Stall dimensions and the prevalence of lameness, injury, and cleanliness on 317 tie-stall dairy farms in Ontario

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Abstract — The study objectives were to provide a province-wide description of stall dimensions and the aspects of cattle welfare linked to stall design in the tie-stall industry. Data on stall design; stall dimensions; and the prevalence of lameness, injury, and hind limb and udder cleanliness in lactating dairy cattle were collected from a sample of 317 tie-stall farms across Ontario. The majority of the study farms (90%) had stalls with dimensions (length, width, tie-chain length, and tie rail height) that were less than the current recommendations. This may explain, in part, the prevalence of lameness measured as the prevalence of back arch (3.2%) and severe hind claw rotation (23%), hock lesions (44%), neck lesions (3.8%), broken tails (3%), dirty hind limbs (23%), and dirty udders (4.6%). Veterinarians and producers may use this information to compare farms with the industry averages and target areas in need of improvement.

Résumé — Dimensions des stalles et prévalence de la boiterie, des blessures et de la propreté dans 317 fermes laitières en stabulation entravée de l'Ontario. Les objectifs de l'étude étaient de fournir une description valable pour toute la province des dimensions des logettes et des différents aspects du bien-être des bovins selon les différents modèles de logettes disponibles dans l'industrie. Les données concernant les modèles de logettes et leurs dimensions ainsi que la prévalence de boiteries, de blessures et de propreté des membres postérieurs et du pis chez les vaches laitières ont été recueillies dans 317 fermes en stabulation entravée de tout l'Ontario. La majorité des fermes participantes (90 %) avaient des stalles de dimension inférieure aux recommandations courantes (longueur, largeur, longueur des chaîne de cou, hauteur des barres d'attache). Ces observations pourraient expliquer en partie la prévalence de boiteries (mesurée par la prévalence de dos voûtés (3,2 %) et de rotation marquée de l'onglon des membres postérieurs (23 %), de lésions au jarret (44 %), de lésions du cou (3,8 %), de queues cassées (3 %), de membres postérieurs (23 %) et de pis (4,6 %) malpropres. Dans le but d'améliorer la situation, les vétérinaires et les producteurs auraient avantage à utiliser ces données afin de comparer l'état actuel des étables avec les standards et les objectifs de l'industrie.

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Introduction

In Ontario, 80% of dairy cows are housed in tie-stall operations in which cows are restrained in stalls throughout the lactation phase. Many farms allow a daily exercise period on pasture or in an exercise yard; however, some do not. Hence, the design of a tie-stall can impact whether a cow is lame, injured, or dirty (1–9). In particular, lameness, injury, and mastitis are painful conditions associated with management factors and barn design. These conditions decrease dairy cattle welfare and increase the probability of premature culling, lost production, and negative attitudes by the public toward the dairy industry.

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This study provides benchmarks for animal and design-based parameters by using a sample of dairy cattle in Ontario that were housed in tie-stalls. Many recommendations for stall designs and dimensions can be found, such as those provided in the Canadian Codes of Practice for Dairy Cattle (10) and extension publications (11). However, these guidelines are voluntary and compliance by the dairy industry is unknown. Hence, information is needed to assist producers and veterinarians wishing to compare their on-farm assessments with current industry standards. This information could facilitate discussions of animal health and husbandry among producers, or between veterinarians and their clients, and could provide incentives for addressing lameness, injury, or cleanliness of cattle on farms below the industry averages.

Similarly, animal-based assessments could provide positive reinforcement for good husbandry and management. Some animal-based scoring parameters that measure aspects of animal well-being are linked to stall design. The measurement of animal-based parameters, such as the presence of an arched back while standing and hind claws that are rotated outwards (both associated with lameness) (12,13), docked or broken tails, hock and neck lesions, and levels of hind limb and udder cleanliness, can provide direct information about how the quality of the barn environment and stockmanship is experienced at the "cow-level." Scientific evidence is needed to identify the effects of tie-stall design on cow welfare, while the Ontario industry norms for animal-based measurements of cow well-being for tie-stall operations need to be established. The purpose of the 1st stage of this study was to develop an objective assessment to evaluate aspects of dairy cattle welfare and to establish the range of stall dimensions and the prevalence of lameness, injury, and cleanliness on tie-stall farms in Ontario.

Materials and methods

Selection of study population

Farms were required to participate in the study as part of the mandatory Dairy Farmers of Ontario (DFO) annual Grade A inspection process. Prior to the start of data collection, letters were sent to all DFO members with tie-stall housing. The letters described the project and detailed what information the inspectors would be collecting at the time of the inspection. In addition, a notice was placed in the DFO monthly journal *Milk Producer,* describing the project and what information the DFO inspectors would collect.

The DFO divides Ontario into 15 field zones, with a field staff inspector assigned to each zone. The zones are based on the number of producers and dairy committees within the zone and geographical size. Each of the 15 DFO inspectors is responsible for the farms within his or her assigned area of Ontario. To select farms for inspection, the DFO generates a list of all producers who have had a penalty-level test result for milk quality or are due for their biannual inspection. Within the group due for a particular month, the names are listed randomly and include farms with both free-stall and tie-stall housing. Starting in March 2003 and continuing until September 2003, data were collected from all tie-stall farms during the biannual inspection. The inspectors from the DFO collected data from 317 farms. Three of 4 regions of Ontario (eastern, southern, and central) were represented by project herds. The northern region (Kenora, Rainy River, and Thunder Bay districts) was not represented, as there are only a small number of dairy farms within this region and none were due for their biannual inspection during the study data collection period.

Data collection

Determining what data to collect was a multistage process. Initially, a literature search was conducted seeking all prior information on cattle welfare or cow comfort scoring indicators. Information on the aspects of stall design that affect the lameness, injury, or cleanliness of cattle was also gathered. A list encompassing all possible cow comfort indicators was created and presented to a group of experts from the dairy cattle industry. The group included veterinarians, animal scientists, DFO executive, and DFO inspectors. Both the amount of data needed for the study and the time-frame inspectors had at each farm visit were considered when deciding how many parameters would be appropriate for this study. Each member was then asked to choose what he or she felt were the 10 most important factors to be recorded. The 10 top ranked factors were listed, followed by a discussion about the appropriateness of their use until an agreement was reached. We recognize that the list of parameters used in this study did not give a complete picture of all the aspects of stall design that may affect lameness, injury, and cleanliness. Ideally, more stall information and animal-based measurements would have been collected. The parameters chosen were a compromise between what would describe tie-stall housing and animal well-being in the sample population and what would provide good compliance and reliability of data recording.

Table 1. Animal and stall-based parameter definitions used for scoring the 317 Ontario tie-stall study farms

Parameter	Definition
Back arch 0	No arch is seen in the back while standing
Back arch 1	An arch is seen in the back while standing
Hind claw 0	No rotation of the hind claw
Hind claw 1	Hind claw rotated outward more than 20 degrees from the cow's midline
Hind limb 0	No manure on hind leg from claw to hock
Hind limb 1	Manure is seen only on the dewclaw
Hind limb 2	Manure is seen from dewclaw to shank
Hind limb 3	Manure is seen from dewclaw up to or over hock joint
Hock 0	No hair loss broken skin or scabs
Hock 1	Hock is swollen with no hair loss, broken skin, or scabs
Hock 2	Hock has hair loss with or without swelling
Hock 3	Hock has broken skin or scabs with or without swelling
Neck 0	No hair loss, broken skin, or scabs visible
Neck 1	The neck has visible hair loss, broken skin, or scabs
Teat 0	No visible injury to the teat
Teat 1	Visible injury to the teat
Udder 0	No manure visible on udder
Udder 1	Slight amount of manure visible on udder
Udder 2	Significant amount of manure visible on udder
Tail 0	Tail is not docked or broken
Tail 1	Tail has a deviation in the vertebrae from a previous or recent break
Tail 2	Tail is docked
Stall length	From inside (stall bed side) of manager curb to inside of gutter curb
Stall width	Between the stall dividers on their center
Chain length	From snap at cow collar to tie rail
Tie-rail height	From stall bed to underside of tie rail

The animal-based parameters were presence of hock or neck lesions, presence of teat injuries, presence of broken or docked tails, presence of a back arch, presence of the hind claws rotated outward more than 20 degrees from the cow's midline, and the cleanliness of the udder and hind limbs. Parameter definitions are listed in Table 1.

Concise definitions of each possible score of the animal-based parameters and their representative pictures were placed on a laminated reference card. For parameters involving limbs, the most severely affected limb was scored. For stall-based measurements, the precise points of measurement were described (Table 1). Inspectors from the DFO were presented with the laminated scoring cards and stall-based measurements and asked to review

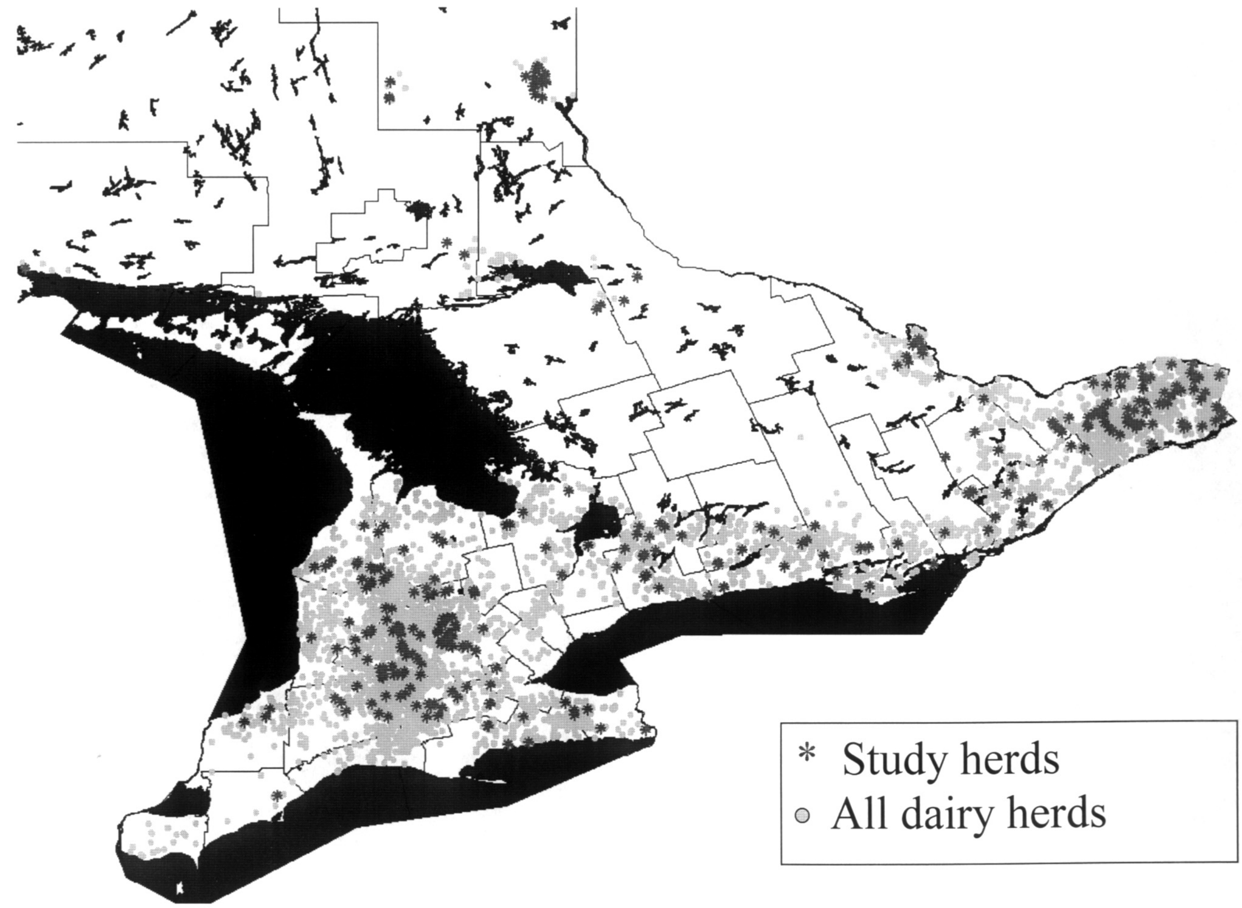

Figure 1. Distribution of 317 tie-stall study herds compared to all dairy herds in Ontario.

the wording and make suggestions to ensure the repeatability of scoring. Suggested wording and picture changes were made. Training sessions were scheduled and, at each training session, farms were visited where all inspectors were asked to identify and score the cattle, using the scoring card for guidance. After scoring the cattle, the scores were compared among inspectors. Where discrepancies were found, that cow was studied by the inspectors as a group and a consensus reached. Inspectors were then asked to identify and rescore the cattle in the opposite order from which they had initially scored them. Scores were informally compared for agreement both among inspectors and with each inspector's previous score for that cow. If agreement was poor for a particular inspector, one-on-one training was applied until the reliability and repeatability of his or her scoring was acceptable.

Data were initially collected on paper recording forms. During Grade A farm inspections, DFO inspectors use a hand-held electronic data recorder to answer standard report questions and input specific farm information. Once programmed for the purpose of this study, the inspectors used these hand-held data loggers to record the stall measurements and animal scores. At each of the study farms, the assigned inspector individually scored all of the lactating cattle for hock, neck, teat, and tail appearance; presence of back arch or rotated hind claws; and the cleanliness of the udder and hind limbs. Stall measurements were taken on one of the lactating cow stalls. If the farm had more than one size of stall, the most common size of stall was used for the measurements. The data were then downloaded from the data logger to a central database at the DFO office. The animal scores, stall measurements, date inspected, inspector, farm ID and cattle breeds were then entered into a spreadsheet (Excel; Microsoft, Redman, Washington, USA)

Table 2. Breed and stall design characteristics of the 317 Ontario tie-stall study farms

Characteristic	Number of farms	Proportion of study herds with the characteristic
Breed		
Holstein	282	89%
Jersey	7	2.2%
Purebred other	10	3.2%
Mixed herds	18	5.6%
Stall type		
Tie rail	257	81%
Comfort stall (tombstone or arch stall)	30	9.5%
Stanchion	25	7.9%
Other	5	1.6%
Use electric trainers	240	76%
Use tail ties	86	27%
Willing to participate in a further case study of farm	295	93%

Analysis

All data were sent electronically from DFO headquarters in a spreadsheet once a month and imported into a

Table 3. Range of stall dimensions categorized by stall type, of the 317 Ontario tie-stall study farms

Stall dimension	Minimum cm	1st quartile cm	Median cm	3rd quartile cm	Maximum cm
Stall length					
Tie-rail	147.3	167.6	177.8	182.9	218.4
Comfort	144.8	170.2	176.5	182.9	182.8
Stanchion	137.2	149.1	152.4	163.2	182.8
Stall width					
Tie-rail	91.4	114.3	121.9	127	144.8
Comfort	91.4	114.3	119.3	121.9	139.7
Stanchion	91.4	101	106.3	115.9	137.2
Chain length					
Tie-rail	33	45.7	53.3	66	114.3
Comfort	10.2	36.2	44.5	50.8	58.4
Tie-rail height	76.2	91.4	96.5	104.1	132.1

Table 4. Percentiles of stall dimensions for the 257 study farms using the "tie-rail" design of stall

Measurement	10th	25th	50th	75th	90th
Stall length	160 cm	167.6 cm	177.8 cm	182.9 cm	182.8cm
Stall width	106.7 cm	114.3 cm	121.9 cm	127 cm	137.2 cm
Tie-rail height	83.8 cm	91.4 cm	96.5 cm	104.1 cm	114.3 cm
Chain length	40.6 cm	45.7 cm	53.3 cm	66 cm	78.7 cm

database (Access; Microsoft). Data were organized and graphed to identify outliers. Validation of the outlier data was done by contacting the DFO inspector responsible for collecting them and then the producer, to double check measurements. Thirty additional study farms were randomly selected and the data were validated in the same manner. Descriptive data regarding the study farms, including cattle breed, stall type, and the use of tail ties and electric trainers, were summarized in the database. Scoring information was compiled by using the spreadsheet to give the proportion of each herd with a particular score (the proportion of lactating cattle on each farm with a hock lesion score of 3).

Results

Data were collected from 320 farms. The data from 317 farms were utilized. Three farms were excluded from the study due to incomplete collection of data. The distribution of the study farms, over-laid on the distribution of all dairy farms in Ontario is shown in Figure 1.

Average lactating herd size was 56 cows and ranged from 8 to 178. Other descriptive characteristics of the study population are presented in Table 2.

The stall dimension data were not normally distributed. The median, quartiles, minimum, and maximum of the stall measurements for each stall type are presented in Table 3. The percentiles for specific stall measurements of the tie-rail housing style only are presented in Table 4.

The proportion of the study population with each score parameter is presented in Figure 2. Over 50% of the herds had at least 1 cow with an arched back. The prevalence of back arch within a herd ranged from 0% to 21%. Hind claw rotation was prevalent on most farms. Only 51 out of the 317 (16%) study farms had 60% or more of the herd with no hind claw rotation. The proportion of farms with unaffected and affected cattle for all the scored parameters is presented in Table 5. Data in this table were grouped into 5% increments, after discussions with producers had established that many producers think of the "cut-off," or acceptable levels, for lameness, injury, and cleanliness in these increments.

Teat injury was not included in the results.

Discussion

Stall measurements

In this sample population of tie-stall herds in Ontario, 90% of the farms did not meet the current extension publication recommendations for stall length, width, tie-rail height, or tie-chain length (11). These recommendations are based on the assumption that the animal being housed is an averaged-sized Holstein. The average weight of a lactating Holstein in Ontario is approximately 700 kg (14). The stalls in this study housed mature lactating cattle, with the predominant breed being Holstein. Only 2.2% of the study herds were the smaller stature Jersey breed.

The comfort (the arch or tombstone style) tie-stall and the stanchion were uncommon in the study herds (9.5% and 7.9%, respectively). Both are in older styles of tie-stalls that are being replaced as barns are renovated and are not used in new tie-stall facilities. The majority of the study farms used the tie-rail style stall. The median tie-rail stall length in this study (177.8 cm) met the standards set in the Canadian Codes of Practice recommendations (147.3 cm for 400 kg cow and up to 182.8 cm for an 800 kg cow) (10). While the codes recommend a stall length of 172.7 cm for a 700 kg Holstein, 30% of the tie-rail study farms had stalls shorter than this. More recent research recommends a stall length of 182.8 cm for this size of cow (11,15). Ninety percent of the study farms had stall lengths less than this recommendation. The complete tie-stall recommendations for the Canadian Codes of Practice are given in Appendix 1A.

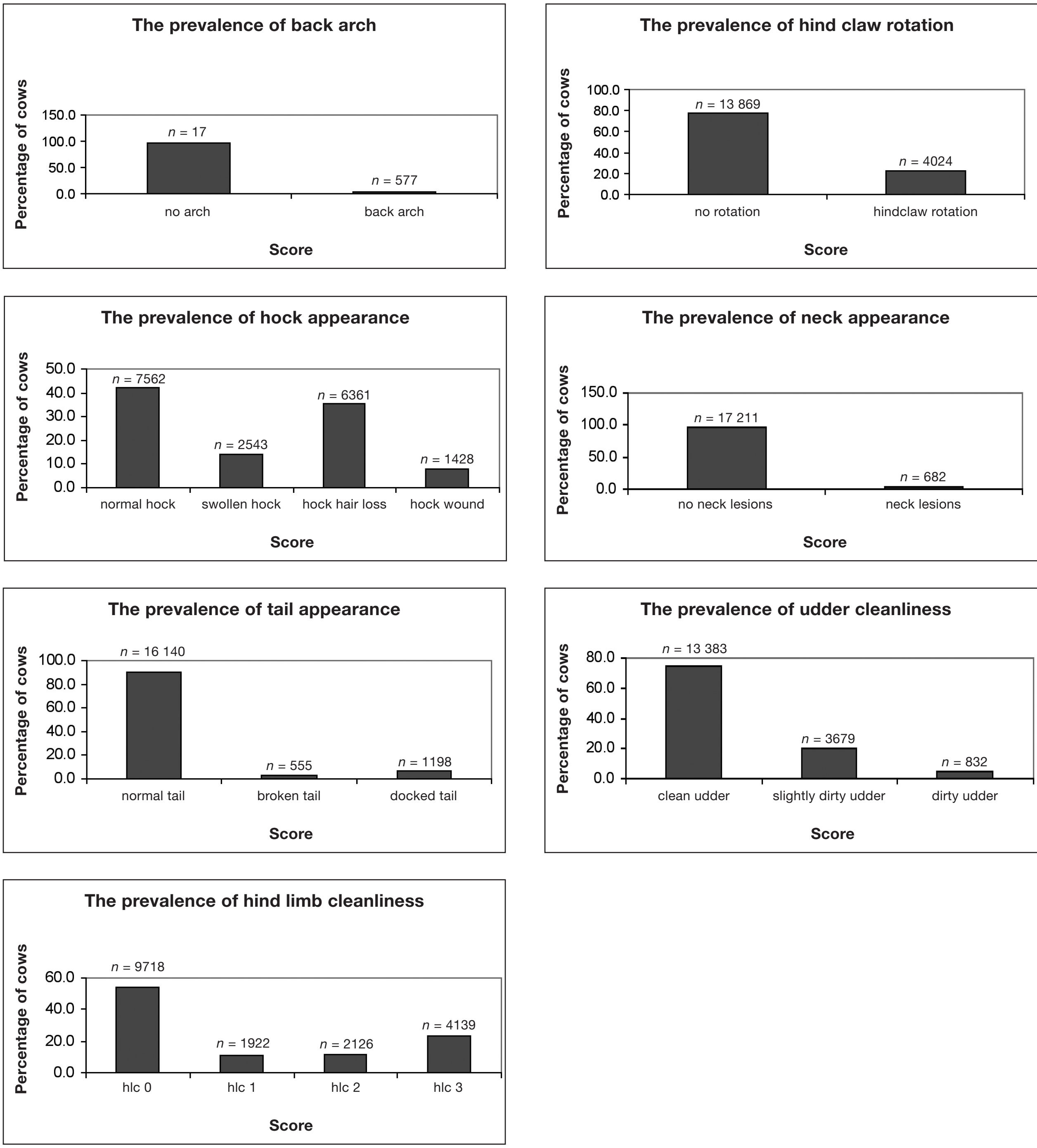

Figure 2. Histograms of the distribution of the 17 893 study cows with each score parameter.

Providing dairy cattle with the opportunity to rest is important for maximizing production and well-being (16). The time spent ruminating (17) and blood flow to the udder (18) are increased when cows lie down. Normal resting positions used by cows on pasture should define the width needed for a properly sized tie-stall. This encourages the cow to lie down and rest. Median stall width for the tie-rail style stalls (121.9 cm) fell below the recommendations of both the Canadian Codes of Practice (10) and the more recent recommendations for an average-sized Holstein (11,15). Based on observations at pasture, Anderson (11) recommends a stall width of 144.8 cm for an average Holstein. Over 90% of the farms in this study had narrower stalls. The minimal recommendation for stall width is 132.1 cm (10) and 85% of the tie-rail style farms in this study had stalls narrower than this. The complete tie-stall recommendations by Anderson are given in Appendix 1B.

The proper location of a tie-rail allows a cow to stand straight with all 4 feet in the stall and to rise and lie down without any contact with the rail. The median tie-rail height for the study farms was 96.5 cm from the stall bed to the underside of the rail. This height can be found as a standard recommendation in older literature and it positions the cow at the back of the stall to promote stall cleanliness (15). Stalls designed to

Table 5. The number and percentage of the 317 study farms with unaffected and between affected cattle for each score parameter

Parameter (numeric score)	Farms with all cows unaffected (%)	Farms with 1% to 5% of cows affected (%)	Farms with 6% to 10% of cows affected (%)	Farms with 11% to 15% of cows affected (%)	Farms with > 15% of cows affected (%)
Arched back (1)	152 (48)	94 (30)	48 (15)	16 (5)	7 (2)
Hind claw rotated outwards (1)	20 (6)	25 (8)	35 (11)	50 (16)	187 (59)
Neck abrasions (1)	227 (72)	30 (9)	20 (6)	9 (3)	31 (10)
Hair loss from hocks (2)	10 (3)	13 (4)	13 (4)	26 (8)	255 (80)
Open wounds on hocks (3)	83 (26)	76 (24)	70 (22)	37 (12)	51 (16)
Significantly dirty udder (2)	154 (49)	75 (24)	51 (16)	11 (3)	26 (8)
Dirty hind limbs (manure up and over hock joint) (3)	43 (14)	48 (15)	48 (15)	32 (10)	146 (46)
Broken tails (1)	196 (62)	59 (19)	34 (11)	11 (3)	17 (5)
Docked tails (2)	260 (82)	29 (9)	7 (2)	1 (.003)	20 (6)

allow the greatest freedom of movement for the cow and prevent neck injuries should have a tie-rail at 121.9 cm for an average Holstein (11). Greater than 90% of the study farms had their tie-rail placed lower than this recommendation.

Longer chains allow cows to perform normal behaviors, such as grooming and resting, with their heads tucked at their side. There is scant literature on the appropriate length of chain for tie-stalls. The most current extension publication recommends that the tie-chain length (including attachment snap) should extend from the rail to the top of the manger curb (11). Based on the recommended tie rail height of 121.9 cm, the tie-chain should be 91.4 cm, plus attachments for the rail and cow collar (11). Greater than 90% of the study farms used tie chains shorter than 91.4 cm, similar to the proportion of study farms that had a tie-rail height of less than 121.9 cm.

Animal-based measurements

Teat injury was originally included in the parameters to be recorded. After viewing the total data set and speaking with several of the DFO inspectors, it became obvious that compliance on recording teat injury was low. For this reason, the teat injury scores were dropped from the data set and not listed in the results. Compliance for correctly recording all other parameters was excellent.

Stall design factors associated with lameness include stall length; stall bed surface; type and amount of bedding; and the cleanliness, dampness, or both, of the stall bed (1–4). Locomotion scoring is the preferred method for establishing an estimate of the prevalence of lameness on a farm. However, since this study dealt only with tie-stall facilities and visits were restricted to time periods convenient for the DFO inspectors, locomotion was not scored. Instead, back arch was recorded and used to estimate the prevalence of lameness. It has been established that lame cows both stand and walk with an arch in their back (12,13). Back arch becomes more pronounced as the severity of lameness increases (12,13). Cook (1) and Wells et al (2) used locomotion scoring to determine the mean prevalence of lameness in their respective study herds in Wisconsin. Lameness prevalence varies between reported studies, partly due to different case definitions and differences in the collection of data. Mean prevalences between 5.3% and 23.9% have been reported (1–3,19). Within our study herds, the prevalence of arched backs ranged from 0% to 21%, which is in accordance with the wide range found in other studies (1,19). Of the total population in this study, 577 out of 17 893, or 3.2% of cows had arched backs.

The lateral hind claw bears most of the shearing forces during locomotion, has the most ground contact, and has more lameness producing lesions and overgrowth than does the medial claw (19–21). During normal locomotion, 80% of the cow's weight is borne on the lateral claw, 20% on the medial claw (20). At rest, there is a relatively even weight distribution between the medial and lateral claws (20). The lateral claw on the hind foot is larger and flatter and the posterior portion of the lateral claw touches the ground first during forward motion. The hind feet also have greater exposure to urine, manure, and wet bedding, which may decrease foot health and lead to lameness (21). To provide relief from the pressure and pain, lame cows will rotate the affected hind feet outwards to transfer their weight from the lateral to the medial claw (20,22). Scoring the number of cows with an outward hind claw rotation of greater than 20 degrees from the midline gives an indication of the cases of subclinical lameness within the herd (23). A study of 600 free stall-housed cattle in the Netherlands reported that 60% of the cows had rotated hind claws (23), more than double the 23% found in this study. Van Lenteren and Korsten (23) recommended that a healthy herd should have over 60% of the herd with no rotation. Based on this recommendation, only 16% of the farms in this study would be considered healthy. Subclinical lameness resulting in rotated hind claws is commonly associated with inadequate hoof trimming and sole ulcers. Sole ulcers are associated with increased time standing (24–25). Proper stall design and bedding would encourage cows to spend more time lying down and could decrease the prevalence of sole ulcers.

In an extension publication (6), it was noted that neck injuries on tie-stall farms appear to be caused by the dorsal aspect of the neck repeatedly being rubbed against or hitting the underside of the tie-rail while the cow is feeding or rising. Data from this study and observations by Anderson (6) show that not all cows within a herd will be affected. This suggests that other factors also affect the occurrence of neck lesions. Some of these factors may include cow size, amount of bedding, stall bed surface, manger height, and tie-chain length (6). The presence of electric cow trainers (7) and whether or not 2-year-old heifers were accustomed to being tied before being milked for the first time have also been associated with increased soft tissue lesions (26). Few reports of the prevalence of neck injuries due to stall design have been published. Busato et al (7) detailed the prevalence of all types of traumatic injuries in dairy cattle related to housing for 152 small, organic herds in Switzerland. The prevalence of neck injuries presented in that study (1.3%) was less than the 3.8% of cows found with neck injuries in our study. The position of the tie rail is critical to avoid neck injuries to the cows (5,25).

Injuries to the hocks have been associated with stall length, stall bed surface, and bedding type (20,27–29). Other possible factors include stall width, tie-rail height, the size of the cow, and her health status. An improperly designed stall could make rising and lying behaviors difficult and result in more injuries to the hocks. Health status could impact hock lesions, as cows with lameness or other ailments may spend more time lying down and have greater difficulty changing postures. Several studies regarding the prevalence of hock lesions in free-stall housing have been completed; however, little information has been published on the prevalence of hock lesions in tie-stall housing. Weary and Taszkun (28) found 73% of the cows on 20 free-stall farms had at least 1 area of hock hair loss or skin breakage. Livesey (27) found that the prevalences of hock lesions for free stalls containing mats versus those with mattresses were 68% and 74%, respectively. Both studies labeled cows with hock hair loss or skin breakage as cows with hock lesions. By adding the number of cows in this study with hair loss (6361) and hock wounds (1428), the hock lesion prevalence on tie-stall farms was 7789 out of 17 893 cows (44%). Although this prevalence is less than prevalences found in the free-stall studies, a higher percentage of the farms had cows with hock lesions in this study, as compared with the free-stall studies. Only 3% of study farms had cows without any hair loss from their hocks and only 26% of study farms had cows without open hock wounds.

Hygiene scoring systems have been used to determine if there are associations between stall design, bedding type, electric cow trainer use, and dairy cattle hygiene (32–34). The use of trainers has been shown to reduce the amount of manure in the stall bed, which results in cleaner cows (33). However, Oltenacu et al (9) found that trainers were associated with other problems, such as increased silent heats and culling rates. Clean hind limbs and udders are important for milk quality and udder health. Reneau (30) recently used cow cleanliness scoring to compare cow hygiene with somatic cell count and found that as the udder and leg scores increased (dirtier cows), the somatic cell count also increased. Schreiner and Ruegg (31) found that udder and hind leg hygiene scores were associated and that both increased linearly with somatic cell count. Their study also demonstrated an association between intramammary environmental pathogens and udder hygiene score. Cook (8) has suggested that it is more meaningful to report hygiene scores as the proportion of the herd that has udders or hind limbs that are "too dirty" than to report the number of animals with each level of hygiene score. In a study of 20 herds in Wisconsin, he found that, on average, 20% of cows in tie-stalls had udders that were "too dirty." For hind limbs, the proportion of cows considered "too dirty" was 30%. These figures are higher than those found in our study; however, while the scoring systems were similar, they were not identical. Of our 317 study farms, 8% had greater than 15% of the cows with significantly dirty udders and 46% had greater than 15% of the herd with significantly dirty hind limbs.

Tail fractures in cattle housed in tie-stalls may result from the tail being stepped on or through forceful manipulation of the tail by stockpeople. The "tail twist" is sometimes used to force a cow to step forward or move sideways within the stall. If too much pressure is applied, the tail will break. Anecdotal reports indicate that when heifers are first moved into stalls from pens, extra restraint is needed during milking and that the tail is often "jacked" to force the cow to stand still or twisted to get the cow to step forward or sideways. However, scant scientific literature is available on the cause of broken tails in dairy cattle. No studies on the prevalence of broken tails in tie-stall herds were available to compare with the prevalence of 555 broken tails out of 17893 cows (3%) in this study. Depending on the location of the break, affected cows may show signs ranging from pain and discomfort to neurologic deficits, such as decreased tail movement or flaccidity of the anus and vulva (35). Further research is needed to determine if broken tails are interrelated with tie-stall design and stockmanship and to find methods of restraint that do not harm the cattle. Investigations should include study of the location and age of the break.

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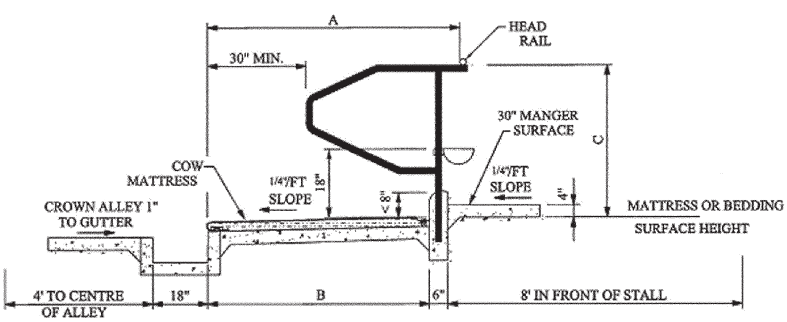
Appendix 1A. Tie stall dimensions[a] from the Recommended Codes of Practice of the Handling of Dairy Cattle

Animal size		Stall width		Stall platform (length with trainer[a])	
kg	(lb)	mm	(in)	mm	(in)
400	(880)	1000	(40)	1450	(58)
500	(1100)	1100	(44)	1500	(60)
600	(1320)	1200	(48)	1600	(64)
700	(1540)	1300	(52)	1700	(68)
800	(1760)	1400	(56)	1800	(72)

[a]Stalls should be 100 mm (4 in) shorter if used without trainers. For new or renovated facilities, stalls of varying width are recommended. When planning the length of tie stalls, keep in mind that they will be affected by the design of the tie system chosen.

Appendix 1B. Dairy cow tie stall recommendations for Holstein cows (11). Illustration by Harold House, Engineer, OMAF



Holstein cows	Dimension (in) A	B	C	Width	Chain length
First lactation	84	70	46	54	C-8
Milking	86	72	48	54	C-8
Dry Cow	86	72	48	60	C-8