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Direct genetic and maternal effects for Birth and Weaning Weight of Egyptian Friesian Calves

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Abstract

The present study was carried out to estimate genetic parameters associated with direct and maternal genetic effects on birth and weaning weights in Friesian herd and to estimate the prediction of breeding values for both traits, by using bivariate repeatability animal model. The data used in the study included pedigree and weight records of calves born between 1984 and 2014**.** Overall means of birth weights B.Wt and weaning weight W.Wt were 37.66 ± 0.08 and 64.02 ± 0.75kg respectively; the average of suckling period (SP) was 61.62± 3.44 days of age. The person correlation coefficient between birth weight and weaning weight was 0.312, considering that the duration of suckling introduced as partial variable. The results showed that the year and season of birth had high significant effect on calf birth weight and weaning weight (P <0.0001) in addition the influence of) of sex of calf and dam parity on calf birth weight was highly significant (P<0.0001). Direct heritability estimates for birth weight B.Wt and weaning weight W.Wt are 0.33 and 0.12, respectively, while, maternal heritability estimates for the same traits are 0.12 and 0.08, respectively. Total heritability estimates are 0.24 and 0.07 for B.Wt and W.Wt, respectively. Repeatability estimates are 0.41 and 0.22 for B.Wt and W.Wt, respectively. Phenotypic and genetic correlations between the traits are 0.38 and 0.80, respectively. Values of Estimated breeding values ranged from -5.43 to 7.73 kg for B.Wt and ranged from -2.54 to 2.75 kg for W.Wt. It concluded that the direct and maternal heritability and direct and maternal correlation coefficients for birth and weaning weights were moderate to low, the additive genetic variation for traits was deemed sufficient to allow effective selection for growth performance

Key words: Friesian, birth weight, weaning weight, genetic, maternal, animal model

1. Introduction

Frisian cattle have been reared commonly for the milk production in the world, however, male calves are to rear for beef production; Some research has focused on growth in lactating dairy cattle because of its economic cost (Coffey et al., 2006), it was necessary to introduce birth weight trait in dairy cattle breeding programs (Rahbar, et al 2016). In cattle breeding, the weight of the calf at birth is of great importance so it has been used as an early selection criterion; knowledge on body weight at early ages (until weaning) in farm animals plays a vital role for genetically improving meat production; fetal development in most animal species is influenced by exogenous factors related to the uterine environment. Feed intake, hormones, antibodies, uterine environment, and maternal behavior are referred to as prenatal effects. Birth weight is a sign of the calves' future development and growth rate, as well as an indicator of the calving ease. In this respect, it is one of the most fundamental herd management traits that should be focused on (Aytekin et al., 2019); birth weight is the result of gestational growth rate and gestation length. Weaning weight is the consequence of birth weight and growth during the suckling period, On the other hand birth weight is important for calving ease of the cow and neonatal survival of the calves, high calf birth weight are associated with

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dystocia and neonatal mortality which can lead to economic losses meyer, et al., (2001) reported that dead calves cause losses to the dairy industry in the United States of more than $125.3 million per year. Both traits are measured as the phenotypic value of the calf, but they are composed of at least two components, calf genetics for growth and a maternal effect contributed by the dam. Kaygisiz, et al., 2012 indicated that the cows in the farms were treated well during gestation when intrauterine growth of the fetus was rapid. In dairy cows, calves are taken out of their mothers immediately after birth; thus, any maternal effect on the calf would be a combination of the prenatal uterine environment and cytoplasmic inheritance (Banos, et al., 2007). Birth and weaning weights are controlled by many genetic, maternal, and environmental factors, and these factors may be related to calf genes, dam genes, or environmental factors affecting the calf and/or dam. (Şahin, et al, 2017). The objectives of this study were attempting to separate direct effects, genetic and permanent environmental maternal effects and assessing the breeding value of the birth and weaning traits.

2. Material and methods

2.1 Data collection

The data included in this study were obtained from breeding records of dairy cattle in the University of Alexandria dairy herd, for the years from 1984 to 2014. The 3032 male and female records for birth weights and only 519 female records for weaning weights. The calves descending from 846 dams and 89 sires. Calves were allowed to suckle their dam for the first three days after parturition. There after they were artificially raised on natural milk twice daily on an age basis until weaning, (the average of suckling period (SP) was 61.62 day of age). In addition to milk, green fodder was given to the calves ad-libitium. Green fodder in winter was (Trifolium Alexandrium) and green maize in summer. The calves were weighed following birth. All birth weights of live single and normal calves were included, while twins and stillbirths were excluded from the data.

2.2 Data analysis

General Linear Model (GLM) of SAS statistical software (SAS, 2002) was used to identify the random and fixed effects to be included in the models. The following models were used to analyze calf birth weights and weaning weights

$$Bwt_{ijklmn} = \mu + y_i + s_j + g_k + p_l + \alpha + e_{ijklmn}$$

$$Wwt_{ijkl} = \mu + y_i + s_j + \beta_k + e_{ijkl}$$

Bwt_{ijklm} = The individual observation of Bwt

Wwt_{ijklm} = The individual observation of Wwt

μ = Overall mean of the trait

y_i = The random effect of the year i^{th}

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s_j = The fixed effect of season of birth (j=winter, spring, summer and autumn)

g_k = The fixed effect of gender (k=male and female)

p_l = The fixed effect of dam parity (L=1-10)

α = Dam age as covariate

β_k = age at weaning as covariate

e = The residual effect

Bivariate animal model with maternal effects was applied to estimate genetic (co)variance components for BW and WW. In matrix notation, the statistical model was:

$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 & 0 \\ 0 & x_2 \end{bmatrix}\begin{bmatrix} b_1 \\ b_2 \end{bmatrix} + \begin{bmatrix} z_1 & 0 \\ 0 & z_2 \end{bmatrix}\begin{bmatrix} u_1 \\ u_2 \end{bmatrix} + \begin{bmatrix} w_1 & 0 \\ 0 & w_2 \end{bmatrix}\begin{bmatrix} m_1 \\ m_2 \end{bmatrix} + \begin{bmatrix} s_1 & 0 \\ 0 & s_2 \end{bmatrix}\begin{bmatrix} pe_1 \\ pe_2 \end{bmatrix} + \begin{bmatrix} e_1 \\ e_2 \end{bmatrix}$$

where y_i = vector of observations for the i^th^ trait b_i = vector of fixed effects for the i^th^ trait, u_i = vector of random animal effects, m_i = vector of random maternal (indirect) genetic effects, pe_i = vector of permanent maternal environmental effects, e_i = vector of random residual effects, and X_i, Z_i, W_i and S_i are incidence matrices relating records of the i^{th} trait to fixed, animal, maternal genetic and permanent environmental effects, respectively.

The Mixed Model Equations (MME) to be solved to obtain the BLUP of *u, m* and *pe* and BLUP of estimable functions of *b*. Estimates of genetic parameters were obtained with MTDFREML (BOLDMAN *et al*., 1995). Total heritability was calculated as defined by Willham, (1980) below:

$$h_T^2 = \left[\frac{\sigma_A^2 + 0.5\sigma_M^2 + 1.5\sigma_{AM}^2}{\sigma_P^2}\right]$$

3. Results and discussion

Overall mean, standard deviation and coefficient of variance for birth weights (Bwt) and weaning weight (Wwt) of Friesian calves are provided in Table 1. Means for Bwt and Wwt were 37.66 ± 0.08 and 64.02 ± 0.75kg respectively, the average of suckling period (SP) was 61.62± 3.44 days of age. Mean of Bwt higher than those reported by Atil and Khattab, (2005) and Sanad and Gharib, 2017 in Friesian calves, while mean of Wwt Similar to results obtained by Coffey, *et al,* 2006 and lower than that reported by Atil and Khattab, (2005) and Sanad and Gharib, (2017). Maybe due to a short suckling

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period led to decrease weaning weight. The coefficient of variance for Bwt, Wwt and SP were 11.5, 9.38 and 43.52%.

Table (1) Descriptive statistics of birth weight (Bwt) kg, weaning weight (Wwt) kg and suckling period (SP) days for Egyptian Friesian calves

Trait	Records	Mean (Kg)	Standard Deviation	C.V%	Min.	Max.
Bwt	3032	37.66	4.33	11.50	15	55
Wwt	519	64.02	6.00	9.38	36	116
SP	519	62.62	27.25	43.52	152	27

Aytekin, *et al*, (2019) found that CV% for birth and weaning weights are 13.78 and 9.7%, respectively. However, the differences between the results of this study and other references may be due to differences in the genotypes, management, and number of records and methods of statistical analysis. The person correlation coefficient between birth weight and weaning weight was 0.312, considering that the duration of suckling introduced as partial variable.

Table (2) Analysis of variance of non-genetic factors affecting birth weight (Bwt) and weaning weight (Wwt) in Egyptian Friesian calves

S. O. V	weight of Birth (Bwt)			Weaning weight (Wwt)		
	df	MS	Pr > F	df	MS	Pr > F
Year of birth	1	1322.16	< 0.0001	1	9182.43	<0.0001
Season of birth	3	196.29	< 0.0001	3	1192.18	<0.0001
Sex of calf	1	5515.98	< 0.0001	-	-	-
Dam parity	9	79.68	< 0.0001	-	-	-
Partial regression of Dam age	1	86.13	< 0.05	-	-	-
Partial regression of calf age at weaning	-	-	-	1	2915.62	<0.0001
Residual	3017	18.85		514	43.35	

The analysis of variance of weight traits under investigation as affected by random and fixed effects are presented in Table (2) year of birth as random effect, season of birth, Sex of calf and parity of dam had highly significant effects (P<0.0001) on birth weights. The Year of birth as random effect, season of birth had significant effects (P<0.0001) on weaning weights. Year effect reflects the environmental conditions such as temperature and relative humidity, feeding, hygiene, and management conditions of dam during gestation (Manzi et al., 2012). Birth weight of calves is related to the dam's body size. It is lightest in the first parity because the dam has not completed her own body development and growth. As the number of parities increases, the calf birth weight increases and generally reaches its maximum around the fourth or fifth parity. Estimation of variance components, heritability (direct and maternal), and repeatability

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for calf weight at birth and weaning and direct genetic, maternal genetic correlations, phenotypic and genetic correlations between the two traits studied are presented in Table 2. Estimates of Maternal heritability was lower than direct heritability for birth weight, Overall, estimates of direct and maternal heritabilities were low, accounting for 33% and 12% of the phenotypic variance, respectively, the maternal heritability amounted to 36% of that due to direct heritability. Birth weight was affected by maternal permanent environmental effects, explaining 8.3% of the phenotypic variance. The direct and maternal heritability for weaning weight were 12 % and 8% respectively, the maternal heritability amounted to 36% of that due.

Table (3) Estimates of parameters for birth weight (Bwt) kg and weaning weight (Wwt) kg in Egyptian Friesian calves

Genetic parameters	Abbreviations	Birth weight	Weaning weight
Additive genetic variance	(σ_a^2)	6.36	4.15
maternal genetic variance	(σ_m^2)	2.43	2.58
Additive maternal covariance	(σ_{am})	-1.93	-1.97
Maternal permanent environmental variance	(σ_{Pe}^2)	1.61	3.33
Residual variance	(σ_e^2)	9.11	24.14
Phenotypic variance	(σ_p^2)	19.51	34.20
Total heritability	(h_T^2)	0.24	0.07
Additive heritability	(h_a^2)	0.33	0.12
maternal heritability	(h_m^2)	0.12	0.08
Repeatability	(t)	0.41	0.22
Additive maternal correlation	(r_{am})	-0.49	-0.60
Phenotypic correlation	$(r_{p1,p2})$	0.38	
Additive genetic correlation	$(r_{a1,a2})$	0.80	
Maternal genetic correlation	$(r_{m1,m2})$	0.88	
Estimated breeding value	(EBV)	max. 7.73	2.75
		min. -5.43	-2.54
Animals over the mean EBVs	(%)	52.4	44.4

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to direct heritability, weaning weight was affected by maternal permanent environmental effects, explaining 9.7% of the phenotypic variance. Repeatability (t) estimates for birth and weaning weights are 0.41 and 0.22, respectively (Table 2), Tilki et al. (2008) obtained estimates for (t) of 0.001 and 0.08 for Brown Swiss calves. The estimate reported by Sahin, *et al,* (2012) for Brown Swiss calves in Turkey using a similar model were similar (0.17) birth weight of Brown Swiss calves and are in agreement with Orange et al. (2009) for birth weight. The higher estimate of repeatability for birth weight in the present study than on weaning weight, indicate that the permanent environmental fractions of variance was high and decrease of permanent environmental until weaning. Therefore, if the early evaluation of the first calf of each cow will lead to an accurate prediction of future performance, and increase the efficiency of progeny testing for bulls. The present results indicate that selection for weights at early weights is a good indication for weights at later ages

The findings in this study were similar with Sanad and Gharib, (2017) in Friesian herd. Atil and Khattab, (2005) found that direct heritability estimations for BW and WW are 0.28 and 0.13, respectively, while, maternal heritability estimations for the same traits are 0.14 and 0.06, respectively, for Friesian calves. Khattab et al (2009) found that direct and maternal heritability estimations were 0.21 and 0.13 for BWt 0.29 and 0.09 for WWt in Holstein-Friesian in Egypt, respectively. Lengyel, *el. al.* (2001). working on Simmental calves, found that heritability for WWt estimates from sire model and animal model are 0.096 and 0.11, respectively. Szabó, Ferenc *et al* (2021) found that total heritability of WWt were 0.25 and 0.17 for purebred Limousin and crossbredrespectively. Bryan Irvine Lopez *et al (2020)* reported that the estimated direct heritability for BW and WW was moderate 0.22 and high 0.51, respectively, while the maternal heritability for both traits was 0.12 and 0.17, respectively They concluded that the lower heritability estimates could be due to small genetic variance and the effect of sire ranged from 3 to 5% of the total variance. Phocas and Laloe (2004) reported that the direct heritability ranged from 0.28 to 0.38 and from 0.13 – 0.32 for birth and weaning weights in four beef French breeds. Şahin, *et al*. (2017) working on Holstein cattle, using six animal models, that either included or excluded the maternal genetic and/or permanent maternal environmental effects they found that direct heritability for birth weight ranged from 0.07 to 0.11 and maternal heritability for the same trait from 0.09 to 0.26. Contrary to several authors, the direct maternal correlations (r_{am}) for birth weaning weights values - 0.49, -0.60 respectively estimate of the correlation between direct and maternal genetic effects was large and negative, this indicates a discrepancy between the effects of calves genes and those of dams. Orange et al., (2009), Sahin et al., (2012) Szabó, Ferenc et al., (2021) reported that the negative relationship between additive and maternal genetic effect calls attention to the importance of maternal genotype. Positive and high phenotypic and genetic correlation between birth and weaning weight indicated that selection for higher birth weight would cause a correlated increase in weaning weight. The estimated breeding values (EBVs) are presented in Table (3) which were predicted with best linear biased prediction BLUP, the success in selection and culling of animals for the next generation can be achieved by choosing animals with EBVs over the mean. Estimates of breeding values (BV) for studied traits in Table 3. The range of (EBV) 13.53 and 5.293 kg for Bwt and Wwt. Although the current results found that the positive values of EBV for BW and WW were 52.4, 44.4% of the total records. The genetic trend was determined as non-zero. Changes in breeding values are shown in Figure 1. The progression of weaning weight in recent years according to the year of birth. There was an irregular trend in expected breeding values. The value was negative in some years and positive in the others.

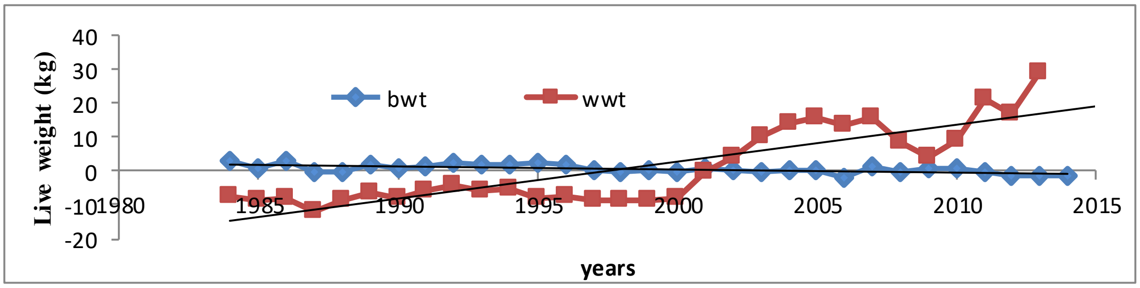

Figure (1) Genetic trend for calf birth weight and weaning weight of Egyptian Friesian herd

6.Conclusion

- Descriptive statistics determined in the present study were similar to the findings in literature.
- As found in several studies, (Bwt) and (Wwt) traits had a direct genetic and a maternal genetic component, which indicated that the cows in the farms were treated well during pregnancy when intrauterine growth of the fetus was rapid. The obtained estimates of heritability and genetic correlation coefficients were moderate; they will be used in a breeding plan that will be effective to improve this breed. we can conclude that the (Bwt) and (Wwt) traits effect should be included in the genetic evaluation of breeding programs.
- Although the genetic parameters were moderate to low, the additive genetic variation for birth and weaning weights were deemed sufficient to allow effective selection for growth performance

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التأثيرات الوراثية المباشرة والأمية على وزن الميلاد والفطام في عجول الفريزيان المصرية

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الملخص

أجريت هذه الدراسة لغرض تقدير المعايير الوراثية المتعلقة بالتأثير الوراثي المباشر والأمي ولتقدير القيمة التربوية لصفتي وزن الميلاد ووزن الفطام لقطيع فريزيان باستخدام نموذج الحيوان حيث تضمنت البيانات المستخدمة في الدراسة نسب الأفراد وسجل الأوزان لحيوانات ولدت في الفترة من 1984 وحتى 2014. المتوسط العام لصفتي وزن الميلاد ووزن الفطام 0.08 ± 37.66 و 0.75 ± 64.02 كجم على التوالي , وكان متوسط فترة الرضاعة 3.44 ±61.62 يوما من عمر المولود . معامل ارتباط بيرسون بين صفتي وزن الميلاد ووزن الفطام 0.312 باعتبار طول فترة الرضاع متغير جزئي. كما أظهرت نتائج تحليل التباين أن سنة الميلاد وشهر الميلاد لها تأثير عالي المعنوية على صفتي وزن الميلاد ووزن الفطام, في حين أن جنس المولود وعمر الأم لها تأثير عالي المعنوية على صفة وزن الميلاد فقط . المكافئ الوراثي المباشر لصفتي وزن الميلاد ووزن الفطام 0.33 و 0.12 على التوالي , والمكافئ الوراثي الأمي لنفس الصفات 0.12 و 0.08 على التوالي . أما المكافئ الوراثي الكلي 0.24 و 0.07 للصفتين على التوالي، والمعامل التكراري 0.41 و 0.22 لصفتي وزن الميلاد ووزن الفطام على التوالي . معامل الارتباط الظاهري والوراثي بين الصفتين 0.38 و 0.80 على التوالي . تراوحت القيم التربوية المقدرة من 5.43– إلى 7.73 كجم لصفة وزن الميلاد وتراوحت من 2.54– إلى 2.75 كجم لصفة وزن الفطام . نستنتج من هذه الدراسة أن المكافئ الوراثي المباشر والأمي وكذلك معامل الارتباط الوراثي المباشر والأمي لصفتي الوزن عند الميلاد ووزن الفطام يكفي لأن يجعل الانتخاب لهذه الصفات وسيلة فعالة للتحسين الوراثي.

الكلمات المفتاحية: فريزيان – وزن الميلاد – وزن الفطام – الوراثي – الأمي – نموذج الحيوان.