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Original Research

Impact of Calves Gender Birth Weights on Predicting the Future Performance of Friesian Cattle under Farm Conditions

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Abstract

A total of 4913 Friesian cows at Sakha Experimental Farm were analyzed between 1975 and 2020 to determine the effects of gender calf birth weight (CBW) on the future performance of their dams. The fixed effects of CBW classified into five groups: ≤ 25, 26-30, 31-35, 36-40 and >40kg on lactation period, total (TMY) and 305- day (305MY) milk yield, age at first calving (AFC), gestation length (GL), days open (DO), and calving interval (CI), as well as their genetic (r_G) and phenotypic correlations with CBW, were estimated using BLUPF90 software. Increased CBW had a highly significant (P<0.001) effect on milk productivity; the maximum TMY was obtained at >36 kg for males, but at > 31 kg for females in 305MY. Until >40 kg, CBW had a linear effect on AFC and CI (P< 0.001). High positive r_G estimates were obtained between CBW categories with TMY and 305MY, ranging from 0.48 to 0.89 and 0.23 to 0.87, respectively. Moderate to high positive r_G estimates were obtained between CBW and reproductive traits, ranging from 0.24 to 0.76 for dams. Selection for intermediate CBWs combined under appropriate management conditions should be beneficial for maximizing milk production, controlling fertility, with delivering healthy calves without dystocia.

KEYWORDS
Dairy cattle, Genetic and phenotypic correlations, Productive and reproductive traits, Sex birth weights.

INTRODUCTION

Understanding the relationships between calf birth characteristics and future productivity would facilitate the development of management strategies to optimize calf growth and enable the selection of replacement heifers based on early-life measurements that are relatively easy to record (Wathes *et al*., 2008). Calf birth weight (CBW), though considered a reason for calving difficulty, may serve as an early indicator of lifetime performance, selection of replacement heifers that are more likely to remain in the herd and produce optimal milk yields (Kamal *et al*. 2014). Ghoraishy and Rokouei (2013); Ghoraishy *et al*. (2015); Rahbar *et al*. (2016); Hoka *et al*. (2019) and Eldawy *et al*. (2021) concluded that CBW could be used as an aid to improve reproductive and productive traits in breeding and management programs. Johanson and Berger (2003) and Linden *et al*. (2009) reported that CBW is associated with dairy cow survivability, disease incidence, and reproductive and lactation performance. Easa *et al*. (2022) stated that selection for high milk yield would be associated with genetic improvement in birth weight.

However, Lim *et al*. (2012) stated that the smaller CBW did not have any subsequent adverse effects on fertility, but the high groups were more likely to have worse fertility parameters with undesired increases in perinatal calf mortality and dystocia. Atashi *et al*. (2012) suggested that genetic selection for reducing CBW could be one of the means of diminishing the incidence of dystocia in dairy cattle.

While Glover *et al*. (2019) revealed that CBW was not associated with the probability of mortality incidence, and higher CBW will induce a higher growth rate (Coffey *et al*., 2006; Boligon *et al*., 2010) and milk production persistency than lower CBWs (Lamb and Barker 1975).

The objectives of this study were to investigate the interactive relationship between gender and birth weight categories of calves with the performance of their dams. Assessing the genetic and phenotypic correlations between calves' birth weights and the performance of their dams.

MATERIALS AND METHODS

Data set

The gender and birth weight of 4913 Friesian calves born between 1975 and 2020 at the Sakha Experimental Station, Animal Production Research Institute, Egypt, were used. Calves were grouped by gender and calf birth weight (CBW), which was classified into 5 categories: ≤ 25, 26-30, 31-35, 36-40 and >40 kg.

Furthermore, the dams' lactation period (LP), total milk yield (TMY), 305 milk yield (305MY), age at first calving (AFC), gestation length (GL), days open (DO), and calving interval (CI) traits of the studied calves were recorded. Table 2 shows the number of available records for the studied traits and the means +SD on the dams of the study.

Statistical analyses

The generalized linear model (GLM) procedure of SAS (2014) was utilized to assess the significance of the environmental ef-

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fects of parity, year, season of calving, birth weight, and sex of calf on the studied productive and reproductive traits of the dams of the experimental calves.

The fitted linear model was:

$Y_{ijklmn}= \mu+A_i+Bj+C_k+BW_l+D_m+e_{ijklmn}$ (1)

Where;

Y_{ijklmn}: an individual phenotypic record of each studied trait measured on dams of calves.

μ: the overall mean of each trait.

A_i: the fixed effect of i^th^ parity (i= 1, 2…6);

B_j: the fixed effect of j^th^ year of calving subclass (j= 1, 2…9);

C_k: the fixed effect of k^th^ season of calving (k = 1 (Jan. - Mar.); 2 (April - June); 3 (July - Sept.) and 4 (Oct. - Dec.)).

BW_l: the fixed effect of l^th^ birth weight groups (l = 1 (25kg); 2(26 -30kg); 3(31-35kg); 4 (36-40) and 5 (>40)).

D_m: the fixed effect of m^th^ sex (m =1 for (male) and 2 for (female)).,

e_{ijklmn}: random residual assumed to be independent normally distributed with mean zero and variance σ^2_e.

Genetic and phenotypic correlations were estimated using BLUPF90 software (Tsuruta and Misztal, 2006). The model was described in matrix notation as follows:

$y = X\beta+Z_{1a}+Z_{2pe}+e$ (2)

y is a vector of observations,

β: a vector of fixed effects with an incidence matrix *X*,

a: a vector of random animal effects with an incidence matrix Z_1,

pe: a vector of random permanent environmental effects with an incidence matrix Z_2, and *e*: a vector of random residual effects with a mean equal to zero and a variance σ^2_e.

The vector of additive (animal) effects (*a*) was assumed to be N~(0, *A* σ²a), where *A* is the numerator relationship matrix among animals in the pedigree file and σ^2_a is direct genetic variance. The vector of random permanent environmental effects (*pe*) was assumed to be N~ (0, $I_c\ \sigma^2_{pe}$), where I_c is the identity matrix of order equal to the number of cows, and σ^2_{pe} is the permanent environmental effects variance. The vector of residual (environmental) effects (*e*) was assumed to be N~ (0, $I_n\ \sigma^2_e$), where In was the identity matrix of order equal to the number of records and σ^2_e was the environmental variance.

A bivariate animal model fitting all records available was used to estimate genetic correlations between CBW categories and each of the studied traits as follows:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 & 0 \\ 0 & x_2 \end{bmatrix}\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} z_1 & 0 \\ 0 & z_2 \end{bmatrix}\begin{bmatrix} a_1 \\ a_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix} \quad (3)$$

Where y_i = vector of observations, b_i = vector of fixed effects, a_i = vector of random animal effects for the i^th^ trait, e_i = vector of random residual effects for the i^th^ trait, and X_i and Z_i are incidence matrices relating records of the i^th^ trait to the fixed and the random animal effects, respectively.

It is assumed that:

$$\mathrm{var}\begin{bmatrix} a_1 \\ a_2 \\ e_1 \\ e_2 \end{bmatrix} = \begin{bmatrix} g_{11}A & g_{12}A & 0 & 0 \\ g_{21}A & g_{22}A & 0 & 0 \\ 0 & 0 & r_{11} & r_{12} \\ 0 & 0 & r_{21} & r_{22} \end{bmatrix} \quad (4)$$

Where g_{11} is the genetic variance for trait 1, g_{22} is the genetic variance for trait 2, $g_{12} = g_{21}$ is the genetic covariance between both traits, r_{11} is the residual variance for trait 1, r_{22} is the residual variance for trait 2, $r_{12} = r_{21}$ is the residual covariance between both traits.

RESULTS

Distribution of calves' numbers on birth weight categories

Table 1 indicates that the majority of all, female, and male calves were born at CBW between 26 and 35 kg, while only about 16% were born at ≤ 25 or 36-40 kg, and the lowest was for >40kg.

Effect of calves' birth weight on dams' productive traits

TMY and 305 MY (Table 3) were affected (P<0.001) and increased linearly by increasing CBW, while LP was not affected. The highest TMY and 305MY by dams were obtained for CBW >40 kg and the lowest were at CBWs of ≤ 25kg and 26-30kg.

Effect of sex of calves' birth weight on dams' productive traits

The calves' gender had a significant influence on the subsequent TMY and 305MY of dams (P<0.001) but did not affect

Table 1. Distribution of calves numbers and percentages in calf birth weight (CBW) categories.

CBW (kg)		≤25	26-30	31-35	36-40	>40	Total
Total calves	No.	671	1735	1564	803	140	4913
	%	13.7	35.3	31.8	16.3	2.8	100
Female calves	No.	357	906	748	365	42	2418
	%	14.8	37.5	30.9	15.1	1.7	100
Male calves	No.	314	829	816	438	98	2495
	%	12.6	33.2	32.7	17.6	3.9	100

Table 2. Number of records after editing and the traits (Mean+ SD) measured on dams.

Traits	No.	Dams of calves
Lactation period (days)	4413	319.9±17.5
Total milk yield (kg)	4408	3228.1±146.1
305-day milk yield (kg)	3217	3140.1±107.4
Age at first calving (year)	4913	2.7±0.39
Gestation length (mo.)	4913	9.3±0.38
Days open (days)	2776	159.6±40.7
Calving interval (days)	4217	274.8±6.1

LP. TMY and 305MY gradually increased within sex groups by increasing CBW up to >40 kg (Table 3). For CBW 25 and 31-35 kg categories, dams of female births gave higher TMY than those of male births, but as CBW expanded, the gender differences in TMY of dams of male births increased for CBW > 36kg. However, in 305MY, dams of female births production increased between CBW 31 and >40 kg more than that of males.

Effect of calves' birth weight on dams' reproductive traits

AFC and CI of dams were significantly influenced by CBW (P<0.001) under the events of male and female births. However, GL and DO were influenced by CBW only under the incidence of female births (P < 0.001). CBW≤ 25 and >35 kg were associated with early and late AFC, respectively. Heavy CBW had a linear re-

Table 3. Least square means (LSM) for productive and reproductive traits of dams as affected by calving birth weight (CBW) categories and gender.

CBW (Kg)	Trait	All calves	Male calves	Female calves
P-value		0.25	0.80	0.12
≤25	LP	316.9Ns	327.8Ns	307.46Ns
26-30		326.3Ns	325.2Ns	327.24Ns
31-35		320.4Ns	318.5Ns	322.51Ns
36-40		308.1Ns	312.4Ns	302.89Ns
>40		317.9Ns	322.0Ns	308.79Ns
P-value		<.0001	<.0001	<.0001
≤25	TMY	3047.8c	3032.7c	3061.0b
26-30		3108.6c	3118.2c	3100.1b
31-35		3315.9b	3245.8bc	3394.4ab
36-40		3371.6b	3420.6b	3313.0b
>40		3753.4a	3788.3a	3675.4a
Total kg		16597.3	16605.6	16543.9
P-value		<.0001	<.0001	<.0001
≤25	305MY	3010.88c	3010.9c	3010.8c
26-30		2982.88c	2984.1c	2981.8c
31-35		3216.72b	3175.6bc	3262.4bc
36-40		3366.94b	3361.3b	3374.1b
>40		3642.57a	3622.5a	3690.9a
Total kg			16154,4	16320 kg
P-value		0.00	0.00	0.04
≤25	AFC	2.66468b	2.66146b	2.66751b
26-30		2.67216b	2.67274b	2.67163b
31-35		2.68242b	2.67549b	2.68997b
36-40		2.7193ab	2.721a	2.71726b
>40		2.76929a	2.74082a	2.83571a
P-value		0.00	0.4127 Ns	0.01
≤25	GL	9.23189b	9.26497Ns	9.2028b
26-30		9.28559a	9.29602Ns	9.27605ab
31-35		9.28868a	9.3011Ns	9.27513ab
36-40		9.30125a	9.31895Ns	9.28ab
>40		9.32786a	9.31327Ns	9.3619a
P-value		0.00	0.1017 Ns	0.00
≤25	DO	170.381a	174.83Ns	166.62ab
26-30		165.476ab	167.97Ns	163.36ab
31-35		152.065b	156.7Ns	147.11b
36-40		152.759b	158.16Ns	146.35b
>40		167.292ab	159.96Ns	187.74a
P-value		<.0001	<.0001	<.0001
≤25	CI	272.8778d	272.9733d	272.7994c
26-30		274.2572c	274.5202c	274.022bc
31-35		275.3491b	275.612b	275.0673b
36-40		276.1176b	276.7368a	275.3754b
>40		277.4746a	277.2169a	278.0857a

LP: lactation period (days); TMY: total milk yield (kg); 305MY: 305-day milk yield (kg); AFC: age at first calving (years); GL: gestationlength (months); DO: days open; CI: calving interval (days).

lationship with dam GL. While a steady decline in DO was found for dams giving female births in response to the increase in their CBWs but was prolonged for CBW >40 kg (Table 3).

Effect of sex of calves' birth weight on dams' reproductive traits.

The gender of born calves significantly influenced within genders for AFC (P = 0.0018 ; 0.036) for males and females, respectively, and for CI (P = 0.0001). However, for GL and DO of dams, the differences were significant within females only (P = 0.007 and P = 0.001), respectively. All reproductive traits showed a general tendency to increase with the expanded CBWs from 25 to >40 kg, except DO which was shortened up to 40kg CBW and increased thereafter (Table 3).

Correlation between CBW categories and dams' productive traits.

Estimates of r_p between CBW and LP, showed no trend as CBW increased, but were 0.38 for 26-30 kg and >40 kg and 0.19 for 36-40 kg (Table 4).

The ranges of r_p estimates for CBW with TMY and 305MY were 0.62 to 0.94 and 0.34 to 0.95, respectively, and the lowest were found for the ≤ 25kg CBW with TMY, and for 25-30 kg with 305MY. While the highest r_P estimates were found for 31-35 and >40 kg CBW with TMY and for 36-40 and >40kg with 305MY.

Estimates of r_G among CBW categories and LP varied less than r_p estimates and were mostly low, ranged from 0.13 for 25kg and 36-40 kg to 0.21 for 26-30 kg and >40kg categories. However, the r_G estimates between CBWs with TMY and 305MY were moderate to high and tended to increase above 31 kg up to >40 kg CBW to be in the ranges of 0.48 to 0.89 and 0.23 to 0.87 for TMY and 305MY, respectively.

Correlation between CBW categories and dams' reproductive traits.

The r_P estimates between CBWs and AFC were moderately to highly positive, ranging from 0.48 to 0.87. The lowest and highest r_P estimates were found for ≤25kg and >40 kg categories, respectively (Table 5).

The r_P estimates between CBWs and GL, were positive, ranging from 0.52 to 0.77 with a tendency to increase with expanded CBW. Estimates of r_P between DO and CBW were moderately to highly positive; ranged from 0.61 to 0.79 and decreased with the expanded CBW up to 40 kg, but increased thereafter which is probably due to sampling. The extended CBWs from ≤ 25kg to >40 kg showed linearly positive r_P estimates with CI from 0.34 to 0.77.

The r_G estimates between reproductive traits and CBWs were positive, varied from moderate to high, and generally increased with expanded CBW, except for DO, which showed declines to 0.39 and 0.27 for CBW from 31 to 40 kg, respectively. AFC had higher r_G estimates of 0.54 to 0.76 with a CBW of 36 to >40 kg than those with <36 kg. High r_G estimates of 0.65 to 0.68 were shown between GL and heavy CBW. Moreover, estimates of r_G between DO and CBW categories were variable, showing an irregular trend.

DISCUSSION

In this study, most male and female calves were born at intermediate weights between 26-35 kg. While, Atashi, (2021) discovered that the highest CBW % was found in >40 kg Holstein females.

CBW affected (P<0.001) linearly the milk yield of dams of the calves, which demonstrate the good dam body condition score from better nutrition, health, and fertility management during late gestation and at delivery, while LP was not affected. Similar results were found by Ghoraishy and Rokouei (2013); Ghoraishy *et al*. (2015); Visker *et al*. (2015); Rahbar *et al*. (2016); Haile-Mariam and Pryce (2018) on 305MY and Eldawy *et al*. (2021) on TMY. While for LP, Hermiz and Hadad (2020) found a positive (P<0.01) regression coefficient of 1.661 days per kg of dam's LP on CBW. The highest TMY and 305MY were obtained for CBW >40 kg. This agreed with the results of Rahbar *et al*. (2016); Haile-Mariam and Pryce (2018) and Atashi (2021) for 305MY; with Eldawy *et al*. (2021) for TMY; and with Easa *et al*. (2022) for the studied productive traits.

Dams with CBWs of ≤ 25kg and 26-30kg obtained the lowest TMY and 305MY. Confirming the results of Ghoraishy and Rokouei (2013); Rahbar *et al*. (2016) and Haile-Mariam and Pryce (2018), that dams giving calves between ≤25kg and <35 kg milked less 305MY than those giving CBW >40 kg. Similarly,

Table 4. Phenotypic (r_p) and genetic (r_G) correlations and standard errors (SE) between calves birth weight categories (CBW) and productive traits of their dams.

CBW (Kg)	LP		TMY		305MY	
	r_P	r_G	r_p	r_G	r_p	r_G
25	0.22(0.06)	0.14 (0.07)	0.62(0.09)	0.48 (0.10)	0.35(0.06)	0.23 (0.08)
26-30	0.38(0.10)	0.20 (0.09)	0.65(0.08)	0.49 (0.11)	0.34(0.09)	0.25 (0.07)
31-35	0.31(0.06)	0.18 (0.09)	0.93(0.11)	0.85 (0.16)	0.71(0.09)	0.66 (0.11)
36-40	0.19(0.08)	0.13 (0.07)	0.68(0.10)	0.51 (0.09)	0.95(0.11)	0.84 (0.17)
>40	0.38(0.09)	0.21 (0.11)	0.94(0.12)	0.89 (0.17)	0.95(0.14)	0.87 (0.20)

LP: lactation period; TMY: total milk yield; 305MY: 305-day milk yield; SE: standard error.

Table 5. Phenotypic(r_P) and genetic (r_G) correlations and standard errors (SE) between calves birth weight categories (CBW) and reproductive traits of their dams.

CBW Kg	AFC		GL		DO		CI	
	r_P	r_G	r_P	r_G	r_P	r_G	r_P	r_G
25	0.48 (0.10)	0.39 (0.12)	0.52 (0.07)	0.44 (0.08)	0.61 (0.09)	0.54 (0.08)	0.34 (0.08)	0.24 (0.09)
26-30	0.61 (0.07)	0.51 (0.09)	0.67 (0.10)	0.61 (0.15)	0.62 (0.07)	0.56 (0.08)	0.43 (0.06)	0.40 (0.05)
31-35	0.55 (0.09)	0.49 (0.08)	0.53 (0.10)	0.48 (0.09)	0.40 (0.05)	0.39 (0.02)	0.50 (0.04)	0.47 (0.07)
36-40	0.66 (0.08)	0.54 (0.10)	0.74 (0.12)	0.65 (0.19)	0.34 (0.06)	0.27 (0.04)	0.73 (0.08)	0.61 (0.12)
>40	0.87 (0.09)	0.76 (0.13)	0.77 (0.09)	0.68 (0.12)	0.79 (0.07)	0.71 (0.09)	0.77 (0.10)	0.69 (0.14)

AFC: age at first calving; GL: gestation length; DO: days open, CI: calving interval; SE: standard error.

Hoka *et al*. (2019) discovered that giving heavy CBW (31-39kg) produced significantly (P<0.001) more milk than lighter calves. Hamed and ElMoghazy (2015) and Visker *et al*. (2015) supported the significant effect of CBW between 25 and > 55kg on 305MY. Furthermore, Van de Stroet *et al*. (2016) revealed that cows with medium CBWs produced 2.2 kg more milk / day (P < 0.05) and TMY than heavy CBWs. While Chew *et al*. (1981) stated that dams having high CBW, possessing higher persistency and correlated linearly with milk production, between 23 and 50 kg. The expected increase was 15.2 % and 9.4% for 200-day and 305MY in heavy CBW relative to 30 kg. Although Malau-Adulia *et al*. (1996) reported little importance of CBW in predicting the future milk yield of Friesian cows.

The significant influence of calves' gender on the subsequent milk production of dams (P<0.001) which gradually increased up to >40 kg CBW. Confirming with the results of Ghoraishy and Rokouei (2013) for 305MY in both sexes and with Haile-Mariam and Pryce (2018) and Atashi (2021) in female calves. Moreover, Hamed and ElMoghazy (2015) proved that the interaction between sex and CBW was significant (P<0.05) for milk yields in 60, 90, and 120 days of lactation.

Current results show that the 305MY of dams of female births increased between CBW 31 and >40 kg more than that of males, which is in line with the results of Atashi (2021). Haile-Mariam and Pryce (2018) confirmed these findings for the same trait (P<0.05) in females and suggested that the low 305MY of dams delivering small CBW may be due to some stressful conditions, such as suboptimal feeding throughout pregnancy (Rutherford *et al*., 2012). Such conditions may result in reduced milk yield and even survival after delivery. However, Van Eetvelde *et al*. (2017) stated that the heifers CBW were not correlated with the first lactation milk production.

The significant effects of CBWs (P<0.001) on the studied reproductive traits were confirmed by the results of Lim *et al*. (2012) for female CBW of 30 - >40kg, Ghoraishy and Rokouei (2013); López *et al*. (2018); Haile-Mariam and Pryce (2018); Eldawy *et al*. (2021); Atashi (2021) and Easa *et al*. (2022) on AFC; by Nogalski and Piwczyński (2012) and Atashi and Asaadi (2019) on GL by Linden *et al*. (2009) and Ghoraishy and Rokouei (2013) on 33 - 48kg CBW, and Ghoraishy *et al*. (2015) on DO and CI, and by Fiems and Ampe (2015), Haile-Mariam and Pryce (2018) and Atashi (2021) for CI. Eldawy *et al*. (2021) reported that AFC, DO and CI might be affected by CBW between 25 and >35kg.

For AFC, the current findings contradict those of Ghoraishy and Rokouei (2013,), López *et al*. (2018) and Atashi (2021) who found that heavy born heifers had young AFC dams and high rates of weaning growth traits, thus reaching the required weight for successful pregnancy earlier than the average. However, CBW showed a curvilinear relationship with AFC (Kamal *et al*., 2014) implying that the intrauterine environmental condition may control fetal growth due to the competition for nutritional needs between the fetus and the growing dam (Wathes *et al*., 2008). In contrast, Wakchaure and Meena (2010) and Boopathi *et al*. (2019) stated no influence of CBWs on dam AFC in other breeds.

Heavy CBW had a linear relationship with dam GL (Lykins *et al*., 2000; Nogalski and Piwczyński, 2012; Atashi and Asaadi, 2019). Calves born after a short or medium GL were 5.01 and 2.18 kg lighter than those born after a long GL (P < 0.001), respectively (Kamal *et al*., 2014). While Hoka *et al*. (2019) reported a non-significant effect of CBW on GL.

A steady decline in DO was found for dams giving female births in response to the increase in CBWs; however, the increase in DO for CBW >40 kg could be attributed to that high CBW cows had a greater tendency to lose body condition postpartum and therefore showed less efficient reproductive behavior (Dechow *et al*., 2002). Contradicting with that of Ghoraishy and Rokouei (2013); Atashi (2021) and Eldawy *et al*. (2021), who objected that high female CBWs were associated with longer DO and CI and possibly the dystocia (P<0.001).

Similar to the current results, Bastin *et al*. (2010) and López *et al*. (2018) concluded that low CBW resulted in reduced conception rates for dams compared to heavy calves. The first insemination period was shortened by ten days (P<0.01) for CBW >39 kg compared to 36-39 kg. Lim *et al*. (2012) indicated that the average pregnancy rate in dams giving 30-36 kg CBW after one service was 60%, greater than 48% for CBWs of 37-41kg and the chance with small CBWs is reduced due to the lack of dam potentials to provide sufficient energy necessary for ovarian activities (Bastin *et al*., 2010). While Kusaka *et al*. (2022) detected no effect of CBWs between 21- 75.5 kg on DO of dams in the first parity.

Female CBW between 34 and 40kg were found to be more appropriate for a standard first lactation CI than heavier CBWs (Ghoraishy and Rokouei, 2013,), owing to the latter's need for enhanced embryonic development (Lykins *et al*., 2000; Atashi, 2021). While Fiems and Ampe (2015) revealed that dams giving small CBWs had longer subsequent CI, regardless of the positive regression of CI and DO on CBWs in several dairy breeds (Hermiz and Hadad, 2020).

Estimates of r_p between LP and CBW of 26-30 and >40 kg (0.38) and of 36-40 kg (0.19) were higher than those of -0.08 and 0.12 by Musa *et al*. (2021) and Easa *et al*. (2022,), respectively. The present correlations between TMY and CBW for 25 kg were higher and positive (0.62) compared to those of -0.05 reported by Musa *et al*. (2021), and for TMY and 305MY with 36-40 kg CBW (0.68 and 0.95) were higher than around 0.16 documented by Easa *et al*. (2022). Chew *et al*. (1981) discovered positive linear relationships between milk yield and CBWs ranging from 23 to 50 kg. However, Malau-Aduli *et al*. (1996) found a little r_p estimates with TMY with no emphasis on predicting the future production in Friesian heifers.

Estimates of r_G between CBWs and 305MY (0.23 to 0.87), were higher than the 0.17 reported by Haile-Mariam and Pryce (2018) of 30-50 kg CBW. Also, between CBW of 36-40 kg with TMY; 305MY and LP of 0.51; 0.84 and 0.13, were higher than the corresponding r_G estimates of 0.26 and 0.33, but lower than 0.48, respectively, reported by Easa *et al*. (2022). Moreover, current r_G estimates for 25 kg CBW with LP and TMY of 0.14 and 0.48 were different from the corresponding estimates of -0.42 and -0.21, respectivelly obtained by Musa *et al*. (2021). Hoka *et al*. (2019) documented a significant positive correlation (r^2 = 0.73, P≤ 0.001) between CBW and TMY. On the contrary, CBWs showed weak negative correlations with 305MY (Berry *et al*., 2003) and non-significant estimates with LP as stated by Hoka *et al*. (2019).

The r_p estimates between AFC and CBW categories from 0.48 to 0.87 were higher than the 0.24 found by Bekele *et al*. (2017). Also, with a CBW of 36-40 kg 0.66 was higher than the corresponding value of 0.12 reported by Easa *et al*. (2022), and similarly with CBW of 31-35kg of 0.55 was higher than that of 0.12 documented by Bourdon and Brinks (1982). However, Wakchaure and Meena (2010); Lopez *et al*. (2020) and Musa *et al*. (2021) stated weak r_p estimates of -0.01 to 0.06 between AFC and CBW of ≤25kg.

The r_p estimates between CBWs and GL (0.52 to 0.77) were higher than those in the range of 0.22 to 0.31 reported by Van Graan *et al*. (2004) and Hwang *et al*. (2008). Our findings suggested that long GL causes heavy CBW, with more dystocia and longer CI, despite the faster growth during the suckling period. The present r_p estimates of 0.52 between GL and CBW of 25kg and 31-35kg were higher than the corresponding values of 0.31 and 0.21 reported by Bourdon and Brinks (1982) and Lopez *et al*. (2020), respectively. Also, the r_p estimate of 0.74 with CBW of 36-40 kg was higher than 0.21 and 0.36, reported by Kemp *et al*. (1988) and Coleman *et al*. (2021,), respectively. While Bekele *et al*. (2017) revealed a weak r_p estimate of 0.03 between GL and CBW. The linear r_p estimates for CI with the extending CBW indicate that low CBW does not always result in high CI, but dams with high CBW have a higher chance of having prolonged CI. The current r_p estimate between CBW of ≤25kg and CI (0.34), conflicted with the negative correlation of -0.10 reported by Musa *et al*. (2021).

The moderate to high positive r_G estimates between reproductive traits and CBWs, except for DO, which showed declines up to 40kg suggested that selecting for increasing CBWs above the average might not be recommended, as they may have adverse effects on fertility with the possibility of dystocia (Bekele *et al.*, 2017 and Lopez *et al.*, 2020).

Genetic correlations between CBW of 25 kg and AFC 0.39 was higher than the 0.33 and 0.22 reported by Lopez *et al.* (2020) and Musa *et al.* (2021), respectively; with a GL of 0.44, it was near 0.40 reported by Van Graan *et al.* (2004), but lower than the 0.53 found by Lopez *et al.* (2020). Furthermore, the current r_G estimate with a CI of 0.24 is greater than the 0.08 obtained by Musa *et al.* (2021).

The present positive r_G estimates of AFC with CBWs of 36 to >40 kg (0.54 to 0.76) were in accordance with the 0.77 reported by Bekele *et al.* (2017); higher than the 0.24 and 0.11 documented by Haile-Mariam and Pryce (2018) and Easa *et al.* (2022). Also, the r_G estimate with CBWs of 31-35kg (0.49) conflicted with the negative estimate of -0.17 by Bourdon and Brinks (1982).

The r_G estimate of 0.48 between GL and CBW of 31-35 kg was greater than the 0.22 reported by Bourdon and Brinks (1982), and the 0.65 for CBW of 36-40kg was greater than the 0.49 reported by Kemp *et al.* (1988), who suggested that selection for short GL, cows, deliveries easily calves. While Bekele *et al.* (2017) and Coleman *et al.* (2021) revealed negative r_G estimates of -0.84 and - 31, respectively, between GL and CBW of 30 - 40 kg. In contrast, Hoka *et al.* (2019) reported non -significant relationships between CBWs and GL.

The positive r_G estimate of 0.27 between DO and CBW of 36-40 kg in this study was different from that of -0.42 reported by Easa *et al.* (2022). Similarly, Berry *et al.* (2003) obtained negative and positive r_G estimates of - 0.25 and 0.37 for CBW with intervals to first service and to conception, respectively. However, Hoka *et al.* (2019) found a strong positive correlation ($r^2 = 0.79$, $P \leq 0.001$) between 31-39 kg CBW and period to first heat, concluding that heavy CBW dams require a longer period to the first heat after parturition. The current r_G estimates between CI and CBW >31 kg of 0.47 to 0.69 were higher than the 0.29 obtained by Haile-Mariam and Pryce (2018).

CONCLUSION

Dams giving heavy born males produce high TMY, and those giving heavy born females produce high 305MY, regardless of the lack of LP effects. For late AFC dams, CBW is heavier, especially for females compared to male births after longer GL and CI but DO is short. CBW has a greater effect with strong positive correlations on dams' milk production. Furthermore, the moderate to high positive genetic association between female CBW and reproductive traits, except for DO, may reflect the compatibility between the genetic control of CBW and the dam's milk and reproductive efficiency, or the common effects of the environment and health conditions on the cow's status during pregnancy. It would be more acceptable to alter selection plans to favor medium CBWs from cows with an intermediate body condition score to produce healthy calves with a normal lactation. Then, the effect of calves' growth rate during suckling on their dam's performance can be studied.

CONFLICT OF INTEREST

The authors declare that they have no competing benefits.

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