A NOVEL OPERANT CONDITIONING TEST TO DETERMINE WHETHER DAIRY COWS DISLIKE PASSAGEWAYS THAT ARE DARK OR COVERED WITH EXCRETA

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Both the presence of slurry and dark conditions may deter dairy cows from using passageways in cubicle accommodation, thus restricting movement and normal behaviour. We attempted to train seven dairy cows to recognize the quantity of reward offered in a transparent tube containing molasses in a Y-maze. Only one cow failed to consistently select the aisle containing the larger reward. The cows were then individually offered the choice of traversing either a passageway with a 5cm-depth of cow excreta or a clean, dry passageway to collect their rewards. The quantity of the rewards on the two sides was varied between zero and 400ml of molasses to determine the price that the cows were prepared to pay for entering the aisle with excreta. Only two of the seven cows showed a clear avoidance of the passageway with excreta. There was a tendency ($P < 0.1$) for the cows to avoid the passageway with excreta only when it contained no reward and the clean passageway contained a reward of 400ml molasses. Otherwise, there was no clear avoidance of the passageway with excreta. We also investigated whether cows preferred to enter a lighted or unlighted passageway. All the cows, except one, showed a strong avoidance of the dark passage, even when it contained the largest reward and the lighted passage contained no reward. We conclude that dairy cows demonstrate only mild avoidance of passageways with excreta but strongly avoid passageways without lighting. Therefore, we suggest that passageways for dairy cows should be lit at all times.

Keywords: *animal welfare, cattle, excreta, lighting, operant conditioning*

Introduction

Most dairy cows in the UK are housed in buildings with raised cubicle beds and passageways into which they defecate and urinate. The excreta forms a slurry that is removed from the passageways at frequencies varying from once a day, if a tractor and scraper is used, to approximately once an hour, if automatic scrapers on chains are used (Phillips 2001). The effects of the passageway slurry on the welfare of the cows are unclear. Prolonged standing in wet, acid slurry predisposes cows to hoof disorders (Blowey 1993),

and many herbivores naturally avoid contact with their own faeces to protect against parasites (Hutchings *et al* 1999). Indeed, cattle are reluctant to consume herbage contaminated with slurry (Laws *et al* 1996) or even to lie on the contaminated herbage (Pain *et al* 1974; Broom *et al* 1975), due to its smell (Marten & Donker 1966; MacDiarmaid & Watkin 1972). They can, however, be conditioned to accept herbage soiled with excreta by adding dilute slurry to their feed and hanging sacks of manure in their accommodation (Garstang & Mudd 1971), suggesting that slurry in cubicle passageways may become less noxious over time because the cows habituate to the stimulus.

A similar uncertainty exists concerning the provision of light in the cubicle passageways of dairy cow buildings. Lighting the passageways alters the behaviour of cows, apparently making their locomotion more confident (Phillips *et al* 2000). However, individual cattle in stalls do not show a marked preference for a lighted environment, other than for feeding (Phillips & Arab 1998). A partial preference for a lighted environment exists in calves housed in groups in strawed yards (Weiguo & Phillips 1991), but it is unclear whether this extends to dairy cows in cubicle buildings.

We conducted preference tests to examine whether the presence of slurry or lighting influenced the selection of passageways by dairy cows. Previously, tests devised to make animals work to obtain a reward have used computer-controlled electronic doors (Smith *et al* 1996) or levers pressed for food, but these have disadvantages when used with large animals such as cattle. Electronically controlled doors may not be sufficiently robust, and lever pressing will interfere with the behaviour of the animal (Phillips & Arab 1998), thus potentially confounding choice tests relying on behavioural motivation. A simpler solution, which does not interfere with the animals' behaviour or require the animal to open a door, is to offer a variable quantity of food reward in a Y-maze, with the animal being informed of the size of the reward in each arm of the maze before making its selection. Therefore, we devised a feeder that could be placed in each arm of a Y-maze, and which allowed cattle to see the quantity of the feed reward before choosing which of the two arms to enter.

Methods

Seven, non-lactating British Friesian cows with no detectable gait abnormalities were selected from the University of Wales' dairy herd at Bangor. They were housed in one half of a cubicle building that was separated from the rest of the herd, with access to grass silage and water *ad libitum*. In the second half of the building, a Y-maze was constructed (each arm comprising a covered 7x1.3 m passage with a concrete floor). The first part of the experiment involved training the cows to select the aisle in the Y-maze in which the larger feed reward was situated.

Part 1: training the cows to detect the size of reward on offer

The reward was initially 100–500 ml of sugar beet molasses (United Molasses Ltd, Burton upon Trent, UK), a feed which is palatable to cattle (Huang *et al* 1999) and attracts them by its smell (Ministry of Agriculture, Fisheries and Food 1968). It was supplied in a drinking bowl with a graduated, clear plastic tube above it containing the same quantity of molasses as offered in the bowl (Figure 1). Cattle could, therefore, potentially relate the length of molasses in the tube to the amount of reward on offer. One feeding device was placed 5m down each arm of the Y-maze. After collecting the reward and proceeding to the end of the passage the cow could return to the rest of the group. Cows were taken out individually for tests.

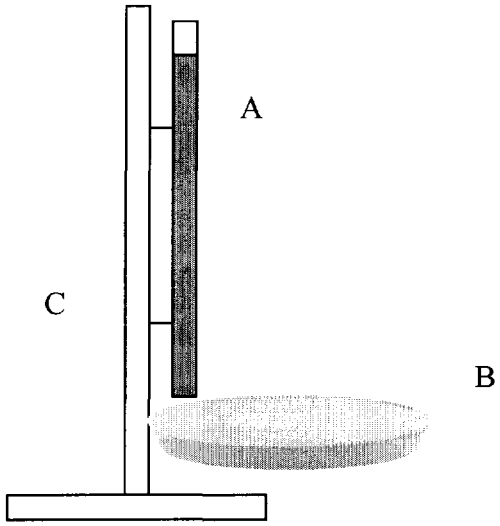

Figure 1 **Schematic diagram of the feeder for offering reward to the cows. (A – graduated tube containing 0–400 ml of molasses during tests; B – feeding bowl; C – stand.)**

Cows were initially allowed six visits to the maze with equal rewards (200ml) on either side of the Y-maze to accustom them to the experimental design. Then they made nine visits with the maximum reward (500ml) on the left side and no reward on the right, and nine visits with the reverse reward pattern. These visits were conducted in rotation, with each cow tested every seventh test. Only two cows learned to choose the correct side, with a mean correct choice (MCC) of 93 per cent and 87 per cent; the other five had MCC values of 35 per cent to 62 per cent – and apparently selected the same arm of the maze each time.

Next, to reinforce the association between the molasses in the tube with the feed reward, each cow in rotation made 18 visits where she was guided down alternate correct arms to learn that a reward was available in each. This was followed by a further 18 visits with the maximum reward again offered first on the left side (nine tests) and then on the right (nine tests). Once again, only two cows succeeded in obtaining the reward consistently, so a third training period was instigated during which each cow completed eight tests consecutively, rather than in rotation. The same two cows were successful (MCCs of 87 and 80 %), with the others achieving MCCs of 33 per cent to 53 per cent.

A further series of 20 successive tests was then conducted, which comprised four tests at each of the following ratios of reward in the left and right side aisle in the order: 100:300; 0:400; 100:300; 300:100 and 400:0 ml molasses. In these tests, all cows except one had a MCC of 70 per cent or more (93%, 87%, 87%, 73%, 73%, 73% and 47 % for the seven cows), and were, therefore, judged to have learned to select the side of the Y-maze offering the greater reward.

Part 2: offering cows a choice of passageways with or without slurry on the floor

A slurry of excreta from the remainder of the herd was spread to a depth of 5cm on the floor of one aisle of the Y-maze and each cow was tested 20 times with the following reward

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schedules for the left and right passageways, respectively (brackets indicate the number of tests at each level): 0:400 (3), 100:300 (6), 200:200 (5), 300:100 (3); 400:0 (3) ml. The number of replications at the 200:200 ml reward level was increased, as this was believed to be important if the food reward proved more influential than slurry in determining the cows' choice of aisle; the 100:300 tests were repeated to see if there was any evidence of learning. All tests were conducted in natural daylight, allowing equal and adequate light for each passageway.

Part 3: offering cows a choice of a lighted or unlighted passageway

One aisle of the Y-maze was rendered light-proof and six, 100W tungsten filament bulbs were installed to provide a mean light intensity of 22 lux, as measured with a spectroradiometer (Macam Digital Spectroradiometer SR 3000, fitted with cosine corrected Photometric Adaptor; Macam Photometrics, Livingston, Scotland) in the six directions of the faces of a cube at cow eye level. Both reward feeders were lit with a 12V DC bulb, which provided sufficient light for the cow to see the feeder but not to light the passageway significantly. The 22 lux level of lighting provided in this experiment is approximately that recommended by the UK Electricity Agricultural Advisory Service (1990) for cattle buildings (20 lux). The mean light intensity in the unlighted passageway was 0.03 lux. Between tests, the cows occupied a part of the building that was not lighted and had a mean light intensity of 0.14 lux from incidental light. Each cow was tested 20 times after dusk, using the same reward schedule as in Part 2.

Statistical analysis

The selection of aisles with and without slurry and light was compared using chi-square tests, both for individual cows and for the mean response of the group of cows at each reward level.

Results

Offering cows a choice of passageways with or without slurry on the floor

Two cows (cows 2 and 6) showed a clear avoidance of slurry (Table 1). Of the other five, two tended to show a preference ($P < 0.1$), one for (cow 7) and one against (cow 5) the side of the maze with slurry. The other three cows showed no preference. Table 2 shows the effects of varying the levels of reward: only when the highest level was offered in the aisle without slurry and no reward was offered in the aisle with slurry was there a trend for all the cows to avoid the aisle with slurry ($P < 0.1$).

Table 1 The preference of individual cows for aisles with or without slurry. (ns – not significant.)

Cow no	No of times surface with slurry selected	No of times surface without slurry selected	*P* value
1[1]	13	7	ns
2	4	16	< 0.01
3	12	8	ns
4	12	8	ns
5	6	14	< 0.1
6	1	19	< 0.001
7	14	6	< 0.1

[1] This cow was not successful in selecting the side with the greatest reward in the training programme.

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Table 2 **Mean[1] number of cows selecting the aisles with and without slurry. (ns – not significant.)**

Reward offered in each side (ml)		Mean number of cows selecting each aisle in each replicate		*P* value
Slurry	No slurry	Slurry	No slurry	
0	400	2.3	4.7	< 0.1
100	300	4.3	2.7	ns
200	200	3.6	3.4	ns
300	100	2.7	4.1	ns
400	0	2.4	4.6	ns

[1] Mean of three replications for all the reward levels except 200:200, which had five replications and 100:300 which had six (see text for details).

Offering cows a choice of a lighted or unlighted passageway

All cows, with the possible exception of cow 4, showed a clear avoidance of the dark passage (Table 3), even when the largest reward was offered in the unlighted aisle and no reward was offered in the lighted aisle (Table 4).

Table 3 **The preference of cows for aisles with or without light.**

Cow no	No of times aisle with light selected	No of times aisle without light selected	*P* value
1[1]	20	0	< 0.001
2	20	0	< 0.001
3	19	1	< 0.001
4	14	6	< 0.1
5	16	4	< 0.01
6	15	5	< 0.05
7	19	1	< 0.001

[1] This cow was not successful in selecting the side with the greatest reward in the training programme.

Table 4 **Mean[1] number of cows selecting the aisles with and without light.**

Reward offered in each side (ml)		Mean number of cows selecting each aisle in each replicate		*P* value
Lighted	Not lighted	Lighted	Not lighted	
0	400	6.0	1.0	< 0.001
100	300	7.0	0	< 0.001
200	200	6.2	0.8	< 0.001
300	100	6.0	1.0	< 0.001
400	0	5.3	1.7	< 0.01

[1] Mean of three replications for all the reward levels except 200:200, which had five replications and 100:300 which had six (see text for details).

Discussion

Only a mild avoidance of the aisle with slurry was detectable when the greatest reward was offered in the aisle without slurry. This suggests that the cows had habituated to the odour of the slurry and were not greatly distressed by walking through it, supporting the finding of Garstang and Mudd (1971) that cattle can be conditioned to accept the presence of excreta by repeated exposure. However, individual variation was evident in this test, with two cows showing a clear preference for the passage without slurry. One of these two had learned to recognize the reward level earlier than the rest, so in this case the preference may have been partly due to improved learning of the task. One of the cows which failed to demonstrate a

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preference had also been unable to select the greater reward during training (cow 1). Cow 7 preferred the side with slurry, perhaps because it was most similar to her normal housing environment. More aversive behaviour might have been exhibited if the depth of slurry had been greater than 5cm. A greater reduction in walking speed has already been observed for dairy cows walking through deep slurry (13cm) than shallow slurry (5cm), in comparison with a floor with no slurry (Phillips & Morris 2000). The cows kept their legs more vertical at the end of the support phase[1] in deep slurry (which probably helped to lift the limb out of the slurry), but this departure from normal walking behaviour might have caused some discomfort.

Avoidance of the dark passageway was demonstrated by nearly all the cows. Even cow 1 – which had failed to select the greater reward during the training period – avoided it, demonstrating that the quantity of reward was not important in this selection. The cows' strong preference probably relates to the fear of encountering slippery floor conditions or obstacles. This contention is supported by observations of a more vertical leg action in the dark – which reduces the risk of slipping (Phillips *et al* 2000). Falling over on slippery concrete is particularly common among cattle in abattoirs (Grandin 1998), but also occurs regularly in cubicle passageways where the concrete is old and worn, the cattle are highly stocked or are hurried out of the building by a stockperson. It may result in a fractured pelvis, dislocated hip or ruptured ligaments and frequently leads to the cow having to be destroyed (Blowey 1985).

The large number of training tests that were required before almost all of the cows learned to select the greater reward suggests that this technique may be too time-consuming for operant conditioning of cattle. Each test takes considerably longer for cattle than if the same test was being conducted with laboratory rodents or chickens, which can be picked up and placed at the entrance to the Y-maze. It often requires two people to handle the cattle quickly and safely. The rate of learning in the training period may be state-dependent, with the dry cows used in this study probably not being particularly hungry and, therefore, not learning fast. We made no attempt to starve the cows before the tests, which might have increased their rate of learning. However, short-term starvation probably does not induce stress in ruminant animals in the same way as in monogastrics, because of the reservoir of fermentable material in the rumen. The cattle appeared to learn quicker when subjected to an infrequent series of consecutive tests for individual cows, rather than one test approximately every hour by taking group members in rotation. However, despite the length of training required, the method was able to distinguish between weak avoidance of a noxious stimulus and strong avoidance. It is possible that return to the social group acted as an additional reward for completing the test, potentially diminishing the effect of different food rewards. Cattle are stressed by isolation (Rushen *et al* 1999), but our subjects may have learned a reduced fear response with repeated testing.

Animal welfare implications

The strong avoidance of dark passageways found in this study, together with reports from other studies that cows adopt a more vertical leg angle in the dark (Phillips *et al* 2000), suggest that light should be provided in all cattle passageways to improve their welfare. Recommendations concerning the accumulation of excreta may be justified on the grounds

[1] Lasting from the placement of the hoof on the floor until the lifting of the hoof at the end of the stride.

of hoof health, but are probably not justified solely on the grounds of animal comfort. The technique described in this paper could be used to compare the preference of cattle for other resources, but training the cattle may take some considerable time.

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