Swine

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EFFECTS of CONTROLLED TEMPERATURES, SLOTTED FLOORS and SPACE ALLOWANCES on SWINE PRODUCTION in Southeastern Virginia

Research Division Report 134
Virginia Polytechnic Institute
Blacksburg 24061
August 1969

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ACKNOWLEDGEMENTS

The investigators concerned with this research acknowledge with appreciation the contribution of funds and materials that helped initiate the study and provide the facilities. Assisting were: The Peanut Hog Growers Association, Capron, Virginia; Gwaltney, Incorporated, Smithfield, Virginia; Smithfield Packing Company, Smithfield, Virginia; Portland Cement Association, Chicago, Illinois; Kaiser Aluminum and Chemical Sales, Inc., Elmhurst, Illinois; Southern States Cooperative, Richmond, and Franklin, Virginia; Joel L. Harrell and Sons, Suffolk, Virginia; and the Community Electric Cooperative, Windsor, Virginia.

The authors gratefully acknowledge the valuable assistance provided by Vernon McCoy, Robert Gupton, and Donald Wingo in the construction of the facility and the equipment and its installation and maintenance. Other V.P.I. Division of Research personnel due credit for their interest and advice in the initiation and conductance of the study are: Professors E. T. Swink, J. H. Lillard, G. D. Kite, Bynum L. Driggers, and Dr. J. P. H. Mason, Agricultural Engineers; Professors G. W. Litton, Paul P. Graham, and Dr. C. C. Brooks, Animal Scientists; Dr. John W. Davis, Veterinary Scientist; and Dr. C. Y. Kramer, Statistician. The interest, advice, and assistance of Dr. T. E. Hienton, Chief, Farm Electrification Research Branch, Agricultural Engineering Research Division, ARS, USDA, now retired, is gratefully acknowledged; also, the consultation and advice of Mr. L. E. Campbell, Agricultural Engineer, FERB, AERD, ARS, USDA, is gratefully acknowledged. Professor H. Marshall Clark, Tidewater Research Station Superintendent, assisted and advised the authors and researchers in many ways, and his valuable help is acknowledged with appreciation. The authors also gratefully acknowledge the interest and valuable assistance given by Dr. E. T. Kornegay, Animal Scientist, V.P.I. Division of Research, in preparing this report for publication.

CONTROLLED TEMPERATURES AND SPACE ALLOWANCES

Facilities

It was determined that the following facilities were needed in order to conduct the experiment:

a. A temperature controlled house, with equipment and instrument room at one end.
b. A half-open shed-type structure with same floor plan except no equipment room.
c. An open dirt lot.

Concrete foundations and floors for the temperature-controlled house, Figure 1, and the half-open structure, Figure 2, were designed and constructed alike. Floors sloped to a center gutter which drained to an outlet in the middle of the floor.

Conventional frame construction was used in building the facilities. Standard corrugated aluminum sheets were installed on the roof. The exterior was also covered with aluminum sheets installed horizontally; preformed aluminum corners and trim were used.

Figure 1. Temperature controlled swine house.

The 24' x 48' temperature controlled house, with the 24' x 12' equipment and instrument room addition, was well insulated in order to minimize heat transfer. Perimeter insulation was placed along the floor edges and a plastic-film vapor barrier was installed under the floor. Eight farm-type insulating windows were used to provide light in the building. The walls were insulated with 3-1/2-inch thick batt-type fiberglass, and 6-inch thick fiberglass insulation was installed over the ceiling. The interior walls and the ceiling of the swine section were also covered with corrugated aluminum sheets installed horizontally. All of the doors had insulating cores and were hung to be tight fitting.

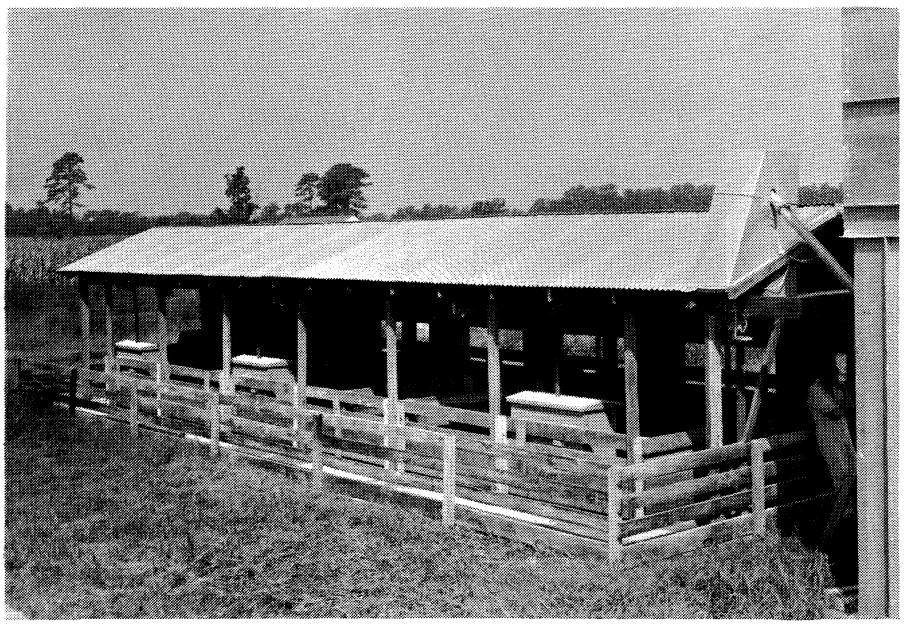

Figure 2. Half-open swine building.

The 24' x 48' half-open house, Figure 2, was framed as a regular shed-type building with southern exposure. Corrugated aluminum roofing was installed, and the sides and two ends were covered with aluminum sheets put on horizontally. Hinged doors were installed the full length of the back wall for summer ventilation. After one summer test, the roof of this house was extended across the front as shown in Figure 2, to prevent the sun from shining into the pen area during the warm part of the day.

A 15 x 42-ft. pen area was centered on each floor and enclosed with oak planks. Movable partitions were used to divide the large pen into smaller pens of desired widths. Slotted wooden panels were made to cover the foot-wide gutter in the floor. There were alleyways around the swine enclosures for convenience.

The open dirt lot was a 50' x 80' fenced area near the buildings, and included a concrete slab for feeder and waterer. A small portable, three-sided range shelter was placed in the lot.

Procedure

Groups of 15 hogs were considered to be of minimum sample size to allow for statistical analysis and reasonable duplication of conditions of farm handling and management. Three groups of hogs were housed in the temperature-controlled environment and three groups in the shed structure under natural environmental conditions. Floors of these houses were washed daily with high-pressure water and the manure was flushed through a drain into a lagoon. One other group of hogs ran loose in the open dirt lot.

Bond, Kelly, and Heitman (1)* reported that 100 to 200-lb. hogs gain most rapidly in a constant-temperature environment of 70°F, and Hazen and Mangold (4) showed a maximum rate of gain for 50 to 200-lb. hogs when average daily temperatures were 60° to 70°F. Therefore, the V.P.I. temperature-controlled housing facility was designed for maintenance of 65° to 70°F environment. Two five-ton heat pumps were installed. One, a reserve unit, could be used as a supplemental unit when extremes in weather conditions were encountered. This equipment enabled the temperature to be controlled within the range of 65° to 70°F. The indoor circulatin fan of the heat pump ran continuously, maintaining an air flow of 2000 cubic feet per minute (cfm). Adjustable louvers and vents were installed so that a mixture of 75 percent indoor air and 25 percent outdoor air was provided. The ventilation rate of 500 cfm resulted in approximately 11 cfm per hog.

Two summer tests and two winter tests were completed in these facilities. Crossbred pigs from the Tidewater Research Station herd that received no special treatment prior to weaning were used in these tests. Outcome groups of littermates were used as far as possible. Some groups were made up of non-littermates, but with comparable breeding, size and other factors. The seven pigs from each outcome group were randomized into each treatment. Treatments consisted of the spacing allowances and environments as indicated in Table 1.

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*Refer to listed references.

TABLE 1. FLOOR SPACE ALLOWANCE PER HOG

	Floor space in weight ranges (square feet per hog)		
	40-75 lb.	75-125 lb.	125-200 lb.
Temperature controlled environment			
Treatment No. 1*	10	14	18
Treatment No. 2	6	10	10
Treatment No. 3	8	12	14
Natural Open-shed environment			
Treatment No. 4	10	14	18
Treatment No. 5	6	10	10
Treatment No. 6	8	12	14
Open feed lot			
Treatment No. 7	4000 sq. ft. log		

* 15 hogs per treatment

The hogs were individually weighed at 14-day intervals. The animals housed under temperature-controlled conditions were not removed from the house. This eliminated subjection to thermal stress on either very hot or cold days. Feed was maintained before the hogs in self-feeders and the quantity of feed used by each 15-hog groups was recorded for each 14-day period. These hogs were fed a ration consisting of corn, soybean oil meal fortified with minerals, vitamin premix and antibiotics which was comparable to rations used by commercial growers in the area.

Due to variations in size and other uncontrollable factors, it was impractical to remove all hogs from the test at the same time. They were therefore removed at the 14-day weight-period interval when the individual hog reached approximately 200-lb. liveweight. The market weight hogs were slaughtered and carcass quality measurements were made according to procedures as outlined in the Proceedings of the Fifth Annual Reciprocal Meat Conference (1952).

Temperature data were obtained during the tests by using thermocouples and a recording multipoint potentiometer. Outside temperatures were indicative of the open shed and the open dirt feedlot

environmental conditions. The heatpump thermostats maintained temperature in the environment controlled house within the 5-degree optimum range of 65° to 70°F. Temperatures at critical locations in each facility were also recorded. Wet and dry-bulb temperature readings in the temperature controlled house were taken intermittently throughout the tests to check relative humidity ranges. These were found to average 85 percent during the summer tests and 75 percent for the winter tests.

Table 2 gives ambient temperature data for all tests. The line headed "Normal for Area" is the long-period average monthly temperature and is included so each growth period can be compared to normal conditions as well as to other growth periods. An inspection of the data showed that temperatures experienced during these tests were representative of conditions that may normally be expected in southeastern Virginia.

TABLE 2. OUTDOOR TEMPERATURE DATA

		Average Temperatures (°F)			
Month	Norm. for Area	Test 1 Summer 1961	Test 2 Winter 1962	Test 3 Summer 1962	Test 4 Winter 1963
Jan.	38.2		36.5		
Feb.	40.8		41.8		36.8
Mar.	48.3		46.5		53.9
April	56.2		55.5		60.0
May	65.8				66.5
June	74.5				
July	77.5	79.5		77.0	
Aug.	76.2	76.1		76.5	
Sept.	71.1	72.0		69.1	
Oct.	60.0	55.7		63.0	
Nov.	49.9				
Dec.	41.1				
Test Duration		73.1	44.4	69.9	52.0

Results

Physical data on first 4 tests are given in Table 3.

TABLE 3. PHYSICAL DATA

	Summary of Four Tests			
	Test 1 Summer 1961	Test 2 Winter 1962	Test 3 Summer 1962	Test 4 Winter 1963
TEST DATES				
Start	6-23	12-20	6-28	1-23
Finish	10-23	4-23	11-6	5-28
AVG. DAYS TO MARKET				
Controlled Temp. Environment	93	102	113	106
Open-Shed Environment	101	105	113	99
Open Feed Lot	99	99	112	No Test
AVG. WEIGHT (lbs.)				
Start	49	39	41	47
Finish	204	204	204	204

Data collected during the tests were analyzed and showed some differences in the average daily gains (ADG) of hogs grown under the different housing conditions. These, however, were erratic, favoring no particular growing condition during the course of the four tests. Sizes of the floor spacings per animal had no effect on average daily gain in any of the tests; however, larger space allowances resulted in cleaner hogs with the same frequency of floor washing. The smallest pens, with 10 sq. ft. per hog, did not become particularly objectionable if a daily wash schedule was followed to remove the waste.

Average daily gain for all hogs is given in Figure 3. The data are grouped according to housing conditions and show that no one housing condition was consistently better than any other.

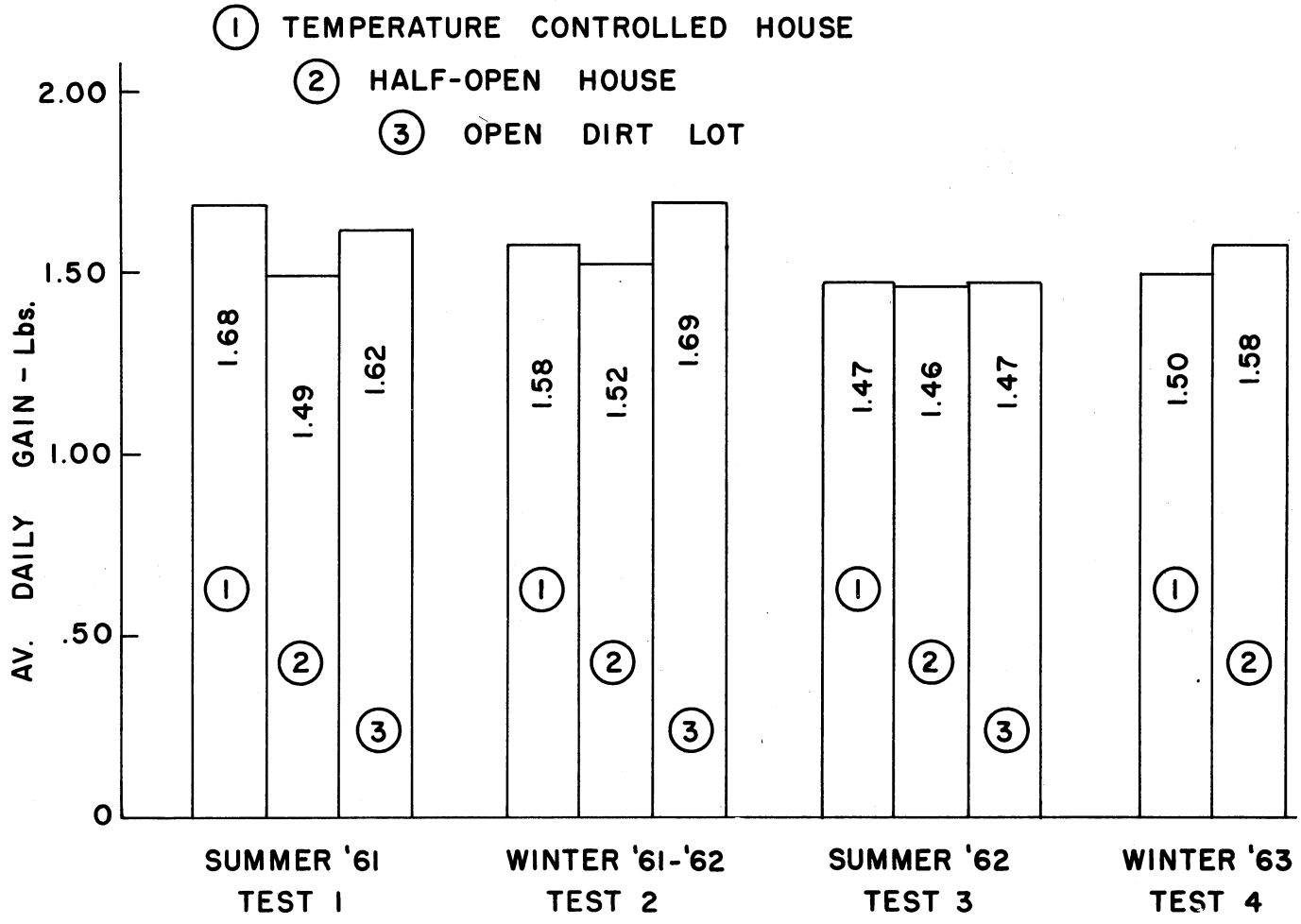

FIG. 3 AVERAGE DAILY GAINS

A significant difference in daily gain was indicated in only the first two tests. In the 1961 summer tests, hogs raised in the temperature-controlled house showed greater daily gains than those in the half-open house. This was significant at the one percent level. In the 1962 winter tests, hogs grown in the open lot had greater gains than others when tested at the 5 percent level. The slight advantage indicated for hogs grown in the temperature-controlled house in the first test gradually disappeared as subsequent tests were conducted.

Feed conversion ratios for the hogs in the first two tests are shown in Figure 4. The average feed conversion was 3.46 lb. of feed per pound of gain. The data available show an advantage of 0.10 lb. of feed per pound of gain for hogs grown in the temperature-controlled house when compared to the hogs in the half-open shelter. Since the hogs were fed in groups, no statistical analysis could be made of these data to determine their significance. However, this slight feed savings could not justify the added expense of the controlled-temperature environment.

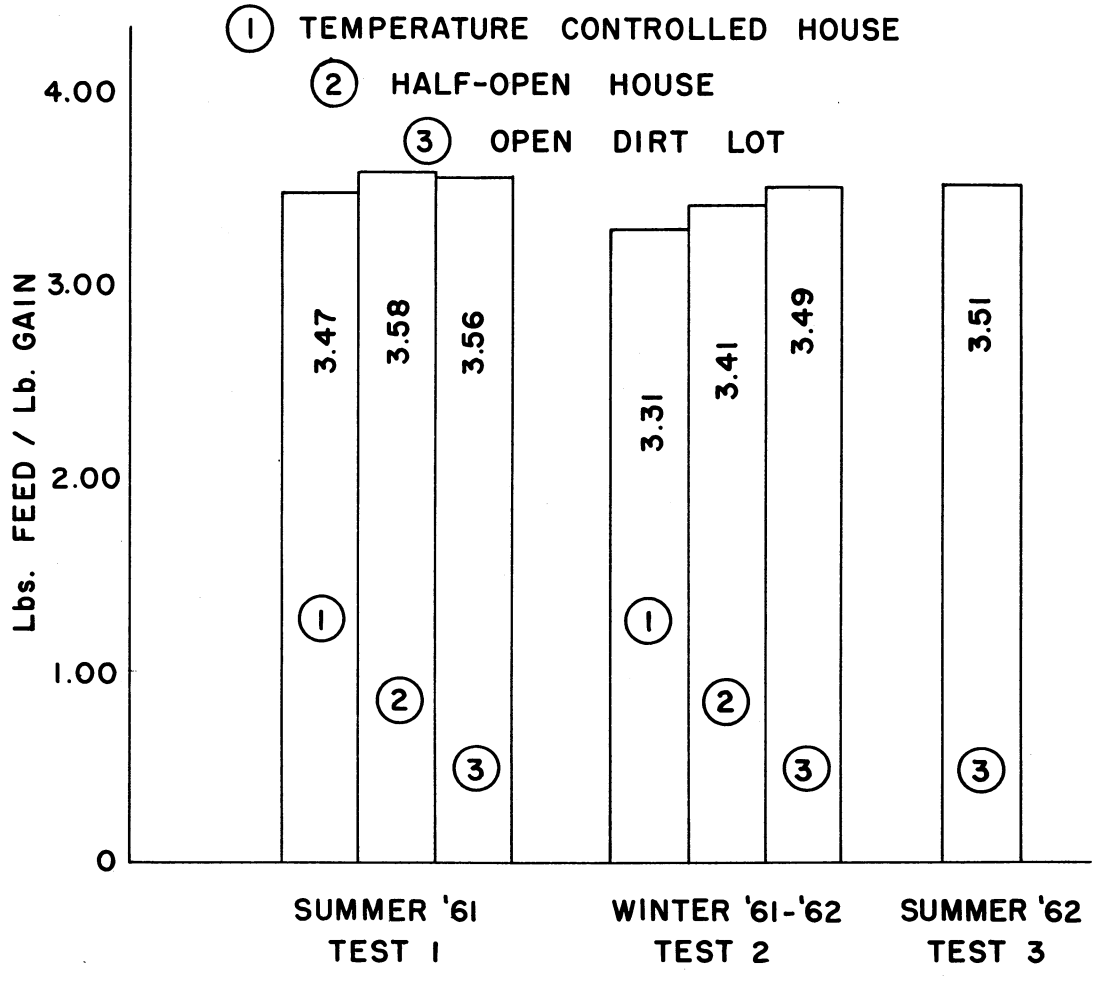

FIG. 4 FEED CONVERSION

Carcass quality evaluations were made on animals grown to market weight in the four tests. These were made in Tidewater area slaughter houses and at the V.P.I. Meat Processing Laboratory. The data have been averaged as indicated in Table 4.

TABLE 4. AVERAGE CARCASS QUALITY FACTORS FOR TEST CONDUCTED

	Environment controlled house	Natural Environment half-open house	Open feed lot and shelter
Average carcass weight chilled	145.50	145.60	145.90
Carcass length	29.00	28.80	28.80
Back fat thickness	1.55	1.55	1.49
Loin-eye area 10th rib	3.60	3.72	3.86
Feather	6.30	6.20	6.50
Overflow	2.50	2.40	2.50
Uniformity of back fat	2.20	2.30	2.20
Final USDA grade	4.60	4.60	4.80

Analysis of these and other carcass-quality facets have shown no significant difference between results of the environmental and spacing treatments, nor with respect to the type floors that the animals were grown on. A very slight trend toward smaller "loin-eye area" can be noted as environmental conditions progressed from open dirt lot toward confinement growing methods.

Discussion

Bond, Kelly, and Heitman (2) report a reduction in average daily gain when pigs were subjected to daily cycling temperatures, even though the average temperature was the same as the constant optimum temperature used for comparison. They also reported reductions in gain when the cycling temperature varied from 70°F minimum to various daily maximums up to 120°F. The one exception was with temperatures cycling from 70 to 90°F, a 20-degree range, in which no reduction in gain was noted.

In view of the above findings, the naturally occurring variation in temperature during the tests being reported may partially account for the lack of difference in the average daily gains for the hogs in the controlled temperature environment versus those in the half-open conventional house. The diurnal temperature variation at the Tidewater Research Station for one-third of the test days was less than 20 degrees, for another one-third of the days it varied no more than 30 degrees, and the remaining days up to 45 degrees.

Kazarian and others (5) reported an experiment which compared the growth of pigs in a conventional open-sheltered lot, an insulated and ventilated house, and an insulated and air-conditioned house through the summer months. They found a 10 percent improvement in growth rate and feed efficiency in both of the experimental housing conditions.

Garrett (3) when reporting on investigations carried out in California's Imperial Valley, in cooperation with Bond and Kelly, was unable to show a consistent growth advantage for air-conditioned environments over shaded wallows, even in a climate with maximum temperatures that are well over 100°F throughout the summer months.

Hazen and Mangold (4) plotted curves indicating that the average daily gain of hogs with good feeding and housing should be around 1.75 lb. per day as they grow from 50 to 200 lb. weights, with progressive reductions as daily average temperatures deviate from optimum. The test animals in this investigation show somewhat lower average daily gains (1.50) even though temperatures were maintained near optimum. It was known that the swine herd at the Tidewater Research Station was infested with virus pneumonia and strophic rhinitis during the periods of the tests, and it was probable that physical conditions influenced the average daily gain. Young and others (7, 8) reported that hogs from a herd which was free of these two diseases reached 200 lb. market weight about a month earlier than hogs from an infected herd. They also indicated an ADG of 1.49 lbs. for hogs in the Nebraska experiment station herd which was infected, and an ADG of 1.77 for the first three pig crops after repopulating with disease-free pigs.

SLOTTED FLOORS AND SPACE ALLOWANCES

Facilities

The same buildings that were used in the study of controlled-temperature swine housing were modified in 1964 to provide two pens in each house with fully slotted floors and two pens with the original concrete floors. The slotted floors, made of steel T-bars spaced 5/8 in. apart, were built about 16 in. over the concrete floor. The area underneath was washed daily. The enclosed building was maintained during summer and winter tests at a controlled temperature of 65° to 70°F and the half-open building was operated under naturally existing conditions. In two tests, hogs were grown on steel T-bar floors. Many animals experienced severe foot damage, so the use of these floors was discontinued.

In 1965, the floors were remodeled to provide a 25 percent slotted pen-floor area in half of each building; 50 percent of the pen-floor area was slotted in the remaining part of the open building, and the entire pen-floor area was slotted in the remaining half of the enclosed building. All slotted floors were made of 3/4-in. expanded metal installed over water-filled waste collecting pits.

The enclosed building was remodeled and ventilating equipment installed to provide a semicontrolled temperature environment. Ventilating fans had a maximum capacity of 10,000 cfm, or 100 cfm per hog, for summer ventilation. Methods of reducing air flow in cold weather were incorporated in the system.

Ventilation controls were designed so that, when temperatures both inside and outside the house reached 85°F, the fans shut down and the heat pump cooling cycle was activated. This protected the animals from being exposed to more than 85°F temperature conditions. For the winter tests the heat pumps were similarly used for heating the building as required to prevent exposure to below 50°F conditions. It was found, however, that the animals produced sufficient heat to maintain 50°F temperatures during the winter tests except for one or two cold nights.

Procedure

Previous to the slotted-floor studies the Tidewater Research Station herd was entirely repopulated with specific pathogen-free (SPF) hogs. It required about 6 months to remove existing hogs from the station and execute the required sanitation measures and time delay prior to bringing in the SPF hogs. Subsequent tests used pigs from the new herd.

Tests #5 and #6 were the first run with SPF hogs. A winter and a summer test were conducted comparing concrete pen-floor areas to those with the entire pen area slotted with steel T-bars. In these tests, outcome groups were used, based on littermates and weights at time of starting tests.

The next test, #7 was conducted in pens with 25 percent, 50 percent and fully slotted floor areas. Four equal-size pens with 65 sq. ft. of floor space were provided on each floor type and were used to study space requirements by varying the number of animals. Maximum cleanliness resulted where pens were fully slotted. For test #8, the fully slotted area was converted to a 50 percent slotted floor area, in order to make all respective floors identical.

Earlier tests reported had shown no effect on growth rate of swine from reducing the floor area per animal to eight square feet. In the 1965 test, space allowances were seven, six, five, and four square feet per animal, and were accomplished by placing nine, 11, 13, and 16 hogs in pens having 65 sq. ft. of useable floor area each.

Fifty hams from hogs grown in test #6 were tagged and cured by an area meat processor. They were processed along with other commercial hams under standard curing procedures.

Results

The analysis of data indicated that the kind of floors had no statistically significant effect on average daily gain in any tests conducted (Figure 5). Average values of feed conversion for each group of hogs grown did not indicate an advantage in feed efficiency for any type of floor.

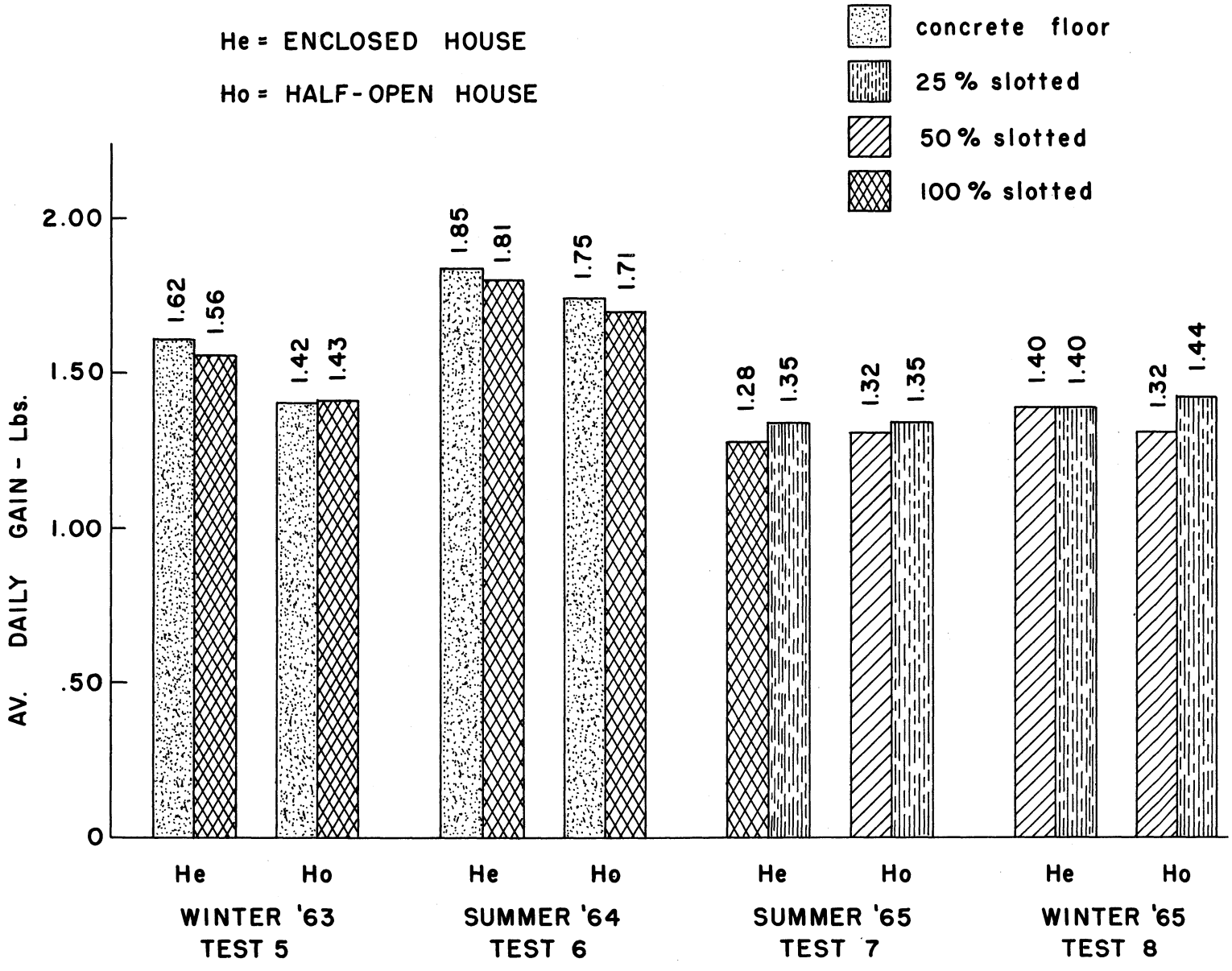

FIG. 5 AV. DAILY GAIN OF SWINE ON 4 DIFFERENT FLOOR TYPES

A study of Table 5 reveals that hogs on slotted floors in air conditioned or 1/2 open houses had more marbling than those on concrete floors or on the dirt lot. There were no differences in fresh ham color or firmness that could be attributed to the type of housing or pens that the hogs were grown in. When the hams were in cure or being smoked in the commercial ham operation there were no significant differences in losses. However, during the 120 day ageing period, hams from the dirt lot hogs (treatment 5) had highly significant greater losses than the hams from any of the other treatments. The reasons for this observation are not clear although the treatment 5 hams had greater losses in each of the processes and greater total loss.

TABLE 5. SUMMARY OF PHYSICAL AND CURING CHARACTERISTICS OF HAMS

Treatment	Fresh Ham Scores			Curing & Ageing Losses			
	Color	Firmness	Marbling	Loss in Cure	Loss in Smoke	Loss in Ageing 120 da.	Total
				%	%	%	%
No. 1 Slot-Floor Air-Cond.	2.6	3.0	4.4^{a}	5.9	11.1	9.7^{a}	26.8
No. 2 Conc-Floor Air-Cond.	2.4	2.6	$3.2^{b,c}$	5.8	11.5	9.6^{a}	26.9
No. 3 Slot-Floor 1/2 Open	3.2	2.8	$4.0^{a,b}$	5.2	10.7	9.7^{a}	26.1
No. 4 Conc-Floor 1/2 Open	2.2	2.4	2.4^{c}	5.5	12.0	11.2^{a}	26.3
No. 5 Dirt Lot	2.8	2.8	2.8^{c}	6.2	12.1	13.5	27.4

^{a,b,c} Values in columns with same superscript are not significant diff. (.01)

Color code: 1=light, pinkish gray, bright; 2=intermediate; 3=dark red
Firmness code: 1=soft and watery; 2=intermediate; 3=firm
Marbling code: 1=devoid; 2=practically devoid; 3=traces; 4=slight, etc.

The hams were cooked and presented to a trained taste panel for evaluation of flavor, saltiness and overall satisfaction. There were no differences noted that could be attributed to the treatment. All of the hams received high scores on overall satisfaction.

Cleanliness of the pens and pigs was related to floor type and to the floor space allowed per animal. On fully slotted floors, all pens and pigs remained clean with little or no labor expenditure, even with the highest population density of 16 pigs per pen. Solid concrete floors, on the other hand were not so clean. Daily cleaning, requiring considerable labor, was necessary to maintain these floors in acceptable condition. On concrete floors, cleanliness of both the pen and animal was greatly affected by the population density. Observed evaluations of conditions of partially slotted pen floors at various times throughout the winter growing period (Table 6) indicated that these pens became cleaner as animal size increased. The pens were noticeably cleaner after pigs weighed 100 lb. In the enclosed building, 50 percent slotted-floor pens were consistently cleaner than 25 percent slotted-floor pens, but this did not hold true in the half-open houses. The number of animals per pen did not seem to be related to pen cleanliness and there was no consistent pattern among pens of similar animals. Pen cleanliness was highly unpredictable; some pens stayed clean and others dirty and the reasons for these differences were not apparent.

TABLE 6. OBSERVED PEN AND ANIMAL CLEANLINESS

Winter Test 1965

Dates Test Started 11-23-65	Hog Weights, Avg. lb.	Enclosed House (Avg. score rating) 50% Slotted Floor	Enclosed House (Avg. score rating) 25% Slotted Floor	Half-open House (Avg. score rating) 50% Slotted Floor	Half-open House (Avg. score rating) 25% Slotted Floor
Nov. 30	55	2.0	3.9	4.1	4.5
Dec. 8	65	2.75	4.6	5.0	4.5
Dec. 21	80	3.0	4.25	3.5	4.25
Jan. 13	105	3.0	4.75	4.0	4.0
Jan. 19	110	1.0	2.5	3.0	2.0
Feb. 3	140	1.0	3.1	3.0	2.5
Mar. 5	180	1.0	3.5	1.25	2.25

Score Rating:

1 Excellent conditions
2 Good conditions
3 Fair conditions
4 Poor conditions
5 Very poor conditions

Observers:

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Discussion

Average daily gain was not different for the various types of floors. Cleanliness of the hogs and the pens was affected by certain types of floors. With a heavy population on concrete floors, it was not possible to maintain clean animals even with frequent floor cleaning. Costs of partially or fully slotted floors should be charged to savings of labor in cleaning pens, and to the preference of the manager for maintaining more pleasing appearance of the animals and facilities.

The type of housing used in a climate similar to that in southeastern Virginia seems to have little consistent effect on growth rate. In some tests, type of housing has shown a statistically significant effect; however, advantages have been inconsistent and have favored the less expensive half-open house in this particular climate as often as the enclosed building. In colder climates advantages favoring enclosed swine- housing facilities would probably become more evident.

Animal scientists cooperating in this project are of the opinion that small pigs housed in half-open shelters on slotted floors during cold weather are exposed to undesirable conditions, and exhibit extreme discomfort. Therefore, enclosed buildings may be desirable on the basis of animal comfort and perhaps personal preference. The growth data tend to substantiate this observation, since during the first six weeks after weaning, small pigs (45 to 100 lbs.) showed less gain in the half-open shelter than in the enclosed ventilated building. When expanded to the complete growth period of weaning to market, however, no difference in ADG was indicated. Feed efficiency data have shown some slight advantage for the enclosed housing in winter tests.

When swine were grown on partially or fully slotted floors, a population density of one animal per five sq. ft. of floor space was used for small hogs (up to 100 lb.) without adversely affecting the rate of gain. For larger animals, reduction in growth rate was indicated when floor space was decreased from six to five sq. ft. per animal. An additional reduction was shown when only four sq. ft. of space was allowed per animal. Each increment reduction in ADG was approximately 0.1 lb. per day.

In deciding what population density of hogs may be most profitable, an operator can weigh the decreased gain of high-density population against the increase in total meat yield from the swine housing facility. More data of this nature are needed in order to make the best decisions concerning efficient expansion of the swine enterprise. The present trend seems to indicate an increase in the population density of existing houses as a means of increasing production.

The amount of space allowed per animal did affect ADG (Figure 6). Since the size of hogs is an important factor in determining the amount of space needed, the growing period was divided into two parts for the analysis of space requirements. The two periods selected were the first six weeks after weaning and the last six weeks before marketing. This allowed an analysis of the data for both small and large hogs.

In the 1965 summer test, no difference was noted during the first six weeks in ADG with seven, six, or five sq. ft. per animal, but a depression of ADG at four sq. ft. per animal was detected. This involved pigs that were grown from 55 to 120 lb. average weight. Due to unavoidable circumstances this group of hogs was not maintained on test until market weight was attained; consequently no data for large pigs were available.

In the subsequent winter test, no differences were found in ADG for any animal density through the first growth period. The average weights of these animals were 45 lbs. at the start and 100 lb. six weeks later.

In the final six-week growth period a significant depression in gain was noted as space was decreased below six sq. ft. per animal. Results with animal densities of seven and six square feet did not differ, but five and four sq. ft. per animal yielded a lower ADG, with gains decreasing as floor space became less. The average weight range for this period was from 137 lb. at the start to 196 lb. at the end of the test. Feed efficiency (Figure 7) was slightly higher in pens with seven and six sq. ft. per hog, but no statistical conclusion was formulated from the data.

All carcass evaluation data indicated the meat quality was essentially the same regardless of how the hogs were grown or what type floors they were grown on.

GENERAL SUMMARY

Confinement housing facilities for swine production were constructed and studied in southeastern Virginia at the Tidewater Research Station. One building was completely enclosed, equipped, and instrumented to control temperature at an optimum level. Another building was constructed as an open-shed type structure in which temperatures varied with the natural occurring conditions in the area.

In each of the tests conducted, hogs were grown from weaning to market weight in each building under conditions designed to simulate an average farm operated and managed enterprise. The environment house was maintained at a constant 65° to 70°F temperature, and the half-open house temperature condition varied with natural cycles.

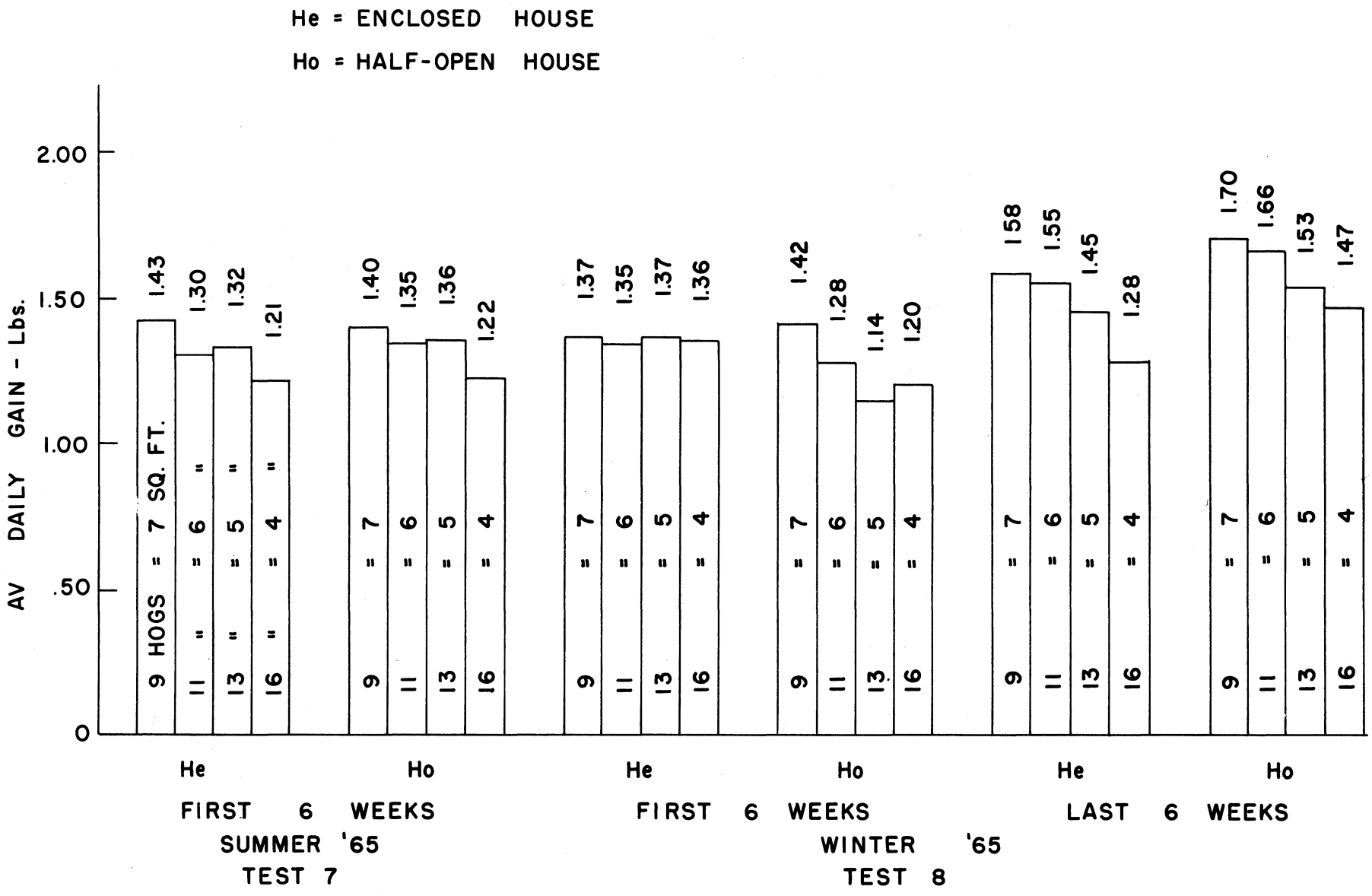

FIG. 6 AV DAILY GAIN OF SWINE ON 4 DIFFERENT SPACE ALLOWANCES

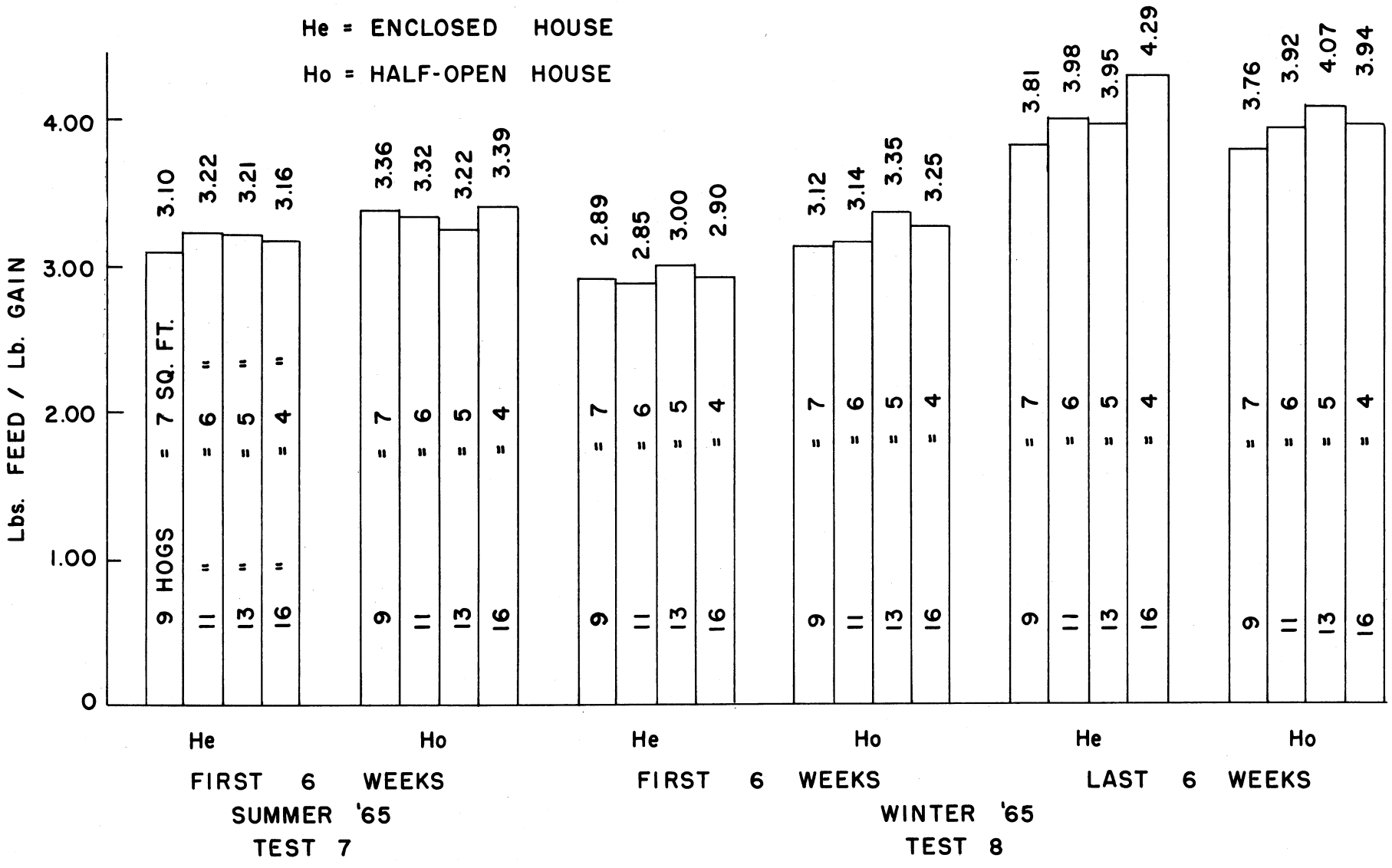

FIG. 7 FEED CONVERSION OF SWINE ON 4 DIFFERENT SPACE ALLOWANCES

Test groups of hogs were grown in these facilities under both summer and winter conditions. All physiological factors concerning the test animals were not altogether constant; however, the study showed that the rate of gain, feed efficiency, and carcass quality were not significantly different for hogs grown at the optimum environment temperature of 65° to 70°F than for hogs grown under naturally varying temperature conditions occurring in southeastern Virginia.

Various types of floors for growing swine were investigated. These were solid concrete, 25 percent slotted, 50 percent slotted, and fully slotted floors. All floor types were installed in the enclosed building and duplicated in the conventional half-open type building with the south side open. Hogs were grown under summer and winter weather conditions. Average daily gain of the animals was not affected by the type of pen floor in these houses. Cleanliness of both pen floor and animals was improved by increasing the slotted area of the pen floor. Carcass quality evaluations showed no significatn difference on account of floor types. Cured hams, when cooked and presented to taste-test panels, received high scores on overall satisfaction.

A reduction of average daily gain was noted when hogs were grown to market weight of 200 lb. with less than six square feet of floor space per animal, on partially or fully slotted floors.