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Preference Tests of Ramp Designs for Young Pigs

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ABSTRACT

Preference experiments were used to identify features of ramp design that influence the voluntary use of ramps by young pigs. In seven experiments, groups of pigs, aged 7-8 wk, were given free access to four different ramps simultaneously. The animals' behavior was monitored to identify the amount of time spent on the ramps and the number of pigs that failed to use specific designs. Slope, in the range of 20-32° from the horizontal, had a major influence on the pigs' behavior, with the shallower slopes attracting more use than steep ones. Pigs preferred ramps with angle-iron cleats (cross-laid on the ramps to provide foot-holds) spaced every 50 or 100 mm rather than 200 or 300 mm. Cleat height, in the range of 10-40 mm, had little effect. Pigs showed a slight preference for ramps with solid or open (wire mesh) side walls, compared to ramps partially enclosed by a railing. Reduced width (510 vs. 710 mm) was not a major impediment to ramp use, although the narrow ramps were used somewhat less, by a degree proportional to their smaller width. Level of illumination (up to 1200 lx) had no major effect. A staircase composed of 20 small steps was used at least as readily as a ramp of similar slope, but staircase designs with fewer, larger steps were not preferred. The results suggest that a ramp sloped at 20-24°, with cleats cross-laid every 50-100 mm, would provide a feasible design with good acceptance by young pigs, either for loading pigs or for two-level housing systems.

In recent research, we explored the principle of free-access, two-level housing for pigs in confinement rearing (Fraser et al. 1986; Phillips and Fraser 1987). Typically, the housing consists of an upper, solid-floored level and a lower slotted-floored level, joined by a short ramp. Such housing makes efficient use of barn space, and has a number of potential advantages in terms of animal welfare (Fraser et al. 1986). For the system to work effectively, pigs must make regular, voluntary use of the ramp over a wide range of body weights. Therefore, the ramp must be designed for maximum acceptance by the pigs.

Most of the available recommendations on ramp design are intended for slaughter weight pigs, and are based on experience with congested loading operations (e.g., Mayes 1978; Grandin 1982, 1986). Poor ramp design is a recognized problem in livestock handling.

In view of the limited information available, a study was initiated to examine ramp design, particularly for young pigs. The emphasis was on design features relevant to two-level housing, but it is hoped that the information will also help to improve loading ramp designs. The present report investigates cleat spacing, cleat height, slope, width, illumination, side-wall construction as well as certain step designs, to determine which features influence voluntary use of ramps and what dimensions appear to be preferred by the animals.

MATERIALS AND METHODS

Test Apparatus

A test apparatus was designed to allow pigs simultaneous access to four ramps of different designs. A holding pen located at floor level provided a common access area adjoining the ramps. The holding pen, equipped with four gates, was located centrally in a 3.5 × 5.6-m room with specially constructed platforms in each corner to accommodate the ramps (Fig. 1). Temperature in the room was maintained at 20°C (± 2°C).

To allow easy modification, the ramps were constructed of 15-mm plywood, reinforced beneath by 38 × 89-mm lumber. The corner platforms were 750 mm high and were also constructed of 15-mm plywood. Metal fixtures were used to attach the ramps to the platforms, and plywood panels (600 mm high) formed walls on the sides of the ramps and platforms to confine the pigs to the test apparatus. The areas of the holding pen and platforms were 1 and 0.55 m^2, respectively.

Colors used on the test apparatus were consistent with the existing barn: grey underfoot and pale yellow for vertical surfaces. The grey paint contained a fine silica sand for traction. A floor-to-ceiling curtain covered the end of the test room where the door was located; the curtain made the wall visually similar to the other walls of the room.

Animals and Procedures

For each trial in the study, four pigs were selected randomly from their 1.2 × 7.2-m weaner decks at approximately 7-8 wk of age and a body weight of about 16 kg. The four pigs of a group were taken from the same pen and either three or all were litter-mates. The pigs received water and feed ad libitum and had not previously been exposed to a ramp. Trials commenced between 0800 and 1000 h.

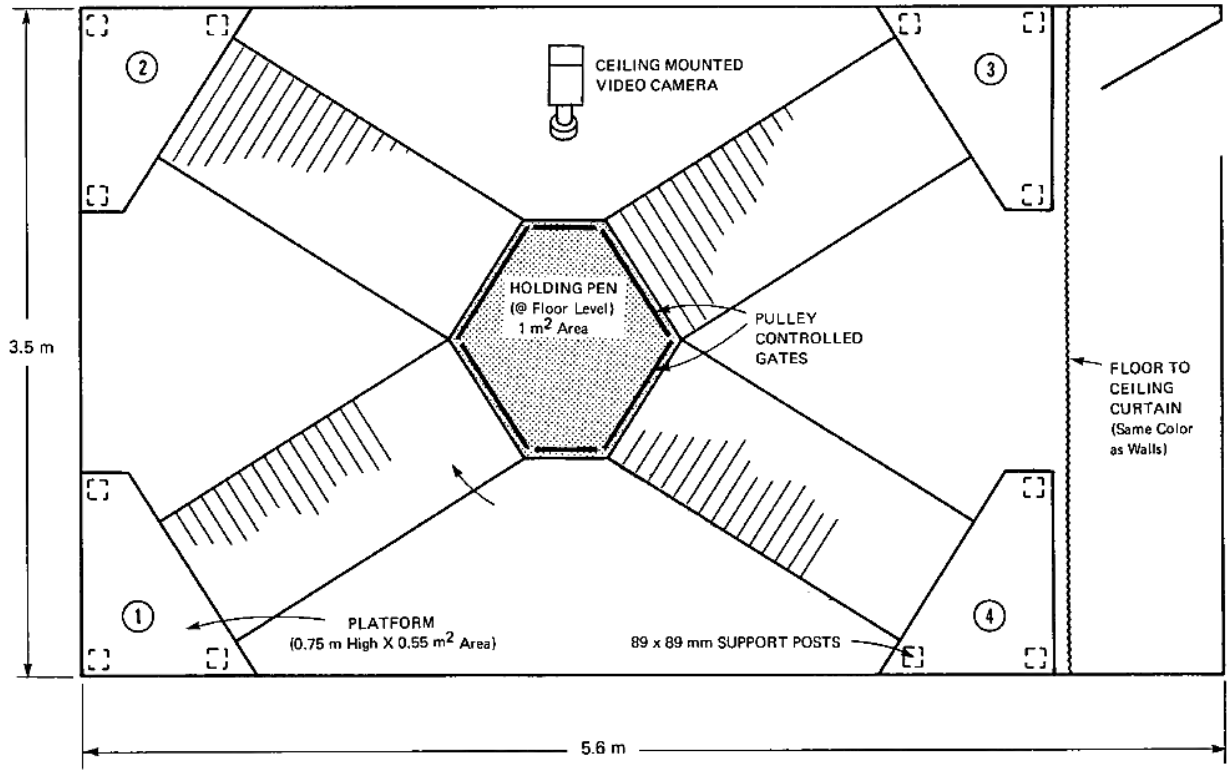
After the group weight had been recorded, pigs were individually marked with stripes on their backs and were transferred to the holding pen. Within 2-3 min the four gates were raised simultaneously, giving the pigs free access to all four ramps. The animals' use of the ramps was recorded by a ceiling-mounted time-lapse video recorder with a 6.0 mm lens and a recording speed of 2.5 frames s^{-1}. The camera's field of view covered the holding pen and at least the bottom two-thirds of each ramp. It was impossible to see when a pig had moved from a ramp onto the adjoining raised platform, but the platforms were small (0.55 m^2; to discourage lingering.

Trials were allowed to continue until it was estimated that the pigs (combined) had spent at least 30 min total time on the ramps. The pigs were then removed and the surfaces of the ramps, platform and holding pen were washed. Normally one trial was run per day and no feed or water was available during the trials.

The video recordings were later replayed at a slow speed, and records were made on the duration of each ramp use by each pig. A pig was considered to be using a ramp when all four of its hooves were off the holding pen floor; ramp use was considered to end as soon as contact with the holding pen floor resumed. Because the four pigs of a group could not be regarded as independent, data on ramp-use time

were based on the group as a whole. In addition, records were kept on any pigs that failed to use one or more of the ramps (termed "refusals"); this was defined as less than 5 s of use of a specific ramp.

Fig. 1. Layout of the preference testing apparatus.



Comparisons of Design Features

Seven experiments were carried out to test seven features of ramp design. Several of the features and dimensions were chosen because of their relevance to the design of two-tiered pens for growing pigs. Except where otherwise stated, the ramps were 710 mm wide and 1900 mm long, were angled at 22° (± 0.5°) from the horizontal, and were enclosed by solid plywood walls 600 mm high. These "standard" ramps were illuminated by a single frosted 100-W light bulb centered over each ramp 2.4 m above the floor and giving an average illumination of 80 lx at ramp level. To provide footing so that pigs would not slip down the incline, the ramps were cross-laid with cleats consisting of 3.2-mm-thick steel angle, normally projecting 20 mm above the ramp and spaced 100 mm apart.

Experiment 1 compared one standard ramp with three stair-case designs offering the same ratio of vertical rise to horizontal run. The stair-case designs consisted of (1) 20 steps, 95 mm wide with a riser of approximately 40 mm, (2) 10 steps, 200 mm wide with a riser of 80 mm, or (3) 6 steps, 355 mm wide with a riser of 130 mm. Cleats were spaced every 100 mm on the ramp, and at the leading edge of each step on the staircases.

Experirnent 2 compared four ramps whose angle-iron cleats were spaced either 50, 100, 200 or 300 mm apart.

Experiment 3 examined the height of the angle-iron cleats, using cleats that protruded 10, 20, 30 or 40 (± 1) mm above the ramp surface.

Experiment 4 compared ramps at four different slopes: 20, 24,28, and 32° (± 0.5°). Ramp lengths were 2200, 1850, 1600, and 1400 mm, respectively, varying inversely with slope so that the total rise from floor to platform level was held constant.

In exp. 5, four different levels of illumination on the ramps were provided by (1) no overhead light, (2) one 25-W frosted bulb, (3) two 100-W frosted bulbs, or (4) two 150-W flood lights. The lights were mounted at ceiling height above the ramps and created average levels of illumination of < 5, 10, 80 and 1200 lx at the ramp surface, respectively. Black curtains were hung around the lights in order to minimize diffusion of light from one ramp to another.

Experiment 6 compared four alternative arrangements for side walls to enclose the ramp: (1) the standard, plywood side walls; (2) side walls made of vertical wooden bars 45 mm wide and spaced 60 mm apart; (3) rails, also 45 mm wide and spaced 60 mm apart, running parallel to the ramp; and (4) fine wire mesh with a hole size of 16 × 20 mm. All side walls were 600 mm high. Walls 2 and 3 had about 30% of the area solid and 70% open. The wire mesh in treatment 4 provided a negligible restriction to the field of view. Because the ramps were lit from above, the partially open side walls cast almost no shadow on the ramps.

Experiment 7 compared two ramp widths of 710 and 510 mm. Two ramps of each width were used; these were offered in a factorial arrangement at a slope of either 22 or 28° (± 0.5°).

Experimental Design and Analysis

Each experiment was designed as a replicated Latin square. A replicate consisted of four trials (i.e., four groups of pigs), with each of the four ramps presented once in each of the four positions (i.e., corners of the room). Experiments 1-5 were replicated six times (24 trials, 96 pigs per experiment), and exps. 6 and 7 were replicated four times (16 trials, 64 pigs per experiment), for a total of 152 trials. To minimize the labor involved in moving the ramps, all trials requiring the same positioning of the ramps were completed before the ramps were moved to their next set of positions.

For each of the trials, the elapsed time on each ramp was determined for the first 5 min, the first 15 min, and the entire 30 min of total ramp-use time for the four ramps combined. In addition, the ramp-use times were determined for the interval 15-30 min. Because the total ramp-use time was constant for a trial, the amount of time spent on a given ramp was not independent of the time spent on the other ramps. Furthermore, the ramp-use times were not normally distributed; hence, the usual analysis of variance was not appropriate. Instead, it was decided to convert times to ranks as a measure of preference. To do so without confounding ramp design with position, the times spent on each ramp were summed for the four trials making up a replicate; the four ramps were then ranked from most used to least used within each replicate. Friedman's test (Hollander and Wolfe 1973) was applied to the rank data. To test whether ramp use differed for the four positions, ranks were also assigned to the four position totals of each replicate, and Friedman's test applied.

Analysis by ranks was admittedly conservative, and did not permit examination of interactions between ramp type, position, and replicate; however, rank analysis was considered the safest approach given the problems of independence and distribution. Other methods are available which enable tests of trends with ordered treatments such as those found in most of the experiments described here (see, for example, Page's test described by Hollander and Wolfe (1973)), but, because of the magnitude of the 12 values, the extra sophistication was considered unnecessary. Tests of significance were at the 5% level, unless otherwise indicated.

RESULTS

Trial duration varied widely from 14 min up to 8 h 15 min before the criterion of 30 min of total ramp-use time had been met. Of 152 trials, 121 were complete in less than 1 h after the gates were lifted. Simultaneous ramp-use by several pigs of the group accounted for the rapid completion of many trials.

Most ramp-use events were brief (mean = 32 s). Long events were infrequent but these did occur and their impact on the result would be important if a pig had climbed the ramp but was afraid to come down. A survey of the 10 642 events indicated that on 12 occasions pigs used the ramp in excess of 7 min. These events were examined individually and there was no evidence to suggest pigs were trapped in this way. In each case, the pigs used that particular ramp and other ramps on more than one occasion.

In four of the experiments, there was evidence of a position effect. However, because of the experimental design adopted, each of the ramp treatments appeared equally often at each position and hence any position effect would effectively disappear in the treatment comparisons.

Experiment 1: Ramp versus Staircase Designs

The distribution of activity for the four selected time intervals (Table 1) indicated that there was little difference between the ramp and the 40-mm steps, but the 80- and 130-mm steps were significantly less preferred. Actually, the 40-mm steps were used more than the ramp in five of the six replicates but there were fewer refusals with the ramp.

The preference data (Table 1) likely overestimate the acceptance of the 130-mm steps. Because of the slope used, the large steps provided an appreciable horizontal area (360 × 710 mm) on which pigs could stand comfortably. Many animals stood on the first step but did not climb further. Of the 96 pigs in the experiment, only 31 were observed to climb two-thirds or more of the way up the 130-mm steps (i.e., off the video screen) while 48 did so on the 80-mm steps.

Table 1
Response to a standard ramp versus three staircase designs in exp. 1.

		Step height (mm)			
Portion of trial	**Ramp**	**40**	**80**	**130**	***P*†**
		Percentage of time‡			
1st 5 min	33	35	10	22	< 0.01
1st 15 min	30	38	14	18	< 0.10
2nd 15 min	32	36	17	15	< 0.10
Entire test	31	37	15	17	< 0.01
		Number of pigs refusing§			
Entire test	8	10	27	24	

†In all tables, significance levels are based on Friedman's test applied to the data after conversion to ranks, tested as χ^2 with 3 degrees of freedom.

‡Percentage of total ramp-use time spent on the four different ramps, averaged over the six replicates.

§Number of pigs that did not use a given ramp for a minimum of 5 s.

Experiment 2: Cleat Spacing

Cleat spacing had a clear influence on ramp use (Table 2). In the first 15 min of ramp-use time, the 50-mm spacing was preferred. However, during the 15- to 30-mm interval, the 50- and 100-mm spacing

received similar attention and together accounted for 74% of the total ramp-use time. While the pigs showed some signs of adjusting to the 200-mm spacing, both of the wider spacings were less preferred and accounted for only 22% of ramp-use over the 30-min interval.

The pattern of refusals closely conformed with that of ramp-use time. In fact, none of the 96 pigs tested refused to use the ramp with 50-mm spacing, but almost 25% refused to use the ramp with 300-mm spacing.

Table 2
Response of pigs to ramps with four different cleat spacings in exp. 2.

	Cleat spacing (mm)				
Portion of trial	**50**	**100**	**200**	**300**	***P***
			Percentage of time		
1st 5 min	58	23	10	8	< 0.01
1st 15 min	50	31	12	7	< 0.001
2nd 15 min	36	38	17	9	< 0.05
Entire test	43	35	14	8	< 0.001
			Number of pigs refusing		
Entire test	0	2	13	22	

Experiment 3: Cleat Height

There was no conclusive evidence that cleat height influenced ramp use (Table 3). There was a trend towards less use of the ramp with 40-mm cleats, but the results were somewhat contradictory. For example, in one replicate, the 40-mm height was the most preferred, and in another the 10-mm height was the least preferred.

Table 3
Response of pigs to ramps with four different cleat heights in exp. 3.

	Cleat height (mm)				
Portion of trial	**10**	**20**	**30**	**40**	***P***
			Percentage of time		
1st 5 min	33	22	24	21	> 0.1
1st 15 min	34	22	26	18	> 0.1
2nd 15 min	26	32	25	17	> 0.1
Entire test	30	27	26	17	> 0.1
			Number of pigs refusing		
Entire test	15	20	22	25	

Experiment 4: Slope

Slope had a clear effect on ramp-use time and refusals (Table 4). In five of the six replicates, ramp use decreased steadily with increasing slope. The single exception involved 28° being less used than 32°. Almost half of the 96 pigs refused to use the 32° slope while only two refused to use the 20° slope.

Table 4
Response of pigs to ramps with four different slopes in exp. 4.

	Slope (°)				
Portion of trial	**20**	**24**	**28**	**32**	***P***
			Percentage of time		
1st 5 min	63	23	11	3	< 0.001
1st 15 min	58	22	13	7	< 0.01
2nd 15 min	56	26	10	8	< 0.001
Entire test	57	24	12	7	< 0.001
			Number of pigs refusing		
Entire test	2	11	26	44	

Experiment 5: Illumination

While illumination had no clear effect on ramp use, there was a trend towards pigs choosing the lighting intensity to which they were accustomed (i.e., about 80 lx) over more extreme lighting conditions, either brighter or darker (Table 5). With the 15-min data, for example, five of the six replicates ranked 80 lx as the most preferred illumination, but the trend failed to reach statistical significance because the sixth replicate ranked 80 lx as the least preferred.

Table 5
Response of pigs to ramps with four illumination intensities in exp. 5.

	Illumination intensity (lx)				
Portion of trial	**< 5**	**10**	**80**	**1200**	***P***
			Percentage of time		
1st 5 min	20	24	30	26	> 0.1
1st 15 min	23	24	32	21	> 0.1
2nd 15 min	21	17	33	29	> 0.1
Entire test	22	20	32	26	> 0.1
			Number of pigs refusing		
Entire test	20	11	12	16	

Experiment 6: Side-wall Design

During the first 15 min of the trials, pigs tended to prefer ramps with wire and solid side wall construction (Table 6). However, the difference was not sustained over the second 15 min, and the overall pattern was not clear. Refusals were somewhat less common with the wire and solid side walls.

Experiment 7: Width and Slope

As in exp. 4, slope had a major influence on the pigs' behavior (Table 7). The refusal data also indicate a preference for the shallower ramps with about 40% refusal on the 28° ramps but less than 10% on the 22° ramps. Ramp width had much less influence than slope; at a given slope, the use of the ramps over the 30 min was approximately proportional to their width.

Table 6
Response of pigs to ramps with four side-wall designs in exp. 6.

Portion of trial	Side-wall construction				*P*
	Wire	Solid	Rails	Bars	
			Percentage of time		
1st 5 min	41	25	9	25	< 0.05
1st 15 min	32	34	13	21	< 0.05
2nd 15 min	25	37	17	21	< 0.1
Entire test	28	35	16	21	< 0.1
			Number of pigs refusing		
Entire test	4	3	16	11	

Table 7
Response of pigs to ramps of two slopes and two widths in exp. 7.

Portion of trial	Slope, width (mm)				*P*
	22° , 510	22° , 710	28° , 510	28° , 710	
			Percentage of time		
1st 5 min	46	42	2	10	< 0.05
1st 15 min	39	50	3	8	< 0.05
2nd 15 min	27	53	11	9	< 0.10
Entire test	33	51	7	9	< 0.05
			Number of pigs refusing		
Entire test	5	3	29	23	

DISCUSSION

Of the ramp design features studied, the most influential were slope and cleat spacing. Pig sensitivity to ramp slope is not surprising, and the use of slopes even lower than those tested would doubtless have a favorable effect on ramp use. However, slopes below 20° may be impractical for several reasons: space may be restricted; low slopes cost more to construct; and, if the ramp must be moved or lifted, the extra weight and length may be a nuisance. All of these limitations apply to ramp use in two-tiered pens and hence tests at slopes below 20° were not attempted. As slopes increase above 20°, pig acceptance will diminish. However, design values chosen between 20 and 24° provide a practical range without excessive refusals. Most of the experiments in this report were conducted at a 22° slope, midway in this range. Grandin (1982) recommended maximum slopes of 20-25° for slaughter weight pigs.

To walk up an inclined surface of any significant slope, pigs must be provided with cleats for traction. Cleats at spacings of 50 mm initially, and 100 mm later in the trials, were preferred over the wider spacings. This is not surprising. The 50-mm spacing offers the most complete support against slipping downwards. As trials progressed, climbing coordination and confidence presumably improved, and increased use was made of the 100-mm spaced cleats, and to a smaller extent the 200-mm spaced cleats. However, the 50 mm spacing was used by all 96 pigs.

Mayes (1978) recommended cleat heights of 35 mm for slaughter-weight pigs. In the present trials, young pigs showed no strong preference for specific cleat heights over the range of 10-40 mm. In view of this lack of preference, cleat height might best be decided based on practical considerations such as cost and

the need to provide a foothold after some fouling of the ramp has occurred. For young pigs, a height of 20 or 30 mm may be the most practical.

Illumination, sidewall construction and width are other design features discussed in the livestock handling literature. These were tested, but no substantial differences were found. However, certain trends were evident, and were generally consistent with recommendations for swine handling facilities. First, pigs tended to use the ramps with the intermediate levels of illumination to which they were accustomed; the avoidance of the bright and dark ramps was consistent with reports in the literature (Grandin 1982). Second, the tendency over the 1800-s trial interval toward preferring solid panel sidewall construction was also consistent with the recommendations of Grandin (1986). Finally, ramp width had little impact on preference; hence, choice of width should be based on other factors such as traffic control.

Staircase designs provide a possible alternative to ramps for use in pig facilities (Grandin 1982, 1986). In this study, the design with small steps (40-mm high × 95-mm wide) was used much more than the larger steps tested (80 × 200 mm and 130 × 355 mm). However, pigs used a ramp as readily as the most preferred of the staircase designs. Hence, for young pigs, a properly designed ramp should require less construction cost and be at least as effective as steps at slopes of 20-24°.

Rapid acceptance of the ramp is essential to the successful transfer of pigs to the two-tiered pen system. This study shows that some design features can influence voluntary ramp use by weaner-sized pigs and attention to these features should increase the initial traffic flow between the two levels. Once pigs have located the feeder on the upper level, our experience indicates that they will grow to finishing weight in the two-tiered environment without the need for further changes in ramp design. However, ramp design preferences of older market-weight hogs cannot be confirmed from these results and require additional study.

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