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Selection Indexes for Genetic Improvement of Preweaning Growth Traits in Friesin Calves in Egypt

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Abstract: Records of Birth Weight (BWT) and Weaning Weight (WWT) of 1184 Friesian cattle calves (591 male and 593 female), progeny of 49 sires during the period from 1990 to 2000 were analyzed. The objective of this study was to construct selection indexes for selecting Friesian calves on the basis of pre-weaning growth traits included birth weight, weaning weight and Average Daily Gain (ADG) from birth to weaning. The data were analyzed using Least Square Maximum Likelihood Computer Program. Heritability estimates (±SE) were 0.24±0.08, 0.28±0.08 and 0.28±0.08, for BWT, WWT and ADG, respectively. The genetic and phenotypic correlations between WWT and ADG were high and positive (0.907 and 0.892, respectively), while the corresponding correlations between BWT and ADG were low and negative (-0.285 and -0.278, respectively). Four selection indexes were constructed. Index 1 = -1.029 BWT+1.459 WWT -1.207 ADG, index 2 = 0.2201 BWT+0.2077 WWT, index 3 = 0.2426 BWT+0.0991 ADG and the index 4 = 0.1525 WWT+0.0960 ADG. The correlation between the index and the aggregate genotype varied between 0.50 and 0.52. Index 1 which incorporate all traits was the best (R_{IH} = 0.52) and through this index could be improve all traits together. The present results indicated that genetic improvement for pre-weaning growth traits of Friesian calves could be achieved through multiple trait selection indexes.

Key words: Selection index, genetic parameters, correlations, aggregate genotype

INTRODUCTION

Selection indexes allow the animal breeder to apply the appropriate economic weight or relative emphasis on traits to be improved. Currently, selection indexes are generally used in all species of farm animals. Several types of indexes exist for cattle. Animals for breeding are always selected on a multi-trait basis. The main traits for selection of small calves for meat performance are their live body weight and average daily gain during the period of pre-weaning growth performance.

In Egypt, There are no specialized beef breeds. Most domestic output of meet comes from dairy animals. Meat is produced either by native cattle, crossbreds of native cattle and imported cattle, buffaloes, or by imported feeders and ready to slaughter steers. Egyptian local meat production provides 76% of the total demand. Out of which 20% is provided by large commercial feedlots and 80% by smallholders sector. Cattle and buffaloes produce about 70% of the total production of red meat. The balance is produced by sheep, goats and camels (MALR, 2000).

Native (Baladi) and Friesian×native crosses calves are sold alive either when cash is needed or when they are culled. Buffalo calves are sold for slaughter at a very young age to save their dams' milk for family consumption. Farmers and feedlot operators were encouraged by soft loans provided through the National Veal Project, to keep buffalo males for a longer period to attain higher body weights (Sadek, 2002). The current policies encourage the development of commercial farms through increasing the number and size of feedlots and providing financial and technical assistance to veal production.

According to the annual statistics of Animal Production Sector of Egyptian Ministry of Agriculture (MALR, 2000), there are 1 687 986 Egyptian holders have less than 10 heads of buffaloes and/or cattle which represents about 85% of the total buffalo and cattle population in Egypt. This number of holders also represents 97% of all Egyptian holders (1 741 349 holders). With the absence of breeding programs and economic evaluation of genetic improvement, the smallholders can not find simple and easy way

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to select the calves for the purpose of meat production and fattening.

The objective of this study was to construct selection indexes for selecting Friesian calves on the basis of pre-weaning growth traits included Birth Weight (BWT), Weaning Weight (WWT) and Average Daily Gain (ADG) from birth to weaning and to determine the relationships among these traits by simple and easy way to use by the smallholders in Egypt.

MATERIALS AND METHODS

Records on birth and weaning weights of 1184 locally born purebred Friesian calves (593 males and 591 females) progeny of 49 sires collected during the period from 1990 to 2000 were used in the present investigation. The average number of calves per sire was 18.3. The calves were maintained at Sakha Research Station, Kafr El-Sheikh Governorate belonging to Animal Production Research Institute, Ministry of Agriculture, Egypt. The farm is located at the northern middle part of the Nile Delta (about 160 km north of Cairo), Egypt. The nucleus of this herd was imported from the Netherlands to Egypt as pregnant heifers during the period from 1959 to 1961. The management and rearing of these calves were described briefly by Oudah and Mehrez (2000).

Statistical analyses: Data were statistically analyzed utilizing the linear mixed model least squares and maximum likelihood (LSMLMW) computer program (Harvey, 1990). The effects of sire (random effect), year and season of birth, sex of calf (fixed effects) and dam weight at calving (covariate) on BWT, WWT and ADG from birth to weaning were studied. Estimates of heritability (h^2) and genetic (with standard errors), phenotypic and environmental correlation coefficients among different traits were computed by using the LSMLMW program (Harvey, 1990). Heritability estimates (h^2) were computed by the paternal half sibs method according the formula of Henderson (1953):

$$h^2 = 4\,\sigma^2 s/(\sigma^2 s+\sigma^2 e)$$

Where, σ^2 s is sire variance component and σ^2e is variance of error.

Selection indexes construction: Index development was based on selection index theory described by Hazel (1943) from discounted economic weights of traits involved in the breeding goals and their genetic relationships with traits included in the index.

The basic index including three traits, BWT and WWT and ADG from birth to weaning was calculated using the matrix technique described by Cunningham (1970). Prior to compute the complete index, three reduced indexes were computed using all combinations of the traits studied.

According to the recent prices levels of the end of the year 2004 available from The Animal Husbandry Center, Animal Production Research Institute, Sakha, Ministry of Agriculture, Egypt, the economic weight for each trait was approximated based on the final actual net profit as follows:

- Calf price at birth = 500 Egyptian Pounds (EGP). This value considers profit because the calf at birth is produced at farm.
- The total cost of calf rearing from birth to weaning (about 105 days in average) = 529.7 EGP and average selling price of calf at weaning as 1650 EGP, giving a profit of 620.3 EGP [(1650 EGP - (500+529.7 EGP)].
- The average daily gain for calf is 0.7 kg d^{-1}. The cost of one kg growth = 7.25 EGP. Selling price of one kg live weight at weaning estimated by 10.5 EGP, then the profit per 0.7 kg ADG is 2.27 EGP. Thus the relative economic values for BWT, WWT and ADG according these estimates are 1:1.24:0.005. However, the efficiency of an index is not very sensitive to changes in the economic weights (Vandepitte and Hazel, 1977).

Selection index parameters: The index value was calculated as:

$$I = b_1P_1+b_2P_2+.....+b_nP_n = \sum_{i=1}^{n} bipi$$

Where:

bi = Partial regression coefficient and

Pi = Phenotypic value of traits

Regression coefficients (b) of all selection indexes were estimated as:

$$\underline{P}\,\underline{b} = \underline{G}\,\underline{a} \text{ or } \underline{b} = P^{-1}\,Ga$$

Where:

P = The phenotypic variance-covariance matrix,

G = The genetic variance-covariance matrix,

b = Vector of partial regression coefficient to be used in the index,

a = Vector and constant representing the economic value of yield trait and

P^{-1} = The inverse of phenotypic variance-covariance matrix.

Values of partial regression coefficients and phenotypic variance-covariance matrix (P) were used to calculate values of index variance as $\sigma^2 I = \underline{b}' \, \underline{P} \, \underline{b} = \underline{b}' \, \underline{G} \, \underline{a}$, where b′ is the transpose of (b) vector of partial regression coefficients.

The amount of contribution of each traits in the expected genetic gain were measured percent of reduction in selection sub indexes (SR) in case of omitting any trait from the sub index. This value was calculated as:

$$SR = 100 - [(b'P\underline{b} - b_i^2/Wii)/b'P\underline{b}]^{1/2} * 100$$

Where Wii is a diagonal element of P^{-1} (Cunningham, 1970). Variance of the total aggregate genotypic value was estimated as $\sigma^2 H = a'Ga$, where $\sigma^2 H$, is the aggregate genotypic variance and a′ is the transpose of economic value column vector.

Accuracy of the index (defined as correlation between variance of aggregate genotypic value and variance of the index value), was calculated as $R_{IH} = \sigma I/\sigma H$. The expected genetic gain (ΔG) for any one of the traits was calculated as $\Delta G = i \, R_{IH} \, \sigma I$, where i is the selection intensity and for a trait was set to be 1.00 for only the purpose of comparisons, or calculated as according to Tabler and Touchberry (1955, 1959), $\Delta G = \sigma I * i * B_{YI}$ where i is the selection intensity (assume selection differential as one standard deviation), B_{YI} is the regression of each trait in the index on the index value and calculated as $B_{YI} = \underline{b}' c_i / \underline{b}' \, \underline{P} \, \underline{b}$, where c_i is the i th column of G matrix.

To determine which trait and how many traits to combine best into an index, relative efficiencies of the different selection indexes were evaluated on the basis of the correlation of index with aggregate genotype (R_{IH}) and the efficiency (RE%) of different indexes relative to the original index (I_1).

RESULTS AND DISCUSSION

Means: Least square means, Standard Deviations (SD) and Coefficient of Variation (CV%) of Birth Weight (BWT), Weaning Weight (WWT) and Average Daily Gain (ADG) from birth to weaning are presented in Table 1. The mean of BWT (31.5±4.46 kg) fall within the range (25.9 to 37.3 kg) which estimated by Alim and Taher (1979), Abdel-Moez (1996), Emam (2000), Badawy *et al.* (2002) and El-Awady (2003) on Friesian calves in Egypt. The present WWT is the same mean reported by Alim and Taher (1979) and Oudah and Mehrez, (2000) (96.9±9.25 kg), while it was lower than that estimated by Badawy *et al.* (2002) (118.3 kg), whereas, higher estimated for WWT reported by El-Gaffarawy (1979) (76.2 kg). Also the present estimate of ADG (620.9±89.5 g d^{-1}) is agreement with this estimated by Oudah and Mehrez (2000). They working on 988 Friesian calves and found that the average daily gain from birth to weaning was 622 g day^{-1}. However, the present means for all traits are agreement with the most studies carried out on the Friesian calves under Egyptian conditions and notable the differences between the present results and others may be due to differences in the management, the genotype, number of animals, year and months of study and/or models of analyses.

Table 1: Characteristics of the data and summary of significance levels of independent variables on Birth Weight (BWT), Weaning Weight (WWT) and Average Daily Gain (ADG)

	Trait		
Item	BWT (kg)	WWT (kg)	ADG (g d^{-1})
Mean[1]	31.5	96.6	620
SD	4.46	9.25	89.5
CV%	14.2	9.58	14.4
Independent variables:			
Sire of calf	**	**	**
Year of calving	**	**	**
Season of calving	**	NS	**
Sex of calf	**	**	**
Regression:			
DWT, (L)	1493.359	2167.299	75.339

[1]No. of records = 1184, **significant at p<0.01., NS = Not Significant and DWT = Dam Weight at Calving

Effect of non-genetic factors: Least squares analysis of variance showed highly significant (p<0.01) effects of all factors on all traits studied (Table 1) except the effect of season of calving on (WWT) was not significant. Similarly, Khalifa and Khalafallah (1979), Oudah and Mehrez (2000) and Lengyel *et al.* (2002), working on different breeds of cattle, reported that the effect of sire was highly significant on growth traits. Also, significant effect of year and month of calving on growth traits were reported by several studies on different breeds of cattle (Badran and El-Barbary, 1986; Kabuga and Agyemang, 1984; Oudah and Mehrez, 2000; Lengyel *et al.*, 2002). Afifi and Soliman (1971), Khalifa and Khalfallah (1979), Kabuga and Agyemang (1984) reported significant effect of sex on growth traits of Friesian calves which are in agreement with the results reported in the present study.

Variance and covariance components: It is important that the appropriate (co)variances are used to ensure optimal accuracy in genetic evaluations because prediction error variances for predicted genetic values increase as the difference between true and estimated (co)variance components decreased (Lee *et al.*, 1997). Estimates of sire (σ^2_s) and residual (σ^2_e) components of variance and covariance were computed using the formula of Henderson (1953) and published before by the first author

Table 2: Genetic variance-covariance structure of birth weight, weaning weight and average daily gain traits used in the model. (Variances are given on the diagonal and covariance above the diagonal)

Trait	BWT	WWT	ADG
BWT	4.5186	1.5181	-2.8904
WWT		23.6558	21.0474
ADG			22.7868

Table 3: Phenotypic variance-covariance structure of birth weight, weaning weight and average daily gain traits used in the model. (Variances are given on the diagonal and covariance above the diagonal)

Trait	BWT	WWT	ADG
BWT	18.7196		
WWT	7.3945	84.8978	
ADG	-10.843	73.9555	81.0358

Table 4: Heritability (±SE) (on the diagonal), genetic correlation (above the diagonal) and phenotypic correlations (below the diagonal) between the traits studied

Traits	BWT	WWT	ADG
BWT	0.24±0.08	0.147	-0.285
WWT	0.185	0.28±0.08	0.907
ADG	-0.278	0.892	0.28±0.08

(Oudah, 2002). Genetic and phenotypic (Co) variance components are given in Table 2 and 3, respectively. Estimates of genetic and phenotypic variance and covariance of BWT, WWT and ADG were used for construction of various selection indexes using Henderson's modifications of Hazel's (1943) method. The selection intensity for a trait was set to the unit.

Genetic parameters: Estimates of heritability (h^2), genetic and phenotypic correlations are presented in Table 4. Heritability estimates (±SE) for BWT and WWT were 0.24±0.08 and 0.28±0.08, respectively. These estimates were moderate and in agreement with those estimates obtained by Oudah and Mehrez (2000) (0.24 and 0.27), Abdel-Glil and El-Banna, 2001 (0.21 and 0.30) and El-Awady, 2004 (0.28 and 0.24) for BW and WW, respectively.

The present heritability estimate for BWT fall within those estimates reported by Afifi and Soliman (1971), Badran and El-Barbary (1986), Maarof *et al.* (1988), Dzama *et al.* (2001), Badawy *et al.* (2002) and El-Awady (2004), ranging from 0.17 to 0.44 with the different breeds in different countries.

Higher heritability estimate for WWT was reported by Afifi and Soliman (1971) and Maarof *et al.* (1988) working on Friesian calves. They reported that the estimate of h^2 for WWT was 0.53 and 0.43, respectively. While the lower estimate of h^2 for WWT was reported by Lengyel *et al.* (2002) (0.10). According to the present moderate h^2 estimates of BWT and WWT, it could be concluded that the genetic improvement for BWT and WWT can be achieved through selection. Khalifa and Khalafalla (1979) on Kenana cattle calves, Abdel-Glil and El-Banna (2001) and El-Awady (2003) on Friesian calves, came to the same conclusion.

Heritability estimate for ADG from birth to weaning was 0.28±0.08 (Table 4). This estimate fall within the range of h^2 estimated by Bennett and Gregory (1996), Lengyel *et al.* (2002) and El-Awady (2003) for the same trait.

Estimates of genetic and phenotypic correlations between different traits studied were positive except the genetic and phenotypic correlation between BWT and ADG were negative (Table 4). The present positive genetic and phenotypic correlations between BWT and WWT and between WWT and ADG indicated that selection for birth weight would associated with genetic and phenotypic improvement in the growth traits from birth to weaning. Abdel-Glil and El-Banna (2001) arrived to the same conclusion. Similarly, Peterson and Willis (1974), Abdel-Moez (1996) and El-Awady (2003) reported that there were positive genetic and phenotypic correlations between birth weight and weaning weight. El-Awady (2003) using another set of data of Friesian calves, found that direct genetic correlation between BWT and WWT was 0.49, while phenotypic correlation between the same two traits was 0.56. In addition, he estimated the negative genetic and phenotypic correlation between BW and ADG, being -0.14 and -0.22, respectively. The present genetic correlation coefficient between BWT and WWT indicating a positive genetic relationship between pre-and postnatal effects. This conclusion was confirmed previously by Koots *et al.* (1994).

Selection Indexes: Four selection indexes were constructed (Table 5). The original selection index (I_1) incorporating birth weight, weaning weight and daily gain from birth to waning was the best index (R_{IH} = 0.52). The maximum decrease in R_{IH} was observed in the index I_3 which included BWT and ADG traits (R_{IH} = 0.50) (Table 5). This reduction in the value of R_{IH} of the index I_3 may be due to the negative phenotypic and genetic relationship between BWT and ADG as shown in Table 2-4.

The comparative study of various selection indexes showed that the selection index I_1 was the best and it was recommended for improving preweaning growth traits from birth to weaning in Friesian calves in Egypt and this index is very simple and easy to construct.
The suggested index is:

$$I = -1.029\ BWT + 1.459\ WWT - 1.207\ ADG$$

From birth to weaning.

Table 5: Summary of selection indexes, expected genetic gain (ΔG) per generation in each trait, correlation of index with aggregate genotype (R_{IH}) and the efficiency (RE%) of different indexes relative to the original index (I_1)

Selection index	Expected genetic gain (DG)				
	BWT kg	WWT kg	ADG g d^{-1}	R_{IH}	RE(%)
I_1 = -1.029 BWT+1.459 WWT -1.207 ADG	0.35	2.52	2.06	0.52	100
I_2 = 0.2201 BWT+0.2077 WWT	0.57	2.29		0.51	98.1
I_3 = 0.2426 BWT+0.0991 ADG	0.69		1.33	0.5	96.2
I_4 = 0.1525 WWT+0.0960 ADG		-0.06	2.25	0.51	98.1

The positive relationship was found between BWT and WWT (Table 5). It is necessary to select against the increase of BWT due to it is positive relationship with dystocia (MacNeil *et al*., 1998; Dzama *et al* 2001). Similarly, several studies (Smith *et al*., 1976; Amer *et al*., 1998; El-Awady, 2004) obtained positive correlation between birth weight and weight at subsequent ages. They concluded that the selection for reduced birth weight may compromise production efficiency through prolonged feeding to reach market weight. They also added that, a selection strategy with negative emphasis on birth weight and positive emphasis on subsequent growth might be effective in reducing the incidence and severity of dystocia, while minimally reducing the rate of genetic progress for subsequently growth.

The expected genetic gain per generation for BWT, WWT and ADG are shown in Table 5. The expected genetic changes per generation ranged between 0.35 and 0.69 kg for BWT, -0.06 and 2.52 kg for WWT and 1.33 and 2.25 g d^{-1} for ADG. The maximum predicted genetic progress in WWT and ADG were 2.52 kg and 2.25 g d^{-1} per generation was achieved by I_1 and I_4, respectively. Meanwhile, the maximum improvement for BWT was achieved by using I_3 (0.69 kg).

The efficiency of an index is based on percentage of reduction in correlation between genetic worth (aggregate genotype) and index value (accuracy, R_{IH}). The accuracy of index I_1 which including all traits (BWT, WWT and ADG) was higher (0.52) comparing with indexes I_2 and I_3. Generally, the third index (I_3) was the lowest accuracy (0.50). The relative efficiency (RE%) for different indexes is shown in Table 5. Adding WWT or ADG from birth to weaning to I_2 or I_3 as demonstrated I_1, lead to decreasing in the accuracy of index by 1.90 and 3.8% for I_2 and I_3, respectively.

The maximum decrease (3.8%) in R_{IH} was noticed when WWT was dropped from an index I_3 (Table 5). Meanwhile, when BWT dropped from an index I_4, the R_{IH} was decreased only by 1.90%. The present results suggesting that postnatal growth can be increased without increasing birth weight.

From this study, it could be concluded that genetic improvement for pre-weaning growth traits of Friesian calves could be achieved through multiple trait selection index. Selection of calves after weaning should be used on the basis of their weaning weight and average dairy gain.

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