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ESTIMATION OF GENETIC PARAMETERS FOR GROWTH TRAITS USING DIFFERENT MODELS FOR FRIESIAN CATTLE RAISED IN EGYPT

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SUMMARY

This study was conducted to detect the most appropriate model that fits data of birth weight (BW) and weaning weight (WW) traits of Friesian calves. Body weights of 1371 calves over a 22 years and WW of 678 Friesian calves over a 19 years from a herd of Friesian in Gemmaza Ministry of Agriculture, Egypt were used. The fixed effects included in the model were parity, season, sex, year of calving in addition to the random effects to estimate direct and maternal heritability's, permanent maternal environmental and error. The parameters were estimated by using Variance Component Estimation (MTDFREML) programs. Six different animal models were fitted for the traits ranging from a simple to the most comprehensive model, were used to compare them.

The overall means were 30.4 kg and 85.1 Kg, for BW and WW, respectively. Non-genetic factors (fixed effects) had highly significant ($P<0.001$) effects on BW and WW of calves. Estimates of direct heritability were moderate, they ranged from 0.28to 0.30 for BW and from 0.18 to 0.28 for WW. Maternal heritability was relatively low for both BW and WW, ranging from 0.06 to 0.08 for BW and was 0.04 for WW. Permanent environmental effect Pe^2 in the 2nd model was relatively higher than that of other models, while inclusion of maternal genetic effects (Models 3-6) showed further reduction in h^2_a for which there was negligible difference in h^2_a of the other models within each trait.

Akaike Information Criterion (AIC) was used to determine the most appropriate model for the studied traits. Model 5 : $Y = Xb+Z1a+Z2c+ Z3m + e$ $Cov (a, m)= 0\ A\ \sigma\ am$ was the most appropriate model for BW, while, Model 4 : $Y =Xb+Z1a+Z3m+e$ $Cov (a, m)= A\ \sigma\ am$ was the most appropriate model for WW trait.

The higher range of calves breeding values compared with those of sire or dams means that selection for BW for calves is leading to an increase in WW for the next generation.

Keywords: Birth and weaning weight, Friesian calves, genetic and non-genetic parameters, models Comparisons

INTRODUCTION

Animal models utilize all relationships available in a given data set. The search for a suitable statistical model is an important step in the development of genetic improvement (Assan *et al.,*2011).Genetic models, including maternal effects and the covariance of direct and maternal genetic effects, fit data better than the simple additive model (Martinez *et al.,*2016); for maternal traits such as weight in early ages. Animal models used to analyze post weaning growth traits in beef cattle typically may not assume maternal effects. Genetic and phenotypic parameters in quantitative genetics include heritability, genetic and phenotypic correlations, which play a vital role in the formulation of any suitable breeding plan for genetic improvement program (Aynalem,2006). Growth traits in cattle are important in selection program. So that, estimating the genetic parameters for estimation of variance and covariance components (Sadek *et al.,*2005)as well as growth traits and implementing them in a selection program would be of great value, for beef breeds for the purpose of fattening small calves.

The objectives of the present work were to compare estimates of genetic parameters for Friesian cattle birth weight (BW) and weaning weight (WW) using different statistical models to determine whether simpler models produce estimates similar to those produced by more complex alternatives.

MATERIALS AND METHODS

Data used in the present study were collected from the history sheets of Friesian cows maintained at Gamaza farm belonging to Animal Production Research Institute (APRI), Ministry of Agriculture, Egypt. Herd size is shown in Table1. This data were used for assessment of genetic parameters that affect growth traits of Friesian cattle in dairy herds.

Table1. Structure of data used in the study

Structure of data	BW	WW
Number of calves	1371	678
Sire	79	59
Dams	432	285
Environmental effects		
Year	22	19
Calving season	4	4
Calving number	8	8
Calf sex	2	2

It is noted that the number of calves born is more than the number of calves weaned which may be due to the management of herd, registration systems and the presence of some of the losses of calves born before reaching weaning stage.

Herd management:

Animal nutrition in the experimental farm depends on concentrate feed mixture along with wheat or rice straw in addition to Egyptian clover in winter or clover hay during summer (May to November). As a common practice, milking cows were subjected to machine milking twice daily.

Calves were produced mainly by artificial insemination (imported frozen semen of Friesian sires) rather than by natural service mating. After calving, birth weight, sex and pedigree were recorded. Calves were allowed to receive the colostrums, from their dams for the first four days. Colostrum was offered three times daily totaling 10% of the calf's body weight. From the fifths day of age, calves were fed on natural whole milk and then milk, starter and hay Natural whole milk, starter and hay were offered based on the weight of the calve. The starter (18 % protein) was formulated as follows: Maize (54%), soybean (25%), wheat bran (15%), limestone (2%), ordinary salt (1%) and molasses (3%). Water was available all the time except one hour before every time of feeding on milk. Feeding program was essentially that applied in the experimental farm under consideration. Friesian calves were used to evaluate the growth performance of Friesian calves from birth to 90 days of age as a weaning weight of Friesian calves after weaning were evaluated.

Besides all herd had regular veterinary consultants for disease management control and vaccination.

Statistical analysis:

Data was analyzed using the general linear model (GLM) procedure (SAS 2003).

The following statistical mixed model was used:

$Y_{ijklm} = \mu + S_i + P_j + SE_k + YE_l + X_n + (YE * SE)_{lk} + e_{ijklnm}$

where,

Y_{ijklm}: either (BW)or (WW)

μ: an underlying constant specific to each trait;

$i^{\underline{th}}$ sire(random effect);

P_j: the fixed effect of j^{th} parity of calving;

SE_k:the fixed effect of k^{th} season of calving; YE_l: the fixed effect of l^{th} year of calving , X_n sex of calf;

$(YE * SE)_{lk}$ the interaction between l^{th} effect of year of calving and K^{th} effect of season of calving and

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

Variance and covariance components were estimated with derivative-free restricted maximum likely hood (REML) procedures using the MTDFREML program according to Boldman *et al.*(1995), six animal models were fitted examined for each trait.

The following models were used:

Model 1:$\mathbf{Y=Xb + Z_1a + e}$ (1)

Model 2:$\mathbf{Y=Xb + Z_1a + Z_2c + e}$ (2)

Model 3:$\mathbf{Y=Xb+Z_1a+Z_3m+e, Cov (a,m)= 0A \sigma_{am}}$(3)

Model 4:$\mathbf{Y=Xb+Z_1a+Z_3m+e, Cov (a,m)= A \sigma_{a,m}}$ (4)

Model 5:$\mathbf{Y=Xb+Z_1a+Z_2c+Z_3m+e, Cov(a,m)=0A\sigma_{am}}$ (5)

Model 6 :$\mathbf{Y=Xb + Z_1a + Z_2c+ Z_3m + e, Cov(a, m)=A \sigma_{a,m}}$(6)

Where Y is the vector of observations while **b, a, m, c** and **e**are the vectors of fixed effects, direct additive genetic affects, maternal genetic effects, permanent environmental, maternal effect and the residual effect, respectively. X, Z_a, Z_m, and Z_c, are the matrices of fixed effects, direct additive genetic effects, maternal genetic effects and permanent environmental effect of dam, respectively. A is the numerator additive genetic relationship matrix between animals and Cov (a,m) = A $\sigma_{a,m}$ where $\sigma_{a,m}$ is the covariance between direct and maternal genetic effects, σ^2_a the direct additive genetic variance, σ^2_m the maternal genetic variance, σ^2_c the variance of the permanent environmental effect of the dam and σ^2_e the variance of the residuals. Depending on the model the log likelihood function was maximized with respect to direct heritability (h^2_a), maternal heritability (h^2_m), permanent environmental variance of the dam as a proportion of the phenotypic variance (c^2), and the genetic effects as a proportion of the total variance (c_{am}).

Log-likelihood ratio tests (LRT) were used to determine the most appropriate model by comparing the differences between log-likelihoods (-2Log L) to a critical value from a chi-square distribution. Using LRT, the Akaike information criterion (AIC) of Akaike (1973) was computed to rank the models. Letp denote the number of random (co) variance parameters to be estimated and -2 Log L is the maximum likelihood. Then the Akaike information criterion is defined as: AIC=-2LogL+2p.The model yielding the smallest AIC fits the data best.

RESULTS AND DISCUSSION

Means, standard deviation (SD) and coefficients of variation (CV%) for BW and WW of Friesian calves are given in table (2). Means of BW and WW were 30.4 Kg, and 85.1 Kg, respectively. These estimates were higher than those of Frisian cows in Egypt as reported by Safaa and Gharib (2017)for BW while were less than for the WW in the same study. They found that means of BW and WW were 28.6 kgand92.6kg, respectively, while, means of BW and WW were lower than those obtained by Atil *et al.*(2005)BW(31.8kg) and WW (97.4kg) on Friesian cattle. The present estimates of BW and WW were similar to those observed by Hwang *et al.*(2008) on Friesian cows in Egypt.

Table 2. Means, standard deviation (SD) and coefficients of variation (CV%) for growth traits of Friesian calves

Traits	No. of records	Mean	SD	CV%
BW	1371	30.4	3.8	12.4
WW	678	85.1	9.9	11.6

The coefficients of variation (CV %) for BW and WW in the present study were 12.4% and 11.6, %respectively. Safaa and Gharib (2017) found that CV % for BW and WW were 11.1 % and 12.1%, respectively. Also, Hwang *et al.* (2008) found that, estimates (CV%)for BW and WW were 15.3 and 22.0 respectively. Differences between estimates of this study and the previous research may be due to the assumed differences in methods of statistical analysis, the number of used records or due to different farm management.

Non genetic parameters:

The number of lactations and season of calving had highly significant ($P<0.001$) effect on BW and WW (Table 3). Similar results were obtained byAbdel-Glil and El-Banna(2001). It seems likely that improved conditions of dams in winter season of calving refers to the confound effects of moderate climate and availability of green forages under the Egyptian conditions.

Abdel-Glil and El-Banna (2001)concluded that winter and spring had the highest means for WW than the other seasons. On the other hand, Amr (2013) and Faid-Allah (2015)noticed that spring had the highest means for calf BW than the other seasons.

Year of calving had highly significant ($P<0.001$) effect on BW and WW as shown in table (3). The differences in BW and WW from year to year of calving may be due to variation in management practices, change in herd size from year to another.

Body weights of calves in the first parity were the least when compared with other parities. Weaning weights were increasing with advancement of parity and almost reached its maximum at the 5th parity then decreased thereafter (Table 3). Similar result were reported by Abdel-Glil and El-Banna (2001)who found gradual increase in average birth weight in both male and female calves from the first to the fourth parity followed by a decrease in that weight thereafter.

Interaction between year of calving and season of calving hade highly significant ($P<0.001$) effect on BW and WW.

Genetic parameters:

Direct heritability (**h^2_a**)estimates were moderate. They ranged from 0.28to 0.30 for BW and from 0.18to 0.28 for WW (table 4). In general, there was a decrease in the estimate of heritability for BW and differences in h^2_a estimates among various studies for the same traits of the same breed which may be due to differences in the number of records used.

Estimates of heritability from the animal model were comparable to those reported by Meyer *et al.* (1993), Koots*et al.* (1994), Bennett and Gregory (1996), Eriksson *et al.* (2004), Sadek *et al.* (2005), Atil *et al.*(2005) and El-Saied *et al.* (2006) in Friesian cows. Differences between the results of this study and the results of previous research may be due to differences in the methods of statistical analysis, the number of records used or to different management and ways of care.

Maternal heritability's(h^2_m)were higher for BW (0.06 to 0.08) than that for WW (0.04), indicating the importance of the maternal effect on birth and weaning weights. Atil *et al.*(2005)observed that maternal heritability were estimates for the same traits, being 0.14 and 0.06, respectively. A lower maternal heritability estimate (0.02) was found in the work of Montaldo and Kinghorn (2003) for a multi breed population of beef cattle.

Stamer *et al.* (2004) found that, direct heritabilities were 0.63 for birth weight, and 0.50 for weaning weight. Maternal heritabilities were 0.07 and 0.02, respectively. Also Coffey *et al.* (2006) found that, direct heritability estimates were 0.53 for birth weight, and 0.45 for weaning weight.

Estimates of Permanent environmental effect Pe^2 ranged from 0.003 (WW) to 0.08 (BW)across the tested models, being the highest (0.08) in the 2nd model. Permanent environmental effect (Pe^2) in the2nd model was relatively higher, while inclusion of maternal genetic effects (Model 3-6) showed further reduction in h^2a for which there is negligible difference in h^2a of the other models within each trait (table 4).

Ranking the Models:

The six models of the current study were compared. The likelihood function showed that the full animal model best fit the data. Narrow differences in AIC values were observed. The models of the study were arranged according to the AIC values to arrive at the best model for each attribute after the AIC ranking. It was observed that Model 5 was best for BW while Model 4 was the best for WW trait, Models (4&5) were sufficient to explain the variation in the data. It is notable that data structure has a great impact on the accuracy of maternal effects estimation. The best model is different between the two traits. This may be due to the difference in number for the two traits or for care and farm management reasons. Gad (2014) and Jhony *et al.* (2017) indicated that Akaike Information Criterion (AIC) was used to determine equation which model shows the best performance of the studied traits.

Table 3. Least square means (LSM) and standard Error (SE) for factors affecting growth traits in Friesian Calves.

	No.	BW	No.	WW
Parity				
1	400	29.7± 0.39	176	81.7±1.38
2	287	31.4± 0.39	137	85.3±1.41
3	202	32.2±0.43	100	85.6±1.54
4	145	32.8±0.46	83	87.1±1.65
5	113	32.6±0.50	53	87.8±1.85
6	79	33.1±0.61	38	83.7±2.03
7	58	32.3±0.61	31	85.5±2.17
8	106	32.3±0.49	60	84.4±1.75
Sig.		***		*
Season				
Autumn	360	32.1±0.40	194	87.8±1.40
Winter	457	32.3±0.38	204	85.3±1.34
Spring	350	33.0±0.38	160	83.4±1.39
Summer	223	31.4±0.43	120	84.1±1.49
Sig.		***		**
Year				
1990	259	29.1±0.77	29	80.63±4.89
1991	30	29.1±1.08	-	-
1992	52	28.2±0.93	-	-
1993	51	25.4±1.03	16	81.6±7.29
1994	52	25.9±1.04	51	87.08±6.96
1995	50	26.1±1.07	43	88.93±6.97
1996	63	28.3±1.05	51	82.95±6.77
1997	246	29.9±0.89	106	94.9±6.17
2000	67	31.7±0.98		
2001	82	32.3±0.88	31	87.3±3.98
2002	28	33.8±1.15	24	93.9±4.11
2003	52	35.9±0.93	45	92.1±3.76
2004	61	36.06±0.97	50	92.3±3.87
2005	59	34.9±0.96	41	85.6±3.9
2006	30	34.9±1.05	23	86.9±4.16
2007	46	34.9±1.06	39	78.9±4.16
2008	43	35.05±1.06	40	87.1±4.14
2009	25	35.9±1.25	19	86.8±4.77
2010	27	36.9±1.33	17	78.9±5.30
2011	31	36.8±1.23	26	78.9±4.96
2012	23	31.7±1.63	15	73.6±6.24
2013	13	34.9±1.55	12	79.3±6.09
Sig.		***		***
Sex				
1	687	32.9± 0.37	333	86.5±1.28
2	703	31.5±0.36	345	83.8±1.22
Sig.		***		***

Table 4. Estimates of covariance components and direct (h^2d±SE) and maternal heritability (h^2_m±SE) as well as direct (e^2± SE), maternal permanent variances (c^2± SE)

		Covariance components						Heritability				
Model	Traits	σ^2_a	σ^2_m	σ^2_{am}	σ^2P_e	σ^2_e	σ^2_p	h^2_a	h_m	R_{am}	P_{e2}	e^2
Model1	BW	4.64				10.73	15.36	0.30±0.09				70±0.9
	WW	29.57				73.66	103.24	0.29±0.18				0.71±0.17
Model2	BW	4.12			1.22	9.30	14.64	0.28±0.09			0.083±0.11	0.64±0.14
	WW	25.73			0.26	74.78	100.77	0.26±0.17			0.003±0.20	0.74±0.26
Model3	BW	4.0	1.2	0.0		10.0	15.2	0.26±0.09	0.08±0.03	0.0		0.66±0.09
	WW	22.0	4.0	0.0		80.0	106.0	0.21±0.16	0.04±0.04	0.0		0.75±0.16
Model4	BW	4.0	1.0	1.0		10.0	16.0	0.25±0.09	0.06±0.04	0.50±0.54		0.63±0.38
	WW	22.0	4.0	2.4		80.0	108.4	0.20±0.18	0.04±0.08	0.26±1.8		0.74±0.16
Model5	BW	3.6	0.90	0.0	0.50	10.0	15.0	0.24±0.09	0.06±0.03	0.0	0.03±0.12	0.67±0.14
	WW	19.35	4.3	0.0	3.22	73.8	100.67	0.19±0.15	0.04±0.04	0.0	0.03±0.21	0.37±0.26
Model6	BW	3.6	1	1.0	0.60	10.0	16.2	0.22±0.81	0.06±0.04	0.53±0.58	0.03±0.11	0.62±0.13
	WW	19.08	4.24	4.2	3.18	73.80	104.54	0.18±0.16	0.04±0.08	0.47±01.0	0.04±0.20	0.71±0.25

σ^2_a-additive direct genetic variance ; σ^2_m-additive maternal genetic variance; σ^2am= genetic covariance between direct and maternal effect, σ^2_{pe}-permanent environmental maternal variance ;σ^2_p-phenotypic variance-sum of variance and covariance components;h^2_a-direct heritability;h^2_m-maternal heritability.;R_{am}= direct -maternal genetic correlation; σ^2_e-error variance .

Table 5.Akaika information criteria (AIC) ranking of animal models

	BW		WW	
Model	-2log	AIC	-2log	AIC
1	5126.7	5128.7	3764.11	3766.1
2	5124.11	5128.1	3746.0	3750.0
3	5118.1	5122.1	3743.6	3747.6
4	5121.7	5125.7	3743.4	3747.4
5	5116.4	5122.4	3743.2	3749.2
6	5119.8	5125.8	3742.5	3748.5

AIC= -2(Log. L) + 2P.

Estimates of breeding values (EBV) ofthe studied traits are shown in Table 6 and 7. On the basis of the selected model for each traits, using Model 5 for BW and Model 4 for WW, where these models (4, 5) were used to estimate EBV. The ranges of breeding value for sires(SBV) were 5.6 kg and 9.39 kg for BW and WW respectively; where the sire represents great importance in the inheritance of future generations, while they were 6.8 kg and10.6 kg for dam breeding value (DBV) for BW and WW, respectively. Calves breeding values(CBV) were in the range7.4 kg and 13.9 kgfor BW and WW, respectively. The higher range of calves breeding values compared with that of sire or dams means that selection for BW for calves lead to an increase in WW for the next generation. On the other hand, the accuracy of (SBV) for both traits was relatively greater (65% and 58%) than that of DBV (47%to 54%) or CBV (0.56% to 0.50%).Stamer *et al.* (2004)observed that, breeding values estimate show clear differences between sires combined with high reliabilities. Different rankings of sire breeding values for both traits allow selecting sires with both average and low birth weights and high daily gains. These findings indicate the vital role of sire effect on BW and WW which might be due to the large number of daughters per sire. The same trends were observed by Atil *et al.*(2005) and Safaa and Gharib (2017).

Table6. Minimum, maximum, range and accuracy of predicted breeding values of estimated breeding values for BW

	Minimum	S.E	Accuracy	Maximum	S.E	Accuracy	Range
Sire	-2.416	1.08	0.84	3.196	1.52	0.65	5.61
Dam	-1.636	1.73	0.50	5.161	1.76	0.47	6.79
Calves	-3.955	1.58	0.61	3.483	1.66	0.56	7.44

S.E = Standard error; Min. = minimum; Max. = maximum, Range = Maximum minus Minimum and Range (BW Max- BW Min)

Table7. Minimum, maximum, rangeand accuracy of predicted breeding values of estimated breeding values for WW

	Minimum	S.E	Accuracy	Maximum	S.E	Accuracy	Range
Sire	-4.342	4.26	0.42	5.045	3.83	0.58	9.39
Dam	-5.565	4.44	0.52	5.01	3.96	0.54	10.58
Calves	-7.512	3.96	0.54	6.404	4.06	0.50	13.92

S.E = Standard error; Min. = minimum; Max. = maximum, Range = Maximum minus Minimum and Range (BW Max- BW Min)

As shown in the next figure, the genetic trend expressed by animal breeding value for birth weight and weaning weight revealed almost parallel trend for both traits except those estimates of the year's 3,4,5 and 6. However, the genetic trend of breeding values fluctuated across years of the study. This indicates changes in genetic values. Similar results were obtained by Plasse *et al.* (2002), Hossen *et al.* (2012) and Safaa and Gharib (2017). of particular importance is effect of year of birth which could be related to better nutritional and climatic environments mainly due to the difference the direct effect on the availability and quality of nutrients.

In general, year of calving is considered the most important source of variation in different weights at per weaning period and this may be attributed to changes in genetic values.

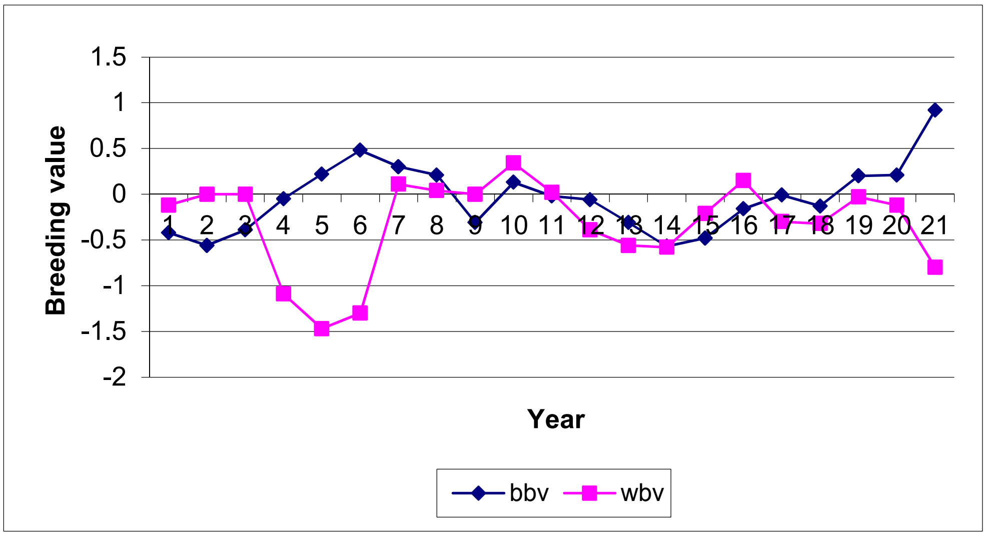

Figure 1. Genetic trend of estimated values for birth weight (bbv) and weaning weight (wbv) as regressed against year

CONCLUSION

The differences in BW and WW from year to year of calving may be due to variation in management practices including changes in weather and feeding practices, change in herd size from year to another. Thus, year of calving is considered as the most important source of variation in different weights at calf weaning. This fact was evidenced by fluctuated genetic trend of breeding values across years of the study denoting variable level of management among years of production.

Among six models tested using Akaike Information Criterion (AIC) to determine the most appropriate model for the studied traits, Model 5: $Y=Xb + Z_1a + Z_2c + Z_3m + e, Cov(a, m) = 0\ A\ \sigma_{am}$ was the most appropriate model for BW, while, Model 4: $Y=Xb + Z_1a + Z_3m + e, Cov(a, m) = A\ \sigma_{a,m}$ was the most appropriate model for WW trait, to represent BW and WW of claves of the used data.

The higher range of calves breeding values compared with that of sires or dam's means that selection for BW of calves may lead to higher WW for the next generation; in addition to selection the parents in high production in beef cattle. On the other hand, the accuracy of (SBV) for both traits was relatively greater than that of DBV or CBV. This finding indicated the vital role of sire effect on BW and WW; these might be due to the large number of daughters per sire.

The study recommends using model 5 when evaluating BW of the herd of and the use of model 4 for evaluation of WW trait; with an estimate of the EBV of the herd based onthe best model for each trait.

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تقدير المعالم الوراثية لصفات النمو باستخدام نماذج إحصائية مختلفة لأبقار الفريزيان المرباه في مصر

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تهدف هذه الدراسة الى تقدير المعالم الوراثية لصفات النمو في ماشية الفريزيان المربأة في مصر باستخدام نماذج متعددة حيث أجريت الدراسة لاختيار أفضل نموذج ملائم لتحليل بيانات صفتي وزن الميلاد (BW) ووزن الفطام للعجول (WW) الفريزيان . وقد تم أستخدم بيانات (BW) ١٣٧١ عجل يمثل نتاج ٧٩ طلوقة وعدد ٤٣٢ أم علي مدار ٢٢ عام ، كما تم استخدام بيانات (WW) ٦٧٨ عجل فريزيان يمثل نتاج ٥٩ طلوقة و٢٨٥ أم علي مدار ١٩ عاما والبيانات تمثل قطيع الفريزيان بمحطة الجميزه التابعة لوزارة الزراعة المصرية . واشتملت النماذج الاحصائية على التأثيرات الثابتة (عدد مواسم الولادة للأمهات – جنس المولود - موسمالولادة- سنه الميلاد) بالإضافة الى التأثيرات العشوائية وذلك لتقدير المكافئ الوراثي المباشروالأميوالتأثيرالبيئي المضيف والخطأالقياسي.

تم حساب المعايير الإحصائية الغير وراثية باستخدام برنامج (SAS 2003) بينما تم تقدير المعايير الوراثية بواسطة برنامج نموذج الحيوان MTDFREML لمقارنة ٦ نماذج إحصائية المستخدمة في الدراسة.

كان المتوسط للوزن عند الميلاد، الوزن عند الفطام٣٠.٤ و ٨٥.١ كجم علي التوالي وكانت العوامل غير الوراثية (التأثيرات الثابتة) ذات أهمية كبيرة ($P <0.001$) حيثكانت عالية المعنوية لجميع الصفات المدروسة.

تراوحت قيم المكافئ الوراثي المباشر متوسطة من (٠.٢٨ الى ٠.٣٠) للوزن عند الميلاد ومن (٠.١٨ الى ٠.٢٨) للوزن عند الفطام. كانت قيم المكافئ الوراثي الأميمنخفضًة نسبيًا بالنسبة للصفات المدروسة كما تراوحت هذه القيم من٠.٠٦ الى ٠.٠٨ للوزن عند الميلاد وكانت (٠.٠٤) للوزن عند الفطام. وقد أظهر التأثير البيئي الدائم في النموذج الثاني بينما تضمن التأثيرات الوراثية للأم (النموذج ٣-٦) كان منخفضا في h^2_aبالمقارنة بالنماذج الأخرى ،تم استخدام معيار (AIC) لتحديد أنسب نموذج للصفات المدروسة. النموذج الخامس كان الأنسب لـصفة الوزن عند الميلاد$\mathbf{Y=Xb + Z_1a +Z_2c+ Z_3m + e,Cov(a, m)= 0 A \sigma_{am}}$

بينما كان النموذج الرابع $\mathbf{Y=Xb + Z_1a + Z_3m+ e,Cov (a, m)= A \sigma_{a,m}}$الأنسب لصفة الوزن عند الفطام .تم استخدام معيار(AIC) لتحديد أنسب نموذج للصفات المدروسة. النموذج الخامس الأنسب لـصفة الوزن عند الميلاد بينما كان النموذج الرابع الأنسب لصفة الوزن عند الفطام.

تم تقدير القيم التربويةللوزن عند الميلادلصفات الدراسة حيث أظهرت النتائج ان مديالوزن عند الميلادللعجول (CBV) أعلى من نظائرها للآباء والامهات وهذا يعني ان الانتخاب علي أساس الوزن عند الميلاد للعجول يؤدي إلى زيادة صفه الوزن عند الفطام للجيل القادم.