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PRODUCTIVE LIFETIME AND LIFETIME EFFICIENCY IN HOLSTEIN COWS AS AFFECTED BY FIRST LACTATION MILK YIELD

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SUMMARY

The longevity of dairy cows affects their lifetime performance and lifetime efficiency. In this paper the effect of first lactation milk yield on the lifetime (LT, in days), productive lifetime (PL, in days), total lifetime milk yield, productive lifetime milk yield efficiency (PLE) and lifetime milk yield efficiency (LTE) of South African Holstein cows are presented. Lifetime production records of 523 020 cows, born between 1989 and 2008, calving down at least once, were included in the study. For each cow, the total milk, fat and protein yield, all days in milk and lifetime of cows was determined. The PLE (total lifetime milk yield divided by PL) and LTE (total milk yield divided by LT) for milk yield were estimated for each cow. The LT and PL of Holstein cows increased up to first lactation milk yield of 6000 and 7000 kg, respectively. The milk yield LTE and PLE increased with higher milk yield levels in first lactation.

INTRODUCTION

Milk recording in South Africa has always focused on the lactation milk yield and milk composition of cows (Du Toit 2016). Local breed societies often reward lifetime performance of dairy cows by awarding special status to cows reaching milestone production levels. However, the efficiency of production has not been considered nor rewarded. A considerable re-ranking of cows occurs when lifetime production is divided by lifetime (using lactation number). Already in 1953, Leitch & Godden estimated the whole-life energy efficiency of cows at different milk production levels and different ages as indicated by lactation number. While energy efficiency increased with age, higher producing cows reached higher efficiency levels at an earlier age. Low yielding cows, regardless of a long productive life, were less efficient than higher producing cows even at a shorter productive life. As the repeatability of milk production in dairy cows is high (>0.55), it would be expected that first lactation milk yield give some indication of the future milk yield and, therefore, lifetime performance of cows. While it has been shown that lifetime milk yield and milk yield per day of productive life increases with increasing first lactation milk yield levels (Sawa & Krezel-Czopek 2009), local dairy farmers are reluctant to select for a higher production in first lactation probably because of unfavourable correlations between high milk yield levels and traits such as live weight, fertility and longevity. Little research has been done in South Africa on the lifetime performance and the efficiency of production of dairy cows. Muller & Botha (2003) showed that genetic progress in a dairy herd can be increased by selecting for higher milk yield levels in first lactation. The number of days in milk, number of completed lactations and milk yield level affects lifetime milk yield as well as economic efficiency (Heins *et al*. 2012 and Martens & Bange, 2013). The duration of each lactation is affected by calving interval which is influenced by traits like the number of days from calving to first service, first service conception rate, number of services per conception and number of days from calving to conception or days open (Muller *et al*. 2014). The aim of the study is to determine the effect of first lactation milk yield on the LT, PL, total lifetime milk yield, productive lifetime milk yield efficiency (PLE) and lifetime milk yield efficiency (LTE) of Holstein cows.

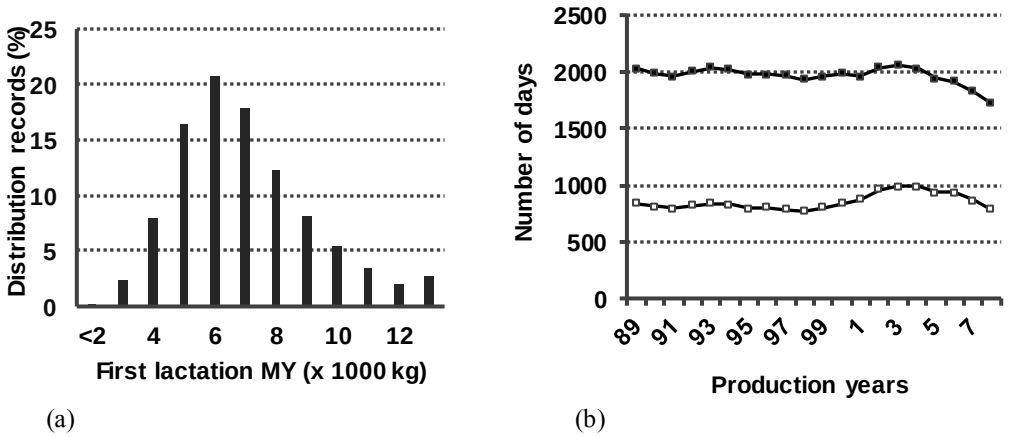
MATERIALS AND METHODS

Data. Milk production records of about 523 020 Holstein cows that had calved down for the first time between 1989 and 2008 were extracted from the South African National Milk Recording Scheme data base of the Agricultural Research Council (ARC). Milk production 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 per cow (De Waal & Heydenrych, 2001). All cows that had completed a first lactation of at least 240 days, were included in the study. The milk, fat and protein yield for all lactation periods were added up until the end of each cow's last lactation period. Productive life (PL) was estimated for each cow adding all the days in milk per lactation. The lifetime (LT) of cows was derived from birth date to the end of the last lactation period which was regarded as the cows' cull date as their actual cull dates were not recorded.

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

RESULTS AND DISCUSSION

About 67% of first lactation milk production records were between 4 001 to 8 000 kg per lactation (Figure 1a). The trends for PL and LT of cows over production years remained constant until 2003 after which both traits followed a downward trend (Figure 1b). The reason for this is unclear although average age at first calving decreased from about 30.3 in 1989 to 26.9 months in 2008. It could also be related to fewer cows in milk recording or a genetic change in longevity.



(a) (b)

Figure 1. The (a) distribution of first lactation milk yield (MY) records in production categories and (b) the effect of production year on the productive lifetime (□) and lifetime (■) in days for South African Holstein cows.

Increasing first lactation milk yield had small linear negative (P<0.05) effects on fat and protein percentages (Table 1). Lifetime milk yield showed a linear increase (P<0.05) with increasing first lactation milk yields. Although LT and PL initially increased reaching peaks at first lactation milky yield intervals of 5001-6000 and 6001-7000 kg per lactation, respectively, traits decreased (P<0.05) after peaking. However, the PL of cows changed little at milk yield levels beyond 7000 kg per lactation being 862 and 806 days for cows producing within production intervals of 8001-9000 and 10001-11000 kg milk, respectively. In contrast to decreasing LT and PL number of days, PLE and LTE increased for cows producing at a higher level in first lactation.

Table 1. The mean (standard deviation) and data ranges for milk production, fat and protein percentages and lifetime parameters for Holstein cows in different first lactation milk yield classes. Least significant differences (LSD) for first lactation milk yield intervals indicate significant differences between first lactation milk yield classes. (PLE = Productive life efficiency; LTE = Lifetime efficiency).

	First lactation milk yield classes (kg)						
Variables	**4001-5000**	**5001-6000**	**6001-7000**	**7001-8000**	**8001-9000**	**Range (min-max)**	**LSD**
First lactation milk yield (kg)	4537 (286)	5503 (287)	6474 (286)	7465 (287)	8466 (285)	1005-17329	62.6
First lactation fat (%)	3.63 (0.38)	3.59 (0.38)	3.57 (0.39)	3.57 (0.40)	3.59 (0.40)	2.10-6.01	0.014
First lactation protein (%)	3.20 (0.21)	3.19 (0.20)	3.18 (0.19)	3.17 (0.19)	3.17 (0.19)	2.10-5.33	0.007
Total lifetime milk yield (kg)	15874 (11052)	19310 (12225)	21795 (12867)	23478 (13257)	25316 (13683)	1006-135538	438.9
Lifetime (days)	2004 (721)	2054 (713)	2041 (689)	1987 (651)	1940 (621)	785-4295	24.1
Productive life (d)	835 (500)	888 (497)	892 (474)	862 (440)	840 (412)	241-3239	16.5
PLE (kg)	18.01 (2.89)	20.96 (2.90)	23.88 (2.97)	26.82 (3.15)	29.83 (3.25)	1.2-150.8	0.22
LTE (kg)	7.02 (2.87)	8.47 (3.12)	9.74 (3.35)	10.90 (3.54)	12.14 (3.74)	0.22-43.9	0.13

Sawa & Krezel-Czopek (2009) also showed that LT milk yield in Polish Holsteins increased with increasing first lactation milk yields, the correlation coefficient being 0.44 (P<0.01). However, lifespan and PL decreased when first lactation milk yield exceeded 7000 kg milk, correlation coefficients being positive, albeit low at 0.23. In the current study, the phenotypic correlation between first lactation milk yield and LT milk showed a curvilinear trend (P<0.05). Similarly PLE and LTE were affected positively (P<0.05) with increasing first lactation milk yield levels possibly indicating that the decreases in PL and LT had a limited effect on efficiency measures. To improve efficiency measures, two possible methods can be used, i.e. improving LF milk yield while maintaining PL and LT or maintain milk yield and increasing PL and LT. Heritability estimates for cow herd life and productive life are generally, below 10% while the heritability of milk yield is moderate at about 0.25.

To improve the efficiency of production two possible methods can be used, i.e. direct selection for production traits or using ratio traits. The main advantage of most ratio traits is their ease of

calculation and interpretation, as well as the ability to easily compare efficiency statistics across populations. However, according to Gunsett (1984) direct selection on ratio traits is complicated by the disproportionate fashion by which selection pressure is exerted on the component traits. This makes expected responses to selection on ratio traits difficult to determine mainly because of the poor statistical properties of ratio traits due to the antagonism between the desirable response in the numerator (i.e., increased milk yield) and the denominator (i.e., increased productive life) and the unknown relative selection pressure on each (Gunsett, 1984).

Heritability estimates for cow herd life and productive life are low. Buenger *et al*. (2001) reported heritability estimates for functional length of productive life to be 0.09 to 0.14. Increasing productive life should therefore focus on an improved environment. Although increased first lactation milk yields improves PLE and LTE, the PL and LT is decreased as shown in the present study. Juszczak *et al*. (1994) showed that the optimum first lactation milk yield regarding efficiency of production varies according to management conditions and herd milk yield levels.

CONCLUSION

This study reported on the effect of first lactation milk yield on the milk yield, PL, FT, PLE and LTE of Holstein cows. Higher first lactation milk yields resulted in an increased lifetime milk yield, productive lifetime yield, as well as PLE and LTE. Cows producing high levels of milk yield in first lactation (>8000 kg) are expected to have shorter PL and LT although the reduction is small. This resulted in increasing PL and LT efficiencies, possibly indicating that first lactation milk yield could be used as a selection tool for increased production efficiencies. To improve production efficiencies PL (days in milk) should be increased by more calving down events rather than extending lactation periods. Further work includes the estimation of genetic parameters for PL, LT and efficiency measures towards estimating breeding values for lifetime production traits. Genomic analyses may be required to identify high and low genetic merit sires for PLE and LTE.

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