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SELECTION INDICES FOR GENETIC IMPROVEMENT OF WEANING WEIGHT IN FRIESIAN HEIFER CALVES

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ABSTRACT: *The aim of this study was to improve weaning weight of Friesian heifer calves (records of 1024 progeny of 52 sires and 810 dams) via selection index method which included general, reduced, sub and restricted indices at different levels of restrictions on increase in birth weight.*

Estimates of genetic and phenotypic parameters for body weight at birth, 30, 60 and 90 days of age were computed and used to construct nineteen selection indexes to improve the weaning weight in Friesian heifer calves. The full index incorporating weights of birth (W0), 30 (W30), 60 (W60) and 90 (WW) days of age had the highest correlation with aggregate breeding value (R_{ih} = 0.765). The correlation fell to 0.56 when body weight at birth was omitted from the index. Selection for body weight at 90 days of age alone is expected to be 0.49% as efficient as selection for the full index.

The maximum expected genetic gain in 90 body weight was 1.31 kg per generation when all four body weights were included in the index; this decreased to 0.96 kg/ generation when body weight at birth was excluded and further decreased to 0.96 kg/ generation when selection based on weaning weight only.

It could be suggested using (I_1, I_3, I_2 and I_6) to improve weaning weight in Friesian heifer calves under strategy one and using $I_{18\ (75\%\ restriction\ on\ W0)}$, $I_{17\ (50\%\ restriction\ on\ W0)}$ under restriction strategy in case of population that have already not reached optimal W0 but in case of population that have already reached optimal W0, we suggest using completely restriction index (I_{19}).

Key words: *body weight, genetic parameter, selection index, restriction, Friesian heifer calves.*

INTRODUCTION

Friesian heifers of high growth performance show decreased time to conception and better milk yield during the first lactation as compared with those of low or average growth performance (Shemeis *et al.*, 2006). Thus, it appears that a primary interest of dairy producers would concentrate on the improvement of pre and post weaning growth rates of their heifers without much concomitant increase in birth weight to minimize the risk of calving difficulties (Laster *et al.*, 1973). MacNeil *et al.*, (1998) showed that it is necessary to select against the increase of birth weight due to it is positive relationship with dystocia.

Friesian cattle are the most reputed dairy cattle in Egypt and they are potential dual-purpose animals (Abdel-Glil and Elbanna, 2001).

Selection index was developed by Hazel and Lush (1942) and Hazel (1943) as a method of selection for more than one trait at the same time. This method helps breeders to rank and evaluate the individuals on their total breeding values by condensing and summarizing the breeding values of the different economic traits in one total score for each one. Multiple trait selection requires the definition of a breeding goal including individual traits weighted according to their relative contribution to efficiency of production as expressed by economic values (Hazel, 1943).

This study was carried out to estimates the genetic parameters of growth traits during suckling period of Friesian heifer calves in Egypt, and construct different selection indices to improve their weaning weight under different strategies especially restriction strategy on increase in W0 to avoid risk of the dystocia.

MATERIALS AND METHODS

Data used for this study obtained through the period from 1994 to 2004 for body weights at birth, 30, 60 and 90 days of age in Friesian heifer calves (records of 1024 progeny of 52 sires and 810 dams). Data collected from Experimental and Researches Unit of Animal Production in Tokh Tanbisha, in the middle Delta, which belongs to Faculty of Agriculture, Minufiya University, Egypt. Calves were mainly produced through artificial insemination (imported frozen semen of Friesian sires) rather than by natural service. The management and rearing of these calves were described by Ghoneim *et al.*, (2006)

The genetic parameters were estimated by derivative free REML with a simplex algorithm using the Multiple Trait Derivative Free Restricted Maximum Likelihood (MTDFREML) programs of Boldman *et al.* (1995).

The animal model in matrix notation was:

$$Y = Xb + Za + e$$

Where: Y= the vector of observations (W0, W30, W60 and WW); b= the vector of fixed effects (i.e. parity, year, season of birth); a = the vector of random additive genetic direct effects; X and Z=Known incidence matrices relating observations to the respective; e= vector of residual effects $(0, I\sigma_e^2)$.

Selection Index Program (Wagenaar *et al.*, 1995) and Matlab program (Matlab, 2002) were used to set up and construct the selection indices. The four traits studied were used in different combinations to construct 19 selection indices. The selection index obtained by solving the following equation:

$$I = b_1P_1 + b_2P_2 + \cdots b_nP_n = \sum_{i=1}^{n} biPi$$

Where: I = selection index, bi = index weights for each trait in the index;
P_i = phenotypic measurement for each trait in the index.

The general index was obtained by solving the following equations given in matrix expression according to Cunningham (1969):

$$Pb = Gv \quad \text{to give} \quad b = P^{-1}Gv$$

Where: P = Phenotypic variances (cov.) matrix; G = Genetic variances (cov.) matrix; v = Economic weights column vector; b = Weighting factors column vector.

The reduced selection index can be developed by omitting one or more traits from the original index. In relation to the original index the efficiency of the new index, the reduced one, is expected to be decreased depending on the value of the omitted trait in the original index.

The general idea of the restricted index is to keep a particular trait from changing genetically, and permit optimum genetic gains in other traits in the index from generation to generation of selection. According to Cunningham *et al.* (1970) for each completely restriction (i.e. zero change) of a particular trait a dummy variable was added to the general index; a row and column were added to the original P matrix to get P*, the row consists of genotypic co-variances of the other variables with the trait being restricted to zero change, the column is the transpose of the row and the diagonal element is zero. A row of zeros was added to the original G matrix to get G* matrix and zero economic value attaches to every restricted trait. The weighting factors (b*) of completely restricted index could be obtained by solving the following equation: $b^* = P^{*-1} G^* v$

Furthermore, according to Cunningham (1969), the other different properties of the selection index were calculated as following:

The standard deviation of the index = $\sigma i = \sqrt{b'Pb}$

The standard deviation of the aggregate genotype = $\sigma t = \sqrt{v'Gv}$

The correlation between the index and the aggregate genotype = $R_{IH} = \sigma i / \sigma t$

The expected genetic change (ΔG) for each trait, after one generation of selection on the index (i = 1) was obtained by solving either of the following equations (Van der Werf and Goddard, 2003): $\Delta Gi = (i\, b'\, GI)/\sigma I$.

Where: i = Selection differential in phenotypic standard deviation units; σI = Standard deviation of the index; Gi = the i^{th} column of the G matrix.

The four traits studied were used in combinations to construct 19 selection indexes grouped under two strategies based on (W0, W30, W60, and WW) as follow: Strategy 1: General and reduced indices (zero% restriction on increase in W0). Strategy 2: Restriction indices on increase in W0 via different degrees of restrictions (25%, 50% and 75% as partially restriction indices and 100% restriction on increase in W0 as completely restriction index).

The economic values (v) were calculated as $1/\sigma p$, where: σp is phenotypic standard deviation of each trait (Sharma 1982; Sharma and Basu 1986 and Cameron 1997) as shown in table 1. The Selection criterion and the selection objectives are the same.

RESULTS AND DISCUSSION

Table (1) shows the means of W0, W30, W60 and WW which are 32.04, 40.94, 51.86 and 81.98 kg, respectively. The W0 average of Friesian heifer calves obtained in the study is not so far from 32.81 kg (Gaffer *et al.*, 2005), but lower than 38.6, 37.8 and 39.2 kg (Akayezu *et al.*, 1994; Bar-Peled *et al.*, 1997 and Baumgard *et al.*, 2002), respectively. The present study shows average of WW is lower than 97.24 kg at 105 days of age (Gaffer *et al.*, 2005) and higher than 75.83 kg at 90 days of age (Abdel-Glil and Elbanna, 2001). The WW average of heifer calves is lower than that reported by Gaffer *et al.* (2005) who reported 94.97 kg at 105 days of age and greater than 73.89 kg that reported by Abdel-Glil and Elbanna (2001). The coefficient of phenotypic variability decreased with advancing of age from birth to weaning (Table 1).

Table 1: Means, standard deviation (SD), coefficient of variability (CV) and economic values (V) for growth related traits in Friesian heifer calves.

Body weight at:	*№ of records*	*Mean, kg*	*SD, kg*	*CV, %*	*V, 1/σp*
Birth (W0)	1204	32.04	4.380	13.67	0.228
30 day (W30)	775	40.94	4.370	10.69	0.229
60 day (W60)	775	51.86	6.870	13.26	0.145
90 day (WW)	1204	81.98	4.679	05.71	0.214

Estimates of heritability (h^2) as well as genetic correlations (r_G) and phenotypic correlations (r_P) among different body weight traits are presented in Table (2). Heritability estimates for body weights at birth, 30, 60 and 90 days of age were 0.16, 0.37, 0.34 and 0.18, respectively. These estimates are moderate and in agreement with those estimates obtained by Oudah and El-Awady (2006) (0.24 and 0.28) for birth weight and weaning weight in Friesian calves, respectively, Oudah and Mehrez (2000) (0.24 and 0.27), El-Awady (2004) (0.28 and 0.24) for W0 and WW in Friesian calves, resp., and Cucco *et al.* (2009) (0.23) for birth weight in Braunvieh cattle. According to the present moderate h^2 estimates, it could be concluded that the genetic improvement of WW can be achieved through selection. Oudah and El-Awady (2006) came to the same conclusion on Friesian calves.

Table 2: Heritability estimates (diagonal), genetic (below) and phenotypic (above) correlations among growth related traits in Friesian heifer calves.

Body weight at:	W0	W30	W60	WW
Birth (W0)	0.16	0.92	0.56	0.61
30 day (W30)	0.88	0.37	0.63	0.60
60 day (W60)	-0.21	0.22	0.34	0.45
90 day (WW)	0.26	0.54	0.84	0.18

Significantly estimates of genetic correlations (r_G) and phenotypic correlations (r_P) among previous traits were positive in general except between W0 and W60 (Table 2). Abdel-Glil and El-Banna (2001) arrived to the same conclusion. Similarly, 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 genetic and phenotypic correlation between birth and weaning weights were 0.49 and 0.56, respectively.

WW was significantly and positively correlated with all traits under study imply that the W0 could be increased as a result of selection for the heavier WW (rg =0.26, table 2; 0.65, Shemeis *et al.*, 2006; 0.60, Bourdon and Brinks, 1982 and 0.50, Koots *et al.*, 1994).

General, reduced, partially and completely restricted selection indices are shown in Table (3). The general index is considered as the main index due to its properties, whereas this index is contained all traits under selection program without any reducing or restrictions. Furthermore, the general index is used as a standard efficient index to determine the relative efficiencies of the other types of selection indices.

Nineteen selection indices were constructed divided according two strategies; first, strategy one included fifteen indices, and second, strategy two included four restricted indices (Table 3). The original selection index (I_1) which included W0, W30, W60 and WW was suggested to be used for improving weaning weight at 90 days of age in case of zero% of restriction.

The comparisons of the various selection indices indicate that the general index (I_1) which incorporated W0, W30, W60 and WW is the most efficient (R_{IH}=0.765) and it is recommended for improving weaning weight (WW) in Friesian heifer calves in Egypt in case of populations that have already not reached optimal W0

The least accuracy; first, in strategy one, [R_{IH} =0.241 (I_{12}), 0.378 (I_{15}), 0.380 (I_8) and 0.385 (I_{14})] would result especially from sub indices in present study; second, in restriction indices, [R_{IH} =0.662 (I_{19})] revealed that the R_{IH} values of restriction indices under study were high. Indices ($I_{3,\ 2\ and\ 6}$) gave high (R_{IH}) and (RE) values comparing with general index (I_1).

The positive relationship was found between W0 and WW (Table 2). MacNeil *et al.*, (1998) showed that It is necessary to select against the increase of W0 due to it is positive relationship with dystocia. So that the authors suggest using restricted strategy (partially or completely restriction on increase in W0)

Strategy two include four indices, the best restricted indices were $I_{18\ (75\%\ restriction\ on\ W0)}$, $I_{17\ (50\%\ restriction\ on\ W0)}$. It could be suggested using $I_{18\ (75\%\ restriction\ on\ W0)}$, $I_{17\ (50\%\ restriction\ on\ W0)}$ to improve weaning weight in Friesian heifer calves under restriction strategy. In case of populations that have already reached optimal W0, we suggest using completely restriction index ($I_{19\ (100\%\ restriction\ on\ W0)}$) to get zero genetic gain in W0.

Table 3: Weighting factors (b-values), standard deviation (σi), efficiencies of selection in absolutes (R_{Ih}) and relative values (RE) in indices used to improve body weight at weaning in Friesian heifer calves.

Selection index	Selection criterion				b-values						
					W0	W30	W60	WW	σi	R_{Ih}	RE
General Index											
I_1	W0	W30	W60	WW	-0.431	0.479	0.019	0.096	1.136	0.765	100
Reduced Indices											
I_2	W0	W30	W60	----	-0.380	0.490	0.020	-	1.074	0.723	0.95
I_3	W0	W30	----	WW	-0.441	0.502	-	0.097	1.130	0.761	0.99
I_4	W0	----	W60	WW	-0.023	-	0.074	0.108	0.728	0.490	0.64
I_5	----	W30	W60	WW	-	0.126	0.041	0.047	0.836	0.563	0.74
I_6	W0	W30	----	----	-0.390	0.514	-	-	1.067	0.719	0.94
I_7	W0	----	W60	----	0.045	-	0.076	-	0.597	0.402	0.53
I_8	W0	----	----	WW	0.016	-	-	0.113	0.564	0.380	0.50
I_9	----	W30	W60	----	-	0.154	0.040	-	0.815	0.549	0.72
I_{10}	----	W30	----	WW	-	0.157	-	0.045	0.800	0.539	0.70
I_{11}	----	----	W60	WW	-	-	0.071	0.098	0.724	0.488	0.64
Sub Indices											
I_{12}	W0	----	----	----	0.088	-	-	-	0.358	0.241	0.32
I_{13}	----	W30	----	----	-	0.183	-	-	0.779	0.525	0.69
I_{14}	----	----	W60	----	-	-	0.086	-	0.571	0.385	0.50
I_{15}	----	----	----	WW	-	-	-	0.120	0.561	0.378	0.49
Restricted Indices ($I_{16-25\%}$, $I_{17-50\%}$, $I_{18-75\%}$, $I_{19-100\%}$)											
$I_{16-(25\%)}$	W0	W30	W60	WW	-0.368	0.299	0.067	0.122	1.016	0.684	0.89
$I_{17-(50\%)}$	W0	W30	W60	WW	-0.378	0.329	0.059	0.117	1.037	0.698	0.91
$I_{18-(75\%)}$	W0	W30	W60	WW	-0.386	0.351	0.053	0.114	1.051	0.708	0.93
$I_{19-(100\%)}$	W0	W30	W60	WW	-0.352	0.254	0.079	0.128	0.983	0.662	0.87

The expected genetic change per generation (EG) in each trait assuming the selection intensity of 1.00 is given in Table (4). The expected genetic change per generation (EG); first, in strategy one, ranged between -0.099 to 0.880 kg for W0, 0.338 to 1.870 kg for W30, -0.336 to 2.548 kg for W60 and

0.205 to 1.309 kg for WW; second, in restriction indices, ranged between zero to 0.280 kg for W0, 0.943 to 1.288 kg for W30, 2.730 to 3.137kg for W60 and 1.387 to 1.461 kg for WW.

The expected genetic gain after one generation through the general index (I1) will be (1) increase in W0 by 0.604 kg, (2) increase in W30 by 1.694 kg, (3) increase in W60 by 2.274kg, (4) increase in WW by 1.309 kg. This index is simple and easy to construct, therefore, its use is recommended for selection for weaning weight in Friesian heifer calves in case of no restriction on increase in W0.

Table 4: Expected genetic changes per generation in body weights (kg) when using indices to improve body weight at weaning (i = 1.0).

Selection index	Selection criterion				Expected genetic changes			
					W0	W30	W60	WW
General Index								
I_1	W0	W30	W60	WW	0.604	1.694	2.274	1.309
Reduced Indices								
I_2	W0	W30	W60	----	0.730	1.789	1.797	1.108
I_3	W0	W30	----	WW	0.680	1.764	2.087	1.254
I_4	W0	----	W60	WW	-0.099	0.527	2.548	1.217
I_5	----	W30	W60	WW	0.547	1.286	1.453	0.964
I_6	W0	W30	----	----	0.817	1.870	1.581	1.044
I_7	W0	----	W60	----	0.031	0.573	1.842	0.897
I_8	W0	----	----	WW	0.241	0.664	1.265	0.809
I_9	----	W30	W60	----	0.640	1.382	1.178	0.851
I_{10}	----	W30	----	WW	0.783	1.480	0.810	0.772
I_{11}	----	----	W60	WW	-0.021	0.598	2.362	1.166
Sub Indices								
I_{12}	W0	----	----	----	0.665	0.923	-0.336	0.205
I_{13}	----	W30	----	----	0.880	1.580	0.527	0.657
I_{14}	----	----	W60	----	-0.205	0.338	2.285	0.979
I_{15}	----	----	----	WW	0.178	0.601	1.396	0.843
Restricted Indices ($I_{16-25\%}$, $I_{17-50\%}$, $I_{18-75\%}$, $I_{19-100\%}$)								
$I_{16-(25\%)}$	W0	W30	W60	WW	0.135	1.109	2.938	1.424
$I_{17-(50\%)}$	W0	W30	W60	WW	0.221	1.215	2.814	1.402
$I_{18-(75\%)}$	W0	W30	W60	WW	0.280	1.288	2.730	1.387
$I_{19-(100\%)}$	W0	W30	W60	WW	0.000	0.943	3.137	1.461

CONCLUSION

It could be suggested using (I_1, I_3, I_2 and I_6) to improve weaning weight in Friesian heifer calves under strategy one and using $I_{18\ (75\%\ restriction\ on\ W0)}$, $I_{17\ (50\%\ restriction\ on\ W0)}$ under restriction strategy in case of population that have already not reached optimal W0 but in case of population that have already reached optimal W0, the authors suggest using completely restriction index ($I_{19\ (100\%\ restriction\ on\ W0)}$) to get zero genetic gain in W0.

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التحسين الوراثى لوزن الفطام باستخدام أدلة انتخابية فى عجلات الفريزيان

إلهام غنيم ، إسلام فيض الله

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الملخص العربي

الهدف من هذا البحث هو تحسين وزن الفطام لعجلات الفريزيان(سجلات ١٠٢٤ عجلة من ٥٢ طلوقة و ٨١٠ بقرة) باستخدام أدلة انتخابية مختلفة والتى تشمل الدليل العام، ادلة مختزلة تحت مستويات مختلفة محددة لزيادة وزن الميلاد لتجنب مخاطر الولادة.

قدر المكافئ الوراثى والمعايير المظهرية والوراثية لصفات الوزن عند الميلاد والوزن عند ٣٠ يوم ، الوزن عند ٦٠ يوم و الوزن عند ٩٠ يوم لاشتقاق ١٩ دليل انتخابى باستخدام توليفات مختلفة من الصفات المدروسة للتحسين الوراثى لوزن الجسم عند الفطام.

تضمن الدليل العام صفات الوزن عند الميلاد والوزن عند ٣٠ يوم ، الوزن عند ٦٠ يوم و الوزن عند ٩٠ يوم وكان له اعلى قيمة لدقة الدليل (R_{Ih}= 0.765) وقد انخفضت قيمتها الى(R_{Ih}= 0.56) عند اسقاط صفة وزن الميلاد من الدليل العام. و توقع ان يعطى الدليل الفرعى لصفة وزن الفطام ان يعطى ٤٩% من الكفائة الكلية للدليل العام.

كان اعلى عائد وراثى متوقع لصفة وزن الفطام ١,٣١ كجم/جيل و ذلك فى حالة تطبيق الدليل العام فى حين يقل الى ٠,٩٦ كجم / جيل عند إستبعاد وزن الميلاد من الدليل و قد يقل الى ٠,٨٤ كجم / جيل عند استبقاء وزن الفطام فقط فى الدليل.

خلصت الدراسة إلى اقتراح استخدام الدليل الأول، الثالث والثانى والسادس لتحسين وزن الفطام فى عجلات الفريزيان تحت الإستراتيجية الأولى واستخدام الدليل الثامن عشر والسابع عشر تحت الإستراتيجية الثانية وذلك إذا ما كان وزن الميلاد لم يصل للحد الأمثل وفى حالة وصوله للحد الأمثل فيقترح استخدام الدليل التاسع عشر (I_{19}).