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Original Article

Effects of two neck rail positions on heifer behavior and stall cleanliness in free stall barn

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ABSTRACT

Stall usage and cleanliness are affected by stall design, which includes the neck rail positions for dairy heifers. A comparison was undertaken for two neck rail positions to determine the preferences for tropical dairy heifers in a free stall barn. Twenty-four crossbred Holstein pregnant heifers were divided into two groups, one using the current position and the second using the new position. The current position of the neck rail was placed at 160 cm from the curb at 124 cm height, whereas the new position was placed at 150 cm from the curb at 122 cm height. The comparison test was followed by a free choice test to assess preferences for one of the two positions. Dairy heifer activity in the stall was video recorded for 7 d consecutively for each period during the comparison test, and for 3 d for the preference test. Stall cleanliness was assessed once daily. The results demonstrated that dairy heifer behavior did not differ significantly between the two positions ($p > 0.05$). Dairy heifers did not show any clear preferences for either of the two neck rail positions. However, the rear area of stalls with the new neck rail position was cleaner than in those with the current neck rail position ($p < 0.01$). Therefore, the new position of the neck rail seemed suitable for tropical dairy heifers in terms of stall cleanliness.

Introduction

Stall design is considered one of the contributing factors to dairy behavior, health, stall usage, stall maintenance, dairy cleanliness and dairy performance (Tucker et al., 2005; Fregonesi et al., 2009; Ruud et al., 2011). Every feature of stall design has its own function (Abade et al., 2015). At least three factors influence the stall design and comfort, namely the stall dimensions, the partition and the surface of stall (Drissler et al., 2005). Neither the stall dimension nor stall partition should interfere with the dairy herd's normal movement.

The neck rail, as one of the stall's partitions, affects the suitability of a free stall (Nordlund and Cook, 2003). The proper neck rail position is characterized by dairy cows standing straight with four legs in the stall, supported with the neck rail under their neck, whereas standing with two forelegs in the stall (perching) and neck lesions are the main signs of an improper neck rail position (Anderson, 2007). It was observed in that study that the stalls with the less restrictive neck rail position tended to be more soiled than the restrictive one. Furthermore, additional time might be required to maintain the less restrictive stall and the dairy could be more susceptible to dirtier udders (Fregonesi et al., 2009). Dirtier udders increase the risk of mastitis (Breen et al., 2009; de Pinho Manzi et al., 2011).

Various studies have examined the effect of the neck rail position and reported various recommendations regarding dairy size; these ranged from 144 cm to 172 cm from the curb (Cook and Nordlund, 2004; McFarland, 2008). Anderson (2002) reported the recommendation of a vertical position at 122–127 cm above the stall surface, but gave no specific recommendation of the horizontal positions due to large variations. Bewley (2008) reported that the neck rail position in the range 117.6–127.4 cm in height and 166.6–171.5 cm distance from the curb were recommended for large-frame dairy cattle.

As the neck rail position is commonly determined by the physical size of individual dairy cows, the existing recommendation may not always be suitable for dairies in tropical regions such as Thailand. As reported by Koonawootrittriron and Elzo (2010) and Chantalakhana and Skunmun (2015), the dairy breed in Thailand is mostly the crossbred Holstein type, which differs from the purebred Holsteins in most reports. The crossbred Holstein developed in

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Thailand has 450–500 kg body weight on average (Tumwasorn, 2014), and the heifer at age 18 mth has 243.4 ± 51.8 kg body weight on average (Borisutsawat et al., 2016). To date, no sufficient data of a suitable neck rail position for tropical dairy cows have been reported. Therefore, the objective of this study was to evaluate the effect of two neck rail positions on tropical dairy cows and to ascertain the behavior and stall cleanliness of free stall barns in Thailand.

Materials and methods

Stall and dairy heifer preparation

This on-farm research was conducted using a large commercial dairy herd located in Wangmai Wangsomboon, Sa Kaeo, Thailand from September to November 2014. A barn was separated into two equal test pens. Each pen was equipped with one water trough, one fan, one automatic dairy brush, 15 self-lock feed mangers and two rows of 16 head-to-head free stalls with fixed mattresses (110 cm width, 180 cm length and 7 cm depth) as the stall surface. In order to determine the new neck rail position, 50 crossbred Holstein pregnant heifers were measured randomly for body length. As the average body length of the dairy heifers was 135.36 ± 8.06 cm (minimum 120 cm and maximum 149 cm), the neck rail in the test pen was moved back 10 cm. Thus, the current neck rail position of the control was at 160 cm from the curb and at a height of 124 cm, while the new neck rail position tested was at 150 cm from the curb and at a height of 122 cm. The height was slightly different as the stall divider was slightly sloped backward. Twenty four crossbred Holstein pregnant heifers with body lengths ranging from 126 cm to 148 cm were tested. Amounts of 17 kg mixed ration feeds were given twice per day to each heifer, in the morning and afternoon at 0900 h and 1500 h, respectively. An H264 digital video recorder with two channels was installed to record heifer behavior in each pen.

Experimental design

Two consecutive tests of the neck rail position were conducted. The comparison test was followed by a preference test that tested adjustments. In the comparison test, 24 pregnant heifers were randomly divided into two groups and allocated into one of two test pens. Each group was allowed to adjust to their new pen during a preliminary week. Heifer behavior in each stall was video recorded for 7 d consecutively during the second week, whereas the stall cleanliness was scored daily for 3 wk. Groups were then switched by pens for the second period of testing and the experimental design repeated. This comparison test was then followed by a preference test, conducted by removing the pen separator between the two test pens. Thus, all heifers had free access to all 32 free stalls. The preference test lasted for 5 d and the behavior was video recorded during the last 3 d consecutively.

Data recorded

The parameters measured in this study were heifer behavior indices and stall cleanliness (only during the comparison test). The behavior indices were measured for the following variables: 1) frequency of visiting the stall, 2) time spent standing with four legs in the stall (standing fully), 3) time spent standing with two forelegs in the stall (perching), 4) time spent lying in the stall, 5) frequency of lying bouts and 6) lying bout duration. Stall usage was calculated using the time spent standing, perching and lying in the stall. Any lying or standing activities outside the stall were not recorded. The heifer preferences were interpreted using behavior indicators. Stall cleanliness was measured in the three areas of the stall surface (front, middle and rear) as displayed in Fig. 1. The measurement was conducted once daily in the morning prior to stall cleaning during the comparison period only. The surface area of the stall without feces was classified as clean, a stall with feces on its surface was classified as dirty.

Statistical analysis

Behavioral data were calculated for each heifer and comprised stall visiting frequency, daily stall usage time, lying time, number of lying bouts, duration of lying bouts, perching time and standing time. The values tested were based on individual means from certain multiple days (7 d consecutively in each period during the comparison test, and 3 d consecutively during the preference test). The behavioral data from the comparison test were analyzed using the PROC GLM in the statistical analysis system (SAS) software (SAS, 2005) as a change-over design (Kaps and Lamberson, 2004). The values reported were the least square means (LSM). The adjusted Tukey-Kramer at $\alpha < 0.05$ was applied to compare the mean values obtained. The model statement included a term each for treatment, heifer, period and order of exposure to each treatment using Equation (1):

$$y_{ijkl} = \mu + \beta_k + H(\beta)_{jk} + T_i + P_l + \varepsilon_{ijkl} \quad (1)$$

where: y_{ijkl} is the observation on heifer j with treatment i, order of treatment k and period l; μ is the overall mean; β_k is the effect of order k of applying treatments ($k = 1, 2$); $H(\beta)_{jk}$ *is* the random effect of subject heifer j within order k with mean 0 and variance $\sigma^2{}_e$; τ_i is the fixed effect of treatment i ($i = 1, 2$); P_l is the effect of period l ($l = 1, 2$); and ε_{ijkl} is the residual random error with mean 0 and variance σ^2.

Stall cleanliness was analyzed by PROC FREQ and the values reported were the percentage of stall cleanliness, χ^2 value and odds ratio at the 95% confidence interval of the odds ratio (Agresti, 1995). The differences between the behavioral data of the two treatments during the preference test were analyzed using a paired comparison with the PROC T TEST.

Results and discussion

Comparison period

As the dairy heifers used in this study were pregnant, it was impossible to obtain the data of all heifers for the entire study

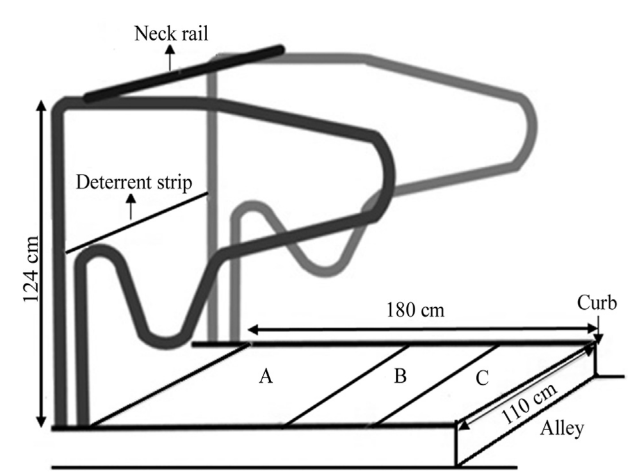

Fig. 1. Three areas of stall cleanliness measurement: (A) front; (B), middle; (C) rear.

period because some of heifers delivered their calves during the experimental period. Thus, no behavioral, comparison or preference data originated from the same total number of heifers. However, the results showed that the dairy heifer behavior demonstrated was not significantly different between the two treatments ($p > 0.05$) as shown in Table 1. The number of stall visits, lying time, number of lying bouts, duration of lying bouts, perching time and standing time, did not seem to be affected by the new neck rail position.

Moving the neck rail 10 cm backward seemed to have no significant effect on heifer behavior. There are at least two plausible reasons. First, these two neck rail positions were within an acceptable range for the heifers; hence no significant effect was found either on heifer behavior or preferences. Alternatively, the different distance between the new and current neck rail position (10 cm) may not have been discernible to the heifer. In contrast, the study of Tucker et al. (2005) reported a significant difference in standing characteristics when the difference between the two neck rail positions was more than 35 cm.

Another contributing factor to the above findings may have been the ingrained learnt behavior of the heifers. Some of those with no experience of free stall housing systems seemed to refuse using a stall altogether. During the rearing period, they were housed in open housing systems and moved into loose barns with recycled dried manure as bedding when they were pregnant. Stall refusal behavior may be demonstrated by heifers transferred into a barn (Kjoestad and Myren, 2001). One of the cattle characteristics noted by Reinhardt and Reinhardt (2015) was that cattle developed strong habits in their daily routine.

Despite the lack of a significant difference, the heifers were more likely interested in visiting the stalls with the new neck rail position. The total lying time and length of each lying bout were similar between the two treatments. However, the average lying frequencies of pregnant heifers in stalls with the new neck rail position were slightly higher than in stalls with the current neck rail position, with most heifers in stalls with the new neck rail position rising and laying down slightly more frequently. From observation, social rank may have affected this behavior. Subordinate heifers commonly used the stall uncomfortably and frequently as they were disturbed by the dominant heifers, which contributed to their greater number of shorter lying bouts as similarly reported by Hasegawa et al. (1997).

The contamination of feces in either the new or current position was particularly evident in the rear of the stalls. The rear area of a stall with the new neck rail position was likely to be two-and-a-half times cleaner than a stall with the current neck rail position (Table 2).

Generally, the standing position of heifers in the new position was straight on four legs in the stall with the hind legs close to the edge of the rear area (Fig. 2). This standing position allowed the feces to fall into the alley when they defecated while standing fully in the stall. Not surprisingly, stall cleanliness between the two treatments particularly in the rear area was significantly different.

Table 1
Heifer behavior in stalls with new neck rail position compared with current neck rail position during the comparison test.

Behavior	Neck rail position[a]		SE	p-value
	New	Current		
Visiting stall (times/d)	10.73	9.74	0.59	0.2535
Stall usage (min/d)	797.18	787.51	19.68	0.7318
Lying (min/d)	622.21	624.77	20.33	0.9299
Lying bouts frequency (times/d)	12.74	10.95	1.76	0.4800
Lying bout length (min/bouts)	59.03	60.86	2.17	0.5577
Perching (min/d)	105.80	87.08	8.36	0.1292
Standing on 4 legs (min/d)	69.18	75.66	6.17	0.4661

[a] New = 150 cm from the curb, Current = 160 cm from the curb; neck rail position data are shown as least square means.

Table 2
Stall cleanliness in three stall areas comparison between new neck rail position and current neck rail position.

Stall cleanliness	New position (%)		Current position (%)		χ^2-value	p-value	Odds ratio
	Clean	Dirty	Clean	Dirty			
Front	99.3	0.7	99.2	0.8	0.1119	0.7379	1.2521
Middle	99.7	0.3	99.5	0.5	0.2008	0.6541	1.5025
Rear	92.8	7.2	83.7	16.3	23.9730	<0.0001	2.4931

Weary et al. (2008) reported that stall cleanliness was commonly related with stall occupancy. Though the differences in either standing time on four legs or lying time within the two treatments were not significantly different, the standing time with four legs in the dirtier stall tended to be slightly higher than in the cleaner stall (75.66 ± 6.17 min/d in the current position versus 69.18 ± 6.17 min/d in the new position), whereas the perching time showed the reverse pattern (87.08 ± 8.36 min/d in the current position versus 105.80 ± 8.36 min/d in the new position).

In a previous study by Tucker and Weary (2002), the relationship between stall soiling and standing time was shown. As demonstrated in this study, the time spent for standing fully was slightly higher in the stall with the current neck rail position. However, the heifer's body size may have had an effect on stall cleanliness, since the largest heifer (body length 148 cm) mostly defecated while perching. In agreement with Tucker et al. (2005), the effect of the neck rail position on stall cleanliness was stronger for the larger dairy cows and seemed to have less effect for the smaller dairy cows. Furthermore, Ruud et al. (2011) reported that the neck rail position can reduce the risk of stall soiling caused by defecating when the animal is standing in a stall with 196 cm maximum diagonal length, whereas the diagonal distance in the new position compared with the current position was 193 cm versus 202 cm. This shorter diagonal distance may have contributed to the better stall cleanliness with the new neck rail position. Nevertheless, the neck rail position had no effect on reducing stall contamination caused by wet footprints and feces when the cows defecated while lying down.

Preference period

During the free choice period, the results demonstrated that dairy heifer behavior was not significantly different between the two treatments ($p > 0.05$) as can be seen from Table 3. Generally, lying and standing behavior were the main indicators that showed how likely respective stall use was and so these were used to evaluate the quality of the stall (Mattachini et al., 2011). Despite the lack of a significant difference, the perching time was slightly longer in the new position, whereas the standing time showed the reverse pattern. The new neck rail position tended to be more restrictive than the current neck rail position. On the other hand, the new neck rail position tended to increase dairy comfort because of greater stall usage, lying time and visits to the stall. However, the differences in the behavior indices between the two treatments were not significant; the new neck rail position did not disturb the normal behavior of pregnant heifers.

The study showed that the new neck rail position did not significantly affect heifer behavior ($p > 0.05$). Likewise, no obvious preference for one of the two options was expressed by the heifers.

Fig. 2. Stall standing position of some heifers while defecating and urinating: (A) feces fall into the alley when the heifer defecates while standing in a stall with new neck rail position; (B) stall soiled by urine or feces which fall on the stall surface when the heifer defecates or urinates while standing in a stall with current neck rail position.

Table 3
Differences in heifer behavior on stall utilization between stalls with new neck rail position and stalls with current neck rail position during preference period.

Behavior	Difference	SE	*p*-value
Visiting stall (times/d)	1.37	0.87	0.1346
Stall usage (min/d)	46.49	79.13	0.5637
Lying (min/d)	41.23	62.49	0.5173
Lying bout frequency (times/d)	0.28	0.99	0.7776
Lying bout length (min/bouts)	1.02	6.43	0.8761
Perching (min/d)	13.30	12.18	0.2885
Standing using 4 legs (min/d)	−8.04	9.77	0.4206

Interestingly, stall cleanliness particularly in the rear area, was significantly different between the two treatments. The rear area of the stall with the new neck rail position was cleaner than for the current position. Thus, the new neck rail position could yet prove to be a more suitable neck rail position for tropical dairy heifers, particularly in terms of stall cleanliness.

Conflict of interest

There is no conflict of interest.

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