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Environmental factors influencing milk urea nitrogen in South African Holstein cattle

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Abstract

By knowing the milk urea nitrogen (MUN) content of dairy cows, the efficiency of dietary nitrogen utilization can be improved. The main objectives of this study were to identify and quantify environmental factors affecting MUN in South African Holstein cows. This will enable better interpretation of MUN results by accounting for such factors. A total of 82 900 test-day records of 9 901 Holstein cows from 40 herds participating in the South African National Milk Recording and Improvement Scheme (NMRIS) during the period 2007 to 2010 were used. An analysis of variance was performed to determine environmental factors significantly affecting MUN. Significant factors were herd-test-day, year of calving, parity, number of times milked per day and lactation stage. Herd-test-day had the largest effect, accounting for 48.3% of the total variation. Trends in least squares (LS) means for MUN over lactation stages were similar for all parities; however, means were slightly lower in parity 3 than the first two parities. The LS mean for 2008 was the lowest (13.9 mg/dL) in comparison to other years. Cows milked twice daily had a higher MUN LS mean (15.5 mg/dL) in comparison to those milked three times per day (13.4 mg/dL). Results of this study provided the basis for proper use and better interpretation of MUN data.

Keywords: Milk urea nitrogen, environmental factors, dairy herd management
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Introduction

The Holstein breed is one of four major South African dairy breeds that undergo routine genetic evaluation by the Agricultural Research Council's (ARC) Animal Production Institute (Mostert, 2007; SA Yearbook, 2009/10). In the 2010 test year, 29 004 registered and 26 571 commercial Holstein cows participated in performance testing in South Africa. This accounted for 41% and 48% of the registered and commercial cows in the national herd, respectively (NMRIS, 2010).

The concentration of urea in milk, commonly known as milk urea nitrogen (MUN), is an important tool in dairy herd management. It can be used to monitor the efficiency of utilization of dietary nitrogen (Jonker *et al.*, 2002a; b), as well as to predict urinary nitrogen excretion (Burgos *et al.*, 2007). Knowing the MUN levels in the herd assists dairy farmers in the nutritional management of their herds, as deviations from target MUN concentrations can be used to identify overfeeding or underfeeding of protein (Jonker *et al.*, 1998; Kohn *et al.*, 2002). The result would be a reduction of environmental nitrogen pollution through dietary manipulation and overall management adjustments (Schepers & Meijer, 1998; Jonker *et al.*, 2002a).

Although MUN has been routinely recorded for dairy cows in herds participating in the national milk recording scheme (NMRIS) since 1994, there has been limited research on the factors affecting MUN. The objective of this study was therefore to identify and quantify non-genetic factors affecting MUN levels in South African Holstein cattle.

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Materials and Methods

Test-day records and pedigree data of Holstein cows participating in the South African NMRIS during the period 2007 to 2010 were used. On test-days, each individual cow's milk was weighed and recorded at each milking. A milk sample was collected from each cow in milk at the evening milking. The MUN content, fat, protein and lactose percentage, and somatic cell count (SCC) were determined using a System 4000 Infrared Analyzer (Foss Electric, Hillerod, Denmark) at the Lacto Lab (Pty) Ltd at the ARC-Irene Institute. The data used in the current study were obtained from the Integrated Registration and Genetic Information System (Intergis). The original data set consisted of 1 167 293 test-day records of 10 133 Holstein cows, with 909 herd-test-days. In Table 1 descriptive statistics for the original data set are presented.

Table 1 Descriptive statistics for test-day records for South African Holstein cows before editing

Trait	Parity 1 (n = 581 150)				Parity 2 (n = 425 229)				Parity 3 (n = 160 914)			
	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max
MUN (mg/dL)	15.3	3.7	4.0	28.0	15.5	3.7	6.0	30.0	15.5	3.7	5.0	27.0
Milk yield (kg/d)	24.7	8.5	1.0	98.0	27.8	10.2	3.0	95.0	28.8	10.5	1.0	97.0
Fat yield (g/d)	910	360	10	6210	1030	430	30	6050	1060	440	50	6050
Protein yield (g/d)	790	270	30	4010	890	310	20	3900	910	320	40	4030

Age restrictions at calving, definition of seasons, yield limits and MUN concentration ranges were in accordance with data editing as performed in the South African Best Linear Unbiased Predictions (BLUP) analyses (Mostert *et al*., 2006). To ensure reasonable calving down ages in specific lactations, restrictions on age at calving were imposed, i.e. between 20 and 42, 30 and 54, and 40 and 66 months for the first, second, and third lactation, respectively (Mostert *et al*., 2006). Seasons of calving were defined as summer (October – March) and winter (April – September). Each lactation period was divided into 10 stages consisting of nine 30-day intervals each and one 35-day interval (Ojango & Pollot, 2001). MUN records exceeding more than 3 standard deviations from the mean were removed from the data set, resulting in records ranging between 8 to 25 mg/dL range for individual cows. Milk yield, fat and protein percentage records exceeding <2 and >90 kg, <2% and >9%, and <2% and >6%, respectively, were regarded as outliers and were removed from the dataset. The final edited data set consisted of 82 900 test-day records of 9 901 cows from 40 herds and 927 herd-test-days. A summary of the number of animals and test-day records that were used for the subsequent data analysis is presented in Table 2. Observations from the three different parities were considered to be separate traits; hence, parities were analysed separately.

Table 2 The number of South African Holstein cows and test-day records per parity used in the analyses

Parity	Number of records				
	Records	HTD[1]	Cows	Sires	Dams
1	26 391	703	4 280	329	3 778
2	21 313	727	3 453	346	3 120
3	14 889	697	2 398	314	2 221

[1]HTD = Number of herd-test-day records.

Descriptive statistics of all traits were computed using the *Proc Means* procedure of the Statistical Analysis System (SAS, 9.2). To determine non-genetic factors affecting MUN, an analysis of variance

(ANOVA) was performed using the general linear model (GLM) procedure of SAS (SAS, 9.2). The following fixed effects model, in matrix notation, was used for the ANOVA:

$$\mathbf{y} = \boldsymbol{\mu} + \mathbf{Xb} + \mathbf{e}$$

where **y** is a vector of observations for MUN; **μ** is a vector of the mean for MUN observations; **b** is a vector of unknown fixed effects. **X** is an incidence matrix relating fixed effects to MUN observations. Fixed effects that were tested were herd-test-day (HTD), herd-year-season (HYS) of calving, year of calving, season of calving, season of test, age at calving, days in milk, number of times a cow was milked per day and two-way interactions among these factors. **e** is a vector of random residual errors.

Results and Discussion

The final data set had an overall mean of 14.2 mg/dL for MUN for cows in parity 1. A similar mean of 14.4 mg/dL was obtained by Hojman *et al.* (2004) in Israeli dairy herds. Higher means of 17.9 and 30.4 mg/dL were observed by Hossein-Zadeh & Ardalan (2010) in Iranian Holstein cows and Abdouli *et al.* (2008) in Tunisian Holsteins. However, Wood *et al.* (2003) obtained a lower value (12.6 mg/dL) for Canadian Holsteins, in comparison to the current study. The overall mean for MUN in the current study was within the standard range (8 - 25 mg/dL) for cows participating in the South African National Dairy Animal Recording and Improvement Scheme. The means and standard deviations for MUN and the three production traits per parity are shown in Table 3 for all cows included in the study after editing.

Table 3 Means and standard deviations for milk urea nitrogen (MUN) and yield traits for South African Holstein cows in parities 1 to 3

Trait	Parity 1 (n = 28 844)		Parity 2 (n = 23 713)		Parity 3 (n = 17 095)	
	Mean	SD	Mean	SD	Mean	SD
MUN (mg/dL)	14.2	3.3	14.4	3.3	14.3	3.2
Milk yield (kg)	26.0	8.3	29.6	10.0	30.5	10.2
Fat yield (g)	970	350	1120	470	1160	420
Protein yield (g)	830	250	950	300	970	300

Mean MUN was lowest in the first parity, followed by an increase in the second parity and then a decrease in parity 3. However, the differences between means of parities 1 to 3 were not significant (P <0.05). Although the means of the current study were generally higher, this trend was similar to those observed by Wood *et al.* (2003) and Mitchel *et al.* (2005).

Factors that had a significant effect (P <0.01) on MUN variation, across parities, were herd-test-day (48.3%), year of calving (1.2%), stage of lactation (1.1%), number of times milked per day (0.04%) and milk (0.02%), fat (0.02%) and protein (0.02%) yields. Stoop *et al.* (2007) found that herd-test-day (HTD) accounted for 58% of the total MUN variation. These results are supported by Wood *et al.* (2003) who reported effects of HTD to be highly significant (P <0.00001).

Least square (LS) means by year of calving were similar for 2007 (14.5 mg/dL), 2009 (14.2 mg/dL), and 2010 (14.5 mg/dL), but lower in 2008 (13.9 mg/dL). The differences in the means over the years could be due to different management practices or nutrition. As the data are limited to four years, it is difficult to tell if there is a trend over many years.

Trends in LS means for lactation stage over parity are shown in Figure 1. Trends in LS means for MUN over lactation stages were similar for all parities, which are in agreement with results of Jílek *et al.* (2006). The LS means for parity 3 were slightly lower compared to those of the first two parities. For all three parities, MUN was lowest in the first lactation stage and increased over the lactation period, reaching a peak in lactation stages 5 to 7. These results concur with those observed in various other studies (Jílek *et al*., 2006; Abdouli *et al*., 2008; Cao *et al*., 2010). In contrast, other studies found no association between MUN and stage of lactation (Godden *et al*., 2001b; Hojman *et al*., 2004; Rajala-Schultz & Saville, 2003).

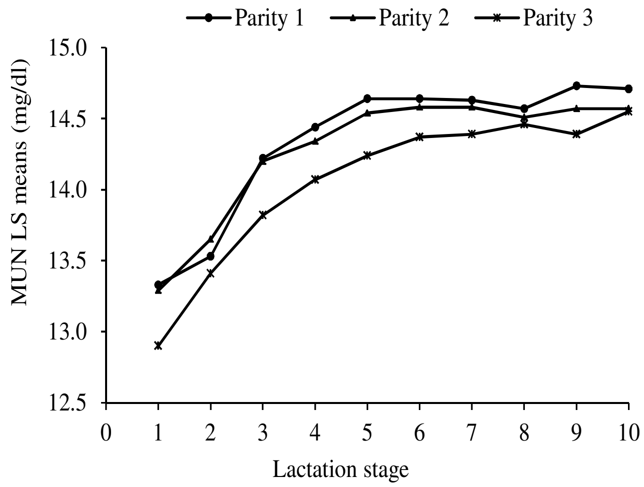

Figure 1 Trends in milk urea nitrogen (MUN) LS means for lactation stages of South African Holstein cows over parities 1 to 3.

Conclusion

Environmental factors having a significant effect on MUN in South African Holstein cows include herd-test-day (HTD), year of calving, stage of lactation, number of times milked per day, and milk, fat and protein yields. The high contribution of HTD indicates that herd management and nutrition are important sources of variation in MUN. These factors should be taken into consideration when interpreting MUN results.

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