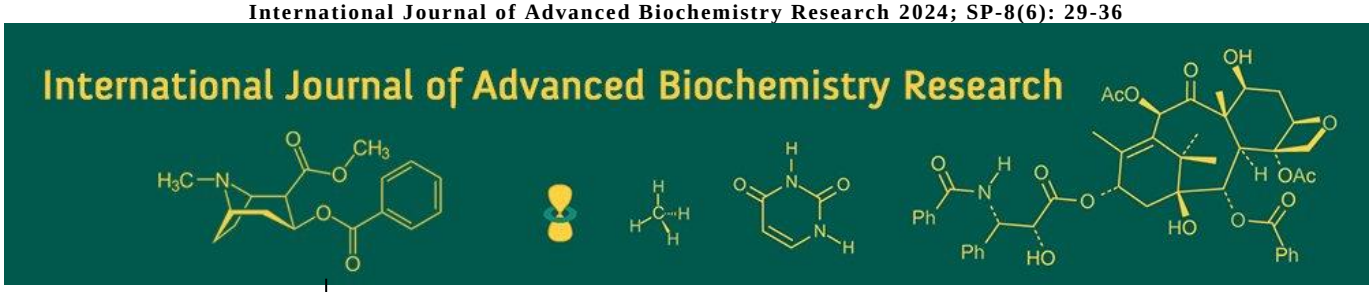

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Reproductive performance of FJG triple cross

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Abstract
The data on reproduction traits of FJG triple cross maintained at R.C.D.P. on cattle, M.P.K.V., Rahuri (Maharashtra) were collected from year 1972 to 2014. The overall least squares means of AFC for FG and FJG genetic group were 974.48 ± 8.31 and 1005.17 ± 7.01 days respectively. In FJG the DMRT indicated that the heifers born during P_1 (907.26 ± 5.47) and P_2 (927.14 ± 7.45) while the heifers born during P_4 (1126.16 ± 13.67) and P_5 (1123.58 ± 24.96) shows highest AFC days which are at par with each other. Although the effect of season of birth on AFC was non-significant the lowest AFC was observed in heifers born during summer season (994.74± 8.74) in FJG. The variation due to season of birth in age at first calving was significant in FJG genetic group of heifers. The heifers born during rainy season (962.43 ± 10.57) shows lowest age at first calving while rest of seasons. The overall least squares mean of OP in FJG genetic group was 72.02 ± 1.76 days as affected by genetic groups. The non-significant effect of period of calving, season of calving, lactation order and AFC group on OP observed. The overall least squares means of Service period in FJG genetic group cows was 141.75 ± 1.70 days. The variation due to SOC, LO and AFC group on SP was non-significant. The effect of generation was significant on SP. In FJG group the lowest SP observed in G_1 (116.85 ± 3.67) while highest in G_3 (177.75 ± 4.05). The overall least squares means of calving interval as affected by genetic group was 398.48 ± 2.05 days. The Generation wise least squares means for significantly higher calving interval in FJG group observed in G_5 (421.32 ± 8.29) days.

Keywords: GIR crossbred, age at first calving, open period, service period, calving interval

Introduction
India ranks first in milk production accounting for 18.5% of world production, achieving an annual output of 165.4 MT during 2016-17. The average daily milk yield for crossbred cattle is better at 7.1 kg per day, but still significantly lesser than the best of global standards *viz.* UK, US and Israel having 25.6, 32.8 and 38.6 kg per day, respectively. India's estimated demand for milk is expected to be about 155 MT by 2016-17 and 200 MT in 2021-22 (Anonymous, 2016) [6]. With the increasing population in worldwide and need to increase milk production, the introduction of high-yielding breeds plays an important role in protein needs supplying.
One of the best methods for solving this problem could be crossbreeding. Crossbreeding as a mating system optimizes the additive genetic and non-additive (heterotic) breed effects of *Bos taurus* and *Bos indicus* cattle in sustainable breeding systems. Gir cow had been used as foundation stock, to produce a breed of cow which should have minimum milk production of 2000 kg per lactation with a herd average of 3200 kg per lactation and fat content in milk should not be less than 3.5 percent. Gir cows were bred with frozen semen of progeny tested Jersey, Holstein Friesian and Brown swiss bulls to generate half-breeds and triple crosses.

Materials and Methods
The data were collected from the history and pedigree sheets maintained at Research Cum Development Project on Cattle, M.P.K.V., Rahuri, Dist. - Ahmednagar (MS), for the period of 43 years (1972 to 2014) on reproduction traits of FJG triple cross.

Reproductive traits

1. Age at first calving (AFC)(days)
2. Open period (OP) (days)
3. Service period (SP) (days)
4. Calving interval (CI) (days)

The data were classified according to genetic group, generations, season of birth / calving, period of birth / calving, age at first calving and lactation order. The details as below

Generation under study: The following generations were considered for estimation of least square means for production and reproduction traits.

Genetic group	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8	G_9
FG: 50% HF + 50% Gir	FG	IH	3IH	4IH	5IH	6IH	7IH	8IH	9IH
FJG: 50% HF + 25% J + 25% Gir	FJG	H	3H	4H	5H	6H	7H	8H	9H

Season of birth/calving: As per climatic conditions of the farm the data of each year were divided into three seasons as under.

Season	Months	Code
Rainy	June- September	S_1
Winter	October – January	S_2
Summer	February – May	S_3

Period of birth: The data pertains to 43 year from 1972 to 2014 were divided into different groups according to period of birth as under.

Periods Genetic groups	P_1	P_2	P_3	P_4	P_5	P_6	P_7
FG	1972-77	1978-83	1984-89	1990-95	1996-01	2002-07	2008-13
FJG	1974-79	1980-85	1986-91	1992-97	1998-03	2004-09	2010 -14

Period of calving: The data generated from 1974 to 2014 were divided into different groups according to period of calving as under

Periods Genetic groups	P_1	P_2	P_3	P_4	P_5	P_6	P_7
FG	1974-79	1980-85	1986-91	1992-97	1998-03	2004-09	2010 -2014
FJG	1976-81	1982-87	1988-93	1994-99	2000-05	2006-11	2012 -2014

Lactation order: The parity wise data were collected up to 7th lactation of animal maintained at the farm and coded as below.

Lactation order	Code
First Lactation	L_1
Second Lactation	L_2
Third Lactation	L_3
Fourth Lactation	L_4
Fifth Lactation	L_5
Sixth Lactation	L_6
Seventh Lactation	L_7

Age at first calving: The age at first calving was classified into following groups:

Sr. No.	AFC (days)	Code
1	< 800	A_1
2	801 to 850	A_2
3	851 to 900	A_3
4	901 to 950	A_4
5	951 to 1000	A_5
6	1001 and above	A_6

Analysis was carried out by using least squares analysis method for non-orthogonal data as described by Harvey (1990). The following mathematical model was used.

Model I

$Y_{ijk} = \mu + P_i + S_j + e_{ijk}$

Where,

Y_{ijk} = Observations on age at first calving of k^{th} animal belonging to i^{th} period of birth and j^{th} season of birth

μ = Overall population mean

P_i = Effect of i^{th} period of birth (i =1, 2,----,n)

S_j = Effect of j^{th} season of birth (j = 1, 2 and 3)

e_{ijk} = Random error associate with NID (0, $\delta^2 e$)

The data was corrected for significant effect of period of birth / calving, season of birth / calving, lactation order and age at first calving group. The correction of data was one as per the formula suggested by Gacula *et al.* (1968).

Corrected record Y_{ijkl} = Uncorrected record Y_{ijkl} – ($P_i + S_j + L_k + A_l$)

Where,

P_i = i^{th} period of birth / calving constant

S_j = j^{th} season of birth / calving constant

L_k = k^{th} lactation order constant

A_l = l^{th} age group at first calving group constant

The corrected data was further used for estimation of genetic and generation wise effect on traits under study.

The DMRT as modified by Krammer (1957) [19] was used for testing differences among least squares means. The differences were considered significant if

$X_i - X_j = SQRT [2/(C_{ii} + C_{jj} + 2C_{ij})] > 6eZpn_2$

Where,

X_i and X_j were the least square means for i^{th} and j^{th} treatment, and C_{ii}, C_{jj} and C_{ij} were diagonal and off-diagonal elements in the inverse of coefficient matrix in the least squares normal equations.

Results and Discussion

Reproduction traits

The data pertaining to FJG genetic group reproduction traits consists of age at first calving (AFC), open period (OP), service period (SP) and calving interval (CI) were analyzed by least squares technique to study the effect of non-genetic factors *viz*., period of birth / calving, season of birth / calving and lactation order on the traits under study.

Age at first Calving (AFC)

The age at first calving is an important economic trait in dairy cows. The least squares means according to season of birth, period of birth, generation and genetic group are presented in Table 1.

Table 1: Least squares means for AFC (days) in FG and FJG genetic group

Sources of variation	Genetic groups		
	FJG		
	N	Mean	S.E.
μ	1575	1005.17	7.01
Period of Birth			
P_1(1974-1979)	643	907.26^{a}	5.47
P_2(1980- 1985)	349	927.14^{a}	7.45
P_3(1986-1991)	319	1005.06^{b}	7.76
P_4(1992-1997)	103	1126.16^{c}	13.67
P_5(1998-2003)	31	1123.58^{c}	24.96
P_6(2004-2009)	115	990.51^{b}	12.95
P_7(2010- 2014)	15	956.45^{ab}	35.81
Season of Birth			
S_1 (Jun-Sept)	509	1002.92^{b}	8.49
S_2 (Oct-Jan)	575	1017.83^{b}	8.39
S_3 (Feb-May)	491	994.74^{a}	8.90

Means under each class in the same column with different superscript differed significant

The overall least squares means of AFC for FJG genetic group was 1005.17 ± 7.01 days.

Effect of period of birth (POB)

In FJG the DMRT indicated that the heifers born during P_1 (907.26 ± 5.47) and P_2 (927.14 ± 7.45) while the heifers born during P_4 (1126.16 ± 13.67) and P_5 (1123.58 ± 24.96) shows highest AFC days which are at par with each other.

Effect of season of birth (SOB)

Although the effect of season of birth on AFC was non-significant the lowest AFC was observed in heifers born during summer season (994.74± 8.74) in FJG.

The variation due to season of birth in age at first calving was significant in FJG genetic group of heifers. The heifers born during rainy season (962.43 ± 10.57) shows lowest age at first calving while rest of seasons were at par with each other.

Effect of generation

The overall least squares means of AFC as affected by generations was 994.77 ± 5.75 days in FJG genetic group.

As pertains to age at first calving was significantly lowest noticed in G_1 generation of FJG (879.37 ± 7.25) genetic group cows. However, in FJG genetic group cows the highest age at first calving noticed in G_7 (1086.74 ± 15.32).

Open period (OP)

The least square means according to non-genetic factors, generation and genetic group are presented in Table 2. The overall least squares mean of OP in FJG genetic group was 72.02 ± 1.76 days as affected by genetic groups.

Effect of period of calving (POC)

Analysis of variance showed non-significant effect of period of calving on cows of FJG group. However, cows calved during period P_2 had lower (64.97 ± 1.98) and P_5 had higher (79.77 ± 5.45) open period in FJG group.

Effect of season of calving (SOC)

Analysis of variance showed non-significant effect of season of calving on open period in all genetic groups under study. It showed that the year round climatic conditions were similar. In FJG lowest OP observed in S_1 (Jun-Sept) 70.75 ± 2.26 while highest OP in S_3 (Feb-May) 74.42 ± 2.20 days.

Effect of lactation order (LO)

The analysis of variance revealed that the lactation order had non-significant effect on OP in all genetic groups (Table 2). However in FJG lowest OP observed in L_7 (68.62 ± 7.10), while highest OP observed in L_1 (78.70 ± 2.06)

Table 2: Generation wise least squares means for AFC (days) in Gir crossbred cow

Sources of variation	Genetic groups		
	FJG		
	N	Mean	S.E.
μ	1575	994.77	5.75
	Generation		
G_1	362	879.37^{a}	7.25
G_2	365	915.42^{ab}	7.21
G_3	297	967.60^{c}	8.00
G_4	184	979.67^{c}	10.17
G_5	150	1054.30^{d}	11.26
G_6	87	1069.97^{d}	14.79
G_7	81	1086.74^{d}	15.32
G_8	34	962.64^{bc}	23.65
G_9	15	1037.20^{d}	35.62

Means in the same column with different superscript differed significantly.

Effect of AFC group

The analysis of variance revealed that the age at first calving group had non-significant effect on open period in all genetic groups (Table 1).

However in FJG lowest open period observed in A_6 (1001 and above) 69.65 ± 2.33, while highest OP observed in A_2 (801 to 850) 75.06 ± 3.07 days.

Effect of generation

The analysis of variance indicated significant effect of generation on open period in FJG genetic group (Table 3).

The overall least squares means of open period as affected by generations was 71.17± 1.57 in FJG genetic group. In FG the OP in all generation are at par with other while in FJG significantly lowest OP observed in G_1 (67.66 ± 1.98),G_7 (68.06 ± 4.20),G_8 (65.73 ± 6.48) and G_9 (62.40 ± 9.76) which were at par with each other while significantly higher open period observed in G_6 (82.77±4.02).

Service period (SP)

The least squares means according to season of calving, period of calving, lactation order, generation and genetic group are presented in Tables.

The overall least squares means of Service period in FJG genetic group cows was 141.75 ± 1.70 days.

Effect of period of calving (POC)

The overall least squares means of Service period in FJG group cows was 133.30 ± 3.36 days. In FJG P_6 shows lowest (100.02 ± 8.76) SP while P_2, P_3, P_4 and P_5 shows highest SP which are at par with each other.

Effect of season of calving (SOC)

The variation due to season of calving in service period was non-significant in all the genetic groups under study (Table 3).

In FJG group the lowest service period was observed in cows calved during S_3 (Feb – May) summer season (132.31±

4.19) followed by S_1 (Jun – Sept) rainy season (132.62 ± 4.31) and in S_2 (Oct – Jan) winter season (134.98 ± 4.20) days.

Table 3: Least squares means for open period (days) in FG and FJG genetic group

Sources of variation	FJG		
	N	Mean	S.E.
µ	**1575**	**72.02**	**1.76**
Period of Calving			
P_1(1974-1979)	394	71.30	2.48
P_2(1980-1985)	461	64.97	1.98
P_3(1986-1991)	323	74.98	2.43
P_4(1992-1997)	198	76.16	2.99
P_5(1998-2003)	52	79.77	5.45
P_6(2004-2009)	75	69.83	4.60
P_7(2010-2014)	72	67.16	4.60
Season of Calving			
S_1 (Jun-Sept)	475	70.75	2.26
S_2 (Oct-Jan)	589	70.90	2.20
S_3 (Feb-May)	511	74.42	2.20
Lactation Order			
L1	518	78.70	2.06
L2	397	71.60	2.20
L3	265	71.71	2.50
L4	186	69.69	2.93
L5	120	69.51	3.60
L6	60	74.33	5.01
L7	29	68.62	7.10
AFC group			
A_1 (< 800)	236	71.50	3.00
A_2 (801 to 850)	214	75.06	3.07
A_3 (850 to 900)	178	72.28	3.22
A_4 (901 to 950)	260	71.09	2.72
A_5 (951 to 1000)	232	72.56	2.80
A_6 (1001 and above)	455	69.65	2.33

Means in the same column with different superscript differed significantly.

Effect of lactation order (LO)
The analysis of variance revealed that lactation order had non-significant effect on service period in the group under study (Table 4).

Effect of AFC group
The analysis of variance revealed that the age at first calving had a non-significant effect on service period in FJG group under study (Table 4).

Table 4: Generation wise least squares means for open period (days) in Gir crossbred cow

Sources of variation	Genetic groups		
	FJG		
	N	Mean	S.E.
µ	**1575**	**71.17**	**1.57**
	Generations		
G_1	362	67.66^{a}	1.98
G_2	365	74.41^{ab}	1.97
G_3	297	71.54^{ab}	2.19
G_4	184	72.93^{ab}	2.78
G_5	150	74.25^{ab}	3.08
G_6	87	83.55^{b}	4.05
G_7	81	68.06^{a}	4.20
G_8	34	65.73^{a}	6.48
G_9	15	62.40^{a}	9.76

Means in the same column with different superscript differed significantly.

Effect of generation
The overall least squares means of service period as affected by generations was 137.61± 2.91 days in FJG genetic group. In FJG group the lowest SP observed in G_1 (116.85 ± 3.67) while highest in G_3 (177.75 ± 4.05).

Calving interval (CI)
The least squares means for Calving interval are depicted in Table 4. The overall least squares means of calving interval as affected by genetic group was 398.48 ± 2.05 days.

Effect of period of calving (POC)
The influence of period of calving period of calving had non-significant effect on calving interval in all three genetic groups. In FJG group, DMRT showed that the cows calved during P_5 (381.76 ± 14.78) and higher CI in the cows calved during P_2 (408.87 ± 5.38).

Effect of season of calving (SOC)
DMRT of FJG highest CI observed in S_2 (Oct – Jan) 395.22 ± 5.98 and lowest in S_1 (Jun – Sept) 392.07 ± 6.14 and S_3 (Feb – May) 394.53 ± 5.97 days which are at par with each other.

Effect of lactation order (LO)
In FJG, highest CI was in L_3 (402.11 ± 6.80) and lowest in L_5 (375.16±9.77)

Effect of AFC group
In FJG, highest CI was in A_1 (< 800) 402.54 ± 8.13 days and lowest in A_4 (901 to 950) 380.35 ± 7.37 days

Effect of generation
The effect of generation had significant effect on calving interval in FJG genetic group (Table 5). The overall least squares means of service period as affected by generations was 395.26 ± 4.23 days in FJG genetic group respectively.
The Generation wise least squares means for significantly higher calving interval in FJG group observed in G_5 (421.32 ± 8.29) days. While the significantly lowest CI observed in G_5 (402.57 ± 7.37), G_9 (363.66 ± 26.21) which was at par with G_2 (418.42± 5.31) days which are at par with G_2, G_3 and G_4, respectively.

Summary and Conclusion
To assess the magnitude of different factors along with genetic, phenotypic and environmental trends affecting the reproductive traits. This investigation also aimed at studying the association between age at first calving, open period, service period and calving interval on reproduction performance of FJG group of cow.

Reproductive traits
The data on pre-partum and post-partum reproductive traits consists of age at first calving (AFC), open period (OP), service period (SP), calving interval (CI) were analyzed by least squares technique to study the effect of non-genetic factors *viz*., period of birth / calving, season of birth / calving and lactation order on the traits under study.

Age at first calving (AFC)
The overall least squares means of AFC in cows of FG and FJG group were 974.48 ±8.31 and 1005.17±7.01 respectively.

Table 5: Least squares means for service period (days) in FG, FJG genetic group

Genetic Groups			
Sources of variation	**FJG**		
	N	**Mean**	**S.E.**
μ	1575	133.30	3.36
Period of Calving			
P_1 (1974-1979)	394	119.83^{b}	4.72
P_2 (1980- 1985)	461	146.10^{c}	3.78
P_3 (1986-1991)	323	150.82^{c}	4.63
P_4 (1992-1997)	198	152.38^{c}	5.70
P_5 (1998-2003)	52	142.46^{c}	10.38
P_6 (2004-2009)	75	100.02^{a}	8.76
P_7 (2010- 2014)	72	121.52^{b}	8.76
Season of Calving			
S_1 (Jun-Sept)	475	132.62	4.31
S_2 (Oct-Jan)	589	134.98	4.20
S_3 (Feb-May)	511	132.31	4.19
Lactation Order			
L_1	518	141.71	3.93
L_2	397	136.57	4.20
L_3	265	136.84	4.77
L_4	186	128.67	5.57
L_5	120	119.89	6.86
L_6	60	140.92	9.53
L_7	29	128.53	13.52
AFC group			
A1 (< 800)	236	137.99	5.71
A2 (801 to 850)	214	133.06	5.85
A3 (850 to 900)	178	123.40	6.13
A4 (901 to 950)	260	135.27	5.17
A5 (951 to 1000)	232	132.54	5.34
A6 (1001 and above)	455	137.56	4.44

Means in the same column with different superscript differed significant.

Table 6: Generation wise least squares means for service period (days) in Gir crossbred cow

	Genetic groups		
Sources of variation	**FJG**		
	N	**Mean**	**S.E.**
μ	1575	137.61	2.91
	Generation		
G_1	362	116.85^{a}	3.67
G_2	365	138.00^{ab}	3.65
G_3	297	177.75^{c}	4.05
G_4	184	154.26^{bc}	5.14
G_5	150	155.13^{bc}	5.70
G_6	87	121.78^{a}	7.48
G_7	81	114.67^{a}	7.75
G_8	34	124.20^{a}	11.97
G_9	15	135.86^{ab}	18.02

Means in the same column with different superscript differed significantly

Table 7: Least squares means for calving interval (days) in FG and FJG genetic group

Genetic Groups			
	FJG		
Sources of variation	N	Mean	S.E.
μ	1575	393.94	4.79
Period Of Calving			
P_1(1974-1979)	394	402.01^{b}	6.72
P_2(1980- 1985)	461	408.87^{c}	5.38
P_3(1986-1991)	323	394.82^{c}	6.60
P_4(1992-1997)	198	403.49^{c}	8.11
P_5(1998-2003)	52	381.76^{c}	14.78
P_6(2004-2009)	75	388.92^{a}	12.47
P_7(2010-2014)	72	377.70^{b}	12.48
Season Of Calving			
S_1(Jun-Sept)	475	392.07^{a}	6.14
S_2(Oct-Jan)	589	395.22^{a}	5.98
S_3(Feb-May)	511	394.53^{a}	5.97
Lactation Order			
L_1	518	401.57	5.59
L_2	397	395.69	5.98
L_3	265	402.11	6.80
L_4	186	400.37	7.93
L_5	120	375.16	9.77
L_6	60	390.40	13.58
L_7	29	392.27	19.25
AFC group			
A_1 (< 800)	236	402.54	8.13
A_2 (801 to 850)	214	390.73	8.33
A_3 (850 to 900)	178	399.11	8.73
A_4 (901 to 950)	260	380.35	7.37
A_5 (951 to 1000)	232	399.40	7.61
A_6 (1001 and above)	455	391.51	6.33

Means in the same column with different superscript differed significantly

Table 8: Generation wise least squares means for calving interval (days) in Gir crossbred cow

	Genetic groups		
Sources of variation	**FJG**		
	N	**Mean**	**S.E.**
μ	1575	395.26	4.23
	Generation		
G_1	362	406.41^{bc}	5.33
G_2	365	418.42^{c}	5.31
G_3	297	391.82^{abc}	5.89
G_4	184	391.31^{abc}	7.48
G_5	150	421.32^{c}	8.29
G_6	87	397.47^{abc}	10.88
G_7	81	373.27^{ab}	11.28
G_8	34	393.67^{abc}	17.41
G_9	15	363.66^{a}	26.21

Means in the same column with different superscript differed significantly

Effect of period of birth (POB)

In FG, the heifers born during P_2 (876.47 ± 7.80) had significantly lower AFC (days), than born in P_4 (1056.16 ± 16.51), P_3 (1026.97 ± 10.24) and P_6 (1016.88 ± 40.47). The differences in AFC among heifers born during P_3, P_4 and P_6 were at par with each other.

In FJG the DMRT indicated that the heifers born during P_1 (907.26±5.47) and P_2 (927.14±7.45) while the heifers born during P_4 (1126.16±13.67) and P_5 (1123.58±24.96) shows highest AFC days which are at par with each other.

Effect of season of birth (SOB)

Although the effect of season of birth on AFC was non-significant the lowest AFC was observed in heifers born during winter season (960.38 ± 10.24 days) in FG and summer season (994.74± 8.74) in FJG.

Effect of generation

The generation overall mean for AFC was 983.65 ± 7.26 days in FG and 994.77±5.75 days in FJG group. The AFC significantly lowest age at first calving was noticed in G_1

generation cows of both FG (819.91±6.24) and FJG (879.37±7.25) group. However, in FG group the highest age at first calving noticed in G_8 (1037.18±44.17) and in FJG it is in G_7 (1086.74±15.32)

Open period (OP): The overall least squares mean of open period in FG and FJG group it was 76.55± 2.08 and 72.02± 1.76 days, respectively

Effect of period of calving (POC)
Analysis of variance showed non-significant effect of period of calving on cows of FG and FJG group. Open period of cows born in P_6 (67.33 ± 11.56) period of calving it was lowest and in P_3 (84.58 ± 2.52) it is highest in FG group. While cows born during period P_2 had lower (64.97 ± 1.98) and P_5 had higher (79.77 ± 5.45) open period in cows of FJG group.

Effect of season of calving (SOC)
Analysis of variance showed non-significant effect of season of calving on open period in all genetic groups under study.

Effect of lactation order (LO)
The analysis of variance revealed that the lactation order had non-significant effect on OP in all genetic groups.

Effect of AFC group: In FG lowest open period observed in A_6 (1001 and above) 72.96 ± 2.51, while highest OP observed in A_3 (850 to 900) 80.46 ± 3.75, in FJG lowest OP observed in A_6 (1001 and above) 69.65 ± 2.33, while highest OP observed in A_2 (801 to 850) 75.06 ± 3.07 days.

Effect of generation
In FG and FJG genetic group the least square means of open period was days in FG and FJG group were 79.29 ± 1.69 and 71.17 ±1.57 days, respectively.

Service period (SP)
The overall least squares means of Service period in FG and FJG group cows were 133.26 ± 1.84 and 141.75 ± 1.70 days, respectively.

Effect of period of calving (POC)
The overall least squares means of Service period in FJG group cows was 135.70 ± 5.79. In FJG P_6 shows lowest (100.02 ± 8.76) SP while P_2, P_3, P_4 and P_5 shows highest SP which are at par with each other.

Effect of season of calving (SOC)
In FJG group the lowest service period was observed in cows calved during S_3 (Feb - May) summer season (132.31± 4.19 days) followed by S_1 (Jun - Sept) rainy season (132.62 ± 4.31 days) and in S_2 (Oct - Jan) winter season (134.98 ± 4.20 days).

Effect of lactation order (LO)
The analysis of variance revealed that lactation order had non-significant effect on service period in all the groups under study.

Effect of AFC group: The analysis of variance revealed that the age at first calving had a non-significant effect on service period in all the groups under study.

Effect of generation
Analysis of variance revealed that the effect of generation was significant on service period in FJG group. In FJG group the lowest SP observed in G_1 (116.85 ± 3.67) while highest in G_3 (177.75 ± 4.05).

Calving interval (CI)
The overall least squares means of calving interval in FJG group cows was 403.22 ± 2.47 respectively.

Effect of period of calving (POC)
The analysis of variance revealed that the influence of period of calving period of calving had non-significant effect on calving interval in FJG genetic groups.
In FJG group, DMRT showed that the cows calved during P_5 (381.76 ± 14.78) and higher CI in the cows calved during P_2 (408.87 ± 5.38).

Effect of season of calving (SOC)
The influence of season of calving on calving interval was non-significant in all three genetic groups. DMRT of FJG highest CI observed in S_2 (Oct - Jan) 395.22 ± 5.98 and lowest in S_1 (Jun - Sept) 392.07 ± 6.14 and S_3 (Feb - May) 394.53 ± 5.97 days which are at par with each other.

Effect of lactation order (LO)
Analysis of variance indicated that lactation order had non-significant effect on calving interval in FJG genetic group under study. In FJG, highest CI was in L_3 (402.11 ± 6.80) and lowest in L_5 (375.16 ± 9.77).

Effect of AFC group: Analysis of variance indicated that age at first calving had a non-significant effect on calving interval in all genetic groups under study. In FJG, highest CI was in A_1 (< 800) 402.54±8.137 and lowest in A_4 (901 to 950) 380.358±7.373.

Effect of generation
The overall generation CI in FJG group was 395.26 ± 4.23 days. The Generation wise least squares means for highest calving interval in FJG group observed in G_5 (421.32±8.29) days. While the lowest CI observed in G_9 (363.66 ± 26.21) days.

Conclusions
In view of the above findings the following conclusions were drawn:
1. The FJG triple cross performed better for all reproduction traits.
2. Most of the reproduction traits under study were affected by non- genetic factors indicating the importance of feeding and management for enhancing performance.

References
1. Ahmed MA, Teirab AB, Musa LMA, Kurt JP. Milk production and reproduction traits of different grades of Zebu x Friesian crossbreds under semi-arid conditions. Arch Tierz, Dummerstorf. 2007;50(3):240-249.
2. Ahuja L, Luktuke SN, Bhattacharya P. Certain aspects of physiology of reproduction in Hariana females. Indian J Vet Sci. 1961;31:13-14.1.
3. Food and Agriculture Organization. Statistical Data. The second report on the state of the world's animal

genetic resources for food and Agriculture in brief; c2012.
4. Central Statistical Organization, Govt. of India, Ministry of Statistics and Programme Implementation. Statistical year book-2012, Livestock and Fisheries 10.1 to 10.6. 2012.
5. National Dairy Development Board. Annual Report c2013-14. Anand: National Dairy Development Board; 2014. Available from: http://www.nddb.coop
6. Economic survey 2015-16: India ranks first in milk production accounting for 18.5% of world production. News18.com. Ist Pub. Feb.26th; c2016. Anonymous.
7. Bhoite UY, Fulpagare YG, Bhoite SU. Milk production performance Phule Triveni crossbred cows under field conditions. J Mah Agri Univ. 2010;35(3):443-445.
8. Deokar DK, Pachpute ST, Lawar VS, Naikare BD. Studies on factors affecting calving interval in two and three breed Gir crosses. Indian J Anim. Res. 2005;39(1):69-72.
9. Deokar DK, Ulmek BR, Bhagat RL, Pachpute ST. Seasonality in Gir crossbred cattle. J Maharashtra Agric Univ. 2005;31(1):107-108.
10. Garudkar SR. Lifetime comparison of fertility and milk production in halfbred and three breed crosses of Gir. PhD Thesis submitted to M.P.K.V., Rahuri. 2015.
11. Harvey WR. Least squares analysis of data with unequal subclass number. APSH4, U.S.D.A; c1990.
12. Jadhav PD. Generation wise comparative reproduction and production performance of HF X Gir and Phule Triveni synthetic cow. M.Sc. (Agri.) Thesis submitted to MPKV, Rahuri; c2011.
13. Jawale SB. Comparative reproduction performance of 5/8 Gir crossbred and Phule Triveni. M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri; c2015.
14. Kamble SS. Effect of different types of calving on reproduction and productive performance of crossbred cattle. M.Sc. (Agri.) Thesis Submitted, MPKV, Rahuri; c2003.
15. Kamble SS. Estimation of genetic, phenotypic and environmental trends for economic traits in Gir crossbred cattle. Ph.D. (Agri.) Thesis Submitted, MPKV, Rahuri; c2015.
16. Kathpatal BG. The fraction of Holstein - Dairy Zebu crosses resulting in maximum milk production and growth in India. Ph.D. thesis, Univ. of Illinois, Urbana. Diss. Abstr. Intern. 1970;32(9):5189 B.
17. Kharat AS, Kuralkar SV, Ali SZ. Genetic studies on first lactation and lifetime traits in Holstein Friesian crossbred cows. Indian J Anim Res. 2008;42(4):261-263.
18. Khekare MM. Comparative production performance of 5/8 Gir crossbred and Phule Triveni. M.Sc. (Agri.) Thesis submitted to M.P.K.V., Rahuri; c2014.
19. Krammer CV. Extension of multiple range test to group correlated. M.Sc. (Agri.) Thesis Submitted, MPKV, Rahuri; c1957.
20. Kulkarni PP. Persistency of milk yield in Red Sindhi cattle. M. Sc. (Agri.) Thesis submitted to MPKV, Rahuri; c2001.
21. Kumar D, Kumar P. Genetic studies on breeding efficiency in crossbred cows. Indian J Anim Sci. 2003;73(10):1180-1181.
22. Kumar S, Singh YP, Kumar D. Genetic studies on performance traits in Frieswal cattle. Indian J Anim Sci. 2008;78(1):107-110.
23. Lobo RB, Duarte FAM, Concalves AAM, Oliviera JA, Wilcox CJ. Genetic and environmental effects on milk yield of Pitangueiras cattle. Anim Prod. 1984;39:157–163.
24. Madhuri SB, Suman CL, Pandey HS. Reproduction and Production performance of three-breeds crosses in cattle. Indian J Anim Res. 2009;43(1):32-36.
25. Mandakmale SD, Bhoite UY, Lawar VS, Deokar DK. Studies on effect of age and weight at first calving on production performance of Phule Triveni a triple crossbred cow. J Maharashtra Agric Univ. 2002;27(1):94-95.
26. Mhasade BS. Effect of age and weight at first calving on production performance of Hf x Gir crossbreds. M. Sc. (Agri.) Thesis submitted to MPKV, Rahuri; c2010.
27. Misra SS, Joshi BK. Genetic and non-genetic factors affecting lactation milk constituents and yield traits in Karan Fries cattle. Indian J Dairy Sci. 2004;57(1):69-72.
28. Nanavati S, Khan FH. Studies on lactation yield of Gir cattle. Indian J Dairy Sci. 1997;50(3):217-219.
29. Nanvati S, Singh A. Non genetic factors affecting production traits in Gir cattle. Indian J Dairy Sci. 2004;57(5):342-346.
30. Narula HK, Kanaujia AS, Malik CP, Sikka AK. Performance evaluation of reproduction efficiency traits in Friesian x Red Dane x Hariana three breed crosses. ISAGB 111/32. 2005.
31. Panda PB, Sandhu DP. Some genetic and non-genetic factors affecting milk production in crossbreds of Holstein and Jersey with Hariana and Deshi Bengal cows. Indian Vet J. 1983;60(2):99-106.
32. Patel AM, Mathur BK, Mathur AC, Mittal JP, Raushish SK. Production and reproduction performance of Tharparkar cattle in nonarid region. Indian J Anim Sci. 2000;70(5):530-532.
33. Panda PB, Sadhu DP. Genetic and non-genetic factors affecting milk production in cross-breds of Holstein and Jersey with Hariana and Deshi Bengal cows. Indian Vet J. 1983;60(2):99–106.
34. Saha DN, Parekh HKB. Factors affecting reproductive traits in half three fourth crossbred cattle. Indian J Dairy Sci. 2010;41(2):196-201.
35. Sawant VS, Jagtap DZ, Deokar DK, Garkar RM. Reproductive traits and breeding efficiency of Khillar cow. Indian J Anim Sci. 2006;76(2):141-142.
36. Shubha Lakshmi B, Ramesh Gupta B, Gnana Prakash M, Sudhakar K, Sharma LS. Genetic analysis of production performance of Freiswal cattle. Tamilnadu J Veterinary & Animal Sciences. 2010;6(5):215-222.
37. Shull GH. Duplicate genes for capsule form in Bursa bursa-pustoris. Zeit. ind. Abst. Ver. 1914;12:97-149.
38. Singh K, Khanna AS, Kanaujia AS. Factors affecting lactation performance and persistency in crossbred cattle. Indian J Dairy Sci. 2000;53(5):354-360.
39. Singh K, Khanna AS, Jaiswal UC. Genetic and non-genetic factors affecting reproduction traits in crossbred cattle. Indian J Anim Res. 2002;36(2):90-93.
40. Singh RR, Dutt T, Kumar A, Tomar AKS, Singh M. Evaluation of production and reproduction traits in

Vrindavani cattle. Indian J Anim Sci. 2011;81(3):296-298.
41. Smith DJ. Genetic Improvement of Livestock in Developing Countries Using Nucleus Breeding units. World Anim Rev. 1988;65:2-10.
42. Swami PD, Kumar V, Murdia CK, Barhat NK, Joshi RK, Kumar P. Effect of non-genetic factors on production traits in Hariana cattle. Indian J Dairy Sci. 2005;58(4):299-301.
43. Taneja VK, Bhat PN. Additive and non-additive genetic effects for various economic traits among Sahiwal and Sahiwal × Holstein cross-bred grades. Indian J Anim Sci. 1978;48(12):845-852.
44. Thombre BM, Mitkari BV, Gujar BV, Padghan PV. Factors affecting reproductive traits in Deoni and Holstein Friesian x Deoni halfbreds (F1). Indian J Anim Res. 2002;36(2):141-143.
45. Thakur YP, Singh BP. Performance of Jersey x Sindhi crossbreds. Indian Vet J. 2001;78(1):62-63.
46. Thorat AG. A comparative study of productive traits of the first and highest lactation in FG and their interbreds. M.Sc.(Agri.) Thesis submitted to MPKV, Rahuri; c1995.
47. Ulmek BR. Genetic studies on production traits in Gir Cattle. Ph.D. Thesis submitted to Gujrat Agril. Univ. Sardar Krishinagar, Gujrat; c1991.
48. Varade PK, Khire DW, Ali SZ, Kuralkar SV. Effect of genetic and non-genetic factors on productive and reproductive traits in Jersey crossbred cows. Indian J Anim Prod Mgmt. 2002;18(12):38-40.
49. Vinoo R, Narasimha Rao G, Ramesh Gupta B, Babu Rao K. Genetic study on productive and reproductive traits of Ongole cattle. Indian J Anim. Sci. 2005;75(4):438-441.
50. Yadav AS, Rahri SS, Dahiya SP, Arora DN. Factors affecting some reproductive and productive traits in Sahiwal cattle. Indian J Dairy Sci. 1990;45(10):522-526.