Egyptian J. Anim. Prod.(1993) 30(1):1-20.

SELECTION INDICES AND SUBINDICES FOR IMPROVING SINGLE AND COMPOSITE MILK TRAITS IN FLECKVIEH CATTLE

M. H. Khalil[1] and A. M. Soliman[2]

1) Animal Production Department, Faculty of Agriculture at Moshtohor, Zagazig University, Moshtohor, Qalyoubia Governorate, Egypt;
2) Animal Production Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt

SUMMARY

Milk production of first lactation records of Fleckvieh cows in Austria were used to construct different selection indices and subindices. Data on 19215 daughters from 933 sires were used to estimate the genetic and phenotypic variation and covariation of 100-day and 305-day milk, carrier (= milk minus fat and protein), fat and protein yield traits. Ten indices of selection for improving yield traits of cows were constructed involving the combinations of two or three traits. Subindices were derived as if the three or two sources of information were used to select for just one trait, viz. yield of milk or carrier or fat or protein or fat-plus-protein as a composite trait.

Large differences in index coefficients (b's) for fat yield against yields of milk or carrier or protein were observed. Rate of genetic progress in aggregate genotype decreased when fat yield was dropped and consequently, a considerable genetic improvement for cow productivity might be achieved through selection for fat yield. Milk and fat yields contributed about 90% of the total economic-genetic gain while yield of protein contributed the remainder, 10%, i.e. an index including milk and fat yields in selection programmes of Fleckvieh cattle offers more economic-genetic gain over an index including milk and protein only. Index including carrier yield would contribute about 18% of the total economic-genetic gain, while yields of fat and protein would contribute the remaining 82%. Percentages of expected gain in traits of 305-day lactation were higher than traits of 100-day lactation. The expected genetic gain per generation in yield traits was large in all of the indices and subindices constructed; estimates averaged 4% of the respective overall mean of the trait. Correlations between the index or Subindex constructed and each individual trait in the aggregate genotype were relatively high and ranged from 0.47 to 0.56. A reduced index or subindex based on fat yield with either milk or protein yield could be practically applied efficiently to improve the productivity of Fleckvieh cows under the local Austrian conditions.

Keywords: Dairy cows, Milk traits, Selection indices and Subindices

INTRODUCTION

Selection programmes in dairy cattle based on selection indices including measurements on milk, fat and protein have small economic-genetic advantage over those including measurements on milk and fat, but not protein (Hanna and Cunningham, 1974; Anderson et al., 1978). Anderson et al (1978) and Kuipers and Shook (1980) reported additional genetic gain in milk yield when protein yield was included in the selection index. With changing attitudes of human nutrition, constituents of milk other than fat are likely to become more important (De Jager and Kennedy, 1987). In addition to milk yield and yields of fat and protein, other constituents are of interest. Carrier, defined as the part of the milk other than fat and protein, is of concern because milk with a low carrier requires less energy in processing (transportation, drying, cooling, separation). Also, increased yield of fat-plus-protein (as a composite trait) relative to carrier may be desirable and of considerable value in cheese and butter production. The objectives of the present study were: (1) to construct a series of cow selection indices and subindices for improving yields of milk or carrier, fat and protein of Fleckvieh cattle, and (2) to compare the effectiveness of selection indices and subindices with and without fat and protein information.

MATERIAL AND METHODS

Data and analysis

Records of first lactation Fleckvieh cows in Austria were collected over five consecutive calving years (1978 through 1982). Data were available on 19215 paternal half-sisters from 933 sires. Details of the breeding policy and management followed for Fleckvieh cattle in Austria were described by Hartmann et al. (1992). All records were expressed as deviations from their herd averages and therefore, the herd effect was eliminated. Data of the first lactation were analysed using the following mixed model:

$$Y_{ijkl}= \mu+S_i+A_j+B_k+(AB)_{jk}+b1_L(X1_{ijl}-X1_{\mu})+b1_Q(X1_{ijkl}-X1_{\mu})^2+ b2_L(X2_{ijkl}-X2_{\mu})$$

$$+b2_Q(X2_{ijkl}-X2_{\mu})^2+e_{ijkl}$$

where Y_{ijkl} denotes the performance of ijklth record; μ= the overall mean; S_i= the random effect of ith sire; A_j= the fixed effect of the jth year of calving; B_k= the fixed effect of the kth season of calving: $(AB)_{jk}$=the effect of the interaction between year and season, $b1_L$ and $b1_Q$= the partial linear and quadratic regression coefficients of yield trait on age at calving; $X1_{ijkl}$= the age of cow at calving in months for the corresponding Y_{ijkl} record; $X1_{\mu}$= the mean of age at calving; $b2_L$ and $b2_Q$= the partial linear and quadratic regression coefficients of yield trait on period of days open; $X2_{ijkl}$= the length of days open for the corresponding Y_{ijkl} trait; $X2_{\mu}$= the mean of days open, and e_{ijkl}= a random deviation of lth cow and assumed to be independently randomly distributed $(0,\sigma^2e)$.

Paternal half-sib analyses (Harvey, 1990) were performed in order to quantify the average genetic and phenotypic variation and covariation of 100- and 305-day yield traits of milk (M), carrier (milk minus fat plus protein, C), fat (F), protein (P) and fat-plus-protein (as a composite trait, FP). Components of variance and covariance for sire (σ^2S) and remainder (σ^2e) were computed according to Method 3 of Henderson. Heritabilities were estimated for yield traits as: $h^2 = 4\sigma^2_S/(\sigma^2_S + \sigma^2_e)$. Estimates of genetic and phenotypic correlation were obtained by computing techniques described by the LSMLMW program of Harvey (1990).

Relative economic values

The production means in the present study for Fleckvieh cows were 1554 and 3790 kg milk with 3.92% and 3.96% fat and 4.06% and 3.27% protein for 100- and 305-day lactation, respectively. The base price in Austrian Schilling (OS) per kg of milk (3.94% fat& 3.24% protein) was calculated according to WOM (1992) as:

1.117 OS	for each kg of carrier, i.e. milk minus fat plus protein.
+2.495 OS	for 3.96% fat, where each point of fat is worth 0.63 OS, i.e. 3.96 X 0.63= 2.495.
+1.014 OS	for 3.27% protein, where each point of protein is worth 0.31 OS, i.e. 3.27 X 0.31= 1.014 OS.
+0.060 OS	extra value as guiding price.
+0.845 OS	extra value per Kg for 1st grade quality of milk.
5.531 OS	price per kg of milk.
+0.558 OS	for 10% of the price as value-added taxes.
6.089 OS	total base price per kg of milk.

Charges of advertising and milk recording per Kg of milk were 0.015 and 0.066 OS, respectively. Therefore, net price of one kg of milk (3.96% fat, 3.27% protein) paid to the Austrian farmers is 6.089-(0.015+0.066)=6.008 OS. The price paid to the farmer for one kg of fat (included value-added taxes) is 70.95 OS. According to WOM (1992), the fat value is almost twice that of protein and consequently price of one kg of protein is 35.48 CS. Hence, the relative economic values for yields of milk, fat and protein were set to be 6.008: 70.95: 35.48 or 1 : 11.8: 5.9, while the values for yields of carrier: fat: protein were set to be 1: 63.5: 31.8. However, several investigators (e.g. Vandepitte and Hazel, 1977; Lin, 1978; Smith, 1983; Allan et al., 1985; Dommerholt and Wilmink, 1986) have concluded that the expected response and efficiency of index selection are not very sensitive to changes in the economic weights.

Construction of indices and subindices

Traits considered for constructing a cow genetic index (I) were 100- and 305-day yields of milk (M), fat (F), protein (P) and fat-plus-protein as a composite trait (FP). Theory and procedures of construction of the selection index were described by Cunningham and Mahon (1977). The partial regression coefficients for indices (b's) were computed as $b=P^{-1}G\underline{a}$ where P^{-1} is the inverse of phenotypic variances-covariances matrix, G= genotypic covariances matrix, and $\underline{a}$= vector of relative economic values. Percentage of total economic-genetic gain attributed in each ith trait was computed according to Cunningham (1970) as $(b'G_i/b'Ga)(a_i)(100)$. The expected genetic change (EG) in any trait achieved by an index is the genetic standard deviation for the index multiplied by the correlation coefficient of the index with the genetic value for such trait, assuming selection intensity is equal to one. The correlation of the calculated index with the aggregate genotype (H) was estimated as $r_{IH}=b'Ga/a'Ca$, where C= squared matrix of genotypic variances-covariances of the traits in H. The subindices coefficients (i.e. partial regression coefficients, b's) were computed as $b=P^{-1}G$. Correlation of subindex and ith trait was calculated as $r_{IY}= ((b'G_i)/C_{ii})$, where C_{ii} is the diagonal element of C matrix.

RESULTS AND DISCUSSION

Means, standard deviations, coefficients of variation, additive genetic variance and estimates of heritability and correlation of first lactation milk (M), carrier (C), fat (F), protein (P) and fat-plus-protein (FP) yields of Fleckvieh cattle are presented in Table 1. Ten selection indices and subindices were constructed for improving yields of milk, fat and protein or fat-plus-protein along with a reduction in carrier. The full matrix of heritabilities and phenotypic and genetic correlations estimated for 100-day and 305-day of lactation are shown in Table 1. Studies in Europe on Fleckvieh Cattle (e.g. Graml et al., 1987) have shown similar estimates of heritabilities and correlations for yield traits.

TABLE 1. Means (kg), standard deviation (SD), coefficients of variation (CV%), additive genetic standard deviation (σ_A), phenotypic standard deviation (σ_P) and estimates of heritability and correlations of first lactation traits in Austrian Fleckvieh Cattle.

Trait	Mean	SD	CV%	σ_A [a]	σ_P	Heritabilities and Correlations [b]				
						M	C	F	P	FP
305-day lactation										
M	3790	629	17.5	333	600	<u>0.31</u>	0.87	0.90	0.88	0.93
C	3512	568	17.1	309	559	0.92	<u>0.31</u>	0.89	0.87	0.91
F	154	27	16.0	14	26	0.91	0.90	<u>0.32</u>	0.86	0.97
P	124	22	15.9	11	20	0.95	0.94	0.95	<u>0.27</u>	0.96
FP	278	46	15.3	25	44	0.94	0.93	0.99	0.98	<u>0.31</u>
100-day lactation										
M	1554	239	14.5	120	233	<u>0.27</u>	0.99	0.85	0.83	0.89
C	1444	224	15.9	113	218	1.00	<u>0.27</u>	0.83	0.81	0.87
F	61	11	16.4	4.8	10	0.92	0.91	<u>0.22</u>	0.78	0.96
P	49	8	15.8	3.6	8	0.93	0.92	0.93	<u>0.21</u>	0.93
FP	110	18	15.2	8.2	17	0.94	0.93	0.99	0.98	<u>0.23</u>

[a] Sire affected (P<0.001) all traits studied.
[b] Estimates of heritability underlined on diagonal, while estimates of phenotypic correlation are shown above diagonal and genetic correlation below diagonal; standard errors of heritabilities are around 0.020 and of genetic correlations ranged between 0.001 to 0.014.

Selection indices

For multi-trait selection, two sets of indices (I' s) were constructed for either 100-day or 305-day lactation traits (Table 2). One set of indices included milk yield together with fat or protein or fat-plus-protein, while the second set included carrier yield instead of milk yield along with yields of fat and/or protein or fat-plus-protein. The original indices (I1 and I2) included three varieties to be used for improving the aggregate genotype of the three traits while the indices I3 up to I8 included two varieties to be used for improving three traits (i.e. milk-fat, milk-protein and fat-protein for I3, I5 and I7 for first set, while carrier-fat, carrier-protein and fat-protein for I4, I6 and I8 for second set, respectively. The reduced indices (I9 and I10) included only the two varieties of milk or carrier with fat-plus-protein to be used for improving the two traits.

Index coefficients

The index coefficients (b's) for each of the ten indices constructed are shown in Table 2. These partial regression coefficients indicate the relative emphasis each trait should receive to maximize profitable genetic response and they are nearly similar to those obtained by Mbah and Hargrove (1982) and Ashmawy and Khalil (1990). Values of b's for fat yield were greater than those of other varieties in the different indices (Table 2). Ashmawy and Khalil

TABLE 2. Selection indices (I's) for yield traits of Fleckvieh cattle, index coefficients (b), value of each variate in index (V%) and percentage of total gain attributable to each trait (H%).

Index	Item	Variates in the index								Variates in aggregate genotype
		305-day lactation				100-day lactation				
		M/C	F	P	FP	M/C	F	P	FP	
Indices included milk yield										
I1	b	0.26	5.0	1.4		0.37	0.81	0.77		M,F,P
	V%	1.90	1.5	0.1		8.60	0.10	0.10		
	H%	60.00	29.2	10.8		63.30	26.60	10.10		
I3	b	0.29	5.4			0.38	0.99			M,F,P
	V%	3.00	1.9			12.60	0.20			
	H%	60.10	29.2	10.7		63.40	26.50	10.00		
I5	b	0.40		3.2		0.38		1.07		M,F,P
	V%	7.70		0.5		14.50		0.10		
	H%	61.30	28.0	10.7		63.60	26.30	10.10		
I7	b		8.5	4.4			5.01	5.42		M,F,P
	V%		7.2	1.2			6.50	4.40		
	H%	58.40	30.6	11.0		60.60	28.70	10.70		
I9	b	0.27			3.15	0.36			0.7	M,FP
	V%	2.20			1.60	8.80			0.2	
	H%	61.40			38.60	64.40			35.6	
Indices included Carrier										
I2	b	0.31	27.7	8.6		0.78	7.81	5.41		C,F,P
	V%	0.20	4.3	0.3		4.70	1.20	0.30		
	H%	16.00	54.4	29.6		20.40	57.80	21.80		
I4	b	0.39	28.1			0.88	9.34			C,F,P
	V%	0.60	6.5			7.80	1.90			
	H%	17.80	60.6	21.6		20.50	57.90	21.60		
I6	b	0.97		18.1		0.98		8.91		C,F,P
	V%	4.80		2.2		10.90		1.10		
	H%	19.20	58.3	22.5		20.90	56.90	22.20		
I8	b		29.1	9.6			16.00	14.54		C,F,P
	V%		9.0	0.6			7.60	3.60		
	H%	17.40	60.9	21.7		18.90	59.10	22.00		
I10	b	0.34			15.98	0.78			6.3	C,FP
	V%	0.40			5.50	5.00			2.0	
	H%	18.70			81.30	21.10			78.9	

(1990) also reported greater values of b's for fat yield than those for milk and protein in Holstein-Friesian cows in Britain. This might be attributed to positive and high genetic correlations between fat yield and yields of milk or protein (Table 1) which appeared in all indices. In practice, the relative responses in the aggregate genotype are determined by the appropriate choice of selection index weights. Estimates of b's obtained in the present study for yields of fat and milk (or protein) would be advisable to be used in selection programmes.

Varieties contribution

The contribution of each variate to the index (V%) can be measured as the percentage reduction in overall rate of genetic progress which results if that variate is dropped (Cunningham and Mahon, 1977). Estimates of V% ranged from 1.9 to 7.7 % if milk was dropped, from 1.5 to 7.2% if fat was dropped and from 0.1 to 1.2% if protein was dropped for indices including milk yield of 305-day lactation (I1, I3, I5 and I7), while they ranged from 0.2 to 4.8% if carrier was dropped, from 4.3 to 9.0% if fat was dropped and from 0.3 to 2.2% if protein was dropped for indices including carrier yield of 305-day lactation (I2, I4, I6 and I8). The corresponding V% for 100-day lactation ranged from 8.6 to 14.5% if milk was dropped, from 0.1 to 6.5% if fat was dropped, from 0.1 to 4.4% if protein was dropped for indices including milk yield, while they ranged from 4.7 to 10.9% if carrier was dropped, from 1.2 to 7.6% if fat was dropped and from 0.3 to 3.6% if protein was dropped for indices including carrier yield. These estimates showed that the rate of reduction in genetic gain if milk or fat yield is dropped from the index was higher than that rate if protein yield is dropped from the index. Such low contribution of protein yield in all indices constructed may be due to the high genetic correlation between protein yield and yield of milk or fat (Table 1). Some studies (e.g. Hanna and Cunningham, 1974; Van Vleck, 1978; Kennedy, 1982) indicated that measures of milk, fat and protein in dairy-cattle selection offer little economic contribution over measures of milk and fat only. The reduction percentage in rate of genetic progress for aggregate genotype obtained by Ashmawy and Khalil (1990) for Holstein-Friesian cows in Britain also indicated that fat and protein yields contributed little to most selection indices constructed. The same authors attributed the low contribution of milk yield variate in indices constructed to the high genetic correlation between milk and protein (0.89) and due to the high economic value of protein as compared with milk (13.0 vs 1.0).

The range of estimates of V% for 305-day milk and fat yield were in the same order, while the corresponding estimates for 100-day milk yield were higher than those for fat yield and for 305-day milk. These estimates indicated that milk yield in 100-day lactation contributes more in index than any other yield traits.

The effect of dropping of protein yield on index efficiency is negligible even though it is an economically important trait. Although relatively small differences existed in expected responses to an index including and excluding protein yield (Table 2), these differences would compound over generations (Mbah and Hargrove, 1982). In addition, if there is a need for milk with high fat content, maintenance or improvement of that content can be achieved most effectively by using an index including yields of fat and milk

(I3) or using an index including yields of carrier and fat-plus-protein (I10). In this concern, measure of fat-plus-protein contributed little (1.6%) in an index including milk yield (I9), while it contributed 5.5% in an index including carrier yield (I10).

Total economic-genetic gain

Percentages of total economic-genetic gain attributed by gain in each trait (H%) are given in Table 2. These estimates of H% for most indices constructed indicate that including milk and fat yields in selection programmes of Fleckvieh cattle offer more economic-genetic contribution over measures of milk and protein only. An index including 305-day milk yield would contribute about 60% of the total economic-genetic gain while yields of fat and protein would contribute the remaining 40%. On the other hand, an index including carrier yield would contribute about 18% of the total economic-genetic gain, while yields of fat and protein would contribute the remaining 82%. If selection emphasis is on fat and either of milk or carrier (I3 & I4) rather than protein, the economic-genetic responses would be expected to result in relatively large progress in aggregate genotype favourable to milk yield (I3) or carrier yield (I4). Selection for yields of protein and either of milk or carrier (I5 or I6) with no emphasis on fat would result in a relatively similar larger economic-genetic change in aggregate genotype in favour of milk (I5) and fat (I6). De Jager and Kennedy (1987) reported that selection with equal economic values for fat and protein would result in lower expected responses in milk and higher responses in fat and protein.

As expected, the larger benefits in H% attributable to fat selection (Table 2) occurred when fat yield was included in a reduced index with milk or carrier. In this respect H% was 89.2% for milk plus fat (I3) and 78.4% for carrier plus fat (I4) in both 100-day and 305-day of lactation. Economically, it could be stated that considerable expected genetic improvement for cow productivity of Fleckvieh cattle might be achieved through selection for milk yield together with fat yield.

Trait expected-gain

The expected genetic gain (in actual units of measurements, EG) and as a percentage of the overall mean of the trait (G%) per generation in each trait (i.e. milk or fat or protein) are given in Table 3. For 305-day lactation, the estimates of EG averaged 182 kg for milk, 165 kg for carrier, 8.0 kg for fat, 5.8 Kg for protein and 13.8 kg for fat-plus-protein, i.e. 4.8% for milk, 4.7% for carrier, 5.1% for fat, 4.7% for protein and 4.9% for fat-plus-protein as a percentage of the respective overall mean of the trait. With respect to 100-day

TABLE 3. Expected genetic change per generation in each trait using different selection indices derived.

Index	Genetic change[a]	305-day lactation				100-day lactation			
		M/C	F	P	FP	M/C	F	P	FP
Indices included milk									
I1	EG	183	7.9	5.8		61.8	2.3	1.7	
	G%	4.8	5.1	4.7		4.0	3.7	3.5	
I3	EG	183	7.9	5.8		61.8	2.3	1.7	
	G%	4.8	5.1	4.7		4.0	3.7	3.5	
I5	EG	184	7.4	5.7		62.0	2.3	1.7	
	G%	4.9	4.8	4.7		4.0	3.7	3.5	
I7	EG	175	8.1	5.8		54.1	2.3	1.7	
	G%	4.6	5.2	4.7		3.5	4.7	3.5	
I9	EG	183			13.6	61.9			4.0
	G%	4.8			4.9	4.3			3.6
Single trait	EG	186	8.2	5.5	13.7	63.0	2.3	1.7	4.0
selection	G%	4.9	5.3	4.4	4.9	4.0	3.7	3.5	3.6
Indices included carrier									
I2	EG	164	8.1	5.8		56.6	2.3	1.8	
	G%	4.7	5.2	4.7		3.9	3.7	3.7	
I4	EG	164	8.1	5.8		56.8	2.3	1.7	
	G%	4.7	5.2	4.7		3.9	3.7	3.5	
I6	EG	169	7.4	5.7		57.5	2.3	1.8	
	G%	4.8	4.8	4.7		4.0	3.7	3.7	
I8	EG	160	8.1	5.8		50.0	2.3	1.7	
	G%	4.6	5.2	4.7		3.5	3.7	3.5	
I10	EG	166			13.8	56.8			4.1
	G%	4.7			4.9	3.9			3.7
Single trait	EG	173	8.2	5.5	13.7	58.9	2.3	1.7	4.0
selection	G%	4.9	5.3	4.4	4.9	4.1	3.7	3.5	3.6

[a]Expected genetic per generation measured in Kg (EG) and as a percentage of the overall mean of the trait (G%).

lactation, EG averaged 62 kg for milk, 56.6 kg for carrier, 2.3 kg for fat, 1.7 kg for protein and 4.0 kg for fat-plus-protein, i.e. 4.1% for milk, 3.8% for carrier, 3.7% for fat, 3.6% for protein and 3.6% for fat-plus-protein as a percentage of the respective overall mean of the trait. These percentages of expected gain (G%) indicate that the G% in 305-day lactation is higher than that in 100-day lactation. For all indices constructed, the trait expected-gains in both 305-day and 100-day of lactation are nearly similar to the those gains possible from single trait selection for any trait (Table 3). Similarly, estimates of EG obtained by Ashmawy and Khalil (1990) of different indices constructed for Holstein-Frisian cows ranged from 158 to 194 kg for milk, 5.1 to 6.6 kg for fat and 4.5 to 4.9 kg for protein. De Jager and Kennedy (1987) found that expected responses from single-trait selection for yield traits were similar to those responses of selection based on an index which included milk and fat or an index including milk, fat and protein. If one wished to obtain genetic gain in any yield trait similar to those possible from single-trait selection for any trait alone, then I9 or I10 would be recommended. From the genetic point of view, gains in fat yield of 305-day lactation obtained from different indices constructed are relatively higher than those gains obtained for other yield traits. Similarly, Hanna and Cunningham (1974) and Van Vleck (1978) reported that increasing the relative emphasis on yields of fat and protein would result in more genetic progress for yields of milk, fat and protein.

Index-trait correlation

Correlation between the indices constructed and each individual trait in the aggregate genotype (r_{IY}) are shown in Table 4. These correlations are high, all ranging between 0.47 and 0.56. In full agreement with these correlations, Ashmawy and Khalil (1990) reported similar coefficients which ranged between 0.40 and 0.55. However, these high correlations indicate that selection on any cow index would actually lead to a moderate or high genetic gain in the productivity of Fleckvieh cows.

TABLE 4. Indices standard deviations (σ_I), correlation of index with aggregate genotype (r_{HI}) and with each individual trait (r_{IY}) and the efficiency (RE) of different indices to the original index (I1 or I2).

Item	305-day lactation					100-day lactation				
	I1	I3	I5	I7	I9	I1	I3	I5	I7	I9
Indices included milk										
σ_I^{+}	305	304	300	299	299	97.6	97.0	97.0	89.0	96.1
r_{IY1}	0.55	0.55	0.55	0.52	0.55	0.51	0.51	0.51	0.45	0.51
r_{IY3}	0.55	0.55	0.51	0.56		0.48	0.48	0.47	0.47	
r_{IY4}	0.55	0.54	0.54	0.55		0.48	0.48	0.48	0.47	
r_{IY5}					0.55					0.49
r_{HI}	0.56	0.56	0.55	0.55	0.56	0.51	0.51	0.51	0.47	0.51
RE to I1	100.0	99.7	98.4	98.0	98.0	100.0	99.4	99.4	91.2	98.2
	305-day lactation					**100-day lactation**				
	I2	I4	I6	I8	I10	I2	I4	I6	I8	I10
Indices included carrier										
σ_I	1024	920	879	920	884	278	277	274	265	269
r_{IY1}	0.53	0.53	0.55	0.52	0.54	0.50	0.50	0.51	0.44	0.51
r_{IY3}	0.56	0.56	0.51	0.56		0.49	0.48	0.47	0.47	
r_{IY4}	0.55	0.54	0.54	0.54		0.49	0.48	0.49	0.47	
r_{IY5}					0.56					0.50
r_{HI}	0.56	0.56	0.54	0.56	0.56	0.50	0.50	0.51	0.48	0.50
RE to I2	100.0	89.8	85.8	89.8	86.3	100.0	99.6	98.6	95.3	96.8

+ This is the value of economic-genetic gain in aggregate genotype achieved by a selection intensity of one standard deviation on index.

Index accuracy

The accuracy of an index is based on its correlation with the aggregate genotype (r_{IH}). Relatively high values of r_{IH}'s for different indices were observed (around 0.56 for 305-day lactation and 0.50 for 100-day lactation, Table 4). Therefore, all indices constructed were nearly similar in accuracy. The different indices constructed by Ashmawy and Khalil (1990) indicated that adding protein or fat yield in the index increased the accuracy of the index by 1.9%, while adding milk yield to the index increased the accuracy by 8.2%. Smith (1983) concluded that any loss in accuracy of an index is affected mainly by both the genetic and phenotypic correlations among traits involved in the index and therefore the genetic correlations tend to have the more important role in affecting the accuracy, while the phenotypic correlations have a further effect and thus have to be considered in estimating accuracy. De Jager and Kennedy (1987) reported that including protein in the index lead to an increase in the accuracy of the sire breeding value. An index including a composite trait (milk-plus-fat) is closely similar in accuracy to those indices including the individual traits (i.e. fat or protein). In this respect, many investigators (e.g. Henderson and Quaas, 1976; Anderson et al., 1978; Everett et al., 1982) reported that including a composite trait (e.g. fat-protein) in an index could increase the genetic gain of such trait and consequently increases the accuracy of the indices to be used for selection.

Index efficiency

The efficiency (RE) of different indices constructed relative to the original index (I1 for indices included milk yield or I2 for indices included carrier) are given in Table 4. For 305-day lactation, two-trait indices based on milk yield with fat (I3) or protein (I5) were of 99.7 or 98.4% as effective as the three-trait index (I1), while I4 or I6 were 89.8 or 85.8% as effective as the original index (I2), i.e. I3 is considered the best criteria, from an economic and practical point of view, of selection for the genetic improvement of yield traits trait of Fleckvieh cows. The same trend was observed for indices 100-day lactation. An index including fat and protein (I7 or I8) recorded relatively lower efficiency compared to other indices (Table 4). Selection index including milk with the composite trait (fat-plus-protein, I9) is nearly as effective as the index that includes milk with fat or protein (I3 or I5), while the index including carrier with the composite trait (I10) showed lower efficiency compared to indices including carrier with fat or protein (I4 or I6). In this respect, Smith (1983) reported that the main factors controlling the efficiency of a selection index are largely determined by the values of the factors ah^2, the product of economic weight (per standard deviation) and the heritability of each trait. This means that if one trait dominates the index (for example, yield of milk or fat obtained herein), the efficiency will not be sensitive to changes in economic weight of the other traits, but will be sensitive to the loss or reversal (to negative values) or weights of the dominant trait. Mbah and Hargrove (1982) found that selection indices without protein yield was nearly as effective as indices that include protein. They also stated that indices based on yields of milk and fat only were 91 to 100% as effective as the indices included the three varieties.

Selection subindices

A series of subindices (SI's) were constructed to maximize the gain in a specific trait and not the aggregate genotype. Each subindex was computed as if the three or two sources of information were to be used to select for just one trait. Alternatives that cover some possible combinations of information available were obtained and listed in Tables 5 & 6 along with other relevant parameters. The first two subindices (SI1 and SI2) are designed to use the three varieties in both the subindex and the aggregate genotype, while the reduced subindices of I3 up to I8 included only two varieties in the subindex and three traits in the aggregate genotype (as a criterion of selection). The last two subindices (I9 and I10) were designed to include the two varieties (milk or carrier with the composite trait) in the subindex and the aggregate genotype. The efficiencies of these subindices relative to the corresponding original subindex (SI1) were estimated as the ratio of the standard deviations of the two subindices (Cunningham and Mahon, 1977).

Selection for milk or carrier yield

For both 305-day and 100-day lactations, the contribution of milk yield or carrier yield in each subindex (V%) was higher than fat, protein or fat-plus-protein. Estimates of V% ranged from 5.4 to 18.5 % (Tables 5 & 6), i.e. if milk or carrier yield was dropped from any subindex, genetic gain would be reduced by 5.4 to 18.5 %. Similarly, Ashmawy (1990) found that contribution of milk yield in all subindices constructed was higher than protein and fat; estimates of V% ranged from 19.6 to 27.1%. Except SI7 or SI8 (subindices not including milk or carrier), V% for fat and protein or fat-plus-protein in all subindices constructed was very low where most values are equal to or around 0.0%. This means that contribution of fat and/or protein in an subindex to be used to select for milk or carrier yield is little or negligible. This observation is confirmed by Ashmawy (1990) who reported that estimates of V% for fat and protein in all subindices constructed were low; 0.0 to 2.6% if fat

TABLE 5. Selection subindices (SI) including milk yield of 100-day and 305-day lactation traits, value of each variate in subindex (V%), expected genetic gain per generation in each trait (EG), correlation of subindex and each trait (r_{SIY}) and the efficiency (RE) of different subindices relative to the original subindex (SI1)[a].

	305-day lactation										100-day lactation									
Selection	SI1		SI3		SI5		SI7		SI9		SI1		SI3		SI5		SI7		SI9	
Criterion	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%
Selection for milk yield variates in subindex[b]																				
M	0.263	5.4	0.270	7.3	0.263	5.4			0.263	5.4	0.283	13.0	0.283	17.6	0.271	17.7			0.282	13.0
F	0.882	0.1	0.984	0.2			4.37	5.5			-0.435	0.1	-0.436	0.1			2.81	5.5		
P	0.359	0.0			0.359	0.0	3.38	2.0			-0.004	0.0			-0.166	0.0	3.59	5.3		
FP			0.656	0.2															-0.241	0.0
EG (kg)	185.00		185.00		184.00		175.00		185.00		62.10		62.10		62.10		54.00		62.10	
r_{SIY}	0.56		0.56		0.55		0.53		0.56		0.52		0.52		0.51		0.45		0.52	
RE to SI1	100.0		100.0		99.5		94.6		100.0		100.0		100.0		100.0		87.0		100.0	
Selection for fat yield variates in subindex																				
M	0.001	0.1	-0.003	0.0	0.008	4.2					0.005	2.8	0.006	4.5	0.008	10.8				
F	0.312	8.3	0.325	10.1			0.296	12.1			0.104	2.8	0.110	3.4			0.162	10.7		
P	0.045	0.1			0.158	2.1	0.031	0.1			0.026	0.1			0.064	0.8	0.091	1.9		
EG (kg)	8.16		8.15		7.48		8.16				2.34		2.34		2.28		2.28			
r_{SIY}	0.56		0.56		0.52		0.56				0.49		0.49		0.47		0.47			
RE to SI1	100.0		99.8		91.7		100.0				100.0		100.0		97.4		97.4			
Selection for protein yield variates in subindex																				
M	0.002	0.4	0.004	1.8	0.005	3.7					0.004	3.9	0.006	10.4	0.005	6.7				
F	0.105	1.8	0.132	3.2			0.138	4.9			0.013	0.1	0.033	0.5			0.065	2.9		
P	0.095	1.1			0.133	2.6	0.123	2.4			0.085	2.1			0.090	2.5	0.143	8.6		
EG (kg)	5.86		5.80		5.76		5.83				1.77		1.73		1.77		1.70			
r_{SIY}	0.55		0.54		0.54		0.55				0.49		0.48		0.48		0.47			
RE to SI1	100.0		99.0		98.3		99.5				100.0		97.7		100.0		96.0			
Selection for fat-plus-protein variates in subindex																				
M									0.001	0.0									0.010	3.4
FP									0.294	6.6									0.113	2.5
EG (kg)									13.86										4.09	
r_{SIY}									0.56										0.50	
RE to SI1									98.9										99.7	

[a] Where b= the partial regression coefficients of the subindex, V%= percentage reduction in rate of genetic gain for each trait if variate is dropped from the subindex, and EG= genetic gain in actual units (kg) in each trait achieved by one standard deviation on the subindex.

[b] Variates in aggregate genotype included three traits (M, F and P) for I1, I3, I5 and I7, while they included two traits (M and FP) for I9.

TABLE 6. Selection subindices (SI) including Carrier yield for 100-day and 305-day lactation traits, value of each variate in subindex (V%), expected genetic gain per generation in each trait (EG), correlation of subindex and each trait (r_{SIY}) and the efficiency (RE) of different subindices related to the original subindex (SI1)[a].

Selection	305-day lactation										100-day lactation									
	SI2		SI4		SI6		SI8		SI10		SI2		SI4		SI6		SI8		SI10	
criterion	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%	b	V%
Selection for carrier yield																				
variates in subindex[b]																				
C	0.261	6.2	0.262	6.2	0.281	11.1			0.261	6.2	0.273	13.9	0.276	18.5	0.266	18.5			0.273	13.9
F	0.719	0.1	0.719	0.1			3.929	5.3			-0.287	0.0	-0.242	0.0			2.58	5.4		
P	0.486	0.0			0.799	0.1	3.231	2.2			0.162	0.0			0.034	0.0	3.35	5.4		
FP									0.623	0.2									-0.087	0.0
EG (kg)	172.00		172.00		171.00		161.00		172.00		58.20		58.10		58.10		50.10		62.10	
r_{SIY}	0.55		0.55		0.55		0.52		0.55		0.52		0.52		0.52		0.44		0.52	
RE to SI1	100.0		100.0		99.4		93.6		100.0		100.0		100.0		99.8		99.8		100.0	
Selection for fat yield																				
variates in subindex																				
C	-0.001	0.1	-0.004	0.0	0.007	3.8					0.005	2.8	0.006	4.5	0.008	10.4				
F	0.311	8.7	0.326	11.4			0.296	12.1			0.109	3.8	0.118	4.3			0.162	10.7		
P	0.044	0.1			0.179	3.0	0.031	0.1			0.031	0.2			0.080	1.3	0.091	1.9		
EG (kg)	8.16		8.15		7.45		8.15				2.34		2.34		2.27		2.28			
r_{SIY}	0.56		0.56		0.51		0.56				0.49		0.49		0.47		0.47			
RE to SI1	100.0		99.3		91.3		99.8				100.0		100.0		97.0		97.4			
Selection for protein yield																				
variates in subindex																				
C	0.002	0.5	0.004	1.7	0.005	3.5					0.004	3.9	0.006	10.1	0.005	6.6				
F	0.108	2.0	0.141	4.0			0.138	4.8			0.017	0.1	0.042	1.0			0.065	2.9		
P	0.097	1.2			0.144	3.3	0.123	2.4			0.090	2.4			0.098	3.2	0.143	8.6		
EG (kg)	5.86		5.79		5.75		5.83				1.77		1.73		1.77		1.70			
r_{SIY}	0.55		0.54		0.54		0.55				0.45		0.48		0.49		0.47			
RE to SI1	100.0		98.3		98.1		99.5				100.0		97.7		100.0		96.0			
Selection for fat-plus-protein																				
variates in subindex																				
C									0.001	0.0									0.010	3.4
FP									0.295	7.7									0.123	3.4
EG (kg)									13.80										4.1	
r_{SIY}									0.56										0.50	
RE to SI1									98.4										99.5	

[a] Where b= the partial regression coefficients of the subindex, V%= percentage reduction in rate of genetic gain for each trait if variate is dropped from the subindex, and EG= genetic gain in actual units (kg) in each trait achieved by one standard deviation on the subindex.

[b] Variates in aggregate genotype included three traits (C,F and P) for I1,I3, I5 and I7, while they included two traits (C and FP) for I9

dropped and 2.1 to 10.8% if protein dropped. Estimates of V% also indicated that milk or carrier yield of 100-day lactation contributed larger in all subindices constructed compared to their contribution in 305-day lactation (V% ranged from 5.4 to 11.1 % for 305-day lactation vs 13.0 to 18.5% for 100-day lactation). Consequently, subindices of 100-day lactation may be effective in early selection for milk or carrier yield in Fleckvieh cattle.

Estimates of expected genetic gain per generation (EG) in milk yield were moderate and ranged from 175 to 185 Kg for 305-day lactation and 54.0 to 62.1 Kg for 100-day lactation (Table 5). Moderate estimates of EG were also observed for subindices including carrier yield (Table 6). The moderate estimates of EG in milk or carrier are expected since heritabilities were moderate and correlations were high (Table 1). For Holstein-Frisian cattle, Ashmawy (1990) reported similar estimates of EG ranging from 160 to 200 Kg of 305-day milk for all subindices constructed. In practice, the author stated that in countries with no information on protein or fat yield, a subindex containing only milk yield as a criterion for selection is recommended with little compromise in gain assuming similar phenotypic and genetic parameters. A subindex including protein to be used to select for milk or carrier is nearly as efficient as a subindex not including protein (Tables 5 & 6) . For such a case, an evidence was obtained by many investigators (e.g. Anderson et al, 1978; Kuipers and Shook, 1980; Mbah and Hargrove, 1982; Ashmawy, 1990) who reported that the extra cost of protein testing might not be recoverable by the extra value of genetic gain from selection based on an index including protein. However, protein content is now evaluated routinely in the Dairy Herd Improvement Program with no additional cost to the breeders (HILLERS, 1984).

The correlation between the subindex and milk trait (r_{SIY}) for the original subindex (SI1) indicated that if all the three varieties are used in a subindex, a genetic value for milk yield of a cow can be estimated as 56% as accurately as it would be if the additive genotype of each cow was completely known. Selection subindices based on milk yield with fat yield (SI3) or with protein yield (SI5) are similar in their efficiencies (RE) relative to the three varieties subindex (SI1) in estimating the genetic value for milk yield; estimates of RE for SI3 and SI5 were around 100% relative to SI1 (Table 5). Consequently, the subindex including milk yield with either of fat or protein may be useful in practice. These results are confirmed by the fact that the correlations of these subindices and each trait (r_{SIY}) showed stable values (0.56 for 305-day lactation and 0.52 for 100-day lactation) and the expected gain per generation in each trait (EG) were closely similar in magnitude (Table 5). On the other hand, a subindex including fat and protein yields (SI7) is considered the least efficient subindex for the improvement of milk yield. It resulted in 5% or 13% decrease in the expected gain (i.e. in accuracy) of 305 milk or 100-milk compared with SI1.

Selection for fat yield

The percent reduction in rate of genetic gain was around 10% if 305-day fat yield was dropped and 6% if 100-day fat was dropped from the different subindices (Tables 5 & 6). The corresponding estimates were averaged 1.3% if 305-day milk or carrier was dropped and 6% if 100-day milk or carrier was dropped, while they averaged 1.0% if 305-day or 100-day protein was dropped. For subindices to be used to select just only for fat yield, Ashmawy (1990) found that V% ranged from 1.6 to 3.8% for protein yield and 0.0 to 2.0% for milk yield. He attributed such relatively higher values for protein compared to milk to that genetic correlation between fat and milk was higher than that between fat and protein (0.80 vs 0.76).

All subindices including fat yield recorded somewhat higher genetic gain in fat than those subindices excluding it (Tables 5&6). Estimates of EG averaged 8 Kg for subindices of 305-day lactation and 2.3 Kg for subindices of 100-day lactation. Ashmawy (1990) found that expected genetic gain in fat yield due to subindices including fat was 7 Kg, while it was 5 Kg for subindices not including fat. The estimates of EG obtained here and those in literature indicate that a subindex includes milk and fat yields is practically recommended for the improvement of fat yield in dairy cattle.

The subindices not including fat yield (SI5 and SI6) to be used for selection for 305-day fat yield allow 91% as much gain as could be made with the original subindices (SI1 and SI2). For 100-day fat yield, these subindices allow 97% as much gain as could be made with the original subindices. The lower efficiency for subindices not including fat yield evidenced through the correlations of subindices and fat yield trait (i.e. r_{SIY}) which were constant of 0.56 for subindices included 305-day fat, while they were of about 0.52 for subindices not including fat. However, changes in the efficiency of selection are more dependent on the genetic correlations among traits than on the phenotypic, but both affect the efficiency (Smith, 1983). In practice, the subindex including fat yield with either of milk or carrier may be useful to select for fat yield.

Selection for protein yield

Genetic gain achieved by different subindices constructed would be reduced by about 2.0% or 4.5% if 305-day or 100-day protein yield dropped from the sub index, i.e. protein yield contributed little in the subindices to be used to select just for protein. On the other hand, genetic gain would be reduced by about 2.0% or 7.0% if 305-day or 100-day milk or carrier yield omitted from the subindex and about 3.5% or 1.2% if 305-day or 100-day fat yield omitted from the subindex. Therefore, fat and milk or carrier showed a relatively higher contribution to the different subindices to be used to select for protein yield. Here and according to Binet (1965) and Kennedy (1982), it is preferable not to use protein yield itself as selection criterion in Fleckvieh cattle, but to use other measurable traits such as fat yield (genetically correlated with protein yield) for the purpose of indirect selection for milk yield. Subindices constructed by Ashmawy (1990) indicated that genetic progress would be reduced by 6% to 17% if protein was dropped, 0.0 to 10.7% if milk was dropped and 0.2 to 0.8% if fat was dropped.

Using fat-plus-protein as a composite trait in the subindex leads to 6.6% and 2.5% reduction in rate of genetic gain if such variate was dropped from SI9 and SI10, respectively. These estimates are nearly similar or less than those estimates averaged if fat or protein separately was omitted from the subindex. For such a case a subindex that includes fat yield (e.g. SI3 or SI4) is considered the most efficient subindices to be used to select for yields of fat and protein.

All subindices constructed gave equal expected gains of about 5.8 Kg protein for 305-day lactation and 1.7 Kg protein for 100-day lactation (Tables 5 & 6). Therefore, the expected gain in protein yield using a subindex including protein may be the same as using a subindex involving fat, i.e. any subindex may be practically effective to select for protein yield. However, using protein in the subindex to select for protein yield is determined on the economics of its estimation in the milk (Mbah and Hargrove, 1982; Hillers, 1984). Correlation coefficients (r_{SIY}'s) between a subindex and protein yield trait were about 0.52 for all subindices of 305-day lactation and about 0.48 for all subindices of 100-day lactation. Consequently, all subindices are nearly similar in accuracy to select for protein yield.

CONCLUSION

From the practical and economic-genetic view points, an index or subindex including fat yield with either milk or protein yield is considered the best criterion for selection for the improvement of cow productivity of Fleckvieh cattle under the local Austrian conditions. Information presented here indicates that it is technically possible through selection for fat yield to achieve near maximum gains in yields of milk and protein. Such a selection program for Fleckvieh cattle would be useful in dairy cattle selection, i.e. to improve protein yield through selection for milk and fat. What then are future demands for milk qualities, and how should breeding programs in such breed of dairy cattle respond to them? This question was addressed recently by the Official Federation of Fleckvieh-Cattle Breeders in Austria and by some other investigators in Central Europe (e.g. Graml et al., 1987). Thus if the dairy industry is serious about improving the protein yield of milk, testing and recording should be made on that trait. Consequently, our recommendation is either to stimulate demand for protein-rich-products (e.g. high-protein milk powder or skim milk) or to shift breeding goals in favor of high yields of fat to protein.

ACKNOWLEDGEMENTS

We are grateful to Professor E.S.E.Galal, Department of Animal Production, Faculty of Agriculture, Ain Shams University, Cairo, Egypt for helpful comments and for reading the manuscript. We also gratefully acknowledge the Official Federation of Austrian Cattle Breeders (ZAR) for supplying the data.

REFERENCES

Allan, B.B., H.T. Fredeen and G.M. Weiss, 1985. The sensitivity of a two trait selection index to changes in economic weight and genetic parameter estimates. Can. J. Anim. Sci., 65: 21-29.

Anderson, R.D., R.W. Everett, L.D. Van Vleck, 1978. Economic analysis of protein testing for selection. J. Dairy Sci., 61: 102-108.

Ashmawy, A.A., 1990. Selection subindices for improvement of milk,fat or protein yield in Holstein- Friesian cows. Egyptian Journal of Animal Production, 27 (2):185-194.

Ashmawy, A.A. and M.H. Khalil, 1990. Single and multi-trait selection for lactation in Holstein-Friesian cows. Egyptian Journal of Animal Production, 27(2): 171-184.

Binet, F.E.,1965. On construction of an index for indirect selection. Biometrics, 21: 291-299.

Cunningham, E.P., 1969. The relative efficiencies of selection indexes. Acta Agricultural Scandinavica,19: 45-48.

Cunningham, E.P. and G.A.T. Mahon, 1977. SELinD: A Fortran Computer Program for Genetic Selection Indexes (User's Guide). Co. Dublin and Dublin University, Ireland: An Foras Taluntais (Mimeograph).

Cunningham, E.P., R.A. Moen and T. Gjedren, 1970. Restriction of selection indexes. Biometrics, 26(1): 67-74.

De Jager, D. and B.W. Kennedy,1987. Genetic parameters of milk yield and composition and their relationships with alternative breeding goals. J. Dairy Sci., 70: 1258-1266.

Dommerholt, J. and J.B.M. Wilmink, 1986. Optimal selection responses under varying milk prices and margins for milk production.Livestock Production Science, 14: 109-121.

Everett, R.W., K. Hammond and J.F. Taylor, 1982. Possibilities of improving genetic progress by finding a new component of milk production. J. Dairy Sci., 65(6): 980-987.

Graml, R., J. Buchberger, H. Klostermeyer and F. Pirchner, 1987. Heritabilitätswerte und Bedeutung von Markergenotypen bei Milchleistungseigenschaften des bayerischen Fleckviehs und Braunviehs. Züchtungskunde, 59: 161-174.

Hanna, M.V. and E.P. Cunningham, 1974. Selection alternatives for improving the yield of milk and its constituents in Irish dairy cattle. Irish J. Agric. Res., 13: 239-249.

Hargrove, G.L., D.A. Mbah and J.L. Rosenberger, 1981. Genetic and environmental influences on milk and milk component production. J. Dairy Sci., 64:1593-1597.

Harvey, W.R.,1990. User's Guide for LSMLMW. Mixed model least-squares and maximum likelihood computer program. PC-Version 2, Ohio state university, Columbus, USA (Mimeograph).

Hartmann, O., N. Ratheiser and H. Eder, 1992. Cattle Breeding in Austria. Zentrale Arebeitsgemeinschaft Osterreichischer Rinderzüchter, 1060 Wien, Austria.

Henderson, C.R. and R.L. Quaas, 1976. Multiple trait evaluation using relatives' records. J. Anim. Sci., 43: 1188.

Hillers, J.K., 1984. Sire selection under alternative systems of milk pricing. J. Dairy Sci., 67: 444-448.

Kennedy, B.W., 1982. Reducing fat in milk and dairy products by breeding. J. Dairy Sci., 65: 443-449.

Kuipers, A. and G.E Shook, 1980. Net return from selection under various component testing plans and milk pricing schemes. J. Dairy Sci., 63(6): 1006-1018.

Lin, C. Y., 1978. Index selection for genetic improvement of quantitative characters. Theoretical and Applied Genetics,52:49-56.

Mbah, D.A. and G.L. Hargrove, 1982. Genetic and economic implications of selecting for milk protein. J.Dairy Sci., 65: 632-637. C. Smith, 1983. Effect of changes in economic weights on the efficiency of index selection. J. Anim. Sci, 56(5): 1057-1064.

Vandepitte, W.M. and L.N. Hazel, 1977. The effect of errors in the economic weights on the accuracy of selection indexes. Annales Genet. Sel. Anim., 9(1): 87-103.

Van Vleck, L. D., 1978. Breeding for increased protein content in milk. J. Dairy Sci., 61:815.

WOM ,1992. Wegweiser durch die osterreichische Milchwirtschaft. Milchwirt schaftsfonds. / Presseabteilung, Wien, Austria.

أدلة الإنتخاب الأساسية والجزئية لتحسين صفات اللبن الفردية والمركبة فى ماشية الفلاك فى

ماهر حسب النبى خليل[1] ، أشرف محمد سليمان[2]

١ - كلية الزراعة بمشتهر - جامعة الزقازيق - مشتهر -قليوبية
٢ - كلية الزراعة بالزقازيق - جامعة الزقازيق

استخدمت سجلات الموسم الأول لإدرار اللبن فى اشتقاق أدله انتخاب لتحسين إنتاجية ماشية الفلاك فى النمساوية. استخدم لذلك بيانات ١٩٢١٥ بقرة أنصاف أشقة منتجة من ٩٣٣ طلوقة لتقدير التباين والتغاير الوارثى والمظهرى لصفات محصول اللبن والدهن والبروتين وصفة محصول اللبن الخالى من الدهن والبروتين (كصفات فردية) وصفة محصول الدهن زائد البروتين (كصفة مركبة) عن ١٠٠ & ٣٠٥ يوما من الإدرار. اشتقت من تلك البيانات عشرة أدلة إنتخابية لغرض تحسين تلك الصفات. استخرجت من الأدلة الأساسية مجموعة من الأدلة الجزئية والتى تشتمل على صفتين او أكثر لغرض الأنتخاب والتحسين لصفة واحدة فقط.

تلخصت النتائج المتحصل عليها فيما يلى:

- لوحظت فروق كبيرة بين قيم معاملات الإنحدار الجزئية (معاملات الأدلة) لصفة محصول الدهن مقارنة لمحصول اللبن او محصول البروتين او محصول اللبن الخالى من الدهن والبروتين.

- تناقص معدل التحسين الوراثى فى وراثة البقرة الكلية عندما سقطت صفة محصول الدهن من الأدلة الإنتخابية المختلفة ومن ثم يمكن تحقيق تحسيننا وراثيا ملموسا لإنتاجية البقرة من خلال الإنتخاب لصفة محصول الدهن .

- ساهم محصول اللبن والدهن بحوالى ٩٠٪ من العائد الإقتصادى والوراثى فى حين ساهم محصول البروتين على ١٠٪ فقط.

- كان العائد الكلى الوراثى والإقتصادى المتوقع عن كل جيل من تطبيق أدلة الإنتخاب المشتملة على محصول اللبن والدهن اعلى من أدلة الإنتخاب المشتملة على محصول اللبن والبروتين . من الناحية الإخرى ساهم محصول اللبن الخالى من الدهن والبروتين بحوالى ١٨٪ فقط من العائد الوارثى والإقتصادى وذلك باستخدام الأدلة المشتملة على هذه الصفة بينما كانت مساهمة محصول الدهن والبروتين بحوالى ٨٢٪ .

- كانت نسب العائد الوراثى المتوقع عن كل جيل من إلانتخاب لصفات المحصول عند ٣٠٥ يوما من الإدرار أعلى من مثيلتها عند ١٠٠ يوما من الإدرار.

- يمكن لأدلة إلانتخاب الإساسية والجزئية تحقيق عائدا وراثيا متوقعا قدره ٤٪ من متوسط كل صفة.

- كانت الإرتباطات بين جميع الأدلة الإنتخابية التى اشتقت وأى من الصفات التى استخدمت فى عمل تلك الأدلة ارتباطات عالية نسبيا حيث تراوحت القيم بين ٠,٤٧ الى ٠,٥٦.

- يمكن عمليا وبكفاءة عالية تطبيق الأدلة الأساسية والجزئية المختصرة المشتملة على محصول الدهن مع اى من محصول اللبن او البروتين وذلك لغرض التحسين الوراثى والمظهرى للإنتاجية الكلية لماشية الفلاك فى.