Expected Genetic Gain from Newly Developed Selection Indices for South African Holstein Cattle

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ABSTRACT: The effect of selection on recently developed selection indices on genetic changes in milk volume (VOL), fat yield (FY), protein yield (PY), somatic cell score (SCS), calving interval (CI) and overall economic merit (ECON) were determined for South African Holstein cattle. Expected genetic change was calculated for the four pathways of selection using selection index theory. Selection based on the fluid index resulted in responses of 950.61 l, 18.73 kg, 26.33 kg, 7.64 days, and -0.02 score, per generation, for VOL, FY, PY, CI and SCS, respectively. Genetic merit for ECON increased by ZAR460.43. The corresponding genetic changes, for selection applied on the solid index, were 14.65 l, 12.22 kg, 10.92, 1.82 days and -0.11 score, respectively for VOL, FY, PY, CI and SCS, and ZAR480.49 for ECON. These results form the basis for evaluating any modifications to the South African Holstein selection indices, in the future.
Keywords: breeding objective; economic value; selection response; index selection

Introduction

The Holstein is the most widely-used dairy cattle breed in South Africa. Estimated breeding values (EBVs) of Holstein cattle are routinely produced by national genetic evaluation centres for 5 milk production traits, 17 linear type traits, somatic cell score and calving interval. In the past, selection in the South African Holstein cattle population focused mainly on increased production and, to a lesser extent, on improved type, as shown by genetic trends (National Dairy Animal Improvement Scheme, 2007). A selection index known as the Breeding Value Index (BVI) was used. The BVI was derived by a consensus approach, which is generally considered inappropriate as it lacks scientific and economic basis. It also focused on yield and type traits. Large increases in genetic merit for yield traits and considerable genetic change in linear type traits were realized (Theron & Mostert, 2004; National Dairy Animal Improvement Scheme, 2007). This was, however, coupled with a deterioration in fitness traits, such as cow fertility (Makgahlela *et al.*, 2008) and udder health (Dube et al., 2009).

Recently, efforts have been made to develop scientifically-based and balanced breeding objectives, incorporating all economically relevant traits for South African Holstein (Banga *et al*., unpublished). Two selection indices have been developed and are now officially available to the industry. These indices comprise the traits milk volume, fat yield, protein yield, somatic cell score and calving interval. The fluid index is based on a payment system that pays for milk volume, while the solids index is for payment systems that only pay for solids (fat and protein).

The primary objective of this study was to determine expected responses in the breeding objective traits and overall economic merit when selection is applied on these new indices. Such information is important in providing an indication of the impact of adopting these indices to industry. It also provides the basis for evaluating any changes to the indices that may be contemplated.

Materials and Methods

Data. Calculations were based on EBVs for the South African Holstein breed produced by the Agricultural Research Council (ARC) in the 2012 routine evaluation. The economic values used to compute the index values, for each of the two indices, are shown in Table 1.

Table 1: Economic values used to calculate indices

Trait	Economic Value	
	Fluid Index	Solids Index
Milk volume (l)	0.28	-0.49
Protein (kg)	7.62	21.88
Fat (kg)	1.21	5.81
Somatic cell score (Log SCC)	-949.26	-1759.26
Calving interval (days	-5.75	-5.75

Calculation of response. Expected response was calculated per cycle of selection. Response was calculated for each of the four pathways of selection (Rendel and Robertson, 1950) using selection index theory as applied in the MTINDEX Excel program file (www-personal.une.edu.au/~jvanderw/MTINDEX20T.xls; Van der Werf, 2012). Table 2 contains the estimates of genetic and phenotypic parameters that were used (Mostert *et al*., 2006; Mostert *et al*., 2010). Genetic standard deviations were ZAR531 and ZAR 303, respectively, for the fluid and solids indices. Bulls were assumed to have 75 daughter records in different herds and cows were evaluated from two of their own lactation records. The assumed selection intensities and generation lengths are shown in Table 3.

Table 2: Estimates of genetic and phenotypic parameters[1]

	Volume	Protein	Fat	Somatic Cell score	Calving interval
Volume (l)	0.177	0.92	0.77	0.20	0.53
Protein (kg)	0.88	0.136	0.84	0.20	0.53
Fat (kg)	0.63	0.74	0.105	0.20	0.53
Somatic cell score (Log SCC)	0.20	0.20	0.20	0.062	0.10
Calving interval (days)	0.53	0.53	0.53	0.10	0.071

[1]Phenotypic correlations are on the upper off diagonals, genetic correlations are on the lower off diagonals, and heritabilities are on the diagonal.

Table 3: Selection intensities and generation intervals assumed for the four selection pathways

Selection pathway	Selection intensity (Proportion selected)	Generation interval (years)
Bull to bull	0.15	6.0
Bull to cow	0.30	7.0
Cow to bull	0.10	4.70
Cow to cow	0.95	4.21

Results and Discussion

Expected responses to selection on the fluid and solid index are presented it Tables 4 and 5, respectively. The magnitude of genetic change was comparatively larger for all traits and the overall economic change higher by about ZAR34 under the fluid index. For both indices, positive response was obtained for all traits except SCS. This implies that a decreasing genetic trend, which is desirable, would be achieved for SCS. For calving interval, however, the increasing trend observed by Makgahlela *et al* (2008) would persist. Despite receiving negative emphasis under the solid index, milk volume increased by 14.65 litres. Calving interval also increased under both indices, despite its negative economic value.

Table 4: Genetic and economic change for selection on the fluid index

Trait	Genetic Change	Economic change
Volume (l)	950.61	266.17
Protein (kg)	26.33	200.61
Fat (kg)	18.73	22.61
SCS (score)	-0.02	14.91
CI (days)	7.64	-43.92
Total		**460.43**

Table 5: Genetic and economic change for selection on the solids index

Trait	Genetic Change	Economic change
Volume (l)	14.65	-7.18
Protein (kg)	10.92	239.01
Fat (kg)	12.22	17.00
SCS (score)	-0.11	188.12
CI (days)	1.82	-10.46
Total		**426.49**

Conclusions

Selection on the newly-developed indices for South African Holstein cattle will result in improvement in total economic merit. The fluid index will result in higher genetic improvement in overall economic, compared to the solids index. The results of the current study form the basis for evaluating any modifications to the South African Holstein selection indices, in the future.

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