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# PRELIMINARY ESTIMATES OF PRODUCTIVE LIFETIME AND LIFETIME EFFICIENCY IN HOLSTEIN COWS AS AFFECTED BY AGE AT FIRST CALVING

**C.J.C.Muller[1], H.L. de Waal[2] and M.M. Scholtz[2,3]**

[1]Department of Animal Sciences, University of Stellenbosch, Stellenbosch 7602, South Africa;
[2]National Milk Recording, Agricultural Research Council, Stellenbosch 7602, South Africa;
[3]Natural and Agricultural Sciences, University of the Free State, Bloemfontein 9300, South Africa

## SUMMARY

Longevity in dairy cows affects their lifetime performance and lifetime efficiency. Limited research has been conducted in South Africa on the effect of age at first calving (AFC) on lifetime performance. In this paper, preliminary estimates of the productive life (PL, total number of days in milk), lifetime (LT, birth date to cull date) and productive lifetime efficiency (PLE) and lifetime efficiency (LTE) for Holstein cows in South Africa as affected by AFC are presented. Lifetime production records of 509 715 cows born between 1989 and 2008 which had calved down at least once, were included in the study. Cows calving down earlier than 18 months and later than 48 months of age were removed from the data set. For each cow, the total milk, fat and protein yield, days in milk (PL) and LT of cows was determined. From this, the PLE and LTE of the milk yield for each cow was derived. Extending AFC increased LT, although decreasing PL, especially after 29 months of age. Productive lifetime efficiency peaked at an AFC of 25 months and decreased thereafter. Further analyses to estimate genetic parameters for production and ratio traits are envisaged towards identifying individual cows and sires for possible genomic analyses.

## INTRODUCTION

Longevity in dairy cows is an important trait affecting the genetic progress, LT performance, LFE, and financial sustainability of a dairy herd (Fricke 2004). An early AFC increases PL (Nilforooshan & Edriss 2004) while also reducing rearing costs (Ettema & Santos 2004), being 4.3% per month less when first calving is one month earlier (Tozer & Heinrichs 2003). However, calving problems may increase when AFC is too early (Ettema & Santos 2004). For this reason most farmers rear heifers to reach first calving at an older age although not necessarily at a higher live weight. This increases the overall rearing costs because of a longer feeding period. High growth rates and longer feeding period may result in over-conditioned heifers resulting in dystocia problems (Ettema & Santos 2004). Age at first calving is therefore a benchmark that should be properly managed to increase economic returns. Torshizi *et al*. (2016) found an average AFC of 24.7±1.4 months for Iranian Holsteins which was similar for Irish seasonal calving Holsteins at 24.3 months (Berry & Cromie 2009). The heritability of AFC is generally low, ranging from 0.09 to 0.11 (Weigel & Rekaya 2000 and Changhee *et al*. 2013) indicating a large environmental effect. Limited research has been done in South Africa on factors affecting the lifetime performance of dairy cows. Mostert *et al*. (2001) found, as expected, that milk yield increased with age at calving reaching a peak at about 4$^{th}$ lactation. Makgahlela *et al*. (2008) showed that actual AFC decreased by 0.2 months per year. Mean breeding value for AFC also decreased by 0.06 months per year. Local breed societies present lifetime awards to cows reaching specific production milestones. Cows reach such milestones at different ages, i.e. 6 and 10 lactations, indicating differences in production and possibly production efficiency. Cows ranked for total fat and protein yield are re-ranked when lactation number is used to estimate an efficiency index (fat + protein yield/lactation number). Production efficiency should be estimated using PL or LT in days as lactations could vary being short or longer than standard lactation periods. The aim of this study is to determine the effect of AFC on the LT, PL, LF performance, PLE and LTE of Holstein cows.

## MATERIALS AND METHODS

**Data**. Milk production records of 509 715 Holstein cows that had calved down for the first time between 1989 and 2007 were extracted from the South African National Milk Recording Scheme data base of the Agricultural Research Council (ARC). Milk production and milk composition records were compiled using standard procedures, i.e. on 10 milk recording events during the year, starting from 5 days after calving, for at least 8 milk recording events (De Waal & Heydenrych 2001). Each cow that had completed a first lactation of at least 240 days was included in the study. The milk, fat and protein yield for all subsequent lactations were added up until the end of each cow's last lactation period. Productive life was estimated for each cow totalling all the number of days-in-milk for all lactations. The LT of cows was derived from birth date to the end of the last lactation period which was regarded as the cow's cull date as exact cull dates were not available. For each cow, PLE and LTE were estimated by dividing the total milk, fat and protein yield by PL and LT. Records from cows calving down for the first time before 18 months of age and after 48 months of age were deleted from the data set. Herds with fewer than 30 records were also removed from the data set.

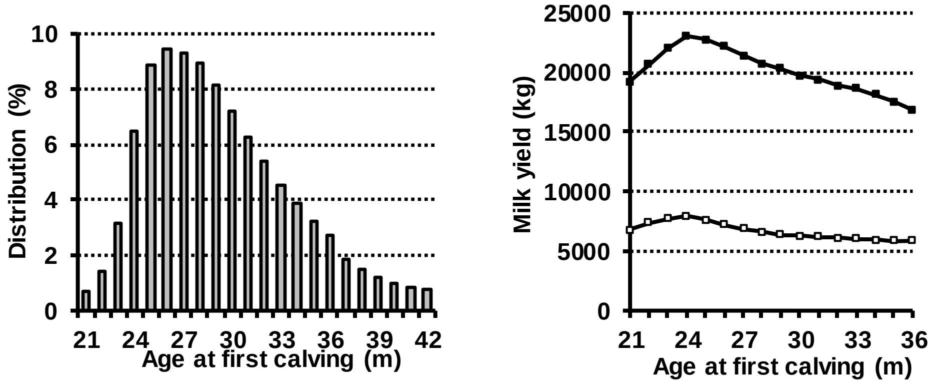
**Statistical analyses.** Analysis of variance was performed, using cows as random replicates, using GLM Procedure of SAS software (Version 9.4; SAS Institute Inc, Cary, USA) to test the effect of age at first calving (in months) on the production parameters milk, fat and protein, productive life, lifetime and productive life efficiency (total milk yield/productive life in days, PLE) and lifetime efficiency (total milk yield/lifetime in days, LTE). Fisher's least significant difference was calculated at the 5% level to compare month means (Ott 1998). A probability level of 5% was considered significant for all significance tests. The Shapiro-Wilk test was performed on the standardized residuals from the model to test for normality (Shapiro & Wilk 1965).

## RESULTS AND DISCUSSION

Table 1 shows mean±standard deviation, range of records and analysis of variance results for some production parameters. Except for fat and protein percentages, the coefficient of variation was high for all traits, exceeding 30%. Average AFC was 29.6±5.1 months which is higher than general recommendations (Tozer & Heinrichs 2003). However, AFC decreased from 30.0 in 1987 to 25.3 months of age in 2006. In the present study AFC is skewed to the right with most (88%) of heifers calving down later than 24 months of age (Figure 1a). Almost 36% of heifers calved down after 30 months of age.

**Table 1. The mean±standard deviation and data ranges for milk production, fat and protein percentages and lifetime parameters for Holstein cows. Least significant differences (LSD) for age at first calving intervals indicate significant differences between age at first calving intervals. (Significance **: P<0.01)**

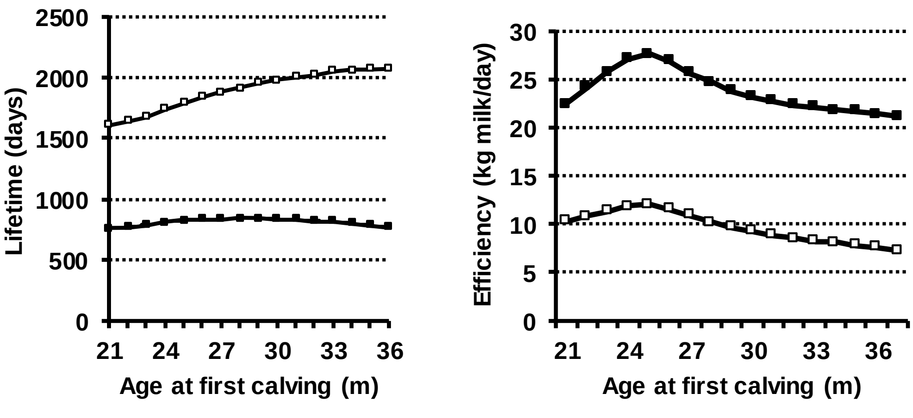
| Variables | Mean | Range | LSD | Significance |
|---|---|---|---|---|
| Age at first calving (m) | 29.6±5.1 | 17.8-48.0 | - | - |
| First lactation milk yield (kg) | 6217±1985 | 144-17329 | 118 | ** |
| First lactation fat (%) | 3.57±0.41 | 0.55-7.67 | 0.03 | ** |
| First lactation protein (%) | 3.17±0.21 | 0.50-5.33 | 0.01 | ** |
| Total lifetime milk yield (kg) | 20300±14887 | 364-135538 | 813 | ** |
| Lifetime (days) | 2004±720 | 785-4295 | 44 | ** |
| Productive life (days) | 849±523 | 241-3239 | 31 | ** |
| Lifetime efficiency (kg/d) | 9.24±4.44 | 0.22-43.9 | 0.23 | ** |
| Productive life efficiency (kg/d) | 22.9±6.9 | 1.2-150.8 | 0.40 | ** |




(a) (b)

**Figure 1. The distribution (a) of age at first calving (AFC) records and (b) the effect of AFC on first lactation (□) and lifetime milk yield (■) for Holstein heifers.**

Torshizi *et al.* (2016) found that the proportion of Holsteins cows calving down before 20 and after 30 months were low. In an earlier survey, Muller *et al.* (2014) similarly found that while only 12% of Holstein heifers calved down before 25 months of age, more than 35% of Holstein heifers calved down after 30 months of age. First lactation and LT milk production increased from 21 months of AFC (Figure 1b), peaking at 24 months of age after which production decreased indicating no advantage for a later AFC. Nilforooshan & Edriss (2004) also showed an initial increase in first lactation milk yield from 21 to 24 months of age after which production decreased. A slight negative phenotypic correlation (-0.089) was found between AFC and first lactation milk yield. In the present study, as expected, the LT of cows increased in a quadratic fashion (P<0.05) with an increasing AFC (Figure 2a). However, while the PL of cows increased (P<0.05) up to 29 months of age, it decreased (P<0.05) after that.




(a) (b)

**Figure 2. Effect of age at first calving on (a) lifetime (□) and productive lifetime (■) and (b) milk production lifetime efficiency (□) and productive lifetime efficiency (■) of Holstein cows.**

The phenotypic correlation between first lactation and lifetime milk yield levels followed a quadratic trend (P<0.05). Similarly, PLE and LTE peaked at about 24 to 25 months of age after which efficiencies decreased. Heinrichs & Vazquez-Anon (1993) found that AFC of Holstein heifers was 26.4 months. In that study, the distribution of AFC was also skewed towards older ages at first calving. Holstein cows calving down at more than 26 months of age produced similar amounts of milk as cows calving down at 24 months of age. Cooke *et al*. (2013) found that the total days-in-milk for heifers calving down before 23 months of age was higher (P<0.01) than for heifers calving down later than 30 months of age. Mostert *et al*. (2001) found that the average 305-day milk yield of Holstein cows increased when AFC increased from <24 to >32 months of age.

Changing AFC genetically would be slow as heritability ($h^2$) is low (<0.09) indicating that this trait is highly influenced by environmental factors (Nilforooshan & Edriss 2004). However, Makgahlela *et al*. (2008) found a moderate $h^2$ for AFC for South African Holsteins being 0.26±0.02.The present study showed that, over time, AFC was reduce presumably because of management improvement.

## CONCLUSION

The effect of AFC on the LT (longevity) and PL of South African Holstein cows was presented. While LT increased with a later age at first calving, PL decreased especially after 29 months of age. An earlier AFC resulted in a higher LT production. Milk production PLE and LTE increased to 25 months of age after which both traits decreased. Genetic parameters should be estimated for AFC, LT, PL, LT production, PLE and LTE measures to determine relative emphasis of selection. Further analyses using alternative statistical methods, which include pedigree or genotype information, may offer additional parameters for selection in this breeding programme.

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