Review Article

FROM WELFARE TO WELL-BEING: SHAPING DAIRY ANIMAL WELFARE DYNAMICS IN CHANGING AGRO-ECOSYSTEMS

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ABSTRACT

Animal welfare refers to an animal's capacity to navigate its life circumstances and is grounded in the "five freedoms" and "four principles" of responsible animal care. This multidimensional construct is gaining significance across social, political, ethical, and scientific realms. However, evaluating animal welfare necessitates a consensus on its definition. Notably, dairy welfare has now been integrated into the spectrum of milk quality standards, bolstering consumer confidence in products originating from animals raised and nurtured in adherence to sound farming practices. Given the intertwined relationship between cattle and humans, prioritizing cattle health and mitigating their suffering stands as an imperative. Owing to its intricate nature, quantifying the welfare of dairy cattle is a multifaceted endeavor, relying on a range of direct and indirect metrics. The selection of welfare indicators and evaluation methodologies, therefore, embodies the foundational assumptions underlying diverse interpretations of animal welfare. The criteria should take animal welfare evaluation based on housing, environment, animal health, seasons, feed, management, etc. into consideration. The housing system is one of the most important factors to consider when assessing an animal's welfare because it has an impact on the animal's well-being and ability to produce. Assessment frameworks for animal welfare within dairy farms exhibit diversity shaped by the definition of animal welfare and the intended assessment objectives. In this comprehensive review, we undertake an examination of the indicators and evaluation approaches concerning the welfare of dairy cattle, aiming to illuminate the intricacies of this vital domain.

Keywords: Dairy animal welfare, animal health, animal behavior, welfare indicators, ethical farming.

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INTRODUCTION

India's national economy is intricately woven with the livestock industry, holding a pivotal role. Among the noteworthy economic endeavors within rural areas is livestock rearing, which supplements the income of numerous families reliant on agriculture (FAO, 2020). As this sector grows in importance, the surge of interest in the welfare of dairy cattle mirrors the heightened awareness and concern of individuals in recent years, especially given the direct connection between animal well-being and the livelihoods of those dependent on livestock. This growing recognition underscores the need for better management practices to ensure both the economic stability of rural communities and the health and welfare of the animals they rely on. The term "welfare" encapsulates the state of a human or animal's sound, content, and secure existence (Wehmeier, 2005). At the core of an animal's "needs" lies the essentials for survival, while optimal well-being necessitates supplementary requisites that enhance living conditions and potentially augment productivity (Stull *et al*., 2005). The success of a dairy farmer in ensuring both quality and quantity of milk hinges upon fulfilling the welfare requirements of dairy animals (Fraser, 2003). The crux of efficient farm animal husbandry rests on furnishing the necessary resources and oversight to ensure the efficient production of sustenance and commodities, while safeguarding the animals' health and welfare (Appleby, 2005).

In the contemporary context, dairy welfare is integral to milk quality standards, instilling consumer confidence through assurance that products originate from animals nurtured and raised in accordance with proper farming practices (Hristov *et al*., 2012). Beyond its immediate significance, farm animal welfare is a subject of public concern on multiple fronts stemming from moral obligations to animals, impacting the economics of food production, and influencing human well-being (Broom, 2002).Signs of diminishing productivity, such as a drop in milk yield, illness or injury, can signal underlying welfare challenges (Whay, 2007). Likewise, a decrease in reproductive rates or a surge in mortality and morbidity serves as overt indicators of compromised livestock welfare. In today's context, consumers of milk and its derivatives exhibit heightened curiosity regarding the treatment of dairy animals involved in the production process (Hristov *et al*., 2011). In comparison to weaned calves, naturally suckled buffalo calves had better growth performance, immune status, health performance, behavior and lower levels of oxidative stress (Kumar *et al*., 2015; Kumar, 2014). Lying behavior in dairy cows is affected by various factors, including health issues like mastitis and environmental stressors such as heat. Mastitis, a painful udder infection, significantly reduces lying time, indicating compromised welfare (Fogsgaard *et al*., 2015). Heat stress is also often found to reduce lying time (Heinicke *et al*., 2018; Tullo *et al*., 2019) as cows prefer to rest while standing to increase the body surface available for cooling (Wang *et al*., 2018). The dynamic nature of agro-ecosystems further complicates the management of dairy cow welfare. Climate change, technological advancements, and evolving agricultural practices continuously shape how dairy farms operate and influence animal welfare. A holistic approach that integrates welfare indicators into broader well-being frameworks not only benefits the animals but also promotes the sustainability and resilience of dairy farming. By understanding and addressing the multifaceted aspects of dairy cow welfare, we can better support the health and happiness of these animals, leading to more sustainable and ethical dairy farming practices.

Climate change and its impacts on dairy animal welfare

Climate change presents a significant challenge to both agro-ecosystems and dairy animal welfare. Rising global temperatures, altered precipitation patterns, and the increased frequency of extreme weather events, such as heatwaves and floods, are already having detrimental effects on livestock health and productivity (Thornton, 2010). Heat stress, for instance, is one of the most immediate concerns in dairy farming, leading to reduced milk yields, lower fertility rates, and weakened immune systems (Renaudeau *et al*., 2012).

In agro-ecosystems, the impact of climate change is not limited to temperature increase. Changes in the availability of water, shifts in forage composition and quality, and the spread of disease vectors all play a role in shaping the conditions under which dairy cattle are raised (St-Pierre *et al*., 2003). Therefore, it is crucial for farming systems to adapt to these changes by incorporating strategies that mitigate environmental stresses on livestock. Some of the solutions include breeding heat-tolerant cattle breeds, improving shelter and cooling systems, and diversifying forage sources (Hoffmann, 2010).

Additionally, innovative farming techniques such as precision agriculture and integrated water management can help optimize resource use and mitigate the effects of climate change on dairy production (Cameron *et al*., 2013). These strategies not only improve animal welfare by reducing environmental stress but also contribute to the sustainability of agro-ecosystems.

Welfare indicators

A comprehensive evaluation of animal welfare in the context of dairy cattle has led to the categorization of indicators into two distinct domains: animal-based indicators encompassing mastitis, lameness, and human-animal interactions, and environmental-related indicators that encompass housing and management factors (Phillips, 2002). Historical perspectives on farm animal welfare assessments have largely concentrated on quantifying the resources availed of animals, primarily focusing on housing standards and design. While these resource-based criteria, rapid and dependable, offer an indirect measure of animal welfare, they may not always provide a complete picture (Knierim & Winckler, 2009). Intriguingly, the dynamics of management practices and the bond between humans and animals constitute additional facets of husbandry that wield influence over animal welfare. However, evaluating the impact of these elements can prove to be more intricate (Hemsworth *et al.*, 2015). It's noteworthy that while adept management and favorable environmental conditions contribute significantly to animal welfare, they do not invariably guarantee the attainment of high welfare standards (Sejian *et al*., 2011). Delving into the realm of dairy cattle criteria unveils a diverse array of categories. These encompass production-related, physiological, pathological, ethological and integrated dimensions, collectively offering a comprehensive framework to gauge the multifaceted aspects of dairy cattle welfare (Calamari and Bertoni, 2009).

Housing parameters

Efficient shelter management involves adjusting an animal's microclimate to meet their well-being needs, reduce climatic stress, and minimize construction costs. This ensures adequate protection, increased productivity and energy conservation (Nagpal *et al*., 2005). A comprehensive evaluation of animal welfare includes housing, feeding, sanitation and hygiene practices. These elements should be considered integral for fostering good conditions, as they are pragmatic, measurable and documentation feasible, despite not guaranteeing optimal welfare (Johnson *et al*., 2001). The quintessential aim of effective animal housing systems is to encapsulate all the "five freedoms," those essential prerequisites ensuring animal welfare. Disregarding these foundational tenets within animal housing jeopardizes not only the animals welfare but also their health and productivity (Hristov *et al*., 2012).

Cow comfort

The metric reflecting the proportion of recumbent cows within stalls is recognized as the "cow comfort index." This index typically peaks one to two hours subsequent to milking. The pivotal role of rest is underscored by the findings of Munksgaard and Lovendahl (1993), who demonstrated that cows experimentally restrained from lying down for a cumulative 14 hours daily exhibited diminished plasma levels of growth hormone-a hormone intricately linked to milk yield (Hart *et al*., 1978). Research by Rushen *et al*. (2007) illuminates the disparities in joint health among dairy cows based on housing surfaces. Specifically, cows housed on concrete surfaces displayed a threefold increased likelihood of experiencing swollen carpal joints, in contrast to their counterparts housed on rubber mats. Furthermore, cows situated on abrasive substrates such as reclaimed sand demonstrated elevated susceptibility to hair loss and carpal joint inflammation. Comparative studies reveal nuanced insights into housing systems' impact on cow welfare. Compared to stalls equipped with concrete or mattresses, compost or straw-based systems were associated with reduced occurrences of leg injuries, both in the front and rear limbs (Fulwider *et al*., 2007).

Behavioral indicators

One of the best ways to study animal welfare is through the observation of their behavior. In dairy cows, it is well established that lying behavior is a useful indicator of their health and welfare (Tucker *et al*., 2021;

Leliveld, *et al.,* 2020). A secure surface for grooming, such as the fold between the udder and leg, compels cows to stand on three legs-both front legs and one hind leg. Infrequent instances of grooming conduct can signal floor slipperiness (Jungbluth *et al*., 2003). In certain stall setups like tie systems, caudal licking might not be feasible (Anderson, 2008). The repercussions of confinement extend to eliciting additional behavioral anomalies in cattle. Tongue rolling is observed in confined dairy bulls and heifers, often as a response to chronic stressors or under-stimulation in barren settings. Similarly, overstimulation, such as persistent noise, can engender behaviors like stereotypies in cattle (Ekesbo, 2011).

Production parameter

The question of whether production factors, such as milk yield, serve as suitable welfare , remains a subject of debate. As elucidated by Huzzey *et al*., (2007), cows grappling with metritis exhibited a noteworthy reduction of approximately 8 kg day in milk yield during the initial three weeks of lactation. Unquestionably, a decline in milk production can be indicative of underlying health concerns. Furthermore, transient deviations in milk production have been illuminating in gauging cows' responses to stress-inducing scenarios. The presence of acute stressors, including unfamiliar surroundings, can precipitate a suppression of oxytocin release, subsequently impeding milk ejection and diminishing milk yield. In such contexts, a discernible decrease in milk production is regarded as a telltale sign of compromised welfare (Appleby, 2005).

However, a pivotal caveat warrants consideration: neither elevated nor diminished milk production levels can be simplistically construed as definitive indicators of animal welfare (Phillips, 2002). The complex interplay of factors underscores the nuanced nature of this relationship. Genetic correlations reveal a link between milk yields and lameness incidence, suggesting that increased milk production may worsen welfare concerns. However, while higher production levels may impact animal health, they don't necessarily lead to increased lameness (Bertoni *et al*., 2007).

Reproductive parameters/ indicators

Indeed, animals are selectively bred with a focus on their reproductive attributes, driven by an array of factors encompassing economic viability and animal welfare considerations (Berglund, 2008). The evaluation of animal welfare often relies on gauging indicators tied to reproductive prowess, given the pivotal role reproduction plays in ensuring productive outcomes. However, a comprehensive assessment necessitates a broader perspective, encompassing elements such as fertility and lifespan. These facets not only contribute to maintaining commendable production levels but also foster sustainability, in tandem with milk production (Appleby, 2005).

Body condition scoring

The study by Whay *et al.,* (2003) assessed cows' physical robustness using a five-point body condition scoring system. The study found that cows' well-being significantly impacts milk production, reproductive capacity, health resilience and longevity. Cow weight can indicate inadequate nutrition, metabolic anomalies, health issues or suboptimal farm management practices. Body condition scoring (BCS) systems, used in dairy cattle, are a five-point rating system with quarter-point gradations. Lower values indicate undernourishment, while higher scores indicate obesity. BCS is crucial for gauging animal welfare, making it a vital welfare indicator (Sprecher *et al*., 1997). The scale may vary across countries, but lower values generally indicate undernourishment.

Human–animal relationship

The extent of the connection or divide between humans and animals is encapsulated within the concept of the human-animal bond (Estep and Hetts, 1992). The evaluation of the human-animal relationship assumes paramount importance while assessing farm animal welfare, given its profound implications across various livestock species. There exists a need for a robust and dependable methodology to assess bovine reactions towards human presence within large-scale surveys. This study embraced avoidance distance as a metric to quantify the human-animal relationship within dairy cow herds (Waiblinger *et al*., 2003). It was observed that animals demonstrated greater docility in the face of diminished avoidance distances, and conversely, heightened distances correlated with increased apprehension. The extensive research on human-animal interactions within the context of farm animals has predominantly focused on fear responses, both in behavioral and physiological dimensions. Fear is recognized as a potent emotional state that frequently triggers defensive or evasive behaviors (Waiblinger *et al*., 2006).

Health performance

Mastitis :

Diverse interpretations of health and disease exist, but the subsequent definition proves valuable when examining the nexus between welfare and health. As articulated by Tyler and Cullor (2002), disease encompasses both physical and mental states wherein an animal's typical functioning becomes compromised. While illness and injury significantly influence animal welfare, the nuanced connection between animal health and overall welfare is periodically underestimated. Mastitis in dairy cows serves as an exemplar, where instances span a spectrum from painful conditions to subclinical variants that exert limited impact on welfare. Monitoring methods for clinical and subclinical mastitis predominantly encompass somatic cell counts and clinical assessments. Notably, mastitis emerges as a pronounced challenge impacting dairy cow welfare, concurrently impinging on farmers' economic viability (Capdeville and Veissier, 2001). Incidence of mastitis is underpinned by an array of risk factors, including breed, parity, lactation stage, milk production intensity, teat-tip to floor distance, housing conditions, udder and teat attributes and milking practices (Sharma and Singh, 2003).

Genetic selection for elevated milk yields and mechanical stresses inflicted by milking machines correlate with mammary gland infections (Sordillo, 2005; Heringstad *et al*., 2003). As posited by Tyler and Cullor (2002), the transmission of pathogenic bacteria through teat apertures stands as the chief causative agent for mastitis cases. This underscores that unclean housing systems and cows elevate mastitis risks (Schreiner and Ruegg, 2003), whereas frequent bedding changes and hygienic milking parlors mitigate this risk. Notably, mastitis emerges as an opportunistic affliction affecting the mammary gland, with its classification as a multifactorial ailment attesting to its complexity. Its occurrence stems from potential infections by up to 100 distinct pathogens, influenced by an array of predisposing factors (Phillips, 2010). In crossbred cows, the prevalence of clinical mastitis ranged from 3.0% to 5.5% (Bitew *et al*., 2010), underscoring its relevance in the context of dairy cattle welfare.

Lameness

Lameness stands as a prominent and telling indicator of a dairy cow's welfare. According to the Farm Animal Welfare Council (1997), lameness not only leads to substantial productivity decrement but also negatively affects reproductive capabilities, often culminating in culling. Pain, a prevalent consequence of lameness, manifests as altered movement patterns or deviations from normal gait across species. Foot lesions, encompassing conditions such as sole ulcers, white line disorders, digital dermatitis and interdigital dermatitis, constitute primary instigators of lameness (Vokey *et al*., 2001). This issue bears far-reaching implications contributing to health challenges, economic detriments and operational disruptions within dairy production (Cook *et al*., 2004).

While a genetic association between production levels and lameness incidence is noted by Bertoni *et al*., (2007), the intricate interplay implies that augmented milk production is not always coupled with elevated lameness rates. Acknowledging lameness as a salient welfare concern, Loberg *et al.,* (2004) elaborate that infectious diseases (like digital dermatitis and foot rot) and horn or claw lesions (including ulcers, hemorrhages, and white line separation) can trigger this affliction. The multifaceted nature of lameness etiology includes housing, nutrition and genetics-variables interlinked with cows' reproductive and productive success (Somers *et al*., 2003). Housing dynamics, such as concrete flooring, uncomfortable surfaces, limited grazing access and inadequate stalls, significantly influence lameness prevalence (Cook and Nordlund, 2009). The repercussions of lameness extend to the operational and reproductive aspects of dairy cattle, encompassing compromised performance and reproductive efficacy (Vermunt, 2005). Notably, milk yield may experience a downturn as well (Warnick *et al.*, 2001). Reflecting its impact, lameness ranks as the third most common reason for culling dairy cattle, following mastitis and calving complications (Espejo *et al*., 2006). Prevalence figures serve as yardsticks for assessing lameness: prevalence exceeding 3-4% in heifers or 2-3% in cows raises red flags, while figures surpassing 7% underscore identifiable and treatable issues

(Whay *et al*., 2003). Lameness rates span the spectrum, with the top quintile exhibiting below 14% prevalence, contrasting the 30-50% range seen in the least favorable category (Whay *et al*., 2003).

Hock lesions

According to Lavan and Livesey (2011), the term "hock lesion" encompasses a range of clinical indicators of hock damage, varying from minor hair loss to pronounced ulceration and swelling. Hock lesions, stemming from reduced comfort, emerge as potent markers of compromised animal welfare. Lameness is intrinsically linked to hock lesions, eliciting not just financial losses but also a diminishing state of well-being and a potential tarnishing of the dairy industry's public perception (Kester *et al*., 2014).

CONCLUSIONS

The review underscores the growing importance of integrating environmental, socio-economic and ecological factors when addressing dairy animal welfare within the context of changing agro-ecosystems. As climate change intensifies, the welfare of dairy animals is increasingly threatened by heat stress, reduced forage availability, and the changing distribution of diseases. Utilizing animal genetic diversity, such as breeding for heat tolerance or disease resistance, can significantly contribute to mitigating the negative impacts of climate change on livestock health and productivity. Furthermore, the review highlights the necessity of adopting sustainable farming practices that align animal well-being with broader agro-ecosystem health. By fostering resilient farming systems through practices like agroecology, which promotes biodiversity and soil health, farmers can ensure the long-term viability of both their livestock and the ecosystems in which they are raised. The integration of climate-adaptive strategies and the use of genetically diverse livestock breeds can support more sustainable, resilient dairy farming systems. In conclusion, the future of dairy animal welfare in shifting agro-ecosystems depends on the careful balance between environmental management, genetic innovation and socio-economic policies, ensuring that animal well-being remains central in the face of an uncertain climate future.

REFERENCES

Anderson, N. (2008). Cow behaviour to judge free-stall and tie-stall barns. OMAFRA, *Ontario*. Pg 1-10

Appleby, M.C. (2005). The European Union ban on conventional cages for laying hens: History and prospects. *Journal of Applied Animal Welfare Science*, **6**(2): 103-121.

Berglund, B. (2008). Genetic improvement of dairy cow reproductive performance. *Reproduction in Domestic Animals*, **43**: 89-95.

Bertoni, G., Calamari, L. and Trevisi, E. (2007). How to define and evaluate welfare in modern dairy farms, *13th International Conference on Production Diseases in Farm Animals, Leipzig, Germany*, pp. 590-606.

Bitew, M., Tafere, A., and Tolosa, T. (2010). Study on bovine mastitis in dairy farms of Bahir Dar and its environs. *Journal of Animal and Veterinary Advances*, **9**(23): 2912-2917.

Broom D.M. (2002). Does present legislation help animal welfare? Landbauforsch. *Völkenr*, **227**: 63-6.

Calamari, L. and Bertoni, G. (2009) Model to evaluate welfare in dairy cow farms. *Italian Journal of Animal Science,* **8**: 301-323.

Cameron, R.D., Anderson, I.C. and Sutton, S.A. (2013). Water management in agroecosystems: implications for dairy farming and ecosystem health. *Agricultural Systems*, **116**: 72-80.

Capdeville, J., and Veissier, I. (2001). A method of assessing welfare in loose housed dairy cows at farm level, focusing on animal observations. *Acta Agriculturae Scandinavica, Section A-Animal Science*, **51**: 62-68.

Cook, N.B., andNordlund, K.V. (2009). The influence of the environment on dairy cow behavior, claw health and herd lameness dynamics. *The Veterinary Journal*, **179**(3): 360-369.

Cook, N.B., Bennett, T.B., and Nordlund, K.V. (2004). Effect of free stall surface on daily activity patterns in dairy cows with relevance to lameness prevalence. *Journal of Dairy Science,* **87**(9): 2912-2922.

Ekesbo I. (2011). Farm animal behavior: characteristic for assessment of health and welfare. *CABI, UK*, pp. 237.

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. *Journal of dairy Science*, **89**(8): 3052-3058.

Estep, D.Q. and Hetts, S. (1992). Interactions, relationships, and bonds: the conceptual basis for scientist–animal relations. *The Inevitable Bond: Examining Scientist–Animal Interactions*, pp. 6-26.

FAO (Food and Agriculture Organization). (2020). Animal Welfare in Practice: From Codes to Improving Welfare. *FAO Animal Production and Health Guidelines* No. 16. FAO.

Farm Animal Welfare Council. (1997). Report on the welfare of dairy cattle. *The Farm Animal Welfare Council, London*.

Fogsgaard, K.K., Røntved, C.M., Sørensen, P. and Herskin, M.S. (2015). Sickness behavior in dairy cows during naturally occurring clinical mastitis. *Journal of Dairy Science*, **98**(5):3091-3100.

Fraser, D. (2003). Assessing animal welfare at the farm and group level: the interplay of science and values. *Animal Welfare*, **12**: 433-443.

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. *Journal of Dairy Science*, **90**(7): 3559-3566.

Hart, I.C., Bines, J.A., Morant, S.V. and Ridley, J.L. (1978). Endocrine control of energy metabolism in cows: comparison of levels of hormones (prolactin, growth hormone, insulin, and thyroxine) and metabolites in the plasma of high and low yielding cattle at various stages of lactation. *Journal of Endocrinology*, **77**: 333-345.

Heinicke, J., Ibscher, S., Mohr, E., Meyer, U. and Danicke, S. (2018). Effects of heat stress on lying behavior of lactating dairy cows and the impact of low-energy fan cooling. *Journal of Dairy Research*, **85**(4): 398-403.

Hemsworth, P.H., Rice, M., Karlen, G.A., Calleja, L., Barnett, J.L., Nash, J. and Coleman, G. J. (2015). Human–animal interactions at abattoirs: Relationships between handling and animal stress in sheep and cattle. *Applied Animal Behaviour Science*, **174**: 54-60.

Heringstad, B., Klemental, G. and Skjerve, T. (2003). Selection responses for clinical mastitis and protein yield in two norwegian dairy cattle selection experiments. *Journal of Dairy Science*, **86**(9): 2990-2999.

Hoffmann, I. (2010). Climate change and the role of animal genetic resources. *Animal Genetics*, **41**(1): 59-62.

Hristov, S., Stankovic, B. and Maksimovic, N. (2012). Welfare of dairy cattle-today and tomorrow, Third International Scientific Symposium "*Agrosym Jahorina*", 56-62.

Hristov, S., Stankovic, B., Todorovic-Joksimovic,M., Mekic, C., Zlatanovic, Z., Ostojic, A.D. and Maksimovic, N., (2011). Welfare problems in dairy calves. *Biotechnology in Animal Husbandry*, **27**(4): 1417-1424.

Huzzey, J.M., Veira, D.M., Weary, D.M. and von Keyserlingk. M.A.G. (2007). Prepartum behavior and dry matter intake identify dairy cows at risk for metritis. *Journal of Dairy Science*, **90**: 3220-3233.

Johnson, P.F., Johannesson, T. and Sandoe, P. (2001). Assessment of farm animal welfare at herd level: many goals, many methods, *Acta agricultureScandinavica*, **30**: 26-33.

Jungbluth T., Benz, B. and Wandel, H. (2003). Soft walking areas in loose housing systems for dairy cows. *Proc. 5th Int'I Dairy Housing Conference*, ASAE, 171- 177.

Kester, E., Holzhauer, M. and Frankena, K. (2014). A descriptive review of the prevalence and risk factors of hock lesions in dairy cows. *The Veterinary Journal*, **202**: 222-228.

Knierim, U. and Winckler, C. (2009). On-farm welfare assessment in cattle: validity, reliability and feasibility issues and future perspectives with special regard to the welfare quality® approach. *Animal Welfare*, **18**: 451-458.

Kumar, A. (2014). Influence of weaning on the performance and behaviour of calves and their dams in Murrah buffaloes. Ph.D thesis submitted to NDRI, Karnal, Haryana.

Kumar, J., Singh, Y.P., Kumar, S., Singh, R., Kumar, R. and Kumar, P. (2015) Genetic analysis of reproductive performance of Frieswal cattle at Military Farm, Ambala. *Veterinary World*, **8**(9): 1032–1037.

Laven, R., and Livesey, C. (2011). Getting to grips with hock lesions in cattle. *Veterinary Record*, **169**(24): 632-633.

Leliveld, L.M.C., Langbein, J., and Puppe, B. (2020). The importance of social and environmental factors for lying behavior in dairy cows. *Applied Animal Behaviour Science*, **230**: 105049.

Loberg, J., Telezhenko, E., Bergsten, C. and Lidfors, L. (2004). Behaviour and claw health in tied cows with varying access to exercise in an outdoor paddock. *Applied Animal Behaviour Science*, **89**: 1-16.

Munksgaard, L. and Lovendahl, P. (1993). Effects of social and physical stressors on growth hormone level in dairy cows. *Canadian Journal of Animal Science*, **73**: 847-853.

Nagpal, S.K., Pankaj, P.K., Ray, Bhiswajit. and Kataktalware, M. (2005). Shelter management of dairy animals: A review. *Indian Journal of Animal Sciences*, **75**(10): 1199-1214.

Phillips, C.J.C. (2002). Cattle behaviour and welfare, 2nd Edition, Blackwell scientific, Oxford, UK.

Phillips, C.J.C. (2010). Principles of cattle production, 2nd Edition, CAB International, UK.

Renaudeau, D., Collin, A. and Yahav, S. (2012). Adaptation to hot climate for dairy cows. *Animal*, **6**(5):1-10.

Rushen, J., Haley, D., and De Passillé, 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.

Schreiner, D.A., and Ruegg, P.L. (2003). Relationship between udder and leg hygiene scores and subclinical mastitis. *Journal of Dairy Science*, **86**(11): 3460-3465.

Sejian, V., Lakritz, J., Ezeji, T. and Lal, R. (2011). Assessment methods and indicators of animal welfare. Asian *Journal of Animal and Veterinary Advance*s. **6**: 301-315.

Sharma, P. and Singh, K. (2003). Milk yield and milk composition of crossbred cows under various shelter systems, *Indian Journal of Dairy Science*, **56**(1): 46-50.

Somers, J.G.C.J., Frankena, K., Noordhuizen-Stassen, E. N. and Metz, J.H.M. (2003). Prevalence of claw Disorders in Dutch dairy cows exposed to several floor systems. *Journal of Dairy Science*, **86 (6)**: 2082-2093.

Sordillo, L.M. (2005). Factors affecting mammary gland immunity and mastitis susceptibility. *Livestock Production Science*, **89**(1-2): 89-99.

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

St-Pierre, N.R., Cobanov, B. and Schnitkey, G. (2003). Economic losses from heat stress by US livestock industries. *Journal of Dairy Science*, **86**(1), 1-7.

Stull, C.L., Reed, B.A. and Berry, S.C. (2005). A comparison of three animal welfare assessment programme on California dairy. J*ournal of Dairy Science*, **88**: 1595–1600.

Thornton, P.K. (2010). Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society B*, **365**(1554), 2853-2867.

Tucker, C.B., Weary, D.M. and Fraser, D. (2021). Assessment of lying behavior in dairy cattle: a valuable indicator of animal welfare. *Journal of Dairy Science*, **104**(2): 1234-1245.

Tullo, E., Finzi, A., and Guarino, M. (2019). Environmental impact of livestock farming and precision livestock farming as a mitigation strategy. *Science of the Total Environment*, **650**(2): 2751-260.

Tyler, J.W. and Cullor, J.S. (2002). Bovine mastitis, In: Smith, B.P (ed): Large animal Internal Medicine (St. Louis, MO:Mosby Inc) pp.1019-32.

Vermunt, J.J. (2005). The multifactorial nature of lameness. a few more pieces of jigsaw. *Veterinary Journal*, **196**: 317-318.

Vokey, F.J., Guard, C.L., Erb, H.N. and Galton, D.M. (2001). Effect of alley and stall surfaces on indices of claw and leg healthin dairy cattle housed in free stall barn. *Journal of Dairy Science*, **82**(12): 2686-2699.

Waiblinger, S., Boivin, X., Pedersen, V., Tosi, M.V., Janczak, A.M., Visser, E.K., and Jones, R.B. (2006). Assessing the human–animal relationship in farmed species: a critical review. *Applied Animal Behaviour Science*, **101**(3): 185-242.

Waiblinger, S., Menke, C., Folsch, D.W. (2003) Influences on the avoidance and approach behaviour of dairy cows towards humans on 35 farms. *Applied Animal Behaviour Science*, **84**: 23-39.

Wang, X., Liu, Z., Su, Y., and Chen, Y. (2018). Effects of heat stress on dairy cow behavior, milk production, and rectal temperature in a ventilated barn. *Journal of Dairy Science*, **101**(5): 4390-4403.

Warnick, L.D., Janssen, D., Guard, C.L. and Grohn Y. T. (2001). The effect of lameness on milk production in dairy cows. *Journal of Dairy Science*, **84**: 1988–1997.

Wehmeier, S. (2005). Oxford advanced learner’s dictionary. Oxford University Press.

Whay, H.R. (2007). The journey to animal welfare improvement, *Animal Welfare,* **16**: 117–122.

Whay, H.R., Main, D.C.J., Green, L,E. and Webster, A.J.F. (2003). Assessment of welfare of dairy cattle using animal based measurement: direct observations and investigation of farm records. *Veterinary Record,* **153**: 197-202.