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Effects of stocking density on behavior, productivity, and comfort indices of lactating dairy cows

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ABSTRACT

The objective of this study was to investigate the effects of different stocking densities of 82 (0.82 cows per freestall and feed bin), 100, and 129% on behavior, productivity, and comfort indices of lactating Holstein dairy cows. Twenty-seven lactating cows (15 primiparous and 12 multiparous) were assigned to 1 of the 3 treatments, which were balanced for parity, milk yield, days in milk, and body weight in a 3 × 3 Latin square design with 14-d periods. After 7 d of adaptation to the treatments, lying time and bouts were recorded at 1-min intervals for 3 d, DMI and feeding time were monitored electronically by feed bins, and rumination time was quantified at 2-h periods for 5 d during each period. The cow comfort index, stall standing index, stall perching index, and stall use index (SUI) were calculated using 10-min scan samples of video recording from d 8 to 10 of each period. Milk yield was recorded from d 8 to 12 and milk composition was determined from composite samples on d 12 in each period. Daily lying time, lying bouts, and bout duration did not differ among the stocking densities. The ratio of lying time ≥12 h/d (the number of cows with daily lying time ≥12 h/d divided by number of cows per pen) was higher for cows housed at 82% stocking density compared with those housed at 100% stocking density, with stocking density of 129% intermediate. Hourly lying time was lower at 100% stocking density compared with 82 and 129% stocking densities during the peak period (2300–0400 h), determined based on diurnal pattern of lying time. Daily dry matter intake, feeding time, and feeding rate were not affected by stocking density. After morning milking, dry matter intake and feeding time was reduced at 129 versus 82% stocking density during peak feeding time (0600–0800 h), determined based on diurnal patterns of feeding behavior. Stocking density had no effect on rumination time, milk yield and milk composition. The ratio of SUI ≥85% (mean of the number of SUI ≥85% divided by the number of SUI at 10-min scan samples during a 24-h period) was lower at 129 versus 82% stocking density, with stocking density of 100% intermediate. During peak lying time after evening milking (2300–0400 h), both cow comfort index and SUI were higher at 129 than at 100% stocking density. The SUI was lower 2 h after morning milking (0800–0900 h) for cows housed at 129% compared with those housed at 82 and 100% stocking densities. In conclusion, when compared with 100% stocking density, understocking contributed to natural behaviors of cows that including lying, feeding, and rumination behavior, whereas overstocking did not cause negative effect on behavior, productivity, and comfort indices of cows in this study.

Key words: dairy cow, stocking density, behavior, productivity, cow comfort

INTRODUCTION

Dairy cow welfare has become a hot topic in recent years, especially considering the rise of large-scale dairy farms. The most important concerns regarding dairy cow welfare include whether the dairy cow is feeling well, functioning well, and performing natural behavior (von Keyserlingk et al., 2009). Behavior and welfare of dairy cows is affected by the physical environment they are housed in (stall design, flooring type, feed bunk design, environmental quality, and so on) and by grouping strategy and stocking density (Krawczel and Grant, 2009). A practice employed by dairy farmers is to increase the herd size without extending housing facilities, which has resulted great farm to farm variation in stocking densities for stalls (number of cows per number of stalls × 100) and feed bunks (61cm/number of feed bunk spaces × 100) ranging between 71 to 197% and 58% to 228%, respectively, on North American dairy farms (von Keyserlingk et al., 2012), and stall stocking density ranging from 59 to 161% on commercial freestall farms in China (Chapinal et al., 2014).

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The effect of stocking density on stall comfort, welfare, and natural behavior of cows can be evaluated by determining their resting, feeding, and rumination patterns (Krawczel and Grant, 2009) and using practical indices including cow comfort index (**CCI**; number of cows lying in stalls per number of cows in contact with stalls; Nelson, 1996), stall standing index (**SSI**; number of cows standing in stalls per number of cows in contact with stalls; Cook et al., 2005), stall perching index (number of cows standing with 2 front feet in the stall and the rear feet in the alley per number of cows in contact with stalls; Tucker et al., 2005), and stall use index (**SUI**; number of cows lying in stalls per number of cows not actively feeding; Overton et al., 2002). Krawczel et al. (2008) found that SUI reduced as stocking density increased from 100 to 142% with no change in CCI or SSI during 24-h periods. Recent studies indicate that overstocking of stalls and headlocks to about 115% did not affect daily lying and rumination time (Hill et al., 2009; Krawczel et al., 2012a), whereas increasing stocking density above ~130% frequently resulted in reduced daily lying time (Fregonesi et al., 2007; Krawczel et al., 2012a), decreased eating time (Proudfoot et al., 2009; Krawczel et al., 2012b), and decreased the ratio of time spend ruminating within a stall (Krawczel et al., 2012a).

Previous findings indicated a positive correlation between milk production and lying time (Grant, 2007) as well as milk production and availability of lying stalls (Bach et al., 2008). Precursors for milk synthesis are provided by blood flowing to the mammary gland (Delamaire and Guinard-Flament, 2006), which is enhanced during lying (Rulquin and Caudal, 1992). Therefore, stocking density may affect milk production of dairy cows, as it has an effect on lying behavior of dairy cows (Krawczel et al., 2012a).

To our knowledge the effects of stocking densities representative of on-farm situations on diurnal patterns of behavior and cow comfort indices have not been studied before. Therefore, the aim of the current study was to investigate effects of different stocking densities [82, 100, and 129% (i.e., 0.82, 1.00, and 1.29 cows per stall and feed bin, respectively)] on daily and diurnal patterns of behavior, productivity, and comfort indices in lactating dairy cows.

MATERIALS AND METHODS

Animals, Treatments, and Management

Twenty-seven Holstein cows, including 15 primiparous and 12 multiparous, were selected and assigned to 1 of 3 pens balanced for parity (1.80 ± 0.06; mean ± SD), milk yield (35.03 ± 5.19 kg/d), DIM (192.07 ± 23.15 d), and BW (493.47 ± 50.31 kg) at the beginning of the study. Three treatment stocking densities of 82 (11 stalls and feed bins for 9 cows), 100 (9 stalls and feed bins for 9 cows), and 129% (7 stalls and feed bins for 9 cows) were applied to the 3 pens, with cows in a balanced 3 × 3 Latin square design with 14-d periods that included 7 d of treatment acclimatization and 7 d of data collection. Each pen (20 m long, 12.75 m wide) contained 16 head-to-head waterbeds (2.40 m long, 1.20 m wide; Advanced Comfort Technology Inc., Sun Prairie, WI) covered with 2.5 to 4.0 cm of rice husk, 16 electronic feed bins (1.00 wide, 0.75 m high, 0.84 m depth; Roughage Intake Control system, Insentec B.V, Marknesse, the Netherlands; validated by Chapinal et al., 2007), and one box-type water bin. Feed alleys and back alleys were 4.25 and 3.70 m wide, respectively, and scraped with an automatic scraper system (GEA Farm Technologies, Düsseldorf, Germany). The TMR fed to all cows was formulated according to recommendations in NRC (2001; Table 1) and was refilled twice daily at 0730 and 1430 h for ad libitum intake. Feed samples that were collected on d 8, 11, and 14 of each experimental period for particle size distribution determination using a Penn State Particle Separator (Nasco, Fort Atkinson, WI); fresh feed samples were collected from d 8 to d 12 of each experimental period for DM and chemical composition analysis by State Key Laboratory of Animal Nutrition of China Agricultural University. Cows were milked 3 times daily at 0600, 1300, and 2000 h in a double-48 parallel parlor.

Data Collection

Environmental Conditions. The data of daily temperature and relative humidity were recorded at 5-min intervals during the whole experimental period using a temperature data logger (HOBO Pendant G, Onset Computer Corp., Bourne, MA).

Lying Behavior. Data loggers (HOBO Pendant G, Onset Computer Corp.; validated by Ledgerwood et al., 2010) were attached to right hind leg along the metatarsus bone of all cows to record lying time and bouts at 1-min intervals from d 8 to 10 of each experimental period. To avoid any interference with lying behavior of cows, data loggers were attached on the night before starting data collection. Lying time was summarized in 1-h periods to draw the diurnal pattern of lying that was based on to determine peak periods of lying behavior. The recommended lying time for dairy cows by Dairy Farmers of Canada (2009) is 12 to 13 h/d (Fregonesi and Leaver, 2002; Fregonesi et al., 2007; Tucker et al., 2009). Therefore, the ratio of lying time