# Relationship between social dominance and milk production of dairy cows grazing pasture

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## Abstract

The objectives of this experiment were to study factors determining social dominance of grazing dairy cows and the relationship between social dominance and milk production under grazing systems. A total of 252 spring calving Friesian x Jersey dairy cows in three groups differing in stocking rate and herd size grazing perennial ryegrass and white clover pasture were observed for three months in early lactation to determine their dominance value. All cows ranged in age from 2 to 11 years and live weight (LW) ranged from 340 kg to 648 kg. Dominance values were determined by social interactions indicating dominance and submission between cows. Social interactions were recorded on a win and loss basis. In all three groups, the dominance value was positively correlated ($P<0.05$) with age ($r = 0.42$ to 0.65), live weight ($r = 0.33$ to 0.47) and milk production ($r = 0.32$ to 0.42), but no relationship with body condition score was found. In conclusion, older cows with higher live weight were more dominant and tended to have higher milk production.

**Keywords:** social dominance; dominance value; dairy cows; milk production

## Introduction

Dairy cattle are gregarious animals that form their social hierarchy through dominance establishment. Dominance is associated with higher-ranking individuals having supremacy in the distribution of resources. The cow's dominance value (DV) can be quantified by recording aggressive social interactions, which are the basic component of dairy cattle's social rank establishment (Guhl & Atkeson 1959).

The social dominance of cattle has been positively related to age and measurements of animal size such as body condition score (BCS) and live weight (LW) (Phillips & Rind 2002; Schein & Fohrman 1955; Sottysiak & Nogalski 2010). Age is related to the animal's experience in having dominance encounters and weight is associated with the animal's strength. These factors are associated with the competition for space and considered the main driver for aggressiveness of cows in confined spaces in indoor feeding systems (Potter & Broom 1987). For cows managed at pasture, adequate space is generally assured, and thus priority to the best grazing spots, having longer and undisturbed feeding time or having a preferred area to lie down may be the major drivers of cow's dominance behaviour (Barroso et al. 2000; Phillips & Rind 2002). Therefore grazing behaviour is an important aspect when evaluating any potential effect of DV on DM intake.

In New Zealand, dairy systems typically involve cows grazing pasture in a large group. This practice may have an influence on cow's social dominance resulting in an increase in social interactions. Aggressive social interactions create stress conditions between dominant and subordinate cows which may affect milk production (Schein & Fohrman 1955), especially for the subordinate cow. Brakel & Leis (1976) reported a reduction in milk production following a series of aggressive social interactions. Furthermore, dominant cows have greater opportunity to obtain basic resources such as feed and space compared to subordinate cows (Arave & Albright 1981), which may explain the greater milk yield sometimes found in dominant cows (Reinhardt 1973). Previous studies, however, have shown contradictory results for relationship between milk production and DV, ranging from no effect (Beilharz et al. 1966; Schein & Fohrman 1955) to a strong positive relationship (Sambraus 1970; Sottysiak & Nogalski 2010). Many of the studies to date have been conducted with cows under confinement systems, and limited data are available on social dominance of dairy cows in relation to milk production, especially in the New Zealand pasture-based system.

The objectives of this experiment were to study factors determining social dominance of dairy cows and to investigate the relationship between dominance and milk production of dairy cows under a pasture based system.

## Materials and methods

*Experimental site and herd management*

The study was conducted at the Lincoln University Research Dairy Farm, Canterbury, New Zealand (43°38S', 172°27E') between September and December of 2014. Three groups of cows were used in this study: a large group of 189 cows stocked at a medium stocking rate (4.2 cows/ha; MSR); a small group of 34 cows stocked at high stocking rate (5.0 cows/ha; HSR); and a small group of 29 cows stocked at a low stocking rate (3.5 cows/ha; LSR). The two smaller groups were part of a long-term farm systems trial (details described by Clement et al. 2016). All cows had calved in spring (17 July-17 September 2014), and ranged in age from 2 to 11 years old with live weight ranging from 340 to 648 kg. Each group was grazed separately on perennial ryegrass (*Lolium perenne* L.) and white clover (*Trifolium repens* L.) pastures, with *ad libitum* access to water. The HSR group were fed pasture supplemented with up to 3 kg DM grain/cow/day. The

LSR and MSR groups were offered pasture only. Over the period of observation, herbage allowance was offered above a post-grazing herbage mass of 1400 to 1500 kg DM/ha. Pasture allowance ranged from 11 to 14 kg DM/cow/day for HSR and MSR groups, and from 12 to 16 kg DM/cow/day for the LSR group. Based on pre-grazing herbage mass, and paddock size, daily space allocation per cow of pasture was 129 $m^2$ for LSR, 110 $m^2$ for HSR and ranged from 32 to 81 $m^2$ for MSR. Cows were milked twice daily according to group at 0600 h to 0800 h and 1430 h to 1630 h. Milk yield was measured using an automated system (DeLaval Alpro Herd Management System, DeLaval, Tumba, Sweden). Cow LW was recorded manually once every two weeks using an electronic walk-over scale. Body condition score was assessed once a week based on a ten-point scale scoring (Roche et al. 2004).

*Behaviour observations*

Visual observations of behaviour were conducted for 12 weeks between September and December of 2014. Permanent rubber ear tags with an identification number were used to identify cows. Cows were observed on one occasion each week by the same single trained observer. Each group was observed on separate days. One week prior to the study, pre-observation was conducted as a transition period for cows to become familiar with the presence of the observer and to prevent distraction during observations.

*Dominance value*

To determine the cow's DV, all observed cases of social interactions over 12 recording days indicating dominance and submission between cows were recorded on a win and loss basis (Beilharz & Mylrea 1963). During observations, behaviour such as bunting (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) were recorded (Phillips 2002; Phillips & Rind 2002). Cows that initiated one of these behaviours were classified as a winner. Due to the size of the group, not every interaction was recorded.

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:

$$DV = \sin^{-1} (\Sigma x/x + y)^{1/2}$$

Where $x$ = number of wins, and $y$ = number of losses (Beilharz & Mylrea 1963).

*Grazing behaviour*

During each observation in the HSR and LSR groups, the grazing behaviour of all cows was recorded by visual scan observation at 10-minute intervals. The behaviour was recorded in the following categories: grazing (actively prehending herbage with the head lowered) and ruminating (rhythmic chewing of herbage accompanied by regular regurgitation of boli from the rumen). Cumulative time spent in each activity was calculated, assuming activity recorded occurred over the entire 10 minutes period. Due to the size of the group, no grazing behaviour data was recorded for the MSR group.

*Statistical analysis*

The relationships between DV and milk yield, age, LW, BCS and grazing behaviour were examined using Pearson's correlation coefficient using GenStat (V.6) separately for each group.

## Results

*Milk production and grazing behaviour*

The mean production, dominance value, social interactions and grazing behaviour for the three groups are shown in Table 1. Less than five social interactions per cow were observed in the MSR group, while 10 or more social interactions were observed between cows in the smaller LSR and HSR groups (Table 1).

**Table 1** Mean production and standard error (SEM) for milk production, dominance value, social interactions and grazing behaviour in low-stocking-rate (LSR), medium-stocking-rate (MSR) and the high-stocking-rate (HSR) group. No grazing behaviour data recorded for MSR group.

| Item | LSR | | MSR | | HSR | |
|---|---|---|---|---|---|---|
| | Mean | SEM | Mean | SEM | Mean | SEM |
| Milk yield (kg/d) | 26.5 | 0.9 | 21.7 | 0.4 | 24.5 | 0.7 |
| Live weight (kg) | 530.4 | 11.5 | 477.3 | 4.3 | 511.3 | 8.9 |
| Body condition score | 4.1 | 0.1 | 4.1 | 0.1 | 4.2 | 0.1 |
| Age (year) | 5 | 0.4 | 4.7 | 0.2 | 4.7 | 0.5 |
| Group size (No. of cows) | 29 | | 189 | | 34 | |
| Dominance value | 40.7 | 3.1 | 50.3 | 1.5 | 43.9 | 2.1 |
| Total social interactions | 297 | | 589 | | 475 | |
| Social interactions/cow | 10 | | 3 | | 14 | |
| Grazing time (min/5 h) | 167 | 4.8 | | | 176 | 2.7 |
| Ruminating time (min/5 h) | 77 | 4.3 | | | 53 | 2.2 |

**Table 2** Pearson's correlation coefficient of dominance value and milk production and grazing behaviour parameters for low-stocking-rate (LSR), medium-stocking-rate (MSR) and high-stocking-rate (HSR) group. No grazing behaviour data recorded for MSR group.

| Production/ | LSR | | MSR | | HSR | |
|---|---|---|---|---|---|---|
| Behaviour parameter | Corr. | *P* Value | Corr. | *P* Value | Corr. | *P* Value |
| Milk yield (kg/day) | 0.42 | 0.02 | 0.32 | <0.001 | 0.13 | 0.48 |
| Live weight (kg) | 0.47 | 0.01 | 0.33 | <0.001 | 0.46 | 0.01 |
| Body condition score | 0.13 | 0.5 | 0.07 | 0.45 | 0.18 | 0.32 |
| Age | 0.65 | <0.001 | 0.42 | <0.001 | 0.44 | 0.01 |
| Grazing time | -0.24 | 0.22 | | | -0.21 | 0.24 |
| Ruminating time | 0.09 | 0.66 | | | -0.04 | 0.81 |

*Factors determining social dominance*

There was a significant positive correlation between DV and LW (r = 0.33 to r = 0.47) and the age (r = 0.42 to r = 0.65) in all three groups (Table 2). Milk yield was positively correlated with DV in LSR (r = 0.42) and MSR groups (r = 0.32) but not in the HSR group.

## Discussion

*Social interactions*

Relative to the smaller groups there were fewer social interactions between cows in the large MSR group. This may be due to the lack of recognition between group mates, leading to relationship breakdowns, which in turn result in less aggression between members of the group. The lower number of social interactions found in the MSR group could also be possibly caused by social interactions that were missed during observation. Although using one observer increases the risk of missing interactions, it reduces potential source of variability associated with multiple observers (e.g. cow distraction). However, recordings were made over 12 weeks in order to increase the total number of social interactions recorded, which exceeded 500 in the MSR group. Furthermore, the finding of fewer observations in a larger herd is in agreement with the result of Lindberg & Nicol (1996), who claimed that larger groups lead to fewer agonistic social interactions.

*Milk production*

The relationship between milk production and DV in previous studies has been shown to be inconsistent, with both positive (Sottysiak & Nogalski 2010) and negative (Collis et al. 1979; Phillips & Rind 2002) relationships recorded. In this study, the relationship between milk production and DV was positive in LSR and MSR, while no relationship was found in HSR. Cows in the HSR group were fed pasture plus grain while cows in the LSR and MSR group were fed only pasture. Social dominance in cows is usually derived from competing for feed. Although nearly 60% more interactions were observed in the HSR than the LSR group, supplementing grain to the HSR group may have compensated for the competitive effects of social dominance on pasture intake. Hence, the absence of social dominance may have explained the non-significant effect on milk production in this group.

*Grazing behaviour*

The time spent grazing was recorded to evaluate any potential effect of DV on DM intake. Phillips & Rind (2002) stated that dominant animals may spend time and effort maintaining their position in the hierarchy at the expense of grazing. However, no significant correlation was found in HSR and LSR groups among grazing, or ruminating and DV. This finding does not mean that there was no effect on grazing behaviour since grazing behaviour was only recorded over a five-hour period and not over a complete day. Furthermore, Stobbs (1978) indicated that bite size and bite rate are more accurate parameters in evaluating grazing behaviour compared to grazing time alone. Additional studies need to be conducted on these parameters as Phillips & Rind (2002) found that dominant animals had faster bite rate than subordinate cows, and milk production is also known to be linearly related to these parameters (Reindhart 1973).

*Factors determining dominance*

In this study, the key factors found to be related to dominance in all groups were LW and age. This is in agreement with previous studies for cows under grazing (Phillips & Rind 2002; Schein & Fohrman 1955; Sottysiak & Nogalski 2010) and confinement systems (Dickson et al. 1970; Guhl & Atkeson 1959). Age is an index of seniority (length of time in herd) and Guhl & Atkeson (1959) stated that higher-ranking cows were usually associated with seniority in a social hierarchical herd due to the fact that older cows were more experienced in having encounters with other cows compared to younger cows. On the other hand, weight is used as an index of strength (Schein & Fohrman 1955) where larger and heavier cows have the advantage in performing more successful agonistic encounters compared to smaller or lighter weight cows. The absence of any correlation between DV and BCS in dominance is primarily based on size of animals not on their fat reserves (Phillips & Rind 2002).

In conclusion, for cows rotationally grazed at pasture, it was found that DV was positively correlated with LW and age of cows, but not BCS. Having identified the positive effect of age and LW on DV and subsequent effect on milk production, future research is required to test whether separating animals, based on these variables, or feeding differentially, could improve milk production. In addition, using these determinants for social dominance may also contribute to a better grouping management in the current New Zealand dairying system.

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