The effect of irregular feeding times on the behaviour and growth of dairy calves

Torfi Johannesson *, Jan Ladewig

Division of Ethology and Health, Department of Animal Science and Animal Health,
The Royal Veterinary and Agricultural University, Groenmeguardsvej 8, 1870 Frederiksberg C, Denmark

Accepted 9 March 2000

Abstract

The objective of this study was to examine the effects of predictable vs. unpredictable management routines on the behaviour, production and health of dairy calves. Three different feeding schedules for milk-fed dairy calves were compared. All calves received milk twice a day, and had free access to concentrate, hay and water. Three groups of 12 calves (divided on two trials) were exposed to one of the following treatments from the age of 5 days to 9 weeks: group C (control) received milk at the same time every day, at 0700 and 1400. Group OD (occasional deviation) received the milk at the same time every day except on treatment days, one in week 5 and one in week 8, where they were fed 3 h later. Group IR (irregular schedule) received milk at irregular times throughout the experimental period. The first daily feeding took place between 0600 and 1300 and the second one between 1300 and 2100. When the calves were 5 and 8 weeks old, the behaviour of eight calves from each group was videorecorded for two days (48 h). The following behaviour was recorded: frequency and duration of lying bouts and frequency of comfort behaviour (defined as licking or scratching own body), eating, drinking, other oral behaviour and extending the head through the feeding barrier (HTB). The milk and concentrate consumption of the calves was measured and the calves were weighed weekly. Diseases were recorded.

The results showed that at the age of 5 weeks, the calves in group IR differed from the control group C by performing more eating behaviour both on the control day (27.5 vs. 15.5; p < 0.05) and the treatment day (28.8 vs. 18.3; p < 0.05). At the age of 8 weeks, no differences were found in the behaviour between groups IR and C. When the OD calves were 5 weeks old, they responded to the delayed feeding by increasing drinking behaviour (14.5 vs. 9.0; p < 0.05). When they were 8 weeks old, they showed increased frequency of comfort (195 vs. 122; p < 0.05), eating (37.5 vs. 27.9; p < 0.05) and HTB behaviour (19.8 vs. 7.4; p < 0.001) on the treatment day.

* Corresponding author. Tel.: +45-3528-3073; fax: +45-3528-3022.
E-mail address: tjo@kvl.dk (T. Johannesson).

0168-1591/00/$ - see front matter © 2000 Elsevier Science B.V. All rights reserved.
PII: S0168-1591(00)00127-1
compared to the control day. The IR group did not respond to the same treatment except for a slight increase in drinking behaviour (9.6 vs. 6.5; \( p < 0.05 \)) at the age of 8 weeks. No differences were observed in the frequency or length of lying bouts, nor health or production parameters between the three groups.

It is concluded that a predictable feeding schedule may not be very important for milk-fed dairy calves. However, when the calves are customised to predictable feeding times, occasional deviations from that schedule may cause frustration when their expectations are not fulfilled.

Keywords: Cattle; Feeding; Nutrition; Feeding-times; Predictability; Circadian rhythm

1. Introduction

Predictability of management routines such as milking, feeding or inspection of the animals has not received much attention in the study of the impact of management on animal behaviour and welfare. The present experiment was conducted to assess the impact of predictability of feeding on animal welfare.

It has been found that many physiological processes and behaviours follow circadian rhythms, primarily controlled by day length (see reviews by Mrosovsky et al., 1989; Mistlberger, 1994). However, some anticipatory processes and activities can additionally be altered by manipulating the feeding schedule of animals (Boulos and Terman, 1980; Honma et al., 1983; Rosenwasser et al., 1983). This indicates that there are at least two systems capable of controlling rhythmic biological processes. One is driven by a pacemaker, adjusted by day length but unaffected by other external stimuli such as feeding times but the other system is dependent upon external stimuli (Honma et al., 1983; Mrosovsky et al., 1989; Rosenwasser et al., 1983). Under normal light–dark conditions, the two systems are usually coupled to each other but if a stable feeding schedule has been entrained, the anticipatory activity system will free-run, even if the animal is held in stable light or dark conditions (Boulos et al., 1980; Aschoff et al., 1983; Mistlberger, 1994). This means that animals can learn to anticipate regular feeding times, even if they are held in environments with either no, or irregular diurnal variations in light intensity.

Various experiments have related the loss of predictability or controllability to the development of experimental neurosis in animals (Mineka and Kihlstrom, 1978). A classical example of experimental neurosis in dogs was described by Pavlov (1960), but also in more natural and less radical experiments, researchers have reached similar conclusions (Glass and Singer, 1972; Andrews and Rosenblum, 1991).

Other studies have shown that predictable events can cause more stress to the animals than unpredictable events (Jordan et al., 1984; Bloomsmith and Lambeth, 1995). Infant squirrel monkeys, removed from their mothers showed less stress responses if the duration of the removal was unpredictable than predictable (Jordan et al., 1984). It has also been demonstrated that chimpanzees kept on an unpredictable feeding schedule show more “species-appropriate behaviour” than those on a predictable schedule (Bloomsmith and Lambeth, 1995). Furthermore, behaviour often referred to as welfare reducing (stereotypies, agonistic behaviour) is seen prior to feeding times in many species (Wasserman and Cruickshank, 1983; Mason, 1993).
Therefore, it is unclear to which extent variable management routines on farms affect the welfare of the animals, and whether the effect on welfare is positive or negative. The present study addresses two questions: (1) does an unpredictable feeding schedule affect the behaviour, production or health of dairy calves and (2) do animals that are used to a predictable feeding schedule react otherwise to occasional deviations in this schedule, than animals that are fed according to an unpredictable schedule.

2. Materials and methods

2.1. Housing

The calves were kept in two identical units in the same building complex. Room temperature was kept at 20°C and the lights were turned off from 1500 to 0700 except for a 30-min inspection period at 2200. When the behaviour was recorded during the nights, the lights were left on. Windows in the walls and roof provided natural day light. The calves were kept in individual pens (0.85 × 1.85 m) with concrete floor covered with 5–15 cm of straw. New straw was added daily.

2.2. Animals

Thirty six Holstein–Friesian calves of mixed sexes were used in the experiment, but only 24 calves were subjected to behavioural recordings. Those were randomly selected within each treatment. The calves were removed from their mothers immediately after calving. After 4–5 days with colostrum feeding, they were bucket fed with 2 l of milk twice a day. The amount was gradually increased to a maximum of 2 × 4.5 l of milk. All calves had free access to hay, concentrate, and water. To minimise the age variation within groups, the behavioural observations were conducted in two parallel trials, with 12 calves — four from each treatment — in each trial. The first trial ran two weeks earlier than the second. Data from the two trials were pooled for statistical analysis.

2.3. Treatments

On day 5, the calves were designated to one of three treatments (C, OD and IR). Group C served as a control and received milk on the same time every day: at 0710 and 1430. Group OD (occasional deviation) was treated the same way except on 2 days (later referred to as ‘‘observation days’’) when they were 5 and 8 weeks old. Here, they were fed both meals 3 h later than usual. Group IR (irregular feeding schedule) received milk according to a feeding schedule with stratified random feeding times. The first time at 0600, 0700, 0800, 1000, 1100 or 1300 and the second time at 1300, 1400, 1500, 1730, 1800 or 2100. The calves were assigned to the groups according to age (mean ± SD age at first behaviour recording: C: 34 ± 4 days; OD: 33 ± 5 days; IR: 35 ± 5 days), birth weight (C: 43 ± 9 kg; OD: 44 ± 7 kg; IR: 43 ± 6 kg), sex (7 out of 12 males in each group), and sire. The minimum interval between the first and the second feeding was set to 4 h. The calves had access to the milk buckets for 15 min.
2.4. Recordings

2.4.1. Behaviour

The behaviour of the calves was recorded with VHS time-lapse equipment. For each of the two trials, four calves per treatment were recorded simultaneously, giving a total sample of 24 animals. The recordings were made when the calves averaged 5 and 8 weeks old for 48 h each time. In the subsequent analysis, the first 24 h are referred to as ‘‘control day’’ and the second 24 h as ‘‘treatment day’’ but the whole 48-h period is referred to as ‘‘observation days’’. The observation period of 2 × 24 h was found to be a sufficient sample to represent the true behaviour of the calves, especially as the eight calves in each treatment were not filmed the same day. For practical reasons, the recordings started at 2200 the day before the control day and ended at 2200 the treatment day. Therefore, for each treatment video recordings were analysed for eight calves; 48 h at 5 weeks of age and 48 h at 8 weeks of age.

The following behaviours were recorded:

- Periods of lying and standing.
- Licking or sucking the interior of the pen (frequency per hour).
- Licking or sucking other calves (frequency per hour).
- Tongue playing (frequency per hour).
- Comfort behaviour, defined as scratching or licking own body (frequency per hour).
- Eating concentrate or hay (frequency per hour).
- Drinking water (frequency per hour).
- Extending the head through the feeding barrier (HTB-behaviour) (frequency per hour).

HTB behaviour is, in contrast to the other behaviours, not commonly used in behavioural research but prior observations showed that this behaviour is very common prior to feeding in our housing system. We suggest it can be used to indicate the calves’ expectations for feeding.

2.4.2. Production and health

All the calves were weighed at birth and weekly thereafter. Milk consumption was measured at every feeding and concentrate and hay consumption was measured weekly. On the basis of these recordings ‘‘mean daily feed intake’’ (SFU/day), ‘‘growth rate’’ (g/day) and ‘‘feed conversion rate’’ (SFU/kg growth) were calculated for each calf. (SFU stands for Scandinavian Feeding Units which roughly equals one kg grain; see Andersen and Foldager, 1980 for details). All incidences of disease were recorded and, if necessary, treated by a veterinarian.

2.5. Statistics

2.5.1. Behaviour

The frequency of licking or sucking the interior of the pen, other calves and tongue playing proved to be very low and not suitable for statistical analysis. Consequently, those data were excluded.
The frequencies for each of the 24-h periods (control day and treatment day) of comfort behaviour, eating, drinking, and HTB-behaviour were calculated for each calf. The averages of number of lying periods, length of lying period and total lying time were also calculated individually for the calves. These parameters were tested for normal distribution using PROC UNIVARIATE (SAS institute, 1987). Differences between treatments were tested by the model:

\[ Y_{ij} = \mu_0 + \alpha_1 T_i + \alpha_2 G_j + e_{ij}; \]

where: \( Y_{ij} \) is the response variable (frequency of comfort behaviour, eating, drinking, and HTB-behaviour) for trial \( i \), group \( j \); \( \mu_0 \) = the general mean; \( T_i \) = trial, \( i = \{1,2\} \); \( G_j \) = group (treatment) effect, \( j = \{C,OD,IR\} \); \( e_{ij} \) = random error.

The analysis for difference between treatments were made separately for each combination of age and observation days to prevent errors caused by repeated measurements of the same individuals. Residuals were tested for normality. To evaluate the effect of observation days, the results for each animal were paired and the difference between the treatment day and the control day was tested with a standard \( t \)-test for paired observations (H0: \( \mu_0 = 0 \)). This was done separately for each treatment.

2.5.2. Production and health

The variables “mean daily feed intake” (FU/day), “growth rate” (g/day) and “feed conversion rate” (FU/kg growth) and frequencies of diarrhoea and pneumonia were tested in the following model:

\[ Y_{ijk} = \mu_0 + \alpha_1 T_i + \alpha_2 G_j + \alpha_3 B_k + e_{ijk}; \]

where: \( Y_{ijk} \) = the response variable (mean daily feed intake, growth rate, feed conversion rate) for trial \( i \), group \( j \) and birth weight \( k \); \( \mu_0 \) = the general mean; \( T_i \) = trial, \( i = \{1,2\} \); \( G_j \) = treatment (group) effect, \( j = \{C,OD,IR\} \); \( B_k \) = birth weight; \( e_{ijk} \) = random error.

The model was subjected to analysis of variance to test the effects of treatments, controlling for trial effect. The residuals were tested for normality. This was done by PROC GLM and PROC UNIVARIATE (SAS Institute, 1987).

3. Results

3.1. Behaviour

Table 1 shows the results from the behavioural observations. All the behavioural parameters were normally distributed and no relevant outliers appeared. As stated in the preceding section, the observed frequency of licking or sucking the interior of the pen or other calves, and tongue playing were very low and therefore excluded from the analysis, and no differences were found between the two trials, why the data from those were pooled.
Table 1
Results of the behavioural observations. Significant differences \((p < 0.05)\) between treatments are indicated by the letters ‘a’ and ‘b’ but differences between days are shown by the curly brackets and ‘*’.

C: control day; T: treatment day.
Feeding schedule: C: control; OD: occasional deviations; IR: irregular

<table>
<thead>
<tr>
<th>Age weeks</th>
<th>Obs. day</th>
<th>Trmt.</th>
<th>n</th>
<th>Comfort freq/day</th>
<th>Eating freq/day</th>
<th>Drinking freq/day</th>
<th>HTB freq/day</th>
<th>No. of lying periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>C</td>
<td>C</td>
<td>8</td>
<td>167.6</td>
<td>15.4</td>
<td>5.9</td>
<td>16.4</td>
<td>51.3</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>OD</td>
<td>8</td>
<td>172.3</td>
<td>17.9</td>
<td>9.0</td>
<td>17.5</td>
<td>56.9</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
<td>IR</td>
<td>8</td>
<td>197.8</td>
<td>27.5</td>
<td>10.0</td>
<td>17.6</td>
<td>50.1</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>C</td>
<td>8</td>
<td>197.1</td>
<td>18.3</td>
<td>9.5</td>
<td>14.9</td>
<td>51.4</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>OD</td>
<td>8</td>
<td>192.6</td>
<td>19.4</td>
<td>14.5</td>
<td>15.8</td>
<td>55.6</td>
</tr>
<tr>
<td>5</td>
<td>T</td>
<td>IR</td>
<td>8</td>
<td>197.2</td>
<td>28.8</td>
<td>10.1</td>
<td>20.0</td>
<td>44.9</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>C</td>
<td>8</td>
<td>133.1</td>
<td>22.6</td>
<td>20.4</td>
<td>17.6</td>
<td>53.6</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>OD</td>
<td>8</td>
<td>121.8</td>
<td>27.9</td>
<td>11.1</td>
<td>7.4</td>
<td>52.9</td>
</tr>
<tr>
<td>8</td>
<td>C</td>
<td>IR</td>
<td>8</td>
<td>129.5</td>
<td>23.3</td>
<td>6.5</td>
<td>6.8</td>
<td>49.6</td>
</tr>
<tr>
<td>8</td>
<td>T</td>
<td>C</td>
<td>8</td>
<td>125.9</td>
<td>22.3</td>
<td>12.5</td>
<td>13.5</td>
<td>54.0</td>
</tr>
<tr>
<td>8</td>
<td>T</td>
<td>OD</td>
<td>8</td>
<td>195.1</td>
<td>37.5</td>
<td>14.3</td>
<td>19.8</td>
<td>46.0</td>
</tr>
<tr>
<td>8</td>
<td>T</td>
<td>IR</td>
<td>8</td>
<td>110.8</td>
<td>27.6</td>
<td>9.6</td>
<td>8.2</td>
<td>53.0</td>
</tr>
</tbody>
</table>

3.1.1. Effect of treatments
At 5 weeks of age, the calves in group IR showed significantly more eating behaviour than the two other groups on both observation days \((p = 0.02)\). When the calves were 8 weeks old, no differences were found between the groups on the control day. However, on the treatment day group OD differed from both group C \((p < 0.05)\) and IR \((p < 0.01)\) in comfort behaviour, from group C in eating behaviour \((p = 0.02)\) and from group IR in HTB-behaviour \((p < 0.01)\). No differences were found in the resting behaviour.

3.1.2. Effects of days
At 5 weeks of age, group OD showed more drinking behaviour \((p < 0.05)\) on the treatment day than on the control day. Here, groups C and IR showed no difference between the two days. At 8 weeks of age, the OD group showed significantly more comfort behaviour \((p < 0.05)\), eating behaviour \((p < 0.05)\) and HTB-behaviour \((p < 0.001)\) on the treatment day than on the control day. Moreover the OD calves had fewer lying periods during the treatment day, although the difference was not significant \((p = 0.08)\). The calves in group IR performed more drinking behaviour during the treatment day than the control day \((p < 0.05)\). As expected, group C did not differ between the two observation days.

3.2. Production and health
The residuals from the model were not normally distributed because of one outlier. When this observation was excluded from the data set, the residuals proved to be
normally distributed but as parameter estimates were not significantly altered it was therefore kept in the model. The mean daily feed intake was 1.92 FU and the mean daily growth rate was 750 g. Diarrhoea and pneumonia were the only observed diseases with total incidences of 57 and 9, respectively. None of the production and health variables differed between treatments, birth weights or trials.

4. Discussion

Calves fed by a predictable feeding-schedule showed various behavioural responses to occasional deviations from this schedule. Those responses were mostly observed when the calves were 8 weeks old. When the calves were 5 weeks old, the only significant difference between the control day and treatment day was the frequency of drinking behaviour (\( p < 0.05 \)). A similar trend (\( p = 0.06 \)) was, however, found for the calves in the control group. Therefore, the increase in drinking in group OD was probably to a certain extent caused by other factors than the 3-h delay in feeding time. The reason for this apparent lack of response to changed feeding time at 5 weeks is unclear. It might be explained in terms of the general feeding activity of the calves, which increases between 5 and 8 weeks (Kerr and Wood-Gush, 1987). It has also been shown that when tested in an open field, calves at 3 weeks of age walked less and vocalised less than the 12-week-old calves (van Reenen et al., 1995). These results do not, however, fully explain the present findings.

The responses to delayed feeding, seen in the OD calves at 8 weeks of age, indicate that they have learned to anticipate the milk at regular times. This is in accordance with results of other studies, which show that most animals easily establish feeding anticipatory rhythms (Mistlberger, 1994) either by the entrainment of circadian rhythms or by the periodic ingestion of food (Boulos et al., 1980). The delay in milk feeding affected the behaviour of the calves in various ways. They showed increased comfort and eating behaviour, which probably should be seen as anticipation for feeding. An unfulfilled anticipation would in most cases lead to some levels of frustration in the animals. The increase in feeding behaviour may also have been caused by a rise in feeding motivation but as the actual feed intake was not measured on a daily basis, it is not possible to evaluate how much more concentrate the calves ate. The increase in HTB behaviour and the reduction in the number of lying periods suggest restlessness or high alertness as the calves’ expectations about feeding were not fulfilled.

In contrast to the OD calves, the IR calves, which where always kept on a variable feeding schedule, showed almost no difference in behaviour between the two observation days. At the age of 8 weeks, they did not differ from the control group in the measured behaviours. Thus, the unpredictability of feeding does not seem to affect the calves considerably. This is in accordance with Mistlberger (1994), who noted in his review that without fixed feeding times, animals do not show specific feeding anticipatory behaviour. It has been found that groups of chimpanzees fed by an unpredictable feeding schedule showed less inactivity and abnormal behaviour than regularly fed groups (Bloomsmith and Lambeth, 1995). This was not found in the present study. However, at the age of 5 weeks the IR calves performed significantly more eating
behaviour than the two other groups, both on the control day and the treatment day. Additional analysis showed that the IR calves were, at that time, actually eating almost twice as much concentrate than groups C and OD ($p = 0.05$) calculated as 7 days average. It cannot be ruled out that the reason is the varying levels of subclinical diseases or a simple coping mechanism as a response to the irregular feeding schedule. Yet this could also be seen as a sign of lower inactivity among these calves. It may be that in a very predictable environment, animals get locked into cycles of anticipating the regularly upcoming events, while individuals in more unpredictable environments have a higher motivation for exploring and foraging. This hypothesis is supported by studies on both chimpanzees (Bloomsmith and Lambeth, 1995) and rhesus monkeys (Jordan et al., 1984) but cannot be confirmed on the basis of the present experiment.

5. Conclusions

Unpredictable schedule for milk feeding did not negatively affect behaviour, growth or health of single housed dairy calves. Calves on a regular feeding schedule, however, showed various behavioural deviations when exposed to a 3-h delay in feeding. The results indicate that under farm or laboratory conditions, the animals may easily adapt to unpredictable management routines while deviations from established routines may lead to various behavioural alterations.

Acknowledgements

The assistance of Knud Kjærgaard, Larley Lawson and Gynter Nielsen is greatly acknowledged.

References


