Modifying Defecation Behavior in Cattle

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Abstract

Cattle do not typically choose where to eliminate their excrement. This creates challenges for hygiene, health, animal welfare, and environmental sustainability in production systems. The ability to toilet train cattle to defecate in designated areas would enable improved management of feces by reducing greenhouse gas emissions, cost of management, and enhancing animal welfare. In this proof-of-concept study, we evaluated whether defecation behavior in steers could be modified using operant conditioning (positive and negative reinforcement). Eight halter-trained steers were randomly assigned to either an experimental (n = 4) or control (n = 4) group. Over a total of 22 consecutive days, individual steers were placed daily in a 13×4-foot training pen for a two-hour session. Experimental steers were tied and released only after defecation occurred, at which point they also received a small feed reward (distillers' grain). If defecation did not occur, steers were released after two hours without reinforcement. Control steers were similarly tied and released upon defecation but received no feed reward. All sessions were observed, and data was collected on defecation timing and frequency. Contrary to expectations, the experimental group (using positive and negative reinforcement) took longer on average to defecate than the control group (only using negative reinforcement). Further investigation is needed to refine training strategies and assess the role of motivation, stress, comprehension, and environmental familiarity in modifying elimination behaviors in cattle.

Introduction

This study aimed to investigate whether conditioning methods could influence conscious control of defecation behavior in steers, to associate the act of defecation with a designated area. We evaluated the effectiveness of operant conditioning protocols that combined positive reinforcement (feed rewards) and negative reinforcement (release from haltered restraint) to train steers to alter the timing to defecation.

Cattle in the United States generate significant quantities of manure rich in nitrogen, phosphorus, potassium, micronutrients, and organic matter, which serves as both a valuable agricultural resource and a potential environmental concern (Overcash et al., 1983a). Confined systems like dairies and feedlots require careful management to prevent environmental contamination. In feedlots, approximately 457,900 Mg of nitrogen, 157,000 Mg of phosphorus, and 482,000 Mg of potassium are collectible annually from about 10 million cattle. This equates to an estimated $461 million in fertilizer (Overcash et al., 1983a; U.S. Department of Commerce, 1987). A better understanding of manure management can both be beneficial for the environment and can also provide economic incentives for producers.

One study, Villettaz Robichaud et al., 2011 found that dairy cows vary widely in how often they urinate and defecate. These behaviors are not strongly correlated with physiological factors such as parity, milk production, body weight, days in milk (DIM), or feed and water intake. In this study defection and urination occurred evenly during the 24-hour period, indicating that dairy cows do not exhibit a strong diurnal rhythm for elimination (Villettaz Robichaud et al., 2011). This suggests there is no optimal time of day to focus manure removal efforts. However, the experiment did find that cows defecated most frequently in the feed alley.

Dairy cows have been found to be more likely to urinate and defecate while standing in stalls than would be expected based on how little time they spend in that posture (likely due to a tendency to defecate shortly after rising). This behavior increases the risk of udder soiling, increasing health complications like mastitis (Schreiner & Ruegg, 2003).

A previous study on operative conditioning was successful in conditioning dairy calves to urinate in a desired location. This study used both positive (feed reward) and negative reinforcement (water spray if urination occurred outside of the desired location) (Villettaz Robichaud et al., 2011). Another study on dairy cows used electric trainers and evaluated the impact of the device on stall cleanliness and hoof health. The electric trainers trained the cows to take a step backwards before urinating or defaecating. This was done by conditioning the dairy cows to avoid an electric shock (Grommets, 1969; Gjestang, 1980; Simensen and Boe, 1988). The study found that dairy cows with trainers deposited fewer dung pats in their stalls and were significantly cleaner on both the caudal and lateral regions than the cows without trainers. The study concludes that electric trainers, when properly implemented, are an effective management tool for reducing heel-horn erosion in herds where standard hygiene practices are insufficient (Simensen & Boe, 1992).

With a better understanding of cattle behavior there is a possibility to improve manure management systems. This would benefit the environment, the animals, and the producers. The prediction for this study is that defecation behavior in cattle can be changed using a mixture of positive and negative reinforcement

Methods

Eight halter-trained fistulated steers were randomly assigned to either an experimental (n = 4) or control (n = 4) group. Over a total of 22 consecutive days, individual steers were placed daily in a 13×4-foot training pen for a two-hour session. Experimental steers were tied and released only after defecation occurred, at which point they also received a small feed reward (distillers' grain). The distillers grain would be provided into a bucket at the end of the training pen. The feed would be given by a research assistant at the moment of a tail raise followed by the presence of new excrement from the steer. If defecation did not occur, steers were released after two hours without reinforcement. Control steers were similarly tied and released upon defecation but received no feed reward.

Results

Data analysis was conducted using SAS. Data was reported for individual animals (figure 1) as well for the two treatment groups (control;1, experimental;2) (Figure 2).

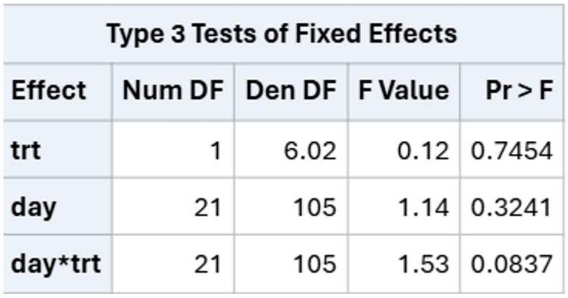
Least Squares Means

Effect	day	trt	Estimate	Standard Error	DF	t Value	Pr > |t|
trt		**0**	56.5258	7.1850	6.04	7.87	0.0002
trt		**1**	59.9773	7.1715	5.99	8.36	0.0002
day	**1**		55.2500	12.3753	96.8	4.46	<.0001
day	**2**		86.7500	12.3753	96.8	7.01	<.0001
day	**3**		57.3750	12.3753	96.8	4.64	<.0001
day	**4**		68.5000	12.3753	96.8	5.54	<.0001
day	**5**		42.8750	12.3753	96.8	3.46	0.0008
day	**6**		63.7500	12.3753	96.8	5.15	<.0001
day	**7**		48.5000	12.3753	96.8	3.92	0.0002
day	**8**		53.0000	12.3753	96.8	4.28	<.0001
day	**9**		66.8750	12.3753	96.8	5.40	<.0001
day	**10**		70.6250	12.3753	96.8	5.71	<.0001
day	**11**		74.3750	12.3753	96.8	6.01	<.0001
day	**12**		60.5000	12.3753	96.8	4.89	<.0001

day	**13**		61.5000	12.3753	96.8	4.97	<.0001
day	**14**		60.5000	12.3753	96.8	4.89	<.0001
day	**15**		66.7500	12.3753	96.8	5.39	<.0001
day	**16**		44.0000	12.3753	96.8	3.56	0.0006
day	**17**		57.3750	12.3753	96.8	4.64	<.0001
day	**18**		28.6590	13.2921	105	2.16	0.0334
day	**19**		55.0000	12.3753	96.8	4.44	<.0001
day	**20**		42.5000	12.3753	96.8	3.43	0.0009
day	**21**		61.6250	12.3753	96.8	4.98	<.0001
day	**22**		55.2500	12.3753	96.8	4.46	<.0001
day*trt	**1**	**0**	60.5000	17.5013	96.8	3.46	0.0008
day*trt	**1**	**1**	50.0000	17.5013	96.8	2.86	0.0052
day*trt	**2**	**0**	91.2500	17.5013	96.8	5.21	<.0001
day*trt	**2**	**1**	82.2500	17.5013	96.8	4.70	<.0001
day*trt	**3**	**0**	72.7500	17.5013	96.8	4.16	<.0001
day*trt	**3**	**1**	42.0000	17.5013	96.8	2.40	0.0183
day*trt	**4**	**0**	86.0000	17.5013	96.8	4.91	<.0001
day*trt	**4**	**1**	51.0000	17.5013	96.8	2.91	0.0044
day*trt	**5**	**0**	48.2500	17.5013	96.8	2.76	0.0070
day*trt	**5**	**1**	37.5000	17.5013	96.8	2.14	0.0346
day*trt	**6**	**0**	49.0000	17.5013	96.8	2.80	0.0062
day*trt	**6**	**1**	78.5000	17.5013	96.8	4.49	<.0001
day*trt	**7**	**0**	27.7500	17.5013	96.8	1.59	0.1161

day*trt	**7**	**1**	69.2500	17.5013	96.8	3.96	0.0001
day*trt	**8**	**0**	77.0000	17.5013	96.8	4.40	<.0001
1 day*trt	**8**	**1**	29.0000	17.5013	96.8	1.66	0.1008
day*trt	**9**	**0**	73.0000	17.5013	96.8	4.17	<.0001
day*trt	**9**	**1**	60.7500	17.5013	96.8	3.47	0.0008
day*trt	**10**	**0**	44.2500	17.5013	96.8	2.53	0.0131
day*trt	**10**	**1**	97.0000	17.5013	96.8	5.54	<.0001
day*trt	**11**	**0**	58.2500	17.5013	96.8	3.33	0.0012
day*trt	**11**	**1**	90.5000	17.5013	96.8	5.17	<.0001
day*trt	**12**	**0**	62.7500	17.5013	96.8	3.59	0.0005
day*trt	**12**	**1**	58.2500	17.5013	96.8	3.33	0.0012
day*trt	**13**	**0**	72.5000	17.5013	96.8	4.14	<.0001
day*trt	**13**	**1**	50.5000	17.5013	96.8	2.89	0.0048
day*trt	**14**	**0**	49.7500	17.5013	96.8	2.84	0.0055
day*trt	**14**	**1**	71.2500	17.5013	96.8	4.07	<.0001
day*trt	**15**	**0**	48.2500	17.5013	96.8	2.76	0.0070
day*trt	**15**	**1**	85.2500	17.5013	96.8	4.87	<.0001
day*trt	**16**	**0**	35.2500	17.5013	96.8	2.01	0.0468
day*trt	**16**	**1**	52.7500	17.5013	96.8	3.01	0.0033
day*trt	**17**	**0**	51.7500	17.5013	96.8	2.96	0.0039
day*trt	**17**	**1**	63.0000	17.5013	96.8	3.60	0.0005
day*trt	**18**	**0**	14.0681	20.0107	112	0.70	0.4835

day*trt	**18**	**1**	43.2500	17.5013	96.8	2.47	0.0152
day*trt	**19**	**0**	59.7500	17.5013	96.8	3.41	0.0009
day*trt	**19**	**1**	50.2500	17.5013	96.8	2.87	0.0050
day*trt	**20**	**0**	26.2500	17.5013	96.8	1.50	0.1369
day*trt	**20**	**1**	58.7500	17.5013	96.8	3.36	0.0011
day*trt	**21**	**0**	72.2500	17.5013	96.8	4.13	<.0001
day*trt	**21**	**1**	51.0000	17.5013	96.8	2.91	0.0044
day*trt	**22**	**0**	63.0000	17.5013	96.8	3.60	0.0005
day*trt	**22**	**1**	47.5000	17.5013	96.8	2.71	0.0079



Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
trt	1	6.02	0.12	0.7454
day	21	105	1.14	0.3241
day*trt	21	105	1.53	0.0837

Figure 2.

There was no statistical significance found between the control and the experimental treatment groups or the interaction between day and treatment group. Additionally, there was no statistical significance between the change in defecation time across days for both the experimental and control groups. Low frequency values for the control and the experimental treatment groups or the interaction between day and treatment group are consistent with no statistical significance. The higher frequency value for change in defecation time across days for both the experimental and control groups is moderate.

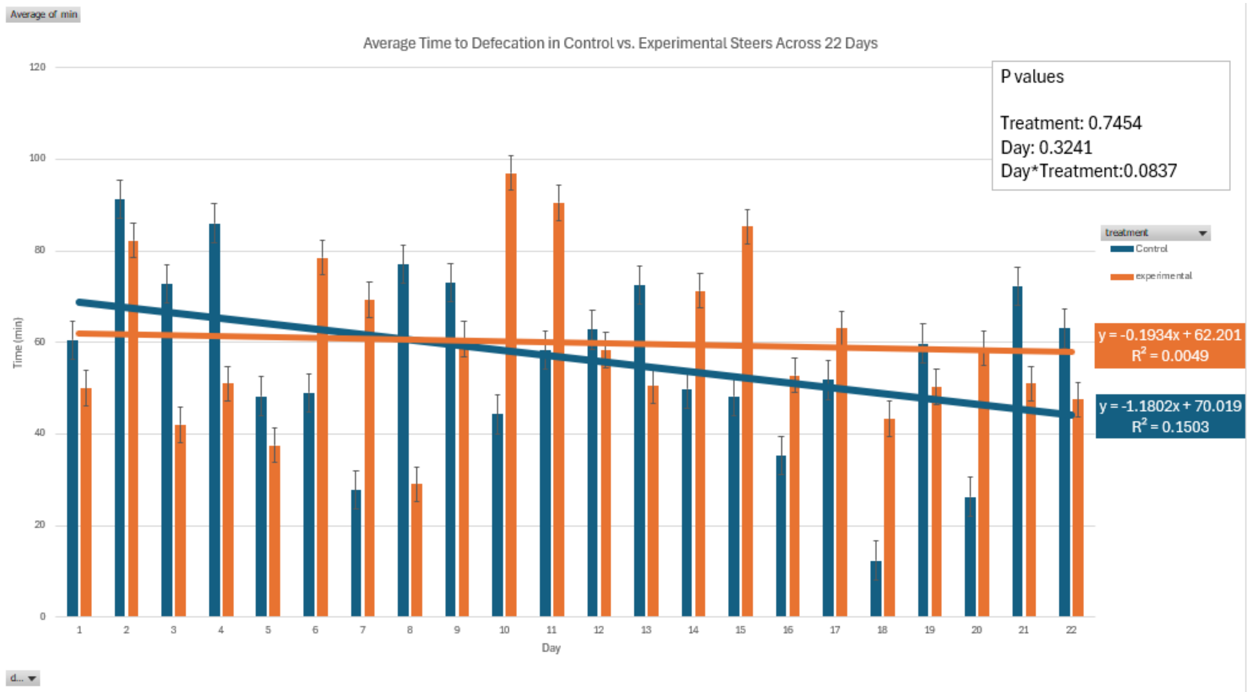


Figure 3.

Trendlines show that there was no meaningful relationship between time to defecation and days for the experimental group due to both the slope and R-squared value being very close to zero. Trendlines also show that there was a weak negative relationship between time to defecation across the 22 trial days for the control experiment (moderate slope and weak R-squared value).

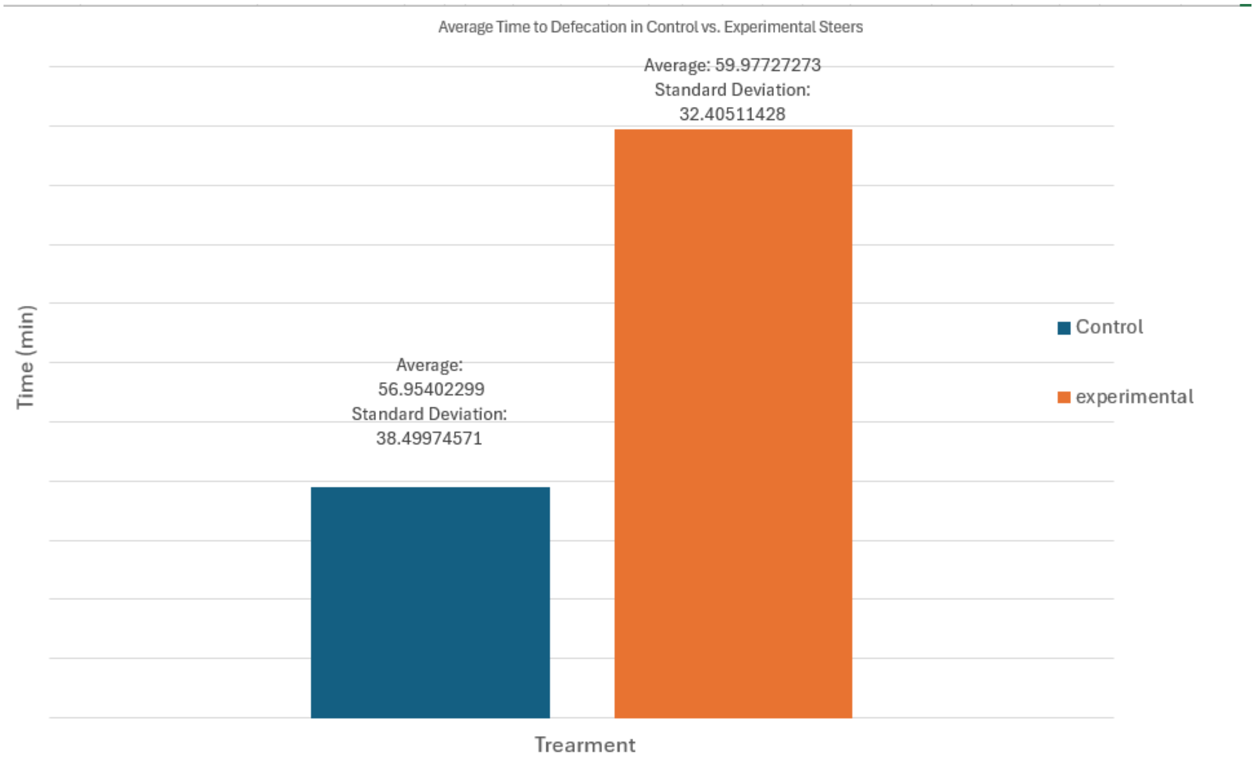


Figure 4.

On average the experimental group took longer to defecate after being tied than the control group.

Discussion

Overall, there was no statistically significant difference in defecation time between the control and experimental groups ($P = 0.7454$), or a significant effect for the day ($P = 0.3241$) or day by treatment interaction ($P = 0.0837$). Although the F-value for the interaction in defecation time across days for both the experimental and control groups was not statistically significant ($P = 0.0837$), it is relatively close to the conventional threshold ($P < 0.05$). This suggests that the effect of treatment may vary over time. Overall, the control group appeared to improve (shorter time to defecation), while the experimental group remained consistent. This potential difference in behavioral change across days may warrant further investigation in a larger or a longer term study.

Trendline analysis supports these findings, showing no meaningful change in defecation time across days for the experimental group ($R^2 = 0.0049$), while the control group exhibited a modest decrease ($R^2 = 0.1503$). This implies that defecation time improved slightly in the control group but had little to no change in the experimental group.

Figure 4 further shows that the experimental group took slightly longer to defecate (mean = 59.98 min) than the control group (mean = 56.95 min). This was a small but unexpected difference given the added feed reward.

Conclusion

These findings raise questions about cattle learning mechanisms. The feed reward may have introduced competing motivations (e.g., food anticipation), while restraint removal may have served as a more immediate and effective motivator (particularly for halter-trained animals accustomed to being led and released).

It is worth noting that the decreasing trend in defecation time observed in the control group may reflect similar patterns found in previous studies, where excretory behaviors in cattle were successfully modified using negative reinforcement, in this case a release from haltered restraint. For future studies, it should be considered that there were occasional delays in delivering the food rewards to the steers. Additionally, the method of feeding—human delivery into a designated bucket after defecation—may have introduced excessive stimulation. This, combined with the increased human interaction, could have influenced the animals' behavior and may have been a confounding factor in the experiment.

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