Archivos de Zootecnia
Journal website: https://www.uco.es/ucopress/az/index.php/az/

Description of measurable parameters related to animal welfare in freestall and tiestall farms in Northwestern Spain

Trillo, Y.[@]; Quintela, L.A.; Barrio, M.; Becerra, J.J.; Vigo, M.; Peña, A.I. and Herradón, P.G.

Unit of Reproduction and Obstetrics. Department of Animal Pathology. Colleage of Veterinary Medicine of Lugo. University of Santiago de Compostela. Lugo. Spain.

Additional keywords

Cow comfort.
Animal-based measures.
Facility-based measures.
Management practices.

Summary

The aim of this characterization study was to describe several welfare indicators on the farm and find possible difference between the prevalence of hock injuries, body condition (BCS), and hygiene score across 15 free stalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain (Galicia). Data were collected once and it included direct measures of the welfare based on the animal (BCS, hock injuries, locomotion score, hygiene score) and, indirect measures based on facilities (stall design, surfaces, feed bunk, ventilation and milking) and management practices (cleanliness, preventive treatment programs, outdoor access). In the following results, higher values are indicative of a poorer status. Herd-level prevalence of overweight cows to the stage of lactation was greater ($p<0.05$) in F than T (28.9 *vs* 10.5%) and underweight cows were lower ($p<0.05$) in F than T (21.8 *vs* 41.1%). Hock injuries were common in both housing systems, averaging 41.7% in F and 38.5% in T. Prevalence of lameness (score 3, 4, 5) averaged 10.6% in F (not scored in T). Udder hygiene score averaged 2.1 in F and 2.2 in T, upper leg/flank was 2.3 in F and 2.4 in T and lower leg score was higher ($p<0.01$) in F than T (3.0 *vs* 2.4 points on average). Low prevalence of these indicators in some farms should be taken into reference by the other farms to achieve better results. Moreover, considerable variation in facilities management and measurements was described in both housing systems, highlighting the small areas of T, too narrow alleys in F and, inadequate barn design for natural ventilation in both systems and at holding area in F farms.

Descripción de parámetros medibles de bienestar animal en establos libres y trabados del Noroeste de España

Palabras clave adicionales

Confort de la vaca.
Medidas del animal.
Medidas de las instalaciones.
Prácticas de manejo.

Resumen

El objetivo de este estudio de caracterización fue describir varios indicadores de bienestar en la granja y encontrar las posibles diferencias en la prevalencia de las lesiones del corvejón, condición corporal (CC), y la puntuación de la higiene en 15 establos libres con cubículos (F) y 15 trabados (T) de ganado vacuno lechero en el Noroeste de España (Galicia). Los datos fueron recolectados una vez y se incluyen medidas directas del bienestar basadas en el animal (CC, lesiones del corvejón, locomoción y puntuación de la higiene) y, medidas indirectas basadas en las instalaciones (camas, suelos, alimentación, ventilación y ordeño) y las prácticas de manejo (limpieza, programas de prevención, acceso a patios y pastos). En los siguientes resultados, los valores más altos indican las peores condiciones. La prevalencia a nivel de rebaño con sobrepeso con respecto a la etapa de lactación en la que se encontraba cada vaca fue mayor ($p<0,05$) en F que T (28,9 *vs* 10,5%) y las vacas delgadas fueron menos ($p<0,05$) en F que T (21,8 *vs* 41,1%). Las lesiones de corvejón fueron comunes a ambos sistemas de alojamiento, con una prevalencia del 41,7% en F y 38,5% en T. La prevalencia de cojera (puntuación 3, 4, 5) fue 10,6% en F (no puntuada en T). La higiene de la ubre tuvo una puntuación media de 2,1 en F y 2,2 en T, el flanco y parte superior de la pierna fue 2,3 y 2,4 en F y T, respectivamente, y la parte inferior de la pierna tuvo una puntuación mayor ($p<0,01$) en las granjas F que T (3,0 *vs* 2,4 puntos de media). La baja prevalencia de estos indicadores en algunas granjas se debe tomar de referencia por otras granjas para lograr mejores resultados. Además, la descripción de la variación en el manejo y diseño de instalaciones en los dos sistemas de alojamiento señala como puntos críticos las pequeñas dimensiones de las camas en T, pasillos estrechos en F, diseño inadecuado para la ventilación natural en ambos sistemas de estabulación y el área de espera de la sala en F.

Information

Cronología del artículo.
Recibido/Received: 27.07.2016
Aceptado/Accepted: 17.12.2016
On-line: 15.04.2017
Correspondencia a los autores/Contact e-mail:
yolinati8@hotmail.com

INTRODUCTION

Animal welfare is not only about ensuring an animal is not treated cruelly or caused unnecessary pain or suffering, it is about ensuring that an animal's physical state, its mental state and its ability to fulfill its natural needs and desires are considered and attended too. Any cow perceiving situation that induces a negative reaction or response leading to a less than ideal condition, inhibiting her genetic potential and ability for maximum dairy production is considered out of welfare.

The care of cows is an important concern on the mind of farmers and consumers alike so cow comfort plays a major role in obtaining optimum herd health and milk production.

A relevant welfare assessment system should describe the welfare of the animals in the herd, and allow the farmer to assess the development over time and to respond appropriately.

Many of the most important core standards in animal welfare are directly observable animal-based measures that are the outcomes of bad practices or conditions. Stress is generated by environmental factors (i.e., heat, cold, humidity, dust, manure), facilities, handling, nutrition and health problems. Outcomes of these factors should be reflected in the animal conditions and behavior. Early detection of these animal welfare indicators is critical for optimizing treatment and prevention plans, minimizing impaired animal welfare, and reducing economic loss (Welfare Quality®, 2009; Grandin, 2010).

In this regard, body condition score (BCS), hock injuries, lameness and cleanliness of the cow were considered good animal-based welfare indicators due to implications in milk quality, milk quantity and reproduction (Cook, 2002; Waltner *et al*., 1993; Zurbrigg *et al*., 2005; Fulwider *et al*., 2007).

This paper is a characterization study of the farms types in Galicia. It describes direct welfare indicators based on animal measures (BCS, hock injuries, locomotion score/lameness, hygiene scoring) but also indirect measures based on facilities (five areas of the barn: resting, flooring, feeding, ventilation and milking) and management practices (cleanliness, preventive treatment programs, outdoor access) in 15 freestall with cubicles and 15 tiestall dairy cattle farms in northwestern Spain. Moreover, variation in animal-based welfare indicators was compared across both housing systems most common in Galicia.

MATERIALS AND METHODS

Farm selection and description

A sample of 15 freestall with cubicles (F) and 15 tiestall (T) Holstein dairies was selected for participation in the study. The dairies were recruited with the assistance of dairy veterinarian practitioners. Those farms agreeing to participate were visited between November 2011 and March 2012. The dairy farms were located in the province of Lugo (Galicia, NW Spain).

All farms were family with Holstein dairy cattle. Herd size averaged 55.9 ± 14.9 cows in F and 34.9 ± 10.9 cows in T. Cows averaged 4 years lactation and milk production averaged 8,978 kg/lactation. Age of the facilities (since the last restoration or as a new building) ranged from 5 to 20 in F and 5 to 30 in T. All farms milked the cows twice a day. Feed on F farms mainly consisted of total mixed ration (TMR) delivered once a day, while T farms fed cows separately with concentrate and silage twice a day.

During the assessment, humidity level ranged from 80 to 100% and temperature from 0 to 14ºC.

Data collection

Indicators were collected once by the same person (Y.T.) on every farm around the time of first milking which ranged from 7 to 9 am (cows were milked twice).

There were three parts on the assessment of each farm: 1) cows were observed and evaluated in the feed alley, 2) facilities were evaluated and rated by status of maintenance, and 3) dairy producers were interviewed (survey) to know management practices of facilities and herd. Animal-based measures were direct welfare indicators but facility measures and management practices were considered indirect welfare indicators because it may influence on the animal-based measures.

Animal-based measures

Body condition, hock injuries, lameness and hygiene of the cow's coat were considered animal-based measures. To avoid difference in the type of outdoors access, only cows kept indoors were scored for BCS, hock injuries, locomotion and hygiene. All lactating cows were assessed (n), 660 in F and 438 in T. Assessment of dry cows were made of 106 out of 178 dry cows in F (60%) and 20 out of 85 dry cows (23%). Every cow was unlocked (F) and scored by direct observation at a distance of 3 meters on average; cows were not unlocked in T (locomotion score was no assessed).

Body condition score: on each farm the cows were evaluated on a scale of 1 to 5 with 0.25 point increment (Edmonson *et al*., 1989). The spreadsheet designed by Coleen and Heinrichs (2004) was used to classify BCS within each herd as suitable, high (overweight) or low (underweight) based on days in milk (DIM). Thresholds for the lactating and dry cow period were established in the spreadsheet as follows: BCS of 2.5 to 3.5 for 0 to 30 DIM; BCS of 2.25 to 3.0 for 30 to 100 DIM; BCS of 2.25 to 3.0 for 100 to 180 DIM; and BCS of 3.0 to 3.5 for 180 to 300 DIM. The percentage of cows with unsuitable BCS across herds was considered for the analysis.

Hock injuries: the tarsal joints of each cow within the herd were evaluated. A hock scoring system was not applied, to minimize the time cows were immobilized by head locking (farmer's consent). Only the prevalence of cows with scratches, swelling, abrasions or trauma on one or both limbs either inside or outside the leg was considered on the prevalence.

Locomotion score: the cows were awarded a score of between 1 (sound) and 5 (severely lame) according to guidelines proposed by Sprecher *et al*. (1997). Percentage of cows with score 1, 2, 3, 4, 5 and lameness were reported by herd.

Hygiene score: lower leg (rear only), udder and upper leg/flank were scored on a scale between 1 (free of dirt) and 4 (covered with caked on dirt) according to guidelines reported by Schreiner and Ruegg (2003). Average of points by zones was reported within the herd.

Facility-based measures

Parameters were taken in five different areas of the barn either by observation or measuring (tape/laser). Stalls were randomly selected in each farm and average of measures from 10% of the stalls separate an interval of five each other were reported. Variables assessed in each area are described in **table I**.

Management practices of facilities and herd

Dairy producers were surveyed on: feed bunk and water troughs cleaning practices, frequency of water analysis, outdoor access for lactating cows, frequency of footbaths and hoof trimming routine (it does not necessarily imply a trimming, only an inspection), settings of mechanical ventilation when present, cow behavior in the milking parlor (≥15% of the cows/herd) which included cows do not enter in the parlor by themselves and signs of stress (defecation, urination, kicking, fast tail movements). The frequency of practices was reported in times per day and *when producers considered it necessary* (no daily routine).

Table I. Facility-based parameters collected in five areas of the freestalls with cubicles (n=15) and tie stalls (n=15) dairy cattle barns in northwestern Spain (Parámetros medidos sobre las instalaciones en cinco áreas de los establos libres con cubículos (n=15) y trabados (n=15) en ganaderías de vacuno de leche del Noroeste de España).

Area	Variable	Tools and data collection procedure (levels of the variables)
Resting	Stall stocking density	Number of cows/number of stalls*100 (continuous)
	Stall location	Against a side wall or head to head platform
	Stall dimensions	Described in figure 5 and 6
	Slope on the platform	Direct observation - slope towards the rear (yes/no)
	Rails design	Stall dividers (described by Juaristi *et al.*, 2004) Tiestall design (described by Buxadé, 1995)
	Bedding materials type	No materials, rubber mats, mattresses, straw/sawdust, sand
	Dryness of bedding	"knee test"- dry after 3 seconds kneeling on the bedding material (yes/no)
Flooring	Surfaces characteristics	Concrete: Slatted/grooved/flat; slippery/rough - by the graze of the boots
	Dirty alleys	Manure evenly covered the floor at a depth of at least 2 cm (yes/no)
	Rubber on the feeding floor	Feeding alley with rubber on the floor (yes/no)
	Alleys width	Back alley, feeding alley and crossovers (continuous)
	Blocked alleys	Mobile fences or chains obstructing linear circulation (yes/no)
Feeding	Drive-by feed alley width	Feed bunk width not included (continuous)
	Feed bunk characteristics	Materials and conditions (smooth/worn surface - by the graze of the boots)
	Feed bunk height	Cow platform to feeding platform difference (continuous)
	Feed bunk space/cow	Headlock's width (continuous)
	Feed bunk stocking density	Number of cows/number of headlocks*100 (continuous)
	Lighting on the feed bunk	Visual perception, feed bunk lighter than the rest of the barn (yes/no)
	Troughs characteristics	Materials (metal/concrete) and types (dumping/fixed)
	Linear watering space/cow	Total length from all accessible sides/number of cows (continuous)
	Covered feed bunk	Roof covering the feed bunk (yes/no)
Ventilation	Barn orientation	Compass - from the major axis of the stall (N-S, E-W, NE-SW, NW-SE)
	Roof condensation	Humidity and/or cobwebs at least 1m^2 in the roof and corners (yes/no)
	Insulating roofs	Sandwich plate (yes/no)
	Open sides and height	Direct observation (yes/no), sidewall to the roof (continuous)
	Open ridge	Direct observation (yes/no)
	Roof height	Measure from the floor to the middle of the roof (continuous)
Milking	Parlor location and design	Number of milking stalls (continuous), herringbone type (yes/no)
	Holding and release area	Direct observation (yes/no)
	Holding area space/cow	(width*lenght)/number of cows
	Floor characteristics in holding area	Slope (%): height/length*100 (continuous) Drawn parallel lines (yes/no)
	Milking area design	Straight design: cows can see the parlor from the holding area (yes/no) ≥2 turns: turns ≥ 90° in the entrance and exit paths to the parlor (yes/no)

Data analysis

Categorical variables are presented as the frequency (% of farms) and continuous variables as the mean and ranges within each housing system.

One-way ANOVA was used to compare the animal-based welfare indicators across both housing systems. Farm type was the independent variable and BCS, hock injuries, and hygiene were dependent variables. Values of $p<0.05$ were considered significant. Descriptive statistics and analysis made across farms were conducted with SPSS 9.0.

RESULTS AND DISCUSSION

Animal-based measures

Average of the percentage of cows in suitable BCS within each housing system was 49.3% (35.9 - 76.9) in F and 48.4% (31.3 - 59.5) in T **(figure 1)**. Following Coleen and Heinrichs (2004) recommendations for the interpretation of the BCS graph, keeping 95% of the herd within suitable BCS is an achievable target, so there are opportunities to improve it in this study. Any farm had at least 95% of the cows within suitable BCS to their DIM.

Overweight cows were greater ($p<0.05$) in F (28.9%) than T (10.5%) and underweight cows were more common ($p<0.05$) in T (41.1%) than F (21.8%). Only T had five herds (33.3%) with less than 5% of overweight cows. Variation in the prevalence of BCS within and across housing systems may be explained by different factors such as the ingredients type, feed available, feed bunk conditions, intake issues or injuries that might complicate the chewing or metabolic disorders, also decreasing reproductive and productive performance (Waltner *et al*., 1993).

Hock injuries were common in both housing systems which suggested a poor facilities design. Prevalence of hock injuries was 41.7% (12.0 - 86.3) in F and 38.5% (4.2 - 86.0) in T **(figure 2)**. There were three F and T herds (20.0%) respectively with less than 15% of the cows by herd with any lesion. Prevalence in F was less than in other studies: 73% (Weary and Taszkun, 2000), 60.5% (Kielland *et al*., 2009), 50% (Brenninkmeyer *et al*., 2013), however we can't further discuss it because the lesions severity should be considered to determine the cause and importance of each type of lesions within its location. E.x., Zurbrigg *et al*. (2005) found 44% of lesions (hair loss or skin breakage) in 317 tiestall farms and they mentioned this prevalence was less than in freestall studies. And, authors also were able to relate hock injuries with the stall dimensions and bed type.

Lameness has a multifactorial cause in relation with stall design, nutrition, genetic heritability etc. which may lead on reproduction and production failure (Cook, 2003, Espejo *et al*., 2006). Barker *et al.* (2010) reported some risk factors for increased lameness as the presence of damaged concrete in yards, cows turning sharply near the parlor entrance or exit and the use of automatic scrapers. The prevalence of score 3 was 3.6% and scores 4 and 5 were 5.0% and 2.2%, respectively. Therefore, lameness averaged 10.6% (0.0 - 21.0) in F farms **(figure 3)**, while score 2 was 24.8% (7.7 - 48.3). Considering the high prevalence of score 2 it may suggest a high probability to develop lameness if prevention and control is not applied (e.x., footbath protocols). However we couldn't predict this as monitoring is required to test such hypothesis.

Lameness observations were less than 5% in four F (26.7%) and less than 10% in seven F farms (46.7%). Sagüés (2003) recommended a locomotion score preva-

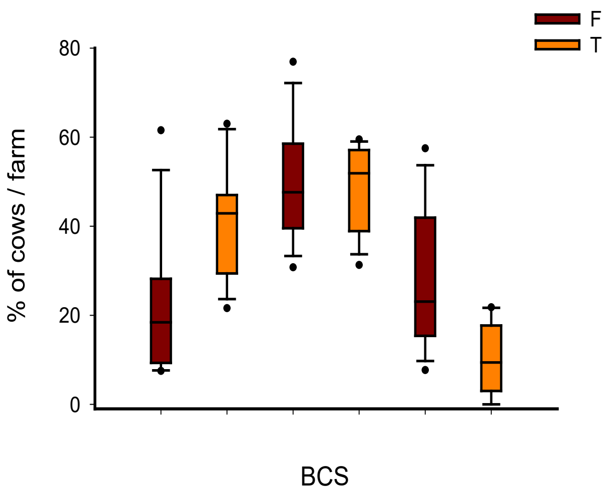

Figure 1. Distribution of the prevalence of cows with low, suitable and high BCS (Body condition score) to their DIM (days in milk) and, difference across 15 freestalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain. BCS = Body Condition Score; F = Freestalls; T = Tie stalls; */**= Significant prevalence (Distribución de la prevalencia de vacas con baja, adecuada y alta condición corporal con respecto a los días en leche y, diferencias entre 15 establos libres con cubículos (F) y 15 establos trabados (T) en ganaderías de vacuno de leche del Noroeste de España).

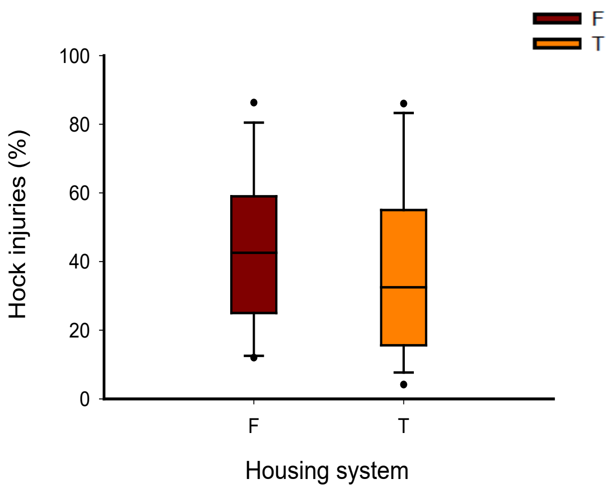

Figure 2. Distribution of the prevalence of hock injuries within 15 freestalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain. F = Freestalls; T = Tie stalls (Distribución de la prevalencia de las lesiones de corvejón en 15 establos libres con cubículos (F) y 15 establos trabados (T) en ganaderías de vacuno de leche del Noroeste de España).

Table II. Description of categorical variables (presented as herd percentage) of facilities in each area of 15 freestalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain (Descripción de las variables categóricas (presentadas en porcentaje de rebaño) de las instalaciones en cada área de 15 establos libres con cubículos (F) y 15 establos trabados (T) en ganaderías de vacuno de leche del Noroeste de España).

Categorical variable of facilities (% of farms)		Level	Housing system	
			F (n=15)	T (n=15)
Resting area	Stall location	Against a side wall	26.7	_
		Head to head platform	73.3	_
	Slope on the platform	Yes	60.0	40.0
		No	40.0	60.0
	Bedding materials type	No bedding (concrete)	6.7	46.7
		Rubber mats	66.7	13.3
		Mattresses	13.3	26.7
		Sand or straw	13.3	13.3
	Dryness of bedding	Yes	66.7	60.0
		No	33.3	40.0
Feeding area	Feed bunk characteristics	Smooth	53.3	20.0
		Worn	46.7	80.0
	Covered feed bunk	Yes	100	100
		No	0.0	0.0
	Feed bunk lighter than the rest barn	Yes	40.0	66.7
		No	60.0	33.3
Ventilation area	Barn orientation	E-W	33.3	26.7
		N-S	20.0	53.3
		NE-SW	40.0	0.0
		NW-SE	6.7	20.0
	Roof condensation	Yes	20.0	60.0
		No	80.0	40.0
	Insulating roofs – sandwich plate	Yes	60.0	20.0
		No	40.0	80.0
	Open ridge presence	Yes	0.0	0.0
		No	100	100
	Open sides	Yes	80.0	6.7
		No	20.0	93.3

lence of 75% for score 1, 15% score 2, 9% score 3, 0.5% score 4 and 0.5% score 5. However, prevalence of locomotion score 1 of the assessed farms did not reach the suggested target (64.4%), so is important to consider management practices and environmental conditions, as previously described on materials and methods to be able to justify maybe these recommendations are not an achievable target for this region, and also to understand the importance of describing parameters for a group of farms with similar management practices and environmental conditions. Moreover Grandin (2010) asserted that less than 5% of lame cows represent an excellent level, over 10% should not be acceptable from a welfare perspective. The mean prevalence of lameness in other studies were as high as 36.8% in UK (Barker *et al*., 2010), 24.6% in Minnesota (Espejo *et al*., 2006), 23.9% in Wisconsin (Cook, 2003) or as low as 5.1% in Sweden (Manske *et al*., 2002), suggesting management practices make a difference as weather conditions may be similar for those places.

Hygiene score variation is associated with manure transfer depending on cow behavior and facilities cleaning which include: direct transfer (cows may lie down in manure), leg transfer (walking through the manure, slipping and splash transfer) or tail transfer (Cook, 2002). The dirtiness of the cow's coat was high in both barn types. Average of udder hygiene (F: 2.1, T: 2.2 points) and upper leg/flank (F: 2.3, T: 2.4 points) was similar across farms **(figure 4)**. Lower leg hygiene showed higher scores ($p<0.01$) in F than T (3.0 vs 2.4 points on average) which could be easily explained by the the freedom to walk on dirty alleys vs tie-stalls. Those results suggest the lack of the routine on the use of automatic scrappers as we discus in the flooring section.

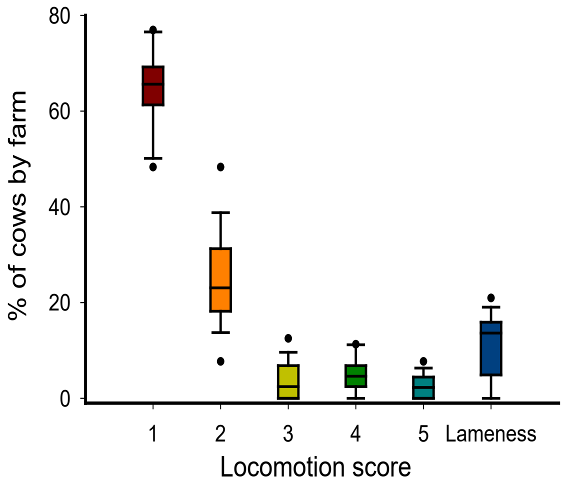

Figure 3. Distribution of the prevalence of locomotion score and lame cows within 15 freestalls with cubicles dairy cattle farms in northwestern Spain (Distribución de la prevalencia de puntuación de la locomoción y vacas cojas en 15 establos libres con cubículos en ganaderías de vacuno de leche del Noroeste de España).

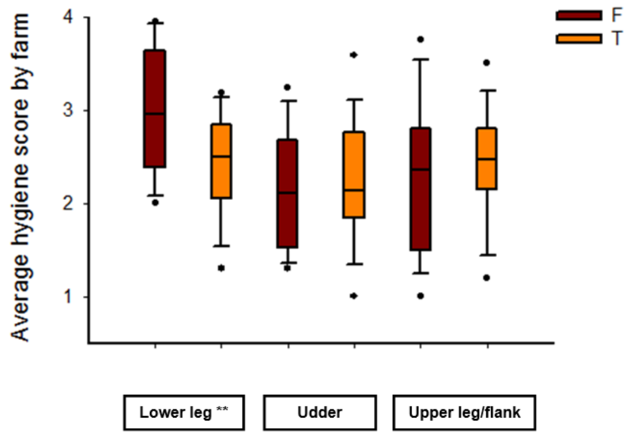

Figure 4. Distribution of the average hygiene score and difference (*p>0.05, **p>0.01) across 15 freestalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain. F = Freestalls; T = Tie stalls; */= Significant prevalence** (Distribución de la media de puntuación de higiene y diferencias (*p>0,05, **p>0,01) entre 15 establos libres con cubículos (F) y 15 establos trabados (T) en ganaderías de vacuno de leche del Noroeste de España).

Average hygiene score by herd less than 2.0 points was: lower leg – F (n=0) and T (n=2), udder – F (n=7) and T (n=4), upper leg/flank – F (n=6) and T (n=2). In other studies, average hygiene score in freestall barns were 2.1 for udders and 2.3 for legs (Schreiner and Ruegg, 2003) and implications were of linear somatic cell scores increasing as udder hygiene score increased. Popescu *et al*. (2009) showed the dirtiest area was the upper leg and flank, followed by lower leg and the udder in tie-stalls and they concluded it happened because of lying down in the manure deposited in stalls.

Facility-based measures and management practices of facilities and herd

Measurements of the facilities were summarized into five areas evaluated of the barn (resting, flooring, feeding, ventilation and milking). Most of categorical variables are reported in **table II** and continuous variables in **table III**. Regarding management practices, most results are presented in **table IV**.

Dry cows were on pasture during the year either in F (40.0%) or T (73.3%). Lactating cows were allowed outdoor access (exercise area) only during warm and dry weather.

Resting area

Free stalls were overcrowded based on stall availability (26.7%), up to 111% of capacity. In overcrowded dairies, dry and lactating cows were housed in the same pen separated by chains and/or mobile fences (n=3) or not (n=1). This may impede linear circulation and cows feel stressed when cornered.

All producers reported bed maintenance that mainly consisted on removing feces from the stall. Moreover, beds in concrete, rubber mats and mattresses (n=13) were added calcium bicarbonate either in F (n=11) or T (n=7) and, all beds (n=2) of sand or straw were groomed (racked) and replaced *when they considered it necessary*, therefore it suggest a lack of cleaning protocols.

Based on our stall evaluation **(table III)** there was a big range of variation in F and T measurements. A total of ten F (66.7%) and three T farms (20.0%) had adequate stall width (115 - 122 cm). Three F (20.0%) might be too width (>125 cm). In contrast, eleven T (73.3%) were too small (<115 cm). Some of F (26.7%) provided cows with stalls that were well length dimensioned based on 178 – 182 cm but 53.3% had too big stalls (>190 cm). In this regard, all T farms (100%) were too short in length (<180 cm). Only two F (13.3%) placed the high lateral bar in adequate height (30 - 35 cm), the other 86.7% were too high (>40 cm). Big dimension may allow diagonal positions when resting and consequently more manure inside of the bed which will promote the dirtiness of the cow's coat, whereas small dimensions may lead on a lack of comfort and therefore more cows standing on the stall

Neck rail was placed in adequate height (115 - 122 cm) in 33.3% of F farms, but 53.3% were considered too short (<115 cm) which may contribute to regret the lying position as the cow hits the head or the neck with the rail during the movement to get down. Therefore it may also increase the time standing on the stall (Cook, 2003).

In F, front lunge space was adequate in 26.7% farms (>90cm) but it was too small (<90 cm) in 73.3%. Small front lunge space at freestalls can provide social obstruction (Anderson, 2007a) and too width stalls can contribute diagonal positions (Bickert *et al*., 2000). Different type of divider designs and bar position may explain range of variation in lateral bars height.

Data suggested most T farms were too small in dimensions but also in some F farms.

Table III. **Description of continuous variables (presented as mean and range) of facilities in each area of 15 freestalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain** (Descripción de las variables continuas (presentadas en porcentaje de rebaño) de las instalaciones en cada área de 15 establos libres con cubículos (F) y 15 establos trabados (T) en ganaderías de vacuno de leche del Noroeste de España).

Continuous variable of facilities (mean, range)		Housing system	
		F (n=15)	T (n=15)
Resting area	Bed width (cm)	116 (90 - 130)	107 (70 - 124)
	Bed length (cm)	191 (165 - 220)	143 (104 - 147)
	Brisket locator height (cm)	14 (0 - 30)	_
	Total stall length (cm)	250 (220 - 285)	_
	Low lateral bar (cm)	30 (0 - 70)	_
	High lateral bar (cm)	50 (35 - 70)	_
	Neck rail height (cm)	114 (95 - 145)	_
	Neck rail position (cm)	153 (85 - 190)	_
	Front lunge space (cm)	64 (0 - 105)	_
	Rear curb height (cm)	26 (18 - 30)	8 (0 - 33)
	Bed height (cm)	_	162 (105 - 178)
	Grid width (cm)	_	66 (22 - 97)
	Grid-wall space (cm)	_	146 (104 - 217)
Feeding area	Drive-by feed alley width (cm)	490 (350 - 620)	≥230*
	Feed bunk space/cow (cm)	64 (50 - 70)	_
	Feed bunk height (cm)	12 (0 - 26)	8 ((-5) - 32)
	Linear watering space/cow (cm)	9 (4.3 - 13.1)	1 water bowl / 2 cows

* Lack of uniformity along the alley due to enlargements in the construction.

Flooring area

Only F farms were assessed and all used automatic scrapers. Most common surfaces were grooved concrete (86.7%) and two of them were slippery. Only one farm was flat (no grooved) and rough concrete and, another one slatted and also rough concrete. Moreover, two of the farms (13.3%) were dirty floors which combined with concrete floors can reduce walking speed and increase the risk of slip or fall (Rushen and de Passillé, 2006). Only one farm (6.7%) had rubber on the feeding alley which provide higher traction, and benefit walking and mounting when compared to concrete flooring (Ouweltjes, 2008).

Crossovers width averaged 187 cm (100 - 350) and 80% had a curb which was 21.4 cm (5 - 30) in height, disturbing the linear circulation flow. Feeding alley width was 415 cm (240 – 500) and 53.3% of the farms had less than 420 cm. Width feeding alleys are recommended to allow at least two rows of cows walking behind the ones eating (Bickert *et al*., 2000).

Back alley width was 340 cm (200 – 620) and 46.7% of the farms had less than 350 cm. As mentioned before, chains and/or mobile fences blocked alleys (26.7%) which may limit linear circulation and increase the stress in situations where the cow feels cornered (Juaristi *et al*., 2004).

Some farms had footbath capability but either they were not being used or they fail to properly implement a footbath protocol. This may contribute to locomotion by reducing dermatitis.

Feeding area

The most highlighted issues were the small dimensions of the platform height and space at the headlocks.

Feed bunk at 10 - 15 cm above the cow alley rather than in an elevated bunk increases salivary flow and reduces sorting, which may help reduce acidosis (Albright, 1993; Anderson, 2007a). Platform height above cow platform was adequate in 40% of F and 13.3% of T and it was too high (>15 cm) in 26.7% of F and 20.0% of T.

At least one headlock per cow 60 - 75 cm on width is required to avoid feeding competitions. Subordinate cows are more frequently affected by reduced space at feed bunk, decreasing intakes or stand up time without any activity (Albright, 1993). Space per cow (headlocks width) was smaller than 60 cm in 20.0% of the farms. Overcrowded at headlocks (26.7%) were also overcrowded at cubicles. Overcrowding at headlocks was explained by blocked alleys like overcrowding at cubicles (chains or mobile fences reduce space available).

All producers cleaned the feed bunk before dropping the feed in the morning. Guidelines of cleanliness are at least twice a day (Juaristi *et al*., 2004; Callejo, 2009). Worn materials are difficult to clean and, at feed bunk leftovers can easily spoil in the hole or crevices and in the case of worn floors can be a barrier for cows walking.

Three F farms (20.0%) had a linear watering space less than 8 cm per cow which may limit water access to some cows on the barn (considering dominant cows the first one on benefit from sources). Moreover, quality and cleanliness of the supplied water (e.g. algae

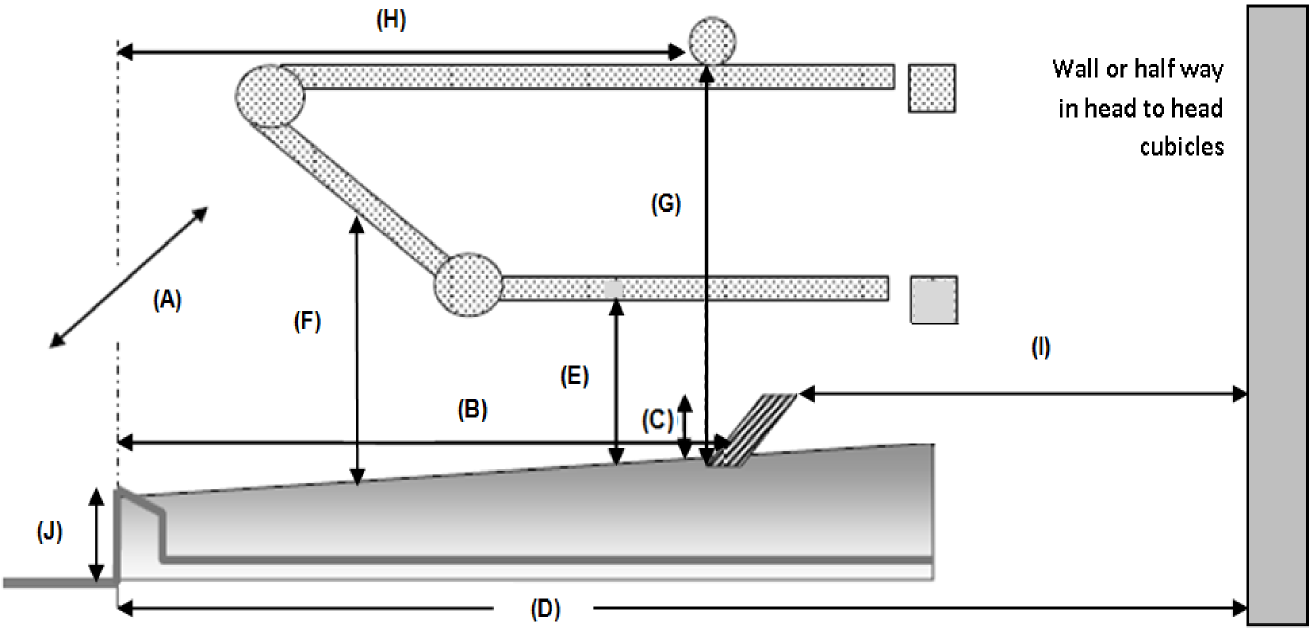

Figure 5. Freestall dimensions. Bed width (A), from the middle of one side divider to another; bed length (B), from the external side of the rear curb to the internal side of the brisket board; brisket locator height (C), vertical line from the bottom to the top; total stall length (D), from the external side of the curb to the middle front with the other cubicle or to the wall; low lateral bar (E), and high lateral bar (F), from the bed to the bottom of the bar; neck rail height (G) from the bedding surface to the bottom of the rail; neck rail position (H), distance from the vertical plane above the rear curb to the internal side of the rail; front lunge space (I), distance from the middle of the brisket locator to the half way with the another cubicle or to the wall (if there was not a brisket locator the reference was the neck rail); rear curb height (J), from the bottom of the alley to the top. Source: adapted from University of Wisconsin-Madisson (Dimensiones del cubículo. Ancho de cama (A), desde la mitad de una barra divisoria a otra; largo de cama (B), desde el extremo exterior del escalón hasta el extremo interior de la almohada; altura de la almohada (C), línea vertical desde la parte inferior a la superior; longitud total del cubículo (D), desde el exterior del escalón hasta la mitad del espacio frontal o extremo de la pared; barra lateral baja (E) y barra lateral alta (F), desde la cama hasta la parte inferior de la barra; altura de la barra del cuello (G), desde la superficie de la cama hasta la parte inferior de la barra; posición de la barra del cuello (H), distancia en un plano vertical desde la parte exterior del escalón hasta la parte interna de barra; espacio frontal libre (I), distancia desde el medio de la almohada hasta la mitad del espacio disponible en cubículos enfrentado o extremo interior de la pared (si no había almohada la referencia fue el medio de la barra del cuello); altura del escalón de la cama (J), desde la parte inferior del pasillo hasta la superior. Origen: adaptación de la Universidad de Wisconsin-Madisson).

contamination, manure or urine may change the palatability) may limit water intake to the point of dehydration (Phillips, 2008).

Barns built in Galicia might have limited sunlight due to short daylight hours especially during the cold season and electrical systems are required to ensure enough visibility at the feed bunk, in this regard evaluation was made considering natural and artificial light.

Ventilation area

Measurements took in this area could help to indirectly asses ventilation. Poor ventilation might stress the immune system and cows might be more susceptible to disease, decreasing well-being and productivity. Most ventilation problems associated with dairy barns are due to inadequate design, construction, and/or operation of the facility.

Barn design may contribute with natural ventilation allowing big open sides to promote air flow. Less signs of condensation were observed in F than in T **(Table II)** also, more open sides were available in F (80.0%) than in T (6.7%). Open sides averaged 132.7 cm (80 - 400) in F and only one F had a 75% of the sidewalls height open. One T had an open side with a height of 250 cm, 93.3% of T were closed with small windows. Also roof height was less in T, 500 cm (300 - 600), than in F, 600 cm (400 - 700).

Callejo (2009) reported barn orientation in cold regions is not a challenge. Juaristi *et al*. (2004) and Buxadé (1998) recommended E-W barn orientation in hot climate and, N-S in cold climate. This study showed a big variation in both housing systems orientation suggesting guidelines for building construction following other patterns. Barn orientation in Galicia might be considering a key building design to avoid doming air flows bringing water inside of the barn in winter time. Moreover, fog is common in Lugo, so roof insulation might help to avoid large temperature variation inside barns (no more than 12°C). Also, open sidewall at the height of 75% is recommended to properly ventilation (Bickert *et al*., 2000). Lack of proper ventilation can lead to high moisture levels, manure gases, pathogens and dust concentrations creating an adverse environment for dairy cows. Due to shifting wind was difficult to

Table IV. Description of categorical measures (% of farms) of management practices of facilities and herd in 15 freestalls with cubicles (F) and 15 tie stalls (T) dairy cattle farms in northwestern Spain (Descripción de las medidas categóricas (% de ganaderías) y prácticas de manejo de las instalaciones y el rebaño en 15 establos libres con cubículos (F) y 15 establos trabados (T) en ganaderías de vacuno de leche del Noroeste de España).

Management variable (% of farms)	Level	Housing system	
		F (n=15)	T (n=15)
Frequency of outdoor access (lactating cows)	Pasture	20.0	6.7
	Exercise area	46.7	0.0
Frequency of bed cleaning	*When necessary*	13.3	40.0
	Once a day	13.3	26.7
	Twice a day	73.3	33.3
Hoof trimming routine	*When necessary*	33.3	46.7
	Once a year	33.3	20.0
	Twice a year	13.3	20.0
	More than twice a year	20.0	13.3
Frequency of drive-by feed alley cleaning	*When necessary*	13.3	40.0
	Once a day	66.7	33.3
	Twice a day	13.3	26.7
	Three times a day	6.7	0.0
Frequency of feed bunk cleaning	*When necessary*	6.7	6.7
	Once a day	86.7	73.3
	Twice a day	6.7	20
Frequency of trough cleaning	*When necessary*	46.7	73.3
	Once a day	46.7	26.7
	Twice a day	6.7	0.0
Frequency of water analysis	≥1 year	100	93.3
	< 1 year	0.0	6.7

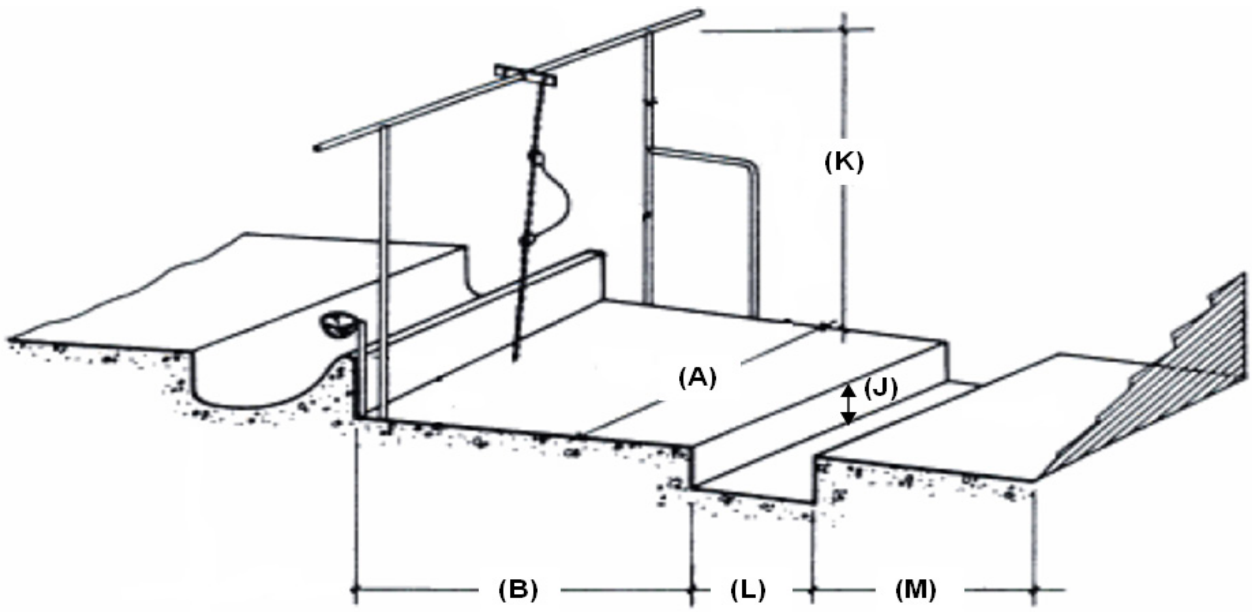

Figure 6. Tiestall dimensions. Bed width (A), from the middle of one side lateral barrier to another; bed length (B), measured from the external side of the curb to the internal side of the feeding wall; rear curb height (J), from the bottom of the grid to the top; bed height (K), from the bed to the bottom of the top barrier on the stall; grid width (L), distance from the external side of the curb to the external side of the back alleys curb; grid-wall space (M), the back alley width, from the end of the grid to the wall. Source: García-Vaquero, 1987. In Buxadé, 1995 (Dimensiones del establo trabado. Ancho de cama (A), desde la mitad de una barra divisoria a otra; largo de cama (B), desde el extremo exterior del escalón hasta el extremo interior de la almohada; altura del escalón (J), desde el fondo de la parrilla hasta la superficie; altura del barrote de cama (K), desde la superficie de la cama hasta la parte inferior del barrote de cama; ancho de la parrilla (L), distancia desde el lado exterior del escalón de la cama al lado exterior del escalón del pasillo; espacio pared - emparrillado (M), ancho del pasillo posterior, desde el final de la parrilla a la pared. Origen: García-Vaquero, 1987. En Buxadé, 1995).

measure the air movement inside the barn so condensation on the roof and/or cobwebs was observed to assess it.

Milking area

A tie stall milking system was available in every T farm. Only F was assessed in this area. Every milking area was communicated with the barn through a door (in the entrance of the milking parlor or holding area when available). Holding area was available in eleven farms (73.3%), space per cow averaged 1.5 m^2 (0.7 - 2.3) and it was less than 1.3 m^2 in three of them. Only one farm had a walkway or release area (prior to the holding area).

Observations showed 46.7% of barn designs did not allow cows to look at the milking parlor before entering into it (no straight design). Presence of holding area or release area might improve cow attitude at milking time when it allows previous visualization of the parlor because is associated with oxytocin production (Callejo, 2009). At least 1.3 m^2 per cow at the holding area is recommended (Bickert *et al*., 2000).

Slope averaged 4.8% (0 - 9.2) and 20.0% of the farms had adequate slope (2 - 4%) however 46.7% were too high (>4%). Slope down 2 to 4% away from the parlor is beneficial for cows entering into it and to keep the peace in waiting before entering in the milking parlor. Six out of eleven dairies with a holding area had parallel lines drawn on the floor which may help on traction.

Moreover, 53.3% of the farms had more than two turns of 90° in the entrance/exit paths to the parlor which can slow cow movement (Juaristi *et al*., 2004; Bickert *et al*., 2000).

Stress factors in the milking parlor may include flies, slippery floors, bad ventilation, small stands and a restless milker. Cow reactions to parlor stress (>15% of cows/herd) were more common in F (40.0%) than in T (6.7%). Producers reported cows entering by themselves in the parlor in 46.7% of farms but it did not happen in the four farms without holding area and also observations showed cows could not look at the milking parlor before arrival.

A follow-up was made through a confidential report provided by individual farms. A benchmarking process allowed farmers compare their herd across the other dairies. Our intention was bring to farm the general concept of animal welfare which involves different areas of assessment and it is recommended to monitor direct and indirect measurements of animal welfare.

CONCLUSION

Animal welfare level was poor in most farms and housing systems, and highlight tie stalls had big opportunities for improvement regarding the different assessed measures.

Animal-based welfare indicators at herd-level had a big range of variation within and across both housing systems. Worst results were observed on the dirtiness of the cows coat followed by hock injuries. Although lameness incidence was high, it did not impede the locomotion of cows.

Considering facilities design and management practices, critical points were at the small space per cow in tie stalls, too narrow alleys in freestalls, inadequate barn design to promote natural ventilation and also the holding area design to facilitate the entrance in the milking parlor.

None of the farms performed consistently well or badly across parameters however all farms could benefit from others to prevent and control several aspects of the animal welfare by changing several management practices.

ACKNOWLEDGMENTS

We thank veterinarians collaborating in this study and also producers for allow data collection on the farm.

BIBLIOGRAPHY

Albright, J.L. 1993. Feeding behavior of dairy cattle. *J Dairy Sci*, *76*: 485-498.

Anderson, N. 2007a. Free stall dimensions. Infosheet. Livestock technology. Ministry of Agriculture, Food and Rural Affairs. OMAFRA. Ontario. pp: 1-15.

Barker, Z.E.; Leach, K.A.; Whay, H.R.; Bell, N.J. and Main, D.C. 2010. Assessment of lameness and prevalence and associated risk factors in dairy herds in England and Wales. *J Dairy Sci*, 93: 932-941.

Bickert, W.; Holmes, B.; Janni, K.; Kammel, D.; Stowell, R. and Zulovich, J. 2000. Dairy freestall housing and equipment (MWPS-7). MidWest plan service. Ames, IA.

Brenninkmeyer, C.; Dippel, S.; Brinkmann, J.; March, S.; Winckler, C. and Knierim, U. 2013. Hock lesion epidemiology in cubicle housed dairy cows across two breeds, farming systems and countries. *Prev Vet Med*, 109: 236-245.

Buxadé, C.C. 1995. Zootecnia: Bases de la producción animal. Tomo VII: Producción vacuna de leche y carne. Ed. Mundi-Prensa. Madrid.

Buxadé, C.C. 1998. Zootecnia: Bases de Producción Animal. Monografía II: Alojamiento e instalaciones. Ed. Mundi-Prensa. Madrid. España.

Callejo, A. 2009. Cow Comfort, el bienestar de la vaca lechera. Ed. SERVET. Zaragoza. España. 516 pp.

Coleen, J. and Heinrichs, J. 2004. Manual for body condition scoring. Excel Spreadsheet series. Pennsyvania State University (05/05/2013).

Cook, N.B. 2002. The influence of barn design on dairy cow hygiene, lameness, and udder health. Proc. of the 35th Ann Conv Amer Assoc Bov Pract. Madison, WI. Amer Assoc Bov Pract Rome, GA. pp. 97-103.

Cook, N.B. 2003. Prevalence of lameness among dairy cattle in Wisconsin as a function of housing type and stall surface. *J Am Vet Med Assoc*, 223: 1324-1328.

Edmonson, A.J.; Lean, I.J.; Weaver, L.D.; Farver, T. and Webster, G. 1989. A body condition scoring chart for Holstein Dairy Cows. *J Dairy Sci*, 72: 68-78.

Espejo, L.A.; Endres, M.I. and Salfer, J.A. 2006. Prevalence of lameness in high-producing Holstein cows housed in freestall barns in Minnesota. *J Dairy Sci*, 89: 3052-3058.

Fulwider, W.K.; Grandin, T.; Garrick, D.J.; Engle, T.E.; Lamm, W.D.; Dalsted, N.L. and Rollin, B.E. 2007. Influence of free-stall base on tarsal joint lesions and hygiene in dairy cows. *J Dairy Sci*, 90: 3559-3566.

Grandin, T. (Ed.). 2010. Improving animal welfare. a practical approach. CABI Publishing. Colorado State, USA. 336 pp.

Juaristi, J.L.; Bach, A. and Rodríguez, P. 2004. Cow comfort. Cuaderno de campo Ivomec. Ed. Merial. Barcelona. España. 221 pp.

Kielland, C.; Ruud, L.E.; Zanella, A.J. and Østerås, O. 2009. Prevalence and risk factors for skin lesions on legs of dairy cattle housed in freestalls in Norway. *J Dairy Sci*, 92: 5487-5496.

Manske, T.; Hultgren, J. and Bergsten, C. 2002. Prevalence and interrelationships of hoof lesions and lameness in Swedish dairy cows. *Prev Vet Med*, 54: 247-263.

Ouweltjes, W. 2008. Influence of floor type on animal behaviour and milk production. Proceedings of the 15th International Symposium and 7th Conference on lameness in ruminants. Kuopio, Finland 9-13th June, 2008. pp. 57-63.

Phillips, C. 2008. Feeding and nutrition. The welfare of cattle. Springer. Dordrecht, NE. Vol 5. pp: 226 -227.

Popescu, S.; Borda, C.; Hegedus, I.C.; Sandru, C.D. and Lazar, E. 2009. Evaluation of the hygiene level in dairy shelters with tie-stalls. *Bull Univ Agric Sci Vet Med Cluj-Napoca*, 66: 253-258.

Rushen, J. and de Passillé, A.M. 2006. Effects of roughness and compressibility of flooring on cow locomotion. *J Dairy Sci*, 89: 2965-2972.

Sagüés, A.G. 2003. Cuidado de pezuñas en vacuno lechero. Cuaderno de campo Ivomec. Ed. Merial. Barcelona. España. 186 pp.

Sprecher, D.J.; Hostetler, D.E. and Kaneene, J.B. 1997. A lameness scoring system that uses posture and gait to predict dairy cattle reproductive performance. *Theriogenology*, 47: 1179-1187.

Schreiner, D.A. and Ruegg, P.L. 2003. Relationship between udder and leg hygiene scores and subclinical mastitis. *J Dairy Sci*, 86: 3460-3465.

Waltner, S.S.; McNamara, J. and Hillers, J. 1993. Relationships of body condition score to production variables in high producing holstein dairy cattle. *J Dairy Sci*, 76: 3410-3419.

Weary, D.M. and Taszkun, I. 2000. Hock lesions and free-stall design. *J Dairy Sci*, 83: 697-702.

Welfare Quality ®Assessment Protocol for Cattle. 2009. IBSN/EAN 978-90-78240-04-4. 180 pp.

Zurbrigg, K.; Kelton, D.; Anderson, N. and Millman, S. 2005. Tie-stall design and its relationship to lameness, injury, and cleanliness on 317 Ontario dairy farms. *J Dairy Sci*, 88: 3201-3210.