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Variations in automatically recorded rumination time as explained by variations in intake of dietary fractions and milk production, and between-cow variation

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ABSTRACT

Individual recording of rumination time (RT) is now possible in commercial dairy herds, through development of a microphone-based sensor, which is able to record RT by the sound of rumination activity. The objectives of this study were to examine the relationship between daily RT and intakes of different dietary fractions, the relationship between RT in minutes per kilogram of dry matter intake (DMI) and milk production, and to examine the variation in RT within and between mid-lactating dairy cows. Data from 3 production trials were used in which a total of 27 different diets were fed. The data contained 761, 290, and 203 daily recordings of RT, milk yield, milk components, DMI, and intake of dietary fractions recorded on 29, 26, and 24 Holstein and Swedish Red cows from trials 1, 2, and 3, respectively. The dietary fractions included forage neutral detergent fiber (NDF), concentrate NDF, crude protein, sugar, starch, and a rest fraction represented by organic matter − (forage NDF + concentrate NDF + crude protein + sugar + starch). The relationship between the dietary fractions and RT was analyzed in 2 steps. In step 1, the dietary fractions, which were significantly related to RT, were selected and simultaneously checked for multicollinearity between the dietary components; in step 2, a multivariate model, including the effect of repeated measurements, the main effect of the selected dietary fractions from step 1, random effects of cow(trial) and trial, and information on breed, days in milk, and parity was used to analyze the relationship between RT and the selected dietary fractions. Relationships between RT in minutes per kilogram of DMI and milk yield and milk components were analyzed, using the same multivariate model as in step 2. Approximately 32% of the variation in daily RT could be explained by variations in intakes of the dietary fractions, whereas 48% of the total variation in RT was accounted for by individual variations between cows. Intakes of forage NDF and starch were positively related to daily RT, whereas intakes of sugar and the rest fraction were negatively related to daily RT. Rumination time in minutes per kilogram of DMI was negatively related to milk yield and protein percentage, but positively related to milk fat percentage.
Key words: dietary fraction, milk yield, rumination time

INTRODUCTION

Rumination activity is often recorded in intensive nutrition experiments studying the relationship between the intake of NDF from various feed types and rumen function expressed by rumination activity (Krause et al., 2002; Yang and Beauchemin, 2007). Mertens (1997) found that rumination activity is stimulated by the intake of physically effective fiber (**peNDF**) defined by a particle size greater than 1.18 mm. Yang et al. (2001) found a correlation of 0.35 between total NDF intake and rumination time (**RT**). Furthermore, Yang and Beauchemin (2007) and Yang and Beauchemin (2009) found a correlation between the intake of forage NDF and RT of 0.41 and 0.44, respectively. The latter of the 2 studies also found a correlation between forage peNDF and RT of 0.51. In the Nordic feed evaluation system, the rumination index value (min RT per kg of DM) for a feed is predicted from the NDF content, particle size, and indigestible NDF/NDF ratio. Furthermore, concentrates with a particle size exceeding 2 mm are considered to stimulate RT (Nørgaard et al., 2011). Nørgaard et al. (2010) found that the mean rumination time was 109 and 88 min per kg of forage NDF intake for grass silage and alfalfa hay, respectively, when data were adjusted to a standard cow with a BW of 625 kg,

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DMI of 20 kg per d, and a forage NDF intake of 0.7% of BW. Although the intake of peNDF is considered to stimulate RT, high intakes of easily fermentable carbohydrates may indirectly result in decreased RT through a higher concentrate intake, because usually a lower content of peNDF is present in concentrate compared with forage. However, other factors such as breed, size (Bae et al., 1983), and parity (Beauchemin and Rode, 1994) have also been shown to affect rumination activity. In addition, high energy density and low peNDF content have been related to a high milk yield, low milk fat yield, and low RT (Teimouri Yansari et al., 2004; Adin et al., 2009). Recently, a rumination monitoring system (**RMS**; RuminAct–Milkline, Gariga di Podenzano, Italy), recording RT by the sound pattern of regurgitation and rhythmic jaw movements during rumination activity, has enabled RT of individual cows in commercial dairy herds to be recorded. The RMS is found to record rumination activity with reasonable accuracy (Schirmann et al., 2009; Byskov et al., 2014). Recent research, which has recorded RT by the RMS on 32 transition Holstein cows, has shown that some of the variation in RT between cows was associated with health status (Soriani et al., 2012). In relation to this, the collection of large amounts of data on RT, enabled by the RMS, provides an opportunity to study variations within and between healthy cows while accounting for variations in dietary intake, which to the authors' knowledge has not yet been performed using a large amount of data. Furthermore, this type of data makes it possible to analyze how the variation in intake of different dietary fractions and milk production can be related to daily recorded RT values on an individual cow basis. Therefore, the objective was to study the relationship between daily RT recorded by RMS and intakes of different dietary fractions and milk production in Swedish Red and Holstein cows. In addition, the objective was to determine variations in RT within and between cows, while accounting for variations in intake of the dietary fractions.

MATERIALS AND METHODS

Trials, Diets, and Experimental Design

Data from 3 experimental trials with lactating dairy cows were used in this study. The experimental design of trial 1 was a 3-factor Box-Behnken design with 3 levels of crushed linseed supplementation, 3 levels of forage, and 3 levels of a grass/corn silage mix. Thirteen different diets were fed, where the crushed linseed supplementations were 1, 3, and 5% of DM; the forage proportions were 35, 50, and 65% of DM; and the grass/corn silage proportions were 20, 50, and 80% of DM. Diet 13 (3% crushed linseed, 50% forage proportion, and 50% grass/corn silage proportion of DM) was considered the center point treatment in the Box-Behnken design. The trial was conducted over 4 periods of 21 d, feeding 4 different diets to 4 groups of cows in each period, with the center point treatment (diet 13) fed in each period. Cows were blocked into the 4 groups according to breed, parity, and milk yield. For further details, see Sterk et al. (2011).

The experimental design of trial 2 was also a 3-factor Box-Behnken with 3 concentrations of soluble carbohydrates without sugar, 3 concentrations of starch, and 3 concentrations of sugar. As in the previous trial, 13 different diets were fed, varying the soluble carbohydrates without sugar concentration between 100, 140, and 170 g/kg of DM; the concentration of starch between 110, 150, and 200 g/kg of DM; and the concentration of sugar between 17 and 52 g/kg of DM. The trial was conducted according to the same principles as for trial 1, with 4 groups of cows fed 4 different diets in 21-d periods. Yet again, diet 13 was considered the center point treatment.

The experimental design of trial 3 was a duplicated 3 × 3 Latin square design with 3 periods and 3 treatments with 12 cows per treatment per period. Each cow received each treatment for a period of 20 d. The treatments included 2 types of silage additives (Kofasil Life containing *Lactobacillus plantarum* DSM 3676, 3677, 400,000 cfu/g and Kofasil Ultra K containing 16.5% sodium nitrite, 11.0% hexamethylene tetramine, 8.1% potassium sorbate, 2.2% sodium benzoate, 0.8% sodium propionate at 2 L/t; ADDCON Europe GmbH, Bonn, Germany) and untreated control grass silage. The silage, which consisted of 77% grass, 18% clover, and 5% alfalfa, was harvested from the same field on June 3, 2010. The silage treatment was mixed with a concentrate before being fed to the cows. For all 3 trials, all recorded data during adaptation and experimentation periods for DMI, RT, milk yield, and milk components were included. The silages fed in all 3 trials were chopped to approximately the same theoretical length of cut.

Housing, Recordings, and Cows

All 3 trials were approved and conducted under the Swedish Law on Animal Experimentation. The trials were conducted in an experimental production herd (Nötcenter Viken, Lantmännen, Sweden). The cows were housed in a free stall barn with slatted floors and cubicles with rubber mats bedded with sawdust. Milk yield, feed intake, and RT were recorded daily for individual cows during the experimental periods. Cows had ad libitum access to feed via automatic feed