

FIXED-INTERVAL CONDITIONED FEED INTAKE IN SWINE AND CATTLE

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HAMMELL, K. L. AND HURNIK, J. F. 1987. Fixed-interval conditioned feed intake in swine and cattle. *Can. J. Anim. Sci.* **67**: 319-325.

An experiment was conducted to measure the influence of scheduled meal times on some behavior and production variables in beef cattle and swine. Ninety-six Yorkshire gilts in one experiment and 32 Hereford heifers in a second study were each housed in groups of four in pens equipped with individual electronic feedgates. The treatment (meal-fed) swine and cattle (T) had access to feed for 20 and 30 min, respectively, every 4 h. The control animals (C) had ad libitum access to feed. The meal-fed animals had to learn the initiation of a specified meal period through the use of a fixed-interval reinforcement schedule. Discriminative cues of a light and buzzer were used to facilitate the conditioning process. The behavioral data indicated that both species were able to be conditioned to the scheduled meal periods by the second day of the trial. The meal-feeding schedule with swine caused the treatment pigs to spend more ($P < 0.05$) time in walking activity (T=124 min, C=98 min) and less time resting (T=1164 min, C=1210 min). The meal-feeding system caused the cattle to spend less time ($P < 0.05$) in eating activity (T=135 min, C=176 min) and more time standing (T=409 min, C=342 min). Both species preferred to spend the majority of their feeding activity during the day (66 and 60% for pigs and cattle, respectively). For both species no statistically significant difference was found between the two treatment groups for production variables, but there appeared to be positive trends in favour of the meal-feeding system in beef cattle.

Key words: Swine, cattle, conditioning, meal-feeding, feed intake

[Consommation conditionnée à intervalles fixes chez les porcs et les bovins.]

Titre abrégé: Consommation conditionnée.

Nous avons mené une expérience visant à mesurer les effets de l'alimentation selon un horaire fixe sur certaines variables du comportement et de la production chez les bovins de boucherie et les porcs. Dans deux études distinctes, 96 truies Yorkshire et 32 génisses Hereford ont été logées en groupes de quatre dans des enclos munis de distributeurs d'aliments individuels à déverrouillage électronique. Les porcs et les bovins des groupes expérimentaux (T) avaient accès aux aliments pendant 20 et 30 min respectivement, toutes les 4 heures. Les animaux témoins (C) pouvaient se nourrir à volonté. Les sujets expérimentaux ont appris à reconnaître le début de la période d'alimentation grâce à un horaire fixe favorisant l'accoutumance. Des signaux lumineux et sonores ont été utilisés pour faciliter le processus de conditionnement. Les données portant sur le comportement ont laissé voir que les deux espèces pouvaient être conditionnées aux périodes fixes d'alimentation dès le deuxième jour des essais. Les porcs des groupes expérimentaux passaient plus de temps ($P < 0,05$) à marcher (T=124 min, C=98 min) et moins de temps à se reposer (T=1164 min, C=1210 min). Les bovins conditionnés à un horaire fixe passaient moins de temps ($P < 0,05$) à se nourrir (T=135 min, C=176 min) et plus de temps en station debout (T=409 min, C=342 min). Les deux espèces préféraient s'adonner à la majorité de leurs activités d'alimentation pendant le jour (66 et 60% pour les porcs et les bovins, respectivement). Pour les deux espèces, aucune

différence significative n'a été observée entre les deux groupes de traitement du point de vue des variables de production mais il semblait exister des tendances positives en faveur de l'horaire d'alimentation fixe chez les bovins de boucherie.

Mots clés: Porc, bovin, conditionnement, distribution d'aliments, consommation

Feed costs constitute a high proportion of production expenses in livestock operations (Sniffen and Robinson 1984). Recently, the interest of many researchers has focused on the possibility of improving feed conversion ratios based on a structured pattern of feed intake (meal feeding). It is known that meal feeding has improved feed conversion in poultry (Conard and Kuenzel 1978), cattle (Burt and Dunton 1967; Gibson 1981; Sniffen and Robinson 1984) and sheep (Gibson 1981).

The objective of this study was to utilize the advantage of operant conditioning techniques to control the feed intake of swine and cattle. The conditioning process followed a fixed interval reinforcement schedule as defined by Hurnik et al. (1985). This form of operant conditioning provides the producer with the benefit of delivering the feed to the animals only once a day, yet allows eating only at specified meal times. The choice of these two species was influenced by their anatomical, physiological and behavioral differences (Swenson 1977), which potentially offer a broader spectrum of animal responsiveness and thus a better comparative assessment of such a feeding technique for livestock operations.

MATERIALS AND METHODS

Pigs

Ninety-six Yorkshire gilts with an average initial body weight of 48 kg and average age of 3 mo were housed in an environmentally controlled building. In each of the two rooms there were four pens of four pigs. Half of the animals were subjected to a fixed-interval feeding schedule (meal-fed), while the other half represented the ad libitum control group. There were two pens assigned to each treatment group in each room. The treatment and control pens were located in diagonal corners of the room to minimize any potential confounding effect due to social facilitation. The whole trial consisted of three replicates, each observed over a period of 8 wk.

The access of pigs to the individual feeders was controlled by electronically operated feeder headgates. Every gilt wore an eartag key to activate a releasing mechanism of the individual pig's specific headgate. In the treatment group, a timer system allowed operation of the headgates by the pigs only at given meal times starting at 0900, 1300, 1700, 2100, 0100 and 0500 h. This provided for a total of six meals in a 24-h period with an even 4-h spacing between meals. Each meal period was 20 min in duration. Discriminative cues of a buzzer and light were mounted above the meal-fed pens. A 5-s-long buzzer signal was synchronized with the start of the meal time and the duration of lighting identified the period of accessibility to the feeder. The control animals had ad libitum access to their individual feeders. Both groups of pigs were given 1 wk to learn their individual headgates before the start of the experiment. All pigs were fed a standard 16% crude protein (dry matter basis) pelleted, growing-finishing ration.

Cattle

Thirty-two Hereford heifers with an average initial body weight of 340 kg and average age of 15 mo were housed in an open-front shed. Sixteen animals were subjected to a fixed-interval feeding schedule, while the other half constituted the ad libitum-fed control group. There were four pens assigned to each treatment group, holding four animals per pen. The treatment pens were situated at opposite ends of the building with pens in between containing animals unrelated to the experiment to minimize any potential confounding effect of social facilitation. The animals in this trial were observed for a period of 12 wk.

Similarly to the pig experiment, the access to the feeders was controlled by electronically operated individual headgates. Each heifer wore a specific key, suspended from a nylon cord around its neck, to activate the releasing mechanism of its own headgate. Meal-fed cattle had the opportunity of six feeding periods, at 4-h intervals, starting at 0900, 1300, 1700, 2100, 0100 and 0500 h. The duration of each meal period was 30 min. Discriminative cues of a buzzer and light were mounted above the feeders. The function and timing of the discriminative cues were the same as described for

pigs. The cattle were given 1 wk to learn their individual headgate before the start of the fixed-interval feeding schedule. All heifers were fed a ground ration of 81% corn silage, 16% high moisture ear corn, 1.5% vitamin mineral premix, and 1.5% MGA premix on an as-fed basis.

Data Collection and Statistics

In both trials the animals were monitored using a time-lapse video recorder. During the first 3 d of the experiment, the recording was continuous (24 h d⁻¹); thereafter, only 1 d a week was recorded. Each animal was marked for individual identification. Night recording necessitated illumination of the pens at the level of 100 lx and 56 lx for pigs and cattle respectively.

For both species, the dependent behavior variables measured were the amount of time spent in resting, walking, standing, eating, drinking and socially interacting with pen peers. Dependent production variables measured for each individual animal were body weight gain, feed consumption and feed-to-gain ratio. Individual body weights and feed consumption were recorded regularly at 14- and 28-d intervals for pigs and cattle, respectively. The carcass variables measured for the swine were hot carcass weight, backfat thickness and carcass index. For cattle the carcass variables were average fat cover, grade fat, ribeye area, marbling, estimated cutability and quality grade. Swine and cattle were slaughtered at market weight. The measurements of carcass variables followed standardized Canadian evaluation procedures (Canadian Pork Council 1982; Agriculture Canada 1983).

For both species, the variables were statistically analyzed using the general linear models program (Statistical Analysis System 1982). Completely randomized block design with a split plot in time and completely randomized design with a split plot in time were used for swine and cattle data, respectively. A level of $P=0.05$ was used in all tests as a truncation point for statistical significance.

RESULTS

Pigs

The behavioral data indicate that on day 1 of the trial, 16.7% of the pigs were not seen to activate the feeder gates within the first 5 min after each presentation of the buzzer and light. By day 2, all of the swine activated the feedgates during at least one scheduled meal period per day within the first 5 min after presentation of the discriminative cues. This indi-

cates that the pigs were able to be conditioned to the fixed interval reinforcement schedule relatively quickly. The treatment animals spent less time resting ($P<0.01$) and more time walking ($P<0.01$) than the control animals. No treatment difference ($P>0.05$) was noted for the other behavioral variables (Table 1). When a t -test with pooled variances was used, it was shown that both the control and treatment pigs spent more time eating ($P<0.05$) during the daylight hours. Approximately two-thirds of total duration of eating activity (66%) occurred between 0600 and 1800 h (Fig. 1). Both the control and treatment animals showed similar overall duration of eating (Table 1). The treatment animals utilized only 44% of the 120 min of total allotted time to reach the feeder via the headgates.

Both groups of animals rested on the average more than 80% of the total time. Walking, the second largest behavioral activity, accounted for 7 and 9% in control and treatment pigs, respectively. The analysis of production data did not reveal any significant differences between the control and treatment pigs in any of the recorded variables (Table 1).

Cattle

The behavioral data indicate that on day 1 of the trial, 41.7% of the cattle were not seen to activate the feedgates within the first 5 min after each presentation of the discriminative cues. However, by day 2, all the animals did so within the first 5 min after presentation of the light and buzzer for at least one scheduled meal period per day. The treatment animals spent less time feeding ($P<0.01$) and more time standing at the feedgate ($P<0.01$) and standing anywhere in the pen ($P<0.05$) than the control animals. No other differences ($P>0.05$) were detected for the other behavioral variables (Table 2). When a t -test with pooled variances was used, both the control and treatment cattle spent more time eating ($P<0.05$) during the daylight hours. Overall, the meal-fed cattle spent 58% and the control animals spent 62% of the total eating

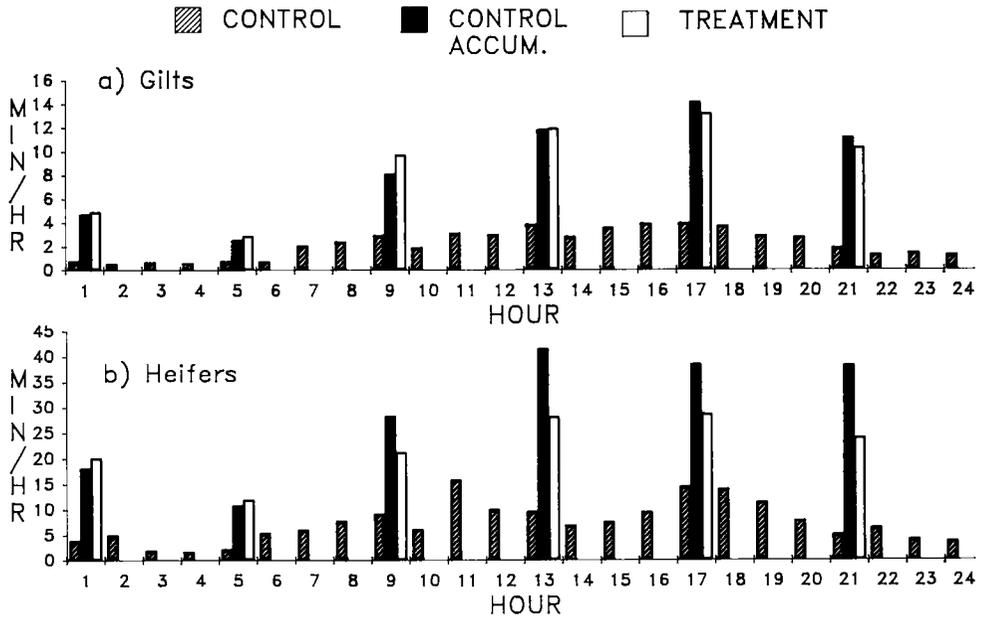


Fig. 1. Average distribution of eating times for control animals (C), control accumulated — control animals accumulated over 4 h (CA), and treatment animals (T).

Table 1. Behavioral and production variables in pigs ($n=76$)

	Control pigs			Treatment pigs		
	Mean	SE	%	Mean	SE	%
<i>Behavioral activities (min/24 h)</i>						
Resting	1209.6 ^a	3.63	83.9	1163.9 ^b	4.01	81.1
Walking	98.1 ^a	2.22	6.8	123.8 ^b	2.46	8.6
Eating	52.5	1.27	3.6	52.2	1.41	3.6
Standing at feedgate	28.3	1.36	2.0	34.3	1.50	2.4
Standing outside feeding area	27.6	0.61	1.9	32.7	1.36	2.3
Drinking	14.0	0.63	1.0	13.4	0.70	0.9
Socially interacting	12.1	0.74	0.8	14.9	0.82	1.0
<i>Production performance</i>						
Total feed intake (kg)	117.97	2.84		110.78	2.78	
Total weight gain (kg)	41.90	1.18		40.07	1.24	
Feed conversion (ratio)	2.83	0.13		3.03	0.14	
Hot carcass weight (kg)	72.80	1.07		72.21	0.09	
Backfat thickness (cm)	2.93	0.08		3.02	0.09	
Index	103.25	0.69		103.22	0.72	

a,b Means in the same row followed by different letters differ ($P<0.05$).

time between 0600 and 1800 h (Fig. 1) The meal-fed heifers utilized 74% of the total 180 min available for eating. In both groups resting accounted for over 50% of the total

time, with standing anywhere in the pen being the second most frequent behavioral activity, accounting for 20 and 22% for the control and experimental heifers, respectively. Eating

Table 2. Behavioral and production variables in cattle ($n=32$)

	Control heifers			Treatment heifers		
	Mean	SE	%	Mean	SE	%
<i>Behavioral activities (min/24 h)</i>						
Resting	792.7	8.84	55.4	766.0	8.40	53.9
Walking	83.9	4.47	5.9	80.5	3.83	5.7
Eating	175.6 _a	4.50	12.3	134.8 _b	2.68	9.5
Standing at feedgate	57.6 _a	3.52	4.0	95.1 _b	5.36	6.7
Standing outside feeding area	284.9 _a	7.04	19.9	313.6 _b	7.62	22.1
Drinking	19.9	1.50	1.4	20.8	1.38	1.5
Socially interacting	15.4	1.18	1.1	10.9	0.97	0.8
<i>Production performance</i>						
Total dry matter intake (kg)	662.63	17.33		654.65	23.14	
Total weight gain (kg)	80.63	3.73		83.94	3.85	
Feed conversion (ratio)	8.37	0.24		8.01	0.38	
Fat cover (cm)	1.43	0.07		1.44	0.06	
Grade fat (cm)	1.08	0.01		1.09	0.07	
Rib eye area (cm ²)	23.45	0.69		22.86	0.41	
Marbling	6.19	0.01		6.69	0.08	
Average estimated cutability (%)	55.53	0.08		55.28	0.04	
Quality grade	1.81	0.33		1.83	0.58	

a,b Means in the same row followed by different letters differ ($P < 0.05$).

activity accounted for 12.3% for control and 9.5% for treatment animals, respectively (Table 2).

The analysis of production data did not reveal any statistically significant differences between the control and experimental cattle in any of the recorded variables. However, average performance for all production variables favored the meal-feeding system (Table 2).

DISCUSSION

There are many forms of operant conditioning which involve various degrees of difficulty to the animal in learning the correct operant response so as to obtain a positive reinforcement. Many operant response studies have been conducted with swine and cattle using a continuous reinforcement schedule, for example, plate-pressing to obtain a food reward (Moore et al. 1975; Houpt et al. 1983). However, training to use discriminatory cues as aids to obtain a food reward, in instances when the positive reinforcer is offered only at a fixed-interval schedule, involves a much more complex learning process (Hurnik et al. 1985).

Both treatment swine and cattle were able to be conditioned to the scheduled meal periods by the use of discriminatory training

by the second day on trial. Shaw (1978), using a time-controlled feeding system, noted that the cattle associated the onset of the meal period with presentation of the discriminative cue of a buzzer. However, he stated only that the animals were soon conditioned and did not indicate a more accurate account of the time needed to learn the conditioning process. In swine, it seems that no studies have been conducted to provide an accurate comparison for the ability of swine to follow a fixed-interval reinforcement schedule.

For swine, both groups spent the majority of their total time resting, which agrees with Randolph et al. (1981). However, the meal-feeding schedule caused more restlessness and walking in the treatment pigs compared to the control animals. Hansen et al. (1982) found that the social facilitation which prompted the pigs to eat collectively would also motivate them to lie down collectively if several pigs were allowed to reach satiety together. A possible reason why the meal-fed pigs were more active than the control animals may be boredom (Hurnik et al. 1985). The meal-fed gilts ate similar amounts of feed, and spent similar amounts of time in eating activity compared to the control pigs, but were not able to spread their eating activity freely over

a 24-h period, as in the ad libitum group. Perhaps, with a confinement housing system, one distraction which an animal could provide for itself was to eat or play with the feed or feeder.

When observing feeding activity, it was noted that although both groups of experimental animals spread their eating activities throughout a 24-h period, they still had slight peaks of eating at 1300 and 1700 h. This agrees with the results of Auffray and Marcilloux (1980, 1983) and Fraser (1984), who found two to three peaks of eating activity with swine throughout the day, with modest intakes during the night. Diurnal feeding patterns were observed with both treatment groups in each species. Approximately 66% of feeding activity for the pigs and 60% for the cattle was spent during the daytime hours of 0600 – 1800 h. Putnam et al. (1968), Chase et al. (1976) and Vasilatos and Wangsness (1980) found similar feeding patterns with cattle as in this experiment. Operant conditioning, therefore, did not influence the day-night distribution of feeding.

It was found that the meal-fed cattle spent significantly more time in standing activity than the ad-libitum-fed cattle. A high peak of standing at the feedgate was seen by both treatment groups at 1000 h, preliminary to the approach of the feed truck at 1030 h. This indicates expectation conditioning by the cattle to the stimulus of fresh feed delivered by the feed truck.

No significant treatment difference was found for the production variables for either species. Earlier research has shown that the relationship between feeding frequency and feed utilization is not conclusive. Increasing the frequency of feeding may have no effect (Friend and Cunningham 1964; Walker 1970); an adverse effect (Mel'nikov and Struk 1956; Psenicnyj 1958) or a beneficial effect (Friend and Cunningham 1967) on the efficiency of feed utilization. Pigs fed ad libitum gained faster than pigs fed 1 or 8-12 (Cromwell 1965) or 2-3 (Bell 1975) times daily. The ability of the meal-fed pigs in the present experiment to consume a similar

amount of feed and spend a similar amount of time in the feeder to that of the control pigs may explain why no significant difference between the two treatment groups was found for the production variables.

With cattle, the average performance for all production variables favored the meal-feeding system, which agrees with the results of Gibson (1981). Horton (1964), when using different meal frequencies, found no significant difference in weight gain with Holstein and Jersey heifers. However, hay was offered free-choice and the quantity of concentrate feed was held constant for all feeding frequencies.

In summary, both treatment swine and cattle were able to be conditioned quickly to the scheduled meal periods. For the swine, the meal-feeding system may not have been advantageous from a behavioral point of view as the treatment pigs appeared to be more restless than the control-fed pigs and the meal-feeding schedule used in this study had no benefit for the production variables. For the cattle, there was no statistically significant improvement for the meal-fed animals, although all production variables favored the meal-feeding schedule.

ACKNOWLEDGMENTS

We express our thanks to the Ontario Ministry of Agriculture and Food for the use of animals at the Arkell Swine and Elora Beef Research Stations. This study was supported by an NSERC operating grant, No. A6784.

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