

## **Additional concentrates do not affect feeding times of cows, but social positions of cows do**

M. Soonberg<sup>1,\*</sup>, M. Kass<sup>1</sup>, T. Kaart<sup>2</sup>, R. Leming<sup>1</sup> and D.R. Arney<sup>1</sup>

<sup>1</sup>Estonian University of Life Sciences, Department of Animal Nutrition, Fr. R. Kreutzwaldi 46, EE51006 Tartu, Estonia

<sup>2</sup>Estonian University of Life Sciences, Department of Animal Breeding and Biotechnology, Fr. R. Kreutzwaldi 46, EE51006 Tartu, Estonia

\*Correspondence: maria.soonberg@student.emu.ee

**Abstract.** In robotic milking dairy systems lack of control over intakes can be problematic for balancing the forage and concentrate portions of diets. This can lead to problems associated with high concentrate intakes and concomitant low forage intakes. To check this as a problem, the feeding behaviour of cows was observed: the number of daily visits to the feed barrier, the duration of these visits and actual feeding, of high and low yielding cows. The cows were robot-milked and fed a ration comprising, separately, concentrate feed from a robot and a feeder, and a grass/clover silage mix forage at the feed barrier. Individual variation in visiting times and times spent at the feed barrier were greater than the effect of level of production. There was no evidence that cows with higher milk yields are differentially motivated to feed from forage. But more dominant cows spent more time feeding than submissive cows.

**Key words:** behaviour, concentrate feeding, robotic milking, dairy cow.

### **INTRODUCTION**

On dairy farms concentrates are given to cows to increase feed intakes and milk production (Ivemeyer et al., 2014). Concentrate feeding is particularly important in the first weeks immediately after calving when cows go through a period of negative energy balance (Ferris et al., 2003). Currently, concentrate feeding levels in dairy cows' rations are increasing, but so are concentrates' prices, which means they should be used efficiently by producers (Finneran et al., 2012).

There are a wide range of concentrate feeding methods that can be used on farms. Farmers can mix together concentrate with the forage components into a single feed, offer the concentrate portion separately from the forage or combine these two approaches. Whenever the farmer decides to feed concentrates separately from forage there are at least two strategies for this. One option takes account of individual cows' milk yields, and includes the concentrate portion as amounts appropriate to the yield. The second option is to feed the concentrate at a flat rate, which does not take into account the needs of each individual cow (Purcell et al., 2016).

High yielding cows require high levels of concentrate feeds to achieve their maximum potential milk production. Grouping cows based on lactation stage can reduce

the problem of differential concentrate feeding requirements in the herd, but farmers must be cautious not to underfeed or overfeed the cows (Mäntysaari et al., 2004). When farmers are not able to group cows by keeping them in different pens, and offering different feed rations in the different pens, one option could be the use of feeding bins, where it is possible to group cows by allowing them to feed from different bins, with different proportions of concentrates to forage, depending on their milk yield. Access to each bin is permitted through cow recognition by a transponder. This means that cows with higher milk yields should receive more concentrates to support their higher production. A second option is to have a feeding barrier and separate concentrate feeding bins where cows receive the concentrate portion of their ration which, as in the previous option, depends on their milk yield and days in milk. Both options require cows to have ID collars fitted with transponders around their necks.

The use of feed bins and individual access by cows is not a perfect solution, as cows can still access the ‘wrong’ feed bins (Soonberg & Arney, 2014), with highly motivated but lower yielding cows accessing the higher value ration, leading to overcondition in those cows. In addition, where cows are offered concentrates separately from forage, the cows offered higher amounts of concentrates may have a reduced appetite for, and therefore reduced intakes of, forage. This imbalance between concentrate and fibre intakes could have negative effects on degradability, digestion, volatile fatty acid absorption and consequent milk composition and quality. This experiment was designed primarily to investigate whether there is evidence in practice of reduced intakes of forage in the cows which receive the forage and concentrate portions of their diet separately.

If cows are frustrated from satisfying their nutritional needs, or in their motivation to feed, it might be expected that this would be a cause of distress and affect their behaviour. This might affect, in particular, their feeding behaviours and social behaviours (both social and antagonistic behaviours). If therefore cows are identified as having different feeding and social behaviours at different production levels this would suggest an impairment in their level of well-being, and possibly indicate the need for a change in their feeding regime. Feeding behaviour could also be used to estimate the actual intakes and motivation to feed of individual cows.

Our hypothesis for this study was that cows who receive extra concentrate would spend less time feeding on forage when both portions of the ration are offered separately. It was further hypothesised that observation of feeding and social behaviour of dairy cows in a herd could be useful indicators of intakes of dietary rations.

## **MATERIALS AND METHODS**

The study was carried out on the Estonian University of Life Sciences’ experimental farm in Märja, Tartumaa, Southern Estonia. Estonia (57°30’ and 59°50’) is in Northern-Europe where dairy cows are mostly kept indoors, either overwinter or all year round.

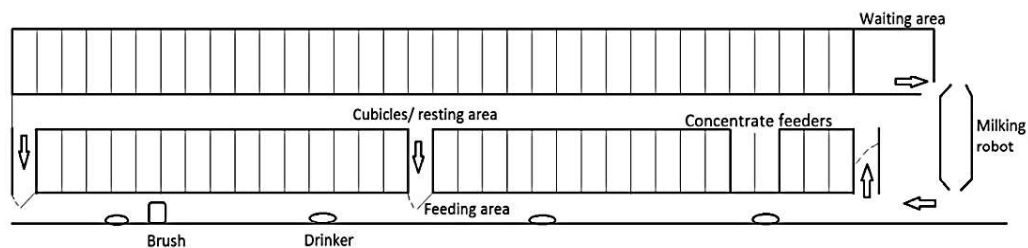
The university farm houses around 250 cows, including dry cows and youngstock, under a zero grazed system. There are approximately 120 lactating cows at any one time. The lactating cows are divided into two groups. Cows in the first group are milked in a milking parlour and fed a total mixed ration (TMR) from individual feeding bins. Cows in the second group are milked with a forced traffic robotic milking system (DeLaval, 2007). Sample cows were selected from the second group.

The study was run in accordance with the Animal Protection Act of the Republic of Estonia.

### Animals and diets

Eight multiparous Estonian Holstein cows (194 + 143.8 days in milk, 30 kg average milk yield, SD 13.1 kg) were selected for the sample group based on the amount of concentrates they received in their diets. Individuals were chosen at random from each of the selected concentrate level dietary groups. The trial was carried out in two groups, each group receiving different amounts of additional concentrate. Four of the sample cows received two or four kg of concentrate feed per day (supplemental concentrate values which were according to the extant practice on the farm and which were according to milk yields), and four cows (control) received no additional concentrate feed from the concentrate feeder. All of the cows were fed a partially mixed ration *ad libitum* and water was freely available at all times from self-filling bowls. The partially mixed ration consisted of a grass and clover silage (63%), and the compound feed was comprised of barley (31%) and rapeseed cake (5%) plus minerals (1%). Additional concentrate was offered at the milking robot, and also from two separate concentrate feed bins, delivered in amounts according to each cow's individual milk yields, to a maximum of half their daily portion per visit.

Forage was provided at a post-and-rail feed barrier three times a day, sufficient to ensure availability of forage was *ad libitum*. Cows were loose housed in an uninsulated building in cubicles (Fig. 1) covered with rubber mattresses. Every day a mixture of peat and sawdust was laid in thin layers on each of the mattresses for additional comfort and to help keep them dry and clean. A mechanical brush (DeLaval, Sweden) was attached to a post in the feeding area where cows could brush themselves. The cows were milked with a milking robot (DeLaval, Sweden), to which the cows had access 24-hours per day.



**Figure 1.** Plan of the housing of the trial cows (‘⇒’ means movement of cows; ‘---’ indicates one-way gate).

### Data collection

Behaviours at the forage feeding area were recorded for three cows in the summer and five in the autumn and winter. Individuals from both groups were presented in both seasons. There were no seasonal differences, average temperature was 9.4 °C with standard deviation of 8.3 °C. Cows behaviour was recorded with video equipment (Sony HDR-PJ580VE, Japan) from an overhead gantry, which was situated directly above the feeding area. Cows were observed such that each cow was observed over 24 hours. Video recordings were analysed by one trained observer playing them back with a

PowerDVD 12. Recordings were made of the starting and ending times of each bout of behaviour. The behavioural parameters recorded were: the time taken by the cows to feed (from the moment of the first apprehension of feed to the moment of the last bite), periods of time spent standing, walking, drinking, grooming (this included the sum of the periods of the time spent allogrooming, being groomed by another and selfgrooming with a mechanical brush). Antagonistic behaviours were also recorded, these included pushing, nudging and intimidating another cow. Pushing was recorded when one cow displaced another cow away from its original position. Nudging meant the aggressor pushed, but did not displace the other cow. Intimidating was recorded when an aggressor cow went close to another cow as if she would start pushing her away but there was no physical contact. When analysing agonistic behaviour, nudging and intimidating data were summed together with the pushing data to form a single antagonistic group of behaviours.

### **Statistical analyses**

Statistical analyses were performed with Microsoft Excel (*t-test* and *F-test*) and with R 3.2.3. Differences between the two groups, were analysed with the *t-test*. Where data were not normally distributed, and could not be normalised by logarithmic transformation, the non-parametric Wilcoxon test was used to identify group differences. A correlation matrix was prepared using the Spearman Correlation coefficients to study the relationships between study variables.

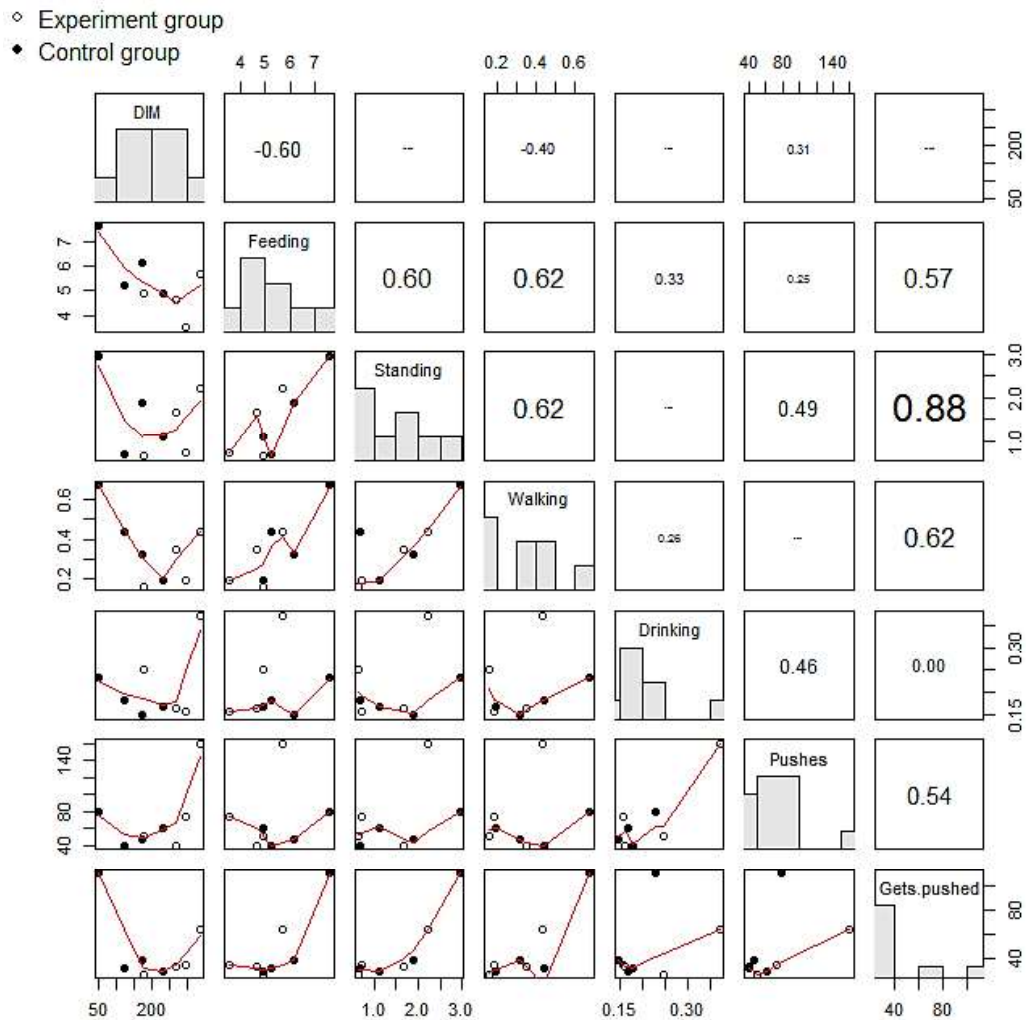
## **RESULTS AND DISCUSSION**

From video recordings, cows receiving no extra concentrate feed had a mean time of feeding of 4 h 40 minutes, walking 17 minutes, standing 1 h 18 minutes and drinking 14 minutes per day. Cows receiving extra concentrate feed fed for 5 h 58 minutes, walked for 24 minutes, stood for 1 h 39 minutes and drank for 11 minutes.

There were no significant differences when comparing the two groups regarding the behaviours observed. However, the cows who received extra concentrate spent more time standing (but not feeding) in the feeding area. Unlike the findings of Nielsen et al., (2010), who reported that cows receiving high concentrate feed fed for a longer period, there was no significant effect of this. More time spent standing in the feeding area might suggest this was so, but it is not evidence for a greater intake of feed, or even a greater time spent feeding itself (Soonberg & Arney, 2014).

From the correlation analyses (Fig. 2), there was a strong correlation between the agonistic behaviour of being pushed away by another cow and standing ( $r = 0.889$ ,  $P = 0.004$ ). Those cows that were pushed away by other cows, spent more of their time standing. It is assumed that the dominant cows were more likely to actively move and find better spots to feed, and push away submissive cows from the feeding barrier. Aggression in dairy cows has been found to be correlated with levels of androgens, and these are both higher in more socially dominant individuals (Bouissou, 1983), a finding confirmed by Phillips & Rind (2001) who identified higher rates of both aggression and allogrooming in socially dominant cows. Submissive cows had less time available for feeding than more dominant cows which indicates that social position may be a factor affecting the feeding times of cows. Such activities can be dependent on time of day and the daily programme of events. DeVries et al. (2004) found that there are more incidents

of antagonistic behaviour between cows after milking, while Val-Laillet et al. (2008) showed the greatest displacement of one cow by another at the feed barrier when fresh feed was delivered. So the observation of, and conclusions about, these behaviours should be considered with regard to the time of day of observations.



**Figure 2.** Spearman correlation coefficients of observed behavioural parameters in cows.

In diagonal: distribution of days in milk (DIM), duration of feeding, standing, walking and drinking (hours), and number of pushes and getting pushed per cow in 24 hours; below diagonal: pairwise scatterplots with white and black dots marking the single cows from experiment and control group, respectively, and smoothed red line showing the potential relationship; above diagonal: Spearman correlation coefficients (bigger font corresponds to stronger relationship; only  $r = 0.88$  was statistically significant,  $p = 0.004^*$ ).

There were no significant differences between those cows who received and those cows who did not receive concentrate feed from the concentrate feeder regarding the times spent on each of the behaviours recorded (Table 1).

**Table 1.** Behavioural observations of cows in the two experimental groups in a 24- hour period. Average (standard deviation), duration of feeding, standing, walking and drinking (hours), and number of pushes and getting pushed per cow in 24 hours in experiment and control group; p-values shows the statistical significance of difference between groups according to Wilcoxon test

| Parameters               | Group   |              | Standard deviation |              | P-value |
|--------------------------|---------|--------------|--------------------|--------------|---------|
|                          | Control | Experimental | Control            | Experimental |         |
| Feeding time, h          | 5.98    | 4.68         | 1.23               | 0.90         | 0.200   |
| Standing                 | 1.65    | 1.31         | 1.00               | 0.76         | 0.686   |
| Walking                  | 0.41    | 0.28         | 0.21               | 0.13         | 0.343   |
| Drinking                 | 1.18    | 0.23         | 0.04               | 0.10         | 0.686   |
| Pushes <sup>1</sup>      | 56.8    | 81.0         | 17.2               | 54.4         | 0.772   |
| Gets pushed <sup>1</sup> | 52.3    | 39.3         | 39.4               | 16.9         | 0.886   |

<sup>1</sup> no of incidences.

Neither the feeding time, walking time, nor standing and drinking were affected by additional concentrate feeding between the two groups. Times spent feeding were not different between the groups. There is therefore no evidence that offering additional concentrates separately from the forage had any effect on reducing, or indeed increasing, feeding times of cows.

The individual cow variation was greater than the variation between groups. This may well have been an artefact related to the lactation numbers of the selected cows, which varied from the second to the fourth lactation. In this study, the cows who received concentrate feed were in early to mid-lactation, which would be expected to have a feed consumption higher than those cows in late lactation (Chaplin & Munksgaard, 2001; Nielsen et al., 2010). This agrees with our findings, as the days in milk and time spent feeding were negatively correlated.

Lawrence et al. (2015) investigated total dry matter intakes on high and low concentrate level and found high concentrate cows to have higher total dry matter intake than cows who received less concentrate, but base feed mix intake was not affected by the concentrate amount. The same result could be hypothesised in this study although in a previous study the time that cows feed over a 24- hour period was recorded, which was used to estimate the amounts of feed removed from feed bins over the same period, and no correlation between these two factors was observed (Soonberg & Arney, 2014). Therefore, it was assumed that estimating intakes from time spent feeding is an unreliable measure.

For a cow it is essential to be able to sleep for four hours a day and drowse for around eight hours (Ternman et al., 2012). Submissive cows can remain longer in the feeding area waiting for an opportunity to feed and looking for a free place at the feed barrier where they can feed without disturbance. This may mean that they either consume feed more rapidly while at the feed barrier or feed at times that are not determined by their own motivation to feed but only when they can secure access to feed. This time spent waiting to feed furthermore leaves them less time to rest, which is needed for adequate metabolic system and immune function (Ternman et al., 2012), and lying down is an activity which it is known that dairy cows are highly motivated to do (Munksgaard & Simonsen 1996; Cooper et al., 2007). This deprivation of lying time can leave the cows at a higher risk of poor welfare, associated distress and can lead to problems with individual cows' health.

For the successful farmer, it is important and profitable to consider the accessibility of feed to all of the cows in his herd, including those cows that are submissive. Therefore, more attention should be paid to optimizing the accessibility of feed to submissive cows as well as the herd average cow.

There was no evidence from this study that cows that are given extra concentrate feed separately from forage in their diet spend less time feeding on forage than cows that are not given concentrate. This does not necessarily imply or indicate that they have the same intakes of forage. Additionally, there may have been an effect if the concentrate offered had been of a larger amount than the maximum offered here.

Antagonistic behaviours between cows increased when feed was delivered. Submissive cows spent a longer time in the feeding area than more dominant cows, and received more antagonistic behaviour (pushing, nudging) towards themselves than more dominant cows.

## CONCLUSION

This study provides no evidence that cows receiving extra concentrate spend less time feeding on forage when both portions of the ration are offered separately. There was a strong correlation between the agonistic behaviour of being pushed away by another cow and standing, suggesting that submissive cows are prevented from feeding when and for how long as they wish.

The main limiting factors of the study were the relatively small number and large variability of cows. This could have been the reason why almost no differences were discovered between groups. However, several behaviour patterns are clear enough to make general conclusions.

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