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Risk factors for subclinical and clinical ketosis and association with production parameters in dairy cows in the Netherlands

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ABSTRACT

Ketosis is associated with many transition cow diseases and the subclinical form has been found to be a common condition in high-producing dairy cows. The objectives of this field study in the Netherlands were (1) to determine risk factors for subclinical ketosis [SCK; 1.2–2.9 mmol of β-hydroxybutyrate (BHBA)/L of serum] and clinical ketosis (CK: ≥3.0 mmol of BHBA/L of serum) at 7 to 14 d in milk and (2) to assess the association of SCK and CK with production parameters at the first dairy herd improvement (DHI) testing. Twenty-three dairies were enrolled by a local veterinary practice from 2009 to 2010, and 1,715 cows were screened for ketosis by measuring serum BHBA concentrations at 7 to 14 d in milk. Overall, 47.2% of cows had SCK and 11.6% had CK. Mixed generalized logit models with a random effect of herd were used to evaluate cow level factors associated with SCK and CK. The associations of SCK and CK with milk production parameters were tested using mixed linear models with a random effect of herd. Cows at a moderate (3.25–3.75) or fat (≥4) body condition score before calving were more likely to develop SCK and CK than thin (body condition score ≤ 3.0) cows. The risk for developing SCK was higher in parity 2 and older cows compared with heifers, whereas for CK only, parity ≥3 cows had a higher risk. The quarter of the year in which a cow calved was associated with the risk for SCK and CK. For SCK quarter 1 (January–March) and quarter 2 (April–June), and for CK quarter 1, quarter 2, and quarter 3 (July–September) all increased the risk of development of the condition compared with quarter 4 (October–December). An increased yield of colostrum at first milking was associated with increasing risk for SCK and CK. Prolonged previous lactation length and dry period length were both associated with increased odds for SCK and CK. Subclinical ketosis and CK were associated with a higher milk yield, a higher milk fat percentage, and a lower milk protein percentage at first DHI test day. Overall the study reinforces previous findings that the major risk factors for both SCK and CK are increasing parity, overconditioning of animals prepartum, season of calving, and dry period length. In addition, previous lactation length and liters of colostrum have been identified as additional risk factors for the development of ketosis.

Key words: dairy cow, ketosis, risk factor

INTRODUCTION

Ketosis, either present at a subclinical or clinical level, is a common metabolic condition in the modern high-producing dairy cow and has been associated with many fresh cow diseases. The transition period, defined as 3 wk before until 3 wk after calving (Grummer, 1995), is a critical period for a dairy cow. During the transition period, the cow needs to adjust her metabolism to partition nutrients and energy to support milk synthesis, a process referred to as homeorrhesis (Bauman and Currie, 1980). The imbalance between energy requirements for milk production and energy intake through feed causes a negative energy balance, which results in metabolic conditions such as hyperketonemia (Herdt, 2000). Around 30 to 50% of dairy cows develop metabolic or infectious diseases around the moment of calving (LeBlanc, 2010) and relationships between hyperketonemia or ketosis and fresh cow diseases have been described (Berge and Vertenten, 2014). Cows with subclinical ketosis, defined as blood BHBA concentrations above 1 to 1.4 mmol/L, are at an increased risk of developing a displaced abomasum, metritis, clinical ketosis, and lameness (LeBlanc et al., 2005; Duffield et al., 2009; Seifi et al., 2011; Suthar et al., 2013; Berge and Vertenten, 2014). In addition, ketosis reduces milk yield and reproductive performance and increases the risk for premature culling in affected cows (Koller et al., 2003; Walsh et al., 2007; Duffield et al., 2009; Ospina et al., 2010; Seifi et al., 2011; McArt et al., 2012).

Several factors have been identified as risk factors for the development of ketosis. Among these are a high

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BCS and lower transition period DMI (Gillund et al., 2001; Hayirli et al., 2002; Goldhawk et al., 2009). Increased parity, dry period length, and transition cow feed management have also been associated with an increased ketosis risk (Gustafsson et al., 1995; Duffield et al., 1997; Vickers et al., 2013; Berge and Vertenten, 2014). The ability to predict the risk of ketosis in cows is important to target the most appropriate preventive measures. The objectives of this study were to determine risk factors for fresh cow ketosis at 7 to 14 DIM and to assess the effects of ketosis on milk production parameters at first DHI test day.

MATERIALS AND METHODS

Twenty-three dairy farms that belonged to the client base of De Graafschap Veterinarians were selected based on willingness of the farmer to participate. All farms were situated within a radius of 20 km around the practice (Vorden) in the east of the Netherlands. Upon enrollment in August 2009, farms were visited by one of the veterinarians and general farm data (herd size, breed, production level, average age of herd), dry cow, and transition cow management practices were recorded in a template document. In all participating dairy farms cows were housed in free-stall barns, with either zero-grazing or pasture access during the grazing season. Upon weekly visits, cows and heifers with a known expected calving date were identified and individual animal information (cow ID, parity, last calving date, date of dry off, expected calving date) was recorded. Cows were scored for BCS on a 5-point scale with 0.25-unit increments (Edmondson et al., 1989) by 1 of 2 veterinarians between 3 and 1 wk before the expected calving date. Farmers were instructed to register on a template document the actual date of calving, any incident of dystocia, calving ease (no assistance or assistance required), twins, stillbirth (birth of a dead at term calf or death within 1 h postcalving), retained placenta, milk fever, as well as any treatments administered around calving. Retained placenta was defined as failure of placental expulsion within 12 h after calving (Laven and Peters, 1996), and diagnosis of milk fever was based on clinical signs (muscular weakness, cold extremities, recumbency, response to intravenous calcium administration, or a combination of these) as described by Berge and Vertenten (2014). Upon first milking, the quantity of colostrum was measured and recorded by pouring the obtained volume of total first milking in a graded 10-L bucket. In the second week after calving (7–14 DIM), a blood sample for BHBA measurement was collected by one of the veterinarians from the coccygeal vein in blood serum collection tubes (BD Vacutainer Serum Tube, BD, Breda, the Netherlands) and allowed to clot. Blood samples were transported to the veterinary practice and serum was collected by centrifugation. Serum samples were stored at −196°C in a cryostat until analysis. Serum BHBA concentration (mmol/L) was measured using a handheld meter (Precision Xceed, Abbott Laboratories, Abbott Park, IL) at room temperature (Iwersen et al., 2009; McArt et al., 2013). Per farm, milk production data of the first test-day for each cow were collected through an online database of the DHI company (https://www.pir-dap.nl/, CRV, Arnhem, the Netherlands).

Date of calving was categorized into yearly quarters (**Q**): January–March (**Q1**), April–June (**Q2**), July–September (**Q3**), and October–December (**Q4**). The quarters of the year were evaluated against temperature and humidity data obtained from the Royal Dutch Meteorological Institute for the region. The meteorological data indicated that division of the year in quarters was in line with observed regional changes in temperature and humidity.

Statistical Analysis

The data were entered into a spreadsheet (Microsoft Excel 2007, Microsoft Corp., Redmond, WA) and statistically analyzed using SAS 9.4 statistical software. Nonparametric testing and stratified analysis were initially performed, and the variability in predictive factors for inclusion into the statistical models was evaluated. The distributions for the continuous variables were assessed using univariate statistics and plots. Categorical variables of continuous variables were created where appropriate, and as previously described (LeBlanc et al., 2005; McArt et al., 2013). A serum BHBA concentration threshold of <1.2 mmol/L was defined as no ketosis (**NK**), thresholds of ≥1.2 and <3.0 mmol/L were defined as subclinical ketosis (**SCK**), and clinical ketosis (**CK**) was defined as BHBA concentrations ≥3.0 mmol/L (Oetzel, 2004; McArt et al., 2013). Cows were categorized according to parity (1, 2, and ≥3) and BCS (thin ≤ 3; moderate 3.25–3.75; fat ≥ 4; Chapinal et al., 2011). Cows eligible for inclusion in the final data set must have had a calving date, parity, and a BCS recorded. For all analyses, statistical significance was set at $P \leq 0.05$.

Generalized logit mixed models were used with the dependent variable being ketosis category: NK, SCK, and CK. The multivariate multinomial logistic regression compared the odds of a cow having SCK or CK compared with NK for various risk factors. The models included a random effect of herd to control for clustering of cows within farm. The first model included both heifers and all higher parity cows. The second model contained parity 2 and higher parity cows to