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Selection indices for improving body weights in Saudi Aradi and Damascus goats

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Abstract

Data on body weight records of Saudi Aradi goat (A) and Damascus goats (D) were used to construct different selection indices. Records of 314 kids produced by (18 Sir and 67 Dam) for Saudi Aradi goat (A) and of 175 kids produced by (18 Sir and 145 Dam) for Damascus goat (D) were used for the study. The variance component estimated from sire-dam mixed models was utilized to calculate heritability estimates. Seven selection indices constructed using phenotypic and genetic variances and co variances for Saudi Aradi (A) and Damascus goats (D). The original index (supposed to be 100% efficient in the genetic sense) was constructed to include all the 3 traits while the other three reduce indices include only two traits, in consequence one trait of the three traits (included in the original index) was dropped, while the last three reduce indices include only one trait in consequence two traits of the three traits (included in the original index) was dropped. High values of partial regressions coefficients (b´s) were obtained in weight at six month (6M) For Aradi goats (A) and weaning weight (WW) for Damascus goats (D) in all indices constructed. On the other hand, Comparing the three indexes (I_5 = 2.122 BW, I_6 = 2.352 WW and I_7 = 2.232 6M), For Aradi goats (A) the b value of birth weight (BW) was lower than that of weaning weight and weight at six month in the single indices, but, Comparing the three indexes for Damascus goats (D) (I_5 = 3.217 BW, I_6 = 1.699 WW and I_7 = 1.075 MW), the b value of birth weight (BW) was greater than that of weaning weight and weight at six month in the single indices. Estimates of (V%) indicate that including weight at six month in selection programs offer more economic-genetic contribution than those of other growth traits studied (birth and weaning weights). But, for Damascus goats (D) estimates of (V%) indicate that including weaning weight in selection programs offer more economic-genetic contribution than those of other growth traits studied (birth weight and weight at six month). The percentage of total economic-genetic gain (H%) accounted for by gain in each trait for most indices constructed indicated that weight at six month would contribute up to 74.99% of total economic-genetic gain for Aradi goat and up to 57.39% of total economic- genetic gain for Damascus goat which is higher than birth and weaning weights. Selection on I_1 and I_2 for Aradi goat gave the greatest improvement in 6M (+2.157 kg) and in WW (+1.180 kg). While, selection on I_1 for Damascus goat gave the greatest improvement in WW (+1.400 kg). Correlation between the indices constructed and each individual trait in the aggregate genotype (r_{ix}) for Aradi goat ranged from 0.109 to 0.391 for birth weight and from 0.084 to 0.669 for weaning weight and from 0.089 to 0.669 for weight at six month. Furthermore, the high correlation for weaning weight and weight at six month indicated that selection per generation based on any index constructed would actually lead to a high genetic gain in weaning weight and weight at six month. Also, these correlations for Damascus goat ranged from 0.020 to 0.641 for birth weight and from 0.343 to 0.599 for weaning weight and from 0.030 to 0.479 for weight at six month. Furthermore, the high correlation for weaning weight and weight at six month indicated that selection per generation based on any index constructed would actually lead to a high genetic gain in weaning weight and weight at six month. While the high correlation for birth weight in (I_5) only for two breeds indicated that the expected genetic change in this trait based on (I_5) would be larger than other indices. The maximum accuracy of selection In Aradi goat (RIH = 0.699) was obtained using the index (I_1). But the accuracy was decreased (RIH = 0.507) when 6M was ignored from the full index (I_4). Selection for 6M alone would be more efficient (RIH = 0.668) than selection for WW (RIH = 0.507) alone or BW (RIH = 0.094) alone. Also, the maximum accuracy of selection Damascus goat (RIH = 0.56) was obtained using the index (I_1). But the accuracy was more decreased (RIH = 0.482) when WW was ignored from the full index (I_3) than (RIH = 0.511) when 6M was ignored from the full index (I_4) Selection for 6M alone would be more efficient (RIH = 0.48) than selection for WW (RIH = 0.466) alone or BW (RIH = 0.235) alone. The efficiencies (RE) of different indices constructed relative to original index (I_1). For Aradi goat, three trait index, (I_2) based on weaning weight and weight at six month, index (I_3) based on birth weight and weight at six month and index (I_7) based on weaning weight and weight at six month were 99% as effective as the index including the three traits (I_1), while the effectiveness of (I_5) was only 14.00%. But, for Damascus goat one trait index, (I_2) based on weaning weight and weight at six month were 99% as effective as the index including the three traits (I_1), while the effectiveness of (I_5) was only 42.00%.

Keywords: Saudi Aradi goats, Damascus goats, selection indices, heritability, variance component.

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1. Introduction

Selection indices have been constructed and used to improve almost all species of animals such as dairy cattle (Harvey and Lush, 1952; Khalil and Soliman, 1989; Legats, 1949), in sheep (Morly, 1950; Rae, 1950) and Rabbit (Khalil *et al.*, 1986) and poultry (Akbar *et al.*, 1984; Gill and Verma, 1983). Selection index is the most efficient method to improve several traits at the same time (Cocheran, 1951; Hazel, 1943; Hazel and Lush, 1942). Construction of a selection index requires knowledge of the phenotypic variances and co-variances of the traits used as criteria for selection, their genetic (co) variances between these traits and their economic weights (Dalton, 1981; Falconer, 1983; Hazel, 1943; James, 1981). The importance of goats as a potential source of meat has been realized particularly in small farming systems in developing countries. In the Kingdom of Saudi Arabia, Aradi and Damascus goats are the most desirable breeds. The average adult weights of Aradi breed are about 40 kg for females and 51 kg for males (Bhattacharya, 1989), while the corresponding values of Damascus goats are Performance of Damascus goats could record an average Damascus bucks could attain 87.75 kg in weight and the does 53.60 kg. Improving goat productivity was frequently suggested to be achieved either through selection within native breeds (Abdelaziz *et a1.*, 1995; Aboul-Naga *et a1.*,1985). Income from goat meat can be economically feasible, if we pay particular attention for improving growth of Aradi and Damascus goats. Some evidence suggests that there is considerable variation among and within both breeds with regard to live weight (Bouillon and Ricordeau, 1975; Ricordeau *et al*., 1972). The objective of the present study was to construct selection indices for improving some growth traits of Aradi and Damascus goat breeds raised under the conditions of Saudi Arabia. The proposed indices are constructed to try to achieve the genetic improvement of growth traits (body weight at birth, weaning and six month) and computing an index is to derive an estimate in which the various growth traits are appropriately weighted to give the best estimate of breeding value for Saudi Aradi goats (A) and Damascus goats (D). What it will produce when it breeds.

2. Materials and methods

2.1 Location of the study and animal management

Saudi goats (Ardi, AA) as a native breed and Syrian goats (Damascus, DD) were carried out at Camel and Range Research Center (Al-Jouf province, Northern region of Saudi Arabia located at latitude of 29.97°N and longitude of 40.21° W and at 684 meters above sea level). Genetically selected and improved bucks were used to disperse these valuable genes throughout the goat herds in Saudi Arabia. All animals were raised under similar environmental, nutritional, and management conditions. The animals were housed in semi-shaded/open front barn and fed on a commercial concentrate and alfalfa hay. The amount of concentrate and hay were calculated according to the nutritional requirements for goats which dependent on animal ages and production status. Water, straw, salt and minerals supplemented in blocks were freely available to all animals.

2.2 Data collection for statistical analysis

The pedigree records of the body weights were obtained from Records of 314 kids produced by (18 Sir and 67 Dam) for Saudi Aradi goat (A) and of 175 kids produced by (18 Sires and 145 Dams) for Damascus goat (D) were used for the study. Birth weight (BW), weaning weigh (WW) and 6 months weight (6MW) were recorded for all animals during season 1 (winter and Autumn) and season 2 (summer and spring) and years from 2006 to 2010. They were classified according to breed, sex, season, year, and type of birth. Data were analyzed using PROC GLM procedure (SAS v8.1) for the Least-squares means (LSM) and standard errors (SE) of the fixed factors. Heritability and genetic parameters were estimated with derivative-free restricted maximum likelihood (REML) procedures using the MTDFREML program of Boldman *et al*. (1995).

2.3 Statistical model used for data analysis

Estimates of variance, co-variance components, heritability, genetic correlation and phenotypic correlation, estimates were obtained by Restricted Maximum Likelihood Method, using the program MTDFREML (Multiple Trait Derivative-Free Restricted Maximum Likelihood), developed by Boldman *et al*. (1993), by an animal model as follows:

$$y = Xb + Z_a a + e$$

Where: y is vector of observations of birth weight, weaning weight or weight at six month, X is the incidence matrix for fixed effects, b is the vector for the overall mean and fixed effects, Z_a is the incidence matrices for random effects, a is the vector of direct genetic effects of animal, e is the vector of random errors normally and independently distributed with zero mean and variance δ^2e.

When selection is applied to improve the economic value of animals or plants it is generally applied to several traits simultaneously, and not just to one, because economic value depends on more than one trait. However, it has been shown that the most rapid improvement of economic value is expected from selection applied simultaneously to all component traits according to its relative economic importance, its heritability and the genetic and phenotypic correlations between the different traits. The principles of constructing and using selection indices which permit the attainment of maximum genetic progress are given by Hazel and Lush (1943) and Hazel (1943). In the present study one selection index have been constructed, it's to improve the body weight. The selection indices constructed for improving body in Saudi Aradi goats and Damascus goats included weight three varieties (*viz*. Birth weight, Weaning weight and weight at six month). These three varieties were considered as three traits for selection criteria. Seven selection indices constructed using phenotypic and genetic variances and co variances for Saudi Aradi (A), Damascus goats (D). For Aradi goats (A) and Damascus goats (D), the original index (supposed to be 100% efficient in the genetic sense) was constructed to include all the 3 traits while the other three reduce indices include only two traits, in consequence one trait of the three traits (included in the original index) was dropped, while the last three reduce indices include only one trait in consequence two traits of the three traits (included in the original index) was dropped. The relative economic value for any trait is the amount of net profit which is due to a unit change in the trait towards the desired direction, (Hazel and Lush, 1942). Vandepitte and Hazel (1977) defined the relative economic value as the amount by which net profit may be expected to increase for each unit of improvement in the trait. An estimate of the economic value of live body weight at Birth, weaning and six month was based on (sale-cost) prices. The information required for constructing the index for body weight is specified in the following 4 vectors and 3 matrices. Y_i is a vector of additive genetic values for the 3 traits (i= 1, 2, 3) included the aggregate genotype, *i.e*. Birth weight, Weaning weight and weight at six month respectively. a_i is a vector of constants, representing the relative economic values of the 3 traits in Y_i. X_j is a vector of phenotypic measures for the 3 variables (j = 1, 2, 3) to be included in the index, *i.e*. Birth weight, Weaning weight and weight at six month respectively. bj is a vector of weighting factors to be used in the index (partial regression coefficients). P is a squared nxn matrix of phenotypic variances-covariances of the three variables in j^{th} varieties. G is a matrix of genotypic variances between the three variables in j^{th} variates and the i^{th} traits in Yi. C is a squared matrix of genotypic variances-covariances of Y-traits. The aggregate genotype (H) or breeding value is designated as:

$$H = a_1Y_1 + a2Y2 + a3Y3$$

Where: Y_1, Y_2 and Y_3 are the genotypic values for Birth weight, Weaning weight and weight at six month respectively. The $a\acute{}s$ are the relative economic values of these traits. Since the H is not measurable, and could not be selected for directly. Improvement in H is brought about by selection on an index or selection criterion:

$$I = b_1x_1 + b_2x_2 + b_3x_3$$

The weighing factors in I are obtained by solving the index equations:

$$pb = Ga$$

Therefore, the index matrices are represented as follows:

$$\begin{bmatrix} V_{P(Y1)} & COV_{P(Y1X2)} & COV_{P(Y1X3)} \\ COV_{P(Y2X1)} & V_{P(Y2)} & COV_{P(Y2X3)} \\ COV_{P(Y3X1)} & COV_{P(Y3X2)} & V_{P(Y3)} \end{bmatrix} \qquad \begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix}$$

P phenotypic variances-covariances b-vector matrix

$$\begin{bmatrix} V_{A(Y1)} & COV_{A(Y1X2)} & COV_{A(Y1X3)} \\ COV_{A(Y2X1)} & V_{A(Y2)} & COV_{A(Y2X3)} \\ COV_{A(Y3X1)} & COV_{A(Y3X2)} & V_{A(Y3)} \end{bmatrix} \qquad \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix}$$

G = Genotypic matrix a-vector matrix

Where: $VP_{(Yi)}$ = the phenotypic variances of the i^{th} traits, (i = 1, 2, 3), $Cov_{P(YiXJ)}$ = the phenotypic co-variances of the i^{th} traits and j^{th} varieties (i= j), $VA_{(Yi)}$ = the additive genetic variances of the i^{th} traits, $Cov_{A(YiXJ)}$ = the additive genetic co-variances of the i^{th} traits and j^{th} varieties (i= j), a_i = the economic weight of the i^{th} traits (i = 1, 2, 3), b_j = the partial regression coefficient of the j^{th} varieties (j= 1, 2, 3). The phenotypic matrix contains the phenotypic variances and co-variances of the j^{th} varieties (j = 1, 2, 3), the genetic variances and co-variances of the i^{th} traits (i = 1, 2, 3) and the genetic co- variances between the j^{th} varieties in x and i^{th} traits in *Y*. The partial regression (b´s) was computed as:

$$b = P^{-1} G\,a$$

Where: P^{-1} is the inverse of the variance-covariance matrix of phenotypic values. Other calculated parameters were:

1. The variance of the index $\sigma_1^2 = b'$ where b´ is the transpose of b-vector, $b' = [b_1\ b_2 \dots \dots\ b_n]$.
2. The variance of the aggregate genotype $\sigma_H^2 = a'c\,a$ where a´ is the transpose of a-vector, a and c as defined previously.
3. The correlation of the calculated index with defined total aggregate genotype is: $r_{IH} = \sqrt{\frac{\sigma_H^2}{\sigma_H^2}} = \frac{b' \quad G \quad a}{a' \quad C \quad a}$

   i.e. dividing of σI by σH.
4. Value of each x- variate in index (= percent reduction in rate of overall genetic gain if the variety is omitted). In other words, the contribution with each variety makes to genetic gain for the total genotype, for j^{th} variety:

   $$100 - \left[\sqrt{\frac{b' \quad G \quad a - b_J^2 \,/\, W_{JJ}}{b' \quad G \quad a}} \times 100\right]$$

   Where: *Wjj* is the j^{th} diagonal element of P^{-1}. The derivation of the method used to calculate the value of each variate in an index is given by Cunningham (1969) and Cunningham *et al*. (1970).
5. Regression of each individual Y-trait on index. For j^{th} trait: $\frac{b' \quad G_1}{b' \quad G_2}$

   Where: G_i is the i^{th} column of G.
6. Correlation of each individual Y-trait with index. For i^{th} trait: $\frac{b' \quad G}{\sqrt{(b'G_2)\,(C_{ii})}}$

   Where: C_{ii} is the ith diagonal element of C.
7. Percentage of economic value of total genetic gain accounted for by gain in each trait. For i^{th} trait:

   $$\frac{b' \quad G_1}{b' \quad G \quad a} \times a_1 \times 100$$

   Where: a_i is the economic value of the i^{th} trait.

According to Cunningham (1977), if one source of information is dropped from the original selection index, then a new index based on the remaining two variables could be obtained. The new index is calculated with a 2 vector of weighting factors, B, which are obtained by solving the reduced index equations: [SB = RO] where S is a 2x2 matrix of phenotypic covariance obtained by deleting the 3rd row and columns of p phenotypic matrix, and RO is a two vector obtained by deleting the 3rd row of G matrix. The efficiency of the reduced index relative to the original index can be estimated as the ratio of the rates of genetic progress in H which they produced (Cunningham, 1969).

$$\frac{\Delta H_I}{\Delta H} = \frac{B' S\, B \quad D}{b'\, p\, b \quad D} = \frac{B' \quad S\, B}{b' \quad p\, b}$$

Which is the ratio of the standard deviations of the two indices and D is the selection differential. Using other procedure, $\Delta H_I/\Delta\, H\; = r_{I1H}/r_{IiH}$, where: r_{I1H} is the correlation between the aggregate genotypic value and the index which included all of the three varieties (original index), and r_{IiH} is the correlation of the index I_i, i $\neq$ I, which included only two varieties and the aggregate genotypic value.

3. Results and Discussion

The aim of computing an index is to derive an estimate in which the various growth traits are appropriately weighted to give the best estimate of breeding value for Saudi Aradi goats (A) and Damascus goats (D). What it will produce when it breeds. In the present study, birth weight, weaning weight and weight at six month are the three growth traits for Saudi Aradi goats (AA) and Damascus goats (DD). Table (1) shows the heritability (h^2) and variance components for all studied traits in both breeds.

Table (1): Estimates of heritability (h^2) and variance components for body weights at birth, weaning and 6 months of ages in Aradi goat (AA) and Damascus goat (DD).

Breed	Body weight	H^2	δ^2 p	δ^2 g	δ^2 e
	BW	0.15	0.513	0.079	0.434
AA	WW	0.26	12.080	3.110	8.970
	6MW	0.45	23.264	10.385	12.880
	BW	0.41	0.564	0.232	0.332
DD	WW	0.35	15.561	5.451	10.110
	6MW	0.18	20.319	3.649	16.670

3.1 Index coefficients

The seven selection indices constructed using phenotypic and genetic variances and co variances for Saudi Aradi (A), Damascus goats (D) are given in tables (2, 3, 4 and 5). These b's indicated the relative emphasis each trait should receive to maximize profitable genetic response. Generally, high values of partial regressions coefficients were obtained in weight at six month (6M) for Aradi goats (A) and weaning weight (WW) for Damascus goats (D) in all indices constructed. These results were expected since weight at six month (6M) for Aradi goats (A) and weaning weight (WW) for Damascus goats (D) have high positive genetic correlations with other traits included in the index. Similar trend for the high values of partial regressions coefficients (b's) for the trait with high genetic correlations with other traits included in the index was indicated by Mbah and Hargrove (1982) in the index constructed for improving milk protein. Similar trend for the high (b's) for the traits having high genetic correlations with other traits included in the index was observed in indices for the estimation of economic-genetic merit of sires (Anderson *et al*., 1978; Cunningham, 1969). On the other hand, comparing the three indexes (I5 = 2.122 BW, I6 = 2.352 WW and I7 = 2.2326 M), For Aradi goats (A) the b value of birth weight (BW) was lower than that of weaning weight and weight at six month in the single indices, These results were also expected since birth weight has low heritability than weaning weight and weight at six month (0.15 vs. 0.26 and 0.45) but, Comparing the three indexes Damascus goats (D) (I5 = 3.217 BW, I6 = 1.699 WW and I7 = 1.075 MW), the b value of birth weight (BW) was greater than that of weaning weight and weight at six month in the single indices, These results were also expected since birth weight has high heritability than weaning weight and weight at six month (0.41 vs. 0.35 and 0.18).

3.2 Variates contribution

The value of including each variety in the index can be assessed by the percentage reduction in rate of genetic gain for aggregate genotype which results if the variety was dropped from the index (Cunningham and Mahon., 1977). Accordingly, weight at six month contributes largely in aggregate genotype in all indices constructed for Aradi (A) (Table 2), estimates of (V%) indicate that including weight at six month in selection programs offer more economic- genetic contribution than those of other growth traits studied (birth and weaning weights). But, weaning weight contributes largely in aggregate genotype in all indices constructed for Damascus goats (D) (Table 4), estimates of (V%) indicate that including weaning weight in selection programs offer more economic-genetic contribution than those of other growth traits studied (birth weight and weight at six month). However, the low contribution of birth weight in all indices constructed may be due to the moderate genetic correlation between birth weight and each of weaning and weights at six month.

3.3 Total economic-genetic gain

The percentage of total economic-genetic gain (H%) accounted for by gain in each trait are given in tables (2 and 4). These percentages for most indices constructed indicated that weight at six month would contribute up to 74.99% of total economic-genetic gain for Aradi goat and up to 57.39% of total economic-genetic gain for Damascus goat which is higher than birth and weaning weights.

3.4 Trait expected-gain

Results of the expected genetic gain changes in body weight at various ages for each round of selection are shown in tables (2 and 4). Selection on I1 and I2 for Aradi goat gave the greatest improvement in 6M (+2.157 kg) and in WW (+1.180 kg). While, Selection on I1 for Damascus goat gave the greatest improvement in WW (+1.400 kg).

Table (2): Selection Indices (I´s) for body weight of Aradi goats.

Index	Traits		
	BW	WW	6M
I_1			
b	0.457	0.252	2.095
V%	0.044	0.156	24.247
H%	0.423	24.611	74.966
ΔG	0.0457	1.180	2.157
r_{ix}	0.163	0.669	0.669
b_{ix}	0.004	0.109	0.200
I_2			
b		0.272	2.092
V%		0.187	24.210
H%	0.394	24.622	74.984
ΔG	0.042	1.180	2.157
r_{ix}	0.152	0.669	0.669
b_{ix}	0.004	0.109	0.200
I_3			
b	0.587		2.22
V%	0.075		85.895
H%	0.433	24.607	74.960
ΔG	0.047	1.178	2.154
r_{ix}	0.166	0.668	0.668
b_{ix}	0.004	0.109	0.200
I_4			
b	0.083	2.349	
V%	0.002	81.411	
H%	0.384	24.625	74.990
ΔG	0.031	0.895	1.635
r_{ix}	0.112	0.507	0.507
b_{ix}	0.004	0.109	0.200
I_5			
b	2.122		
V%	99.981		
H%	7.225	22.0263	70.748
ΔG	0.110	0.149	0.287
rix	0.391	0.084	0.089
bix	0.072	0.098	0.188
I_6			
b		2.352	
V%		94.675	
H%	0.375	24.6291	74.996
ΔG	0.030	0.895	1.635
rix	0.109	0.507	0.507
bix	0.004	0.109	0.200
I_7			
b			2.232
V%			97.657
H%	0.395	24.621	74.983
ΔG	0.042	1.178	2.153
rix	0.152	0.668	0.668
bix	0.004	0.109	0.200

Where, value of the coefficient of the index being partial regressions coefficient (b's), percentage reduction in rate of genetic gain for aggregate genotype if variety is dropped (V%), percentage of total economic-genetic gain attributable to each trait (H%), the expected genetic progress in each traits (ΔG), the correlation coefficient of the index and each traits (r_{ix}), the regession coefficient of each traits on the index (bix). The same notation used in similar table.

Selection on single-trait indices for Aradi goat yielded progressive improvement in 6M (selection on BW: +0.287 kg; on WW: +1.635 kg; and on 6M: +2.153 kg). While, selection on I7 gave the greatest improvement in WW (+1.178 kg).

Table (3): Standard deviation of the index (σI), accuracy of selection (RIH) representing the correlation of selection index with aggregate genotypic value and relative efficiency (RE) for body weight of Aradi goat.

INDEX1	I_1	I_2	I_3	I_4	I_5	I_6	I_7
σI	116.464	116.360	116.100	66.842	2.309	66.839	115.925
RIH	0.669	0.669	0.668	0.507	0.094	0.507	0.668
ER to I1	100	99	99	75	14	76	99

Also, selection on single-trait indices for Damascus goat yielded progressive improvement in WW (selection on BW: +0.838 kg; on WW: +1.380 kg; and on 6M: +0.802 kg). While, selection on I6 gave the greatest improvement in 6 M (+0.916 kg).

3.5 Index-trait correlation

Correlation between the indices constructed and each individual trait in the aggregate genotype (r_{ix}) are shown in tables (2 and 4). These correlations for Aradi goat varied from trait to another. They ranged from 0.109 to 0.391 for birth weight and from 0.084 to 0.669 for weaning weight and from 0.089 to 0.669 for weight at six month. Furthermore, the high correlation for weaning weight and weight at six month indicated that selection per generation based on any index constructed would actually lead to a high genetic gain in weaning weight and weight at six month. Also, these correlations for Damascus goat varied from trait to another. They ranged from 0.020 to 0.641 for birth weight and from 0.343 to 0.599 for weaning weight and from 0.030 to 0.479 for weight at six month. Furthermore, the high correlation for weaning weight and weight at six month indicated that selection per generation based on any index constructed would actually lead to a high genetic gain in weaning weight and weight at six month. While the high correlation for birth weight in (I_5) only for two breeds indicated that the expected genetic change in this trait based on (I_5) would be larger than other indices.

3.6 Index accuracy

The accuracy of an index is based on its correlation with the aggregate genotype (RIH) where the genetic gain from the use of an index is directly proportional to RIH are given in tables (3 and 5). In Aradi goat, it appears that the maximum accuracy of selection (RIH = 0.699) was obtained using the index. I_1 = 0.457 BW + 0.252 WW + 2.095 6M. This magnitude of accuracy did not essentially change (RIH = 0.699) when BW, WW or BW&WW were ignored from the full index, giving. I_2 = 0.272 WW + 2.092 6M. I3 = 0.587 BW + 2.092 6M. I_7 = 2.232 6M. But the accuracy was decreased (RIH = 0.507) when 6M was ignored from the full index, giving I_4 =0.083 BW + 2.349 WW. Comparing the three indexes, I_5 = 2.122 BW, I6 = 2.352 WW and I_7 = 2.232 MW. Selection for 6M alone would be more efficient (RIH = 0.668) than selection for WW (RIH = 0.507) alone or BW (RIH = 0.094) alone.

Table (4): Selection Indices (I´s) for body weight of Damascus goats.

Index		Traits		
		BW	WW	6M
I_1				
	b	0.377	1.692	-0.020
	V%	0.078	26.405	0.004
	H%	2.560	46.951	50.488
	ΔG	0.171	1.400	0.903
	r_{ix}	0.357	0.599	0.473
	b_{ix}	0.025	0.208	0.134
I_2				
	b		1.707	-0.009
	V%		27.671	0.001
	H%	2.391	46.422	51.187
	ΔG	0.160	1.383	0.915
	r_{ix}	0.333	0.592	0.479
	b_{ix}	0.024	0.206	0.136
I_3				
	b	1.308		1.007
	V%	0.990		0.772
	H%	1.425	41.178	57.39
	ΔG	0.070	0.903	0.755
	r_{ix}	0.146	0.387	0.395
	b_{ix}	0.014	0.183	0.153
I_4				
	b	0.366	1.677	
	V%	0.066	50.970	
	H%	2.534	46.85	50.617
	ΔG	0.170	1.397	0.905
	r_{ix}	0.353	0.598	0.474
	b_{ix}	0.025	0.208	0.135
I_5				
	b	3.217		
	V%	31.746		
	H%	12.770	78.104	9.125
	ΔG	0.308	0.838	0.059
	rix	0.641	0.359	0.030
	bix	0.128	0.347	0.024
I_6				
	b		1.699	
	V%		73.958	
	H%	2.381	46.380	51.239
	ΔG	0.160	1.382	0.916
	rix	0.332	0.592	0.479
	bix	0.024	0.206	0.136
I_7				
	b			1.075
	V%			30.728
	H%	0.201	37.197	62.600
	ΔG	0.010	0.802	0.809
	rix	0.020	0.343	0.424
	bix	0.002	0.165	0.167

Table (5): Standard deviation of the index (σI), accuracy of selection (RIH) representing the correlation of selection index with aggregate genotypic value and relative efficiency (RE) for body weight of Damascus goats.

INDEX1	I_1	I_2	I_3	I_4	I_5	I_6	I_7
σI	45.015	44.944	45.980	51.573	10.926	42.913	45.204
RIH	0.560	0.560	0.482	0.511	0.235	0.466	0.478
ER to I1	100	99	86	91	42	83	85

Also, in Damascus goat, it appears that the maximum accuracy of selection (RIH = 0.56) was obtained using the index I1 = 0.377 BW + 1.692 WW – 0.020 6M. This magnitude of accuracy did not essentially change (RIH = 0.560) when BW was ignored from the full index, giving I2 = 1.707 WW – 0.009 6M. But the accuracy was more decreased (RIH = 0.482) when WW was ignored from the full index than (RIH = 0.511) when 6M was ignored from the full index, giving I3 =1.308 BW + 1.007 6M, I4 =0.366 BW + 1.677 WW Comparing the three indexes I5 = 3.217 BW, I6 = 1.699 WW and I7 = 1.075 6M. Selection for 6M alone would be more efficient (RIH = 0.48) than selection for WW (RIH = 0.466) alone or BW (RIH = 0.235) alone.

3.7 Index efficiency

The efficiencies (RE) of different indices constructed relative to original index (I_1) are given in table (3 and 5). For Aradi goat, three trait index (I_2) based on weaning weight and weight at six month, index (I_3) based on birth weight and weight at six month and index (I_7) based on weaning weight and weight at six month were 99% as effective as the index including the three traits (I_1), while the effectiveness of (I_5) was only 14.00%. But, for Damascus goat one trait index (I_2) based on weaning weight and weight at six month were 99% as effective as the index including the three traits (I_1), while the effectiveness of (I_5) was only 42.00%. Generally, these efficiencies were expected since the index accuracy takes the same trend which is affected by the magnitude of correlation and heritability of the traits included in the index.

4. Conclusions

From the practical and economic-genetic view points, an index including weaning weight with weight at six month for A and an index including weaning weight only or with birth weight for Damascus goats is considered the best criterion for selection for improvement of body weights for Saudi Aradi goat and Damascus goats. Information presented here indicates that its technically possible through selection for weight at six month for Damascus goats and weaning weight for Saudi Aradi goat to achieve near maximum gains in other body weights. Selection indices (I_1 and I_2 for two breed) could be applied efficiently to improve the productivity of Saudi Aradi goat and Damascus goats.

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