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Assessment of dairy cows comfort in Algerian farms by the Welfare Quality® Protocol

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ABSTRACT. The objective of this study was to determine the frequency and degree of discomfort in dairy cows and the risk factors associated by taking into account six animal welfare indicators included in the Welfare Quality® Protocol (WQ®): lying time, lying outside lying area, collision and cleanliness assessed on three body areas: udder, hindquarters and hind limbs. These indicators were carried out on 1,200 dairy cows belonging to 100 dairy farms in the province of Algiers, which 53% were kept in permanent tie stalls and 47% in partial tie stalls. Observation results showed a low average overall score of comfort (40.8 ± 10.62). This was mainly related to a long lying time (5.9s ± 0.89) of which 41.0% of the farms surveyed exceeded the alert threshold (>6.3s) and 39.0% the alarm threshold (>5.2s), a very high degree of dirtiness in udder (62.6%±21.9), hind quarters (60.6%±21.5) and hind limbs (60.6±21.4). As a result, the majority of farms exceeded the alert thresholds: 100.0% (udder), 86.0% (hindquarters) and 63.0% (hind limbs). Highly significant correlations were observed between the different aspects of comfort assessed ($p < 0.0001$). To reconcile dairy cows' welfare and productivity, it is essential to improve their comfort.

Keywords: Lying time; lying outside lying area; collision; cleanliness; score; correlation.

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Introduction

Comfort has become a major issue in farms today's in order to optimize milk production and ensure their well-being. Indeed, it improves the physical and psychological of animal health and promotes the expression of its natural behavior (Munksgaard, Jensen, Pedersen, Hansen, & Matthews, 2005; Jensen et al., 2005; Norring & Valros, 2016). This cannot be done without satisfaction of their basic needs (food, movement, rest and lying). When these needs were altered, cows present an increased risk for lameness (Bowell, Rennie, Tierney, Lawrence, & Haskell, 2003) and injuries (Winckler, 2008; Plesch, Broerkens, Laister, Winckler, & Knierim, 2010).

As a result, there is an excessive source of pain and suffering reflecting a state of discomfort and a degraded level of well-being. The latter may be the result of an unsuitable environment, insufficient space per animal, uncomfortable flooring (lack of bedding, slippery floor), poor activity opportunities, high density, etc. ..... This state of discomfort refers to a situation of disharmony between the animal and its environment, which tries to use all the means of adjustment avaible to adapt to its environment. But if the situation is prolonged, the suffering increases and manifests itself through the appearance of various pathologies and injuries.

This reflects the situation of Algerian dairy cattle farms where the number of pathologies is high and often concomitant, the most dominant being mastitis (Kebbal, Baazize-Ammi, Gharbi, Hanzen, & Guetarni, 2020) and lameness. The latter are associated with a high number of injuries (hock, knee, hindquarters), which are often the cause of early culling, and with a very dirty state (udder, hindquarters and rear legs). These disorders are major sources of pain and discomfort for cows (European Food Safety Authority [EFSA], 2009), and economic losses for producers (Enting, Kooij, Dijkhuizen, Huirne & Noordhuizen-StSsen, 1997), thus impairing productivity, longevity and welfare of dairy cows. These severe constraints on dairy farming severely limit its development and sustainability.

In order to address this situation and to better understand the needs of livestock for better welfare and productivity, several studies have addressed problem of discomfort in dairy farms by relying on measures

taken on animal's environment such as the length of stalls and cubicles (Husfeldtand & Endres, 2012; Cazin, Nicks, & Dufrasne, 2014) and other based on measurements taken directly on the animal which really and objectively reflect its state of well-being (De Boyer des Roches et al., 2014).

In this context, the main objective of this study was to determine the frequency and degree of discomfort on Algerian dairy farms and to target the risk factors that contributed to their occurrence by simple means of observation without aversive manipulation of the animal in a perspective of improvement.

Material and methods

Ethical approval

No manipulation which harms the well-being of cows surveyed was carried out during our study, only observations have been made.

Study

The present study was carried out in 100 dairy farms in the province of Algiers (Mitidja), located on the north-central coast of the country, with 1200 dairy cows (12.0 ± 7.9 cows/farm), with a minimum of 6 cows by farm and a maximum of 53 having an average daily milk production of 16 L. These cows belonged to different breeds: Holstein (44.6%), Montbeliarde (34.3%), Fleckvieh (9.7%) and Brown Swiss (11.4%), with an average of 2 breeds per farm. The farms visited are conducted in permanent (53.0) or partial (47.0%) tied stall with access to outdoor loafing area (28.0%) or a pasture (19.0%) from spring to summer The choice of the study sample was made from the list of cattle farmers in the province of Algiers. This list contains only the ones selected according to production type (dairy cattle), farms joining the national milk rehabilitation program (which requires the possession of health approval for enabling them to deliver their milk directly to a government processing unit or milk through a milk collector), the number of dairy cows ($\geqslant 6$) (minimum to have a health approval), the availability and cooperation of farmers to collect information. The visits to 100 selected farms were organized according to a well established schedule with the owners of these farms.

The choice was based on 6 indicators included in the European Welfare Quality® (2009) protocol for dairy cattle: lying time, lying outside the lying area, collision and cleanliness assessed on three body areas: udder, hind limbs and hind train. These indicators concerned a very important aspect of animal welfare, housing and farmer management and its impact on farm animal comfort. This choice was motivated by the fact that these indicators can be easily spotted on the animal, which allows early detection of the problem in order to act quickly to relieve the animal's pain. In addition, this does not require the animal to be handled in an aversive and stressful manner, or the application of a cumbersome and time-consuming detection method or technique. These indicators are defined in terms of alert and alarm thresholds (Welfare Quality®, 2009), which allow the observer (whether a researcher or a farmer) to be alerted to the extent and severity of the situation, e.g. the degree (severe, mild, minimal) and duration of the impairment (acute or chronic), in order to act quickly to improve the situation.

The observations on cows started just after the morning milking and lasted one day per farm. To facilitate the recording and analysis of the observations, observation sheets were designed and used for each farm, based on the WQ® (2009) Protocole, containing data on the animal condition; the degree of freedom (access to a pasture or loafing area); their comfort (cleanliness, injuries, difficulty in lying down and getting up, etc.), which made it possible to characterize the farms surveyed while situating their welfare level. Once all the measurements had been completed, the comfort scores were calculated.

Calculation of scores

The calculation of comfort scores around resting involves the calculation of a weighted sum for each measure of comfort according to alert and alarm thresholds defined by the WQ® (2009).

Statistical analysis

Data processing was performed using Genstat Version 15.0 software (VSN International Ltd., UK). Descriptive statistics (mean, standard error, min and max) were used to describe the well-being level of surveyed farms on the comfort aspect. Also, identify the existence of co-variability between the different measurements of well-being studied by Pearson correlation tests and Chi-square test. The threshold of significance was set at 0.05.

Results and discussion

The results of the present study showed that the farms surveyed welfare varied according to the farming systems and management. The latter had a strong influence on animal comfort, which explains the low score obtained in our study (40.8±10.62) with moderate variability (min: 16.50; fax: 58.70) between the farms visited. This refers to similar results obtained by De Boyer des Roches et al. (2014) in France (36.4±1.5) or lower ones found by Silva (2013) in Portugal (28.40±29.5). This discomfort state is mainly related to a longer lying time, a very pronounced state of dirtiness in different animal's body area and to a lesser degree to problems of collisions and lying outside the lying area, which explains the significant correlations found in this study. This shows that housing conditions have a significant influence on the comfort of surveyed farms and thus on their welfare (Webster, 2003; Hristov, Vučinić, Relić, & Stanković, 2006; 2007; Veissier, Beaumont, & Levy, 2007).

Time needed to lie down

Lying time (average duration and frequency) is a very important and determining criterion to measure the animal's comfort and can serve as an indicator of the ease with which the cow can perform it. Indeed, when they lie down or stand up, cows go through a kneeling position. At this point, the knees carry more than half the body weight and the softness of the floor will inevitably affect the comfort of the animals. Hard floors may cause them to lie down less often, and this may be partially compensated by an increase in the average lying time (Rushen, Haley, & de Passille, 2007; Cazin et al., 2014).

In our study, the average time taken by cows to lie down was (5.9s± 0.89) with moderate variability (min: 4.0s and max 8.1s) (Table.1), between farms visited. This mean time was similar to that of De Boyer des Roches et al. (2014) in France (5.9 ± 0.1 s). However, it is in contrast to several studies in other countries: Brorkens et al. (2009) (4.15 ± 1.0s); Silva (2013) (4.93 ± 1.15) and Ostjic-Andric (2011) (6.53 ± 0.45s).

Table 1. Scores of criterion "comfort around resting of farms surveyed.

Measures	(M±SE)	Min	Max
Time needed to lie down (s)	5.90 ± 0.89	4.04	8.11
% of cows lying outside the lying area	3.00 ± 9.31	0.00	62.5
% of cows colliding with housing equipment	3.00 ±9.56	0.00	57.1
% of cows with dirty udders	62.60 ±21.9	20.0	100
% of cows with dirty hind legs or hind limb	62.62±21.4	16.76	100
% of cows with dirty hind quarters	60.62±21.5	12.50	100

M= mean, SE= standard error, Min= minimum, Max= maximum.

Therefore, 41.0% of farms exceeded the alert threshold (> 6.3s) and 39.0% the alarm threshold (> 5.2s). These thresholds were higher than those found by Silva (2013) in Portugal (8.3% of farms exceeded the alert threshold (> 6.30s) and 25.0% the alarm thresholds (> 5.20s). In contrast, our alarm thresholds were lower compared to De Boyer des Roches et al. (2014) in France (72.0% > 5.20s). These thresholds signaled difficulties to lying down. As a result, serious problems of well-being (WQ®, 2009; Popescu et al., 2013).

The longer lying time is mainly related to the quality of floor, especially hard or concrete floors, which cause cows to lie down less often, although this reduction can be partly compensated by a longer average lying time (Rushen et al., 2007). This finding is consistent with several studies that have shown that cows prefer soft floors to hard or concrete floors (Lidfors, 1989; Haley, de Passille´, & Rushen, 2001, Tucker & Weary 2001). Norring, Manninen, de Passille, Rushen, and Saloniem (2010) also showed that 80% of lying positions were observed on carpet and only 20% on concrete. Thus, the longer lying sequence, the more difficult it is for cows to lie down, which explains the alarm and warning thresholds found in the present study as well as the significant correlation detected between comfort around resting and time spent lying down ($r = -0.70$; $p < 0.0001$) (Figure 1).

Cows lying outside lying down area

The presence of cows lying outside the lying area is also a resting comfort criterion, which generally reflects a mismatch between the lying area and the size of the cow. This problem exists with varying frequencies not only in Algerian farms (3.00±9.31) (Table.1) but also in other countries: Popescu et al. (2014) (3.19%), De Boyer des Roches et al. (2014) in France (0, 34%); Silva (2013) in Portugal (20%).

In our study, a small proportion (1%) of cows exceeded the alert threshold. This proportion was lower than that of De Boyer des Roches et al. (2014) in France (19.1%). This low frequency of cows lying outside the lying area was highly dependent on the level of maintenance of the lying area (Sunderland, 2002; Bowell et al., 2003), its size and density which forced some cows (the dominated) to lie outside the lying area (Phillips, 2002; Mattiello et al., 2009; Krug, Haskell, Nunes, & StilWell, 2015). This explains the significant correlation found between this measure and comfort (r = -0.33; p = 0.0008) (Figure 2).

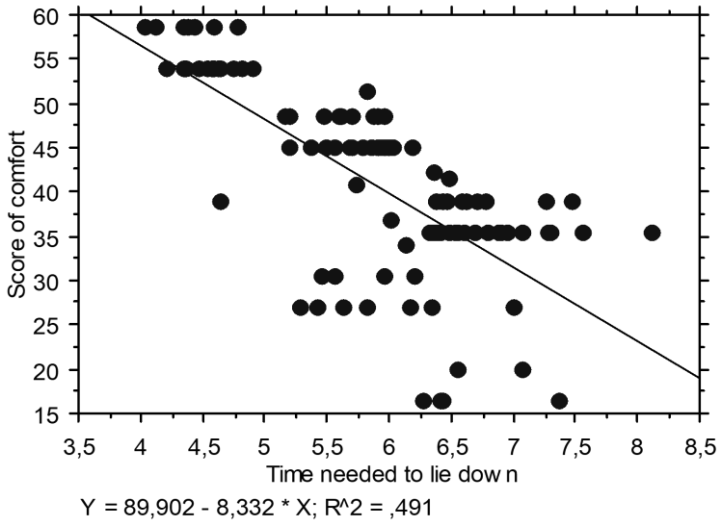

Figure 1. Correlation between time need to lie down and comfort around resting.

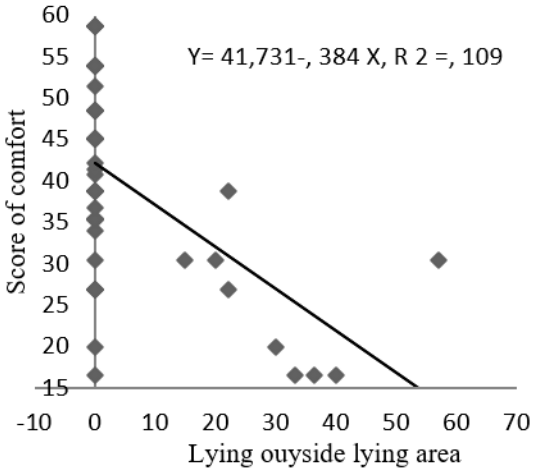

Figure 2. Correlation between lying outside lying down area and comfort around resting.

Collision to housing equipment

Collision is a key issue for animal comfort and welfare (Brorkens et al., 2009; Ostojic-Andric et al., 2011; De Boyer des Roches et al., 2014; Popescu et al., 2014). It indicates a painful condition due to repeated movements with the rearing equipment. Consequently, the occurrence of injuries and diseases (lameness) is increased. In our study, a low average frequency of collisions with rearing equipment was observed in the farms visited (3 ± 9.56) (Table 1). This frequency was close to that found by Brorkens et al. (2009) (1.78%), but much lower than that reported by De Boyer des Roches et al. (2014) in France (27.1). Therefore, a small proportion of surveyed farms cows exceeded the alert threshold (2%). This threshold was much lower than that reported by De Boyer des Roches et al. (2014) in France (47.3%).

This state of discomfort and uneasiness is closely linked to the farmer's management: inadequacy of the lying area with cow movements, short and poorly placed tethering chains, slippery and unsuitable floor. Hence the significant correlation found in our study between the frequency of collisions and comfort (r = -0.43; p < 0.0001) (Figure.3).

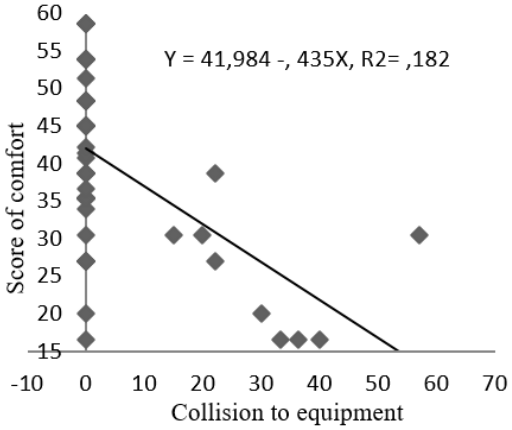

Figure 3. Correlation between collision to housing equipment and comfort around resting.

Cleanliness

Cow cleanliness influences cow comfort, health and hygiene of different parts of the animal's body, including the udder, milk quality and skin integrity. This has been demonstrated by several studies in different countries (Whay et al., 2008; Norring et al., 2008; Andreasen & Folkman, 2012; De Boyer des Roches et al., 2014; Radeski, Janevski, & Ilieski, 2015).

Regarding the cleanliness of dairy cows in our study, we found a high average prevalence of cows with dirty udders (62.6% ± 21.9), dirty hindquarters (60.6% ± 21.5) and dirty hind limbs (60.6 ± 21.4) (Table.1). As a result, a large number of farms exceeded the alert thresholds for these measures: 100.0% for udder cleanliness, 86.0% for hindquarters cleanliness and 63.0% for hind limbs. This high level of uncleanliness indicates serious problems of welfare. Our results are in agreement with those of De Boyer des Roches et al. (2014) in France, who noted a high proportion of farms exceeding the alert thresholds: Hind legs (95.4%), hind quarters (93.9%) and udders (70.7%), which explains the correlations found between cows with dirty limbs and those lying outside the lying area (r = 0.21 ; p = 0.03), dirty udders and dirty limbs (r = 0.21; P = 0.03), as well as cows with dirty hindquarters and those lying outside the lying area (r = 0.21; P = 0.003) (Figure 4).

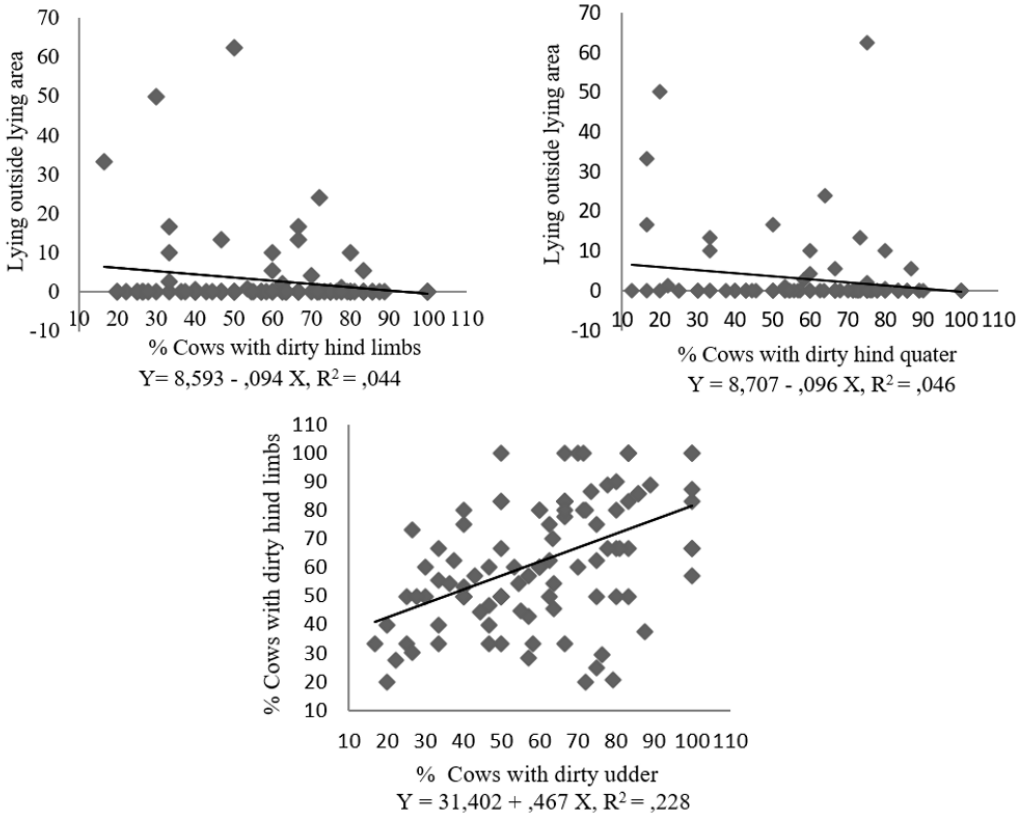

Figure 4. Correlation between the different indicators of cleanliness of farms surveyed.

These frequencies of dirtiness in the surveyed farms were much higher than those of Whay et al. (2008) and De Boyer des Roches et al. (2014) for the udder (22.2; 26.5%) and hindquarters (10.7; 51.5%) respectively, but close to those of Radeski et al. (2015) (65.2%) for the udder. In contrast, our results were lower than those reported by Radeski et al. (2015) (85.5%) and Whay et al. (2008) regarding the frequency of hindquarter soiling and De Boyer des Roches (2014) and Radeski et al. (2015) (100.0; 80.4; 86.5) regarding hind limbs soiling.

This level of dirtiness reflects the poor rearing conditions that constitute a degraded animal environment and depend on a low frequency of bedding replacement (Norring et al., 2008), hygiene of lying area (Bowell et al., 2003; Hulsen, 2007; Leach, Knierim, & Whay, 2009, Ruud, Boe, & Osteras, 2010, Andreasen & Folkman, 2012) and dirty skin and hair can cause itching, decrease thermoregulatory and antimicrobial defense properties and may cause dermatitis (Winckler et al., 2003).

This level of dirtiness reflects poor husbandry conditions that constitute a degraded environment for animal and depended on low frequency of bedding replacement (Norring et al., 2008), hygiene of lying area (Bowell et al., 2003; Hulsen, 2007; Leach et al., 2009; Ruud et al., 2010; Andreasen & Folkman, 2012), and coat cows which can cause itching, decreases thermoregulatory and antimicrobial defense properties and can lead to dermatitis (Winckler et al., 2003).

Several studies have shown an association between dirtiness and mastitis (Sant'Anna & da Costa, 2011). Therefore, udder cleanliness was closely related to milk quality (Ellis et al., 2007). Indeed, Reneau et al. (2005) and Delaval (2006) have shown that the consequences of udder and skin infections increase rapidly as cows get dirtier and that one extra point can increase the somatic cell count in the milk tank by 50,000 milliliters. Therefore, it is essential to keep the cows clean to ensure good milk hygiene and avoid possible contamination. On the other hand, the high prevalence of dirt in the limbs and hindquarters would reflect the cleanliness of the lying area in combination with a high cow density. In addition, when stall sizes are inadequate, cows may lie partially or completely outside the lying area. As a result, they become dirtier and allow skin lesions and limb infections to develop (Mattiello et al., 2009; Von Keyserlingk, Barrientos, Ito, Galo, & Weary, 2012). Thus, efforts are needed to improve the cleanliness of the animals and their environment to overcome several problems related to cow health, behavior and welfare.

Conclusion

Assessment of dairy cows comfort by the WQ® (2009) Protocol in Algerian farms surveyed, enabled us to identify the causes of their discomfort: poorly maintained stables, damp, slippery floors without bedding, very abrasive, unsuitable stalls which push cows to adopt abnormal positions and accentuate their dirt level, exposing them to injuries and diseases. Consequently, impact their productivity and wellbeing. Co-variability's were observed between the different aspects of comfort, revealing an association between these aspects, hence the correlations found in this study. Better farm management is essential to reduce these risk factors and ensure better comfort on the farms surveyed.

References

Andreasen, S. N., & Forkman, B. (2012). The welfare of dairy cows is improved in relation to cleanliness and integument alterations on the hocks and lameness when sand is used as stall surface. *Journal of Dairy Science*, *95*(9), 4961-4967. DOI :https://doi.org/10.3168/jds.2011-5169

Bowell, V. A., Rennie, L. J., Tierney, G., Lawrence, A., & Haskell, M. (2003). Relationships between building design, management system and dairy cows welfare. *Animal Welfare*, *12*(4), 547-552.

Brorkens, N., Plesch, G., Laister, S., Zucca, D., Winckler, C., Minero, M., & Knierim, U. (2009). Reliability testing concerning behavior around resting in cattle in dairy cows and beef bulls. In B. Forkman, L. Keeling (Eds.), *Assessment of animal welfare measures for dairy cattle, beef buls and veal calves* (p. 7-24). Cardiff, UK: Welfare Quality® Reports 11.

Cazin, P., Nicks, B., & Dufrasne, I. (2014). Aménagement des logettes et confort des vaches laitières. *INRA Production Animal*, *27*(5), 359-368. DOI: https://doi.org/10.208/productions-animales.2014.27.5.3083

De Boyer Des Roches, A., Veissier, I., Coignard, M., Bareille, N., Guatteo, R., Capdeville, J., ... Mounier, L. (2014). The major welfare problems of dairy cows in French commercial farms: an epidemiological approach. *Animal Welfare*, *23*(4), 467-478. DOI: https://doi.org/10.7120/09627286.23.4.467

Delaval. (2006). *Guide du confort de la vache DeLaval*. Retrieved from http://www.delaval.com

European Food Safety Authority [EFSA]. (2009). Scientific Opinion of the Panel on Animal Health and Welfare on arequest from European Commission on welfare of dairy cows. Effects of farming systems on dairy cow welfare and disease. *The EFSA Journal*, *1143*, 1-38.

Ellis, K. A., Innocent, G. T., Mihm, M., Cripps, P. W. G., McLean, W. G., Howard, C. V. D., & Grove-White, D. (2007). Dairy cow cleanliness and milk quality on organic and convential farms in the UK. *Journal of Dairy Research*, *74*(3), 302- 310. DOI: https://doi.org/10.1017/S002202990700249X

Enting, H., Kooij, D., Dijkhuizen, A. A., Huirne, R. B. M., & Noordhuizen-StSsen, E. N. (1997). Economic losses due to clinical lameness in dairy cattle. *Livestock Production Science*, *49*(3), 259-267.

Haley, D. B., de Passille´, A. M., & Rushen, J. (2001). Assessing cow comfort: Effects of two floor types and two tie stall designs on the behaviour of lactating dairy cows. *Applied Animal Behaviour Science*, *71*(2), 105-117. DOI: https://doi.org/10.1016/S0168-1591(00)00175-1

Hristov, S., Vučinić, M., Relić, R., & Stanković, B. (2006). Growing conditions, improving the behavior of farm animals. *Biotechnology in animal husbandry, 22, 73-84*.

Hulsen, J. (2007). *Cow signals (el lenguaje de las vacas)*. Madrid, ES: Ediciones Tecnicas Reunidas SL.

Husfeldtand, A. W., & Endres, M.I. (2012). Assocation between stall surface and some animal welfare measurements in freestall dairy herds using recycled manure solids for bedding. *Journal of Dairy Science*, *95*(10), 5626-5634. DOI: https://doi.org/10.3168/jds.2011-5075

Jensen, M. P., Hanley, M. A., Engel, J. M., Romano, J.M., Barber, J. B., Cardenas, D. D., … Patterson, D. R. (2005). Hypnotic analgesia for chronic pain in persons with disabilities: A case series. *International Journal of Clinical and Experimental Hypnosis* , *53*(2), 198-228. DOI: https://doi.org/10.1080/00207140590927545

Kebbal, S., Baazize-Ammi, D., Gharbi, I., Hanzen, C., & Guetarni, D. (2020). Étude descriptive des facteurs de risque des mammites et caractéristiques managériales des exploitations laitières de la wilaya de Blida. *Revue Agrobiologia*, *10*, 1975-1985.

Krug, C., Haskell, M. J., Nunes, T., & StilWell, G. (2015). Creating a model to detect dairy cattle farms with poor welfare using a national database. *Preventive Veterinary Medicine*, *122*(3), 280-286. DOI:https://doi.org/10.1016/j.prevetmed.2015.10.014

Leach, K. A., Knierim, U., & Whay, H. R. (2009). *Cleanliness scoring for dairy and beef cattle and veal calves. Assessment of animal welfare measures for dairy cattle, beef bulls and veal calves* (n. 11). Cardiff University, UK: Welfare Quality® Reports.

Lidfors, L. (1989). The use of getting up and lying down movements in the evaluation of cattle environments. *Veterinary Research Communications*, *13*(4), 307-324. DOI: https://doi.org/10.1007/BF00420838

Mattiello, S., Klotz, C., Baroli, D., Minero, M., Ferrante, V., & Canali, E .(2009). Welfare problem in alpine dairy cattle farms in Alto Adige (Eastern Italian Alps). *Italian Journal of Animal Science*, *8*(2s), 628-630. DOI: https://doi.org/10.4081/ijas

Munksgaard, L., Jensen, M. B., Pedersen, L. J., Hansen, S. W., & Matthews, L. (2005). Quantifying behavioral priorities-Effects of time constraints on behaviour of dairy cows, Bos Taurus. *Applied Animal Behaviour Science*, *92*(1-2), 3-14. DOI: https://doi.org/10.1016/j.applanim.2004.11.005

Norring, M., Manninen, E. A. M., de Passille, A. M., Rushen, J., Munksgaard, L., & Saloniem, H. (2008). Effects of Sand and Straw Bedding on the Lying Behavior, Cleanliness, and Hoof and Hock Injuries of Dairy Cows. *Journal of Dairy Science*, *91*(2), 570-576. DOI: https://doi.org/10.3168/jds.2007-0452

Norring, M., Manninen, E. A. M., de Passille, A. M., Rushen, J., & Saloniem, H. (2010). Preferences of dairy cows for three stall surface materials with small amounts of bedding. *Journal of Dairy Science, 93*(1), 70-74. DOI: https://doi.org/10.3168/jds.2009-2164

Norring, M., & Valros, A. (2016). The effect of lying motivation on cow behavior. *Applied Animal Behaviour Science*, *176*, 1-5. DOI: https://doi.org/10.1016/j.applamin.2015.11.022

Ostojic-Andric, D., Hristov, S., Novakovié, Ž., Pantelié, V., Petrovié, M. M, Zlatanovié, & Z., Niksié, D. (2011). Dairy cows welfare quality in loose vs tie housing system. *Biotechnology in Animal Husbandry*, *27*(3), 975-984. DOI: https://doi.org/10.2298/BAH1103975O

Phillips, C. J. C. (2002). *The welfare of dairy cows, cattle behaviour and welfare* (2nd ed., p. 274). Oxford, EN: Blackwell Science.

Plesch, G., Broerkens, N., Laister, S., Winckler, C., & Knierim, U. (2010). Reliability and Feasibility of selected measures concerning resting behaviour for the on-farm welfare Assessment in dairy cows. *Applied Animal Behaviour Science*, *126*(1-2), 19-26. DOI: https://doi.org/10.1016/j.applanim.2010.05.003

Popescu, S., Borda, C., Diugan, E. A., Mihaela Niculae, M., Razvan, S., & Sandru, C. D. (2014). The Effect of the housing system on the welfare quality of dairy cows. *Italian Journal of Animal Science*, *13*(1). DOI: https://doi.org/10.4081/ijas.2014.2940

Popescu, S., Borda, C., Diugan, E. A., Spinu, M., Groza, I. S., & Sandru, C. D. (2013). Dairy cows welfare quality in tie-stall housing system with or without access to exercise. *Acta Veterinaria Scandinavica*, *55*, 43. DOI: https://doi.org/10.1186/1751-0147-55-43

Radeski, M., Janevski, A., & Ilieski, V. (2015). Screening of selected indicators of dairy cattle welfare. *Macedonian Veterinary Review*, *38*, 43-51. DOI: https//doi.org/10.14432/jmacvetrev.2014.11.031

Reneau, J. K., Seykora, A. J., Heins, B. J., Endres, M. I., Farnsworth, R. J., & Bey, R. F. (2005). Association between hygiene scores and somatic cell scores in dairy cattle. *Journal Amimal Veterinary Medecine Association*, *227*(8), 1297-1301. DOI: https://doi.org/10.2460/javma.2005.227.1297

Rushen, J., Haley, D., & de Passille, A. M. (2007). Effect of softer flooring in tie stalls on resting behavior and leg injuries of lactating cows. *Journal of Dairy Science*, *90*(8), 3647–3651. DOI: https://doi.org/10.3168/jds.2006-463

Ruud, L. E., Boe, K. E., & Osteras, O. (2010). Risk factors for dirty dairy cows in Norwegian Free stall systems. *Journal of Dairy Science*, *93*(11), 5216-5224. DOI: https://doi.org/10.3168/jds._2010-3321

Sant'Anna, A. C., & da Costa, M. J. R. P. (2011). The relationship between dairy cow hygiene and somatic cell count in milk. *Journal of Dairy Science*, *94*(8), 3835-3844. DOI: https://doi.org/0.3168/jds.2010-3951

Silva, C. N. K. M. (2013). *Welfare indicators identification in Portuguese dairy cows farms* (Dissertação de Mestrado). Faculdade de Medicina Veterinária, Universidade de Lisboa, Lisboa.

Sunderland, E. (2002). A study of the association between cattle cubicule design and cow cleanliness. *Cattle Practice*, *10*(2), 147-155.

Tucker, C. B., & Weary, D. M. (2001). Stall design: Enhancing cow comfort. *Advances in Dairy Technology*, *13*, 155.

Veissier, I., Beaumont, C., & Levy, F. (2007). Les recherches sur le bien-être animal : buts, méthodologie et finalité. *INRA Production animal*, *20*(1), 3-10. DOI: https://doi.org/10.20870/productions-animales.2007.20.1.3426

Von Keyserlingk, M. A. G., Barrientos, A., Ito, K., Galo, E., & Weary, D. M. (2012). Benchmarking cow comfort on North American freestall dairies: Lameness, leg injuries, lying time, facility design, and management for high-producing Holstein dairy cows. *Journal of Dairy Science*, *95*(12), 7399-7408. DOI: https://doi.org/10.3168/jds.2012-5807

Webster, A. J. F. (2003). Assessment of the welfare of dairy cattle using animal-based easurements: direct observations and investigation of farm records. *Veterinary Record*, *153*(7), 197-202. DOI: https://doi.org/10.1136/vr.153.7.197

Whay, H. R., Main, D. C. J., Green, L. E., Norring, M., Manninen, E. A. M., de Passille, A. M., & Saloniem, H. (2008). Effects of Sand and Straw Bedding on the Lying Behavior, Cleanliness, and Hoof and Hock Injuries of Dairy Cows. *Journal of Dairy Science*, *91*(2), 570-576. DOI: https://doi.org/10.3168/jds.2007-0452

Welfare Quality®. (2009). *Welfare Quality assessment protocol for cattle*. Lelystad, NL: Welfare Quality® Consortium.

Winckler, C., Capdeville, J., Gebresenbet, G., Hörning, B., Roiha, U., Tosi, M., & Waiblinger, S. (2003). Selection of parameters for on-farm welfare-assessment protocols in cattle and buffalo. *Animal Welfare*, *12*(4), 619-624.

Winckler, C. (2008). *Organic eprints: The use of animal-based health and welfare parameters - what is it all about?* Retrieved from http://www.orgprints.org/13405/1/13405.pdf