A breeding goal for South African Holstein Friesians in terms of economic weights in percentage units

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In South Africa the exact breeding goal for Holstein Friesians still needs to be determined. This means that the traits, which should be most important in selection have to be identified. One method to identify these traits could be to calculate economic weights for production and functional traits. Economic weights calculated in absolute units cannot be compared because some traits are measured in different units. The objective of this study was therefore the calculation of economic weights for production and functional traits, in percentage units, to make a comparison between traits possible. The production traits were milk, butterfat , protein and lactose yield and the functional traits included survival rate, feed efficiency, live weight and calving interval. The study used a simulation model to calculate economic weights. This model included three production enterprises classified according to the production level of the herds. The results show that for all three the production enterprises milk yield is potentially the most important trait to improve in selection, with the second trait being feed efficiency followed by live weight. The results were confirmed by constructing a selection index, including milk yield and live weight, showing that economic improvement with a selection index is about 25% more efficient than direct selection for milk yield alone.

In Suid-Afrika is die presiese teeldoelwit vir Holstein Friese nog nie bepaal nie. Dit beteken dat die eienskappe wat die belangrikste behoort te wees in seleksie nog geidentifiseer moet word. Berekening van ekonomiese gewigte vir produksie en funksionele eienskappe is een manier om hierdie eienskappe te identifiseer. Met ekonomiese gewigte in absolute eenhede is 'n vergelyking tussen die eienskappe nie moontlik nie, omdat eienskappe gemeet word in verskillende eenhede. Die doelwit van hierdie studie was die berekening van ekonomiese gewigte in persentasie eenhede om 'n vergelyking van die eienskappe moontlik te maak. Die produksie-eienskappe in die studie was melk-, bottervet-, proteïen- en laktose opbrengs en die funksionele eienskappe het oorlewingstempo, voerdoeltreffendheid, liggaamsmassa en kalfinterval ingesluit. Die studie het 'n simulasiemodel gebruik om ekonomiese gewigte te bereken met die insluiting van drie produksiesisteme wat geklassifiseer is volgens die produksievlak van die kudde. Die resultate toon dat vir al drie die produksie-sisteme melkopbrengs potensieel die belangrikste eienskap is om te verbeter in seleksie, met voerdoeltreffendheid die tweede belangrikste eienskap gevolg deur liggaamsmassa. Om die resultate te staaf is 'n seleksie-indeks bereken, wat melkopbrengs en liggaamsmassa insluit en getoon het dat ekonomiese vordering ongeveer 25% meer effektief is met indeks-seleksie as seleksie slegs vir melkopbrengs.

Introduction

The purpose of index selection should be to achieve maximum genetic progress toward a stated economic goal. Gain from change in all individual traits included could be summarized into $\Delta H =$

$\Sigma a_i \Delta G_i$, where H is gain in aggregate genotype (economic breeding value), a_i is the economic weight for trait i and G_i is the breeding value for trait i (Hazel *et al.*, 1994). To calculate the possible gain in aggregate genotype, owing to a specific trait, information on the trait's economic weight, correlations, variances and heritability is required.

At present the knowledge about genetic and phenotypic parameters of functional traits, such as live weight and feed efficiency is limited (Koenen & Groen, 1998). Although a number of studies (Svendsen et *al.*, 1990 and Koenen & Groen, 1998) estimated genetic and phenotypic parameters, these parameters could show heterogeneity across countries (Banos, 1994). Therefore for accurate evaluation each country should estimate these genetic and phenotypic parameters from their own data.

In South Africa the exact breeding goal for Holstein Friesians still has to be determined. This means that the traits, which should be the most important in selection have to be identified (Ponzoni & Newman, 1989). One method to identify these traits could be to calculate economic weights for production and functional traits (Groen, 1988; Amer & Fox, 1992 and Philipsson *et al.*, 1994). This follows from the fact that when the economic weight of a trait (a_i) is small then gain in aggregate genotype (ΔH) owing to that trait will necessarily be small.

Although any units can be used, economic weights can also be expressed in units proportional to the mean of the trait (Smith *et al.*, 1986). The use of absolute units makes the comparison of the different traits difficult if they are measured in different units. Therefore percentage units are used in this study to express the economic weights of the traits. Furthermore percentage units are probably more comparable over production levels than given changes in absolute units.

The aim of this study is to identify, in terms of economic weights, the most important traits that influence the economic efficiency of a production enterprise. These calculated economic weights will make it possible to rank the traits in an order of economic importance. The traits being evaluated can be grouped into production and functional traits, with the production traits milk, butterfat, protein and lactose yield while the functional traits include live weight, calving interval, survival rate and feed efficiency. The study included three Holstein-Friesian production enterprises. The average production of the first enterprise is 6 872 kg milk per lactation with a butterfat percentage of 3.7 and a protein percentage of 3.16. The second enterprise has an average of 9 451 kg milk per lactation with a butterfat and protein percentage of 3.64 and 3.08 respectively. The average production of the third enterprise is 10 278 kg with a butterfat and protein percentage of 3.92 and 3.05 respectively. The production enterprises also differ in the number of times milked per day; the first enterprise milked twice a day while the other two enterprises milked three times a day. All three the enterprises use a total mixed ration feed strategy although the diets differ according to the average production of the herds.

Materials and Methods

The simulation model developed for the calculation of economic weights by Du Plessis & Roux (1998) fits into the objective of this study and was found to be useful.

The simulation model

The model was developed in Microsoft Excel of Windows 95. Certain elements of the model were estimated or assumed according to scientific research and management principles. Production elements, such as the feed intake correlated with milk production, cannot be satisfactorily predicted and field data must therefore be used. The model made use of the following input data:

1. The herd composition

2. Diets and their composition
3. The expected milk production for a 300 day lactation period
4. Prices and quantities of production supplies
5. The South African milk price systems

Further information on the input data can be found in Du Plessis & Roux (1998). The model used the above input values to calculate the feeding, replacement and veterinary costs as well as production costs. The herd income consisted of sales of livestock and milk. This resulted in three, 365 day production period budgets, one for each of the production enterprises. From the budgets the economic efficiency ratio (income divided by expenses) was calculated.

Calculation of the economic weights

The approach followed in this study was similar to sensitivity analyses used by Verma & Gross (1978) in a decision-making process. The economic weight of a trait was calculated by determining the effect of a 10% increase or decrease in the trait value on the economic efficiency. For this calculation the other trait values were kept constant. The production traits, feed efficiency and survival rate values, were increased by 10% while calving interval and live weight were decreased by 10%. These trait changes altered the input and output values of the calculated budgets. These changes to the budget are indicated in Table 1.

The changes in the feed cost for milk yield, butterfat yield and live weight were calculated according to the feed tables of Stewart & Dugmore (1995). These feed tables indicated the expected dry matter intake (DMI) of the cows according to milk yield, butterfat percentage and live weight. For both milk and butterfat yield, feed changes were estimated for an increase in these traits, while the feed changes of live weight were for a decrease in live weight. The feed changes, with an increase in protein yield were calculated according to Holter *et al.* (1997). Survival rate and calving interval changes were calculated with the management principles from the Sensitivity Analysis of Milk Production (SAMP) program of the South African Milk Producers' Organization and Ferreira (ARC, pers.comm.).

The milk price of the dairy enterprises was based on two of the major milk price systems in South Africa. The first milk price system is used by a milk buyer with fresh milk and yogurt as

Table 1 Changes to the budget input and output values owing to trait changes

Trait	Fixed costs	Feed costs	Cull rate	Marketing costs	Milk price	Income from livestock sales
Milk yield	+[1]	+			+	
Butterfat yield		+			+	
Protein yield		+			+	
Lactose yield					+	
Survival rate		+	–[2]	–		–
Feed efficiency		–				
Live weight		–		–		–
Calving interval		+		+		+

[1] + equals an increase in the input or output

[2] – equals a decrease in the input or output

main products and the second price system came from a milk buyer with cheese and butter as main products.

Results and Discussion

Results of the trait changes on the economic efficiency were expressed as the percentage change in economic efficiency for each trait. Table 2 shows the percentage change of the price system for fresh milk and yogurt while Table 3 indicates the changes for the cheese and butterfat price system

According to the results in Tables 2 and 3 the traits could be ranked in an order of economic importance within the two milk price systems, presented in Tables 4 and 5.

The results in Tables 4 and 5 show that milk yield is potentially the most important trait to improve in enterprise 1. This result indicates that South African milk price systems still promote an

Table 2 Economic weights for production and functional traits expressed as percentage change in economic efficiency, within the fresh milk and yogurt price system

	Enterprise 1	Enterprise 2	Enterprise 3
Production traits			
Milk yield	8.14	8.80	9.18
Butterfat yield	2.02	2.59	2.90
Protein yield	1.44	1.61	1.00
Lactose yield	0.386	0.398	0.357
Functional traits			
Live weight	4.15	4.57	4.73
Survival rate	1.72	1.35	1.38
Feed efficiency	6.06	6.56	6.58
Calving interval	0.386	0.592	1.24

Table 3 Economic weights for production and functional traits expressed as percentage change in economic efficiency, within the cheese and butter price system

	Enterprise 1	Enierprise 2	Enterprise 3
Production traits			
Milk yield	8.05	8.57	8.96
Butterfat yield	1.61	2.17	2.47
Protein yield	0.902	1.05	0.653
Lactose yield	1.17	1.20	1.18
Functional traits			
Live weight	4.20	4.61	4.76
Survival rate	0.731	1.33	1.35
Feed efficiency	6.06	6.57	6.58
Calving interval	0.505	0.677	1.31

Table 4 Order of the traits in terms of economic importance for the fresh milk and yogurt price system

Enterprise 1	Enterprise 2	Enterprise 3
Milk yield	Milk yield	Milk yield
Feed efficiency	Feed efficiency	Feed efficiency
Live weight	Live weight	Live weight
Butterfat yield	Butterfat yield	Butterfat yield
Survival rate	Protein yield	Survival rate
Protein yield	Survival rate	Calving interval
Lactose yield	Calving interval	Protein yield
Calving interval	Lactose yield	Lactose yield

Table 5 Order of the traits in terms of economic importance for the cheese and butter price system

Enterprise 1	Enterprise 2	Enterprise 3
Milk yield	Milk yield	Milk yield
Feed efficiency	Feed efficiency	Feed efficiency
Live weight	Live weight	Live weight
Butterfat yield	Butterfat yield	Butterfat yield
Lactose yield	Survival rate	Survival rate
Protein yield	Lactose yield	Calving interval
Survival rate	Protein yield	Lactose yield
Calving interval	Calving interval	Protein yield

increase in milk yield. This milk yield increase leads to a decrease in milk components which are important in the manufacturing of milk products such as cheese and butter. The second most important trait is feed efficiency followed by the live weight of the cows. This is due to the fact that the feed cost of the herd is the largest expense in the production enterprise. According to the results live weight is followed by butterfat yield of the herd. The order of the other four traits differed in the price system for fresh milk and yogurt and that of cheese and butter. In the price system for fresh milk and yogurt the economic efficiency was more sensitive to survival rate than protein yield. For the price system of cheese and butter the economic efficiency was more sensitive to lactose yield than protein yield which was followed by survival rate.

The four traits, which are potentially the most important for enterprises 2 and 3, are the same as those of enterprise 1. When enterprise 2 supplies to the milk buyer of the fresh milk and yogurt price system, protein yield is more important than survival rate. Within this price system lactose yield has the smallest effect on economic efficiency. This order of economic importance changed in the cheese and butter price system. In this system survival rate cause a larger change in economic efficiency than lactose yield. Protein yield is less important than lactose yield but of a higher importance than calving interval.

The order of the traits according to the economic weights within enterprise 3 was constant across price systems, except for the two least important traits. In the price system for fresh milk and yogurt the economic efficiency was more sensitive to protein yield than lactose yield whereas this sensitivity order was reversed in the cheese and butter price system.

According to the results the breeding goal should take into consideration the production level of the herd and the milk buyer price system to which farmers supply milk, to identify the traits to improve. The results indicate that the functional traits, live weight and feed efficiency, are important in the improvement of the economic efficiency. Measurement of feed efficiency is not yet economically feasible on individual farms, but there is a high negative correlation between feed efficiency and live weight, $r_A = -0.81$ (Persaud *et al.*, 1991), making live weight potentially the second most important trait to decrease with selection. Therefore selection including an increase in milk yield and a decrease in live weight should also lead to an improvement in feed efficiency for milk production.

To confirm the result, that live weight should be included in selection, selection indexes with milk yield and live weight as the traits to be improved within the two milk price systems were cal-

Table 6 Weighted averages for heritability, variances and correlations of milk yield and live weight

Average	Milk yield*	Live weight
h^2	0.31 (±0.0066)	0.34(±0.0104)
σ_p	3.6492#	59.0578
μ	21.74	598.9
$r_{P(MY;LW)}$	0.1919(±0.012)	
$r_{A(MY;LW)}$	- 0.0230(±0.019)	

* Milk yield averages are for milk yield per day

SE for the averages are given in parenthesis

culated. Owing to insufficient information on the genetic and phenotypic (co)variances of these traits in South Africa, weighted averages were calculated using research data from other countries (Beard, 1987; Svendsen *et al.*, 1990; Persaud *et al.*, 1991; Ahlborn & Dempfle, 1992; Short & Lawlor, 1992; Bowman *et al.*, 1996; Cue *et al.*, 1996; Pryce *et al.*, 1997; Veerkamp & Brotherstone, 1997 and Koenen & Groen, 1998). The weighted averages of the heritabilities' variances and correlations are given in Table 6. The weighted average of the genetic correlation between live weight and milk yield show that the two traits can be classified as genetically independent traits. This means that selection for the one trait will cause no or a low correlated response in the other trait.

These averages were used to calculate the b_i values of the selection index according to Falconer (1989). The economic selection index for the fresh milk and yogurt price system is:

$I = 1.12(MY) - 0.0462(LW)$

The economic selection index for the cheese and butter price system is:

$I = 1.18(MY) - 0.0493(LW)$

The economic gain owing to index selection was furthermore compared with direct selection for a single trait. These economic responses (genetic gain multiplied by the absolute economic weight) are presented in Tables 7 and 8.

Table 7 Economic response with selection index and single trait selection according to the fresh milk and yogurt price system

	Milk yield	Live weight	Total response
Response with single trait selection	3.529i[1]		3.53i
Correlated response		0.04079i	0.041i
			3.57i
Response with single trait selection		1.85574i	1.86i
Correlated response	0.08502i		0.085i
			1.94i
Correlated response with index selection	3.2897i	1.1728i	4.46i

[1] i = selection intensity

According to the calculated total economic response the use of a selection index is economically 25% more efficient than direct selection for only milk yield according to the fresh milk and yogurt price system. The results in Table 8 show that economic improvement with a selection index is 26% more efficient than direct selection for milk yield.

Conclusion

According to the results of this study Holstein Friesian farmers should select animals with an increased potential for milk yield combined with a lower live weight. This should theoretically

Table 8 Economic response with selection index and single trait selection according to the cheese and butter price system

Response type	Milk yield	Live weight	Total response
Response with single trait selection	3.6992i[1]		3.70i
Correlated response		0.04384i	0.044i
			3.74i
Response with single trait selection		1.9959i	1.99i
Correlated response	0.08912i		0.089i
			2.08i
Correlated response with index selection	3.4345i	1.2738i	4.71i

[1] i = selection intensity

increase their economic response with at least 25% more than selection for only milk yield. Therefore further research should definitely include the calculation of genetic and phenotypic parameters for live weight, so that it could be included in the selection index for Holstein Friesians in South Africa.

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