8-1-1970

Controlled Environment for Swine

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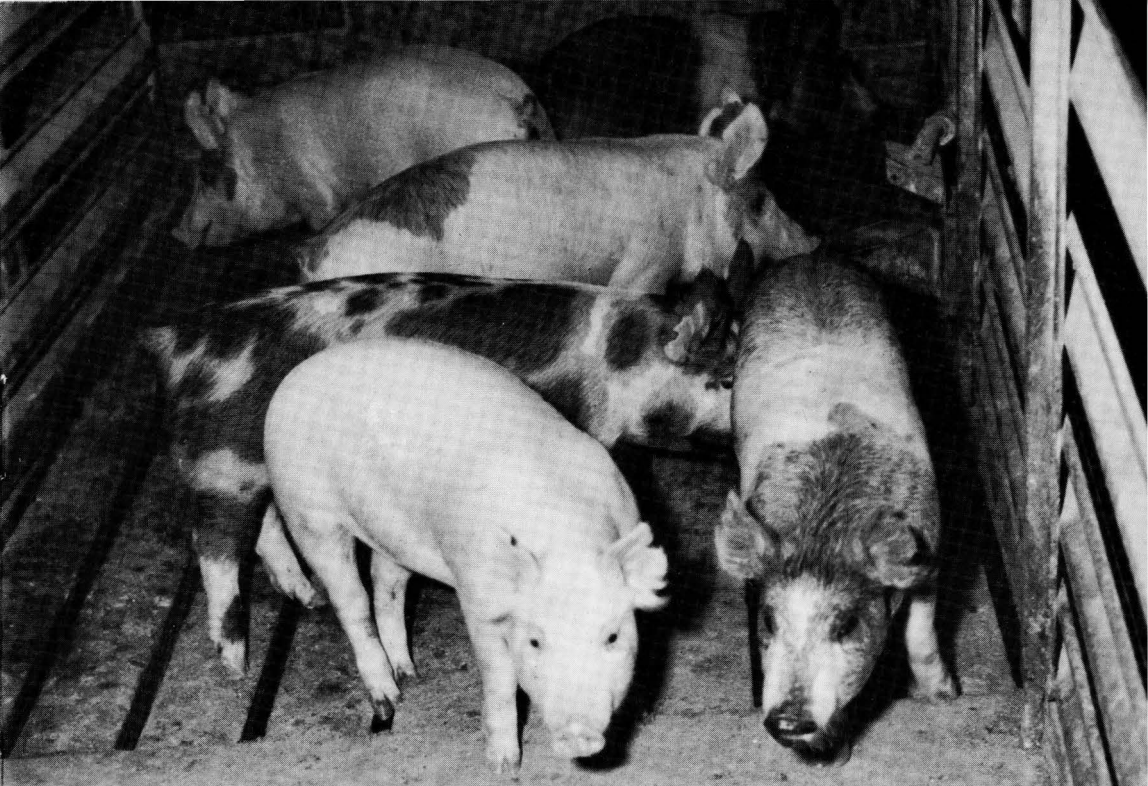

controlled environment for swine

Bulletin 575 • August 1970
Agricultural Experiment Station • South Dakota State University, Brookings

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COVER PHOTO—One of the experimental pens with 50% slotted floor area.

Controlled Environment for Swine

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II—Effect of a controlled environment on the performance of growing-finishing swine.

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Development of the Southeast South Dakota Experiment Farm near Centerville furnished an excellent opportunity to study swine housing management. Initial steps in a research program were construction of temporary houses and later the construction of a permanent, insulated, ventilated house with four different floor types. These structures have been used to gather data on the effects of floor-type and controlled environment on performance of growing-finishing pigs.

Experimental Procedure

Part I

The initial experiment was conducted in two temporary swine houses. The houses (Figure 1) were 22x22 feet in size and they were partitioned through the center to give a total of four, 11x22-foot pens. The houses were constructed of conventional wood framing and plywood sheathing. They were insulated with 2-inch fiberglass blankets with polyethylene vapor barrier in the walls and a 3-inch fiberglass blanket with vapor barrier in the roof. A ventilation fan of 800 cubic feet per minute capacity controlled by a thermostat was installed for cold weather operation. Supplemental heat in each house was supplied by a 4,000-watt electric heater.

In house number 1, concrete floors sloped one-half inch per foot to a slotted gutter across the lower ends of the pens. The gutter width in pen number 1 was 4 feet wide while

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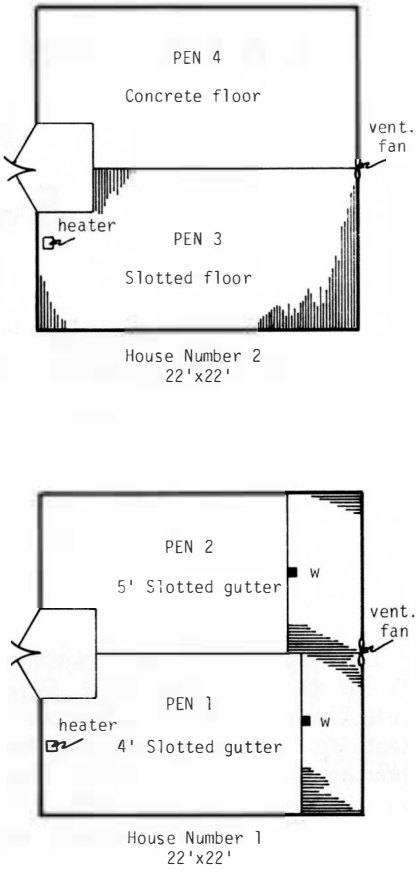
Figure 1. Floor plans of temporary swine houses used in floor-type research conducted during 1963-64.



the gutter in pen number 2 was 5 feet wide. Pigs fed and rested on the sloping floor and used the slotted gutter as the dunging area. An automatic waterer was over the slotted gutter in each pen.

In house number 2, one pen was constructed with a completely slotted floor over a 2-foot deep manure pit. A conventional level concrete floor was used in the other pen. Dimensions of the concrete slats used for all slotted areas were 5 inches wide and 4 inches deep. Spacing between the slats was three-fourths of an inch. The shape of the cross-section and location of the reinforcing steel is shown in Figure 2.

Automatic waterers and self-feeders were used in all pens. Rations shown in Table 1 were used throughout the experiment. Bedding was not provided in three pens, but straw bedding was used in the

Table 1. Composition of rations used in experiment 1 and 2

Ingredient	Experiment 1		Experiment 2		
	Weaning to 110 lb.	After 110 lb.	Weaning to 75 lb.	75 lb to 125 lb.	After 125 lb.
	%	%	%	%	%
Ground corn	61.3	66.5	77.1	82.5	87.5
Ground oats	20.0	22.0			
Soybean meal	12.5	6.8	20.0	15.0	10.0
Tankage	4.0	2.5			
Dicalcium phosphate	1.0	1.0	1.5	1.0	1.0
Limestone	0.5	0.5	0.7	0.8	0.8
Trace mineral salt	0.5	0.5	0.5	0.5	0.5
Premix*	0.2	0.2	0.2	0.2	0.2
	100.0	100.0	100.0	100.0	100.0
Calculated analysis					
Crude protein, %	16.0	12.5	16.0	14.0	12.0
Calcium, %	0.81	0.71	0.72	0.61	0.58
Phosphorus, %	0.57	0.52	0.59	0.48	0.51

*Premix supplied 1,500 U.S.P. units of vitamin A, 150 U.S.P. units of Vitamin D, 1 mg. of riboflavin, 2.5 mg. of pantothenic acid, 7.5 mg. of niacin, 50 mg. of choline chloride, 5 mcg. of vitamin B_{12}, 1.5 mg. penicillin and 7.5 mg. of streptomycin per lb. of ration.

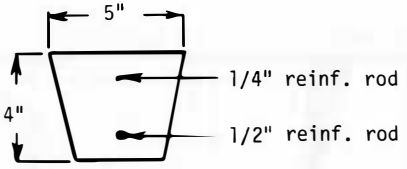


Figure 2. Concrete slat cross-section.

conventional concrete pen during the winter trial. Pens were cleaned as needed to keep the pigs dry and comfortable. A sanitary lagoon was dug and used for manure removal with the two pens with sloping floors. The lagoon allowed approximately 15 square feet of surface area per pig with a depth of approximately 4 feet.

Trials 1 and 3 were conducted during the summers of 1962 and 1964 respectively and trial 2 was conducted during the winter months of 1963-64.

Weanling purebred Duroc, Hampshire, and Yorkshire pigs were allotted on the basis of breeding, sex, and weight in all trials. Records and observations included feed and pig weight, cleanliness and comfort of pigs, and labor required to keep pens clean.

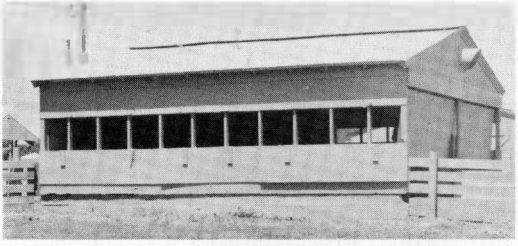
Part II

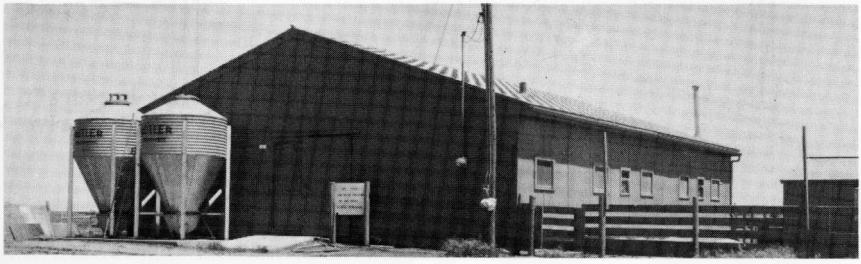
The building used in this experiment was planned to conform as nearly as possible to accepted recommendations in swine housing construction. The basic difference lies in the floor construction where four different floor types were installed. A floor plan of the research unit is shown in Figure 3. The building was 36x50 feet and included an office and feed room as well as swine housing facilities. There were 16 pens, each 5x15 feet in size. One panel was removed on each type of floor to provide one double pen, 10x15 feet, on each floor type.

Three of the floor types had slotted floors with 25%, 50% or 100% of the area slotted. The fourth section had a narrow gutter running across the lower end of the sloped concrete floor. Pit areas under the slotted floors average 2½ feet in depth and

(Right) Temporary swine research buildings with insulated dropdown ventilation doors used during Phase I of the swine housing research.

(Below) The main swine research structure now being used.





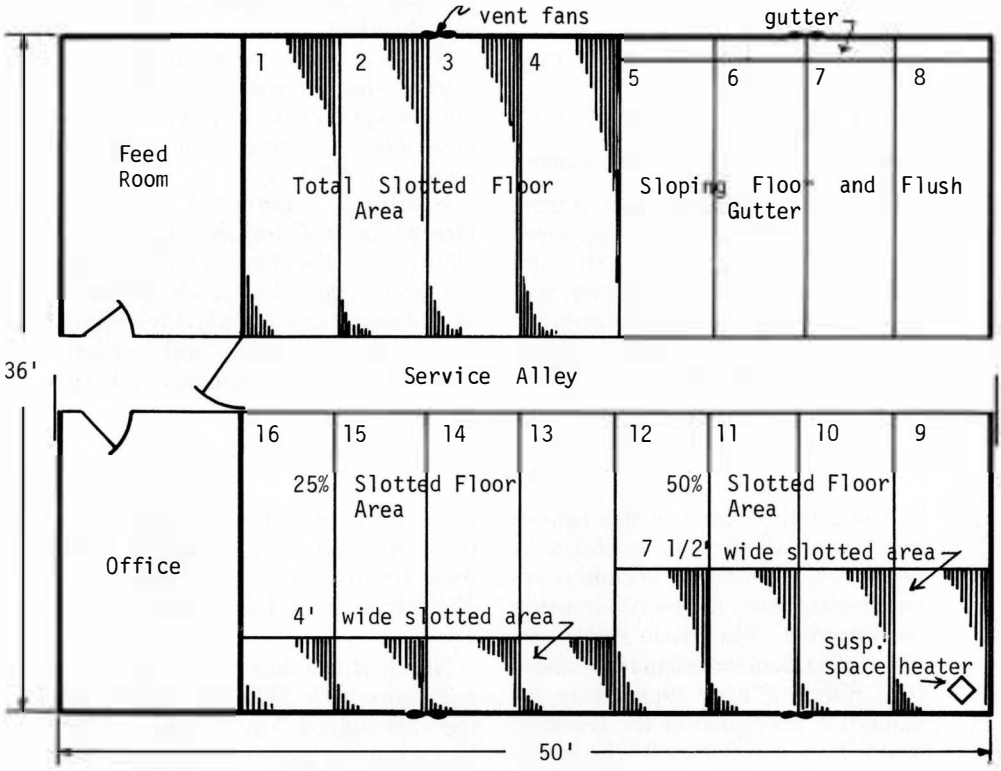
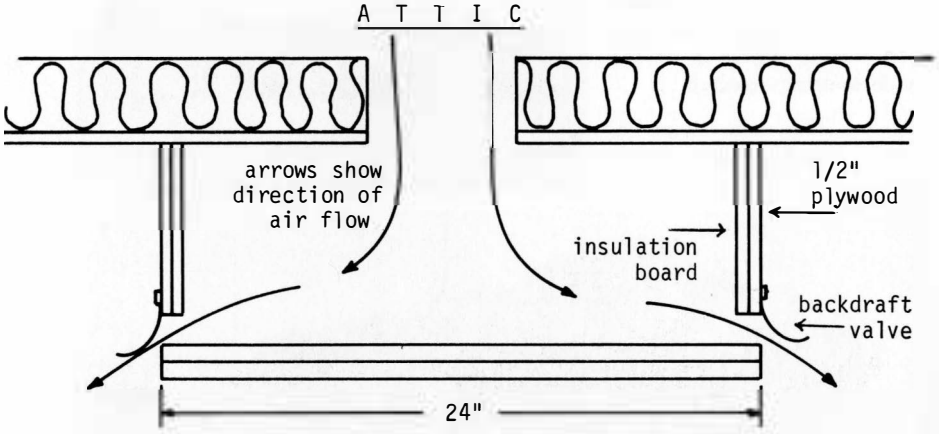


Figure 3. Farrow to finish swine research unit (16 pens 5x15 feet)

Figure 4. Winter ventilation inlet duct.



were adequate to hold at least 4 weeks accumulation of manure.

The structure was of conventional frame construction with trussed rafters and clear span roof. Exterior grade ⅜-inch plywood sheathing was used and walls were lined with 2-inch fiberglass blanket with a vapor barrier. A 3-inch blanket of similar material was placed in the ceiling. Ventilation for the structure was provided by four reversible fans, each having a capacity of 1,700 cubic feet per minute (c.f.m.) totaling 6,800 c.f.m. ventilating capacity for the structure. Each fan was individually controlled by thermostat and, in addition, one fan could be operated with a percentage timer to provide low volume ventilation required during cold weather and farrowing periods when the animal density did not require large volume ventilation.

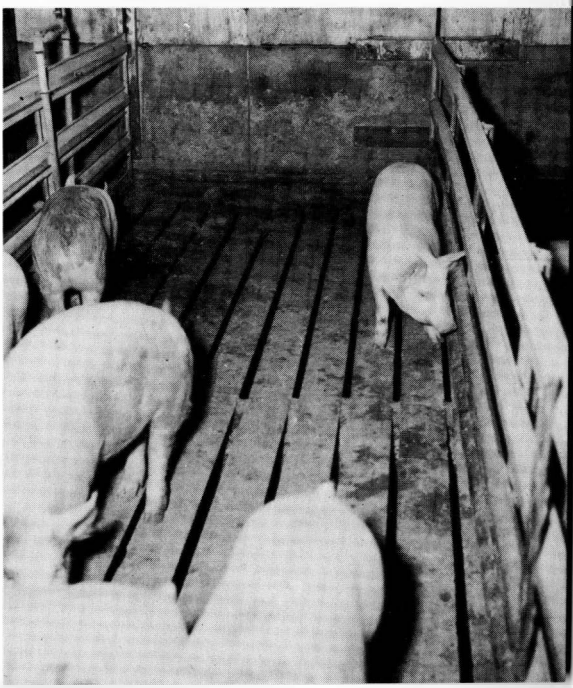
Air for winter ventilation was drawn from the attic through an inlet duct in the ceiling at the center of the building and extending for its entire length. A cross section of the duct is shown in Figure 4. Control of the system for winter operation required adjustment of the percentage timer for low volume ventilation to provide sufficient ventilation to remove the moisture produced by the animals. The thermostat on a second fan was set so the fan would operate when the temperature rose above approximately 55 degrees (F.). The thermostats on the two remaining fans were set at 60 degrees and 65 degrees (F.) respectively; however, these operated only during warm weather.

Supplemental heat for extremely cold weather and farrowing was provided by a 40,000 BTU LP gas space heater. The thermostat on the heater was set to operate at temperatures lower than 50 degrees. Care was taken to insure that the heater would shut off before the second fan (set at 55 degrees) would operate to prevent fuel waste.

Summer ventilation was accomplished by reversing the fans and drawing air directly into the building. Outlets for the ventilation air were provided by opening doors and windows.

The concrete portion of each floor type sloped one-half inch per foot. The slats were essentially the same as shown in Figure 2, except the tops of the slats were slightly rounded. Automatic water cups were on the outside wall at the lower end of each pen. Smidley three-hole, one-half feeders were placed midway in the pen to form a partition which retained the small pigs in a smaller area. Feeders were moved gradually to the higher end of the pen as pigs grew larger. This plan helped the pigs establish good dunging

A 5x15-foot pen with 100% slotted floor area.



habits on the slotted area or near the gutter and minimized the labor requirement in all pens.

Manure collected in the pits under the slotted floor and when the pits were filled to capacity, they were emptied into a sanitary lagoon. The sanitary lagoon was 5 feet deep and planned on the basis of 40 square feet of surface area per pig.

The open housing consisted of house number 1 (see Figure 1) with the door and two windows open. The temperature in the house was cold during the winter months and it varied with the atmospheric temperature. The insulated walls probably did provide excellent protection from wind draft and minimized the possibility of condensation forming on the walls and ceiling. Bedding was used during the winter trials.

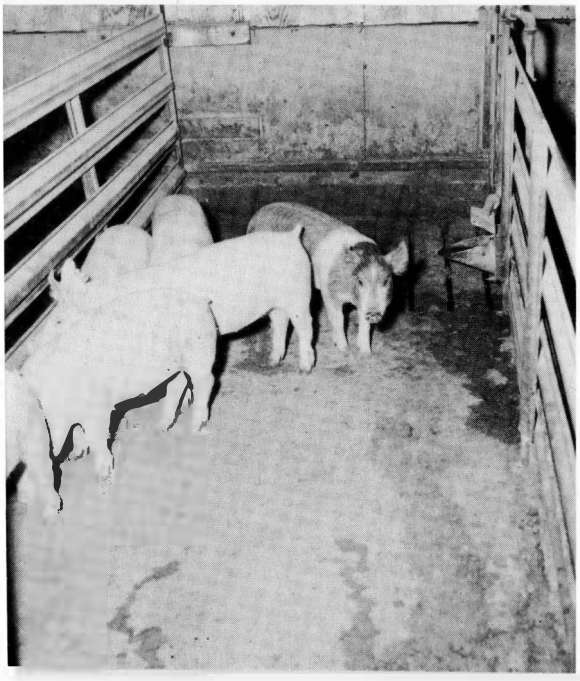
Typical Construction Costs

Current construction costs of controlled environment swine housing range from $6.50 to $7.50 per square foot of building space. The cost variability is influenced by choice of management system, structural type, building materials, feeding system, as well as local influence on material, equipment and labor costs. A reasonable division of construction costs is normally 50% for building erection and 50% for acquiring equipment. Equipment costs include procurement of utilities, heating system, ventilation and feeding equipment, pens and slotted floor systems. Slotted floor costs normally range about $1.00 a square foot more than conventional concrete floor construction. The above costs do not reflect the expenditures for liquid manure disposal facilities since current practices vary widely with respect to procural of this type of equipment.

Open housing construction costs range from $1.75 to $2.50 per square foot of building space with costs being influenced by the same factors as discussed above.

In 1963, all swine were removed and specific-pathogen-free (SPF) crossbred pigs were established on the farm. Crossbred pigs of Duroc, Hampshire and Yorkshire breeding have been used in these trials. Seven trials on floor-type and pen size (number of pigs per pen) and three winter trials on housing type have been conducted.

A pen with 25% slotted floor area.



Results and Discussion

Part I. A summary of the three trials is shown in Table 2. There were no significant differences in rate of gain and feed efficiency between houses or floor types. Although the growth rates were not statistically different, the slightly slower rate of gain of pigs on the completely slotted floor was attributed to lameness in several pigs on

Table 2. Summary on floor types, Experiment 1*

Item	Trial	House No. 1 Sloping floor 4 ft. gutter	House No. 1 Sloping floor 5 ft. gutter	House No. 2 Slotted floor	House No. 2 Concrete floor
Lot number		1	2	3	4
Number of pigs per pen	1	17†	16†	18	18
	2	20	20	20	20
	3	20	20	20	20
Average daily gain, lb.‡	1	1.39	1.47	1.39	1.48
	2	1.54	1.67	1.56	1.54
	3	1.78	1.66	1.70	1.70
	Av.	1.57	1.60	1.55	1.57
Average feed per lb gain, lb	1	3.41	3.27	3.32	3.31
	2	4.01	3.70	4.01	3.96
	3	3.71	3.65	3.31	3.80
	Av.	3.68	3.55	3.50	3.67

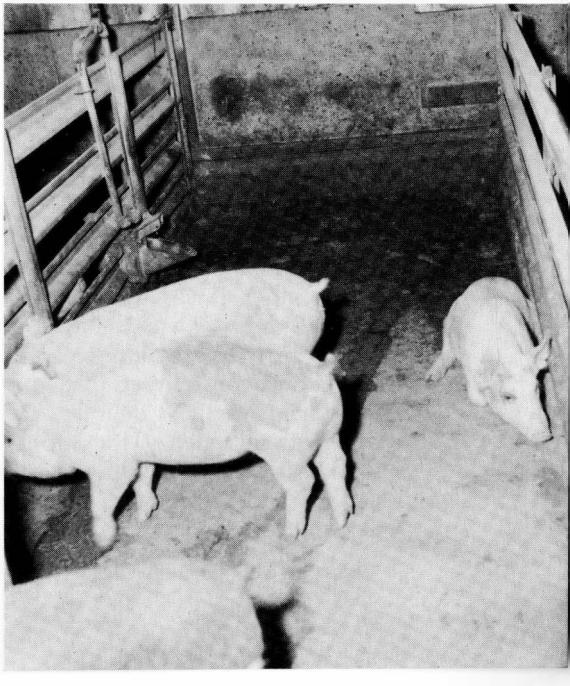
*Average initial and final weights were: Trial 1, 33 and 200 lb.; trial 2, 99 and 212 lb.; trial 3, 61 and 220 lb.
†One pig in lot 1 and two pigs in lot 2 of the first trial had to be removed early in the trial.
‡Least squares means.

the slotted floor. The surface on the slats was relatively rough and apparently caused more irritation on the pig's feet and legs. Two pigs were almost immobile because of feet and leg problems.

There was as much as 5% difference in the feed conversion averages; however, the differences were not statistically significant and the fact that there was a difference in house number 1 with two similar floor types suggests that the effect was minimal. The main advantage of improved feed efficiency on the slotted floor appeared in trial 3. There was no advantage for the slotted floor in the other two trials, thus the effect of floor type probably had little effect on feed efficiency in these trials.

Pigs on the slotted floor were always clean and free of debris. The manure did not accumulate on the slats and most of the floor was dry. Pigs on the sloping floor were usually clean, but some groups formed the habit of dunging along one side of the pen rather than on the slotted area. When this occurred more scraping was required in the pens to keep them dry and comfortable in the winter months. Pigs on the conventional concrete floor without bedding were usually covered with debris due to the difficulty of keeping the pen dry. The level floor was damp most of the time and it required more labor to keep the floor reasonably clean.

Pen with sloping floor and narrow gutter across the lower end. The floors become more littered as the percentage of solid floor area increases.



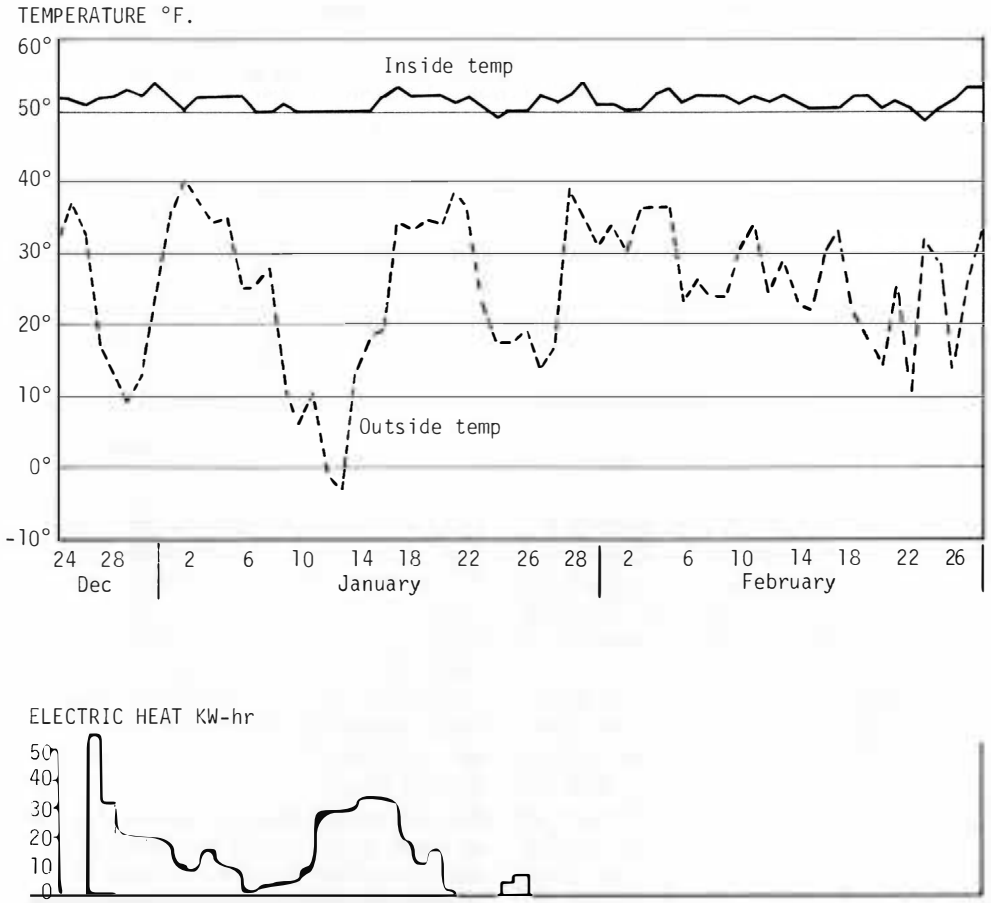


Figure 5. Average daily indoor and outdoor temperatures and heating requirements for house number 1, winter trial 1963-64.

Figures 5 and 6 show the average daily indoor and outdoor temperatures as well as the electrical energy required to maintain inside temperatures in houses 1 and 2 during the 1963-64 cold weather trials. The average temperature maintained in house number 1 was 51.2 degrees, while 50.3 degrees was the average temperature in house number 2. The average outdoor temperature during the trial was 25.3 degrees. The total electrical energy for supplemental heat was 501 Kw-hr. in house number 1 and 760 Kw-hr. in house number 2. The difference in the energy requirements was probably due to the difference in wind exposure of the two houses since house number 2 was located to the northwest of house number 1.

The labor required for pen cleaning during the 1963-64 winter trial is shown in Figures 7, 8, and 9. The extreme peaks in labor requirements shown in Figure 7 and 8 represent time involved in cleaning the slotted gutter in house number 1. The low storage volume of this gutter necessitated frequent cleaning and the re-

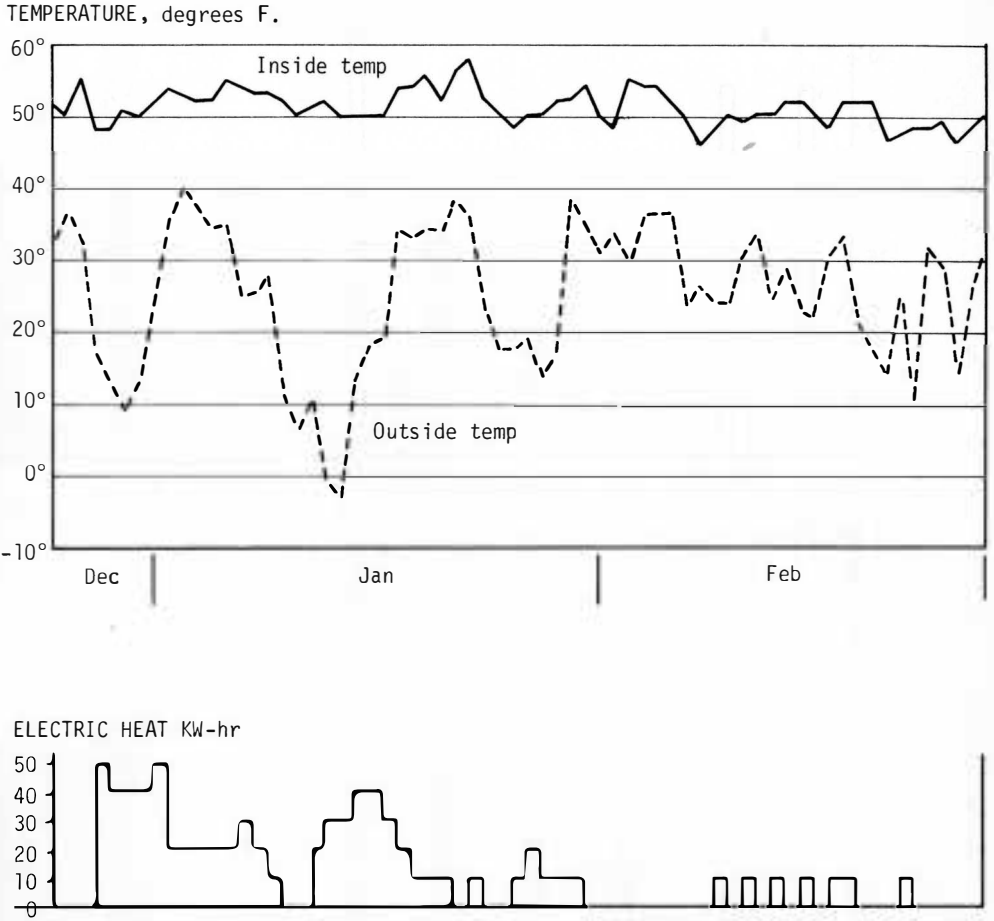
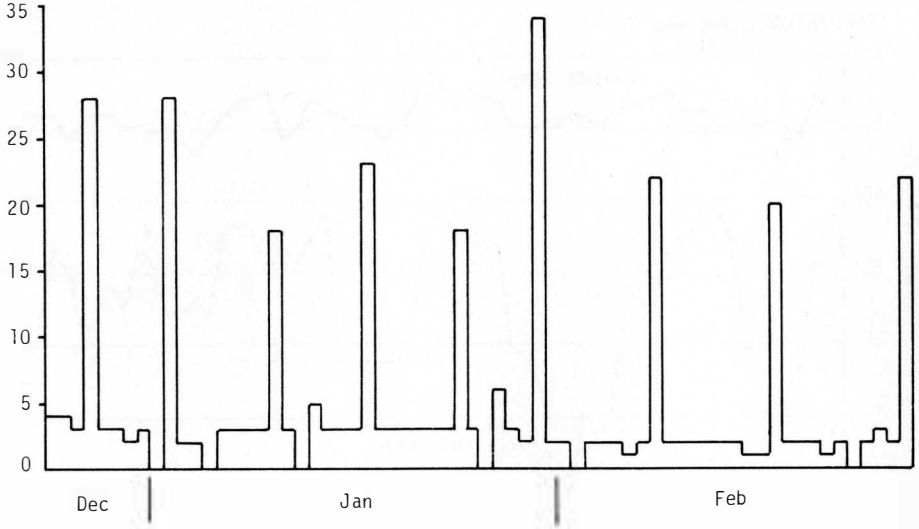


Figure 6. Average daily indoor and outdoor temperatures and heating requirements for house number 2, winter trial 1963-64.

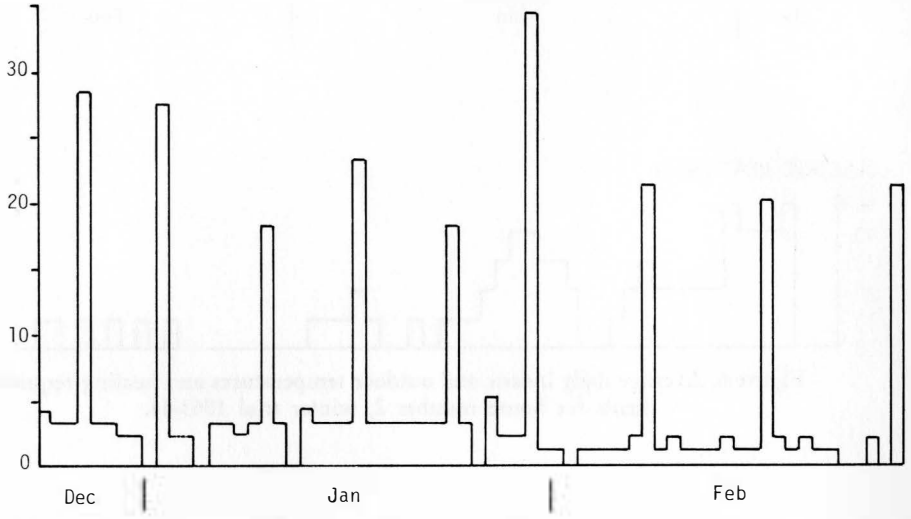
stricted drain opening leading from the gutter to the waste disposal lagoon required excessive time for emptying the gutter. The total time required for cleaning pen number 1 was 5.72 hours and for pen number 2 was 5.30 hours. Figure 9 shows the pen cleaning labor required in pens number 3 and 4. While pen 3 had a completely slotted floor, considerable time was spent in scraping the slat surfaces. This was partially due to poorly made slats with flat surfaces and partially to misjudging when debris should be removed from the slats. The total time required in cleaning the slotted floor was 2.47 hours, and for the level concrete floor 5.57 hours.

The following operating costs for the four pens used during the 1963-64 winter trial consider labor at $2.00 per hour and electrical energy at $.02 per Kw-hr.

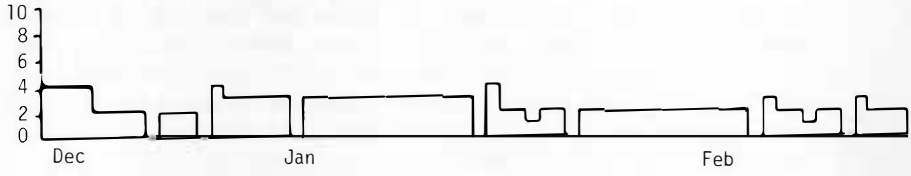
PEN CLEANING TIME, minutes per day (Pen 1)



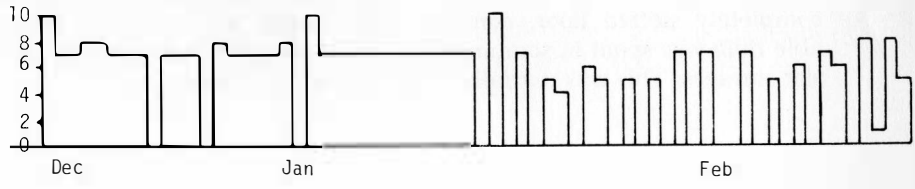
PEN CLEANING TIME, minutes per day (Pen 2)



PEN CLEANING TIME, minutes per day (Pen 3)



PEN CLEANING TIME, minutes per day (Pen 4)



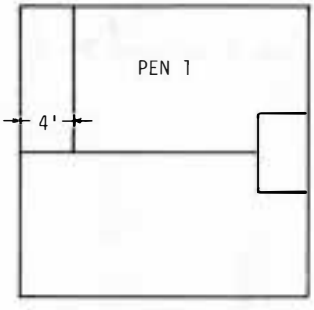


Fig 7. Labor required to clean Pen 1, winter 1963-64.

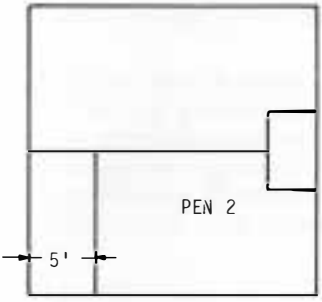
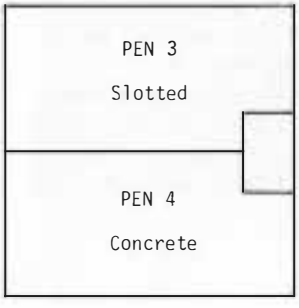


Fig 8. Labor required to clean Pen 2, winter 1963-64.

Fig 9. Labor required to clean Pens 3 and 4, winter 1963-64.



Pen number 1

Electricity for supplemental heat	$ 5.01
Labor for pen cleaning	$11.44
Total cost	$16.45
Cost per pig	$ .822

Pen number 2

Electricity for supplemental heat	$ 5.01
Labor for pen cleaning	$10.60
Total cost	$15.61
Cost per pig	$ .780

Pen number 3

Electricity for supplemental heat	$ 7.60
Labor for pen cleaning	$ 4.94
Total cost	$12.54
Cost per pig	$ .627

Pen number 4

Electricity for supplemental heat	$ 7.60
Labor for pen cleaning	$11.14
Total cost	$18.74
Cost per pig	$ .937

Part II. A summary of the performance of the pigs in the insulated house is shown in Table 3. The data summarize four trials by pen size and the type of floor involved. The type of floor had a significant effect on both rate of gain and feed efficiency. Pigs on the completely slotted floor gained approximately .06 lb. per day slower than the pigs on the three other floor types. The slower gains were observed in both pen sizes. The same trend occurred in the previous trial, which indicates that pigs on the completely slotted floors gained slightly slower than the pigs on the other floor types.

Feed efficiency was improved significantly ($P>.05$) in the groups of pigs on the 50% slotted floor. The reason for this difference is not apparent. The major difference was in the smaller pens and these pens were adjacent to the pen with 25%

Table 3. Summary of size of pen in the Insulated House, Experiment 2*

Item	Percent slotted area	5 ft. by 15 ft. pens	10 ft. by 15 ft. pens	
Number of pigs per pen		8 or 9	16 or 18	
Average daily gain, lb.†	0	1.57	1.61	1.59
	25	1.59	1.58	1.58
	50	1.60	1.57	1.58
	100	1.52	1.52	1.52‡
	Av.	1.56	1.58	
Average feed per lb. gain, lb.	0	3.35	3.40	3.38
	25	3.32	3.36	3.35
	50	3.21	3.32	3.28‡
	100	3.49	3.32	3.38
	Av.	3.34	3.35	

*Each mean represents an average from four trials. Each average is made up from 34 pigs in the smaller pens and 68 pigs in the larger pens, except in cases of death loss.
†Least squares means.
‡Significantly lower than the other groups ($P<.05$).

slotted area; therefore, there should not have been a pen location difference.

There was no difference in rate of gain or feed utilization by pigs in the the two different pen sizes. A visual observation was that 16 or 18 pigs in larger pens were more comfortable than 8 or 9 pigs in the smaller pens. There was less crowding and stepping over other pigs to reach the feeder or waterer in the larger pens, but these movements did not influence the performance of the pigs.

The labor required to clean the various pen areas during the 1964-65 winter trial is shown in Figure 10. The total pen cleaning time required during the 1964-65 winter trial and 1965 summer trial was as follows:

	1964-65 Winter Trial	1965 Summer Trial
Sloping concrete floor	12.56 hours	8.42 hours
25% Slotted floor area	6.70 hours	6.22 hours
50% Slotted floor area	7.07 hours	6.22 hours
100% Slotted floor	1.63 hours	2.18 hours

The times shown represent the total labor required to clean a pen area of 300 square feet divided into three pens and housing 32 pigs. Improved management practices developed during the remainder of the experiment practically eliminated cleaning labor in all pens except the sloping concrete floor. This involved moving the feeders toward the lower end of the pen during the early stages of the trial. Confining the pigs over the slotted area of the pen helped established better dunging habits. As the feeders were moved toward the higher end of the pen to provide more space, the pigs continued dunging on the slotted area. Scraping was still required on the sloping concrete floor.

The results for pigs reared in the large enclosed house in the winter compared with pigs in open housing with insulated walls are shown in

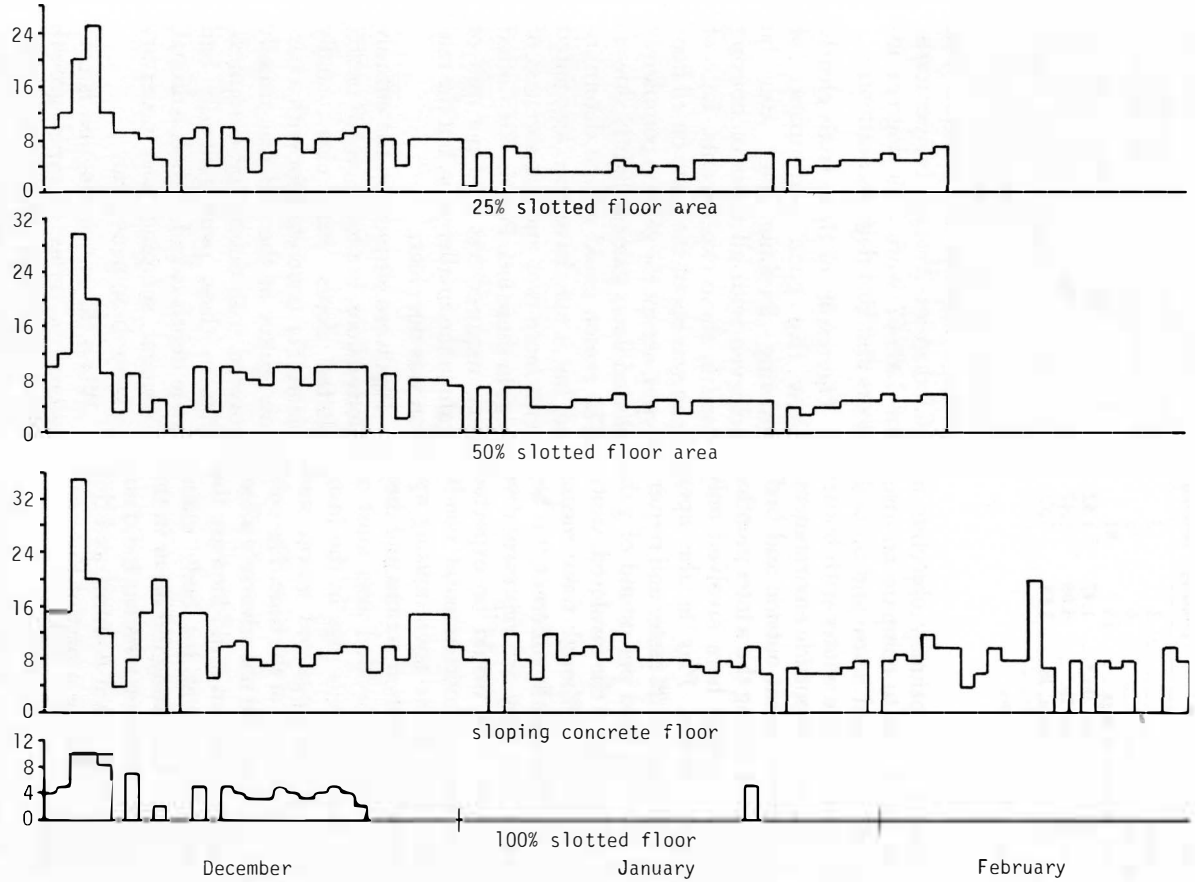


Figure 10. Pen cleaning time in minutes on various floor systems, winter trial 1964-65.

Table 4. Summary of type of housing, winter trials, experiment 2.

Item	Insulated housing	Open housing
Number of years	3	3
Number of pens	6	6
Total number of pigs	83	81
Average daily gain, lbs.*	1.47	1.52
Average daily feed, lb.	5.09	5.47
Av. feed per lb. gain, lb.	3.58	3.72

*Least squares means.

Table 4. The primary objective in this study was to compare an insulated, ventilated house and no bedding used in the winter with houses opening to the outside environment, pigs forced to eat outside and bedding used during the winter months. Trials reported here involved only winter studies. Pigs in the open housing gained 3% faster and required 4% more feed per pound of gain than the pigs in the insulated, ventilated house. Although these means are not statistically different, it is believed that they are representative of results that would be expected with similar environmental conditions. Pigs in the open housing appeared cold in their actions and they stayed in the bedded area most of the time, whereas pigs in the insulated house appeared warm and comfortable all of the time. The cold temperature did not adversely affect rates of gain, but it did increase the feed requirement for body maintenance. Tail biting did occur in the insulated housing whereas it did not occur in the open housing, and this may account for a part of the small difference in rate of gain.

Average daily indoor and outdoor temperatures for the open housing unit are shown in Figure 11. The average indoor temperature was 32.5 degrees while the average outdoor temperature was 14.8 degrees. Average daily indoor and outdoor temperatures for the warm unit are shown in Figure 12. The average indoor temperature was 58.6 degrees.

Figures 13 and 14 show average daily temperature levels for the 1965-66 and 1966-67 winter trials. The average indoor temperature for 1965-66 was 55.0 degrees while the average outdoor temperature was 16.2 degrees. Average temperatures for 1966-67 were 52.9 degrees indoors and 20.4 degrees outdoors.

The results of these trials clearly show that good performance of growing finishing pigs can be achieved with all types of housing used in these experiments. Rate of gain was about the same on all floor types, except the pigs on completely slotted floors gained slightly slower. The reason could not be determined, but it may have been associated with more foot and leg soreness of pigs in these lots. Pigs on 50% slotted floor required less feed per unit of gain in the smaller pens, but the reason was not clear.

Pigs were cleanest on the entirely slotted floor, but those on 50% or 25% slotted floors were also usually clean. The concrete floor with a narrow gutter at the end was usually covered with debris and dampness. Pigs in these pens generally had some debris caked in their haircoat. Frequent scraping was necessary to keep these pens clean.

When the entire program is considered in terms of rapid growth rate, good feed utilization, minimum labor and reasonable construction costs, it appeared that the 50% or 25% slotted-type floors were quite practical for efficient production.

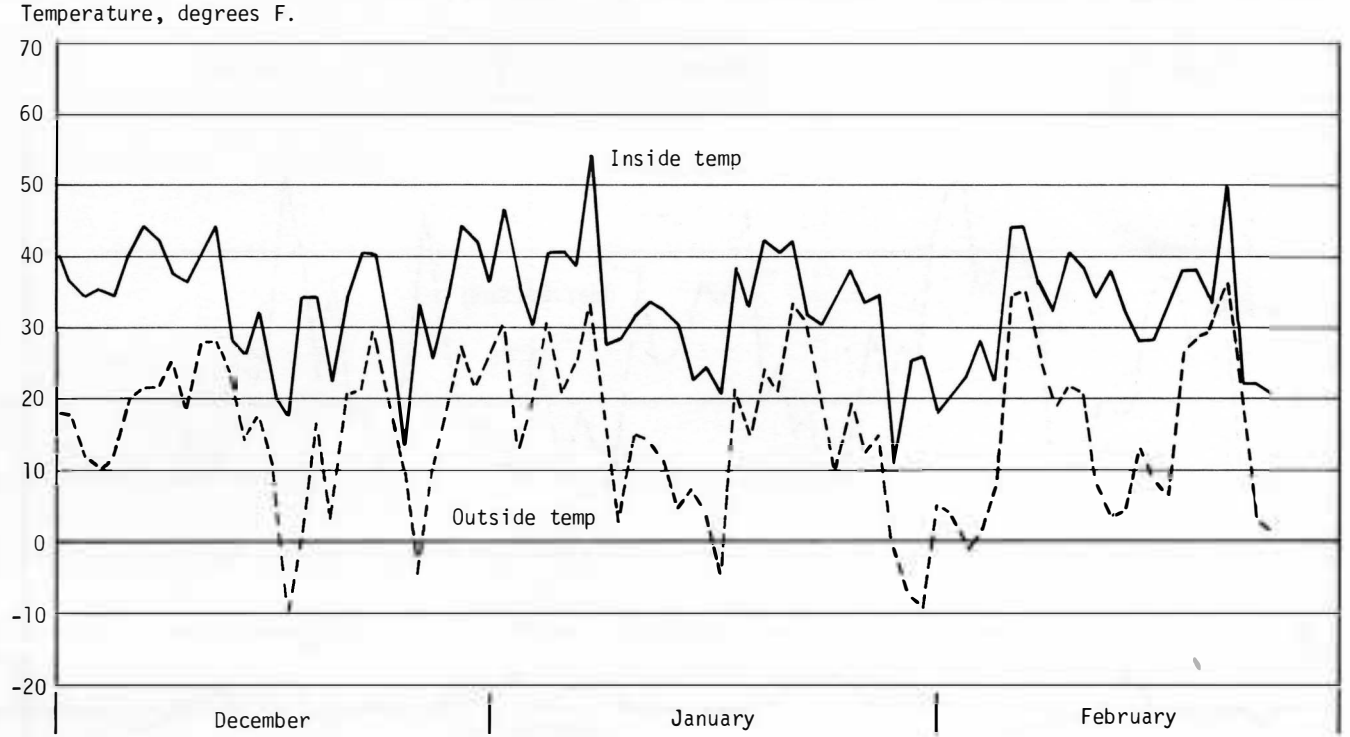


Figure 11. Average daily indoor and outdoor temperatures, in degrees Fahrenheit, for open housing during 1964-65 winter trial.

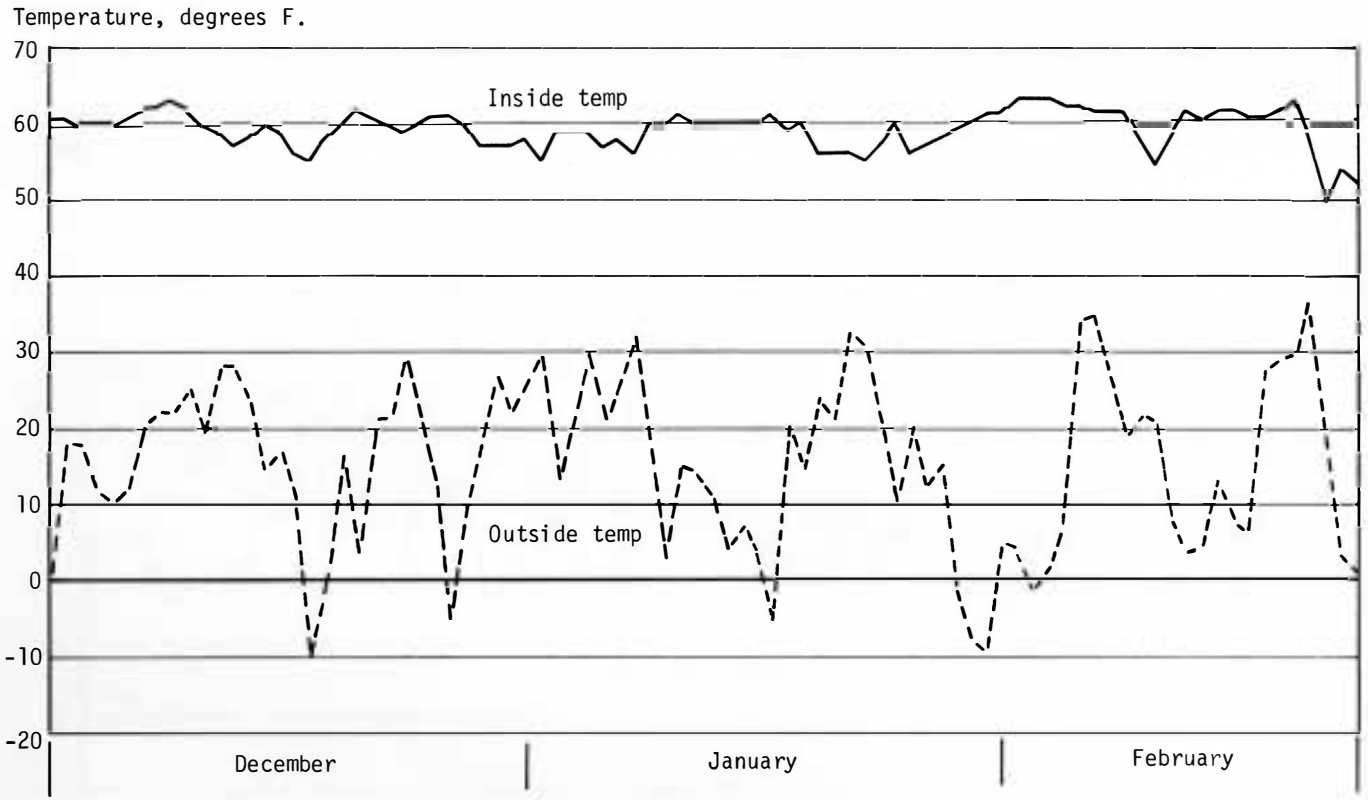


Figure 12. Average daily indoor and outdoor temperatures, in degrees Fahrenheit, for warm housing during 1964-65 winter trial.

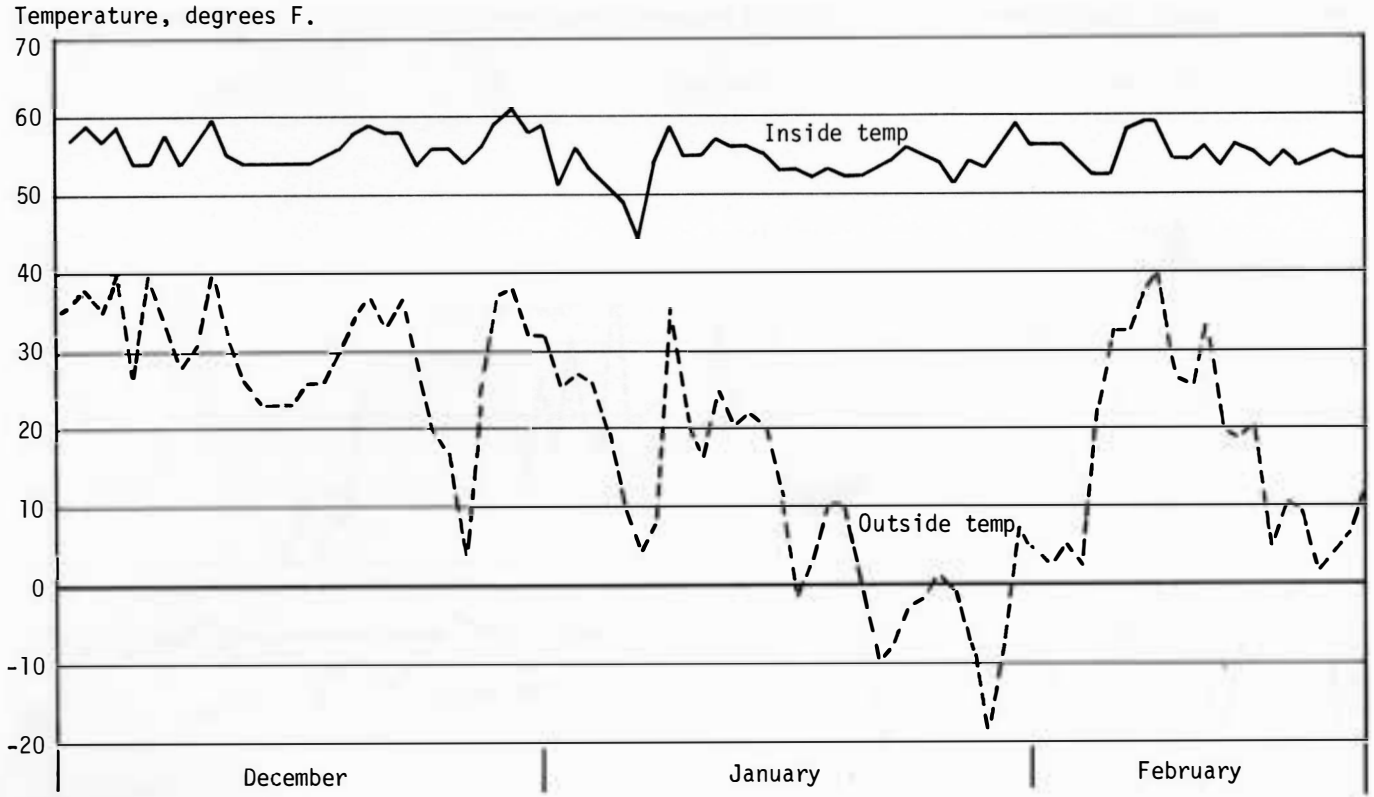


Figure 13. Average daily indoor and outdoor temperatures, in degrees Fahrenheit, for warm housing during 1965-66 winter trial.

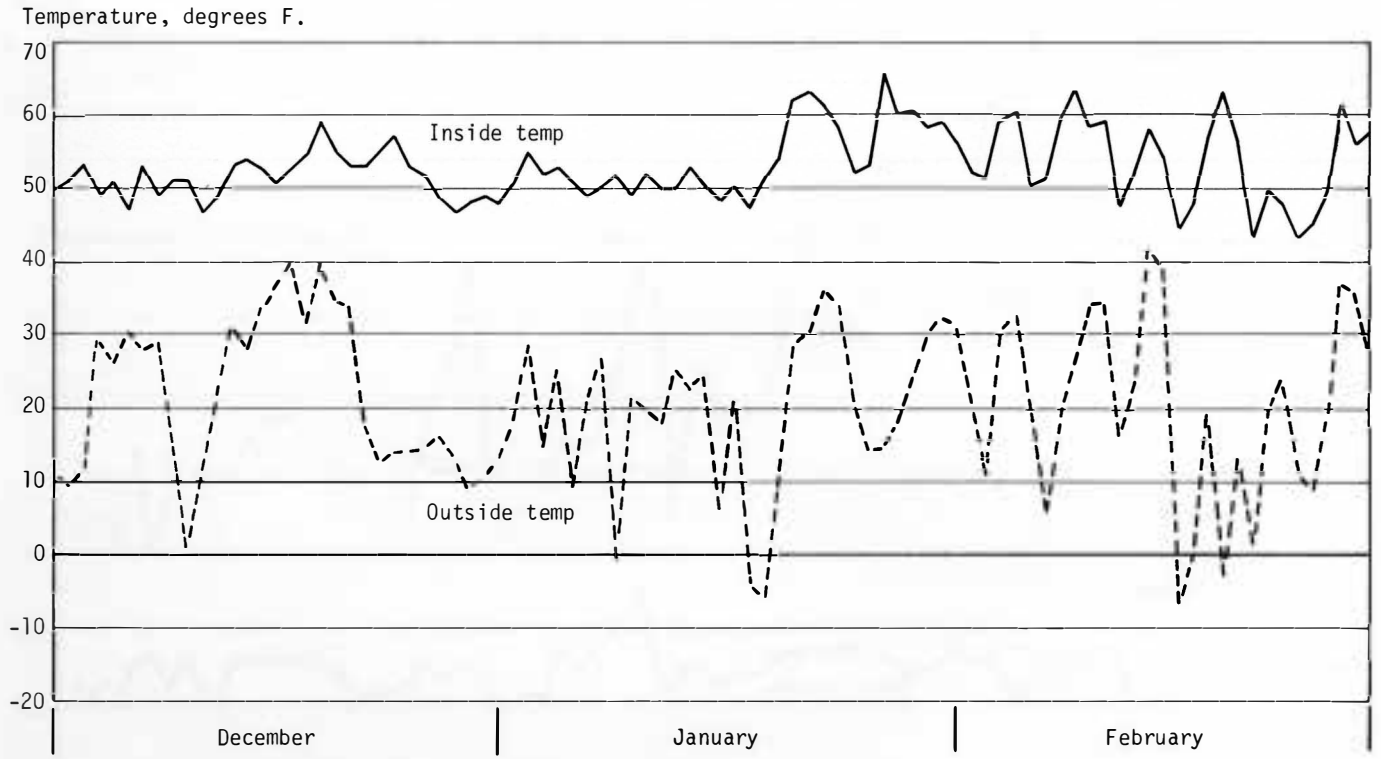


Figure 14. Average daily indoor and outdoor temperatures, in degrees Fahrenheit, for warm housing during 1964-65 winter trial.

These pens were suitable as farrowing pens also, as were the entirely concrete pens. Pig losses were minimized by placing temporary guard rails along the side of the pens and partitioning off an end for the creep area. The 100% slotted floor was utilized for farrowing also. A sheet of 4x8-foot plywood was used in each pen on top of the slats. The space between the slats was adequate to prevent permanent lodging of the baby pig's legs and they learned to walk on the wide slats within a few days.

Pen size, which was associated with a different number of pigs also, did not have any significant influence on the performance of the pigs. Eighteen pigs in the wider pens appeared to have more space for movement than 9 pigs in the narrower pens. If the purpose of a barn is entirely for growing-finishing pigs, some initial cost can be saved with the larger pens by eliminating some partitions, feeders and waterers.

When open housing was compared with the insulated unit, it was found that pigs in open housing with adequate protection and bedding will gain as fast as those in controlled environment. Pigs required approximately 4% more feed during the winter months for body maintenance in the open housing, which accounted for about 21 pounds of feed for each 150 pounds of live weight produced. Tail biting was a problem in the insulated house, but it did not occur in the open house during winter months when bedding was provided.

The total operating costs for the various floor types in the warm housing for the 1964-65 winter trial are shown below considering labor at $2.00 per hour, electricity at $.02 per Kw-hr. and LP gas at 13.5c per gallon.

Sloping concrete floor

Electricity for light and ventilation	$34.56
Heating cost	$27.84
Labor for pen cleaning	$25.28
Total cost	$87.68
Cost per pig	$ 2.74

25% slotted floor area

Electricity for light and ventilation	$34.56
Heating cost	$27.84
Labor for pen cleaning	$13.44
Total cost	$75.84
Cost per pig	$ 2.37

50% slotted floor area

Electricity for light and ventilation	$34.56
Heating cost	$27.84
Labor for pen cleaning	$14.08
Total cost	$76.48
Cost per pig	$ 2.39

100% slotted floor area

Electricity for light and ventilation	$34.56
Heating cost	$27.84
Labor for pen cleaning	$ 3.84
Total Cost	$66.24
Cost per pig	$ 2.07

Improved management practices reduced operating costs in subsequent winter trials to approximately $2.00 per pig on all floor types with the exception of sloping concrete floor where costs continued at near the level shown above.

SUMMARY

Part I

The performance of swine was not significantly affected by floor type although pigs on completely slotted floors gained at a slightly slower rate. This was attributed to foot and leg injuries suffered on rough slat surfaces.

Part II

The rate of gain of pigs on completely slotted floors was significantly slower than on other floor systems while pigs on the 50% slotted floor area had a better feed efficiency. Variations in pen size had no effect on performance although the pigs in the larger pens were cleaner and appeared more comfortable.

Swine raised in cold, open-front housing had a higher rate of gain but lower feed efficiency than pigs in warm housing. Tail biting was a problem in warm housing but did not occur in the open-front units.

Concrete floors required as much as .39 hours per pig cleaning labor during the trial period while proper management of the pigs on the various slotted floor systems virtually eliminated pen cleaning labor.

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