Karan Fries (KF) and TP breeding bulls. Overall percent of males reserved for breeding was 16.67% in KF and 22.73% in TP. Out of males reserved for breeding, 58.97% KF and 20% TP males produced semen. Only 64.9% produced freezable semen in KF bulls whereas in TP bulls, all males which donated semen produced freezable quality semen. Periods of birth showed significant effect on % age at first successful collection (AFSC) and (P<0.05) % age at first successful freezing (AFSF) (based on AFSC) in KF, wherein genetic groups revealed significant influence on % AFSC and % AFSF (on the basis of >18 months of age). For both KF and TP, overall least square means of AFSC, AFSF, ALSF (age at last successful freezing), ALSC (age at last successful collection), SPP (semen production period), FSPP (freezable semen production period) and AD (age at disposal) were 879.21, 1077.65, 1659.87, 1425.53, 831.82, 775.44 and 1329.38 days, respectively. Effect of period of birth was significant for all the traits except AFSC. Season of birth had no significant effect on all the traits while genetic groups and age at disposal have significant effect on AFSC and AFSF, respectively.

Key words: Genetic factors, Karan Fries, Non-genetic factors, Semen production, Tharparkar

For better productivity and profitability, AI centre needs to know the factors affecting the quantity and quality of semen obtained under their specific managemental conditions so as to select the best producers for genetic improvement, adapt management of bulls to improve semen output and to avoid wastage of dairy bulls through culling. Tyagi *et al*. (2006) reported that 8.36% of the crossbred bulls which have reached semen donation stage are culled due to non-donation of semen. Chacko (2005) reported that only 27% of the total bull calves born reach the semen production age. In crossbred bulls (Jersey × Zebu), age at first semen collection is about 29 months (Suryaprakasam and Rao 1993). Tyagi *et al.* (2000) reported 93.01% of the total number of Holstein crossbred bulls ejaculate semen, and only 45.09% of those ejaculating semen can produce freezable quality semen. Semen production is also affected by levels of exotic inheritance as well as breed components of crossbred bulls (Koivisto *et al*. 2009). The proportion of crossbred bulls producing freezable quality semen is decreased with the increase in the number of indigenous and exotic breed inheritance beyond 62.5% (Sagdeo *et al*. 1992; Tyagi *et al.* 2006).

Lunstra and Cundiff (2003) reported that the male offsprings of heat adapted sire breeds are slower to reach puberty than offsprings of European sire breeds. Differences in age at puberty may be attributed by breed composition, management, and environment in which bulls were being reared (Brito *et al*. 2004). Semen production is significantly influenced by season (Mathevon *et al*. 1998, Singh *et al.* 2000, Mathur *et al*. 2002, Bhoite *et al*. 2005, Igna *et al.* 2010, Pileckas *et al.* 2013, Bhakat *et al*. 2014). Seasonal effects include temperature, humidity, length of day etc. Similarly, composition and quality of feed (Peter 1991), temperature on day of collection (Taylor *et al*. 1985, Parkinson 1987), health status of bull and general management may affect semen quantity and quality. Semen production is also affected by period of birth (Bhoite *et al.* 2005). Chase *et al*. (2001) studied the effect of age at the appearance of first spermatozoa in an ejaculate (sexual maturity). Mukhopadhyay *et al.* (2010) reported that the age of starting semen donation is lower in crossbred than indigenous humped breed of cattle. Age of bulls was found

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highly significant for different semen production traits (Mandal *et al.* 2010, Ahmad *et al.* 2011, Paldusova *et al.* 2014). The aim of this study was to investigate genetic and non-genetic factors influencing production performance in KF (Holstein Friesian cross with Tharparkar) and TP (purebred) breeding bulls. Karan Fries and TP bulls in our present study were reared at the Artificial Breeding Research Centre (ABRC) and produced through selective breeding.

MATERIALS AND METHODS

Data collection and classification: The present investigation was carried out on 1740 Karan Fries and 154 Tharparkar males born during the period 1997–2012. Data were collected from the records maintained at Artificial Breeding Research Centre. Different traits were generated, so as to study the production performance of Karan Fries and Tharpakar breeding bulls. These include age at disposal (AD), age at first successful semen collection (AFSC), age at first successful freezing (AFSF), age at last successful semen collection (ALSC), age at last successful freezing (ALSF), frozen semen production period (FSPP) and semen production period (SPP). To assess the effect of various genetic and non-genetic factors on production performance, the data were grouped into different classes based on period of birth (P-1, 1997–2000; P–2, 2001–2004; P-3, 2005–2008 and P-4, 2009–2012), season of birth (Dec-March, winter, S-1; April-June, summer, S-2; July-Sep, rainy, S-3 and Oct-Nov, autumn, S-4), age at first semen donation) (<2years, D-1; 2–2.5 years, D-2; 2.5–3 years, D-3 and >3 years, D-4) and genetic groups (F1, G-1; > ¾ crosses, G-2; interbred,G-3 and TP, G-4).

Statistical analysis: To evaluate the effect of various genetic and non-genetic factors on production performance of breeding bulls, data were analyzed by Chi-square test (Snedecor and Cochran 1968). Data on age and production characteristics were analysed by least squares techniques as described by Harvey (1975) as disproportionate subclass numbers existed in the data. The models were used with the assumption that different components being fitted into the model are fixed, linear, independent and additive. The following model was used to study the effect of season, period, genetic group and age group on the age and production performance:

$$Y_{ijklm} = \mu + S_i + P_j + G_k + D_{l+} e_{ijklm}$$

where Y_{ijklm}, mth observation in ith season, jth period and kth genetic group belonging to lth age group; μ, overall mean; S_i, effect of ith season of birth (i=1 to 4); P_j, effect of jth period of birth (j=1 to 3); G_k, effect of kth genetic group (k=1 to 4); D_l, effect of lth age group (l=1 to 4); e_{ijklm}, random error NID $(0, \sigma^2_e)$.

For AFSC, age effects were deleted from the above model. For testing the differences among least squares means (using inverse coefficient matrix), Duncan's Multiple Range Test as modified by Kramer (1956) was used.

RESULTS AND DISCUSSION

Over the period of our study, 1,740 KF and 154 TP males were born where only 16.8% KF and 22.73% TP males were reserved for further breeding programe. Out of the total male calves reserved, 171 KF (58.97%) and 7 TP (20.00%) males produced semen. The semen from all the donor bulls was not freezable due to poor mass activity and post thaw revival (Table 1). Therefore, semen of only 111 KF (64.91%) was found to be freezable. The present values was higher than the values reported by Sethi *et al.* (1989), Khate (2005) for KF bulls and Tyagi *et al.* (2006) for crossbred bulls. In TP, all the males producing semen also produced freezable quality semen. The results indicated that the percent of male calves reserved and produced freezable semen was higher in TP as compared to KF males. This may be due to the smaller herd size of TP cattle and better adaptability of the breed in existing environment. Breed differences in proportion of males reaching successful freezing were significant (P<0.05).

Table 1. Production performance of KF and TP males.

Breed	No. born	Reserved (%)	Produced semen (% of reserved)	Produced freezable semen (% of produced semen)
KF	1740	16.8 (292)	58.97 (171)	64.91 (111)
TP	154	22.73 (35)	20.00 (7)	100.00 (7)
Chi square value				4.8110*

*χ(P<0.05): **χ(P<0.01).

The effect of period and season of birth on production performance of KF and TP males reaching the age at first semen collection (AFSC) and age at first semen freezing (AFSF) were analyzed (Table 2). The values for % AFSC and % AFSF for the period 2009–2012 for both the breeds were not calculated because most of the males reserved for breeding in this period did not yet reach semen production stage.

Males born in the main herd were reserved and shifted to ABRC where those were trained for semen production at younger age. Overall trends indicated that, the performance of KF males in terms of reaching quality semen production stage was the best in the P-2 and P-3 which may be due to better training, improved feeding and managemental practices over the years although only half of the reserved males in the P-3 could reach AFSC. The values of % AFSC, % AFSF (from out of males donating semen) and the overall % AFSF (out of males reserved) were estimated and found that % AFSC (P<0.01) and overall % AFSF (P<0.05) were significant. In case of TP, there was no male reserved during P-2, as less number of males are born during this particular period. The values of % AFSF

Table 2. Effect of period and season of birth on production performance of KF and TP breeding bulls

Effects	KF					TP				
	No. born	No. reserved	% AFSC	% AFSF	Overall %AFSF	No. born	No. reserved	% AFSC	% AFSF	Overall %AFSF
Period										
P-1 (1997–2000)	447	54	72.22 (39)	53.85 (21)	38.89	19	7	28.57 (2)	100.00 (2)	28.57
P–2 (2001–2004)	470	102	78.43 (80)	68.75 (55)	53.92	11	0	0 (0)	0.0	0
P-3 (2005–2008)	432	90	52.22 (47)	68.09 (32)	35.56	61	14	28.57 (4)	100.00 (4)	28.57
P-4 (2009–2012)	391	46	-	-	-	63	14	-	-	-
Overall	1740	292	56.85(16)	65.06(10)	36.98	154	35	17.14 (6)	100.00 (6)	17.14
Chi-square value			15.675 **	2.8258	7.254 *			0.25	0.19	0.25
Season										
S-1 (Dec-Mar)	667	115	53.04 (61)	60.66 (37)	32.17	46	13	15.38 (2)	100.00 (2)	15.38
S-2 (Apr-Jun)	423	67	64.18 (43)	74.42 (32)	47.76	46	9	22.22 (2)	100.00 (2)	22.22
S-3 (Jul-Sep)	405	62	62.90 (39)	58.97 (23)	37.10	41	6	0 (0)	0 (0)	0 (0)
S-4 (Oct-Nov)	245	48	58.33 (28)	67.86 (19)	39.58	21	7	42.86 (3)	100.00 (3)	42.86
Overall	1740	292	58.56(17)	64.91(11)	38.01	154	35	20.00 (7)	100.00 (7)	20.00
Chi-square value			2.7969	2.9017	4.4382			4.9157	0.3333	4.9157

*χ(P<0.05): **χ(P<0.01).

Table 3. Effect of genetic group on performance of KF and TP breeding bulls

Genetic group	No.born	No. reserved	% AFSC	%AFSF	Overall %AFSF
G-1 (F1)	48	35	82.86 (29)	48.28 (14)	40.00
G-2 (3/4or above)	162	95	56.84 (54)	66.67 (36)	37.89
G-3 (Interbred)	1530	162	54.32 (88)	69.32 (61)	37.65
G-4 (TPXTP)	154	35	20.00 (7)	100.00 (7)	20.00
Overall	1894	327	54.43 (178)	66.29 (118)	36.09
Chi-square value			28.3543**	8.1358*	4.4667

*χ(P <0.05): **χ(P <0.01).

out of TP males donating semen were same i.e 100% in both the two periods (P-1 and P-3) which may be due to less number of animal records for the TP breed of cattle maintained at NDRI herd over these periods. Since, TP Males reserved over the period (1997–2012) were only 35 out of 154 born, leading to small data size, no specific conclusion could be drawn.

Different climatic conditions in different seasons also influence the performance of males in terms of production of quality semen. Reserved KF males donating semen for the first time (% AFSC) was highest in summer (64.18%) and lowest in winter season (53.04%) born males. % of AFSF out of AFSC KF males which reached freezable quality semen production stage (AFSF) was maximum in S-2 (74.42%) and minimum in S-3 (58.97) born males. This variation in proportion of males that actually reach frozen semen production stage is mainly influenced by availability of different quantity and quality of green fodder in different seasons of the year. Considering the effect of season of birth in TP, males born in S-3 are all disposed off before reaching semen production stage which could be due to poor growth, surplus or disease condition. The values of the % AFSC and overall % AFSF indicate that all the TP males reaching first semen production stage also produced freezable quality semen with maximum values found in S-4 (42.86% and 100.00% respectively) born males. Higher values for TP males born during S-4 may be due to favourable climatic conditions and quality leguminous green fodder availability in subsequent months thereby resulting in better growth, early sexual maturity and hence lesser disposal. An overview of the results on production of KF and TP breeding bulls indicated that percentage of bulls producing freezable quality semen was less in the crossbred cattle as compared to purebred bulls which is in agreement with the findings of Mukhopadhyay *et al.* (2010).

The effect of genetic groups on performance of KF and TP breeding bulls was depicted in Table 3. Maximum number of F1 males (82.86%) donated semen, but lesser number of those could reach the stage of freezable quality semen production (48.28%). Lesser number of F1 reaching stage of freezable quality semen productions may be due to higher disposal of F1 males, before they are included in test set of progeny testing programme. Thippeswamy *et al.* (2014) reported that F1 males produced significantly higher proportions (57.00+10.00) of poor quality ejaculates compared to the interse mated bulls. Several investigators

Table 4. Least squares means±SE of the performance traits due to effect of period, season, genetic group and age.

Effects	AFSC	AFSF	ALSF	ALSC	SPP	FSPP	AD
No. of bulls	178	118	107	166	144	90	164
Overall	879.21±20.31	1077.65±31.21	1659.87±31.21	1425.53±79.73	831.82±57.27	775.44±56.46	1329.38±121.03
period of birth							
P-1 (1997–00)	872.05±26.25	1107.57±44.78^{a}	1852.18±93.75^{a}	1753.65±84.90^{a}	949.44±86.75^{a}	941.59±90.21^{a}	1797.20±91.28^{a}
P-2 (2001–04)	860.57±21.68	1022.62±32.90^{b}	1452.72±66.37^{b}	1569.44±66.05^{ab}	735.12±66.75^{b}	623.56±68.15^{b}	1582.42±74.97^{b}
P-3(2005–08)	854.78±23.21	1129.02±34.96^{a}	1674.72±77.77^{a}	1566.95±72.01^{ab}	810.92±76.31^{ab}	761.17±75.54^{ab}	1707.59±80.29^{ab}
P-4(2009–12)	929.44±60.23	1051.38±89.13^{ab}		812.07±294.02^{b}			1030.33±435.08^{ab}
season of birth							
S-1 (Dec-March)	877.18±24.34	1048.86±37.86	1705.76±75.73	1462.66±84.37	820.20±72.62	858.11±78.48	1588.88±125.16
S-2 (April-June)	849.02±27.62	1101.20±40.52	1706.28±75.16	1450.81±97.16	894.75±78.30	800.02±75.99	1546.75±132.84
S-3 (July-Sept)	874.21±28.86	1048.59±46.81	1537.90±97.58	1350.04±102.60	743.72±84.80	669.62±96.07	1463.70±140.26
S-4 (Oct-Nov)	916.43±31.69	1111.94±46.96	1689.56±92.18	1438.61±107.25	868.63±88.84	774.01±89.26	1518.68±141.77
Genetic group							
G-1 (F1)	796.21±32.57^{a}	1174.54±59.60	1647.14±112.66	1274.79±117.04	691.34±96.13	694.13±113.23	1393.08±143.59
G-2 (3/4 or above)	798.41±23.36^{a}	1048.39±45.21	1592.15±85.80	1322.84±97.76	681.73±82.09	758.19±95.08	1453.93±123.40
G-3 (Interbred)	810.84±21.66^{a}	1052.65±38.78	1607.76±55.33	1306.84±92.67	744.93±68.83	692.94±69.90	1456.31±124.31
G-4 (TPxTP)	1111.37±55.22^{b}	1035.01±76.08	1792.44±156.20	1797.65±168.20	1209.31±185.90	956.50±164.47	1814.21±221.49
Age group							
D-1 (<2yrs)	-	834.90± 43.06^{b}	1578.22± 77.92	1402.49±101.20	983.76± 77.51	832.23± 79.38	1467.16± 135.56
D-2 (>2–2.5yrs)	-	992.99±36.87^{a}	1677.14±66.53	1349.39±94.13	841.69±66.51	816.86±66.63	1423.21±128.81
D-3 (>2.5–3 yrs)	-	1102.28± 54.48^{a}	1724.25± 96.96	1402.69±115.76	858.23± 118.54	779.50± 121.72	1472.49± 137.59
D-4 (>3yrs)	-	1380.42±92.96^{b}		1547.54±155.75	643.63±184.15	673.17±194.47	1754.68±203.19

Mean with at least one subscript do not differ significantly (*P<0.05).

also reported that the semen characteristics of the Indian crossbred bulls get better as percentage of exotic level increased in the blood (Mathew *et al*. 1982, Babu Rao and Rama Mohana Rao 1990). Differences in production of breeding bulls due to genetic group were statistically significant (P<0.05) for per cent of breeding bulls donating semen (% AFSC) and also reaching the freezable quality semen (% AFSF) production stage.

For KF and TP males, overall least squares means of age at first semen collection (AFSC), age at first successful freezing (AFSF), age at last successful freezing (ALSF), age at last semen collection (ALSC), semen production period (SPP), freezable semen production period (FSPP) and age at disposal (AD), were 879.21±20.31, 1077.65±31.21, 1659.87±31.21, 1425.53±79.73, 831.82±57.27, 775.44±56.46 and 1329.38±121.03 days, respectively (Table 4). Thippeswamy *et al*. (2014) reported mean AFSC in crossbred bulls as 738.89+18.18 days while the mean AFSF was 865.72+34.60 days.

The effect of period of birth (P) on age at first successful freezing (AFSF) indicated that bulls born in P-2 was the earliest to reach AFSF while P-3 born males was the last to attained AFSF. This may be due to differential managemental conditions across different periods. The effect of period of birth on AFSF and ALSF was significant (P*<0.05)*. The present finding is in consonance with the findings reported by Mukhopadhyay *et al*. (2010). The values for age at last semen collection (ALSC) were highest and lowest for bulls born during P-1 and P-4, respectively. Presence of less number of bulls in P-4 may be due to most of the bulls still undergoing semen donation and had not yet reached the ALSC stage. The results indicate that period of birth had significant effect (P<0.05) on ALSC, SPP, FSPP and AD. In similar line, Mukhopadhyay *et al*. (2010) reported a significant effect of period of birth on SPP, FSPP and AD. Influences of season of birth were not significant for any of the generated traits.

Males belonging to genetic group 1 (F1) were the first to reach AFSC while genetic group 4 (TP) were the last to give their first donation. Brito *et al*. (2004) reported that sexual development (in terms of age at first donation and age at first freezing) of *B. indicus* and crossbred bulls (*B. indicus* × *B. taurus*) is delayed as compared to *B. taurus* bulls. Chase *et al*. (2001) and Casas *et al*. (2007) reported significant effect of breed on age at puberty, though age at first collection generally precedes age of puberty while other investigations failed to detect an effect of genetic group on AFSC (Chauhan *et al*. 2010). At an early stage of semen donation, freezable quality semen could not be produced by most of the bulls. The minimum AFSF was attained by D-1 (<2 years) age group bulls whereas maximum AFSF was attained by D-4 (>3years) age group bulls. The effect of age at sexual maturity was significant (P<0.05) on AFSF. Generally, production performances are reported to increase with age of bull (Mathevon *et al*. 1998, Brito *et al*. 2002, Fuerst-Walt *et al*. 2006, Boujenane and Boussaq 2013). Igna *et al*. (2010) reported that the highest number of doze/ ejaculation were registered in the bulls aged between 5–7 years. Chauhan *et al*. (2010) reported significant effect of age at sexual maturity on AFSF. After analysing the age and seminal attributes, it can be concluded that period of birth had significant effect on AFSF, ALSF, ALSC, SPP, FSPP and AD. Similarly, Khatun *et al*. (2013) reported that period of birth had significant effect (P<0.05) on AFSC, AFSF, ALSF, SPP and FSPP. Season of birth has no significant effect on any of the generated traits under study while genetic groups and age at sexual maturity have significant effect only on AFSC and AFSF respectively.

From all observed effects, period of birth of KF bulls and genetic group of both KF and TP have the highest impact on their performance. The period of birth effect is likely to be caused by improved feeding and managemental practices over the years. Genetic groups and age at sexual maturity have significant effect on AFSC and AFSF, respectively of the breeding bulls. Therefore, our results revealed that the main difference of TP breeds is the late maturity as compared to exotic breeds. Since our present study clearly demonstrates that, though greater number of crossbred (F1) males donates semen, lesser number of those could produce freezable quality semen. However, on the other hand, even though less number of Tharparkar males donate semen, all of them are of freezable quality. In order to take advantage of the above reasons, TP (indigenous) males may be subjecting to training at an early age, thereby decreasing the initial age of semen donation and also to obtain freezable quality semen.

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