THE EFFECT OF INCLUDING STATURE IN SIRE SELECTION ON THE LIVE WEIGHT, MILK YIELD, FERTILITY AND FEED EFFICIENCY OF HOLSTEIN COWS

C.J.C. Muller[1], S.W.P. Cloete[1,2] and M. Burger[2]

[1]Faculty of AgriSciences, University of Stellenbosch, Stellenbosch, 7602 South Africa
[2]Directorate Animal Sciences, Western Cape Department of Agriculture, Elsenburg, 7607 South Africa

SUMMARY

The efficiency of milk production is increasingly under investigation to improve the profit margins of dairy herds. Preliminary results on the live weight (LW), production, fertility and efficiency of first parity Holstein cows descended from sires selected for (i) estimated breeding values (EBVs) for combined fat and protein yield (Prod) or (ii) EBVs fat plus protein yield and the lowest (negative) stature values (Stat) in a pasture-based production system are presented in this paper. Progeny from Stat bulls weighed less while also producing less milk ($P<0.05$) in first lactation. Fertility traits did not differ in heifers and cows from Prod and Stat sires. Efficiency was higher ($P<0.05$) in the progeny of sires selected for production compared with the progeny of sires selected for production and stature.

INTRODUCTION

Feed efficiency in dairy cows is a complex trait as cows undergo lactation cycles marked by declines and increases in milk yield, body reserves and LW (Connor 2015; Roche *et al*. 2009). Breeding and selection programmes in dairy herds have always focused on production and conformation traits (Walsh *et al*. 2007). Because of genetic improvement, better housing, improved feeding and general overall management, the milk yield of dairy cows in most countries has doubled over the last 30 years (Capper *et al*. 2009). This has indirectly resulted in an increased dairy feed efficiency (VandeHaar and St-Pierre 2006). However, higher milk yields have resulted in cows becoming larger and heavier. Berry *et al*. (2003) found that genetic correlations between LW at different stages of the lactation and total lactation milk production were close to zero although becoming positive (0.01 to 0.39) after adjusting LW for body condition score. Furthermore, to perform well in cattle showing, Holstein breeders put a strong emphasis on size. These factors had a positive effect on the LW and body size of dairy cows. This is problematic for cows in housing systems designed and built earlier. For pasture-based dairying systems, farmers suggest that larger cows have difficulty in walking large distances to and from pastures especially on uneven and hilly terrain. Maintenance requirements of cows also increase with size. It is expected that efficiency would be reduced when milk yield does not follow an increase in LW.

Hansen *et al*. (1999) in the USA reported results from a long-term study starting in 1966 comparing large and small Holstein cows in a total mixed ration feeding system. Sires were selected on predicted transmitting ability for stature, strength and body depth using an index consisting of (0.5 x stature) + (0.25 x strength) + (0.25 x body depth). Live weight and body measurements of cows differed significantly between sire groups but there was a large overlap of body size across the two genetic lines. Milk yield did not differ between sire lines resulting in poorer efficiency measures for large cows. Reproduction did not differ between genetic lines (P>0.05) although all traits numerically favoured the small line.

No research has been conducted in South Africa on the effect of sire selection regarding cow size. The aim of the study was to compare the effect of sire selection based on (i) EBVs for fat and protein yield (Prod) and (ii) yield (Prod) + lowest negative stature on the LW, production, some efficiency measures and reproductive performance of Holstein cows in a pasture-based system.

MATERIALS AND METHODS

Data. The study was conducted at the Elsenburg Research Farm of the Western Cape Department of Agriculture. The area has a typical Mediterranean climate with short, cool, wet winters and long, warm, dry summers with an average annual rainfall of about 630 mm. Two groups of five Holstein bulls each were selected annually for artificial insemination based on (i) EBVs for combined fat and protein yield (Prod) and (ii) within the top 25 bulls ranked for EBV for fat and protein yield, sires with the lowest negative values for stature (Stat). At the start of the trial, 120 Holstein cows were divided into two groups based on EBV for milk yield and stature scored by a trained mating programme technician. Bulls were matched to cows within each group using a commercial mating programme to control inbreeding. Heifers born from the two sire groups were reared similarly to first calving. After calving, cows were put in a kikuyu-ryegrass pasture-based production system supplemented with a commercial concentrate mix at 7 kg/cow/day. Fresh drinking water was freely available at all times. Walking distance to the pasture varied from 1-3 km/day. Cows were machine-milked twice a day.

The milk yield of cows at the evening and following morning's milking was recorded according to standard milk recording procedures. At each recording event, milk samples were collected at both the evening and morning milking sessions. Samples were combined and analysed at the milk testing laboratory of the National Milk Recording Scheme for fat, protein and lactose content.

Heifers were weighed at birth and thereafter once a month until first calving. Body size measurements (girth circumference, shoulder height, body length, depth and width) of heifers were recorded at fixed stages during the rearing period until first calving. The LWs of cows were recorded within one week before and after calving. During the lactation period cows were weighed after each milking using a walk-over scale. Insemination dates and pregnancy check results by rectal palpation by a veterinarian were recorded for both heifers and cows. The following efficiency measures were estimated:

1. Component values (CV):	((fat yield x 6)+(protein yield x 13))/2
2. Alternative Kleiber ratio: (Hurley *et al*. 2014)	(daily milk yield x ((0.0929 x fat%) + (0.0547 x protein%) + (0.0395 x lactose%)) / metabolic live weight ($LW^{0.75}$)
3. FCM/LW: (Gaines *et al*., 1940)	4% fat corrected milk yield (FCM)/ live weight
4. MY/LW:	Lactation milk yield / live weight
5. DMi/day: (NRC, 2001)	DM intake (kg/day) = (0.372 x FCM) + (0.0968 x $LW^{0.75}$) x $(1 - e^{(-0.192 \text{ x (Week of lactation } + 3.67))})$
6. MY/DMi	Milk yield(kg)/kg DMi

Statistical analysis. Analysis of variance was performed, using cows as random replicates, using GLM Procedure of SAS software (Version 9.4; SAS Institute Inc, Cary, USA) to test the effect of breed on production parameters and efficiency measures. Third order polynomial trend lines were fitted for body size measurements of heifers.

RESULTS AND DISCUSSION

Body size measurements for heifers from different sire groups did not differ (P>0.05) until 22 months of age when growth rate curves showed a divergence (Figure 1). While shoulder height of heifers from Prod and Stat sires did not differ (P>0.05), chest circumference differed (P<0.05), being 188 vs. 192 cm, respectively. At first calving heifers from Stat sires weighed less (P<0.05) than Prod group heifers, i.e. 610±65 vs. 647±60 kg, respectively.

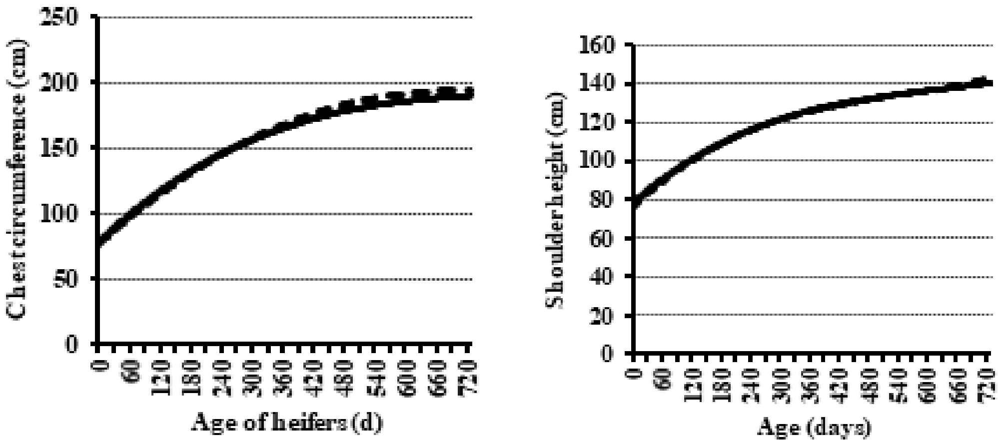

Figure 1. The chest circumference and shoulder height of heifers from production (---) and stature (—) sires from birth to 24 months of age

While the mean LW of cows from Prod and Stat sires differed ($P<0.05$), a considerable overlap was observed (Table 1) similar to the results reported by Hansen *et al*. (1999). Graham *et al*. (1991) showed that New Zealand sires produced first lactation cows similar in LW to Canadian sires, i.e. 533 vs. 528 kg, respectively. Test-day milk yield of Stat cows was less ($P<0.05$) than that of cows from Prod sires. While the estimated dry matter (DM) intake of Stat cows was lower, efficiency measures were also compromised ($P<0.05$) relative to progeny of Prod sires.

Table 1. Means (±SEM) for production parameters and efficiency measures for first parity progeny of Holstein sires selected for production (Prod) and production + stature (Stat) in a pasture-based system (FCM: fat corrected milk yield; CV: component value; KR: Kleiber ratio; MY: milk yield; LW: live weight; DMi: dry matter intake; ^{a,b}Values differ at $P<0.05$)

Production parameters	Sire selection		Efficiency measures	Sire selection	
	Prod	Stat		Prod	Stat
Cows (Test days)	36(199)	24(132)	LW (kg)	546^{a}±4.4	520^{b}±5.0
MY (kg/d)	23.0^{a}±0.4	20.8^{b}±0.4	CV (kg)	7.51^{a}±0.13	6.61^{b}±0.14
FCM (kg/d)	23.0^{a}±0.4	20.1^{b}±0.4	KR (kg)	0.153^{a}±0.036	0.139^{b}±0.032
Fat (%)	4.01^{a}±0.05	3.80^{b}±0.05	FCM/LW (kg)	0.042^{a}±0.001	0.039^{b}±0.001
Protein (%)	3.19±0.02	3.16±0.02	MY/LW (kg)	0.042±0.001	0.040±0.001
Lactose (%)	4.90^{a}±0.01	4.78^{b}±0.01	DMi (kg/d)	18.0^{a}±0.2	16.9^{b}±0.2
Fat (kg/d)	0.92^{a}±0.02	0.79^{b}±0.02	MY/DMi(kg)	1.29±0.02	1.24±0.02
Protein (kg/d)	0.73^{a}±0.01	0.65^{b}±0.01			

Fertility traits in heifers did not differ ($P>0.05$) between sire lines although favouring the Stat line, i.e. age at first calving was 24.1 vs. 23.6 months while the proportion of heifers calving down before 24 months of age was 0.58 and 0.73 for Prod and Stat sires, respectively. Hansen *et al*. (1999) showed better fertility for small cows in comparison to large cows.

The body weight of cows is associated with size and is the most practical measurement in dairy cows (Arango & Plasse 2002). However, Berry *et al*. (2004) showed moderate to strong genetic correlations between stature and milk yield and stature and average body weight of 0.42 and 0.63 respectively. These genetic correlations may reflect past emphasis on milk yield together with increased cow stature, body width, depth and angularity in Holstein breeding programmes. This has resulted in taller, wider and deeper cows that tend to be more angular with less body condition. Moderate to strong genetic correlations of most of the body-related type traits with average body weight reflect an element of the size of animals. As cows are often not routinely weighed, body-related traits could be used to predict live weight. The USA Holstein Association (2017) has developed an efficiency equation using PTA for milk, fat and protein yields together with a body weight composite trait which includes stature, strength, body depth, rump width and dairy form.

A larger source of sires for selection may have resulted in reducing the difference in milk yield potential while reducing body size. Currently no EBVs for the LW of the daughters of bulls are available. The difficulty in recording the LW of cows may be overcome by using automatic milk recording systems which also record cow LW after each milking. Determining the actual feed intake of cows would make it possible to compare sire groups on residual feed intake.

CONCLUSION

This study reported differences in the growth rates and production performance of the progeny of sires selected for production and production plus stature in a pasture-based system. Cows from Stat bulls weighed less than cows from Prod bulls while also producing less milk during first lactation. This reduces efficiency measures for Stat sires progeny.

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