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Performance evaluation of first lactation and lifetime production and reproduction traits of Hariana cattle

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Abstract
The data of 655 Hariana cattle on first lactation and lifetime production and reproduction reared during 1965-2020 at State Livestock and Agriculture Farm, Babugarh, Hapur, India was used for least square analysis. The overall least square means for first lactation traits *viz*. Age at First Calving, Total Lactation Milk Yield in Pail, First Standard Milk Yield in Pail, First Calving Interval, First Dry Period, First Lactation Length and First Service Period were found to be 1580.16 ± 12.20 days, 954.66 ± 19.79 kg, 857.92 ± 14.73 kg, 523.42 ± 6.86 days, 181.09 ± 5.16 days, 343.18 ± 4.81 days and 240.79 ± 7.22 days respectively. Least square estimates for lifetime traits *viz*. Breeding Efficiency by Tomar method, Breeding Efficiency by Wilcox method, Herd Life, Productive Days, Productive Life, Unproductive Days, Total Lactation Milk Yield in Pail, Total Standard Lactation Milk Yield in Pail, Total Lactation Milk Yield in Pail / Herd Life, Total Lactation Milk Yield in Pail / Productive Days and Total Lactation Milk Yield / Productive Life in Pail were 79.54 ± 0.47%, 76.98 ± 0.73%, 4241.91 ± 33.19 days, 1633.53 ± 23.95 days, 2392.06 ± 30.34 days, 758.53 ± 17.87 days, 5365.85 ± 113.60 kg, 5179.09 ± 97.08 kg, 1.17 ± 0.02 kg/day, 3.10 ± 0.04 kg/day, 2.16 ± 0.03 kg/day respectively. Various fixed factors used in the model were found to be significantly affecting first lactation and lifetime traits except for few. The estimated least square means for first lactation and lifetime traits will act as a baseline for animal breeders. The identified fixed factors significantly affecting first lactation and lifetime traits in Hariana cattle will be useful for standardization of data beforehand genetic analysis.

Keywords: First lactation, Hariana cattle, least square means, lifetime traits, production traits, reproduction traits

Introduction
Cattle are the most common and widespread farm animals in the world. They are raised mainly for their meat, milk, hides, draft and dung. Cattles with a population of 193.46 million heads play a crucial role in the Indian animal husbandry sector. This encompasses 142.11 million indigenous livestock (GOI, 20th Livestock Census 2019) [8]. Hariana is a well-known indigenous dual breed among cattle. In Hariana cattle, the milk yield per lactation is approximately between 693 to 1745 kg and milk fat is around 4.5 percent (GOI, 2019) [7]. Better performance of first lactation and lifetime production and reproduction traits paves the foundation profitable dairy farming. Data available on these records require primary screening and standardization owing to various systematic and random sources. Data standardization improvises accuracy of genetic estimates. One of the most widely used technique for estimating correction factors attributable to significant fixed factors along with adjusted means is least square analysis. The least square means are means for groups that are adjusted for means of other factors in the model. The present study undertakes estimation of least square means and associated significant fixed factors for first lactation and lifetime production and reproduction traits Hariana cattle. The production and reproductive performance of first and lifetime lactation records will establish comparative baseline values for future improvement of this Hariana cattle breed and associated research.

Materials and Methods
Data
In the proposed study, lactation records from the history sheet registers and herd inventory registers, etc of Hariana cattle maintained in State Livestock and Agriculture Farm, Babugarh, Hapur will be used. Data on 949 animals have been used to collect the information.

Finally after screening and standardization 655 records were used in the present study spanning from 1965-2020. The basic information will be collected from history sheet as Animal DOB (Date of birth), Parity, DOS (Date of service), DOC (Date of calving), Lactation length, TLMYP (Total lactation milk yield in pail), DD (Date of drying), 300DMYP (300 days milk yield in pail), DP (Dry period), CI (Calving interval), DdD (Date of death) and DOA (Date of Auction). Data were classified into different groups in order to study the effect of different non-genetic factors *viz*., season of birth (SOB), period of birth (POB), age at first calving group (AFCG), first calving season (FCS), first calving period (FCP) and lactations completed groups (LCG) on first and lifetime production and reproduction traits under study.

Traits under study

First lactation records were estimated as Age at First Calving (AFC) in days, Total Lactation Milk Yield in Pail (FTLMYP) in kg, First Standard Milk Yield in Pail (FSLMPY) in kg, First Calving Interval (FCI) in days, First Dry Period (FDP) in days, First Lactation Length (FLL) in days, First Service Period (FSP) in days. The lifetime reproduction and production traits estimated were Breeding Efficiency by Tomar method (BET) in %, Breeding Efficiency by Wilcox method (BEW) in %, Herd Life (HL) in days, Productive Days (PD) in days, Productive Life (PL) in days, Unproductive Days (UPD) in days, Total Lactation Milk Yield in Pail (TLMYP) in Kg, Total Standard Lactation Milk Yield in Pail (TSLMYP) in Kg, Total Lactation Milk Yield in Pail / Herd Life (TLMYP/HL) in Kg/days, Total Lactation Milk Yield in Pail / Productive Days (TLMYP/PD in Kg/days) and Total Lactation Milk Yield / Productive Life in Pail (TLMY/PL) in Kg/day. The breeding efficiency was calculated by the formula as describe by Wilcox *et al*. (1957) [24]:

$$\text{B. E.} = \frac{365 \text{ x } (N-1) \text{ x } 100}{D}$$

and Tomar (1965) [21]:

$$\text{B. E.} = \frac{[\text{N.}\,365 + 1020] \text{ x } 100}{AFC + D}$$

Where, B.E. = Breeding efficiency in percentage, N = Number of calvings, D = Number of days from first to last calving, AFC = Age at first calving in days.

The herd life was considered the duration from birth to disposal of animal. Productive life was defined as total days from date of first calving to date of last dry or date of disposal if animal is in lactation. Productive days were the sum of the number of days in milk in different lactations in the herd. Unproductive days were the sum of dry periods in different lactations in the same herd.

Statistical Analysis

Data were analysed by least squares analysis model (SPSS Statistics 20.0 software) to identify the significant fixed effects. The least squares model for AFC included season of birth (Level 4) and period of birth (Level 10) as fixed effects. Fixed effects for first lactation and lifetime traits were AFCG (Level 7), first calving season (Level 4), and first calving period (Level 10). Lactation completed (Level 5) was also included along with other fixed effects for lifetime traits. The statistical significance was tested at 5% and 1% level. Analysis was carried out by least squares analysis method for non-orthogonal data as described by Harvey (1987) [9].

The models used were as follows:

Age at first calving

$$Y_{ijk} = \mu + Sb_i + Yb_j + e_{ijk}$$

where, Y_{ijk}, k^{th} observation in i^{th} season of birth and j^{th} period of birth; μ, Overall mean; Sb_i, effect of i^{th} season of birth (i=4); Yb_j, effect of j^{th} period of birth (j=10); e_{ijk}, Random error ~NID (0, $\sigma^2 e$).

First lactation traits

$$Y_{ijkl} = \mu + A_i + F_j + Fp_k + e_{ijkl}$$

where, Y_{ijkl}, k^{th} observation in i^{th} AFC group, j^{th} first calving season and k^{th} first calving period; μ, Overall mean; A_i, effect of i^{th} AFC group (i=7); F_j, effect of j^{th} first calving season (j=4); Fp_k, effect of k^{th} first calving period (k=10); e_{ijkl}, Random error ~NID (0, $\sigma^2 e$).

Lifetime traits

$$Y_{ijklm} = \mu + A_i + F_j + Fp_k + L_l + e_{ijklm}$$

where, Y_{ijkl}, m^{th} observation in i^{th} AFC group, j^{th} first calving season, k^{th} first calving period and l^{th} lactations completed group; μ, Overall mean; A_i, effect of i^{th} AFC group (i=7); F_j, effect of j^{th} first calving season (j=4); Fp_k, effect of k^{th} first calving period (k=10); L_l, effect of l^{th} lactations completed group (l=4) e_{ijkl}, Random error ~NID (0, $\sigma^2 e$).

Results and Discussion

First production and reproduction traits

The least square mean of first reproduction and production traits had been presented in Table 1. The overall age of first calving was found to be 1580.16 ± 12.20 days. Age at first calving lower than this had been reported in Dhofari cows of Bangladesh (Bahashwan, S., 2020) [2]. Higher least-squares mean estimates for age at first calving in Hariana cattle had also been reported (Kumar *et al*., 2005; Shetkar *et al*., 2021) [10, 16]. The fixed factors used for AFC as dependent variables were season of birth of the animal and year of birth. The year of birth was found to be highly significantly affecting age at first calving but the season of birth was non-significant. Similarly Doharey (2012) [6] had reported significant effect of period of birth. In FTLMYP and FSLMYP, the overall LSM is 954.66 ± 19.79 kg and 857.92 ± 14.73 kg where the fixed factors used for FTLMYP and FSLMYP as dependent variables were age at first calving groups, first calving season and first calving year. The first lactation milk yield higher than this had been reported in Sahiwal cows (Verma *et al*., 2018) [22] and in Phule Triveni cattle (Ambhore *et al*., 2017) [1]. The first standard lactation milk yield was higher in Sahiwal cow than this result reported by Pandey *et al*., 2019 [12] and lower in Gir cows reported by Singh *et al*. 2016 [19]. All the fixed factor of FTLMYP were highly significant but in FSLMYP, age at first calving groups was significant, first calving season was non-significant and first calving year was highly significant. In an earlier study the period of calving had non significant influence on first lactation milk yield (Singh *et al*. 2016) [18]. The overall FCI in present study was

found to be 523.42 ± 6.86 days. The FCI lesser than present study had also been reported in Hariana cows (Kumar *et al*., 2019) [11]. The fixed factors used for FCI as dependent variables were age at first calving groups, first calving season and first calving year. Both first calving season and first calving year were highly significant but age at first calving groups had non-significant effect. The period and season had earlier been reported to have highly significant influence on FCI (Singh *et al*. 2016) [18]. The overall first dry period was found to be 181.09 ± 5.16 days. The higher first dry period in Hariana cattle than our result had been reported by Shetkar *et al*., 2021 [16] but lower in Red Sindhi cattle reported by Verma *et al*., 2018 [22]. The fixed factors used for FDP as dependent variables were age at first calving groups, first calving season and first calving year. Both first calving season and first calving year had highly significant but the effect of age at first calving groups was found to be non-significant. Both season of calving and period of calving were found to have significant effect on first dry period in an earlier study on Hariana cattle (Shetkar *et al*., 2021) [16]. The overall least square mean of FLL was 343.18 ± 4.81 days. First lactation length higher than this had been reported in Hariana cattle (Kumar *et al*., 2019) [11] and lower FLL had also been reported in same breed (Dalal *et al*., 2002) [4]. The fixed factors used for least square analysis of FLL indicated that first calving season and first calving year had highly significant but age at first calving groups had significant effect on FLL. Similarly in an earlier study, the season had been showed to impart significant effect on FLL (Singh *et al*. 2016) [18]. The overall least square means of FSP was found to be 240.79 ± 7.22 days. The lower FSP than this had been reported in Hariana cattle (Ambhore *et al*., 2017; Dalal *et al*., 2002) [1, 4]. The fixed factors age at first calving group and first calving year had significant and the first calving season had highly significant effect on FSP.

Table 1: Least square means of first lactation production and reproduction traits in Hariana cattle (N=655)

S. No.	Parameter	Least square Mean ± S.Em	Fixed factor				
			SOB	POB	AFCG	FCS	FCP
1.	AFC	1580.16 ± 12.20	NS	HS	–	–	–
2.	FTLMYP	954.66 ± 19.79	–	–	HS	HS	HS
3.	FSLMYP	857.92 ± 14.73	–	–	S	NS	HS
4.	FCI	523.42 ± 6.86	–	–	S	HS	HS
5.	FDP	181.09 ± 5.16	–	–	NS	NS	HS
6.	FLL	343.18 ± 4.81	–	–	S	HS	HS
7.	FSP	240.79 ± 7.22	–	–	S	HS	S

Where, NS= Non-significant (*P*>0.05), S= Significant (0.05≥P≥0.01), HS= Highly significant (*P*<0.01)

Lifetime production and reproduction traits

The least square mean of lifetime production and reproduction parameters had been represented in Table 2. The overall breeding efficiency by Tomar method and Wilcox method were found to be 79.54 ± 0.47% and 76.98 ± 0.73% respectively. The BET and BEW higher than this had been reported in crossbred cattle (Singh *et al*., 2016) [20]. The BEW lowest than this had been reported in Holstein × Haryana F1 (Deshpande and Ingole, 1986) [5]. The fixed factors used for BET and BEW as dependent variables were age at first calving groups, first calving season, first calving year and parity groups. In BET, all fixed factors were highly significant but parity group factor was significant and in BEW, the all fixed factors were highly significant except that age at first calving groups was non-significant. The overall least square mean of herd life was found to be 4241.91 ± 33.19 days. Herd life lower than this had been reported in Gir cows (Patbandha *et al*., 2020) [13] and in Hariana cows (Dalal *et al*., 2002) [4]. The fixed factors as age at first calving groups, first calving year and parity groups were highly significant but first calving season was non-significant. In a study the effect of period of first calving was found highly significant but the effect of season of first calving was having non-significant effect on HL (Patbandha *et al*., 2020) [13]. The overall mean of productive days, productive life and unproductive days were found to be 1633.53 ± 23.95, 2392.06 ± 30.34 and 758.53 ± 17.87 days respectively. The productive life lower than this had been reported in Gir cows (Patbandha *et al*., 2020) [13] and in Sahiwal cows (Vinothraj *et al.,* 2016) [23]. The fixed factors as first calving year and parity groups had highly significant but age at first calving groups and first calving season had non-significant effect on PL, HL and PD. Another study reported that year of birth had significant effect while season of calving has no effect on PL (Berihulay and Mekasha, 2016) [3]. The overall least square mean of TLMYP and TSLMYP was found to be 5365.85 ± 113.60 and 5179.09 ± 97.08 kg respectively. Total lifetime milk yield lower than this had been reported in Hariana cattle (Shetkar *et al*., 2021) [17] and near value results in Hariana cow were reported by Dalal *et al*. (2002) [4]. The total lactation milk yield higher than this had also been reported in Sahiwal cows (Pandey *et al*., 2019) [12]. The fixed factors used for TLMYP and TSLMYP as dependent variables were age at first calving groups, first calving season, first calving year and parity groups. The fixed factor as first calving year and parity groups had highly significant effect but age at first calving groups and first calving season had non-significant on both TLMYP and TSLMYP. Significant influence of season of birth whereas period of birth without significant effect on life time milk yield had also been reported (Reddy *et al*., 2012) [14]. The overall least square mean of TLMYP/HL, TLMYP/PD and TLMYP/PL were found to be 1.17 ± 0.02, 3.10 ± 0.04 and 2.16 ± 0.03 kg/day respectively. An earlier study had reported TLMYP/HL lower than present study in Ongole cattle (Reddy *et al*., 2012) [14]. Higher values of TLMYP/HL than present study had also been reported in crossbred cows (Vinothraj *et al*., 2016) [23]. The TLMYP/PL higher than this had been reported in crossbred cows (Vinothraj *et al*., 2016) [23] and in Hariana cattle Dalal *et al*. (2002) [4]. The fixed factors used for TLMYP/HL, TLMYP/PD and TLMYP/PL as dependent variables were age at first calving groups, first calving season, first calving year and parity groups. The fixed factor as first calving year and parity groups had highly significant effect but age at first calving groups and first calving season had non-significant effect on TLMYP/HL, TLMYP/PD and TLMYP/PL. Another

study had reported that the season of calving had highly significant effect while the period of calving had non significant effect on Life time milk yield (Sahana and Gurnani, 2000) [15].

Table 2: Least square means of lifetime production and reproduction traits in Hariana cattle (N=655)

S. No.	Parameter	Least square Mean ± S.Em	Fixed factor			
			AFCG	FCS	FCY	LCG
1.	BET	79.54 ± 0.47	HS	HS	HS	S
2.	BEW	76.98 ± 0.73	NS	HS	HS	HS
3.	HL	4241.91 ± 33.19	HS	NS	HS	HS
4.	PD	1633.53 ± 23.95	NS	NS	HS	HS
5.	PL	2392.06 ± 30.34	NS	NS	HS	HS
6.	UPD	758.53 ± 17.87	NS	NS	HS	HS
7.	TLMYP	5365.85 ± 113.60	NS	NS	HS	HS
8.	TSLMYP	5179.09 ± 97.08	NS	NS	HS	HS
9.	TLMYP/HL	1.17 ± 0.02	NS	NS	HS	HS
10.	TLMYP/PD	3.10 ± 0.04	NS	NS	HS	HS
11.	TLMYP/PL	2.16 ± 0.03	NS	NS	HS	HS

Where, NS= Non-significant ($P>0.05$), S= Significant ($0.05 \geq P \geq 0.01$), HS= Highly significant ($P<0.01$)

Conclusion

The least square means estimated for first lactation and lifetime reproduction and production traits provides reference values for researchers and Hariana cattle breeders for comparing their herd performances. The significant fixed factors tested against various first lactation and lifetime reproduction and production traits must be subjected to the correction of herd data beforehand genetic analysis.

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