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COMPARISON OF DAIRY COW AVERSION TO CONTINUOUS AND INTERMITTENT CURRENT

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Summary:
The results of studies comparing dairy cow response to steady-continuous, pulsed-continuous and pulsed-intermittent current applied to water bowls are presented. Aversion studies were performed in which current was applied relative to the sensitivity of individual animals. In the first experiment, response to a steady 60 Hz stimulus continuously applied to a water bowl (steady-continuous) was compared to a 10-cycle, 60-Hz stimulus pulsed once per second (pulsed-continuous). In the second experiment one group of cows was exposed to a 10-cycle, 60 Hz stimulus applied to the water bowl once per second. A second group of cows was exposed a 10-cycle, 60-Hz stimulus applied to their water bowls once every 10 minutes (pulsed-intermittent). A third group received only one exposure to a 10-cycle, 60 Hz current. The drinking behavior of these three treatment groups was compared to a control group receiving no current.

Keywords:
Stray Voltage, Transient Voltage, Dairy Cows

COMPARISON OF DAIRY COW AVERSION TO CONTINUOUS AND INTERMITTENT CURRENT

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INTRODUCTION AND OBJECTIVES

Recent research conducted at the University of Wisconsin (Reinemann et al, 1994, 1995, 1996) has characterized sensitivity and aversion to various transient current waveforms. In most previous stray voltage aversion studies by other research groups, current and voltage exposure has been continuously applied, steady 60 Hz stimuli. Previous aversion studies performed at the University of Wisconsin applied transient currents of 60 Hz and 6000 Hz to water bowls once every second. This routine can be characterized as continuous exposure to a pulsed stimulus as cows could not drink without being exposed to current. This is a worst-case scenario, as exposures in the field tend to be intermittent. For example, current and voltage transients produced by motors starting will occur only when the motor is started. This may occur from several times per day up to several times per hour. Steady-state voltage and current levels are generally varied throughout the day depending on the relative magnitude of sources and the use patterns of these sources. The objective of this study was to compare aversive response to steady versus pulsed stimuli and to further investigate the relative effects of current pulses applied once per second to those applied less frequently.

MATERIALS AND METHODS

The test stalls, electrical apparatus and sensitivity measurement methods described previously (Reinemann et al, 1994) were used to determine the sensitivity of each cow to a 10 cycle 60 Hz pulsed current applied via the muzzle-hooves pathway prior to all aversion tests. All current levels are reported in peak milliamps. Cows received no current exposure for a minimum of 3 days between sensitivity testing and averison treatments. The water supply to all water bowls was turned off three hours prior to the start of the aversion treatment voltage exposures (5 a.m.). This was done to reduce variability by insuring that all the cows had a desire to drink upon returning from the morning milking. It is estimated that a cow was deprived of approximately 20 percent of its normal daily water intake during this time. The cows were released from their stalls for milking at about 7 a.m.. As the cows finished milking, they were sent out into an outside yard. The water was turned on, voltage exposures applied and cows returned to the test stalls at about 8 a.m..

Experiment I

This experiment was designed to compare responses to steady-continuous and pulsed-continuous stimuli of the same level. A total of 16 cows were used in two trials of 8 cows each. A switch-back design was used with a 10-cycle, 60-Hz stimulus applied to the water bowls of 4 cows once per second. A steady, 60-Hz stimulus was continuously applied to the water bowls of the other 4 cows. The treatments were set at individual cow reaction levels for 10 cycles of 60 Hz. Cow sensitivity data is shown in Table 1. Previous results have indicated that a 10 cycle 60 Hz pulse will produce reaction at about the same level as a steady 60 Hz stimuli (Currence et al 1990). Hourly total water consumption and quarter hour totals for the first hour of exposure were recorded for each cow on four consecutive days for each trial as follows:

Day 1: Control day with no treatment placed on the water bowls.

Day 2: Sub-perceptions voltage on the water bowl. The voltage levels were set so that 1 mA of current would pass through a 500 Ohm shunt resistor used in the manner recommended for making field measurements of stray voltage. These current levels were well below the reaction

level of all cows. Data from this day were used for the study of cow drinking behavior (LeMire et al, 1997)

Day 3: Treatment day with 4 cows exposed to steady-continuous and 4 cows to pulsed-continuous 60-Hz stimuli.

Day 4: Treatment day with 4 cows exposed to pulsed-continuous and 4 to steady-continuous 60-Hz stimuli.

Experiment II

A total of 16 cows were used in two trials. A crossover design was used with each group of 8 cows divided into 4 subgroups; one control group receiving no stimulus, and three treatment groups. The three treatments were as follows:

Pulsed-continuous: A 10 cycle, 60-Hz current was applied to the water bowl once per second.

Intermittent: A 10-cycle, 60-Hz current was applied to the water bowl once every 10 minutes.

One Exposure: The cow was exposed to a single 10-cycle, 60 Hz current the first time it attempted to drink. The cow was placed in the stall and observed. When the cow contacted the water bowl, it was exposed to current. Immediately after the cow received its first current exposure, the current source was removed from the water bowl for the remainder of the treatment period.

A period of at least 3 days during which cows received no current was allowed between each treatment period. Each subgroup received all three treatments according to the schedule indicated in Table 2.2. There was no significant effect of period or sequence. Exposure levels for the aversion study were done at a level 1.5 times higher than the level at which a reaction for a pulsed 10-cycle, 60 Hz stimulus was first noted. A summary of the cow sensitivity data is shown in Table 1.

RESULTS AND DISCUSSION

Experiment I

The results of drinking behaviors for experiment I are shown in Table 1.2. One cow (#4052) had a twisted stomach after the first treatment and was removed from the first trial. This cow had experienced a twisted stomach about one month earlier while on another research trial.

The mean difference in delay to drink the first gallon of water between the pulsed and steady and treatments was -0.4 hours and was not significant. Seven cows showed no difference in delay to drink, 4 cows had a longer delay for the steady and 4 cows had a longer delay for the pulsed stimulus. The mean difference between water consumed during the first 4 hours of exposure was -0.2 gallons and was not significant. Three cows had less than 0.1 gallon difference, 6 cows consumed more water in 4 hours for the pulsed and 6 cows consumed more water in 4 hours for the steady stimulus. The mean difference between water consumed during the first 8 hours of exposure was +0.8 gallons and was not significant. Five cows had less than 0.5 gallon difference over 8 hours, 5 cows consumed more for the pulsed and 5 cows consumed more for the steady stimulus. Power calculations for paired t-test comparisons are shown in Table 1.3. The study had 80 percent power to find a 2.6 hour difference in delay to drink, a 2.7 gallon difference in water consumed in 4 hours and a 2.6 gallon difference in water consumed in 8 hours. Power calculations were done according to Lachin and Cohen.

Experiment II

A summary of the paired t-test comparison of the delay to drink the first gallon of water for control groups compared to the treatment groups is given in Tables 2.3 . Only the continuous exposure was significantly different than the control group. A power analysis of the delay to drink comparisons is shown in Table 2.4. The power to detect a 1-hour change in the delay to drink was in excess of 92 percent with the sample size of 16 cows. This study had 80 percent power to detect a difference of 0.7 hours delay to drink between the control and one shock treatment group and a difference of 0.84 Hours between the control and intermittent treatment group.

The results of paired t-tests comparing control and treatment groups for water (gallons) consumed during the first 4 hours of exposure is shown in Table 2.5. Only the continuous exposure was significantly different from the control group. A power analysis of 4-hour water consumption comparisons is shown in Table 2.6. The power to detect a 2-gallon difference in water consumption was 80 percent or more.

The results of paired t-tests comparing control and treatment groups for the volume of water (gallons) consumed during the first 8 hours of exposure is shown in Table 2.7. Only the continuous exposure was significantly different from the control group. A power analysis of 8-hour water consumption comparisons is shown in Table 2.8. The power to detect a 1.7-gallon difference in water consumption was in excess of 80 percent for all comparisons.

SUMMARY AND CONCLUSIONS

A significant difference was found in delay to drink and water consumed in 4 and 8 hours between control and the treatment groups in which pulsed-continuous current was applied to water bowls once per second. No significant difference in drinking behavior was observed between steady-continuously and pulsed-continuously current applied to the water bowl. No significant difference in drinking behaviors was observed between control groups and a transient current applied to water bowls once per day and once every 10 minutes.

This study suggests that the aversive response to pulsed-continuous current pulses (applied once per second) is similar to steady continuously applied current for stimuli with the same sensitivity (e.g. 10-cycle, 60 Hz pulse and steady 60 Hz). Further, when currents were applied to water bowls intermittently (every 10 minutes and once per day) the aversive response was significantly less than for application once per second and was not significantly different than the control groups. When cows were given the opportunity to drink between current pulses which could cause aversion; they consumed water at the same rate as cows receiving no current stimulus.

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Table 1. Cow Information.

Experiment and Group	Stall	Cow Number	Reaction Level (mA)	Days In Milk	Lactation Number
I.1	1	4049	14.9	40	2
I.1	2	3810	11.2	50	4
I.1	3	4052	13.8	57	2
I.1	4	3864	12.5	45	4
I.1	5	3995	8.1	153	2
I.1	6	3895	8.9	160	3
I.1	7	3996	7.9	224	2
I.1	8	3804	8.9	228	4
I.2	1	3964	7.2	55	2
I.2	2	3965	8.1	57	3
I.2	3	3894	9.1	51	3
I.2	4	936	8.1	62	4
I.2	5	3985	7	10	3
I.2	6	4061	7	16	2
I.2	7	3732	8.8	67	5
I.2	8	3967	9.9	48	3
II.1	1	4080	6	50	2
II.1	2	3925	5	127	3
II.1	3	3872	7.9	88	4
II.1	4	3730	7.7	124	5
II.1	5	3862	6.7	63	4
II.1	6	3744	5.7	30	5
II.1	7	3851	5.9	133	4
II.1	8	3978	4.0	41	3
II.2	1	3780	9.2	239	4
II.2	2	4151	8.2	244	1
II.2	3	4084	7.2	69	2
II.2	4	4050	5.1	192	2
II.2	5	3813	7.2	281	4
II.2	6	3827	7.1	249	4
II.2	7	3717	5.1	257	5
II.2	8	3884	8	286	3

Table 1.2. Paired t-test comparisons of drinking behaviors for pulsed-continuous (10-cycle, 60 Hz) and steady-continuous (60-Hz) from experiment I.

Comparison	Mean Difference	Dtd.dev Differenc e	P-value Paired t	Significant at 95 % Level
Pulsed / Steady Delay to drink first gallon (Hrs)	-0.4	3.5	0.69	No
Pulsed / Steady Water consumed in 4 hrs. (Gal)	-0.2	3.6	0.81	No
Pulsed / Steady Water consumed in 8 hrs. (Gal)	0.8	3.5	0.40	No

Table 1.3. Power calculations for paired t-test comparisons of drinking behaviors for pulsed-continuous(10-cycle, 60 Hz) and steady-continuous (60-Hz) from experiment I.

Comparison	Mean of 10 Cycles Group	std.dev of Diff.	Given Difference	Percent Difference From 10 Cycles Mean	Power To Find Given Difference (n=15)
Pulsed / Steady Delay to drink first gallon (Hrs)	4.8	3.5	1	21	19
			2.6	54	80
Pulsed / Steady Water consumed in 4 hrs. (Gal)	3.6	3.6	1	28	18
			2.7	75	80
Pulsed / Steady Water consumed in 8 hrs. (Gal)	9.3	3.5	1	11	19
			2.6	28	80

Table 2.2. Sequence of treatments for experiment II.

			Stall Number							
Trial	Day of Trial	Treatment Day	1	2	3	4	5	6	7	8
1	3/18/97	1	Control		Continuous		One		Intermittent	
1	3/20/97	2	Intermittent		Control		Continuous		One	
1	3/24/97	3	One		Intermittent		Control		Continuous	
1	3/26/97	4	Continuous		One		Intermittent		Control	
2	5/2/97	1	Control		Continuous		One		Intermittent	
2	5/6/97	2	Intermittent		Control		Continuous		One	
2	5/8/97	3	One		Intermittent		Control		Continuous	
2	5/14/97	4	Continuous		One		Intermittent		Control	

Table 2.3. Paired t-test comparisons of delay to drink first gallon of water for experiment II.

Comparison	Mean Difference	Std.dev Difference	P-value Paired t	Significant at 95 % Level
Control versus one	0.4	1.0	0.1448	No
Control versus intermitent	0.4	1.2	0.2114	No
Control versus continuous	-5.6	2.6	0.0000	Yes

Table 2.4. Power calculations for paired t-test comparisons of delay to drink first gallon of water for experiment II.

Comparison	Control Delay (Gal)	Std. Dev of Diff. (Hours)	Difference (Hours)	% Power for Difference (n=16)
Control / One	0.8	1.0	1	98
Control / One	0.8	1.0	0.7	80
Control / Intermittent	0.8	1.2	1	92
Control / Intermittent	0.8	1.2	0.84	80

Table 2.5. Paired t-test comparisons of water consumed in first 4 hours for experiment II.

Comparison	Mean Difference	Std. Dev Difference	P-value (paired-t)	Significant at 95 % level
Control / One	-0.6	2.7	0.3624	No
Control / Intermittent	0.0	2.9	1.0000	No
Control / Continuous	7.2	2.7	0.0000	Yes

Table 2.6. Power calculations for paired t-test comparisons of water consumed in first 4 hours for experiment II.

Comparison	Control (Gal)	Std. Dev of Diff. (Gal)	Difference (Gal)	% Power for Difference (n=16)
Control / One	8.1	2.7	2	84
Control / One	8.1	2.7	1.9	80
Control / Intermittent	8.1	2.9	2	79
Control / Intermittent	8.1	2.9	2.02	80

Table 2.7. Paired t-test comparisons of water consumed in first 8 hours for experiment II.

Comparison	Mean Difference	Std. Dev Difference	P-value (paired-t)	Significant at 95 % level
Control / One	-0.1	2.7	0.8800	No
Control / Intermittent	-0.2	2.4	0.7235	No
Control / Continuous	8.8	6.8	0.0001	Yes

Table 2.8. Power calculations for paired t-test comparisons of water consumed in first 8 hours for experiment II.

Comparison	Control (Gal)	Std. Dev Difference	Difference (Gal)	% Power for Difference (n=16)
Control / One	14.4	2.7	2	84
Control / One	14.4	2.7	1.9	80
Control / Intermittent	14.4	2.4	2	92
Control / Intermittent	14.4	2.4	1.68	80