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RESTRICTED SELECTION INDEXES TO INCREASE MARKETING BODY WEIGHT WITH MINIMUM CHANGE IN MATURITY WEIGHT IN EGYPTIAN BARKI SHEEP

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ABSTRACT

Age-weight data of 1150 Barki sheep (600 females and 550 males) progeny of 60 sires and 850 dams were fitted to Brody growth function to estimate body weight at maturing. Genetic and phenotypic parameters for body weights at birth (W_0), weaning (W_{04}), 8-month (W_{08}), yearling (W_{12}) and maturity (W_M) were estimated using a multi-trait animal model including the fixed effects of sex of lamb, year of birth and age of dam and the random effects of direct genetics. The estimated parameters were used to construct seven selection indexes aiming to improve marketing body weights W_{08} and W_{12} , representing the aggregate genotype, with minimum changes in W_M.

From the standpoint of accuracy, the full index (I_1 = 2.69 W_0 - 0.977 W_{04} + 0.909 W_{08} + 0.433 W_{12}) had the highest correlation with the true breeding value (r_{TI} = 0.74) followed by late selection (r_{TI} = 0.56 to 0.62) then early selection (r_{TI} = 0.26 to 0.33). Use of I_1 should result in developing sheep with W_0 (0.14 kg), W_{04} (0.51 kg), W_{08} (1.72 kg) and W_{12} (2.08 kg), provided an increase of 1.36 kg in W_M would be accepted. If not, two restricted selection indexes were recommended viz., $I_{(WM)}$ and $I_{(W0)}$. The index $I_{(WM)}$ = -2.508 W_0 -0.228 W_{04} +0.396 W_{08} + 0.020 W_{12}, would reduce the expected increase to zero in W_M and to essentially zero in W_0, but at the cost of reducing selection accuracy excessively (r_{TI} = 0.30) and limiting improvement in marketing weights (0.67 and 0.87 kg). The index $I_{1(W0)}$ = -2.764 W_0 - 0.391 W_{04} + 0.477 W_{08} + 0.342 W_{12}, representing a good compromise, would lead to only 0.55 kg increase in W_M and zero increase in W_0 together with more acceptable improvement in marketing weights (1.18 and 1.48 kg).

Keywords: Barki sheep, marketing body weight, mature body weight, genetic parameters, selection indexes.

INTRODUCTION

Barki sheep has widely gained good reputation among sheep breeds in the North Western desert of Egypt for their high marketability between 8 and 12 months of age in Egypt and Gulf countries. This breed is well adapted to the desert harsh climatic conditions and scarce vegetation, thanks to its relatively small mature size.

Uncalculated efforts to improve body weight at marketing of this breed would result in an increase in body weight at maturity and, thus, disastrous raise of the maintenance feed requirements of the parental stock. Body weights at various stages proved to be positively correlated genetically and phenotypically (Chopra and Acharya, 1971; Ercanbrack and Price, 1972; Alrawi *et al.*, 1982; Bathaei and Leroy, 1998; Rashidi *et al.*, 1998).

The ultimate objective of the present study was to construct restricted selection indexes to improve Barki sheep marketing body weights while maintaining minimum increase in body weight at maturity.

MATERIALS AND METHODS

Source of Data. The data used in the present study were collected over 20 years started in 1963 and ended in 1995 on an experimental North Western coast Barki sheep flock belonging to Desert Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

Feeding and management. As a rule, mating season takes place around July and lambing starts around December each year. Following their birth, lambs are ear-tagged, and kept with their dams to suckle milk until weaning at 4 months of age. After weaning, lambs were fed a concentrate mixture (50% cottonseed cake; 18%, wheat bran; 15%, yellow maize; 11%, rice polish; 3%, molasses; 2%, limestone; 1%, common salt) amounting 0.5 to 1.0 kg/head/day according to physiological status, plus *ad-libitum* amounts of *Berseem* hay (*Trifolium alexandrinum*). Fresh water is usually available for flock once a day.

Traits considered. For each lamb, the body weights at birth (W_0), 4 (W_{04}), 8 (W_{08}), 12 (W_{12}), 16, 24, 36 and 48 months of age were recorded just before morning feeding.

Estimating the mature body weight. To estimate the mature body weight (W_M) for each lamb, the following non-linear growth model (Brody, 1945) was fitted to the data:

$$W_{it} = A_i (1-b_i e^{-kt}) + e_{it} ,$$

where :

W_{it}	=	the observed body weight of the i^{th} animal at age t ;
A_i	=	the estimate of asymptotic weight for the i^{th} animal;
b_i	=	the estimate related to early weight changes in the i^{th} animal;
k	=	the rate of maturing; and
e_{it}	=	deviation of predicted weight from the observed weight for the i^{th} animal at age t.

The estimation was carried out using the modified Gauss-Newton iterative procedure available in SAS program (SAS, 1996).

Estimation of genetic and phenotypic parameters. The genetic and phenotypic parameters of W_0, W_{04}, W_{08}, W_{12} and W_M were estimated from the additive direct components of variance and covariance using the following multi-trait animal model using the DF-REML Computer Program of Meyer (1998):

$$\mathbf{y = Xb + Za + e ,}$$

where:

y	=	the vector of observations of the four traits:
b	=	the vector of fixed effects (year of birth, sex of lamb and age of dam);
a	=	the vector of random additive direct genetic effects;
X and Z	=	known incidence matrices relating observations to the respective fixed and random effects; and
e	=	the vector of random residual effect.

Aggregate genotype. This was defined as:

$$T= a_1g_{W08} + a_2g_{W12} ,$$

where:

g_{w08} and g_{w12} = the additive genetic value for, respectively, W_{08} and W_{12}, recorded before the morning feeding and expressed in kg; and

a_1 and a_2 = the relative economic value for, respectively, W_{08} and W_{12}.

Since, a kg increase in W_{08} and W_{12} would equally contribute to the net profit of the lamb producer, an economic value that equals to unity was assigned for the two traits.

Selection index alternatives. Sources of information (W_0, W_{04}, W_{08} and W_{12}) were used in different combinations to construct eight selection indexes (Cunningham *et al.*, 1970). They were grouped according to the following alternatives:

(i): Full index : based on the four traits; W_0, W_{04}, W_{08} and W_{12} ;

(ii): Early selection: based on W_0 and / or W_{04};

(iii): Late selection: based on W_{08} and / or W_{12}.

RESULTS AND DISCUSSION

Variation in body weights. Table (1) shows means, genetic and phenotypic coefficients of variation and heritabilities for body weight at various stages.

Body weight at birth was less variable than body weights at weaning, marketing and maturing. The phenotypic coefficients of variation in body weights increased with advances in age from birth to weaning and tended to be constant until maturing.

Table (1): Means, Phenotypic Coefficients of Variation (CV_P) and Heritabilities (h^2) for the Traits Considered.

Trait	Symbol	Mean (kg)	CV_P (%)	h^2
Body weight(kg) at:				
Birth	W_0	3.66	13.05	0.39
4 months	W_{04}	18.03	21.71	0.11
8 months	W_{08}	24.68	21.15	0.32
12 months	W_{12}	31.12	21.35	0.37
Maturity	W_M	49.33	22.14	0.12

The present h^2-value for W_0 (0.39) estimated from the additive direct components of variance using the multi-trait animal model was similar to those obtained on Hampshire (0.39, Tosh and Kemp, 1994), Chios (0.38, Ligda *et al.*, 2000) and Merino (0.38, Duguma *et al.*, 2002) lambs and higher than those obtained on the Barki lambs from the sire components (0.22, Fahmy, 1967; 0.22, Fahmy *et al.*, 1969; 0.21, Aboul-Naga and Afifi, 1982). However, it was comparable to the estimates obtained on other fat-tailed breed (Awassi: 0.34, Chaudhry and Shah, 1985).

The low h^2 estimate obtained in the present study for W_{04} (0.11) is very far from other values obtained on the same breed (0.46, Fahmy, 1967; 0.45, Fahmy *et al.*, 1969; 0.42, Aboul-Naga and Afifi, 1982; 0.39, Abdel Aziz, 2000) or other foreign fat-tail breeds from North Africa (Tunisian Barbary:

0.32, Demali *et al.*, 1994) or Asia (Mehraban Iranian: 0.34, Bathaei and Leroy, 1998). Comparable heritabilities were obtained on other fat-tailed Egyptian breeds (Ossimi: 0.11, Aboul-Naga and Afifi, 1982; Rahmani: 0.14, Aboul-Naga and Afifi, 1982).

The present heritability estimate for W_{08} (0.32) is not far from what obtained by Ercanbrack and Price (1977) on Targhee breed (0.35), slightly higher than the values obtained on Rambouillet (0.26) and Columbia (0.21) and much lower than the value calculated by Johari (1972) on Polwarth sheep (0.68).

The h^2-value given in this work for W_{12} (0.37) was comparable to that already obtained on the same breed (0.41, Fahmy *et al.*, 1969), and on the Mehraban Iranian fat-tailed breed (0.44, Bathaei and Leroy, 1998). These values are much higher than those obtained on other the fat-tailed Egyptian breeds (Ossimi: 0.17, Rahmani: 0.03, Aboul-Naga and Afifi, 1982) and lower than that calculated for Awassi (0.53, Alrawi *et al.*, 1982).

Marketing weight (W_M) was found in this work to be particularly lowly heritable (h^2 = 0.12) as compared to the literature where estimates ranged from 0.26 to 0.53 (Veseley *et al.*, 1970; Stobart *et al.*, 1986; Nasholm and Danell, 1990).

Correlations. Genetic and phenotypic correlations among body weights are shown in Table (2). In agreement with the previous reports on Rambouillet, Targhee and Columbia sheep (Ercanbrack and Price, 1972), the present study showed that the variation in W_{08} expressed itself to a large extent in **W_{12} (r_G =0.99; r_P =0.82).**

The present study(Table 2) showed that the marketing body weights were much related to W_{04} and W_{08}(r_G = 0.79 and 0.76, respectively) than to W_0 (r_G = 0.47 and 0.43, respectively). These results implied the difficulty of selecting heavier lambs at marketing by using the first early information recorded at birth.

W_M showed a strong and constant genetic relationship with W_0 (0.53), W_{04} (0.42), W_{08} (0.50) W_{12} (0.54) (Table 2). Stobart *et al.*(1986) reported much higher correlation with weaning weight (0.75). These results indicated that improving body weight at marketing is expected to be associated with clear increase in W_M.

Table (2): Genetic (above diagonal) and Phenotypic (below diagonal) Correlations among the Traits Considered.

Body weight*	W_0	W_{04}	W_{08}	W_{12}	W_M
W_0	…	0.33	0.47	0.43	0.53
W_{04}	0.29	…	0.79	0.76	0.42
W_{08}	0.22	0.82	…	0.99	0.50
W_{12}	0.17	0.62	0.80	…	0.54
W_M	0.16	0.17	0.18	0.15	…

***: Symbols defined in Table (1).**

Indexes. Table (3) gives for each index the b-value, the standard deviation and accuracy of selection together with the relative efficiency in relation to the full index.

Table 3: Weighing Factor, Standard Deviation, Accuracy of Selection and Relative Efficiency for Various Alternative Indexes.

Alternative	Index number	b-value for body weights*: W_0	W_{04}	W_{08}	W_{12}		σ_I	r_{TI}	R.E.
i. Full index	I_1	2.690	-0.997	0.909	0.433		3.80	0.74	100
ii. Early selection	I_2	2.470	0.293	…	…		1.70	0.33	45
	I_3	3.088	…	…	…		1.42	0.28	38
	I_4	…	0.392	…	…		1.32	0.26	35
iii. Late selection	I_5	…	…	0.263	0.489		3.19	0.62	84
	I_6	…	…	0.703	…		2.89	0.56	76
	I_7	…	…	…	0.677		3.13	0.61	82

***: Symbols defined in Table (1).**

The maximum accuracy of selection (r_{TI} = 0.74) was obtained using the full index (I_1) involving the four traits.

The examination of alternatives ii and iii indicated that body weights at the last third of the 1st year of age (I_5, I_6 and I_7) were more accurate than that at the 1st third (I_2, I_3 and I_4) in predicting the true breeding value (r_{TI} = 0.56 to 0.62 vs. 0.26 to 0.33).

Expected genetic changes in individual traits. Table 4 gives results of the expected outcome for individual traits through use of the most accurate indexes using intensity of selection equal to one. Selection based on all indexes is expected to develop lambs having heavier body weights at all stages. The increase was lowest at early stages (birth: 0.08 to 0.14 kg; weaning: 0.51 to 0.53 kg), greatest at marketing (8 months: 1.41 to 1.72 kg; 12 months: 1.71 to 2.08 kg) and medium at maturity (1.02 to 1.36 kg).

Table 4: Expected Genetic Changes in Body Weights (kg) at Various Stages When Using the Most Accurate Indexes (r_{TI} from 0.61 to 0.74).

Alternative	Index	Source of Information	Expected Genetic Changes (kg) in Body Weights*: W_0	W_{04}	W_{08}	W_{12}	W_M
i. Full index	I_1	W_0, W_{04}, W_{08}, W_{12}	0.14	0.51	1.72	2.08	1.36
iii. Selection at marketing age	I_5	W_{08}, W_{12}	0.08	0.53	1.44	1.75	1.02
	I_7	W_{12}	0.08	0.51	1.41	1.71	1.02

***: Symbols defined in Table (1).**

The maximum amount of increase in W_0, at marketing and at maturity were expected when the selection based on the full index (I_1) was applied.

As, it is important to prevent genetic increase in W_M to keep maintenance requirements at their present level, imposing restriction to the full index to result in zero genetic changes in W_M was carried out. It was further possible to restrict the genetic increase in W_M to 0.55 kg by imposing the restriction on birth weight rather than on maturity weight.

Table 5 gives the results in 3 cases: no restriction, restriction on W_M only and on W_0 only. Compared to the restriction on maturity weight, restriction on birth weight involved less sacrifices in accuracy of selection and in genetic gain in the aggregate genotype traits.

It could be concluded that the use of birth weight (W_0), weaning weight (W_{04}), 8-month weight (W_{08}) and yearling weight (W_{12}) as sources of information in the selection index:

$$I_1 = 2.69\ W_0 - 0.977\ W_{04} + 0.909\ W_{08} + 0.433\ W_{12} \qquad (r_{TI} = 0.74),$$

would be recommended to optimize selection for the given aggregate genotype provided some increase (1.36 kg) in W_M is to be accepted. Otherwise, it is possible to limit this increase to 0.55 kg by restricting the full index to zero genetic increase in W_0 in the index:

$$I_{1(W0)} = -2.764\ W_0 - 0.391\ W_{04} + 0.477\ W_{08} + 0.342\ W_{12} \qquad (r_{TI} = 0.52),$$

provided accepting limited sacrifices in accuracy of selection and genetic gain in the aggregate genotype traits.

Table 5. Effect of Restriction of the Genetic Increase in Body Weights at Maturity and at Birth on Weighing Factors, Accuracy of Selection and Expected Genetic Changes in Individual Traits.

Effect of Restriction on	No Restriction	Restriction to Zero Change in:	
		W_M only	**W_0 only**
Weighing factors for body weights*:			
W_0	2.690	-2.508	-2.764
W_{04}	-0.977	-0.228	-0.391
W_{08}	0.909	0.396	0.477
W_{12}	0.433	0.020	0.342
Index variance	3.80	1.53	2.66
Accuracy of selection	0.74	0.30	0.52
Expected genetic changes (kg) in:			
W_0	0.14	-0.06	0.00
W_{04}	0.51	0.21	0.38
W_{08}	1.72	0.67	1.18
W_{12}	2.08	0.87	1.48
W_M	1.36	0.00	0.55

***: Symbols defined in Table (1).**

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أدلة انتخابية مقيدة لزيادة وزن التسويق مع أقل تغير فى الوزن الناضج فى أغنام البرقى المصرية

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تم تقدير الوزن الناضج من بيانات تمثل العلاقة بين العمر والوزن لعدد ١١٥٠ (٦٠٠ أنثى و ٥٥٠ ذكر) من أغنام البرقى المصرية نسل٦٠ كبش و٨٥٠ نعجة باستخدام دالة برودى. ثم قدرت المعالم الوراثية والمظهرية لأوزان الجسم عند الميلاد (W_0) ، ٤شهور (W_4) ، ٨ شهور (W_8) ، ١٢ شهر (W_{12}) وكذا عند النضج (W_M) باستخدام معادلات نموذج الحيوان متعددة الصفات والتى اشتملت على التأثيرات الثابتة لكل من جنس الحمل وسنة الميلاد وعمر الأم والتأثير العشوائى الراجع لوراثة الحيوان. وقد استخدمت هذه المعالم لبناء ٧ أدلة انتخابية تهدف إلى تحسين وزن الجسم عند التسويق على عمر ٨ و١٢ شهر وملاحظة تأثير هذا التحسين على الوزن النضج للأغنام. وقد أظهرت النتائج المتحصل عليها أن الدليل الانتخابى الكامل:

$$I_1 = 2.69\ W_0 - 0.977\ W_4 + 0.909\ W_8 + 0.433\ W_{12}$$

كان أكثر الأدلة ارتباطا بالوراثة الكلية ($r_{TI} = 0.74$). وقد ظهر أن إتباع الانتخاب المبنى على الأعمار المتأخرة كان أكثر دقة من ذلك المبنى على الأعمار المبكرة حيث بلغت دقة الانتخاب ٠,٥٦ إلى ٠,٦٢ مقابل ٠,٢٦ إلى ٠,٣٣. وأن استخدام الدليل الكامل I_1 سوف يسفر عنه إنتاج أغنام ذات وزن أثقل عند الميلاد (+٠,١٤ كجم) ، عند الفطام على عمر ٤ شهور (+٠,٥١ كجم) وعند التسويق على عمر ٨ شهور (+١,٧٢ كجم) و١٢ شهر (+٢,٠٨ كجم) وكذلك عند النضج (+١,٣٦ كجم).

وقد اتضح أنه لا يمكن تقييد الدليل الكامل لينتج عنه عدم حدوث زيادة فى الوزن الناضج للأغنام وذلك لتدنى دقة الانتخاب (٠,٣٠ فقط) ولكن من الممكن خفض معدل الزيادة فى الوزن الناضج بنسبة ٦٥% عن طريق تقييد الدليل الكامل ليسفر عنه عدم حدوث تغير فى وزن الميلاد باستخدام الدليل:

$$I_{1(W0)} = -2.764\ W_0 - 0.391\ W_4 + 0.477\ W_8 + 0.342\ W_{12}$$

وقد أظهرت مقارنة هذا الدليل مع صورته غير المقيدة أن استخدام الصورة المقيدة سوف يتسبب فى ٣٠% خفضا فى دقة الانتخاب وخفضا لمعدل التحسين الوراثى فى وزن الجسم عند التسويق بمقدار ١٥ و٢٠% على التوالى.