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Influence of breed, milk yield, and temperature-humidity index on dairy cow lying time, neck activity, reticulorumen temperature, and rumination behavior

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ABSTRACT

The objective of this study was to compare weekly mean lying time (LT), neck activity (NA), reticulorumen temperature (RT), and rumination time (RU) among 3 breed groups, milk yield (MY), and temperature-humidity index (THI). Cows (n = 36; 12 Holstein, 12 crossbred, and 12 Jersey) were blocked by parity group (primiparous or multiparous), days in milk, and MY. Lying time, NA, RT, RU, and MY were recorded and averaged by day and then by week for each cow. For study inclusion, each cow was required to have 10 wk of LT, NA, RT, and RU data. Maximum THI were recorded and averaged daily. Mean (±SE) days in milk, LT, MY, RT, RU, NA, and maximum THI were 159.0 ± 6.0 d, 11.1 ± 0.1 h/d, 28.7 ± 0.5 kg/d, 38.8 ± 0.0°C, 6.4 ± 0.1 h/d, 323.8 ± 3.8 activity units, and 56.5 ± 0.6, respectively. The MIXED Procedure of SAS (SAS Institute Inc., Cary, NC) was used to evaluate fixed effects of breed, MY, parity, THI, and their interactions on LT, NA, RT, and RU with cow nested within breed as subject. All main effects remained in each model regardless of significance level. Stepwise backward elimination was used to remove nonsignificant interactions. The interactions of breed × parity group and maximum THI × parity group were associated with RT. Increasing THI coincided with increasing RT. Least squares means LT for multiparous cows was significantly greater than LT for primiparous cows (11.4 ± 0.3 and 10.5 ± 0.5 h/d, respectively). Least squares means NA for primiparous cows was greater than for multiparous cows of all breeds (372.1 ± 10.9 and 303.4 ± 7.8, respectively). The CORR Procedure of SAS was used to evaluate relationships among RT, RU, LT, NA, and MY. Rumination time was positively correlated with MY (r = 0.30) and negatively correlated with LT (r = −0.14). Reticulorumen temperature was negatively correlated with MY (r = −0.11). Rumination time was positively correlated with NA (r = 0.18) and negatively correlated with LT (r = −0.14). Lying time and NA were negatively correlated (r = −0.43). Neck activity was positively correlated with MY (r = 0.14). Lying time was negatively correlated with MY (r = −0.25). Milk yield was associated with RU, which may be related to cows with greater MY also having a greater feed intake. Lying time increased and NA decreased with increasing parity, which may be effects of social hierarchy, where primiparous cows are more susceptible to being pushed away from the feed bunk and freestalls. Milk yield was positively associated with RU. Greater milk production requires greater feed intake, which may result in longer RU than for low-yielding cows. Lying time decreased as milk yield increased. The behavioral and physiological differences observed in this study provide new insight into the effects that breed, parity, MY, and THI have on cows.
Key words: breed, precision dairy farming

INTRODUCTION

Precision dairy farming (**PDF**), or the use of technologies to monitor behavioral, physiological, or production indicators for individual animal disease, estrus, or welfare, is becoming more widely adopted (Svennersten-Sjaunja and Pettersson, 2008; de Koning, 2010) to partly reduce physical labor and labor costs (Rutten et al., 2013). Currently, lying time, rumination time, activity, temperature, and milk yield are a few examples of indicators that can be monitored with PDF technologies.

Many PDF evaluation studies use Holstein cows because they are the predominant dairy breed. However, cows of different breeds may vary in physiological, behavioral, and production responses to various stimuli, which may cause PDF technologies to work differently on cows of different breeds. Cows of different breeds differ in milk yield, milk composition, live weight, body composition (Oldenbroek, 1984), and DMI (Palladino et al., 2010). Crossbreeding may improve dairy cattle health and efficiency through heterosis or the introduc-

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tion of favorable genes from other breeds and removal of inbreeding depression (VanRaden and Sanders, 2003). Crossbreeding can potentially improve calving ease, fertility, health, and survival, which may compensate for the production loss compared with Holsteins (Heins and Hansen 2012).

Although crossbreeding may not be widely adopted in the United States, 20 and 5% of cows in New Zealand and Australia, respectively, are Jersey and Holstein crosses (VanRaden and Sanders, 2003). Jersey × Holstein crossbred cows are desired in New Zealand and some other countries, particularly where pasture grazing is common, because of their smaller body size, higher milk fat and protein composition, great ability to calve seasonally, and superior pasture foraging ability (Heins et al., 2011). Weigel and Barlass (2003) explained that crossbreeding has sparked the interest of US producers for 3 reasons: (1) milk pricing changes in some US regions have created rewards for herds with higher fat and protein percentages, (2) concerns exist about female fertility, calving case, health, and survival in Holsteins, and (3) crossbreeding may reduce the consequences of inbreeding depression.

To our knowledge, this is the first study to evaluate differences with PDF technology data among different dairy cattle breeds. The objective of our study was to compare lying time, neck activity, reticulorumen temperature, and rumination behavior among breed groups, milk yield, and temperature-humidity index.

MATERIALS AND METHODS

This study was conducted at the University of Kentucky Coldstream Dairy from October 8, 2011, to May 15, 2013, under Institutional Animal Care and Use Committee protocol #2010–0776. Thirty-six lactating cows (12 Holstein, 12 Jersey, 12 crossbred) were matched by parity group (primiparous or multiparous), DIM, and milk yield. General cow demographic information was obtained from PCDart (Dairy Records Management Systems, Raleigh, NC) records. Crossbred cows consisted of Jersey × Holstein crossbreds (50% Holstein, 50% Jersey, n = 4), Swedish Red × Jersey × Holstein crossbreds (50% Swedish Red, 25% Jersey, 25% Holstein, n = 7), and a Brown Swiss × Jersey × Holstein crossbred (50% Brown Swiss, 25% Jersey, 25% Holstein, n = 1).

The lactating herd was divided into 2 groups balanced by parity, cow volume (length × width × height), stall base type (waterbed or mattress), and DIM for a separate research study. Both groups were housed in freestalls, either sawdust-covered Dual Chamber Cow Waterbeds (Advanced Comfort Technology Inc., Sun Prairie, WI) or sawdust-covered, rubber-filled PastureMat (Promat, Ontario, Canada) mattresses. Cows shared a feed bunk, accessible from both pens. The lactating herd was fed a TMR of corn silage, alfalfa hay, alfalfa silage, whole cottonseed, and grain mix daily at 0530 and 1330 h. Cows were allowed access to an exercise lot for about 1 h/d at 1000 h, weather permitting. Each group was milked 2×/d, at 0430 and 1530 h, in 1 of 2 double-2 bypass parlors located in the same building.

The Milpro P4C (Milkline, Gariga di Podenzano, Italy) system provided daily milk weights per cow (milk yield; **MY**). The DVM Systems LLC (Boulder, CO) bolus system monitored reticulorumen temperature (**RT**) using a passive radiofrequency identification transponder (Phase IV Engineering Inc., Boulder, CO) equipped with a temperature sensor queried twice daily by a panel reader placed in parlor entrances.

An HR Tag (SCR Engineers Ltd., Netanya, Israel) measured neck activity (**NA**) with a 3-axis accelerometer and rumination time (**RU**) with a microphone and microprocessor, summarized into 2-h time blocks. In an HR tag validation study, rumination recordings were highly correlated with live observations ($r = 0.93$, $R^2 = 0.87$; Schirmann et al., 2009).

An IceQube (IceRobotics Ltd., Edinburgh, Scotland) device measured lying time (**LT**) with a 3-axis accelerometer, summarized into 15-min time blocks. IceTag (IceRobotics) lying and activity monitors were validated and correlations were 0.99 compared with visual observations for lying time (Munksgaard et al., 2006). The monitors used in our study were manufactured by the same company.

All DVM boluses, HR Tags, and IceQubes were assigned to individual cows ≥21 before study enrollment. The DVM bolus was inserted orally using a bolus gun. Each bolus resided in the reticulorumen for the lifetime of the animal. Cows were fitted with an HR tag, snugly hung around their necks with the microphone and microprocessor positioned on the left side. IceQubes were strapped to each cow's left rear leg just above the fetlock.

Hourly temperature and relative humidity were obtained from Kentucky Climate Data, calculated through the University of Kentucky College of Agriculture via a Campbell Scientific Inc. (Logan, UT) 23× data logger, located 5.63 km from the farm. Temperature-humidity index (**THI**) was computed using the following formula (NOAA, 1976): THI = temperature (°F) − [0.55 − (0.55 × relative humidity/100)] × [temperature (°F) − 58.8]. The maximum THI for each day was then averaged to obtain the average maximum THI for each week.

Redden et al. (1993) explained that vaginal temperature increased by 0.6 ± 0.3°C at estrus and remained elevated for 6.8 ± 4.6 h. Restlessness and increased