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Genetic and non-genetic features of female gender determination in Friesian calves as replacements under Egyptian farm conditions

Shereen K. Genena

Animal Production Research Institute, Agricultural Research Center, Dokki, Giza, Egypt.

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***Correspondence:**

Corresponding author: Shereen K. Genena
E-mail address: genena71@yahoo.com

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ABSTRACT

This study aimed to address the genetic and environmental features that affect the calf's sex in dairy farms, which favors female birth for extra milk production and efficient replacements. A total of 4913 calves' records from 1047 Friesian cows collected at Sakha dairy farm between 1975 and 2020 were analyzed to estimate genetic parameters and various environmental effects on calf gender, including year and season of mating, first calving year, gestation length, parity, service period, and number of services per conception. Variance components, heritabilities, and repeatability values were estimated using the THRGIBBS1F90 program based on Gibbs sampling. The results showed highly significant effects of the season ($P < 0.001$) and year of mating, gestation length ($P < 0.01$), and the others ($P < 0.05$) on calf gender. For female birth, direct (h^2_a), sire (h^2_s), and dam (h^2_m) heritability and repeatability estimates are 0.13- 0.16, around 0.12, 0.09, and 0.15-0.18, respectively. Short gestational length, few services per conception, plus first and fifth parties were the main predictors of female births. Moderate estimates of female birth and sire heritability demonstrate that genetic manipulation can change additive genetic variability. With only 0.15-0.18% confidence, the moderate repeatability estimates of female birth indicated that previous calf sex can influence calf gender in subsequent pregnancies. By manipulating some management techniques in addition to genetic parameters in dairy cows before mating, it is possible to change the gender proportion of fresh births to a preferred value.

Introduction

On dairy farms, herdsmen generally desire to have more female births to increase profits from more milk production and a large number of heifer replacements to ensure using the best of them to improve the genetic basis of the breeding stock. It was confirmed to be more essential for modern dairy herds to produce more females than males, since it is more necessary for milk production and herd replacement (Yilmaz *et al*., 2010; Sawa *et al*., 2014; Khan *et al*., 2015). Also, Khan *et al*. (2012); Hossein-Zadeh (2012) and Guta (2021) stated that altering the natural sex ratio in cattle is financially attractive since high female birth rates are advantageous and remain a main feature of economic magnitude in commercial dairy cattle production. Moreover, Khan *et al*. (2012) revealed that modifying the gender ratio can effectively improve genetic advancement plans and selection efficiency.

The dairy industry, which values female birth, is interested in understanding the influence of various factors that determine the sex of calves (Hohenbrink and Meinecke-Tillmann, 2012). The findings of Demüral *et al*. (2007); Yilmaz *et al*. (2010) and Mahmoud *et al*. (2019) who discovered that the gender ratio was influenced by a variety of factors like season and climate (Roche *et al*., 2006a; Hossein-Zadeh, 2012), sire, damage, stress, the season of birth, year, lactation number, fecundation time, management situations, and residents' demography. The associated factors for female birth are dietary management (Stolkowski and Choukroun, 1981), body situation score plus parity (Roche *et al*., 2006b), and length of dry days (Metin- Kıyıcı *et al*., 2022). Furthermore, Kaygisiz and Vanli (2008) and Wata (2012) discovered that various variables, including strain, birth rate, cow age, parity, milk production, pregnancy timing, season, internal housing, weather, and herd management, can affect the determination of a calf's sex. Moreover, Healy *et al*. (2013) recognized that the main predictors of calf gender are semen type, pregnancy period, and the service sire.

An effective breeding technique and a successful genetic evaluation for the sex ratio, both of which are currently under development, involve the estimation of variance components as well as heritability (Xu *et al*. 2000; Roche *et al*. 2006a and b; Berry *et al*. 2011 and Hossein-Zadeh 2012; 2014). Exploiting genetic deviation in sex proportion can yield benefits of sex dimorphism for essential traits, which may promote the strength and return of selection for females, while also diminishing replacement costs.

The objective of the current study was to evaluate the combination of genetic aspects and environmental factors that are responsible for variations in female calf gender determination in Friesian births.

Materials and methods

Ethics approval

This work was achieved in agreement with the dairy cattle breeding research division in the Animal Production Research Institute (APRI), Agricultural Research Center, Dokki, Giza, Egypt.

Dataset

Data were collected from one Frisian experimental herd, Sakha, related to the Animal Production Research Institute, the Agriculture Ministry, and Land Reclamation. The material set used in the current study was for 4913 calf records born from 1975 to 2020. The calf gender was categorized into males and females. The males were donated as 0 and the females as 1. The number of animals available for analysis is presented in Table 1.

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Table 1. Number of animals available for analysis.

Item	Number of record
Base animals (without pedigree)	464
Non-base animals (with pedigree)	1608
All animals	2072
Sires	211
Dams	1047
Calf gender	4913

Statistical analyses

The genmod process (logistic regression) of SAS (2014) was applied to test the significance of the environmental effects: season of mating (SM, 2 levels), year of mating (YM, 5 levels), year of first calving (YFC, 5 levels), gestation length (GL, 3 levels), parity (PR, 6 levels), service period (SP, 7 levels) and the number of services (NSP, 7 levels). Details about the levels of environmental effects are grouped in Table 2.

The model used in the present study included the fixed effects (SM, YM, YFC, GL, PR, SP and NSP).

$\text{Log}\ [p_i/1\text{-}p_i] = \alpha + \beta_0 + \beta_{1x1i} + \beta_{2x2i} + \beta_{3x3i} + \beta_{4x4i} + \beta_{5x5i} + \beta_{6x6i} + \beta_{7x7i} + \varepsilon$

Wherever,

P_i= the ratio with gender concerning observance i,

α= the effect of the intercept term.

x_{1i}= the fixed effect of mating season (i= 1, 2) for observation i,

x_{2i}= the fixed effect of year of mating (i= 1, 2…5) for observation i,

x_{3i}= the fixed effect of the year at first calving (i= 1, 2…5) for observation i,

x_{4i}= the fixed effect of gestation length (i= 1, 2, 3) for observation i,

x_{5i}= the fixed effect of parity (i= 1, 2…6) for observation i,

x_{6i}= the fixed effect of service period (i= 1, 2…7) for observation i,

x_{7i}= the fixed effect of the number of services per conception (i= 1, 2…7) for observation i,

$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5, \beta_6, \beta_7$ are regression co-efficient.

ε=error term.

The threshold animal models, including the aforementioned fixed effects and the random effects, were used; direct additive, dam, sire, and stable environmental and residuary influences were all present in the model. A Bayesian method by THRGIBBS1F90 software (Tsuruta and Misztal, 2006) was used for calculating variance components and heritability. The Gibbs sampling algorithm contains 1000000 reiterations, discarding the first 100000. Following that, single sections in each 50 were saved, and the POSTGIBBSF90 software package was used to acquire the aspects of the significance of the margins for subsequent classifications (Tsuruta and Misztal, 2006).

Two models were used in the present study. The first model was used for the aforementioned fixed effects, and the random effects; the pattern contained direct additive, dam, sire, constant environmental and remaining effects and was described as

y = Xb + Za + Km + Ws + Npe + e, and (model 1)

$$var\begin{bmatrix} a \\ m \\ s \\ pe \\ e \end{bmatrix} = \begin{bmatrix} \boldsymbol{A\sigma^2 a} & \boldsymbol{A\sigma^2 am} & \boldsymbol{A\sigma^2 as} & 0 & 0 \\ \boldsymbol{A\sigma^2 am} & \boldsymbol{A\sigma^2 m} & 0 & 0 & 0 \\ \boldsymbol{A\sigma^2 as} & 0 & \boldsymbol{A\sigma^2 s} & 0 & 0 \\ 0 & 0 & 0 & \boldsymbol{I_i\sigma^2 pe} & 0 \\ 0 & 0 & 0 & 0 & \boldsymbol{I_i\sigma^2 e} \end{bmatrix}$$

Wherever,

y: a vector of samples, b: a vector of fixed effects with an occurrence matrix X, a: a vector of randomly animal effects with an occurrence matrix Z, m: a vector of randomly dam effects with an occurrence matrix K, s: a vector of sire effects with an occurrence matrix W, pe: a vector of randomly constant environmental effects of animals with an occurrence matrix N, and e: a vector of randomly remaining effects.

A is the numerator relation matrix among animals, I is an identification matrix, σ^2_a is direct additional genetic variation, σ^2_m is dam additional genetic variation, σ^2_{am} is the direct x dam genetic covariate, σ^2_s is paternal variation, σ^2_{as} being the direct x paternal genetic covariate, σ^2_{pe} is animal constant environmental variation and σ^2_e is error variance.

The second model was applied without dam effect and can be described as:

y = Xb + Za + Ws + Npe + e, and (model 2)

$$var\begin{bmatrix} a \\ s \\ c \\ e \end{bmatrix} = \begin{bmatrix} \boldsymbol{A\sigma^2 a} & \boldsymbol{A\sigma^2 as} & 0 & 0 \\ \boldsymbol{A\sigma^2 as} & \boldsymbol{A\sigma^2 s} & 0 & 0 \\ 0 & 0 & I_d\boldsymbol{\sigma^2 pe} & 0 \\ 0 & 0 & 0 & \boldsymbol{I_i\sigma^2 e} \end{bmatrix}$$

Wherever,

y: a vector of samples, b: a vector of fixed effects with an occurrence matrix X, a: a vector of randomly animal effects with an occurrence matrix Z, s: a vector of sire effects with an incidence matrix W, pe: a vector of animal randomly stable environmental effects with an incidence matrix N, and e: a vector of randomly error effects. The symbols inside the matrix were explained previously.

Results

Factors affecting calves' gender determination

Effect of the season of mating (SM)

SM exhibited highly significant effects ($P<0.001$) on calf gender determination, especially for male births (Tables 2, 3).

Effect of year of mating (YM)

YM showed significant effects ($P< 0.01$) on calf gender proportions (Tables 2, 3) and the proportions of female births increased from 1974 to 1993 ($P <0.01$), while those of male births increased from 1994 to 2019.

Effect of year of first calving (YFC)

Tables 2, 3 evidence of significant ($P<0.05$) effects of YFC on variation in calve gender determination. The proportion of female calves increased from 1975 to 1984 and from 1995 to 2004 compared to other years of first calving.

Effect of gestation length (GL)

The relationship between GL and calves' gender was significant ($P<0.01$) (Table 3). The frequency of female births was significantly higher as compared to the male counterparts (53% vs. 47% for GL under 270 days), as presented in Table 2. The chances of female birth increased in dams with a GL of <270 days ($P<0.05$) as compared to those with a GL of 270–290 days or more.

Effect of parity (PR)

Our present study (Table 2) revealed that heifers had a greater female birth ratio than cows, with a significant effect ($P<0.05$) of PR on the calf gender rate.

Effect of service period (SP)

The influence of the service period ($P< 0.05$) on calve sex was significant, and as it increased, the probability of giving a male birth increased (Table 3).

Effects of the number of services per conception (NSP)

As presented in Table 3, a significant influence ($P<0.05$) of NSP on calve sex was detected. Furthermore, Table 2 demonstrated that for one service per conception, the proportion of female births was higher than that of males, and as NSP increased, the probability of male births increased.

Variance components and genetic parameters for female birth

As shown in Table 4. The estimates of direct genetic variance σ^2_a; sire variance σ^2_s; dam variance σ^2_m; perpetual environmental variance σ^2_{pe} and phenotypic variance σ^2_p for female births were 0.04; 0.04; 0.03; 0.01 and 0.32, respectively, and the corresponding values in Table 5, except for the contribution of dam variance were 0.05; 0.04;0.01 and 0.34, respectively.

Heritability (h^2) and repeatability (R) estimates

The direct (h^2_a) and sire (h^2_s) heritability estimates for female birth were (0.13± 0.05; 0.16± 0.03) and (0.11± 0.03 and 0.12± 0.02), respectively. The maternal heritability estimate h^2_m was 0.09±0.04. The R estimates were between 0.15±0.05 and 0.18±0.04 (Tables 4 and 5).

Discussion

The highly significant effects ($P< 0.001$) of SM on calf sex determination, agreed with the results of Roche *et al.* (2006a); Demüral *et al.* (2007); Faraidoon *et al.* (2014); Shekalgorabi *et al.* (2017) and Sharma *et al.* (2018). While Hohenbrink and Tillmann (2012); Khan *et al.* (2015) and Arega and Chalchissa (2019), found a non-significant SM effect on calf sex. Earlier studies (Roche *et al.*, 2006a and b) supported the impact of the seasonal change on the sex ratio from conception to calving, and throughout the year, male births were more likely in the warmer months (Berry and Cromie, 2007).

Our explanation regarding the high numbers of males within the two seasons of mating could be due to the fact that male embryos resist temperature and climatic fluctuations more than female embryos. Moreover, Parikh *et al.* (2021) stated that the variation in female births in different calving seasons might be associated with large differences in climate within a season. According to Roche *et al.* (2006a), males were more likely to be born after periods of higher climate heat, and this increased with the rise in air temperature and humidity around the time of conception. Mahmoud *et al.* (2019) pointed out that increasing male calf births during the warm or very cold breeding months elucidate the male zygotes' impedance to the negative consequences of heat and weather fluctuations on cows.

While Redda (2000) reported that, although cows exhibit estrus

Table 2. The significance of the environmental factors affecting calf gender and the number of males and females in each factor level in Sakha farm.

Factors	Levels	Male	Female	Total	P value
SM	1 (10, 11, 12, 1, 2,3)	1147	1127	2274	(P<0.001)
	2 (4, 5, 6, 7, 8, 9)	1348	1291	2639	
YM	1 (1974 to 1983)	348	376	724	(P<0.01)
	2 (1984 to 1993)	524	528	1052	
	3 (1994 to 2003)	861	832	1693	
	4 (2004 to 2013)	468	460	928	
	5 (2014 to 2019)	294	222	516	
YFC	1 (1975 to 1984)	447	472	919	(P<0.05)
	2 (1985 to 1994)	603	588	1191	
	3 (1995 to 2004)	768	775	1543	
	4 (2005 to 2014)	447	385	832	
	5 (2015 to 2020)	144	118	262	
GL (day)	1 (< 270)*	410	460	870	(P<0.01)
	2 (270-290)*	1840	1736	3576	
	3 (> 290)	245	222	467	
Parity	1 (1st)	750	754	1504	(P<0.05)
	2 (2n)	590	562	1152	
	3 (3rd)	420	418	838	
	4 (4th)	297	288	585	
	5 (5th)	176	181	357	
	6 (>5th)	262	215	477	
SP (day)	1 (20 to 70)	385	346	731	(P<0.05)
	2 (71 to 120)	264	233	497	
	3 (121 to 170)	203	159	362	
	4 (171 to 220)	122	116	238	
	5 (221 to 270)	75	73	148	
	6 (271 to 320)	58	53	111	
	7 (> 320)	134	115	249	
NSP (No. of service)	1*	737	806	1543	(P<0.05)
	2*	514	455	969	
	3*	311	258	569	
	4	194	168	362	
	5	115	114	229	
	6	69	65	134	
	7 (>6)	44	40	84	

SM: season of mating; YM: year of mating; YFC: year of first calving; GL: gestation length; SP: service period; NSP: No. of services per conception; *= ($p<0.05$).

Table 3. Marginal effects of factors influencing gender determination in Egyptian Friesian calves.

Environmental factors	Estimate marginal effects ±SE							Value χ^2	*p*-values
SM	1	2							
	1.25 ± 0.01^{a}	1.01 ± 0.02^{b}						12.84	0.00
YM	1	2	3	4	5				
	1.35 ± 0.05^{a}	1.06 ± 0.06^{c}	1.19 ± 0.07^{b}	1.17 ± 0.02^{b}	1.39 ± 0.03^{a}			131.21	0.00
YFC	1	2	3	4	5				
	1.46 ± 0.02^{a}	1.34 ± 0.03^{b}	1.23 ± 0.04^{c}	1.32 ± 0.06^{b}	0.82 ± 0.03^{d}			209.31	0.02
GL (Days)	1	2	3						
	1.13 ± 0.02^{b}	1.30 ± 0.05^{a}	1.26 ± 0.03^{a}					133.34	0.01
PR	1	2	3	4	5	6			
	1.22 ± 0.02^{b}	1.00 ± 0.02^{d}	1.13 ± 0.03^{c}	1.06 ± 0.04^{c}	1.33 ± 0.05^{b}	1.66 ± 0.01^{a}		415.13	0.02
SP (Days)	1	2	3	4	5	6	7		
	1.11 ± 0.01^{c}	1.20 ± 0.01^{b}	1.32 ± 0.02^{a}	1.28 ± 0.02^{a}	1.29 ± 0.02^{a}	1.29 ± 0.01^{a}	1.35 ± 0.02^{a}	189.77	0.05
NSP	1	2	3	4	5	6	7		
	-0.02 ± 0.04^{d}	-0.006 ± 0.05^{d}	0.01 ± 0.07^{c}	0.03 ± 0.09^{c}	0.23 ± 0.01^{a}	0.13 ± 0.09^{b}	0.12 ± 0.01^{b}	508.12	0.05

SM: Season of mating; YM (1 (mo.10, 11, 12, 1, 2, 3), 2 (mo.4, 5, 6, 7, 8, 9); Year of mating (1 (1974 to 1983), 2 (1984 to 1993), 3 (1994 to 2003), 4 (2004 to 2013), 5 (2014 to 2019); YFC: Year of first calving (1 (1975 to 1984), 2 (1985 to 1994), 3 (1995 to 2004), 4 (2005 to 2014), 5 (2015 to 2020)); GL: Gestation length (1 (< 270 days), 2 (270-290 days), 3 (> 290 days)); PR: Parity (1 (1st PR), 2 (2nd PR), 3 (3rd PR), 4 (4th PR), 5 (5th PR),6 (>5th PR and above); SP: Service period :(1 (20 to 70 days), 2 (71 to 120 days), 3 (121 to 170 days), 4 (171 to 220 days), 5 (221 to 270 days), 6 (271 to 320 days), 7 (> 320 days)); NSP: Number of services per conception (1 (1 serv.), 2 (2 serv.), 3 (3 serv.), 4 (4 serv.), 5 (5 serv.), 6 (6 serv.), >6 (>6 serv.).

Table 4. Means and standard deviations (SD) for variance components and genetic aspects for female birth in Sakha farm.

Items	Posterior mean	SD
σ^2_a	0.04	
σ^2_s	0.04	
σ^2_m	0.03	
σ^2_{Pe}	0.01	
σ^2_e	0.21	
σ^2_P	0.32	
h^2_a	0.13	0.05
h^2_s	0.11	0.03
h^2_m	0.09	0.04
R	0.15	0.05

σ^2_a = direct additive genetic variance; σ^2_s = sire genetic variance; σ^2_m = dam genetic variance; σ^2_{pe} = perpetual environmental effect; σ^2_e = remaining variance; σ^2_P = phenotype variance; h^2_a = direct heritability; h^2_s = sire heritability; h^2_m = dam heritability; R = repeatability; SD: standard deviation.

Table 5. Means and SD for variance components and genetic aspects for female birth without dam effects in Sakha farm.

Items	Posterior mean	SD
σ^2_a	0.05	
σ^2_s	0.04	
σ^2_{Pe}	0.01	
σ^2_e	0.23	
σ^2_P	0.34	
h^2_a	0.16	0.03
h^2_s	0.12	0.02
R	0.18	0.04

σ^2_a = direct additive genetic variance; σ^2_s = sire genetic variance; σ^2_{pe} = perpetual environmental effect; σ^2_e = remaining variance; σ^2_P = phenotype variance; h^2_a = direct heritability; h^2_s = sire heritability; R = repeatability; SD: standard deviation.

during the rainy season and the spring, they are less resilient to the impacts of the weather, have poor energy stability, and have a tendency to have more female calves. Furthermore, Hudson *et al.* (2012) and Guta (2021) demonstrated that forage and food availability fluctuate over time as do the ecological stressors and illness occurrences that may cause selected miscarriages, desiring one gender more than others. Further supporting Trivers and Willard (1973) theory that the advantage of a deviating gender proportion occurring once a dam can expand her condition across her progeny, depends on her current fitness and the outer environmental hindrance, dams in good situations are more likely to deliver males, while dams in poor situations are more likely to deliver females. Qureshi (2004) and Delesa *et al.* (2014) discovered that hormonal imbalance results in more abortions of male than female embryos, favoring a greater proportion of female births.

The current variations in proportions of female and male births through different YM (P <0.01), most likely because feed scarcity stress causes the number of male births to be less than that of female births during certain years of mating (Guta, 2021). Moreover, the significant influences (P< 0.01) of YM on calf gender ratios were matched with the findings of Shekalgorabi *et al.* (2017) and Sharma *et al.* (2018), who indicated a considerable influence of the insemination year on the calf sex ratio. According to Delesa *et al.* (2014), cows showing estrus through the rough periods of the year give birth to additional females. Hence, by controlling management tools at a standard stage during the tough times of the year, the calf gender proportion could be altered. Moreover, after a week of high temperatures prior to conception, there is a higher occurrence of male births, according to Roche *et al.* (2006a). However, Foote (1977) and Arega and Chalchissa (2019) concluded that breeding years had no effect on gender births.

The significant (P<0.05) effects of YFC on variation in calve gender determination were in conformity with the results of Farahvash *et al.* (2008) and Sawa *et al.* (2014) for females born and of Hossein-Zadeh (2012); Goshu and Singh (2013) and Guta (2021) for males and females born. According to Guta (2021), the management practices from the previous year may have had an impact on the sex proportion of calves born in different YFCs. Berry and Cromie (2007) reported a significant (P<0.01) relationship between the calving year and the gender ratio. While Roche *et al.* (2006a); Kaygisiz and Vanli (2008); Hossein-Zadeh *et al.* (2012) and Parikh *et al.* (2021) proved there was no significant difference between genders due to YFC.

Female birth increased in dams with a GL of <270 days (P<0.05) as compared to the other lengths of GL and confirming the findings of Parikh *et al.* (2021) who stated that with GL at <275 and 275–290 days, the probability of female birth improved by 2.25 (P = 0.001) and by 2.27 times (P = 0.001), respectively, compared to the period of GL >290 days. The current significant (P<0.01) relationship between GL and calve gender was, supported by the findings of Healy *et al.* (2013); Sawa *et al.* (2014); Shekalgorabi *et al.* (2017); Sharma *et al.* (2018); Ryoung and Gyu

(2019); Rezende *et al.* (2020) and Parikh *et al.* (2021) that GL is the main predictor of calf sex and fetal growth in male calves prolongs GL significantly ($P<0.001$).

Likewise, according to Ryoung and Gyu (2019), there was a significant variance in calf gender ($P<0.05$) between male and female births, with GL periods of 284.6 and 280.3 days, respectively. Sawa *et al.* (2014) stated that female GL was less than males' by 1.3 and 2 days for heifers and cows, respectively. According to Silva *et al.* (1992) and Norman *et al.* (2009), the difference in GL between cows and heifers varied from 0.3 to 1.8 days. A positive relationship existed between GL and the calf birth weight, with GL being 1.1 (Silva *et al.*, 1992) to 2.0 days (Hayr *et al.*, 2015) longer for male calves. Holland and Odde (1992) explained that a significant quantity of testosterone hormone secretion begins at 45 days of pregnancy and extends to its peak at 70 days. Androgen receptors in muscle cells and tissues stimulate growth during embryonic life, resulting in weight differences between genders. Moreover, additional embryonic growth in male births lengthens GL (Rezende *et al.*, 2020). On the other hand, studies by Gowda *et al.* (2019) and Srivastava *et al.* (2020) revealed no association between GL and the gender of born calves.

In the current study, heifers had a bigger female birth ratio than cows, confirming the findings of Sawa *et al.* (2014); Baradar *et al.* (2019) and Parikh *et al.* (2021). However, Delesa *et al.* (2014) declared that young heifers and dams in their 2nd, 4th, and 5th lactations resort to giving more female births. In the current study, the fifth PR had the highest ratio of female births (51%), which complied with the findings of Goshu and Singh (2013). However, the other parties from the 2nd to the 4th had the highest proportion of males, which was consistent with the results of Guta (2021) and Berry and Cromie (2007), who stated that older dams had a significantly ($P <0.05$) higher chance of having male offspring than younger ones.

The present study shows a significant effect ($P<0.05$) of PR on calf gender rate in accordance with those reported previously (Demüral *et al.*, 2007; Hossein-Zadeh, 2012) on female births in the first 3 parities and for both female and male births ($P<0.05$ and $P<0.01$), respectively, by (Goshu and Singh, 2013; Sawa *et al.*, 2014; Delesa *et al.*, 2014; Baradar *et al.* 2019 and Guta, 2021).

However, Roche *et al.* (2006a); Kaygisiz and Vanli (2008); Yilmaz *et al.* (2010); Hossein-Zadeh *et al.* (2012); Hohenbrink and Meinecke-Tillmann (2012); Arega and Chalchissa (2019) and Srivastava *et al.* (2020) found a non-significant effect of PR on calf sex. Also, Parikh *et al.* (2021) demonstrated that PR had no effect on sex ratio, but that female calves born in the 5th PR (56.18%), followed by the 1st (51.24%) and 2nd (49.85%) parties, had the highest ratio. According to Skjervold and James (1979), no clear PR trend existed for gender ratio, but the probability for young cows to give male calves was lower in the first and second pregnancies. Meanwhile, Redda (2000) proposed that dams in weak physical conditions or with few supplies would be fortunate in strongly enhancing the most stable sex in reproduction (females).

The significant influence of service period ($P< 0.05$) on calve sex and the high probability of giving a male birth as it increased were confirmed by Khan *et al.* (2012) and Sawa *et al.* (2014). Sawa *et al.* (2014) indicated that heifer pregnancies showed better fertility with 2 days shorter in SP, regardless of age. While Córdova-Izquierdo *et al.* (2008) discovered that cows giving female births have an 11-day longer DO than those giving male births. Moreover, the significant effect ($P<0.05$) of NSP on calve sex was approved by the studies of Sawa *et al.* (2014). The current results showed that the probability of female births was higher than that of male births for cows conceiving after one service, and as it increased, the ratio of male births increased. Confirming the findings of Michael *et al.* (2005), who stated that the production of a higher proportion of male births increased as the NSP increased from 1 to 5. While, according to Abdalla *et al.* (2014), 88% of female births in Holstein heifers that did not conceive for the first time, were bred after three inseminations.

Moreover, a variety of factors, including uterine and vaginal pH, oocyte growth, and the artificial insemination period, have been proposed to affect the gender ratio (Pursley *et al.*, 1998). According to Trivers and Willard (1973) theory, mutinous females can improve their strength by tilting the gender ratio of their offspring.

Furthermore, the high values of phenotypic variance (σ^2_p) for female birth indicate that environmental effects contributed to a large part of the variation in this trait. As a result, manipulating management practices may modify the calf sex ratio and make it easier to replace calves that can be selected to improve the rate of genetic gain. Our results of σ^2_p of female birth (0.32 and 0.34), were higher than the 0.25 reported by Hossein-Zadeh (2012; 2014), who stated that a large amount of variation (non-additive genetic effects) in female birth was mostly delivered by the environmental effects. Likewise, Hossein-Zadeh (2012) declared favorable genetic and phenotypic trends for females.

The proportion of female births obtained by Parikh *et al.* (2021) ranged from 22.22 to 90.00% ($P<0.05$), and variations in the sex ratio of dairy sires have been documented in previous studies (Berry *et al.*, 2011; Hossein-Zadeh, 2012). Moreover, Goshu (2017) and Sharma *et al.* (2018) proved that sires had a significant effect on the sex proportion ($P<0.01$) and on the ratio of female births up to age at first calving ($P<0.001$). Also, the impregnating sire had a meaningful effect on the sex proportion (Yilmaz *et al.*, 2010; Healy *et al.*, 2013 and Shekalgorabi *et al.*, 2017). In contrast to the current findings, Arega and Chalchissa (2019) found that the inseminating sire line and among different sires had no effect on the sex of born calves.

Greater estimates for h^2_a and h^2_s were obtained compared with dam contribution, which was evaluated to avoid biasing in h^2_a of the female trait (Table 4) in the analysis. This bias could be attributable to specific sires having daughters with constantly low or superior genital capacity, hence raising the proportion of among-sire to within-sire variations (Matos *et al.*, 1997). Furthermore, some non-genetic factors related to fertility traits may be allocated into sire variation in the pattern, suggesting the potential for implementing genetic selection for that trait with a greater response to improving milk production and reducing replacement costs in dairy farms. Current findings revealed that the direct h^2_a of female calves was greater than their h^2_s and h^2_m (Hossein-Zadeh, 2014), suggesting that, the animal effects may have a stronger impact on the genetic variation of female traits than paternal and maternal effects.

Direct h^2_a values of 0.13 and 0.16 were near the results of 0.10 and 0.15, respectively, by Goshu and Singh (2013) and Hossein-Zadeh (2014); lower than 0.48 by Hossein-Zadeh (2014) using the threshold analysis, but higher than 0.00004 to 0.001 by Hossein-Zadeh (2012) and 0.02 by Xu *et al.* (2000); Berry *et al.* (2011); and Pandey *et al.* (2016). Furthermore, the maternal heritability estimates h^2_m 0.09 ± 0.04 was nearly identical to 0.10 (Hossein-Zadeh, 2014), but lower than 0.27 by using threshold analysis by the same author.

Moreover, Kaygisiz and Vanli (2008) and Kumar *et al.* (1993) reported that h^2 estimates for the male birth sex ratio were around 0.06 ± 0.09, but less than the range (0.10 - 0.43) recorded by Tomar and Tripathi (1988) and Rawal and Tomar (1995). According to Goshu and Singh (2013), the low h^2 estimates for the sex ratio could be due to the chance factor, which causes variation primarily from the non-heritable effect of haphazard combinations of gametes during calf gender determination.

The moderate repeatability estimates of female calf gender indicated that the female trait is affected by permanent environmental effects such as uterine biological influences, feeding intensity during the final stage of gestation, and the dam's maternal performance (Snyman *et al.* 1995). Furthermore, Xu *et al.* (2000) and Hossein-Zadeh (2012; 2014) stated that the R-value of calf gender is mostly provided by the dam's stable ecological influences, and improving this trait is associated with improving environmental conditions.

The present R estimates (0.15 and 0.18) were in accordance with the 0.17 obtained by Hossein-Zadeh (2014) from a linear animal model and lower than 0.52 using the threshold animal model analysis, but higher than the range of 0.04 to 0.07 reported by Tomar and Tripathi (1988); Kaygisiz and Vanli (2008) and Goshu (2017). Explaining that previous calf sex had an impact on predicting calf sex in subsequent pregnancies with 15–18% accuracy. While low R values have been observed by Mukherjee *et al.* (2000) and Singh *et al.* (2002).

Conclusion

The present study emphasizes the significant influence of the studied environmental factors on variations in calf sex determination. According to the investigation, short gestation length, few numbers of services per conception, and both first and fifth parities were the main predictors of female calf birth. Reflecting that the mother's situation throughout insemination and gestation is an important element in determining the offspring's gender. The estimates of heritability indicate that there is sufficient additive genetic variance affecting this trait to implement genetic selection with greater intensity for the female birth rate and, as a result, greater progress in improving milk production with efficient replacements. Moderate repeatability estimates of female births indicated that the sex of the previous calf could influence the calf's sex in the subsequent pregnancy with only 15–18% confidence. This will give dairy breeders the option of selecting within high potency dams and delivering new replacement calves only from the best-inherited cows, which will become an important part of selection goals. It is possible to alter the gender ratio of fresh calf births to a preferred value by regulating several management practices to a standard level and within certain parameters in dairy cows prior to mating.

Conflict of interest

The author declares no conflict of interest related.

References

Abdalla, H., Ali, M.A., El-Tarabany, MS., 2014. Fertility of commercial sexed semen and the economic analyses of its application in Holstein heifers. Advances in Anim. and Vet. Sci. 2, 535-542.

Arega, A., Chalchissa, G., 2019. Calves sex ratio in artificial and naturally bred cattle at Adami Tulu agricultural research center. J. of Biology Agriculture and Healthcare 9, 1-5.

Baradar, M.A., Karimi, K., Tabatabaei, S.H., 2019. Investigation of the relationship between some productive and reproductive factors with calf sex in dairy cattle. Anim. Prod. 20, 641-648.

Berry, DP., Cromie, AR., 2007. Artificial insemination increases the probability of a male calf in dairy and beef cattle. Theriogenology 67, 346 –352.

Berry, D.P., Kearney, J.F., Roche, J.R., 2011. Evidence of genetic and maternal effects on secondary sex ratio in cattle. Theriogenology 75, 1039-1044.

Córdova -Izquierdo, A., Xolalpa Campos, V.M., Gustavo Ruiz Lang, C., Saltijeral Oaxaca, J.A., Cortes Suarez, S., Cordova-Jimenez, C.A., Cordova-Jimenez,M.S.,Pena Betancurt, S.D., Guerra Liera, J.E., 2008. Effects of the offspring`s sex on open days in dairy cattle. J. of Anim. Vet. Advances 7,1329-1331.

Delesa, EK., Yohannes, A., Alemayehu, M., Samuel, T., Yehualaeshet, T., 2014. Calves' sex ratio in naturally and artificially bred cattle in central Ethiopia. Theriogenology 82, 433-439.

Demüral, O., Ün, M., Abay, M., Bekyürek, T., 2007. The effect of artificial insemination timing on the sex ratio of offspring and fertility in dairy cows. Turk. J. Vet. Anim. Sci. 311, 21-22. Faraidoon, A.M., Amin, T., Ali, G.M., Burhan, S.M., Sherawan, M.A., 2014. Effect of season, number of service and station on conception rate and calf sex for dairy cow in Sulaimania region .The Iraqi J. of Vet. Medicine 38, 28-34.

Farahvash, T., GolzarAdabi, SH., Ahmadzadeh, A., Davoodi, J., 2008.Some factors affecting sex ratio of dairy herds in east Azarbijan. Iran. Asian J. Anim. Vet. Advances 3, 357-362.

Foote, RH., 1977. Sex ratios in dairy cattle under various conditions. Theriogenology 8, 349-356.

Gowda, A., Shankare, J., Honnappa, TG., Nagaraju, CS., Devaraj, M., Krishnaswamy, A., 2019. Influence of different climatic seasons, order of lactation, sex of calf and sex ratio on gestation period in Holstein-Friesian upgraded cows. The Pharma Innovation J. 8, 516-518.

Goshu, G., Singh, H., 2013. Genetic and non-genetic parameters of replacement rate component traits in Holstein Friesian cattle. SpringerPlus 2, 581.

Goshu, G., 2017. Genetics of threshold characters and distribution cow calving traits in Holstein Friesian cattle at Holeta bull dam station. Ethiopia. J. Vet. Sci. Technol. 8,

Guta, D., 2021. Evaluation of reproduction performance and calf sex ratio of dairy cattle in selected locations of South-East Oromia. J. Agric. Sci. Food Techno. l7, 170-192.

Hayr, M.K., Hess, A.S., Garrick, D.J., 2015. Impact of including calf gender in models to predict breeding values for lactation yields in dairy cattle. Anim. Industry Report 661, 1-2.

Healy, A.A., House, J.K., Thomson, P.C., 2013.Artificial insemination field data on the use of sexed and conventional semen in nulliparous Holstein heifers. J. Dairy Sci. 96, 1905–1914.

Hohenbrink, S., Meinecke-tillmann, S., 2012. Influence of social dominance on the secondary sex ratio and factors affecting hierarchy in Holstein dairy cows. J. Dairy Sci. 95, 5694–5701.

Holland, M.D., Odde, K.G., 1992. Factors affecting calf birth weight: a review. Theriogenology 38, 769-798.

Hossein-Zadeh, N.G., 2012. Factors affecting secondary sex ratio in Iranian Holsteins. Theriogenology 77, 214-219.

Hossein-Zadeh, N.G., Madad, M., Shadparvar, A.A., Kianzad, D., 2012. An observational analysis of secondary sex ratio, stillbirth and birth weight in Iranian buffaloes. J. Agr. Sci. Tech. 14, 1477-1484.

Hossein-Zadeh, N.G., 2014. Linear and threshold analysis of direct and maternal genetic effects for secondary sex ratio in Iranian buffaloes. J. Appl. Genetics, 55, 365–372.

Hudson, C.D., Bradley, A.J., Breen, J.E., Green, M.J., 2012 Associations between udder health and reproductive performance in United Kingdom dairy cows. J. Dairy Sci. 95, 3683-3697.

Wata, H. 2012. Factors affecting the primary sex ratio in cows. J. Mamm. Ova Res. 29, 96–102,

Kaygisiz, A., Vanli, Y.V., 2008. Factor influencing sex ration in Brown Swiss cattle. Indian J. Anim. Sci. 78, 656-657.

Khan, S., Qureshi, M.S., Chand, N.A., Sultan, Rafullah, I., Khan, I., Tanweer, A.J., Sohail, S.M., Hussain, M., Akhtar, A., Khan, D., 2012. Effect of breeding method on calf sex and postpartum reproductive performance of cattle and buffaloes. Sarhad J. Agric. 28, 469-476.

Khan, M. I., Jalali, S., Shahid, B., Shami, SA., 2015. Effect of artificial insemination and natural service on calf sex ratio in dairy cattle. Proceedings of the Pakistan Academy of Sci. 52, 63–66.

Kumar, A., Lavania, GS., Tomar, S.S., 1993. Genetic parameters of sex ratio in crossbred cattle. Indian J. of Dairy Sci. 46, 41-42.

Mahmoud, K.G.M., Sakr, A.M., El-Sisy, G.A., Hegazy, M.M., Nawito, M., Ezzo, O.H., 2019. Bull related factors affecting its calf sex ratio in naturally bred Egyptian native buffalo. Inter. J. Vet. Sci. 9, 149-152.

Matos, C.A., Thomas, D.L., Gianola, D., Tempelman, R.J., Young, L.D., 1997. Genetic analysis of discrete reproductive traits in sheep using linear and nonlinear models: I. Estimation of genetic parameters. J. Anim. Sci. 75, 76–87.

Metin-Kıyıcı. J, Köknur, Ö., Kaliber, M., 2022. Dry period length in dairy cattle: II. Influence on calf survival and growth performance. KSU J. Agric. Nat. 25 (Suppl 1), 300-306.

Michael, R., Murphy, R.D., Shanks, N.H., Patrice, C., Robert, C.R., 2005. Association of age at first conception, week of conception in lactation, and number of inseminations with sex ratio in Holstein cows. Theriogenology 60, 67-75

Mukherjee, K., Tomar, S.S., Singh, R.B., 2000. Variability in sex ratio in Karan Swiss cattle. Indian J. of Anim. Res. 34, 24-28.

Norman, H.D., Wright, J.R., Kuhn, M.T., Hubbard, S.M., Cole, J.B., Vanraden, P.M., 2009. Genetic and environmental factors that affect gestation length in dairy cattle, American Dairy Sci. Assoc. 5, 2259–2269.

Pandey, S., Singh, CV., Barwal, RS., 2016. Selective value, quantification and genetic parameters of components of replacement traits in crossbred cattle. Vet. Med. Open J. 1, 1-5.

Parikh, S.S., Patbandha, T.K., Makwana, R.B., 2021. Secondary sex ratio in Gir cattle and assessment of risk factors. J. Anim. Res. 11, 199-205.

Pursley, J.R., Silcox, R.W., Wiltbank, M.C., 1998. Effect of time of artificial insemination on pregnancy rates, calving rates, pregnancy loss, and gender ratio after synchronization of ovulation in lactating dairy cows. J. Dairy Sci. 81, 2139-2144.

Qureshi, MS., 2004. A review of artificial insemination status in NWFP. Proc. National Seminar on livest. Breeds Improvement, Present status, and it'sfuture.18 Dec. UVAS Lahore, Pakistan.

Rawal, S.C., Tomar, S.S., 1995. Genetic study of sex ratio in herd of Sahiwal cattle. Indian J. of Dairy Sci. 48, 311-12.

Ryoung-Hoon, J., Gyu-Jin, R.2019. Gestation length in Holstein cow depends on the number and sex of fetuses. Korean J. Vet. Res. 59, 181-185.

Redda, T. 2000. Smallholder dairying development project (SDDP) experience on rural milk collection and processing. In the role of village dairy cooperatives in dairy development. Smallholder dairy development Project (SDDP) Proceeding. Addis Ababa, Ethiopia: Min. of Agric. (MOA).

Rezende, E.V., Reis, I.J., Campos, C.C., Santos, R.M. 2020. Influence of gestation length, seasonality, and calf sex on birth weight and placental retention in crossbred dairy cows. Cienc. Anim. Brasileira, 21.

Roche, J.R., Lee, JM., Berry, D.P., 2006a. Climatic factors and secondary sex ratio in dairy cows. J. Dairy Sci. 98, 3221–3227.

Roche, JR., Lee, J.M., Berry, DP. 2006b. Pre-conception energy balance and secondary sex ratio-partial report for the Trivers-Willard hypothesis in dairy cows. J. Dairy Sci. 89, 2119-2125.

SAS, 2014. SAS User's Guide. Statistical analysis system. Institute, Inc., Cary, NC.

Sawa, A., Jankowska, M., Głowska, M., 2014. Effect of some factors on sex of the calf born, and of sex of the calf on performance of dairy cows. Acta Sci. Pol., Zootechnica 13, 75–84.

Sharma, N., Chand, DK., Rawat, S.,Sharma, M., Verma, H., 2018. Effect of sexed semen on conception rate and sex ratio under field conditions. J. of Entomology and Zoology Studies 6, 702-705.

Shekalgorabi,S., Maghsoudib,A., Reza Mansourianc, M., 2017. Reproductive performance of sexed versus conventional semen in Holstein heifers in various semiarid regions of Iran. Italian J. of Anim. Sci. 16, 666–672.

Silva, H., Wilcox, C.J., Thatcher, W.W., Becker, R.B., Morse, D., 1992. Factors affecting days open, gestation length and calving interval in Florida dairy cattle. J. Dairy Sci. 75, 288–293.

Singh, L., Kuma, R.A., Yadav, M.C., 2002. Genetics of sex ratio in Karan Friesian cattle. J. of interacademicia 6, 69-72.

Skjervold, H., James, J. W., 1979. Causes of variation in the sex ratio in dairy cattle. Z. Tierzuecht. Zuechtungsbiol. 95, 293–305.

Snyman, M.A., Erasmus, G.J., Van Wyk, J.B., Olivier, J.J., 1995. Direct and maternal (Co) variance components and heritability estimates for body weight at different ages and fleece traits in Afrino sheep. Livest. Prod. Sci. 44, 229–235.

Srivastava, A.K., Patel, J.B., Ankuya, K.J., Chauhan, H.D., Chaudhary, AP., Patel, J.K., Gupta, J.P., 2020. Non genetic factors affecting gestation length and birth weight in Kankrj cattle. Ruminant Sci. 9, 151-154.

Stolkowski, J., Choukroun, J., 1981. Preconception selection in man. Isr. J. Med. Sci. 17, 1061–1067.

Tomar, S. S., Tripathi, V.N., 1988. Inheritance of sex ration in Murrah buffaloes. Indian Vet. J. 65, 687-692.

Trivers, R. L., Willard, D., 1973. Natural selection of parental ability to vary the sex ratio of offspring. Sci. 179, 90 –92.

Tsuruta, S., Misztal, I., 2006. THRGIBBS1F90 for estimation of variance components with threshold-linear model. Proceedings of the 8th World Congress on Genetics Applied to Livestock Production, Belo Horizonte.

Xu, Z.Z., Johnson, D. L., Burton, L.J., 2000. Factors affecting the sex ratio in dairy cattle in New Zealand. Proceedings of the New Zealand Soc. of Anim. Prod. 60, 301-302.

Yilmaz, I., Eyduran, E., Kaygisiz, A., 2010. Determination of some environmental factors related to sex ratio of Brown Swiss calves. J. Anim. Plant Sci. 20, 164-169.