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Research Article

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Genetic Evaluation of Some Reproductive Traits of Holstein-Friesian Cattle in Five Syrian Dairies

Abstract

Many of the reproductive traits in cows are affected by a group of factors, the most important of which are climatic conditions and the management of the herds. In this paper, the reproductive status of imported Holstein - Friesian cattle breed was evaluated in terms of breeding through the investigation for some traits under the influence of some factors. The records involved cow birth to first service trait (CBFS) (1101 records), cow birth to first days open trait (CBFDO) (1091 record), and age at first calving trait (AFC) (1083 record). The results of the study showed significant differences in CBFS, CBFDO, and AFC traits according to the year and season of birth ($p<0.01$), the lowest values were 19.33, 21.29 and 30.29 months (the year 2000) and 19.40, 21.30 and 30.32 months (winter) respectively. Also, a significant difference ($p<0.01$) was noticed through the interaction between the year and season of birth and between the year of birth and total milk yield level (TMYL). Estimated heritability (h^2) for CBFS, CBFDO, and AFC traits were 0.22, 0.25 and 0.17 respectively. The study showed variation in estimated breeding values (EBV_S) across sires within the reproductive traits. The first three lowest values were achieved by the sires 13.25 and 20, the values were -1.97-1.87 and -1.86 months (CBFS trait), -2.33-2.21 and -2.19 months (CBFDO trait), -2.32-2.20 and -2.18 months (AFC trait) respectively. Based on current given results, it is advised to direct and intensify births during winter and spring seasons to obtain optimal reproductive performance of the herd later.

INTRODUCTION

Reproduction in cattle is one of the most important aspects of the successful management of herds as long as the main goal is productively at the highest levels. Since the last decade of the last century, humans have accelerated evolution by using selective reproduction to improve livestock. Reproduction in livestock is associated with many factors, and as a prominent role, the environmental aspect directly affects the reproductive status of the animal. Cows in any environment may suffer from heat stresses due to high temperature and solar radiation, especially in the mid of the day, and this causes a significant decrease in reproductive efficiency. It is well- known that cattle have a thermoneutral zone (Comfort zone) where they are most comfortable. This zone is within the range of 5 and 25 °C (Shadi and Taneja, 1986). Veissier et al. (2018) stated that heat stress is one of the most important determinants of production and reproduction in hot regions. Directly and indirectly, heat stress affects many aspects like feed intake, body temperature, metabolism, feed efficiency, milk yield, reproductive performance, behaviour, and the risk of diseases (Cook et al. 2007; Rhoads et al. 2009; Bernabucci et al. 2010; Omar, 2020). Dash et al. (2016) referred that fertility is influenced by various factors, including genetic, nutritional, hormonal, physiopathology, management, and environment. However, the fertility traits in cattle show a very low heritability, this indicates to the clear role of non-genetic factors (environmental effects) in determining the fertility variations (Thiruvenkadan et al., 2010). In literature, many studies suggested several genetic applications to improve the reproductive traits like crossbreeding and direct selection because of low heritability or the late expression of reproductive traits across the animal life which in turn make the genetic improvement of these traits occurs at a low rate and efficiency (Cammack et al., 2009). According to the low heritability estimates, there is a need to a considerable data and best model, this, in turn, prepares for the establishment of effective selection programs that improve these traits (Lopez et al., 2019). Given the importance of evaluation and estimation of the genetic parameters of different reproductive traits in selection programs, the present study aimed to evaluate the traits of birth to first service (CBFS), cow birth to first days open (CBFDO), and age at first calving (AFC). Also, estimating the heritability and breeding values of sires for previous traits in Holstein- Friesian cattle spread in five Syrian dairies.

MATERIAL and METHODS

Breeding plan and management

The study was carried out at five Syrian dairies containing the imported Holstein-Friesian breed. Generally, in winter and spring, cows are fed green fodders consisted of yellow corn, sorghum and alfalfa in addition to windrow, silage and hay. Concentrates diets are provided at a rate of 1 kg per 3.5 kg of milk. The monitoring of the estrus took place day and night. Being heifers, the cows were naturally inseminated by a proven sire. Herds are housed in half-open sheds.

Data and statistical analysis

Data related to the reproductive traits at cows in first lactation parity were collected based on the records available in the five dairies during the period between 2000 and 2005 across various seasons of the year (winter, spring, summer, and fall). These records involved the traits of CBFS (1101 records), CBFDO (1091 record), and AFC (1083 record). Farms were given the numbers 1, 2, 3, 4 and 5. Total milk yield levels (TMYL) were determined in three classes: <5000, 5000-5300, and >5300 kg. The sires were renumbered with numbers from 1 to 35. The statistical analysis was done based on the General Linear Model (GLM) using the SAS software package (2017) according to the following mathematical models:

1.The model applied to study the effect of the year of birth, the season of birth, farm, TMYL and all possible interactions among those factors (bilateral and triple):

$$Y_{ijklm}=\mu+YR_i + F_j + S_k + TMYL_l + (YR_i\times F_j) + (YR_i \times S_k) + (YR_i \times TMYL_l) + (F_j \times S_k) +(F_j \times TMYL_l) + (S_k \times TMYL_l) + (YR_i \times F_j \times S_k) + (YR_i \times F_j \times TMYL_l) + (YR_i \times S_k\times TMYL_l) + (F_j \times S_k\times TMYL_l) + e_{ijklm}$$

Where,
Y_{ijklm} is the observed trait (CBFS, CBFDO, and AFC) at YR_i, F_j, S_k, and $TMYL_l$
μ is the population mean for each trait,
YR_i is the effects of year of birth (i = 2000, 2001, 2002, 2003,2004,2005),
F_j is the effects of farm (j=1,2,3,4,5),
S_k is the season of birth effects (k = winter, spring, summer, autumn),
$TMYL_l$ is the milk yield levels effects (l= <5000, 5000-5300, > 5300),
e_{ijklm} is the random residual effects **~(0, Iσ^2_e) (**random sampling error**).**
The contents in the brackets refer to the bilateral and triple interactions among the above factors.
2.The mixed model applied to estimate the variance components for random effects:
$Y_{ijklmn} = \mu + YR_i + F_j + S_k + TMLY_l+S_m+ e_{ijklmn}$
Where,
S_m is the sire effect (35 sires).
The heritability coefficient (h^2) was calculated according to the following equation:

$$h^2= \frac{4\,\sigma_s^2}{\sigma_s^2+\sigma_e^2}$$

Where:
σ_s^2 is the genetic variation of the sires.
$\sigma_s^2 + \sigma_e^2$ is the phenotypic variation of the sires.
Duncan’s multiple range test (DMRT) was used for multiple comparisons of each trait (Gomez and Gomez. 1984). The Restricted Maximum Likelihood estimator (REML) was used to estimate the variance components and heritability based on the half-sibs relation (Patterson and Thompson. 1971). The breeding values of previous traits for assigned sires were estimated based on the Best Linear Unbiased Prediction estimator (BLUP).

RESULTS

General means

In general, Table 1 shows that the grand means of CBFS, CBFDO, and AFC traits reached the values 20.50, 21.40 and 30.55 months respectively. Whereas, the general means values according to the studied factors were closely related to each trait.

Table 1. The grand mean, general means, and standard error (SE) of the studied reproductive traits

	CBFS[1]	**CBFDO[2]**	**AFC[3]**
Source of means	Mean ± SE	Mean ± SE	Mean ± SE
Grand mean	20.50 ± 0.017	21.40 ± 0.017	30.55 ± 0.017
Year of birth	19.68 ± 0.016	21.58 ± 0.017	30.58 ± 0.017
Farm	19.65 ± 0.018	21.55 ± 0.018	30.55 ± 0.018
Season of birth	19.64 ± 0.016	21.54 ± 0.016	30.54± 0.016
TMYL[4]	19.65 ± 0.017	21.55 ± 0.017	30.55 ± 0.017

CBFS[1]: cow birth to the first service, CBFDO[2]: cow birth to first days open, AFC[3]: age at first calving, TMYL[4]: total milk yield level.

Table 2. Least mean squares (LSM) and standard error (SE) for studied reproductive traits (month) according to different factors

Source	CBFS[1]	CBFDO[2]	AFC[3]
Year of birth	LSM±SE	LSM±SE	LSM±SE
2000	$19.33^{A}\pm0.03$	$21.29^{A}\pm0.07$	$30.29^{A}\pm0.07$
2001	$19.40^{AB}\pm0.03$	$21.30^{AB}\pm0.07$	$30.33^{AB}\pm0.07$
2002	$19.70^{B}\pm0.03$	$21.60^{B}\pm0.07$	$30.63^{B}\pm0.07$
2003	$19.77^{B}\pm0.03$	$21.67^{B}\pm0.08$	$30.67^{B}\pm0.08$
2004	$19.92^{C}\pm0.04$	$21.82^{D}\pm0.11$	$30.84^{C}\pm0.11$
2005	$19.81^{D}\pm0.05$	$21.74^{D}\pm0.07$	$30.73^{C}\pm0.07$
p	*	*	**
Farm			
1	19.66±0.04	21.56±0.08	30.59±0.08
2	19.64±0.03	21.54±0.08	30.57±0.08
3	19.63±0.03	21.53±0.07	30.58±0.07
4	19.70±0.03	21.60±0.06	30.62±0.06
5	19.71±0.03	21.61±0.07	30.63±0.07
Season of birth			
Winter	$19.40^{A}\pm0.03$	$21.30^{A}\pm0.06$	$30.32^{A}\pm0.06$
Spring	$19.48^{B}\pm0.03$	$21.38^{B}\pm0.07$	$30.39^{B}\pm0.07$
Summer	$20.01^{C}\pm0.02$	$21.84^{C}\pm0.06$	$30.83^{C}\pm0.06$
Fall	$19.83^{C}\pm0.03$	$21.73^{C}\pm0.06$	$30.78^{C}\pm0.06$
p	*	*	*
TMYL[4]			
<5000	19.82±0.02	21.66±0.06	30.68±0.06
5000-5300	19.87±0.02	21.61±0.05	30.66±0.05
> 5300	19.82±0.02	21.77±0.05	30.80±0.05

CBFS[1]: cow birth to the first service, CBFDO[2]: cow birth to first days open, AFC[3]: age at first calving, TMYL[4]: total milk yield level. *: p =0.0001, **: p = 0.001. Means within a column with different superscripts differ significantly at assigned probability.

Effect of a year of birth

The data of Table 2 shows that the year of birth affected significantly the traits of CBFS (p = 0.0001), CBFDO (p = 0.0001), and AFC (p = 0.001), the lowest values were 19.33, 21.29 and 30.29 months (the year 2000) respectively. On the other hand, cows achieved the highest values in 2004 (19.92, 21.82 and 30.84 months respectively).

Season of birth, also, affected significantly the three traits (p=0.001), the lowest values were 19.40, 21.30 and 30.32 months (winter) for the traits CBFS, CBFDO, and AFC respectively. In summer cows achieved the highest values (20.01, 21.84 and 30.83 months respectively) (Table 2).

Effect of TMYL levels

No significant difference was noticed despite the low encouraging values at mentioned traits. Compared to other factors, the low values of the CBFS and CBFDO traits increased relatively while the AFC values were similar to other values in other factors. However, what is noteworthy, is the high value of CBFS at cows with a production of between 5.000 and 5.300 kg, the value was 19.87 months (Table 2).

Effect of farm

Across the three traits, a great convergence was observed in the values under the influence of the farm without significant difference. As the differences between the highest and lowest values did not exceed 0.08, 0.08 and 0.06 months for the CBFS, CBFDO, and AFC traits respectively (Table2).

Effect of season of birth

Effects of Interaction

All of the bilateral and triple interactions among the factors did not show a significant difference except the bilateral interaction between the year of birth and TMYL (p=0.01) and between the year and the season of birth (p=0.0001) (Table 3)

Table 3. Values of probability (p) of interaction effects and degrees of freedom (DF) among factors across the reproductive traits

Source	DF	CBFS[1]	CBFDO[2]	AFC[3]
		p	p	p
Farm*Season of birth	12	0.6866	0.4852	0.4852
Year of birth *Farm	16	0.3015	0.1423	0.1423
Farm*TMYL[4]	8	0.2060	0.1353	0.1353
Year of birth *Season of birth	15	0.0001	0.0001	0.0001
Season of birth * TMYL	6	0.6117	0.2074	0.2074
Year of birth * TMYL	10	0.0138	0.0133	0.0138
Year of birth *Farm*Season of birth	45	0.9754	0.9049	0.9049
Farm*Season of birth * TMYL	24	0.2007	0.6172	0.6172
Year of birth *Farm* TMYL	32	0.5194	0.3770	0.3770
Year of birth *Season of birth * TMYL	30	0.6895	0.9961	0.9961

CBFS[1]: cow birth to the first service, CBFDO[2]: cow birth to first days open, AFC[3]: age at first calving, TMYL[4]: total milk yield level.

Table 4 presents the upper and lowest values of bilateral interactions of the studied traits and in which significant differences appeared. The cows showed the lowest values of the studied traits during the winter (the year 2000), while the cows showed the lowest values in the same year at TMYL less than 5000 kg. Respectively, as for the traits of CBFS, CBFDO, and AFC, the values were 19.01,20.19 and 29.92 months in the Year of birth ×Season of birth interaction and 19.35, 21.25 and 30.25 months in the year of birth × TMYL interaction.

Table. 4. Least mean squares (LSM) and standard error (SE) of significant interaction effects of studied reproductive traits (month)

Interaction		**CBFS[1]**	**CBFDO[2]**	**AFC[3]**
Year of birth ×Season of birth		LSM±SE	LSM±SE	LSM±SE
2000	Winter	19.01^{A}±0.02	20.91^{A}±0.05	29.92^{A}±0.06
2003	Summer	20.02^{C}±0.03	21.92^{C}±0.07	30.93^{C}±0.07
p		*	*	*
Year of birth × TMYL[4]				
2000	< 5000 kg	19.35^{A}±0.05	21.25^{A}±0.04	30.25^{A}±0.04
2003	> 5300 kg	19.81^{C}±0.06	21.71^{C}±0.05	30.72^{C}±0.05
p		***	***	***

CBFS[1]: cow birth to the first service, CBFDO[2]: cow birth to first days open, AFC[3]: age at first calving, TMYL[4]: total milk yield level. *: p =0.0001, ***: p = 0.01. Means within a column with different superscripts differ significantly at assigned probability.

Heritability and effect of sire

A relative decrease in the values of estimated heritability coefficients (h^2) was observed, the values were 0.22, 0.25 and 0.17 for CBFS, CBFDO, and AFC traits respectively. In Table 5, the estimated breeding values (EBVs) for the best ten sires and the worst ten sires according to the reproductive traits studied were presented. It is noted that sires with numbers 13, 25, and 20 have achieved the most important EBVs for traits of CBFS (-1.97, -1.87 and -1.86 months respectively), CBFDO (-2.33, -2.21 and -2.19 months respectively), and AFC (-2.32, -2.20 and -2.18 months respectively). On the other hand, sire 10 ranked the last by accomplishing the values 2.27, 2.42 and 3.01 months for the previous traits respectively.

Table 5. EBVs[1] of CBFS, CBFDO, and AFC traits according to BLUP estimates

CBFS[2]		**CBFDO[3]**		**AFC[4]**	
Sire No.	EBV	Sire No.	EBV	Sire No.	EBV
13	-1.97	13	-2.33	13	-2.32
25	-1.87	25	-2.21	25	-2.20
20	-1.86	20	-2.19	20	-2.18
19	-1.83	19	-2.19	18	-2.15
2	-1.75	4	-1.98	28	-2.02
30	-1.75	5	-1.95	12	-1.95
6	-1.70	28	-1.93	4	-1.86
18	-1.65	18	-1.33	19	-1.72
5	-1.51	6	-1.12	6	-1.24
31	-1.23	34	-1.01	31	-1.02
14	1.20	15	1.11	8	0.98
7	1.23	1	1.20	16	1.20
11	1.25	32	1.33	11	1.25
17	1.25	7	1.40	22	1.26
8	1.80	16	1.61	32	1.33
24	1.82	24	1.74	15	1.45
22	1.90	22	1.86	24	1.65
27	1.93	27	1.97	22	2.19
3	2.11	3	2.10	27	2.55
10	2.27	10	2.42	10	3.01

EBVs[1]**:** estimated breeding values, CBFS[2]: cow birth to first days open, AFC[3]: age at first calving, TMYL[4]: total milk yield level.

DISCUSSION

Ensuring optimal conditions in animal welfare, including successful management, controlled nutrition and optimal environmental conditions are of the most important constituents of optimal performance of livestock, whether in terms of reproductive or productive sides. In this context, this conception is very important in the first months of the animal's life. Since the establishment of the animal in an ideal form at a young age will result in productive and reproductive horizons that are highly desirable by breeders. In our study, through the given data, a significant increase in the CBFS, CBFDO and AFCS traits attributed to cows that were born in summer and fall was observed (Table 2). Theoretically, the previous differences can be explained by the rise in the temperature of the surrounding environment to the limits where the heat stress in the animal appears as a reaction (impact of heat stress). In terms of weather, Syria is influenced by a Mediterranean climate in general, characterized by long, hot and mostly dry summers and mild, wet winters, and as a result, somehow, the estrus is shortened five hours compared to that in the temperate regions, and this is manifested by a deterioration in the reproductive efficiency, a decrease in libido and the period of estrus (Bridges et al., 2005), ovulation rates, implantation and finally the high rates of embryo lyses and death (Hansen, 2007). Indeed, lactating dairy cows are negatively affected by heat stress, but dry cows and neonatal calves are also affected by this impact (Monteiro et al., 2014). Referring to the chronic (long-term) adverse effects of heat stress impact, heat stress during late gestation is a reason for the low birth weight of calves (Collier et al., 1982; Laporta et al., 2017). On the other hand, the variation that appeared in the studied traits due to the effect of the year of birth and the interaction of this factor with the season of birth can be attributed to the variation of the surrounding environment conditions (Lodhi et al., 2016), management system, feeding pattern, energy balance (Bronson. 2009), production variation and animal health care (Kijlstra and Eijck, 2006). This may also be explained by certain policies in herd management, these policies are based mainly on animal selection objectives of the herd. In terms of reference, most studies focused on the trait of AFC, while the CBFS and CBFDO traits were compensated as the number of services per conception (NSC), making it difficult to compare and extrapolate the last two traits. Anyway, comparing with related studies, estimates of AFC trait reached 25 months at Lopez et al. (2019) and 29.9, 30.9, 30.7 and 13.2 months at Hammoud et al. (2010) in winter, spring, summer, and fall respectively. Kumar et al. (2016) reported the 25.26 months and 36 months as values for AFC and CBFS traits respectively. In general, in the current study, a match in the direction of the results was observed for the studied traits in the maximum and minimum levels for each studied factor, this reveals to a serious positive correlation among those traits, which the care of inseminations (natural mating) by the farm operators may be one of the most important reasons. Relatively, unlike other factors effects, the bilateral interaction between the year of birth and total milk production levels was somewhat contrasting (Table 4), where the periods of the three traits (CBFS, CBFDO, and AFC) decreased in the year 2000 at<5000 kg TMYL and rose in 2003 at>5300 kg TMYL. In addition to previous reasons, total milk yields at the first lactation parity give an imagination of the ability of cows and their genetic complementarity for production in subsequent parities. However, many factors limit the productivity of cows in the first lactation parity, especially the physiological factors that relate to the structure, growth, and readiness of the udder (Monteiro et al., 2016). According to farm factor (herd), the noticed insignificance differences in studied traits can be attributed to the inconsistent ages in which insemination (mating) occurs, also, this can be attributed to the size of the herd and the level of reproductive care applied (Weigel and Rekaya, 2000). Estimates of the heritability in the current study indicate the importance of the genetic variation of the studied traits and their important role in the genetic selection programs applied in parallel with the integration in the successful management of the herd across all aspects (nutrition, health and reproductive cares). The low values of the heritability coefficient, no doubt, are due to the superiority in the phenotypes variations of the different traits associated with each other. It was clear that the heritability coefficient value of AFC trait was lower than the coefficients of CBFS and CBFDO traits, whereas the AFC is affected by many environmental factors, these factors have an unequal effect on animals. For example, not limited to, estrus loss (heat), the efficacy of the person performing the insemination process, the date of insemination, climatic conditions, all of these factors lead to increased phenotypic variation of the various traits and thus a decrease in the heritability. In a study conducted by Oyama et al. (2002), the heritability value of AFC trait reached 0.21, while this value reached 0.32 in a study conducted by Ali et al. (2019). Heritability value of CBFS in the current study was lower than the value attained by Sarar and Tabkı. (2017) (0.30). The wide dispersion in the EBV_S and genetic merit of the studied sires in the current study, is due to the additive genetic effects, in another word; the variation of sire transmitting ability (STA). In some cases, as shown in Table 5, it was noticed that some sires excelled in a trait and regressed in other (sires with the numbers 18 and19). Consequently, the basis upon which genetic improvement programs are based is knowledge of the breeding values in sires for the traits to be improved so that the required genetic structures can be diagnosed and optimized for optimal genetic improvement. By linking the studied reproductive traits and random effects, it is noted that most studies are interested in studying the random effect of the sire, due to two main reasons. The first reason relates to the accuracy of the measurement and the other reason is related to artificial insemination strategy (AI), where the sire inseminates a large number of females (El-Awady et al., 2011). As a result, it is important to pay attention to studying the reproductive traits and finding breeding values based on the actual relationship of the genetic component of the sire and its daughters (El-Bayoumi et al., 2015).

CONCLUSION

Within the Syrian climatic conditions, through the link between the season and the year of birth, there was a clear improvement in the traits of CBFS, CBFDO, and AFC in the winter and spring seasons. These differences led to a clear genetic variation that can be exploited in the genetic improvement processes through selection programs.

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