Effect of Housing System and Physical Environment on Post-Weaning Pig Performance

M. E. Larson, graduate research assistant,
M. S. Honeyman, associate professor,
Department of Animal Science

ASL-R1781

Summary and Implications

A study was conducted to document the physical environment and growth performance of nursery pigs in hoop structures compared with pigs reared in confinement nurseries. A series of six trials involving a total of 1,440 nursery pigs were conducted at two Iowa State University research farms from December 1999 to August 2000.

Regardless of season, the confinement pigs grew faster and consumed more feed than pigs in hoop structures for the first 2 weeks post-weaning. Both housing systems experienced similar growth rates for the last 3 weeks of the trial. Both housing systems experienced similar ADFI and feed efficiencies for weeks 4 and 5.

Overall, the confinement pigs grew faster, consumed more feed and were less efficient than pigs in hoop structures ($P<.05$) during the winter season. Overall the confinement pigs grew faster ($P<.05$), consumed more feed ($P<.05$), and experienced similar feed efficiencies as the pigs in hoop structures during the spring season. Overall, the confinement pigs experienced growth rates, consumed more feed and were less efficient than pigs in hoop structures ($P<.05$)

Hoop structures can be used as nursery facilities throughout the various seasons. The first 2 weeks post-weaning proved to be a very critical time in getting the pigs acclimated to the hoop structures. After this period, they experienced growth rates similar to the pigs in confinement. Further trials with adjustments made for the bedding, heat source, hovers, feeders, and management may improve the growth performance over that seen in these trials.

Introduction

Swine producers use various housing systems as part of their production practices. Many small independent pork producers have shown a considerable interest in low-cost alternative production systems for rearing market pigs to compete. One low-cost, alternative production housing type that is gaining popularity is the bedded hoop structure.

A hoop structure is a Quonset-shaped structure with sidewalls and a tough polyethylene fabric cover, which is resistant to abrasions, ultraviolet radiation, and leakage.

Hoop structures are primarily used as finishing facilities, but also may be used as gestation housing, breeding and isolation facilities, gilt development, and bedding storage.

Recently, a new concept called wean-to-finish has been adopted by the swine industry. This unique concept is the adaptation of technologies used in the nursery and grow/finish phases into a single-stage production system. Wean-to-finish production is successfully working with new and retrofitted confinement barns. Bedded hoop structures may work as a wean-to-finish housing system, if nursery pigs can efficiently grow throughout the various seasonal temperature extremes.

The objectives of this research document the physical environment and growth performance of nursery pigs in hoop structures compared with pigs reared in confinement nurseries.

Methods and Materials

Animals and management. A series of six trials involving a total of 1,440 nursery pigs (average initial body weight of 6.7 kg) were conducted at two Iowa State University research farms from December 1999 to August 2000. In each trial, 240 crossbred pigs were weaned 18 to 22 d of and allotted by weight and litter to six pens found in either the hoop (n=120) or confinement (n=120) nursery facility.

Body and feed weights. The pigs and feeders were initially weighed at weaning (day 0) and at 7-d intervals until the completion of each 5-week trial. Waste feed was not collected during the trials. The gain and feed of the pigs removed from the study were not included in the analysis. Feed consumption by the removed pigs was estimated by averaging the pen's feed intake between the day of removal and the start of the trial. The feed intake attributed to the removed pig was subtracted from the pen's total feed intake. Average daily gain (ADG), average daily feed intake (ADFI), and gain:feed (G:F) were recorded for each replicate pen of the six trials.

Housing. In May 1999, three small-scale hoop structures (6×10.8 m) were constructed at the Iowa State University Western Research Farm, Castana, IA (Figure 1). The small-scale hoop end walls had a crescent shaped vent at the top to prevent condensation in the building. Solid end walls with 3- $\times$ 3-m garage door openings were installed at both ends of the hoop rather than the typical tarp end walls on most hoop structures. During the winter and spring trials, the garage doors remained closed to reduce the drafts in the building. The three hoop structures were divided lengthwise to form two pens per building. The experimental pens (3×4.5 m) in each hoop structure were 2.7 m from the south end and 3.6 m from the north end of the hoops. Each hoop pen was equipped with a 5-hole feeder with each feeding space 15.2 cm in width and 12.7 cm in depth. The two experimental pens shared a 96-liter waterer with two drinking spaces.

Six pens (1.7 × 4 m) in a fully enclosed mechanically ventilated confinement nursery with a slatted plastic floor were used for the experiment. Each pen was equipped with one nipple cup waterer and a 6-hole feeder with each feeding space 14.6 cm in width and 10.2-cm in depth.

Experimental diets/feeding. During each 5-week trial, four commercial diets were fed in phase. During week 1, week 2, week 3, and weeks 4 and 5, the pigs were fed diets 1, 2, 3, and 4, respectively. Diet 1 was pelleted. Diets 2, 3, and 4 were in the meal form. All pigs received the following diets: diet 1 (3241 kcal/kg ME, 19.0% CP, 1.5% Lys, 7% fat); diet 2 (3153 kcal/kg ME, 20.1% CP, 1.4% Lys, 3.8% fat); diet 3 (3146 kcal/kg ME, 19.8% CP, 1.3% Lys, 3.5% fat); and diet 4 (3128 kcal/kg ME, 19.1% CP, 1.2% Lys, 3.3% fat). The diets contained nutrient concentrations that met or exceeded the estimated nutrient requirements of nursery pigs. Diet 1 was supplemented with 5 g/kg CTC Denagard, whereas diets 2, 3, and 4 was supplemented with 5 g/kg CSP 250.

To encourage the nursery pigs to use the self-feeders, feeding mats were placed next to the feeders for the first 4 d of the trials. All feeding mats had a .50-in. lip to reduce feed waste. All pigs were fed twice daily for the first 2 d of the trial. All pigs were fed diet 1 (pelleted) on nursery mats for the first 4 d of the trial with additional feed placed in the self-feeders. After 4 d, all pigs were eating from the self-feeders and the nursery mats were removed. No feed was left on the nursery mats in between feedings.

Hovers. All hoop pens were equipped with hovers during trials 1 through 4, which were conducted from December 1999 to May 2000. A hover is a rectangular enclosure with solid sides, roof, back, and a partially closed front. The hovers (10 × 4 ft) were constructed from plywood (.37 in. in thickness). The height of each hover was 3.6 ft. Four equally spaced (2.4 ft apart) heat lamps (250 watts) were attached to the top of each hover with the reflective shields and bulbs hanging on the underside of the hover top. Trials 5 and 6 did not use hovers because of warm temperatures.

Environmental monitoring. Throughout the duration of each trial, sensors, were placed inside both housing systems and outdoors. The sensors were preprogrammed to start on day 0 and stop at the end of each 5-week trial. The sensors were programmed to record temperature and relative humidity measurements every hour for 5 weeks. One sensor was installed at the pig occupied zone (1.3 ft) in the middle of the confinement nursery (Figure 2). A total of five sensors was used to document the temperature and relative humidity in the hoop structures (Figure 1). One sensor was placed 3.9 ft high on the dividing wall of each pen (Figure 1). Another sensor was placed under the hover to monitor this environment. To monitor outside temperature and relative humidity conditions a sensor was placed on a fence line 35.4 ft south of the hoop buildings (Figure 1).

Air velocity. During trial 6, air velocity measurements were taken during a 1-week period to document the drafts that the nursery pigs may be subjected to in small-scale hoops with open ends. Air velocity measurements were recorded using a heavy-duty hot wire thermo-anemometer, which recorded air velocities in meters per second. Exact air velocity measurements were variable due to gusting winds for the 1-week sample period. All air velocity measurements were recorded in ranges, averaged, and summarized in Table 3.

Data analysis. Data were analyzed as a completely randomized design (CRD) by analysis of variance techniques using general linear models (GLM) procedures of SAS. The error term used to test the effects of season, building, and building × season were respectively, trial (season), building × trial (season), and building × trial (season). The pen was the considered the experimental unit. Data are reported as least square means.

Results and Discussion

Table 1 contains the overall least square means and standard error of the mean (SEM) for pig weight, ADG, ADFI, and G:F for pigs in both housing systems, averaged over seasons. The confinement pigs ADG was higher (148, 289 vs 114, 241 g) than that for pigs raised in hoop structures for the first 2 week post-weaning (P<.001). For the last 3 weeks of the trial, the ADG (418, 521, 603 vs 414, 520, 591 g) for pigs in hoop structures and pigs in confinement were similar (P>.58, .93, and .15, respectively). Overall (1 to 5 week), the pigs in confinement grew faster (392 vs 380 g/d) than the pigs in hoop structures (P<.003).

During the first 3 week of the 35-d trial, the pigs in confinement had a greater ADFI (235, 416, 671 vs 160, 369, 591 g) than the pigs in hoop structures (P<.001). The ADFI (856, 1021 vs 870, 1024 g) for the pigs in hoop structures and pigs in confinement were similar (P< .25 and .80) the last two weeks of the trial. Overall, the ADFI (644 vs 601 g) was greater for the pigs in confinement than pigs in hoop structures (P<.001).

During weeks 1 and 3, the pigs in hoop structures were more efficient than the pigs in confinement (P<.001). By the second week post-weaning, the pigs in confinement were more efficient (695 vs 653 g) than pigs in hoop structures (P<.001). For the last 2 weeks of the trial, both housing systems had similar G:F ratios (P> .22 and .13, respectively). Overall (0-35 d), the pigs in hoop structures were more efficient (632 vs 609) than pigs in confinement (P<.001).

The hoop environment is a dramatic contrast to the controlled environment of the farrowing room and confinement nursery. At weaning, the hoop pigs were exposed to bedding, diurnal temperature cycles, contrasting changes in humidity, stocking densities, hovers, and drafts. During the winter and spring, the hoop pigs may have preferred to stay in the warmer environment of the hover and been less likely to consume feed in the colder hoop environment. Overall, the hoop pigs grew 3% slower, consumed 7% less feed, and were 2% smaller in facilities that cost approximately one-third to one-half of that of the confinement facility (per pig space). Also, a wean-to-finish

confinement system, nursery pigs may not perform at the level of the pigs in this confinement nursery.

Table 2 contains the least square means and SEM for pig weight, ADG, ADFI, and G:F for pigs in both housing systems during the winter, spring, and summer.

Winter. During the first week of the winter trial, the pigs in hoop structures experienced a higher ADG (P<.05), lower ADFI (P<.01) and were more efficient than the pigs in confinement (P<.05). By the second week post-weaning, the pigs in confinement grew faster, consumed more feed, and had similar feed efficiencies as the pigs in hoop structures (P<.05). For week 3, both housing systems had similar ADG and ADFI, whereas the pigs in confinement experienced lower feed efficiencies than pigs in hoop structures (P<.05). During week 4, the pigs in confinement had grew faster (P<.05), consumed more feed (P<.01), and were less efficient than pigs in hoop structures. For the last week of the trial, the pigs in confinement grew faster, consumed more feed, and had similar feed efficiencies as the pigs in hoop structures (P<.05). Overall the confinement pigs grew faster, consumed more feed and were less efficient than pigs in hoop structures (P<.05).

Spring. During the first week of the winter trial, the pigs in confinement experienced a higher ADG (P<.05) and ADFI (P<.01), while having similar feed efficiencies as the pigs in hoop structures. By the second week post-weaning, the pigs in confinement grew faster, consumed more feed, and were more efficient than pigs in hoop structures (P<.05). For week 3, the pigs in confinement experienced higher ADFI, lower feed efficiencies, but had similar ADG than pigs in hoop structures (P<.05). During week 4, both housing systems had similar ADG (P<.05), ADFI (P<.01) and feed efficiencies (P<.05). For the last week of the trial, the pigs in confinement had similar ADG and ADFI as the pigs in hoop structures (P<.05). Overall, the confinement pigs grew faster (P<.05), consumed more feed (P<.05) and experienced similar feed efficiencies as the pigs in hoop structures.

Summer. During the first week of the winter trial, the pigs in confinement experienced a higher ADG (P<.05), lower ADFI (P<.01) and had similar efficiencies as the pigs hoop structures. By the second week post-weaning, the pigs in confinement grew faster (P<.05), consumed similar amounts of feed and were more efficient (P<.05) as the pigs in hoop structures. For week 3, both housing systems had similar ADG, whereas the pigs in confinement experienced higher feed intakes and lower feed efficiencies than pigs in hoop structures (P<.05). During week 4, the pigs in confinement had growth rates, consumed less feed (P<.01) and were more efficient than pigs in hoop structures. For the last week of the trial, the pigs in confinement grew slower, while experiencing similar feed efficiencies and ADFI as the pigs in hoop structures (P<.05). Overall, the confinement pigs experienced growth rates, consumed more feed and were less efficient than pigs in hoop structures (P<.05).

In all seasons, the hoop pigs' ADG an ADFI were decreased for the first 2 weeks post-weaning. For the first 14 days post-weaning, the hoop pigs ate 10% less feed and grew 8% slower compared with the confinement pigs during the winter. In the spring the hoop pigs ate 32% less feed and grew 35% slower compared with the confinement pigs. During the summer, the hoop pigs ate 19% less feed and grew 25% slower than the confinement pigs. The first 2 weeks post-weaning proved to be very critical time in getting the pigs acclimated to the hoop structures. The hovers followed a diurnal temperature pattern, but did not fluctuate as much as the hoop environment Table 4. The pigs in hoop structures were exposed to cold environmental temperatures on average that were below the LCT during the winter and spring. The temperature sensor was mounted above the heat lamp, but the performance data indicate that the pigs were exposed to temperatures near the comfort zone while under the hovers. To get acclimated to the hoop environment during all seasons, the pigs in hoop structures used the first 2 weeks post-weaning as an adjustment period. After this period, they experience growth rates similar to the pigs in confinement.

Dunging patterns/bedding. During the winter and spring, heated hovers were used in the back of each pen. Straw bedding was added at a sufficient rate to each pen to prevent the bedding from getting wet due to urine and feces. The hoop pigs quickly established a dunging pattern that concentrated along the pen walls and near the feeder and waterer. Inside the hover the bedding stayed dry, but some composting of the manure started to generate heat under the fresh bedding. A majority of the bedding outside the hover began to compost and gradually increased to the end of the 5-week trial.

Mortality. Overall, the pigs in both housing systems appeared healthy throughout the various seasons. A total of 14 pigs died during the entire experiment. Because no necropsies were performed the cause of death is unknown. The winter mortality was similar for both housing systems (1%). During the spring, mortality was very low (hoop pigs, .04%; confinement pigs, .08%). Summer mortality was slightly higher for the hoop pigs (1%) than the confinement pigs (.08%). Overall, the mortality was 1% for both housing systems in all seasons.

Implications

Hoop structures can be used as nursery facilities throughout the various seasons. The first 2 week post-weaning was shown to be a critical period for the pigs to acclimate to the variable hoop environment. After this period, the hoop pigs' growth performance is similar to the confinement pigs. Overall, pig performance may be similar during the various seasons, if producers can offset the lag shown during the first 2 week post-weaning. For many years, confinement nurseries have been developed, re/developed and refined to achieve optimal growth performance. By examining the season by building effects and building effects alone, researchers and producers may

be able to develop and refine the housing and management of early weaned pigs in bedded hoop structures to allow production on a year-round basis in the Midwest. Further trials with adjustments made for the bedding, heat source, hovers, feeders, and management may improve the growth performance over that seen in these trials.

Acknowledgments

We gratefully acknowledge and appreciate support by the Leopold Center for Sustainable Agriculture, Ames, IA; Wallace Foundation for Rural Research and Development, Atlantic, IA; Dennis Kent and the ISU Lauren Christian Research Farm staff, Atlantic, IA; and Wayne Roush and the ISU Western Research Farm Staff, Castana, IA.

References

1. National Research Council (NRC). 1998. Swine nutrient requirements. National Academy of Sciences, Washington, D.C.

Table 1. Effect of housing system on growth performance of nursery pigs.

	Housing System			
Item	Hoop	Conf	SEM	Prob.
No of pigs	713	713	—	—
Daily gain, lb				
Week 1	0.251	0.326	2	.001
Week 2	0.531	0.637	4	.001
Week 3	0.921	0.912	5	.58
Week 4	1.148	1.145	6	.93
Week 5	1.328	1.302	6	.15
Overall	0.837	0.863	2	.003
Daily feed, lb				
Week 1	0.352	0.518	1	.001
Week 2	0.813	0.916	4	.001
Week 3	1.302	1.478	6	.001
Week 4	1.885	1.916	8	.25
Week 5	2.249	2.256	10	.80
Overall	1.324	1.419	.9	.001
Gain:feed ratio, lb/kg				
Week 1	0.713	0.629	16	.001
Week 2	0.653	0.695	9	.001
Week 3	0.707	0.617	7	.001
Week 4	0.609	0.598	6	.22
Week 5	0.590	0.577	5	.13
Overall	0.632	0.609	3	.001

Table 2. Effect of seasons on growth performance of nursery pigs in hoop and confinement housing systems.

	Seasons						
	Winter		Spring		Summer		
Item	Building						SEM
	Hoop	Conf	Hoop	Conf	Hoop	Conf	
No of pigs	237	237	239	238	237	238	--
Daily gain, g							
Week 1	129^{b}	116^{c}	116^{c}	170^{a}	95^{d}	158^{a}	5
Week 2	225^{d}	267^{b}	260^{b,c}	337^{a}	240^{c,d}	262^{b}	8
Week 3	409^{b}	394^{b}	436^{a}	443^{a}	409^{b}	406^{b}	8
Week 4	471^{b}	492^{b}	545^{a}	528^{a}	546^{a}	539^{a}	10
Week 5	554^{c}	610^{b}	609^{b}	633^{a,b}	647^{a}	530^{c}	10
Overall	358^{d}	376^{c}	393^{b}	422^{a}	387^{b,c}	379^{b,c}	5
Daily feed, g							
Week 1	172^{j}	192^{i}	153^{k}	251^{h}	151^{l}	263^{g}	2
Week 2	330^{o}	392^{n}	390^{n}	467^{m}	394^{n}	384^{n}	8
Week 3	601^{c}	621^{c}	652^{b}	725^{a}	528^{d}	668^{b}	10
Week 4	752^{i}	877^{g,h}	918^{g}	895^{g}	905^{g}	838^{h}	10
Week 5	996^{c}	1050^{a,b}	1059^{a}	1018^{a,b,c}	1018^{a,b,c}	1002^{b,c}	10
Overall	569^{d}	627^{b}	635^{b}	672^{a}	596^{c}	631^{b}	7
Gain:feed, g/kg							
Week 1	749^{a}	607^{b,c}	758^{a}	680^{a,b}	629^{b,c}	599^{c}	20
Week 2	681^{a,b}	681^{a,b}	667^{b}	721^{a}	609^{c}	682^{a,b}	10
Week 3	680^{b}	634^{c,d}	668^{b,c}	611^{d}	775^{a}	608^{d}	10
Week 4	630^{a,b}	561^{d}	593^{c}	589^{c,d}	603^{b,c}	643^{a}	10
Week 5	557^{b}	580^{b}	575^{b}	622^{a}	636^{a}	529^{c}	9
Overall	629^{b}	600^{c}	618^{b}	628^{b}	649^{a}	600^{c}	.1

^{abcdef}LSMeans in the same row with different superscripts differ (P<.05).

^{ghijkl}LSMeans in the same row with different superscripts differ (P<.01).

^{mnop}LSMeans in the same row with different superscripts differ (P<.001).

Table 3. Range of air velocities pigs may experience in small-scale hoop structures when outside air speed is 1–5.5 m/s.

		Air velocities (m/s)		
	Height (m)	Left Pen	Middle Wall	Right Pen
Pole 1 (0 m front gate SSH)	.30	.3–.6	.6–1.0	.2–.6
	.91	.6–1.1	.6–1.6	.4–.8
	1.5	1.4–2.8	1.4–2.8	1.1–2.4
	2.1	2.0–3.1	2.8–3.8	1.8–2.7
	2.7	.8–1.6	.9–1.8	.6–1.3
Pole 2 (.91 m inside of pen)	.30	.2–.4	.2–.4	.2–.3
	.91	.3–1.4	.8–1.9	.3–1.2
	1.5	1.4–3.1	1.5–3.2	1.2–2.8
	2.1	2.2–3.6	2.2–3.6	2.0–3.1
	2.7	1.1–2.6	1.9–3.1	1.1–2.4
Pole 3 (2.7 m inside of pen)	.30	.2–.4	.2–.4	.2–.3
	.91	.4–.8	.6–.1.6	.4–.8
	1.5	1.3–2.8	1.4–3.2	1.2–2.6
	2.1	1.4–3.3	1.6–3.6	1.1–3.1
	2.7	1.4–1.8	1.6–2.8	1.1-1.5
Pole 4 (4.6 m back pen wall)	.30	.2–.4	.2–.4	.2–.4
	.91	.4–.7	.4–.6	.3–.5
	1.5	.9–1.8	1.1–1.9	.6–1.5
	2.1	1.3–2.8	1.9–3.4	1.3–2.3
	2.7	1.8–2.5	2.1–3.1	1.6–2.1

Table 4. Average seasonal environmental temperatures in a small-scale hoop structure with hover.

	Seasons					
	Winter		Spring		Summer	
Item	Hoop	Conf	Hoop	Conf	Hoop	Conf
Temperature data (°C)						
High	12.0	25.3	26.3	27.4	34.2	31.5
Low	-11.0	21.7	0.8	20.7	15.0	19.5
Ave.	-0.4	23.8	12.6	23.9	23.3	25.2
Relative humidity (%)						
High	90.4	60.7	91.0	70.7	93.0	89.5
Low	38.9	28.0	20.3	32.5	31.9	44.4
Ave.	70.4	40.2	58.1	51.2	69.2	69.6
Hover temperature (°C)						
High	23.1	—	30.3	—	—	—
Low	0.0	—	8.4	—	—	—
Ave.	11.8	—	19.0	—	—	—

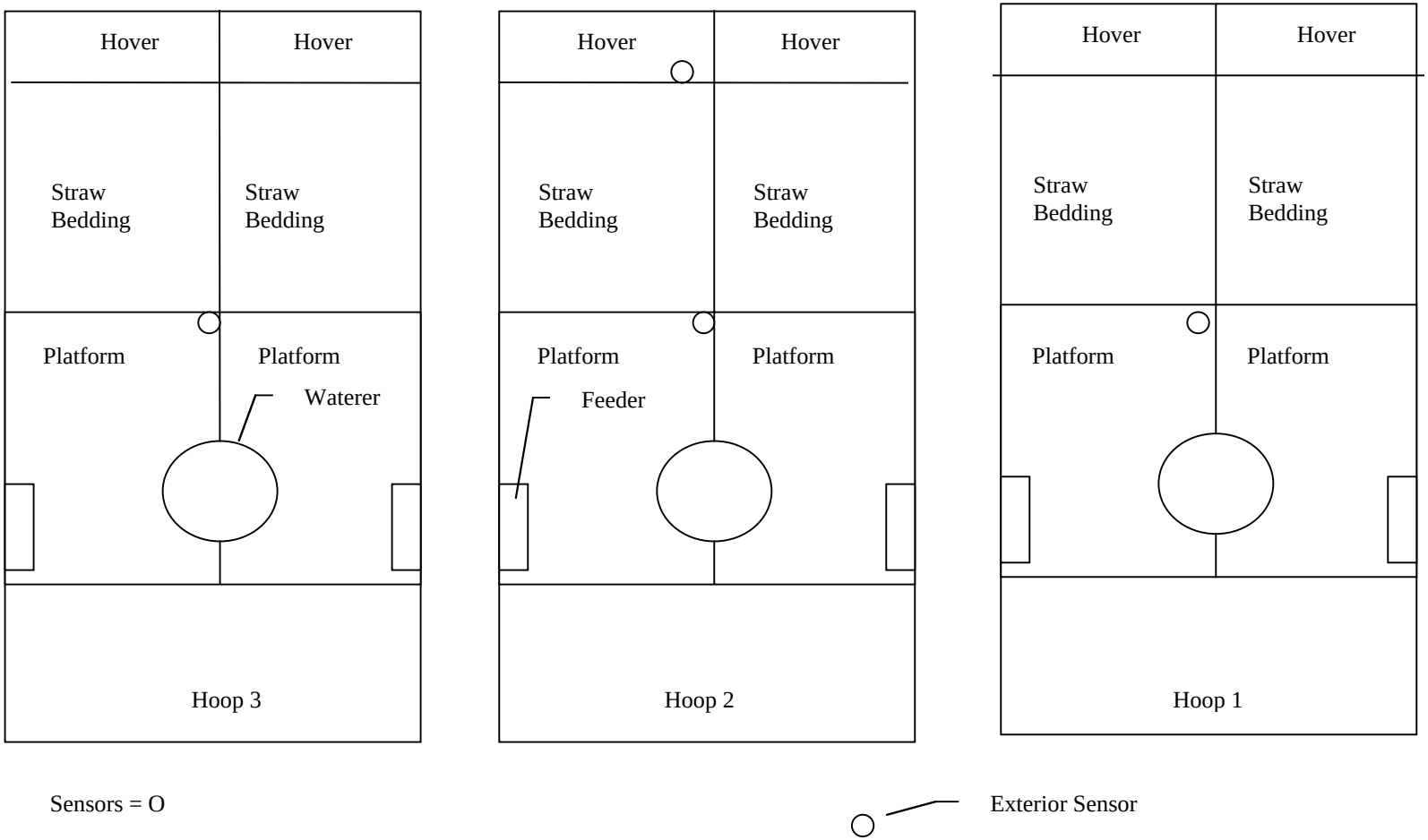

Figure 1. Diagram of hoop structure nursery pens. The experimental pens (10 × 15 ft) in each hoop structure were 9 ft from the south end and 12 ft from the north end of the hoops. The south part (10 × 6.9 ft) of the experimental pen was composed of a 5.9-in. deck of perforated expanded metal with plastic coating and made up 47% of the total pen space. The north end (10 × 7.9 ft) consisted of a bedded, dunging and sleeping area, including hovers. A total of five sensors (3.9 ft in height) were used to document the temperature and relative humidity in the hoop structures. The hovers were used during trials 1, 2, 3, and 4. Trials 5 and 6 did not use the hovers because of the warmer temperature conditions.

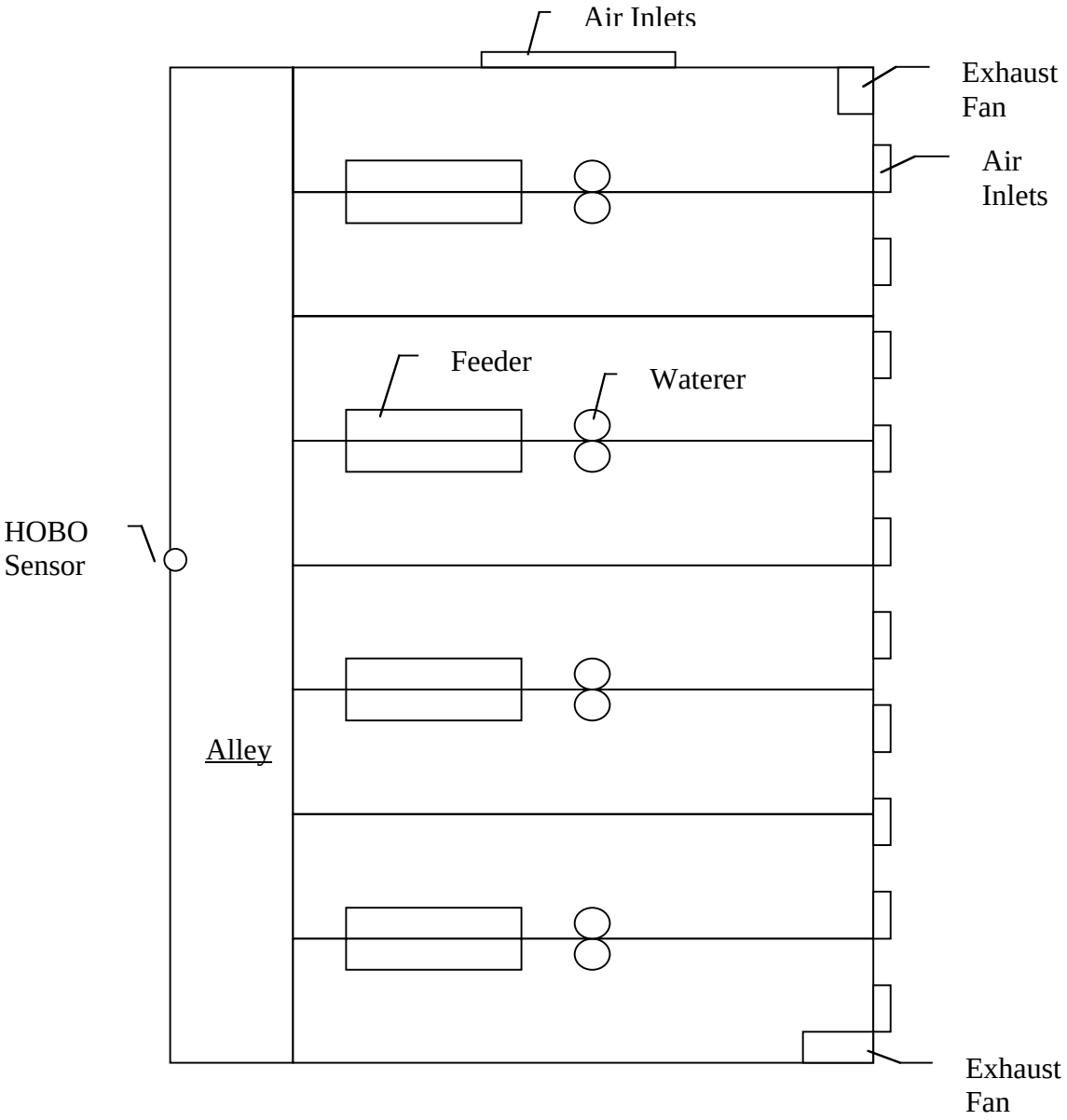

Figure 2. Diagram of the confinement nursery room. The middle six pens (5.6 × 13.1 m) were used for each 5-week trial. The Sensor was installed at the pig occupied zone (1.3 ft in height) in the middle of the confinement nursery.