Effects of Social Dominance on the Behaviour, Production, and Physiological Performance of Lactating Dairy Cow

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Abstract

This study investigated the effects of social dominance on behaviour, milk production, and physiological performance in lactating dairy cows under an intensive farming system in a tropical climate condition. A total of 52 Friesian × Jersey cows were observed for 14 continuous days to determine dominance hierarchy through social interactions. Dominance values (DV) were calculated using a win-loss ratio formula, and cows were categorised into dominant (D), mid-ranking (M), and subordinate (S) social groups. Behavioural observations, milk yield, composition (fat, protein, lactose), and stress biomarkers (Cortisol, Serum Amyloid-A, Haptoglobin, Immunoglobulin G) were analysed. Results showed that dominance was positively correlated with age ($r = 0.453$, $P = 0.006$) and ruminating duration ($r = 0.451$, $P = 0.006$), with D cows being older and ruminating 24 minutes longer than lower ranking cows ($P = 0.0371$). Lower ranking cows were found to have higher cortisol level compared to dominant cows ($P = 0.0008$) which may suggest that lower-ranking cows suffer from social stress more than their higher-ranking counterparts. However, no significant effects of dominance were found in this study on cows' milk yield, milk composition, or other stress biomarkers. These findings suggest that while social dominance influences resting behaviour, it does not directly affect milk production or physiological performance in lactating dairy cows managed in an intensive system under tropical climate condition. In conclusion, farmers should consider the cows' social dominance aspect to be included in their animal grouping management, to reduce social stress that could lead to poor welfare, especially in the lower-ranking cows.

Key words: Dairy cows, milk production, physiological performance, social dominance, stress biomarkers.

Introduction

Dairy cattle are social animals that establish dominance hierarchies to access critical resources such as feed, water, and resting spaces (Phillips & Rind, 2002). In intensive farming systems where cows are confined under high stocking densities, social competition may intensify, potentially exacerbating stress and compromising welfare and productivity (González et al., 2008). When access to resources were restricted, lower ranking cows experienced stress, which can elevate cortisol levels, suppress immune function, and impair reproductive efficiency (Dobson & Smith, 2000; Gupta et al., 2007). For instance, a study of competitively housed Holstein-Friesian cows demonstrated that first-calving heifers (typically subordinate) exhibited 28% higher basal cortisol levels than dominant multiparous cows (< 0.05), coupled with 3.5-fold more frequent displacements from feeding areas and prolonged cortisol elevation after ACTH challenge tests, indicating hypothalamic-pituitary-adrenal axis hypersensitivity due to chronic social stress (González et al., 2003). Stress biomarkers, including acute-phase proteins like Serum Amyloid-A (SAA) and Haptoglobin (Hp),and Immunoglobulin G (IgG), serve as critical indicators of physiological stress and immune status in dairy cows (Murata et al., 2004; Hulbert & Moisá, 2016). For instance, SAA and Hp are upregulated during inflammatory responses (Ceciliani et al., 2012). Immunoglobulins, particularly IgG, are essential for maintaining mucosal and systemic immunity, with reduced levels signaling immunosuppression under prolonged stress (Hulbert & Moisá, 2016). For example, a study on Rubia Gallega calves demonstrated that socially mixed individuals (typically lower-ranking) exhibited significantly higher SAA (median 6.38 μg/mL vs. 4.75 μg/mL in non-mixed) and Hp levels compared to non-mixed counterparts during slaughter processing, reflecting intensified inflammatory responses due to social hierarchy challenges (Soler et al., 2021).

In pasture-based systems, studies have demonstrated that social dominance influences milk production, with dominant cows often outperforming subordinates (Hasegawa et al., 1997; Sołtysiak & Nogalski, 2010; Hussein et al. 2016). However, in an intensive system where feeding regimens are standardised and space is limited the relationship between social dominance, production performance, and stress biomarkers remains poorly understood. For example, Idrus et al. (2021) highlighted that tropical climate countries, impose unique thermal and management challenges that could modulate stress responses in dairy cows. Additionally, standardised resource allocation in feedlots might mitigate stress disparities, yet empirical evidence in such environments is limited (Galindo & Broom, 2000).

This study addresses these gaps by examining how social dominance affect behaviour, milk production, and physiological stress biomarkers (SAA, Hp,IgG) in lactating dairy cows under an intensive farming system in a tropical climate condition. By integrating behavioural observations with analyses of milk production performance and stress-related biomarkers, this research aims to elucidate the interplay between dairy cows' social dynamics, milk production and physiological performance, in an intensive system under tropical environments. The findings will inform strategies to optimize herd management, ensuring both animal welfare and sustainable production.

Materials and Methods

Ethical Statement

This study was approved by ethical committee Institutional Animal Care and Use Committee (IACUC), approval number UPM/IACUC/AUP-R062/2023.

Experimental site and herd management

This study was conducted at Farm Fresh, Ladang 16, UPM, Serdang, Selangor, Malaysia. A total of 52 lactating, Friesian × Jersey, multiparous dairy cows, grouped and managed together under an intensive system were used in this study. All cows were in their mid-lactation phase (DIM = 147±10), ranged between 2.5 and 6.0 years of age (16 cows = 2.5 to 4 years old, and 36 cows = 4 to 6 years old), with average milk yield of 11.6±0.6 L/day. All cows were milked twice daily at 0630 and 1830h, kept in the same barn and offered the same feeding ration twice daily throughout the study period.

Experiment 1
Determining dominance value

To determine the cow's dominance value (DV), direct visual observations on cows' social behaviour were conducted after morning milking for 6 hours between 0730 to 1330 h for 14 continuous days. All observed cases of social interaction such as butting (swinging their head in the direction of the other animals), pushing (uses part of their body other than the head to displace another cow), and allogrooming (one cow licks the head or the neck regions of another cow; Phillips & Rind 2002), were recorded on a win and loss basis (Beilharz and Mylrea, 1963) by a single trained observer.

Each type of behaviour performed and observed were then given a score depending on the level of aggression (Butting score = 4; pushing score = 3; allogrooming score = 1; Sottysiak and Nogalski, 2010). Cows that successfully displaced other cows by performing one of these behaviours were classified as a winner. The DV determined for each cow was based on a minimum of one social interaction (won or lost by the individual) with at least 10 other cows (Beilharz & Mylrea 1963). The ratio of wins to losses for each cow was transformed to a normal distribution using the following formula where x = number of wins, and y = number of losses (Beilharz & Mylrea 1963):

$$DV = \sin -1 (\Sigma x/x + y)\ ½$$

The dominance value derived from the calculation ranges from 0 to 90; cows with the highest DV (90) have won all interactions and did not experience any defeats throughout the entire observation period, and cows with the lowest number of DV (0) have lost all interactions to all others. To determine the social group of cows in the social hierarchy, cows were categorised into three levels of social rank. The lowest social rank being the subordinate group with the DV ranging from 0 to 30. The second level of social rank being the mid-ranking group with the DV ranging from 30.1 to 60.0, and the highest level of social rank being the dominant group, with the DV ranging from 60.1 to 90 (Sottysiak and Nogalski, 2010).

Experiment 2
Experimental unit

A total of 18 cows that have been attributed DV and classified as: dominant (D; top 6 cows), mid-ranking (M; top 6 mid-ranking cows), and subordinate (S; bottom 6 subordinate cows) according to their ranking in the top, the middle and the bottom half of the hierarchy of DV in experiment 1 were identified and used for this study purposes for the period of another 14 continuous days. To assess whether DV changed over time, each cow's DV during this experiment was calculated and compared with its DV from Experiment 1, and the results showed that cows maintained similar DV rankings with minimal change.

Behaviour, milk production and stress biomarkers

The cow's behaviour of interest such as feeding (actively prehending feed with the head lowered), ruminating (rhythmic chewing of herbage accompanied by regular regurgitation of boli from the rumen), drinking (ingesting water from the water trough), standing (maintaining an upright position on extended legs, while ruminating, or idling), and lying (lying down in any resting position, while ruminating, or idling) (Hussein et. al., 2016), were visually observed between morning and evening milking for 9-h between 0800 to 1700 h, with 10-minutes interval. Behavior was observed over a period of 7 alternate days (day 1,3,5,7,9,11, and 13) to obtain representative activity patterns.

To capture stable production levels, cow's milk yield was recorded manually via milk meter during morning and evening milking throughout the behaviour observation days. To avoid additional stress from repeated sampling, a total of 50ml of milk samples from each cow were collected once during morning milking to determine milk composition (milk fat, protein, and lactose) and milk hormone cortisol. A total of 5ml blood samples were also collected from each cow's tail vein, once after morning milking at the beginning of the study to determine stress biomarkers such as Serum Amyloid-A, Haptoglobin, and Immunoglobulin G levels with the aid of commercial ELISA kits.

Statistical analysis

The relationship between the cow's DV and age, behaviour, milk yield, milk composition, and physiological performance was analysed using Pearson's correlation coefficient and One-Way ANOVA using SAS statistical package (SAS Institute Inc., 2005). Statistical significance was considered at $P<0.05$.

Results and Discussion

The dominance hierarchy within the herd stabilised, with 6.58% of cows classified as dominant (D), 78.24% as mid-ranking (M), and 15.18% as subordinate (S). Social dominance exhibited a significant positive correlation with age (r = 0.453, P = 0.006; Table 1), and ruminating behaviour (r = 0.451, P = 0.006; Table 1), aligning with previous studies suggesting that older cows often ascend in hierarchy due to accumulated experience in social interactions (Keeling & Gonyou, 2001; Hussein et al., 2016).

Table 1. Pearson's correlation coefficient between dominance value (DV) and age (years), body condition score, average milk yield (L/day) and resting behavioural (minutes/ 9 hours) parameters of lactating dairy cows.

Parameter	DV	
	Corr.	P value
Age	0.453	0.006
Body condition score	0.199	0.244
Milk yield	-0.035	0.840
Feeding	-0.154	0.370
Ruminating	0.451	0.006
Drinking	0.076	0.661
Standing	0.111	0.518
Lying	-0.115	0.504

Previous studies also indicated the same result (Shinde et al., 2004; Ungerfeld et al., 2014; Fiol et al., 2018), in which higher ranking animals spent more time ruminating than their subordinate members. This finding may suggest that dominant cows spent more time ruminating as most lower ranking herd members began their eating session later than higher-ranking cows, therefore rumination activity began earlier in D cows than in lower-ranking cows. In addition, D cows coped better with a competitive environment and have no fear of being attacked or threatened than subordinate members (Fiol et al., 2018). Thus, this shows that the amount of time spent in ruminating also depends on the period when the cows began their feeding or grazing activity as low rank animals potentially adjusting their behaviour pattern to prevent conflict with high-ranking animals (Arave et al., 1984).

Dominant cows exhibited significantly longer rumination time (119.3 min/9h) compared to medium-ranked (93.9 min/9h) and subordinate cows (96.3 min/9h; P = 0.0371; Table 2). In confined systems, extended rumination is associated with reduced competition for resting spaces, as dominant individuals secure priority access to comfortable lying areas, thereby facilitating uninterrupted rumination, a behavior optimally performed in lateral recumbency (Tucker et al., 2021).

Table 2. The mean and standard error of mean (SEM) for feeding, ruminating, drinking, standing and lying (minutes/ 9 hours) according to the social group of dominance (D), mid-ranking (M) and subordinate (S) cows.

Parameter	D		M		S		P value
	Mean	SEM	Mean	SEM	Mean	SEM	
Feeding	167.4	7.5	169.6	17.0	171.1	9.4	0.9742
Ruminating	119.3^{a}	3.6	93.9^{b}	11.1	96.3^{b}	6.1	0.0371
Drinking	10.2	1.1	10.6	2.7	9.5	1.7	0.9204
Standing	337.2	10.7	299.7	30.7	320.2	11.7	0.3993
Lying	202.9	10.7	191.7	20.6	219.8	11.7	0.4075

$^{a\text{-}b}$ Means of the same variable in the same row with different subscripts differ for one factor LSD

This finding contrasts with studies in grazing systems, where subordinate cows experience 28 - 40% reductions in lying time due to frequent displacements by dominant herd members during critical resting periods (e.g., nighttime), consequently impairing rumination efficiency (Barroso et al., 2000; Rørvang et al., 2021). The divergence highlights how management systems modulate social hierarchy effects; confinement systems amplify resource monopolization by dominants, whereas pasture systems exacerbate spatial competition for optimal grazing/resting sites among subordinates (Grant & Albright, 2022; Weary et al., 2023). The extended ruminating duration in dominant cows may reflect prioritized access to resting areas, a critical resource in high-density environments, which may lead to increase in milk production, thereby reducing metabolic stress and enhancing digestive efficiency (Beauchemin, 2018). However, there was no significant difference in milk production found in this study between cows in different social ranks (Table 3).

Table 3. The effects of social dominance on milk production, milk composition, and stress biomarkers of lactating dairy cows (D = dominance; M = mid-ranking; S = subordinate).

Parameters	D	M	S	P value
Milk yield (L/day)	10.107 ± 0.72	10.658 ± 0.86	12.508 ± 0.73	0.1063
Fat %	3.823 ± 0.27	3.66 ± 0.31	2.885 ± 0.40	0.1422
Protein %	3.43 ± 0.09	3.367 ± 0.06	3.232 ± 0.10	0.3087
Lactose %	4.422 ± 0.06	4.482 ± 0.05	4.487 ± 0.03	0.6202
Cortisol (ng/ml)	2.145 ±0.08^{a}	2.547±0.04^{b}	2.632 ± 0.10^{b}	0.0008
Serum Amyloid A (ng/ml)	0.020 ± 4.28	0.020 ±1.66667	0.020 ± 2.11	0.1363
Haptoglobin (ng/ml)	0.050 ± 0.00001	0.050 ±0.00001	0.050 ± 5.62	0.6900
Immunoglobulin G (ng/ml)	0.089 ± 0.00007	0.089 ± 0.00005	0.089 ± 0.00007	0.8929

$^{a\text{–}b}$ Means in the same row with different superscript letters differ significantly (LSD, $P < 0.05$).

Notably, dominance hierarchy showed no significant correlation with milk yield (r = -0.035, P = 0.840; Table 1), diverging from pasture-based studies where dominant cows often produced more milk (Sołtysiak & Nogalski, 2010; Hussein et al., 2016). This discrepancy may stem from standardized feeding practices in intensive systems, which homogenize nutrient intake and mitigate feed-related competition, a key driver of lactation differences in less controlled environments (Phillips & Rind, 2002). For instance, González et al. (2008) demonstrated that uniform feed allocation in confined herds reduces behavioural aggression and stabilises milk output across social ranks.

Additionally, the lack of variation in stress biomarkers (e.g., SAA, Hp, IgG; P > 0.05) suggests that the established hierarchy had minimal physiological impact, possibly due to habituation to stable social structures over time (Camerlink et al., 2015). For example, Serum Amyloid-A levels (D: 0.0205±4.28 ng/ml; S: 0.0205±2.10 ng/ml) remained comparable across groups, consistent with findings that acute-phase proteins respond more acutely to environmental or health stressors than to chronic social competition (Murata et al., 2004). Similarly, the absence of rank-related differences in immunoglobulins (IgG) aligns with Hulbert and Moisá (2016), who noted that standardised management in intensive systems buffers against immunosuppressive effects of social stress.

These results highlight the nuanced role of management practices in modulating the effects of social dominance. While behavioural differences (e.g., ruminating time) persist, the absence of physiological and production disparities suggests that lactating dairy cows raised in an intensive system with controlled resource allocation may attenuate stress-related impacts observed in pasture-based herds. However, prolonged ruminating in dominant cows underscores the need for welfare-oriented space design to ensure equitable rest access for all ranks.

Conclusion

This study investigated the interplay between social dominance, behaviour, milk production, and physiological performance in lactating dairy cows under a Malaysian intensive farming system. The findings revealed that social hierarchy was positively associated with age and ruminating duration, with dominant cows spending significantly more time resting compared to mid-ranking and subordinate individuals. However, no significant effects of dominance were observed on milk yield, composition, or stress biomarkers such as Serum Amyloid-A, Haptoglobin, and immunoglobulins. These results suggest that standardised management practices including uniform feeding regimens and stable group structures may mitigate the stress-related impacts of social competition typically observed in pasture-based systems.

The absence of physiological disparities across dominance ranks implies that cows in intensive systems may adapt to established hierarchies, reducing chronic stress responses. Nevertheless, behavioural differences, particularly in resting time, highlight potential welfare considerations for subordinate cows in confined environments. To enhance animal welfare and productivity, dairy farmers should prioritise resource allocation strategies that ensure equitable access to resting spaces and minimise social stressors. Future studies should explore long-term physiological adaptations to dominance hierarchies in tropical climates and evaluate the efficacy of management interventions, such as dynamic regrouping or environmental enrichment, in optimising both welfare and production outcomes. This research underscores the importance of integrating behavioural and physiological insights into dairy herd management to achieve sustainable and welfare-compliant farming practices.

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Conflict of Interest

The authors declare no conflict of interest.

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