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Influence of previous medical treatments on social rank in dairy cows

Anne Littooj, Andrew Butterworth

ABSTRACT

Animal health can present economic and animal welfare concerns for dairy farmers. However, it is unknown whether changes in behaviour as a result of sickness have long-term effects, and whether there is a relationship between the social rank of cows in the herd at a moment in time and the medical treatment history of these cows. The behaviour of 100 high-yielding cows in the waiting area (collecting yard) before the milking parlour was studied for five milking sessions to assess the interactions between the cows, as the cows waited to be milked. The cows were filmed, and the interactions between cows were recorded using an ethogram. The summated social rank score of each cow was compared with its medical treatment history. In our analysis, a positive relationship was found between medical treatment history and social rank, however this association was discounted when age was accounted for. When a subsample of cows older than 4.0 years was analysed to examine the relationship between social rank and medical treatment history in older cows, no significant correlation existed. These results suggest that the relationship between social rank and medical treatment history identified in the analysis is predominately an effect of age. This finding is contradictory to the hypothesis that 'a higher historical level of medical treatments, and the disruption and setbacks associated with these disease conditions, would result in a lower position in the social rank.' This preliminary study reports the findings from one particular herd, and across one relatively short time span, and because associations between treatment history and behaviour may be of interest in management decisions for producers, it is recommended that further investigation of this subject is carried out.

INTRODUCTION

Animal health issues can influence dairy production for economic and animal welfare reasons. Common diseases in dairy farms include lameness and mastitis, and much is already known about clinical treatments and the immediate behaviour changes seen in animals suffering from these conditions. For example, it is known that lame cows spend more time lying down, and that they also increase the frequency of lying bouts when compared with non-lame cows.^{1,2} Cows suffering from mastitis reduce their lying times, and increase their time spend walking or standing.³ Being sick can also affect

social behaviour, because the number of social interactions and behaviours is likely to be reduced when cows become sick.⁴ For example, cows with mastitis show less competitive behaviour(s) when they are sick, but this reduction disappears after effective treatment.⁵ It is possible that the social rank of an individual cow is influenced by, and also influences the occurrence and effects of disease. Studies by Galindo and coworkers^{6,7} found that lower ranking cows with lameness could not move around in the herd as freely as higher ranking cows. These authors also found a significant association between dominance rank and the occurrence of lameness when using pairwise comparisons. However, it is unknown whether changes in behaviour as a result of sickness have long-term effects, and whether there is a relationship between the social rank of cows in the herd at a given moment in time and the medical treatment history of these cows.

This study investigated whether historical medical treatments influenced the social rank of individuals in the milking herd. In the present study, dairy cow behaviour in the waiting area (collecting yard) was studied to assess the interactions between the cows as they waited to be milked. Through analysis of these interactions it was possible to determine the social rank of each at the time of the study. A review of the literature indicates that only a limited number of studies have examined cow behaviour in the collecting area just before milking,^{8,9} and there do not appear to be published studies which specifically assess social rank in this area. In the waiting area, cows find it necessary to stand close to each other, with reduced capacity to avoid other cows, and this results in an increase in the frequency and overall number of cow-to-cow interactions.⁸

MATERIALS AND METHODS

Animals and management

The study was conducted at a commercial dairy farm with 204 lactating Holstein-Friesian



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Clinical Veterinary Science, University of Bristol, Bristol, UK

Correspondence to

Dr Andrew Butterworth; andy.butterworth@bris.ac.uk

cows in Somerset, UK. Cows were kept under normal husbandry conditions in a loose cubicle housing system, with sand as the bedding material, with an approximately 100:110 cow:cubicle ratio. The milking was carried out three times a day at 05.00, 13.00 and 20.30 in a 2 x 12 herringbone milking parlour (24 positions in total) and with automatic cluster removal (DeLaval), and lactating cows were milked in two groups. The low-yield (LY) group contained lactating cows producing less than 40 litres of milk per day, cows that were more than 150 days into the lactation and pregnant cows. The high-yield (HY) group, the cows which were filmed, contained the remaining lactating cows in the herd. Some cows moved in and out of milking groups during the observation period as a result of movement from the HY to the LY group for management purposes, and this caused a small variation in the number of milking cows from day to day. The HY group was milked before the LY group. Cows were collected in a waiting area, 6.0 x 23.3 m (139.8 m²), with a gently sloping concrete floor. An electrically operated backing gate with electrified wires and noises (a beeper) was used to move cows towards the parlour. Milking the HY group of 110 cows took approximately one hour per milking.

Collection of filmed data

Two cameras (GoPro HERO4, 2014) were placed above the entrance to the milking parlour at a height of 2 m. Cows were filmed for five consecutive days during the afternoon milking, which started at 13.00, to obtain the best daylight for filming. In the majority of the cases, the cows were identified by using the installed DeLaval Multireader, which electronically read the cow ID from a transponder, and this automated system also recorded milk production for each cow. Photographs were taken of the head, back and both sides of each cow to enable identification of cows on the film which were missed by the Multireader, or cows that were not identifiable in the film sequences from the freeze brand or ear tag numbers.

Behavioural analysis

An ethogram was constructed using previous ethograms described in the literature.^{10 11} The ethogram addressed both agonistic and other interactions between cows (please see [table 1](#) for the behaviour descriptions used in this ethogram, and [figure 1](#) for still image examples of the recorded behaviours). Dominant behaviours were divided into four categories: head-butting, displacing, forceful behaviour, penetration (defined as a cow pushing itself between two other cows) and retaliating (cow reacts with an attack). Head-butting and displacement were also divided into 'strong' and 'weak' behaviours, to enable a measure of the severity of the action. Submissive behaviours were described as one of four categories: avoiding, being displaced (both measures being divided into 'strong' and 'weak'), being penetrated (being pushed past) and walking backwards. Two other recorded behaviours were included: mounting and

overtaking (which was defined as a cow passing a waiting cow before the entrance to the milking parlour). Positive behaviours such as licking were also included in the ethogram as potential measures, although they were not actually seen during the observation period.

After each recording period (duration 1–1.15 hours), the two sets of videos (left and right cameras) were analysed visually by one researcher, and all interactions between cows which were visible on the video were noted on a record sheet. In each recorded event, a cow received one point (+1) for weak butting, forceful behaviour, weak displacement and penetrating; and two points (+2) for strong butting and strong displacement. These behaviours were considered as 'dominant'. A cow received one negative point (–1) for weak avoidance, being 'weakly' displaced and for being penetrated (pushed aside); a cow received two negative points (–2) for strong avoidance, being strongly displaced and walking backwards. These behaviours were considered as 'submissive'. Retaliation was given one point (+1). Overtaking behaviour was analysed separately, with one point (+1) for overtaking and one negative point (–1) for being overtaken. The timing mark taken from the video was recorded for each interaction to allow comparisons of temporal trends in behaviours. Interactions as a result of direct human interference were not recorded because this study focused on direct interactions between cows without immediate human interference. An example of a human interference would be when cows refused to go into the milking parlour and had to be moved by the farmer such that all interactions during this moving period would be discounted. All scores for all interactions (positive and negative) were summated to determine the progressive social rank of each cow, on each day of observation.

Ten cows were excluded from the analysis during the filming period because they were not in the same group for the whole observation period (ie, they either moved out of, or into, the HY milking group), as a result of management changes made by the farmer. This resulted in 100 cows remaining consistently in the HY group for the full analysis. In addition, interactions where those 'removed cows' were involved were also excluded and, thus, cows remaining in the analysis were those present during the entire observation period. During the observation period, 919 interactions, as categorised according to the ethogram of behaviours in [table 1](#), were recorded.

InterHerd data

Historical treatment and management data for each cow were derived from the InterHerd program (NMR, 2011), which was used by the farmer to record information about the cows (including calving dates, milk production data, veterinary treatments). The number of sickness events in the record, starting from first lactation, was summated per cow. Some rules were applied to define a 'treatment case'. If the same disease event was reported again within 14 days of the first recorded event, it was considered as 'one event' (the same event). For example, a case of

**Table 1** Ethogram describing observed behaviours

Agonistic behaviours		Behaviour associated with conflict or fighting between two individuals	Score
Dominant			
Butting	Bw	Weak: When a cow uses head to attack another cow without displacing the other cow (eventually submissive cow can walk away by itself).	+1
	Bs	Strong: When a cow uses its head to attack another cow and displaces the other cow.	+2
Forceful behaviour	FB	A threatening swing of the head in the direction of the subordinate individual, followed by submission or avoidance on the part of the recipient.	+1
Displacing	Dw	Weak: The dominant cow physically displaces another cow with some part of the body other than the head. As a result, submissive cow steps (one step) aside.	+1
	Ds	Strong: The dominant cow physically displaces another cow with some part of the body other than the head. As a result, the submissive cow gives up its position and does several steps aside.	+2
Penetrating	P	Cow pushing itself between two other animals, causing displacement in other cow(s). Filling up an empty space without pushing other cows is not included.	+1
Contact	C	Combat between two cows, with no clear-cut winner.	0
Submissive			
Avoiding	Aw	Weak: Cow turns head in opposite direction in order to avoid aggressor.	-1
	As	Strong: Cow moves in opposite direction in order to avoid aggressor.	-2
Retaliating	R	Cow retaliates with an attack.	+1
Being displaced	BDw	Weak: Cow physically being displaced because of movement by another cow, but with a maximum of one step aside.	-1
	BDS	Strong: Cow physically being displaced because of movement by another cow, does several steps aside.	-2
Walking backwards	WB	Cow walking backwards as a result of dominant behaviour. Walking backwards out of milking parlour is not included.	-2
	BP	Being pushed past.	-1
Other behaviours			
Mounting	M	Interactions as a result of mounting behaviour are not noted (when the cow that is being mounted is trying to get away and pushing other cows away).	0
Being mounted	BM		
Overtaking	O	Cow waiting in front of milking parlour or walking to milking overtaking other cows and entering milking parlour first. Touching is possible, displacement as a result of overtaking is written down as another interaction.	0
Being overtaken	BO	When cow was in position to enter milking parlour, but overtaken by other cows, eventually pushed aside a little bit (which is a new interaction).	0

lameness with multiple entries and reported across up to 14 days in duration was recorded as 'one event'. If the animal was considered 'cured' within 14 days (as shown in the details recorded by the farmer), then a 'new incidence' was recorded, and then it was considered as 'two events'. Events recorded were: mastitis, lameness, milk fever, digestive disorders, downer cow (cow unable to stand), metritis, vulval discharge (visible secretions from the vagina which usually indicate infection of the uterus or vagina), high cell count, ketosis and 'undiagnosed sickness' (when a clear diagnosis was not made).

Statistical analysis

Data were analysed using SPSS V.23 (IBM, 2015). The major focus of the analysis was to examine the associations between previous medical treatments and the social rank of the cows. There are two possible hypotheses: (A) medical events may result in a lower social rank score (the literature suggests that treated cows may not

be able to maintain their position in the herd) or (B) lower social rank scores may result in more medical treatments (because dominant cows would have better access to positions like feeding, sleeping, milking, and so on). Because of these two possible positions, we were not able to determine the dependent and independent variables, which are assumptions for a linear regression and so we chose to use a partial correlation test (SPSS V.23), which takes age into account when determining the correlation between medical treatment history and social rank. Spearman's correlation test was used to test the association between age and social rank and the association between overtaking behaviour (see ethogram descriptions in table 1) and social rank. Correlations were considered significant when $P < 0.05$. Descriptive results are reported as median (\pm IQR) as the data are not normally distributed.

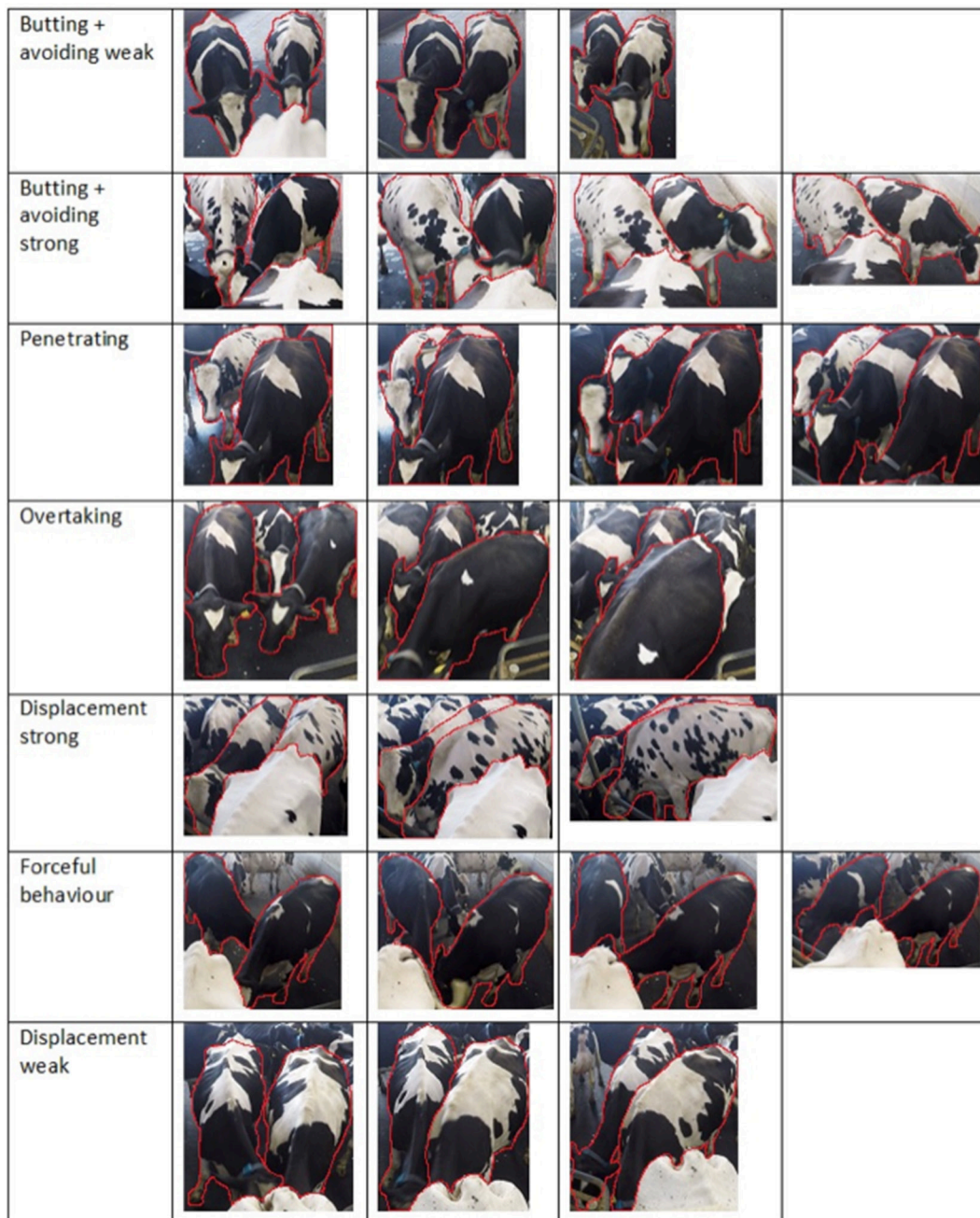


Figure 1 Still image examples of a sequence of cow behaviours.

RESULTS

Social rank

Each cow started with a social rank score of zero (neutral) and as the observation days progressed, a cumulative score denoting alteration in rank was calculated. The mean social rank at the end of the observation period was $-0.00 (\pm 8.0)$ (median (\pm IQR)), with a median of $11.0 (\pm 10.3)$ interactions per cow. Cows were ordered according to this 'social rank' measure, and every 20th cow was selected for the example graph shown in [figure 2](#), which includes the profiles for most dominant and most submissive cows. Some individual cow observations are discussed to explore the range in behaviour profiles seen; for example, cow 654 was the highest ranking cow overall

(with a cumulative score of +14), but showed a mix of both submissive and dominant behaviours during the observation period. Cow 1416 showed an approximate balance of both submissive and dominant behaviours, and had an almost neutral cumulative score in the end (-1). This cow also showed a lower degree of scoring fluctuation, ranging from -4 to 1, during the five days of observation. Cow 415 was the most submissive cow observed, with a predominance of submissive behaviour and a final cumulative score of -53.

Age was compared with social rank using a Spearman's correlation test. The median cow age was $3.8 (\pm 2.7)$ years, with a minimum and maximum age in the group assessed of respectively 1.9 and 9.0 years. A significant

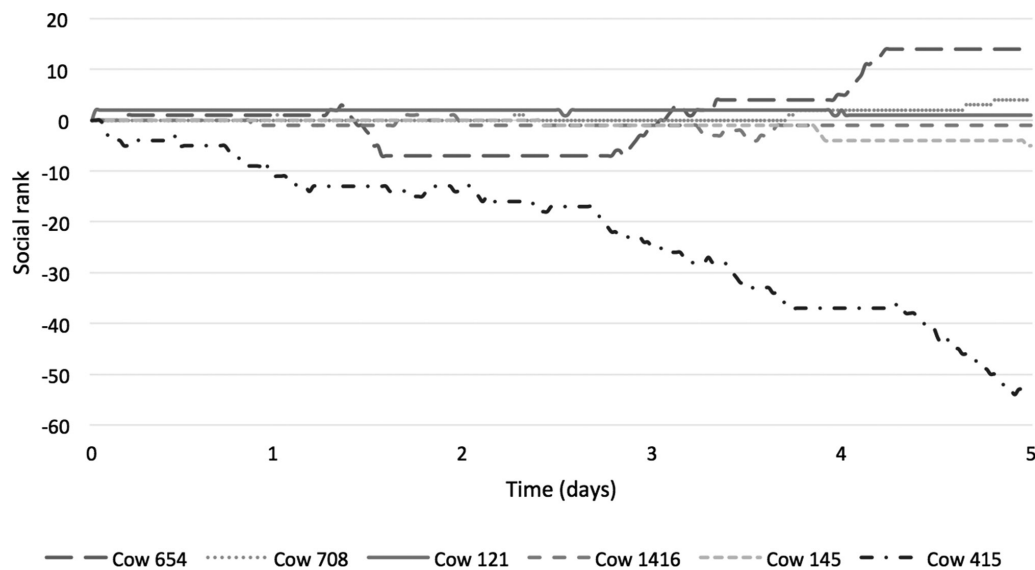


Figure 2 Example of variation in cumulative social ranking score during the observational period (five days).

positive correlation was found between age and social rank ($r=0.444$; $P=0.000$), indicating that older cows tended to have a higher social rank.

Medical treatment history

In total, 82 cows in the observed group (100 cows) had a recorded medical treatment history (some had no treatments so no treatment history), with a median number of treatments of 1.0 (± 3.0), ranging from 1 to 16 health events. Mastitis, lameness and vulval discharge were the most common events recorded (respectively 68, 67 and 52 cases in total). Six cows were recorded as having disease occurrence or a recorded treatment during the observation period. Using Spearman's correlation coefficient, a positive correlation was found between age and the number of diseases recorded in the cows ($r=0.735$; $P=0.000$). The medical treatment history was also weakly positively correlated to social rank ($r=0.206$; $P=0.040$) suggesting that cows with a higher medical treatment history tended to have a slightly higher social rank. However, when using the partial correlation test that takes into account the effect of age, no correlation was found between medical treatment history and social rank (coefficient = -0.117 ; $P=0.251$), suggesting there was no relationship between the number of medical treatments (assessed from first lactation) and social rank score. When only cows of at least 4.0 years old ($n=47$) were analysed on the relationship between social rank and medical treatments, also no correlation was found ($r=0.175$; $P=0.246$).

Because the relationship between social rank and overtaking behaviour (see [table 1](#) for description of this behaviour) was unknown, a Spearman's correlation test was carried out to explore this association. A significant positive correlation was found between social rank and overtaking behaviour ($r=0.411$; $P=0.000$), suggesting that cows with a higher social ranking score tended to 'do more overtaking' and cows with a lower social ranking score tended to be more 'overtaken'.

DISCUSSION AND CONCLUSIONS

It is of course logical that older cows will have a higher medical treatment history, because they have had a longer period of exposure to disease conditions. In our analysis, a positive relationship was found between medical treatment history and social rank when assessed alone ($r=0.206$; $P=0.040$), however this association was discounted when age was accounted for. When a subsample of cows older than 4.0 years was analysed to examine the relationship between social rank and medical treatment history in older cows, no significant correlation existed. These results suggest that the relationship between social rank and medical treatment history identified in the analysis is predominately an effect of age. This finding is contradictory to the hypothesis that higher ranking cows would have had fewer medical treatments, if it were to be assumed that medical treatments would have a negative influence on social behaviour in the long term. In the published literature, there are contradictory findings in studies which explore the relationship between health disorders and social rank. For example, Hessing *et al*¹² found that higher ranking pigs had an improved immune response and were thus better protected against pseudorabies than lower ranking pigs, whereas Galindo *et al*⁷ reported that lower ranking cows were more likely to become lame because they could not move as freely as higher ranking cows. By comparing different methods for determining social rank and comparing these to different health problems in cows, Luchterhand¹³ concluded that it was likely to be difficult to predict health changes by using social rank because there was a lack of consistency in the different methods used to determine social rank. To examine whether overtaking behaviour (when a cow waiting in front of milking parlour or walking to the milking parlour is overtaken by other cows that enter the milking parlour first, [table 1](#)) is related to social rank, a Spearman's correlation test was

carried out. A strong positive correlation for this association was found, suggesting that being overtaken by other cows is a submissive behaviour, while overtaking is a dominant behaviour.

There are some differences, and also a number of similarities between the findings of this study and previous research. This may be caused by the fact that social rank interactions were assessed in the waiting area just before milking, whereas other studies have tended to calculate dominance values in a yard (where cows were feeding, lying or resting). The differences seen between our study and other published studies may, therefore, be partly a result of the 'study area' and may be influential by the type and intensity of interactions between the cows in the collection area before milking, because the short duration of waiting, but high cow density, in the waiting area may cause an increased number of interactions, as cows make close and repeated contact with other cows. This supposition is supported by Irrgang *et al*⁸ and Szabó,⁹ who both studied the effects of space allowance in the waiting area in, respectively, cows and goats. In addition, the queuing nature of some of the activity while waiting to be milked may pressurise some of the behaviours such as penetrating (pushing between) and overtaking behaviours. These factors may have influenced the social ranking score. In the present study, submissive cows were not able to move away from, or avoid, dominant cows, as there was a high density of cows in the collecting area and in front of the left and right entrances to the milking parlour. Submissive cows may have walked away from negative interactions with other cows if there had been more space to do so. This could potentially result in a lower social ranking score for some particularly submissive cows, because a submissive cow could have been forced to stand and tolerate dominant behaviours from dominant animals.

Another discussion point is that cows are likely to give different 'value' to different resources, and dominant cows in the milking parlour may not be dominant in all situations.¹⁴ It is possible that animals classified with low social ranking scores based on interactions in the milking parlour are not low-ranking animals when scored for social ranking in other situations.

Although some differences in findings between the present study and previous research^{15–17} may be caused by the fact that this study is the first to determine social rank in the waiting area, some conclusions can be drawn. This study indicates that the social rank of individual cows is not related to the number of historical medical treatments, and this finding may appear contradictory to the hypothesis that 'a higher historical level of medical treatments, and the disruption and setbacks associated with these disease conditions, would result in a lower position in the social rank.'

Previous studies have reported contradictory results for these types of interactions, with some reports showing a relationship between social rank and health, while others concluded that social rank was not a good predictor of

health. Studies on a larger number of animals, from a larger number of herds and from different management systems might be possible in the future, and would add further understanding, but this was outside the scope of the current preliminary study. The current study shows the findings from one particular herd, at one particular time of year, and assessed only in the collecting yard just before milking, an area which promotes a high frequency of cow-to-cow interactions. The finding is potentially of interest, because it supports a view that a history of medical treatments is not, per se, damaging to a cow's social position in the herd, and this may have implications for cow choice and retention in the herd—as producers may have considered that 'having to treat a cow' might affect its 'place in the herd'—but this study does not support this—cows with more treatments appear to be able to 'hold their social position'. However, this is a preliminary study used to explore the potential of assessing temporal effects of medicine use on cow behaviour, and it is recommended that further investigation of this subject is carried out to confirm that these findings are repeatable in other dairy systems.

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