IMPROVED ENVIRONMENTAL CONDITIONS AND THEIR EFFECT ON THE GROWTH OF MARKET SWINE

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By

Edward Arshak Kazarian

A THESIS

Submitted to the College of Agriculture of Michigan State University of Agriculture and Applied Science in partial fulfillment of the requirements for the degree of

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AN ABSTRACT

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Approved by James L. Boyd

Abstract

This project was conducted to determine the effect of improved environmental conditions on the production of market swine. Double pane windows, air conditioning and artificial heat were used in three experimental hog houses to provide different environmental conditions. A fourth house containing single pane windows was used for evaluation of the double-pane house. All houses were of identical construction and were insulated and ventilated. Control for the study was a conventional house with access to a concrete slab.

Two summer and two winter hog feeding trials were conducted in the houses during the period from 1954 to 1956. Six weaned pigs were placed in each house and the trial was conducted until the pigs had reached an average market weight of 200 pounds. The pigs were confined in the test houses while the pigs in the conventional house were free to go out. Weight and feed consumption were recorded every two weeks.

An automatic potentiometer was used to record hourly wet and dry bulb temperatures in the houses. Ventilation records were obtained by the use of operational recorders.

Data obtained from the study indicated that improved environmental conditions in the test houses were conducive to higher rates of gain and better feed efficiencies. However the varying degrees of improvement in the test houses were not measurable in the performance of the swine.

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INTRODUCTION

History of the Project

The initial study to determine the effect of environmental conditions on the production of swine was made in two wings of a central swine barn. One wing, of solar design, had large double pane windows while the other wing of conventional design had smaller single pane windows. It was determined that certain variables could not be controlled or evaluated in the large building and that smaller buildings would be necessary to continue the study. In 1953 three experimental houses were built and a study was made to determine the effects of using insulating glass windows in swine housing. The houses were identical except for the type and amount of glass. Results of the study were favorable for double pane windows and continuation of the project was necessary to verify the results.

Description of the Project

This project was sponsored jointly by the Michigan Agricultural Experiment Station and the Libbey-Owens-Ford Glass Company.

In previous studies, two of the three test houses had double pane windows, one house containing one-half the area of glass as the other. The third house had single pane windows. Results showed that the two houses with double pane windows did not differ significantly in their respective environmental conditions. Therefore, for future studies the house with the smaller area of glass was converted to a dark house by boarding up the windows, Figure 1. The dark house was used to evaluate the absence of sunlight on the performance of swine.

The conventional house on a concrete slab used as a control for the study was replaced with one of newer design, Figure 2.

The study was duplicated for one year after which a fourth test house was added. The house was built similar to the three existing houses and had double pane windows. This house was equipped with a one horsepower window-type air conditioner to improve the environmental conditions in the house during the summer. The air conditioner was removed for winter studies.

The study consisted of four hog feeding trials. Data for the first trial were obtained by the previous investigator during the summer of 1954. The data were analyzed and presented in this thesis. The second trial was conducted during the winter of 1954-1955. Temperature, relative humidity and ventilation rates were recorded as well as

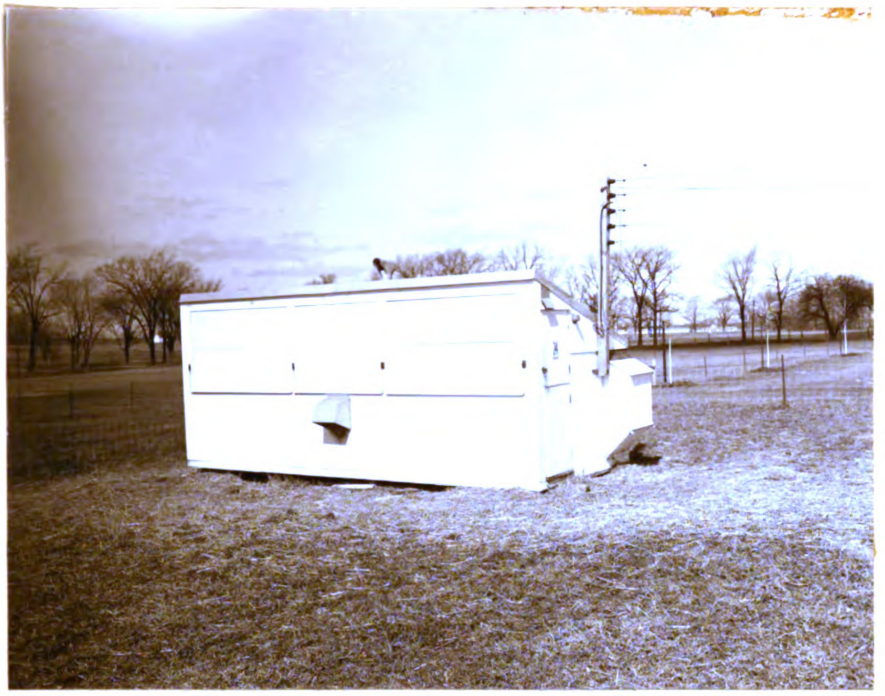

Fig. 1. The dark house used for the study.

Fig. 2. The conventional house used as a control for the study.

the weight and feed consumption of the hogs. The air conditioned house was put into operation and the third trial was conducted during the summer of 1955. Figure 3.

Fig. 3. The four test houses used for the summer study of 1955.

For the final trial during the winter of 1955 - 1956, the air conditioner was removed and the house was oriented to the east. The other houses were oriented to the south. Artificial heat was used in the dark house for the final trial.

A preliminary study to determine the difference in germicidal effect of sunlight passing through double pane and single pane glass was made. The study was conducted by Dr. Mallmann of the Microbiology Department of Michigan

State University. A three comparment constant temperature cabinet was used, Figure 4. One compartment admitted sunlight through double pane glass, the second through single pane glass while the third did not admit sunlight. Bacteria were placed in each compartment and exposed for varying lengths of time. Results of the preliminary tests were all negative and the study was discontinued.

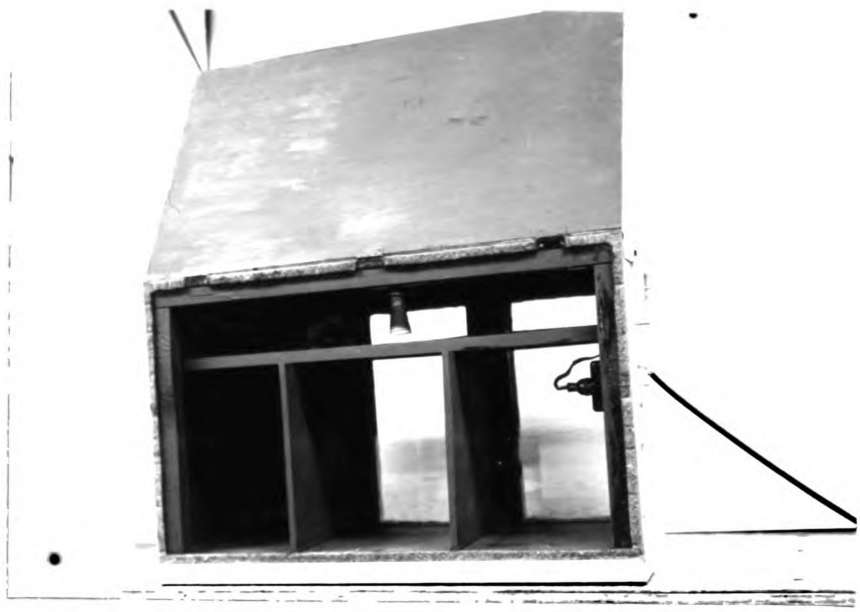

Fig. 4. The cabinet used for the bacteriological study.

Objectives of the Project

The objectives of the project were to determine the effect of improved environmental conditions on the production of market hogs and to determine the practicability of attaining such conditions.

Reasons for the Study

Breeding and nutrition of swine has progressed such that environmental conditions are a big factor in swine management. The effect of temperature on swine has been studied in psychrometric chambers by Heitman, Bond and Kelly (11) and the data obtained indicate that a controlled environment would increase the growth and feed efficiency of swine.

Insulation and ventilation are essential in the attainment of a controlled environment in swine housing. Further improvement may be obtained by using double pane windows in a solar house to utilize solar energy more efficiently. Still further improvement may be obtained by the use of air conditioning during the summer and artificial heat during the winter. Data from this study will be useful in determining the practicality of attaining a controlled environment for swine.

REVIEW OF LITERATURE

The effect of temperature on swine was studied by Heitman, Bond and Kelly (11). The results of their study are shown in Figure 5. The study revealed that fattening hogs weighing 200 pounds reach a peak in their average daily growth rate at 60°F. Pigs that weighed 100 pounds reached a peak at 70°F. Both above and below these temperatures efficient utilization of feed declined. High ambient temperatures cause the average daily gain to drop more readily than feed consumption, therefore, the amount of feed required to produce a certain gain increases rapidly.

For hogs weighing over 200 pounds, Heitman and Hughes (10) found that only their respiration rate increases when the relative humidity is increased except at high temperatures when their body temperatures also increase slightly.

Fletcher and Tidwell (5) reported that direct exposure to sunlight caused an increase in body temperature of swine. Body temperature increases were accompanied by significant increases in respiration rate.

Brandt (3) reported that double pane windows used in a solar oriented hog house provided a more favorable temperature environment during the winter. The better environment was conducive to higher rates of gain in weight.

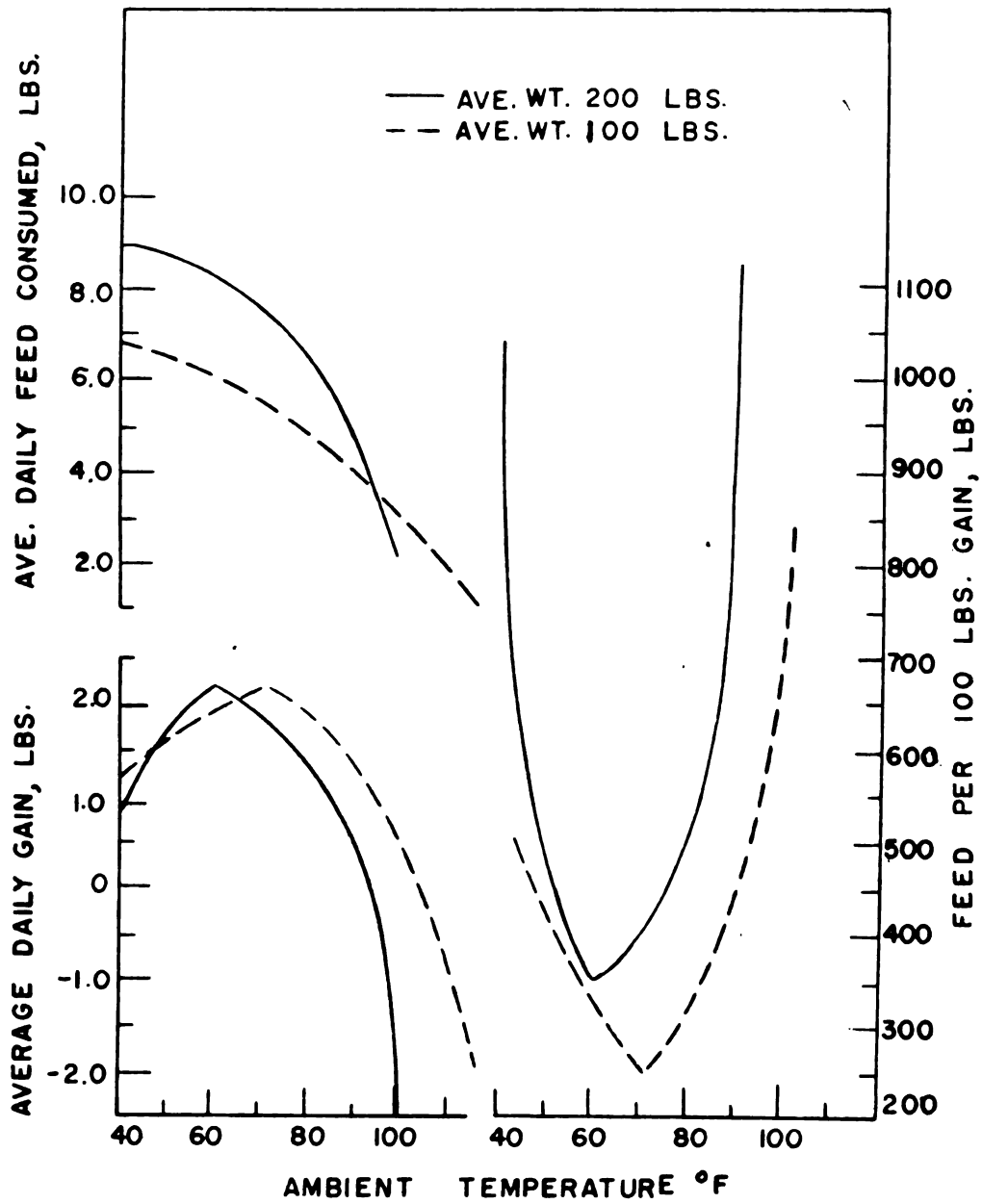

Figure 5. Temperature and its effect on feed consumption, average daily gain and feed utilization (H. Heitman, T.E. Bond and C.F. Kelly, California Agriculture, 1954)

APPARATUS AND METHODOLOGY

Equipment

Wall construction details of the test houses included 2" x 4" studs insulated with one-inch blankets of balsam wool and covered with one-quarter inch exterior plywood on both surfaces. Roof and floor construction contained two and one-half inches of rock wool insulation between the joists and a three-eighths inch exterior plywood covering on both surfaces.

The house was divided into two pens approximately 8' x 8' and each pen was equipped with a self feeder and an automatic waterer. Thermostatically controlled heat lamps protected the waterers from freezing during the winter.

Initial ventilation for each house was provided by a centrifugal fan of 300 cubic feet per minute free air capacity, and later supplemented with a 10-inch propeller fan of 440 cubic feet per minute free air capacity. To provide constant ventilation rates for each house the large fans were controlled by a single thermostat located in the single pane house, while the small fans were controlled by a time clock.

Winter, 1954 - 1955

The only change made in the test houses for the winter study of 1954 - 1955 was the installation of aluminum coated roll roofing over the exterior plywood roof deck. The conventional house used as the control was replaced with a house of newer construction.

Summer, 1955

For the summer study of 1955 the air conditioned house was put into operation. The window type air conditioner was installed in the center of the rear wall of the house as shown in Figure 6. The unit was protected from the hogs inside of the house by a wood cabinet. The top and bottom of the cabinet was open since the air outlet and inlet were respectively located at the top and bottom of the unit. An auxiliary air filter was placed immediately below the air inlet of the unit to trap the dust entering the unit. The interior view of the air conditioner is shown in Figure 7.

The air conditioner was a one horsepower unit with a cooling capacity of 10,600 Btu/hr and a moisture removal capacity of 3.25 pints per hour. The unit was also equipped with a four-way reversing valve enabling it to heat as well as cool. Baffles in the unit directed either the room air or the outside air through the cooling coils. The maximum cooling capacity could be obtained by recirculating the room air through the unit.

Fig. 6. Installation of the air conditioner in the rear wall of the house.

Fig. 7. Interior view of the air conditioner installation.

A 10 inch propeller fan was installed in the air conditioned house for future use, since it was assumed that ventilation would not be needed with air conditioning.

The thermostat controlling the propeller fans in the other test houses was moved from the single pane house to the double pane house.

The conventional house on the concrete slab was supplemented with a metal livestock shade. (Figure 8)

Fig. 8. The conventional house supplemented with a portable shade for the summer study of 1955.

Winter, 1955 - 1956

Changes in equipment for the winter study of 1955 - 1956 included removal of the air conditioner and orientation of

the house to the east. The other test houses remained in their southern orientation.

Six 375 watt heat lamps were installed in the dark house and controlled by a thermostat. The lamps were placed at the top front wall in adjustable holders so they could be directed as desired.

The large ventilating fans in each house were equipped with individual time switches and thermostat arrangements. For the winter study of 1955 - 1956, the ventilation rates in the test houses were not constant but dependent upon the environment in each house. The small ventilating fans were not in operation.

Instrumentation

A sixteen point Brown recording potentiometer was used to record wet and dry bulb temperatures. A time clock was used to limit the operation of the potentiometer to one complete cycle of readings every hour. The potentiometer was housed in a heated shelter near the test houses.

Two copper-constantan thermocouples were located in each of the test houses, one used for the measurement of dry bulb temperature and the other for wet bulb temperature. One thermocouple was used for measuring the dry bulb temperature in the conventional house on the slab and one thermocouple for outside dry bulb. The thermocouples

were centrally located about five feet above the floor. The thermocouple for measuring outside temperature was located under the instrument shelter to minimize radiation effects.

Wet bulb temperatures were obtained by using a constant feed wet bulb apparatus as described by Brandt (3)*.

Operation of the ventilating fans were recorded by "Tempscribe" operational recorders located in the instrument shelter.

Procedure

For each study healthy pigs were lotted into uniform lots according to standard procedure. Weight, sex, litter and breed were taken into account. Six pigs were placed in each house. The pigs were weighed at two-week intervals and feed consumption figures were recorded.

The rations were self-fed and adequately balanced for all known nutrients and included antibiotics.

The houses were cleaned and bedded every morning.

Operation of the recording instruments was checked and maintained periodically.

Hourly records of temperature and relative humidity were summarized as maximum, minimum and mean daily temperatures, and mean daily relative humidity.

The criteria for analysis of climatic data to determine the extent of improved environment were based on the

*Numbers in parenthesis refer to the appended bibliography.

level and attainment of a constant temperature. Emphasis was placed on comparison of mean daily temperatures and the daily variation in temperatures.

PRESENTATION AND ANALYSIS OF DATA

The hourly recorded temperature, relative humidity and ventilation data are bound and kept on file in the Department of Agricultural Engineering, Michigan State University.

The temperature data were summarized and presented as daily maximum, minimum and mean temperatures. Since the effect of relative humidity on swine is not thoroughly determined the humidity data were summarized only as daily mean relative humidity. A wet bulb apparatus was not maintained in the conventional house because the humidity in the house was very similar to the outside humidity. Data for outside humidity were obtained from the Michigan Hydrologic Research Project at Michigan State Univeristy.

In the following discussion the four types of housing used for the summer study of 1954 and the winter study of 1954 - 1955 are referred to as: House A, the conventional house on the concrete slab; House B, the house with the double pane windows; House C, the house with single pane windows; and House D, the dark house. House D was provided with artificial heat for the winter study of 1955 - 1956.

The fifth house added for the summer study of 1955 and the winter study of 1955 - 1956, is referred to as House E. House E was equipped with an air conditioning unit for the

summer study of 1955 and for the winter study of 1955 - 1956 the air conditioning unit was removed and the house was oriented to the east.

Part 1 - Analysis of the Summer Study of 1954

The summer study started on June 3, 1954 and ended on September 23, 1954, when several of the hogs had reached market weight. Missing temperature and humidity data were due to operational failure of the potentiometer or the wet bulb apparatus. The maximum, minimum and mean daily outside temperatures and inside temperatures of Houses A, B, C and D are shown in Figures 9, 10, 11, 12 and 13, respectively. The mean daily relative humidity in the four test houses is shown in Figure 14.

Temperature. The temperatures in House A followed closely the outside temperatures. The mean daily temperatures in the house were slightly higher than the outside temperatures throughout the entire study. Daily maximum temperatures in the house agreed with the outside maximum temperatures but the daily minimum temperatures were considerably higher than outside minimum temperatures.

For the first twelve weeks of the study the maximum, minimum and mean temperatures in both Houses B and C were similar to House A. This was attributed to the high ventilation rates used in the summer. During the last four

weeks of the study the minimum temperatures in Houses B and C were considerably higher than in House A due to colder weather. The mean temperatures in Houses B and C were only slightly higher than in House A. The temperatures in Houses B and C were almost identical throughout the entire study.

In House D the temperatures were generally lower than in Houses B and C but the difference was not great. The lower temperatures in House D were due to the absence of windows which reduced the heat gain into the building.

Hourly recorded temperatures in the four test houses did not vary appreciably.

Relative humidity. Figure 14 shows that the humidity in House A varied widely during the study while the humidity in Houses B, C, and D were very similar and no definite trend was noticeable.

Ventilation. Maintenance of minimum ventilation rates for moisture removal was accomplished by the centrifugal fans controlled by the time clock. At the start of the study the fans were operated seven and one-half minutes every half hour which resulted in a minimum ventilation rate of 12 cubic feet per minute per hog. When the hogs had reached an average weight of 125 pounds the fans were operated for ten minutes every half hour to give a minimum ventilation rate of 16 cubic feet per minute per hog.

The propeller fans were controlled by a thermostat located in the single pane house. A 75°F setting was maintained from the start of the study until the hogs had reached an average weight of 125 pounds. The thermostatic setting was then reduced to 70°F. Ventilation records showed that the fans ran continuously during the day for most of the study. Operation at night was intermittant.

Feeding trial. Results of the hog feeding trial are summarized in Table I. Highest daily gain of 1.53 pounds was made by the hogs in House B, while lowest daily gain of 1.39 pounds was made by the hogs in House A. The hogs in Houses C and D made respective daily gains of 1.47 and 1.49 pounds.

The best feed efficiency was made by the hogs in House B with 3.79 pounds of feed consumed per pound of gain, followed by the hogs in House C with 3.81 pounds of feed consumed per pound of gain. The hogs in Houses A and D had respective efficiencies of 4.03 and 3.94 pounds of feed consumed per pound of gain.

The average daily gain, average daily feed and feed consumed per pound of gain for each two-week period of the trial are shown in Figures 15, 16 and 17, respectively. The hogs in House B made consistently higher gains after the fourth week of the trial.

The hogs in House A consumed the greatest amount of feed per pound of gain during the first half of the study. No other significant trend was apparent in the gain or feed efficiency.

Conclusions. Environmental conditions in Houses B, C and D were similar and better than the conditions in House A. The hogs in Houses B, C and D showed a 7 percent increast in their rate of gain over the hogs in House A. The feed efficiency of the hogs in Houses B and C were 5 percent better than the hogs in House A. Improved conditions affected the gain and feed efficiency of the hogs.

The absence of sunlight in House D did not affect the performance of the hogs.

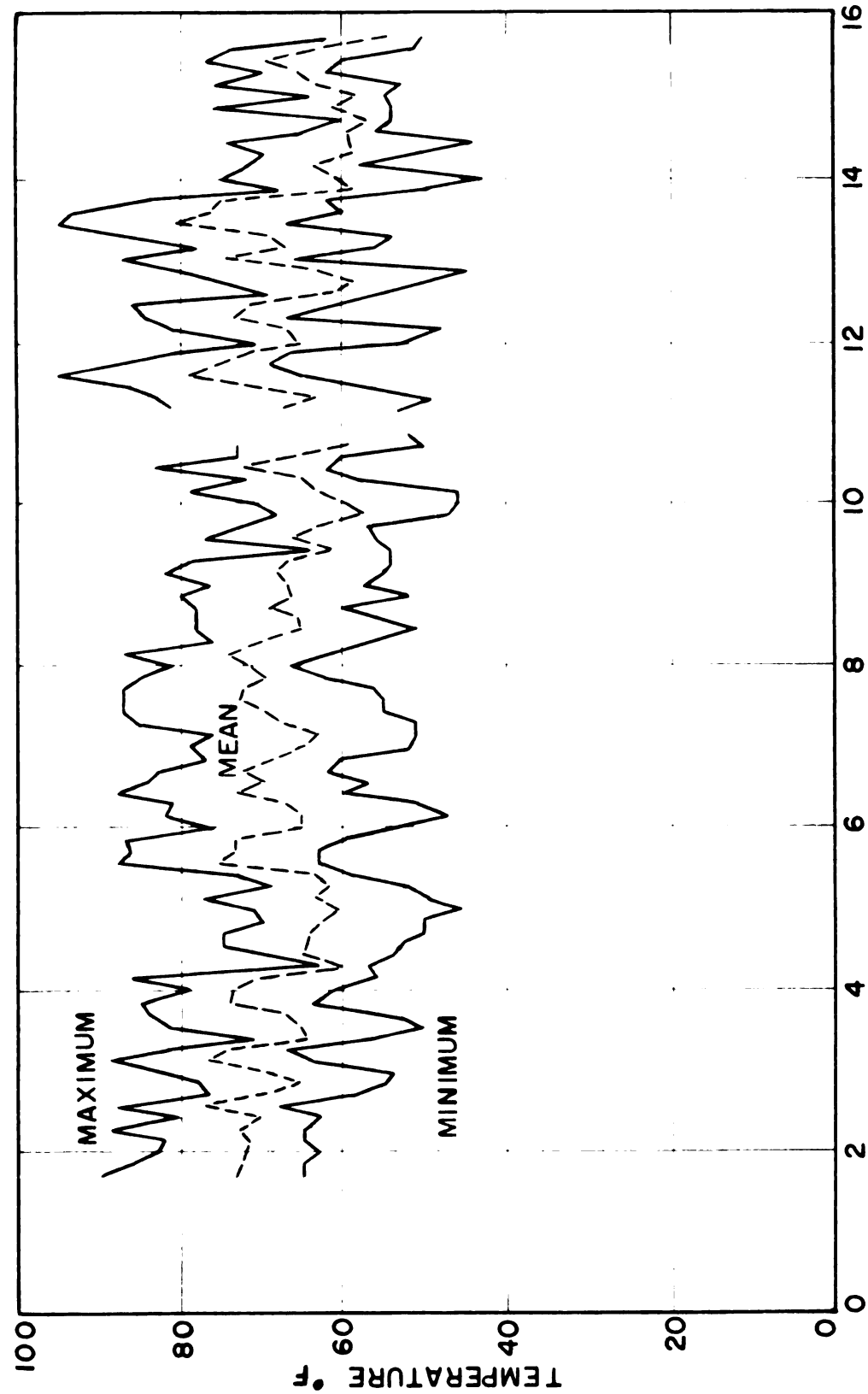

Figure 9. The maximum, minimum and mean daily outside temperatures from June 3, 1954 to September 23, 1954.

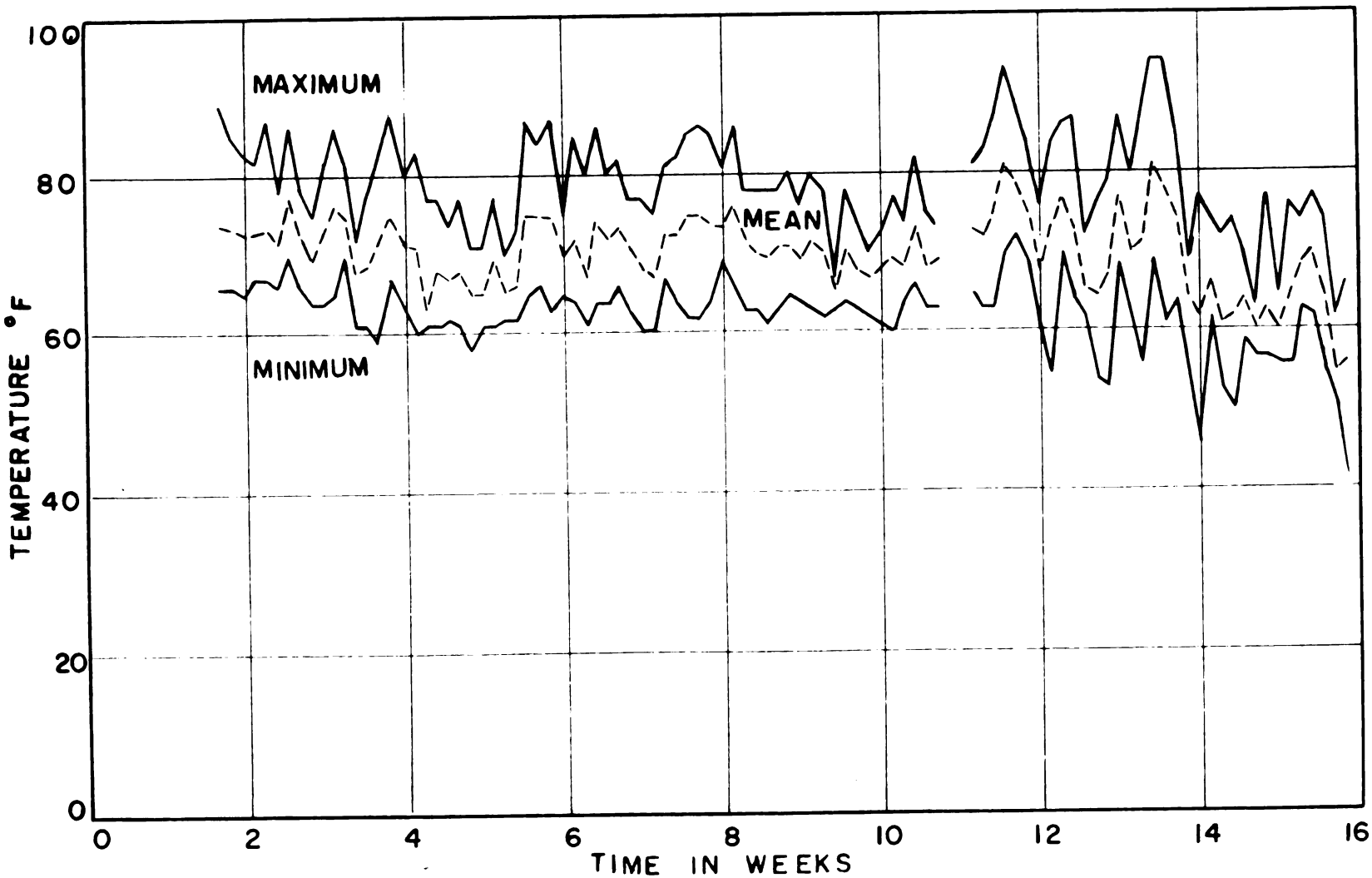

Figure 10. The maximum, minimum and mean daily temperatures in the conventional house from June 3, 1954 to September 23, 1954.

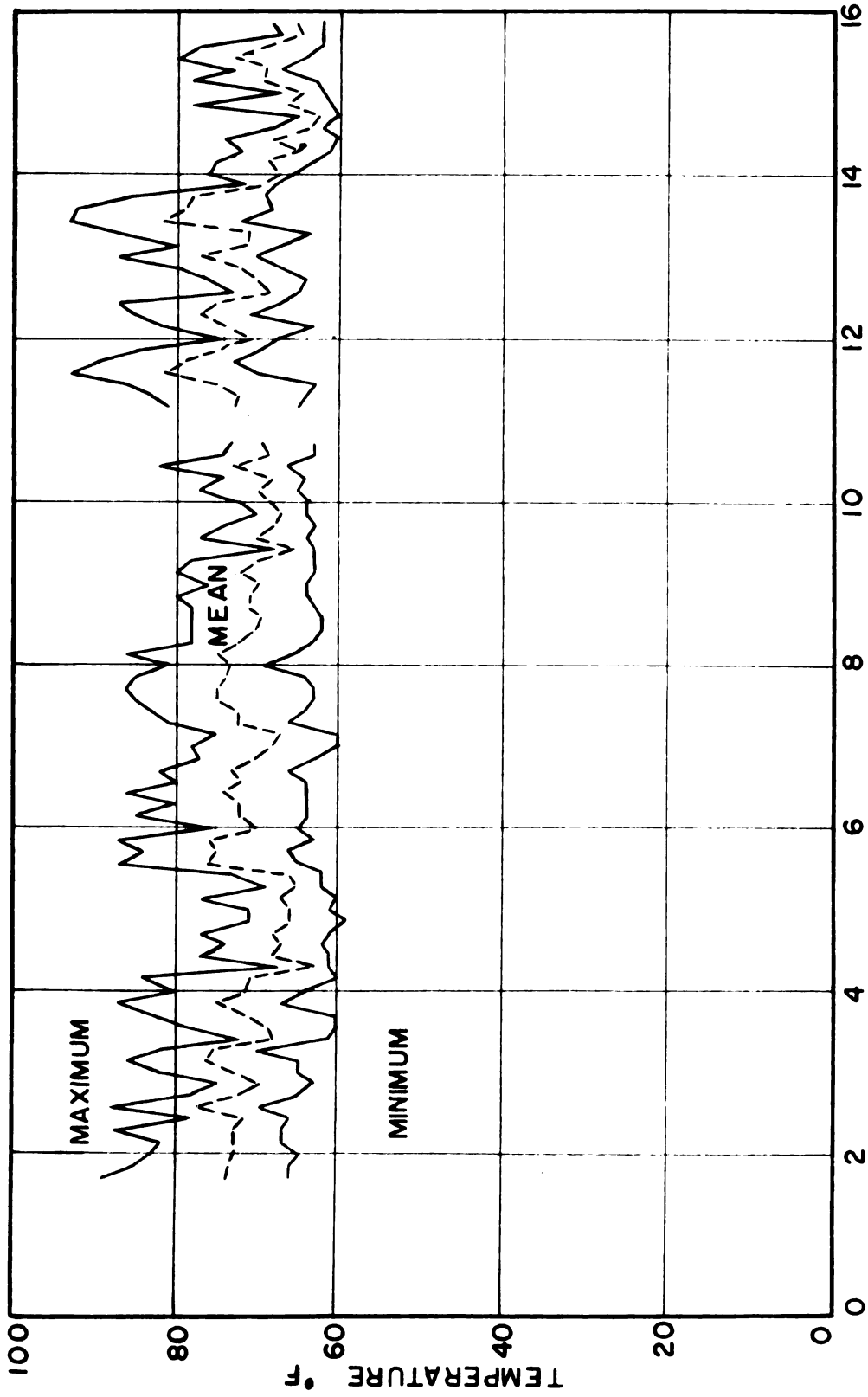

Figure 11. The maximum, minimum and mean daily temperatures in the double pane house from June 3, 1954 to September 23, 1954.

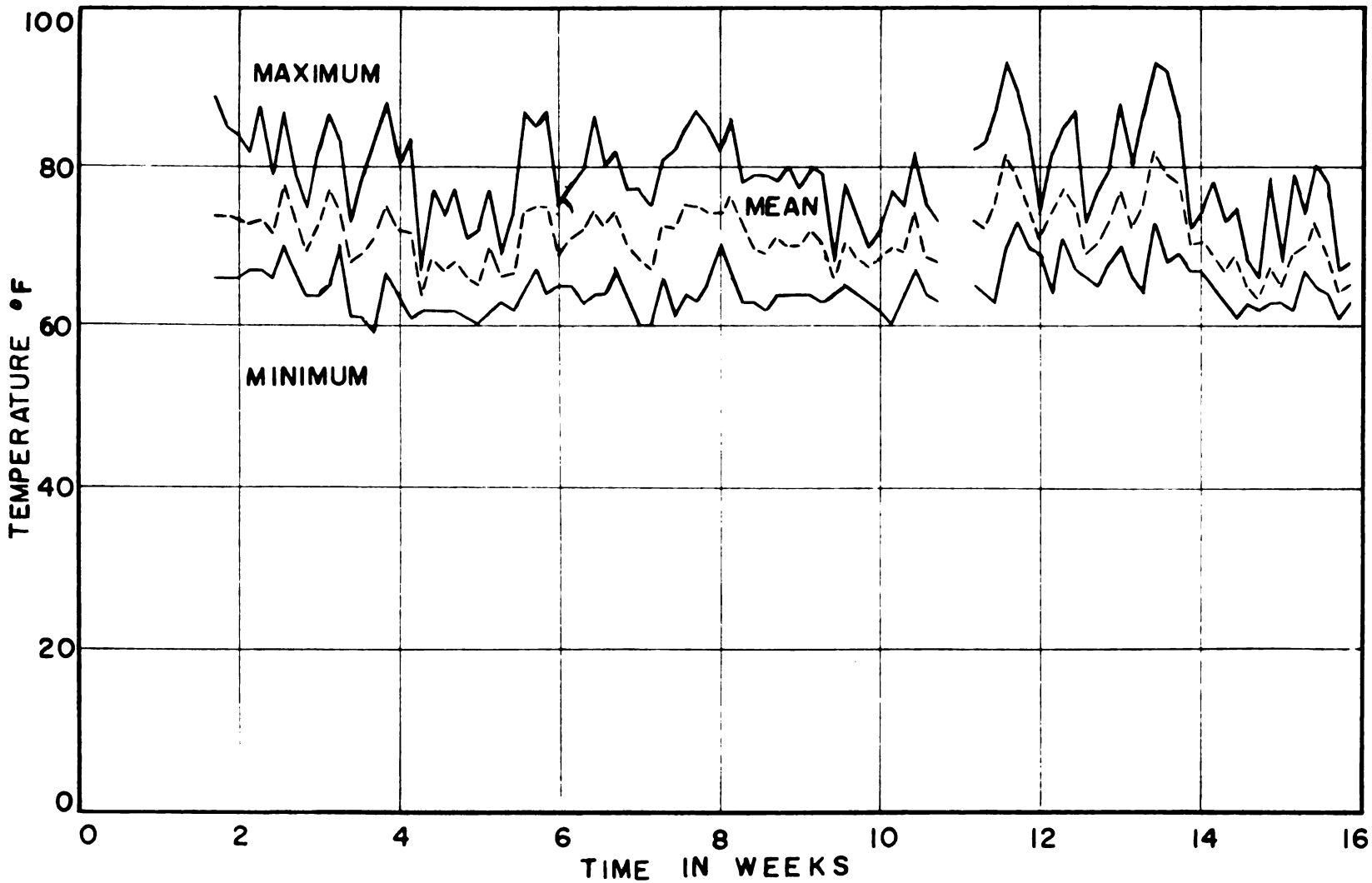

Figure 12. The maximum, minimum and mean daily temperatures in the single pane house from June 3, 1954 to September 23, 1954.

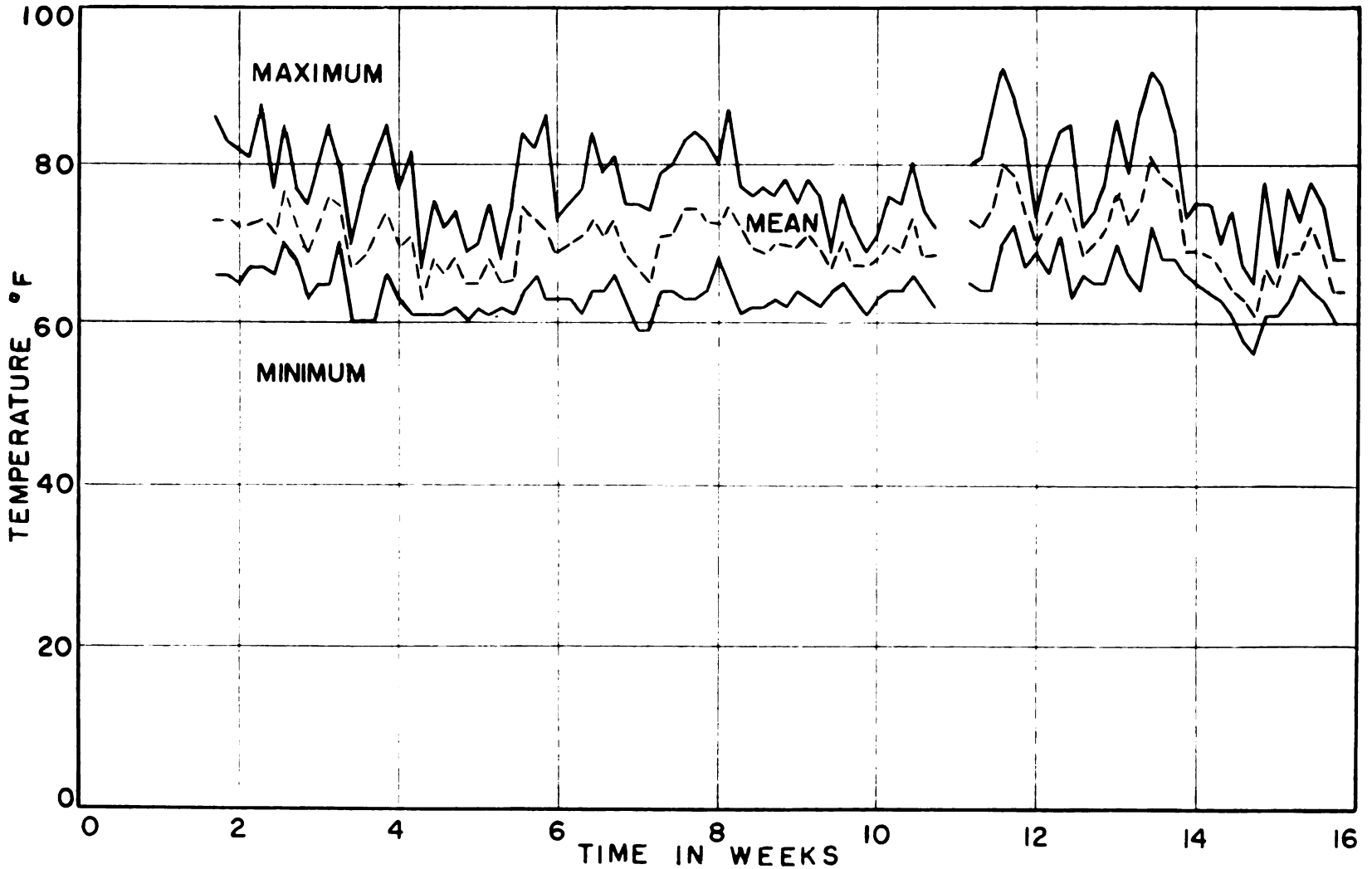

Figure 13. The maximum, minimum and mean daily temperatures in the dark house from June 3, 1954 to September 23, 1954.

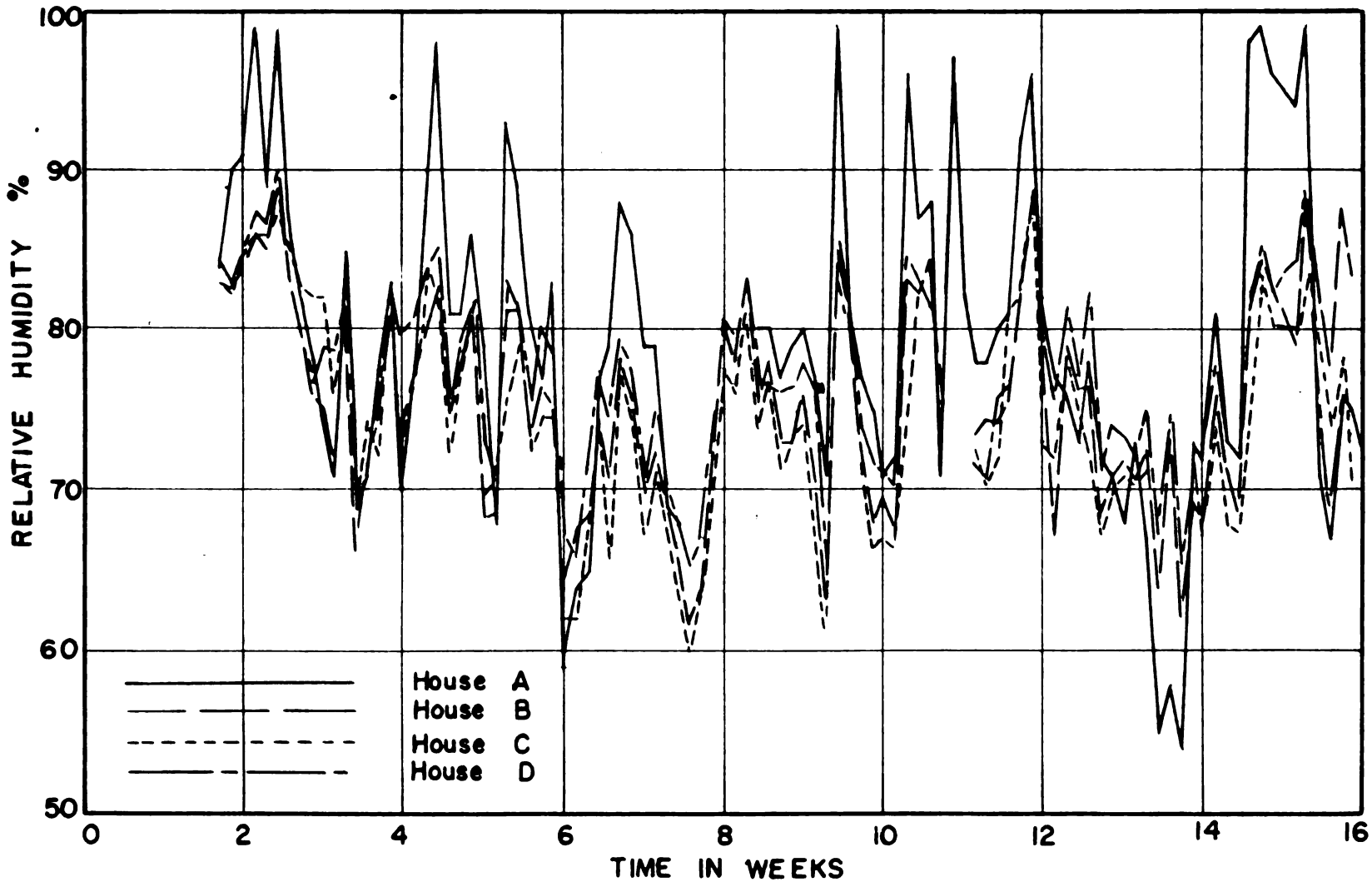

Figure 14. The mean daily relative humidity in the four test houses from June 3, 1954 to September 23, 1954.

TABLE I

SUMMARY OF THE RESULTS FOR THE HOG FEEDING TRIAL OF THE SUMMER STUDY OF 1954

	Treatment			
	House A	House B	House C	House D
Number of pigs	6	6	6	6
Average initial weight in pounds	39.7	39.5	39.9	39.9
Average final weight in pounds	194.8	210.4	204.5	206.5
Average daily gain in pounds	1.39	1.53	1.47	1.49
Average daily feed consumption per pig in pounds	5.57	5.77	5.59	5.86
Pounds of feed consumed per pound of gain	4.03	3.79	3.81	3.94

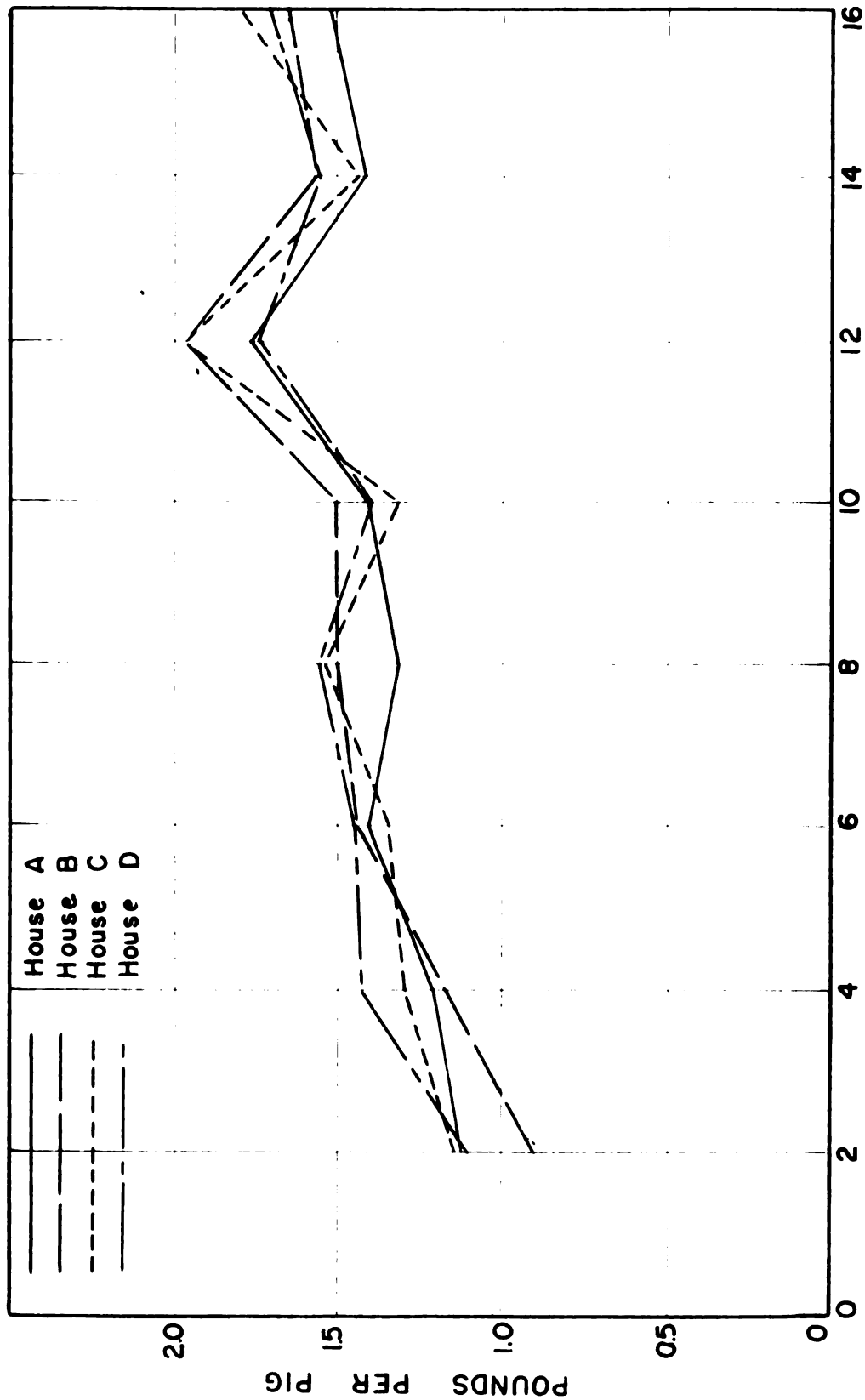

Figure 15. The average daily gain per hog for each two week period of the summer study of 1954.

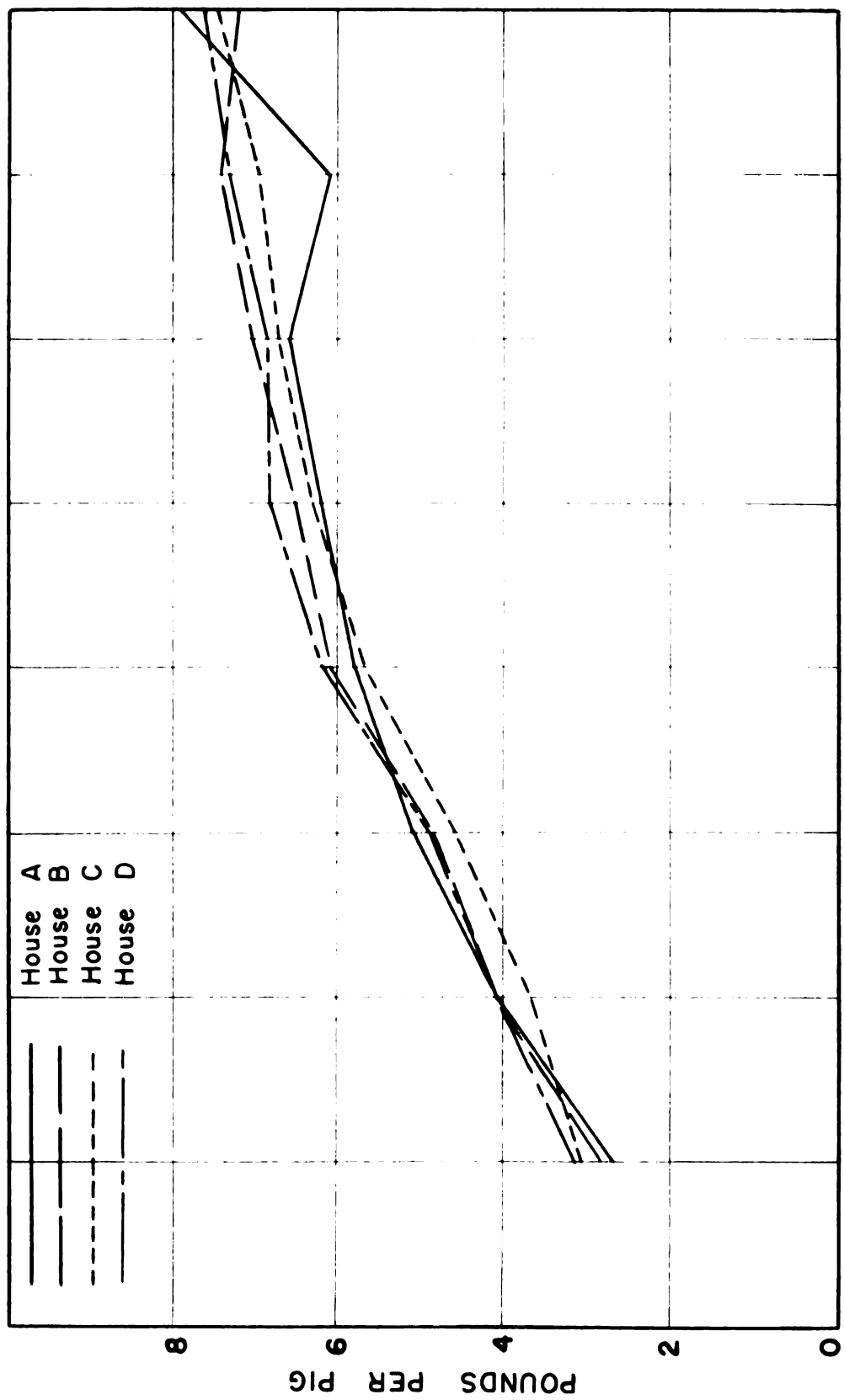

Figure 16. The average daily feed consumption per hog for each two week period of the summer study of 1954.

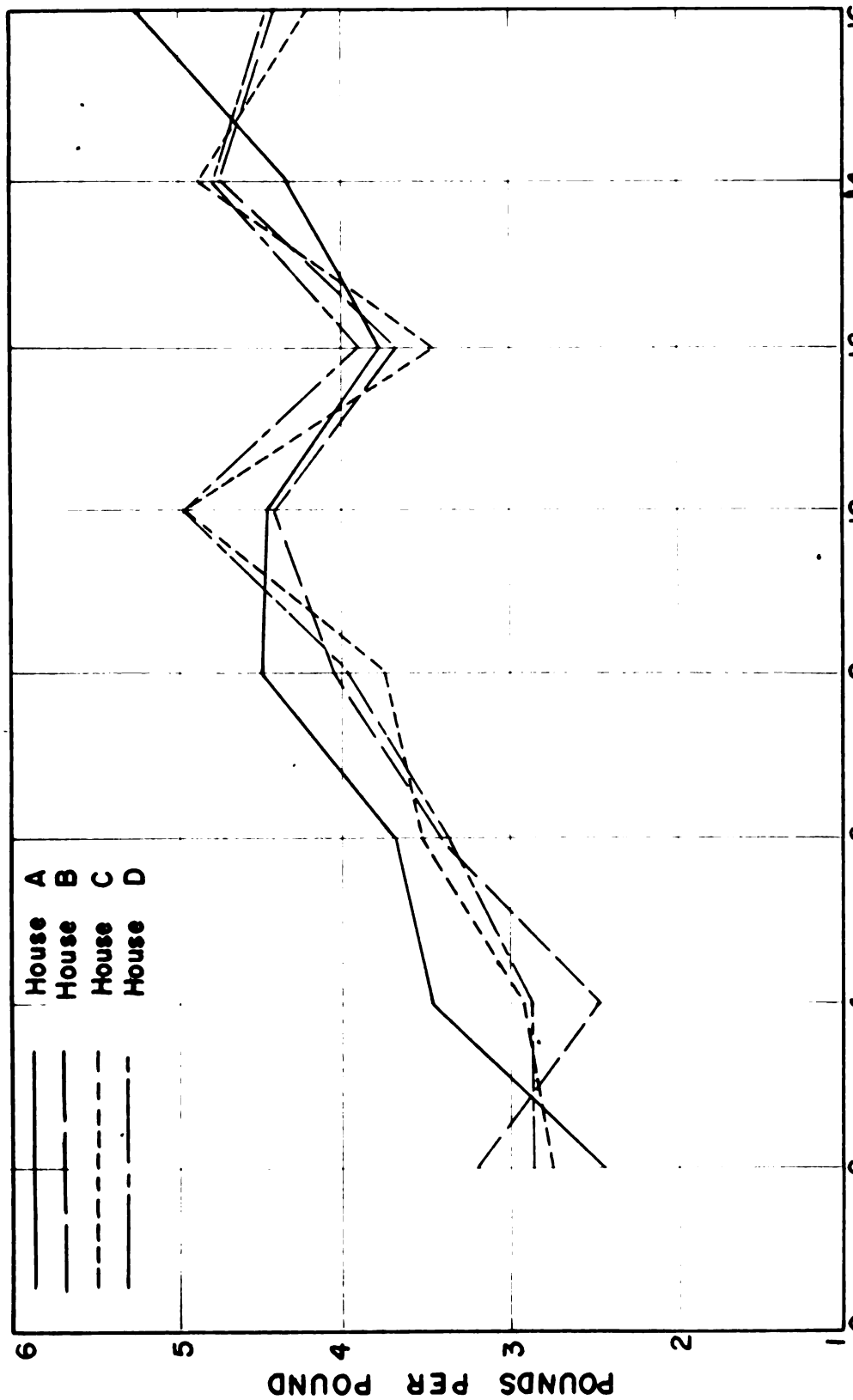

Figure 17. The amount of feed consumed per pound of gain for each two week period of the summer study of 1954.

Part II - Analysis of the Winter Study of 1954 - 1955

The winter study was started on December 17, 1954 and ended on April 8, 1955.

The maximum, minimum and mean daily outside temperatures and inside temperatures of Houses A, B, C and D are shown in Figures 18, 19, 20, 21 and 22, respectively. The mean daily relative humidity in the four test houses is shown in Figure 23.

Temperature. The temperatures in House A again were higher than outside temperatures and the difference was greater as the study progressed.

During the first six weeks of the study the minimum temperatures in Houses B and C were similar while the maximum temperatures were higher in House C. The higher maximum temperatures in House C were due to the greater amount of solar heat gain through the single pane windows. Since higher maximum temperatures were reached in House C the mean temperatures were also higher, and daily variations in temperature were greater.

For the last six weeks of the study the minimum temperatures in House C were lower than in House B while the mean temperatures in House B were higher than that of House C. No definite trend was noticeable for the maximum temperatures during the last eight weeks of the study.

The maximum temperatures in House D were considerably lower than in Houses B and C due to the lower heat gain of the building. The minimum temperatures in House D were similar to Houses B and C for the first six weeks of the study, but consistently lower during the last six weeks.

The rate of increase and decrease of temperature in the test houses was greatest in House C, and least in House D. Houses B and D had the best temperature conditions for the trial based on the level and attainment of a constant temperature.

Relative humidity. As in the previous study the relative humidity in House A varied widely while the humidities in the other three houses had a much narrower range. The mean relative humidity in House D was consistently higher than in Houses B and C. No trend was noticed between Houses B and C although higher humidities occasionally appeared in House B. This may have been due to large amounts of water splashed from the waterers by the hogs.

Ventilation. Ventilation rates were maintained in the same manner as described for the summer study of 1954.

Ventilation records showed that the propeller fans seldom went on during the first half of the study, while intermittent operation during the day occurred for the last half of the study.

Feeding trial. Results of the feeding trial are summarized in Table II. An epidemic of dermatosis at the swine farm necessitated the removal of three pigs from the trial. Two pigs were removed from House A and one from House C. All pigs in the trial were afflicted with the disease but the mildest cases occurred in House B. One ruptured pig was removed from House D.

Results of the trial show that the hogs with the highest daily gains of 1.50 pounds were made in House A and the hogs with the lowest daily gain of 1.28 pounds in House D. The hogs in Houses B and C had gains of 1.45 and 1.44 pounds respectively. No significant difference in feed efficiency was shown.

Figure 24 shows the average daily gain per hog for each two-week period of the study. The daily feed consumption and the feed consumption per pound of gain are shown in Figures 25 and 26, respectively. The only trend noted in the daily gains of the hogs was in House A where the gains were lowest for the entire first half of the study and consistently high for the last half of the study. The same trend was noted for the daily feed consumption of the hogs in House A.

Conclusions. Since the presence of disease in the feeding trial affected the performance of the hogs, sound conclusions could not be drawn.

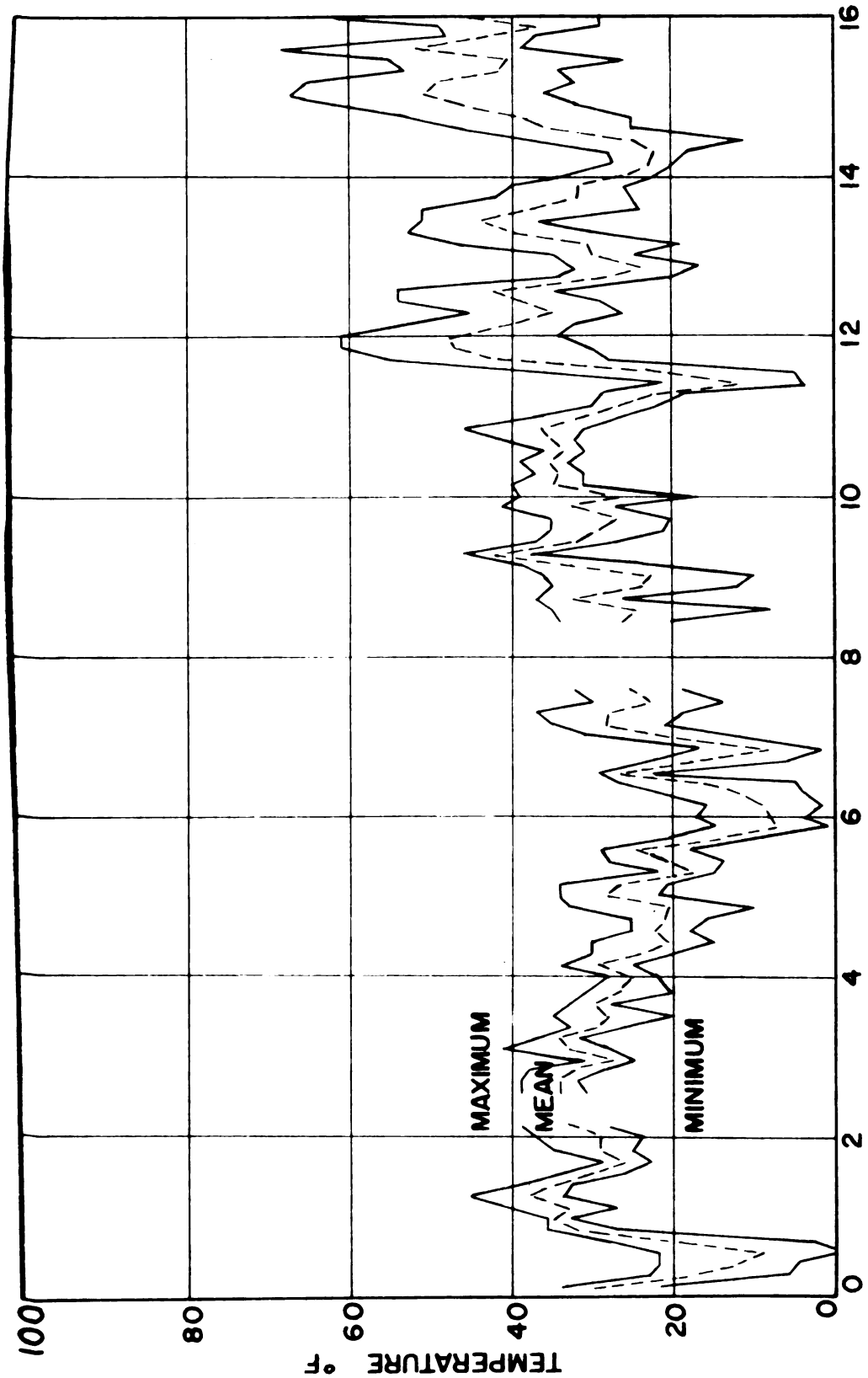

Figure 18. The maximum, minimum and mean daily outside temperatures from December 17, 1954 to April 8, 1955.

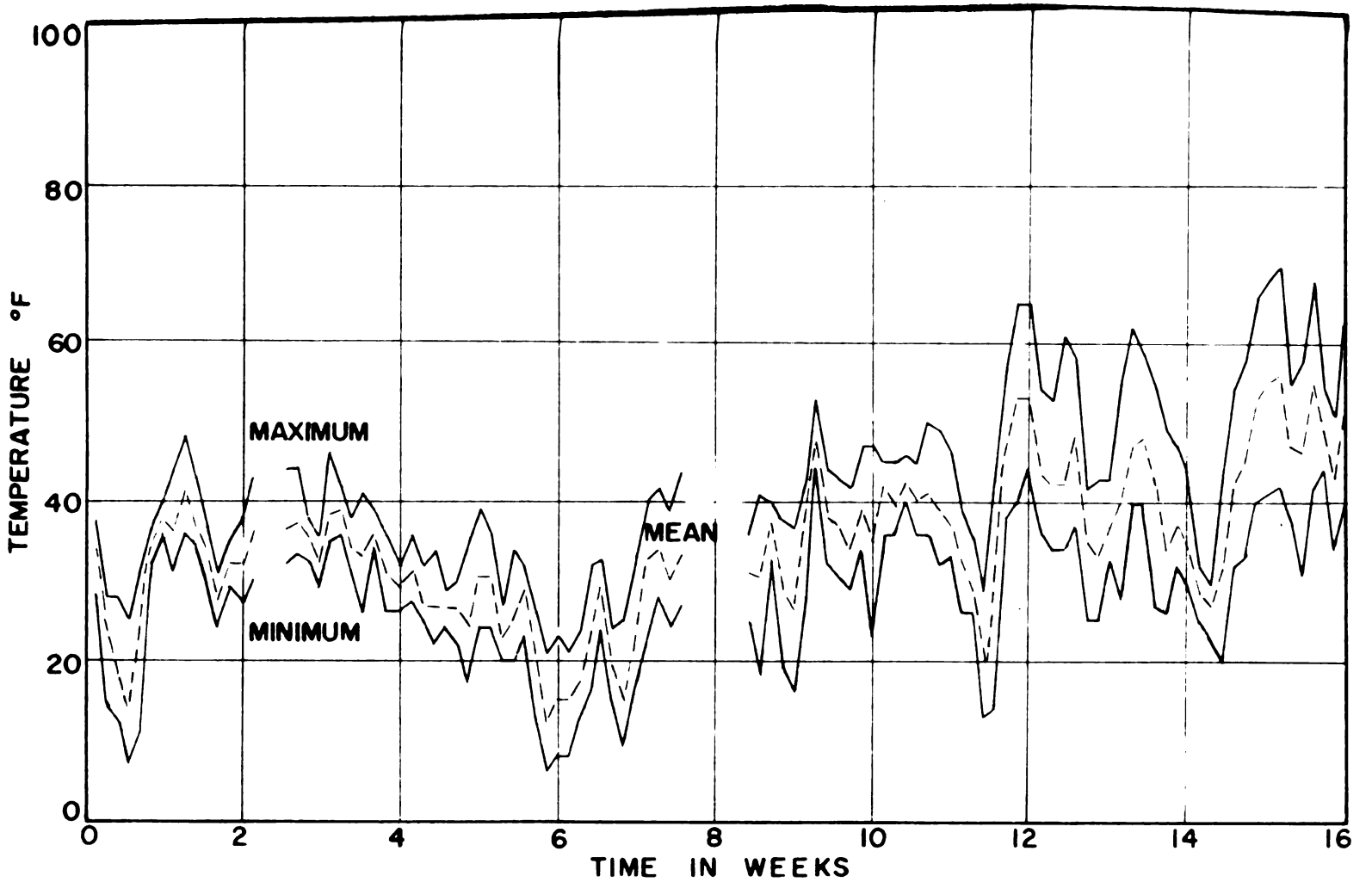

Figure 19. The maximum, minimum and mean daily temperatures in the conventional house from December 17, 1954 to April 8, 1955.

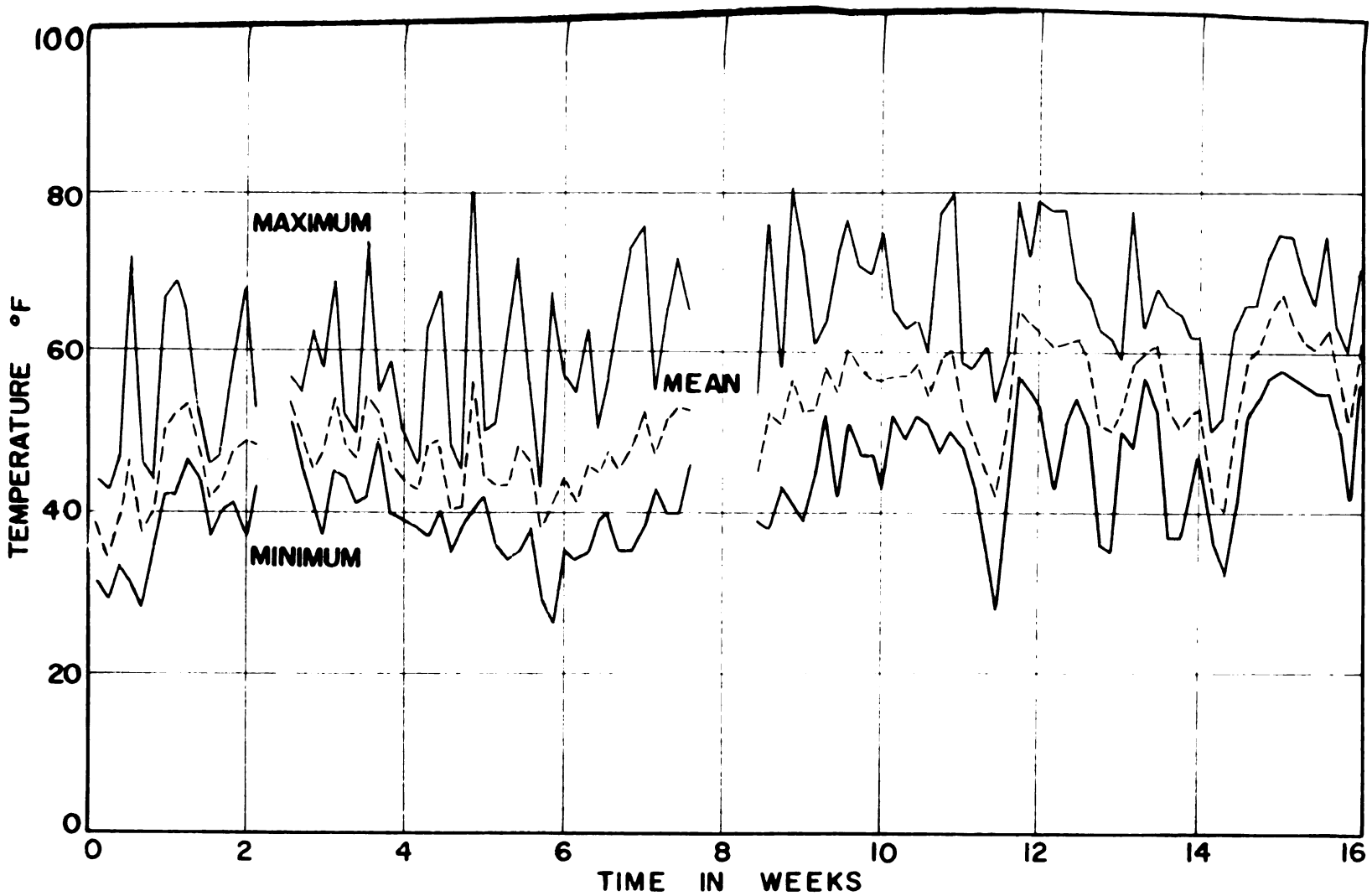

Figure 21. The maximum, minimum and mean daily temperatures in the single pane house from December 17, 1954 to April 8, 1955.

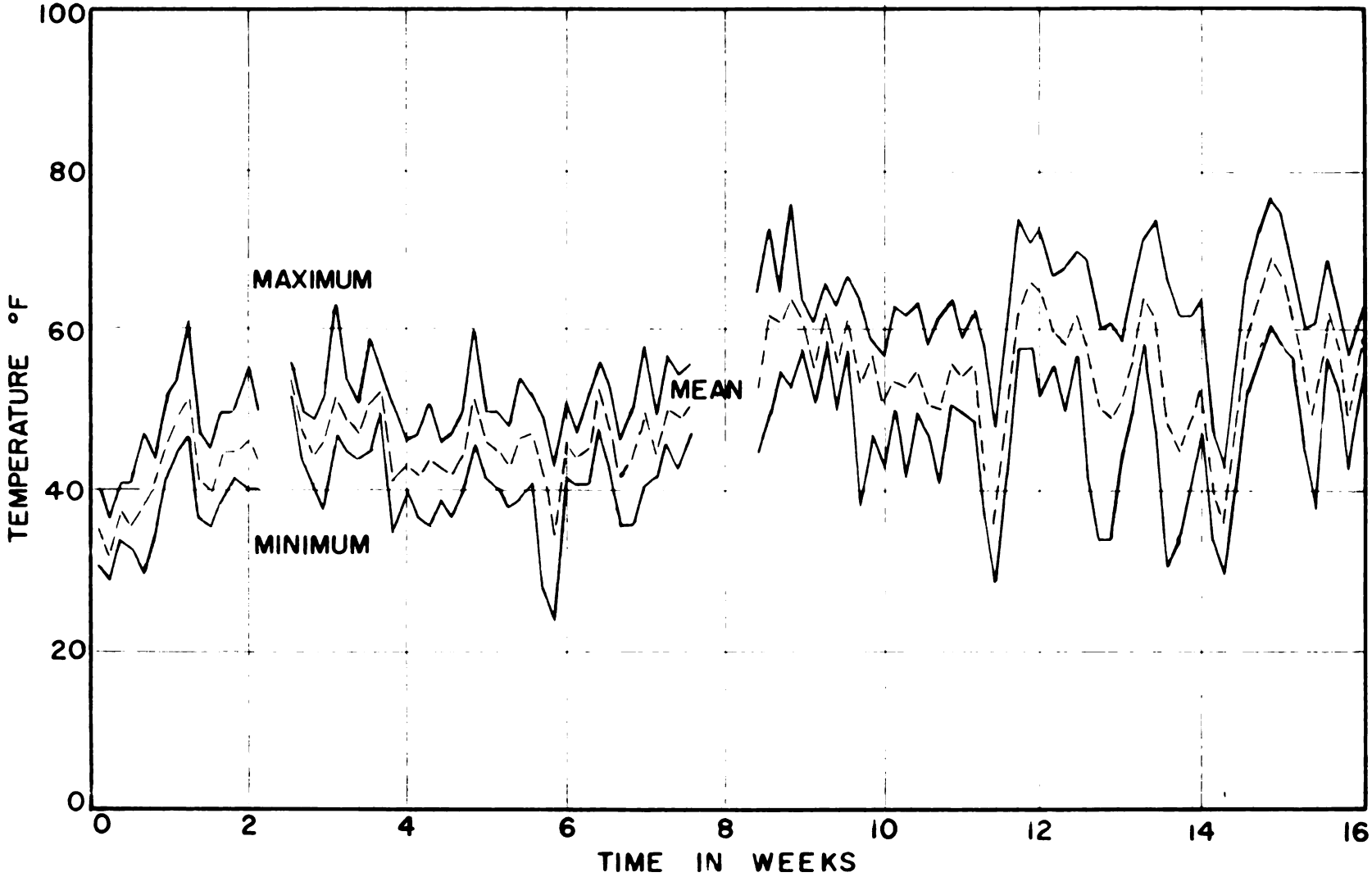

Figure 22. The maximum, minimum and mean daily temperatures in the dark house from December 17, 1954 to April 8, 1955.

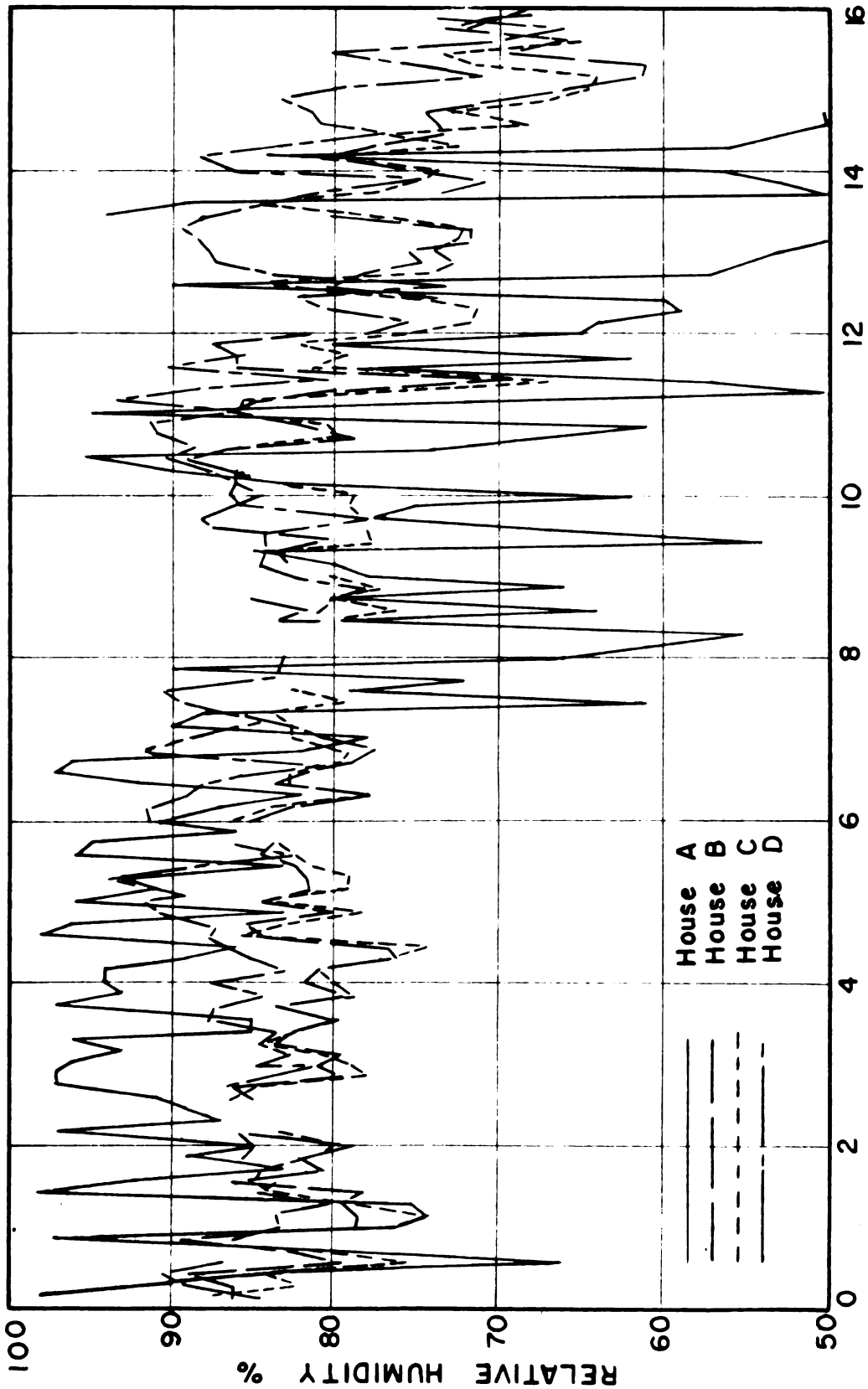

Figure 23. The mean daily relative humidity in the four test houses from December 17, 1954 to April 8, 1955.

TABLE II

SUMMARY OF THE RESULTS FOR THE HOG FEEDING TRIAL OF THE WINTER STUDY OF 1954-1955

	Treatment			
	House A	House B	House C	House D
Number of pigs	4*	6	5**	5#
Average initial weight in pounds	36.5	36.5	36.5	36.5
Average final weight in pounds	206.5	202.5	201.2	181.5
Average daily gain in pounds	1.50	1.45	1.44	1.28
Average daily feed consumption per pig in pounds	5.18	5.74	5.31	5.07
Pounds of feed consumed per pound of gain	4.07	3.97	3.97	4.01

*Two pigs removed (dermatosis)
**One pig removed (dermatosis)
#One pig removed (rupture)

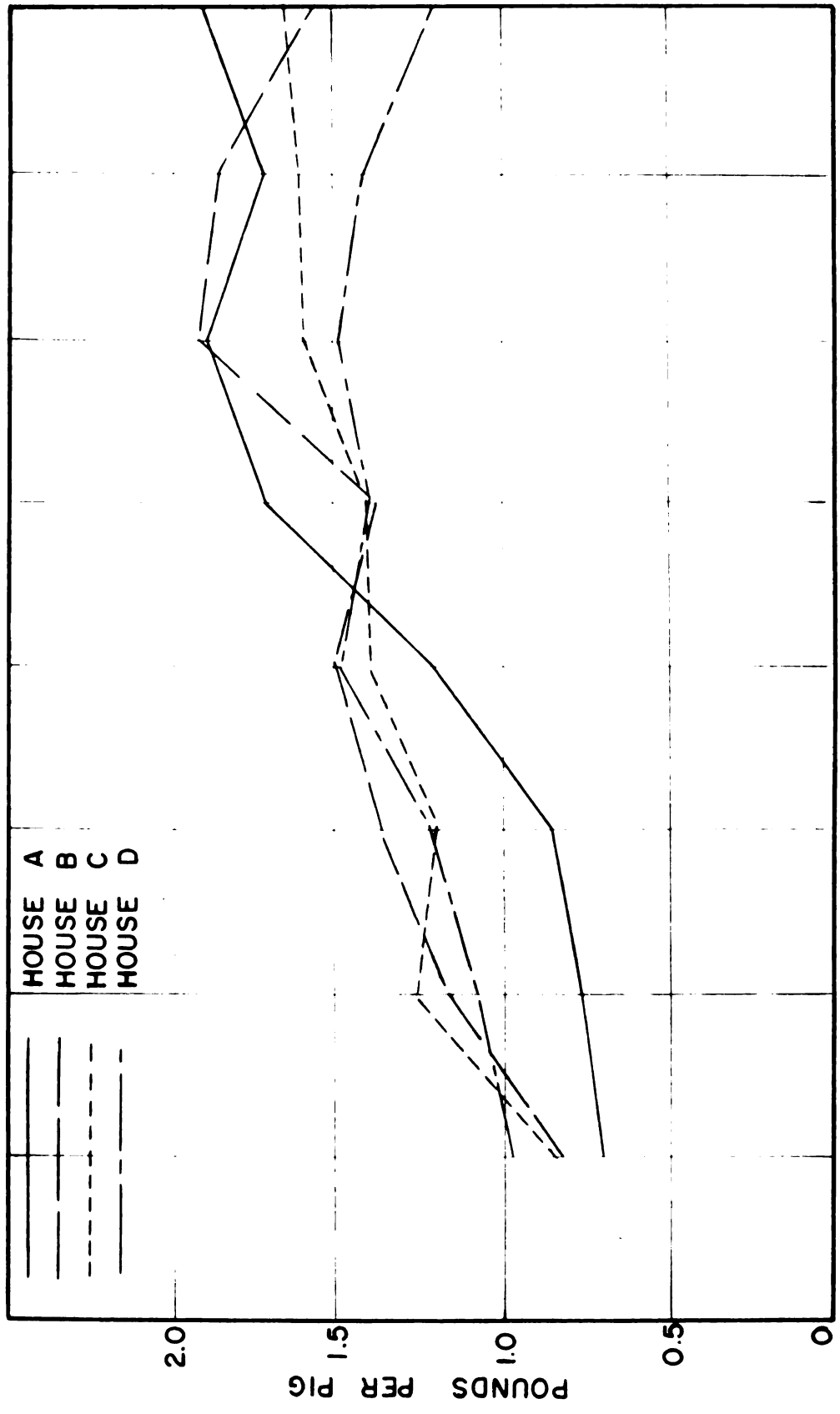

Figure 24. The average daily gain per hog for each two week period of the winter study of 1954 - 1955.

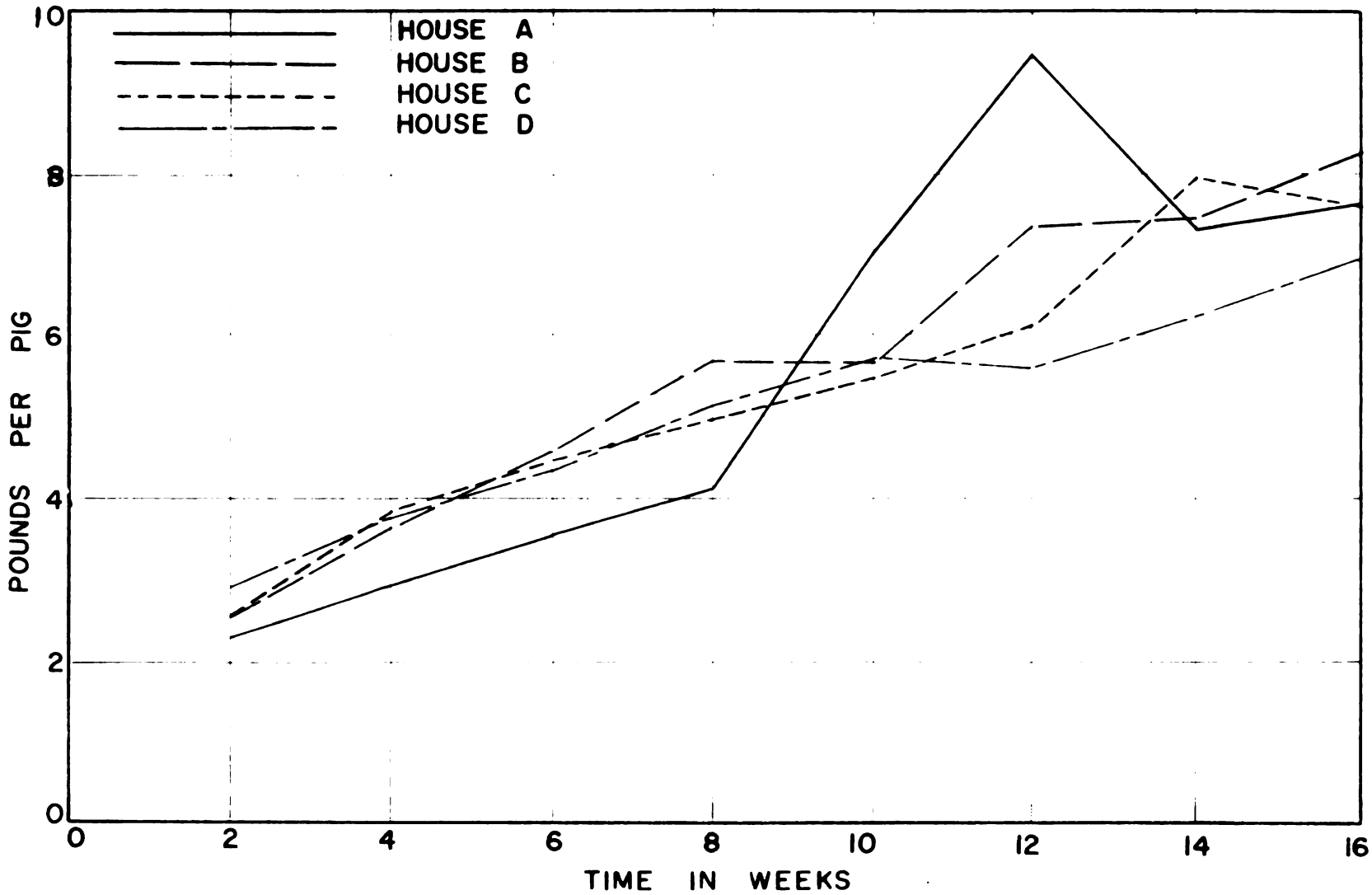

Figure 25. The average daily feed consumption per hog for each two week period of the winter study of 1954 - 1955.

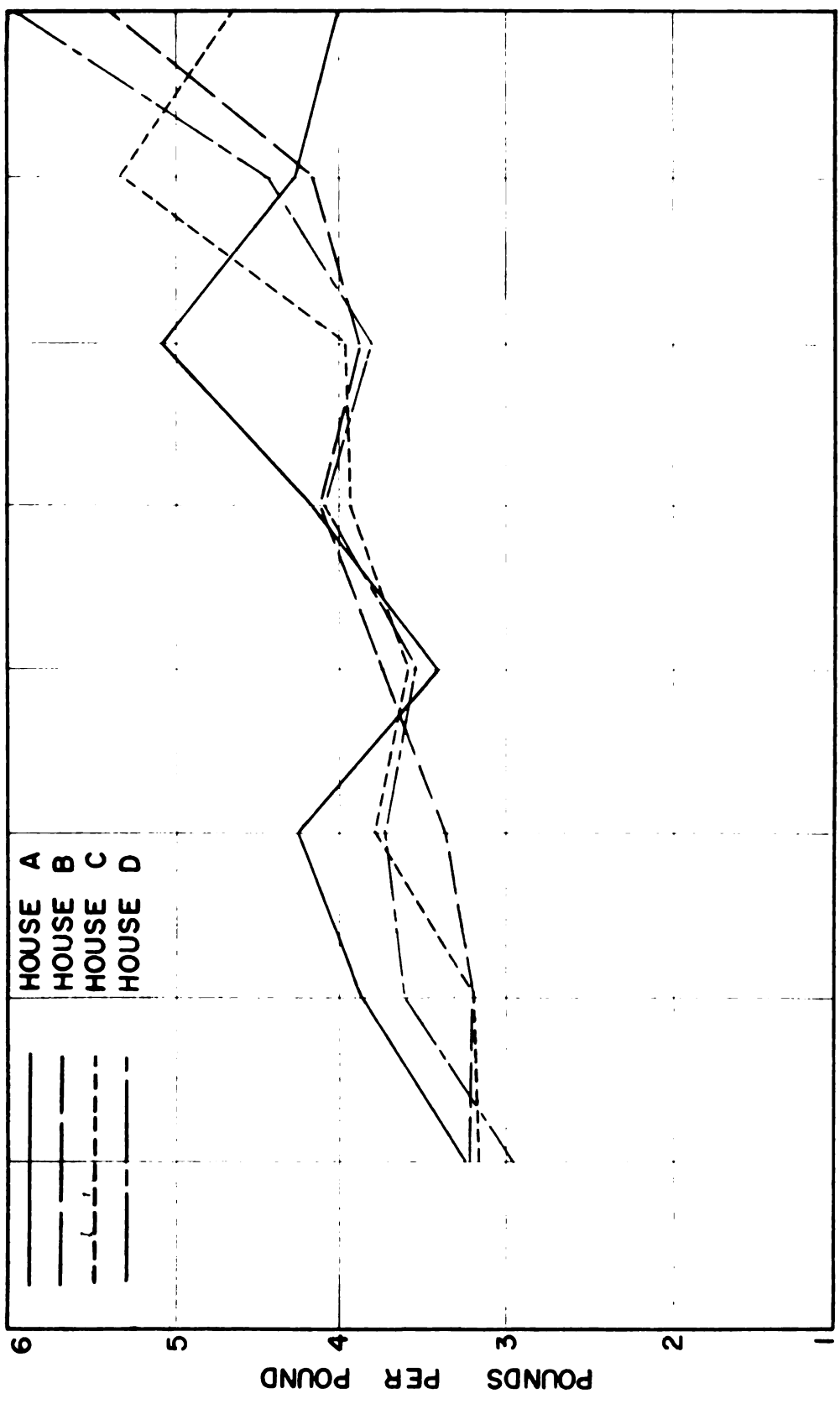

Figure 26. The amount of feed consumed per pound of gain for each two week period of the winter study of 1954 - 1955.

Part III - Analysis of the Summer Study of 1955

This study started on May 27, 1955 and ended September 2, 1955. Duration of the feeding trial was fourteen weeks.

The thermostat controlling the air conditioner was set at 75° for the entire trial. The unit did not have the capacity to maintain 75° by cooling the outside air and consequently the air in the house had to be recirculated.

The daily maximum, minimum and mean outside temperatures and inside temperatures of Houses A, B, C, D and E are shown in Figures 27, 28, 29, 30, 31 and 32, respectively. The mean daily humidity in Houses A, B and C is shown in Figure 33 and the mean humidity in Houses D and E is shown in Figure 34.

Temperature. As in the previous summer study the temperatures in House A were similar to the outside temperatures with only the daily means being slightly higher.

The temperatures in House B were lower than in House A with the greatest difference in the minimum and mean temperatures.

Temperatures in House C were similar to House B except that the minimum temperatures were occasionally lower.

Maximum temperatures in House D were generally lower than House B and C.

Hourly recorded temperatures in Houses B, C and D did not vary appreciably.

Temperatures in House E varied approximately from 69°F to 79°F except for a few days when the air conditioning unit was not functioning properly. Attainment of a constant temperature environment was best approached by House E.

Relative humidity. A comparison of the mean relative humidity in the houses showed that the greatest variation was in House A. Highest humidity existed in Houses D and E with House E containing the highest during the first half of the study and lowest for the last half.

Ventilation. Minimum ventilation rates in Houses B, C and D for moisture removal were increased for this trial. A minimum rate of 16 cubic feet per minute per hog was maintained for the first four weeks of the study. The hogs had reached an average weight of 70 pounds. For the remainder of the trial the minimum rate was maintained at 25 cubic feet per minute per hog.

A minimum ventilation rate was not maintained in House E because it was assumed that the air conditioning unit would accomplish moisture removal. However manual operation of the ventilating fan became necessary when ammonia odors began to build up in the house.

The location of the thermostat controlling the propeller fans in Houses B, C and D was moved from House C to House B. Thermostat settings were identical to those in previous trials. Ventilation records showed that the fans operated

continuously during the day and intermittently during the night. Air quality in the houses was improved by the increased ventilation rate.

Feeding trial. Results of the hog feeding trial are summarized in Table III. The hogs in House D had the highest daily gain of 1.66 pounds followed closely by the hogs in Houses B, C and E with respective gains of 1.63, 1.63 and 1.61 pounds. Lowest daily gain of 1.48 pounds was made by the hogs in House A.

The hogs in Houses E and B had the best feed efficiencies with 3.42 and 3.49 pounds of feed consumed per pound of gain, respectively. The hogs in Houses C and D made respective efficiencies of 3.55 and 3.53 pounds of feed consumed per pound of gain. The hogs in House A had the poorest efficiency with 3.79 pounds of feed consumed per pound of gain.

Figure 35 shows the average daily gain per hog for each two-week period of the study. The hogs in House A consistently had the lowest daily gains while no other marked trend was apparent.

Feed consumption and feed efficiency for each two-week period are shown in Figures 36 and 37 respectively. The hogs in House E had the poorest feed efficiency for the first half of the study but improved for the last half. The most erratic efficiency throughout the study was shown by the hogs in House A.

Conclusions. The environmental conditions in Houses B, C, D and E were better than in House A. The hogs in Houses B, C, D and E had 10 percent better gains and feed efficiencies than the hogs in House A. The degree of attainment of the ideal constant temperature was not measurable in the performance of the swine.

The absence of sunlight in House D did not affect the performance of the hogs.

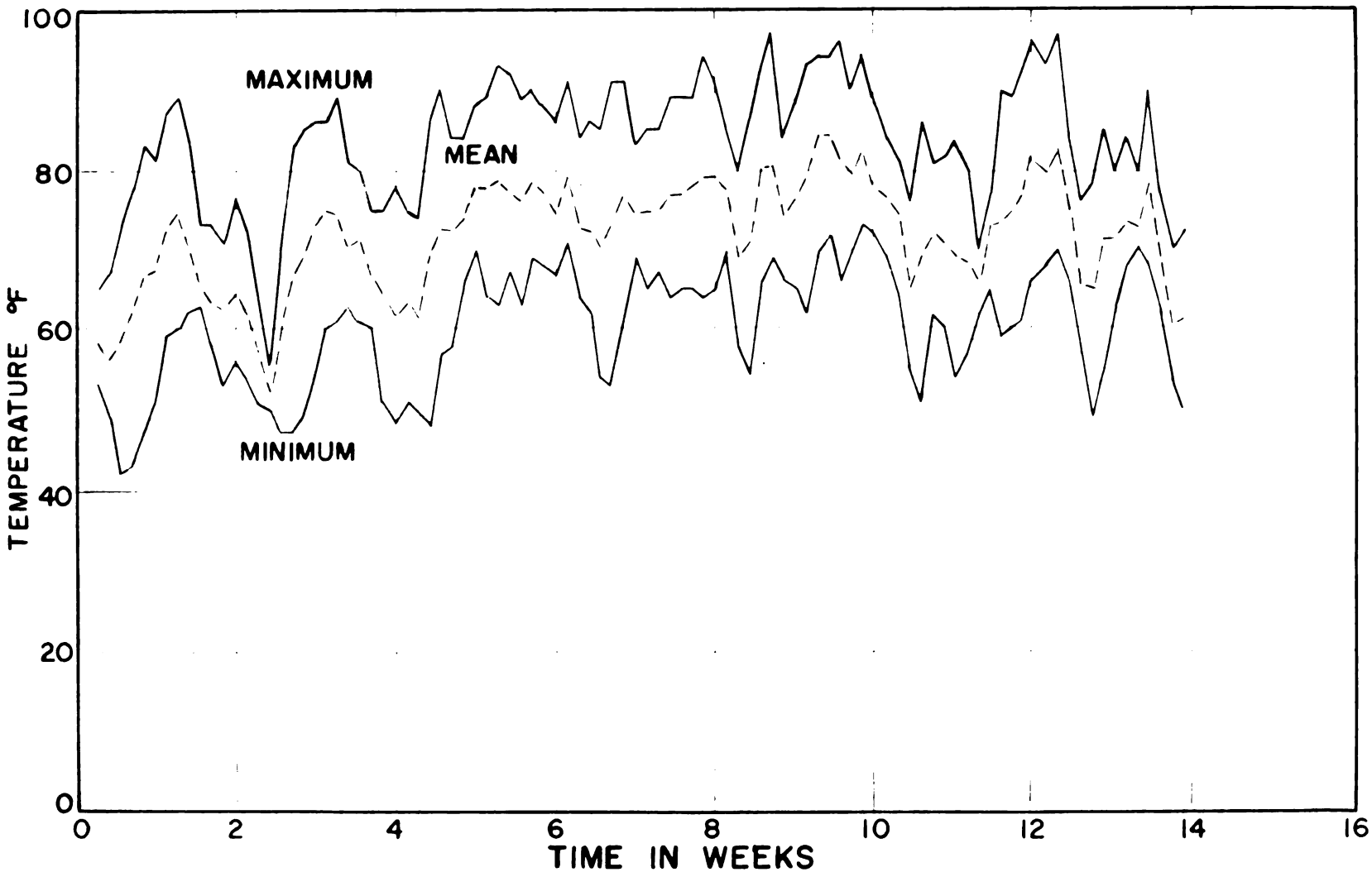

Figure 27. The maximum, minimum and mean daily outside temperatures from May 27, 1955 to September 2, 1955.

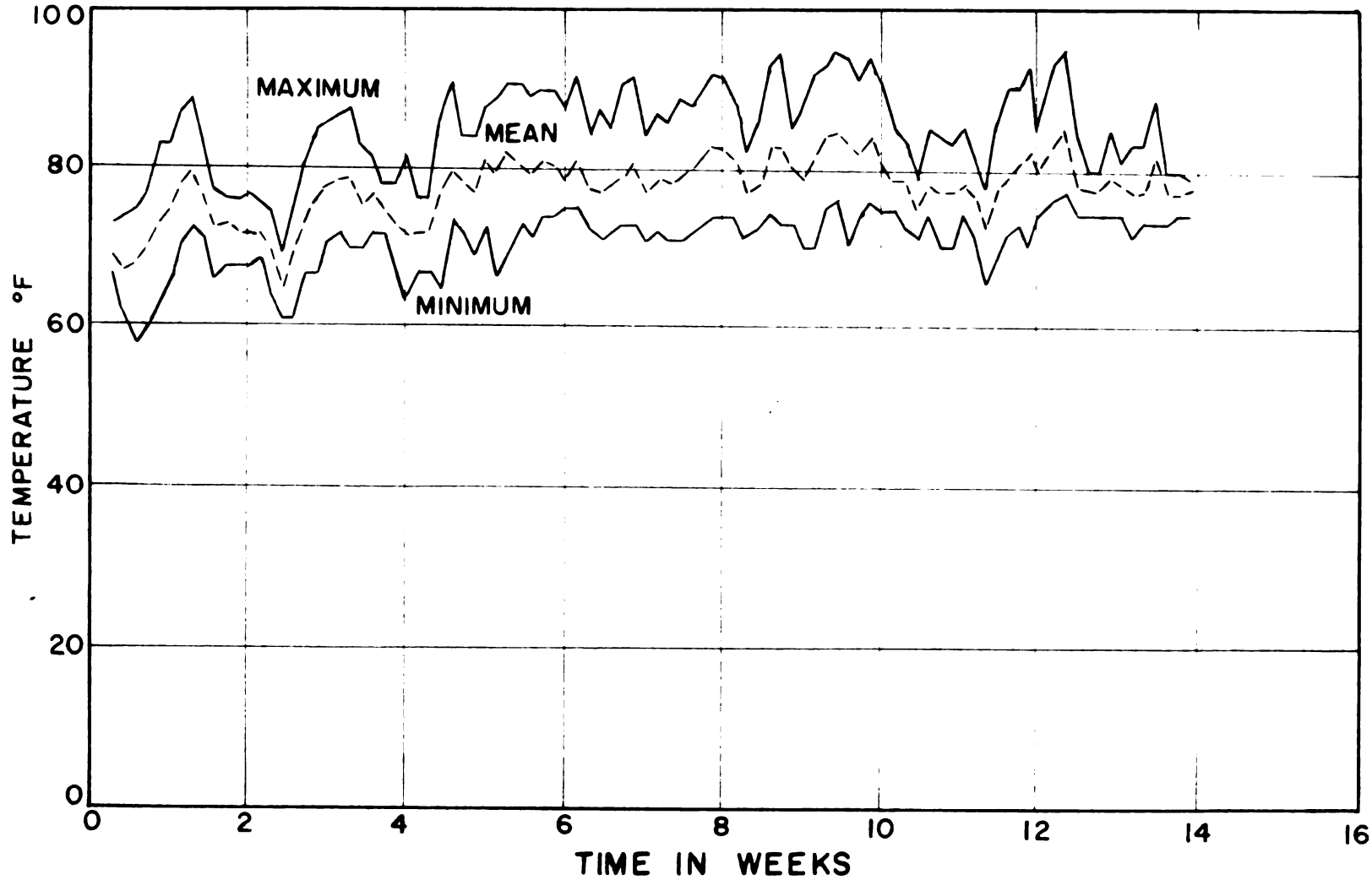

Figure 30. The maximum, minimum and mean daily temperatures in the single pane house from May 27, 1955 to September 2, 1955.

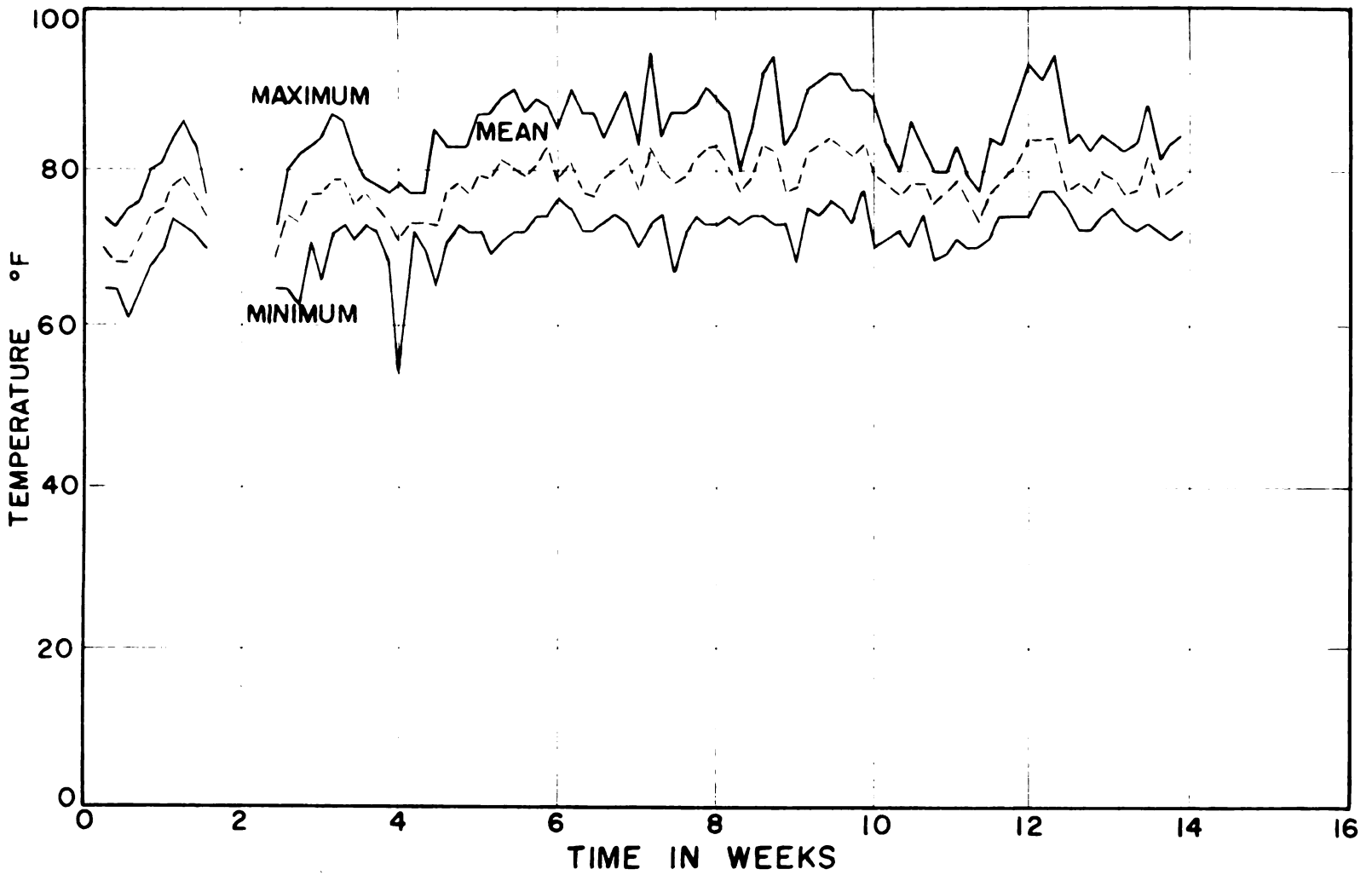

Figure 31. The maximum, minimum and mean daily temperatures in the dark house from MAY 27, 1955 to September 2, 1955.

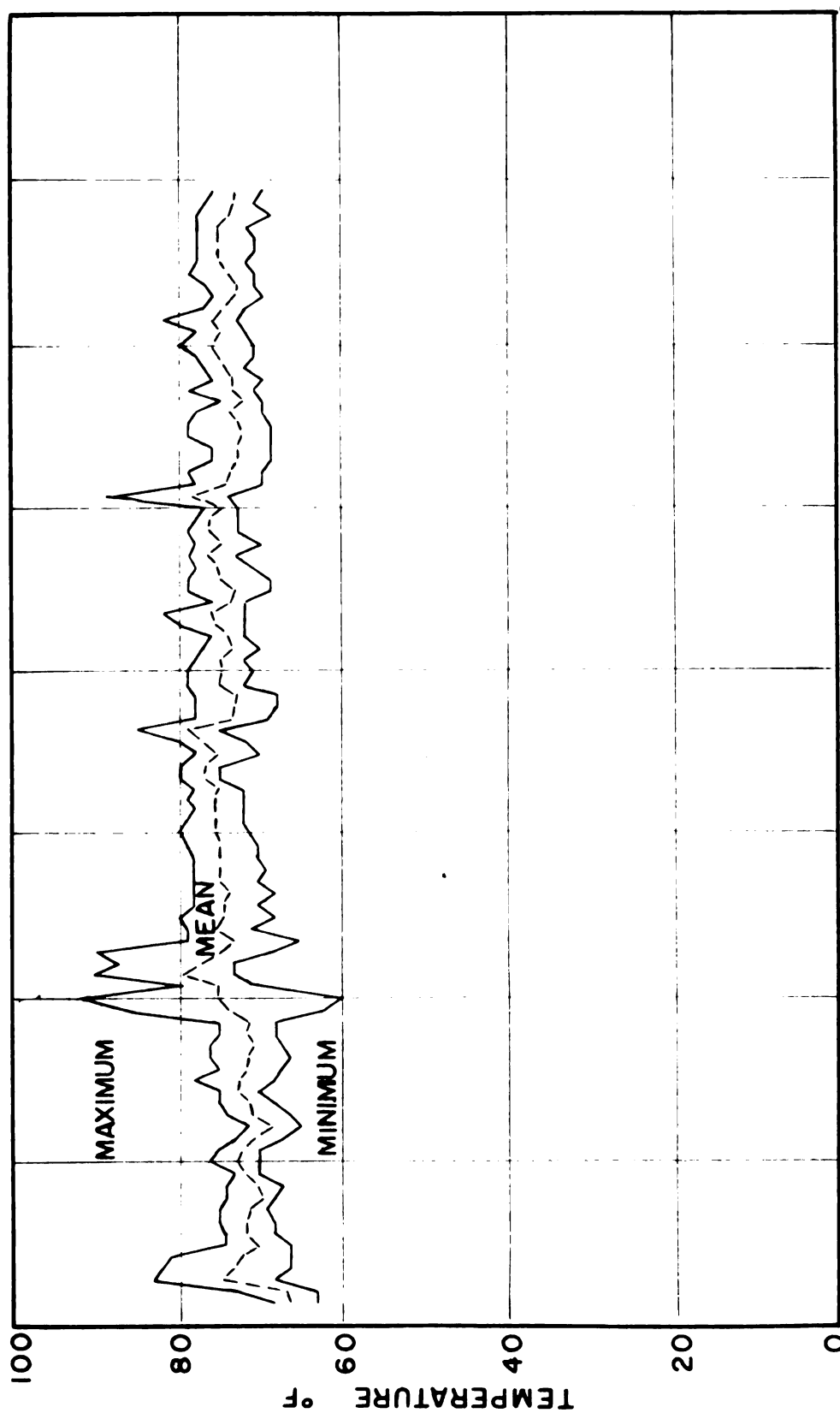

Figure 32. The maximum, minimum and mean daily temperatures in the air conditioned house from MAY 27, 1955 to September 2, 1955.

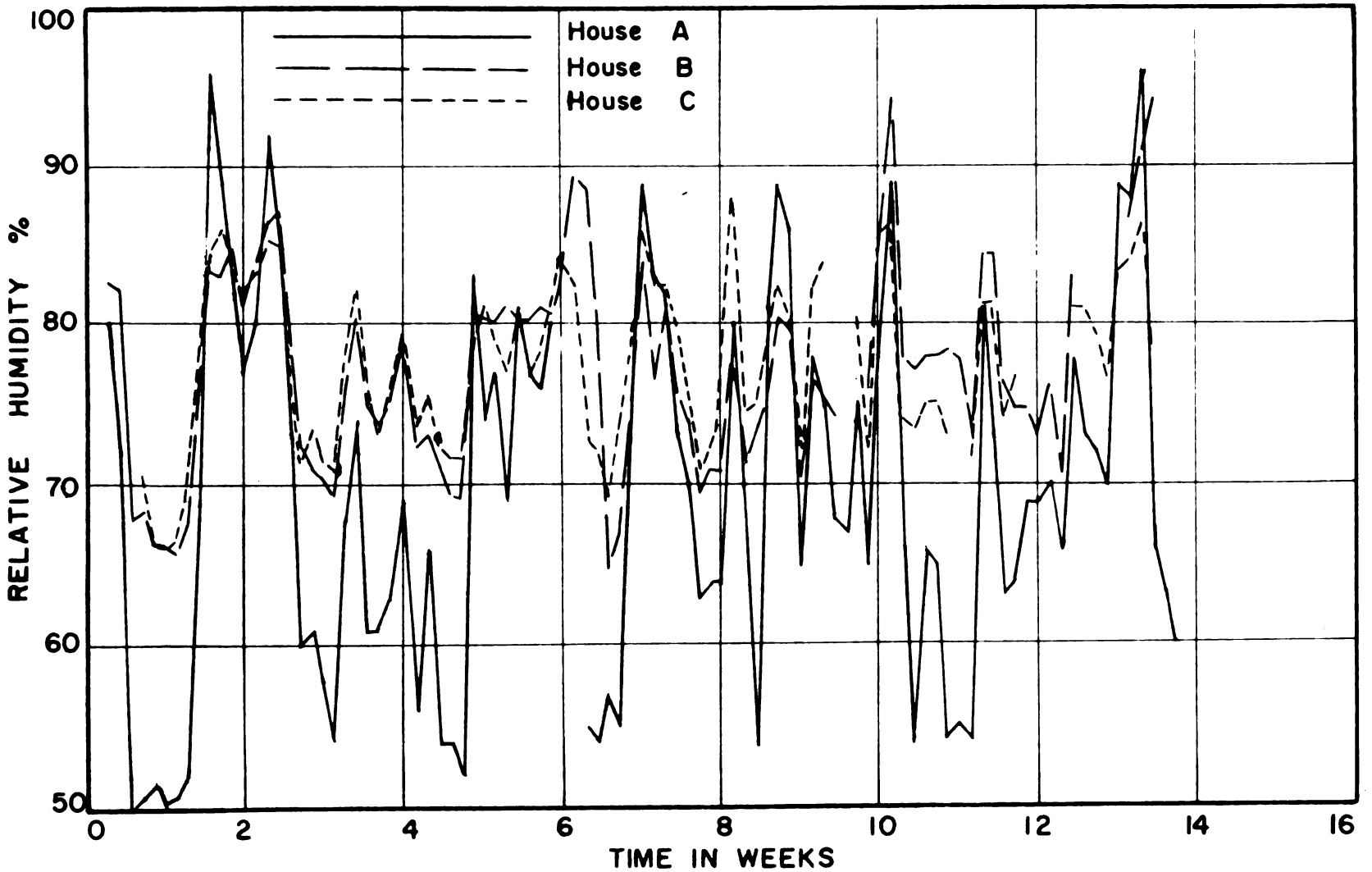

Figure 33. The mean daily relative humidity in Houses A, B and C from May 27, 1955 to September 2, 1955.

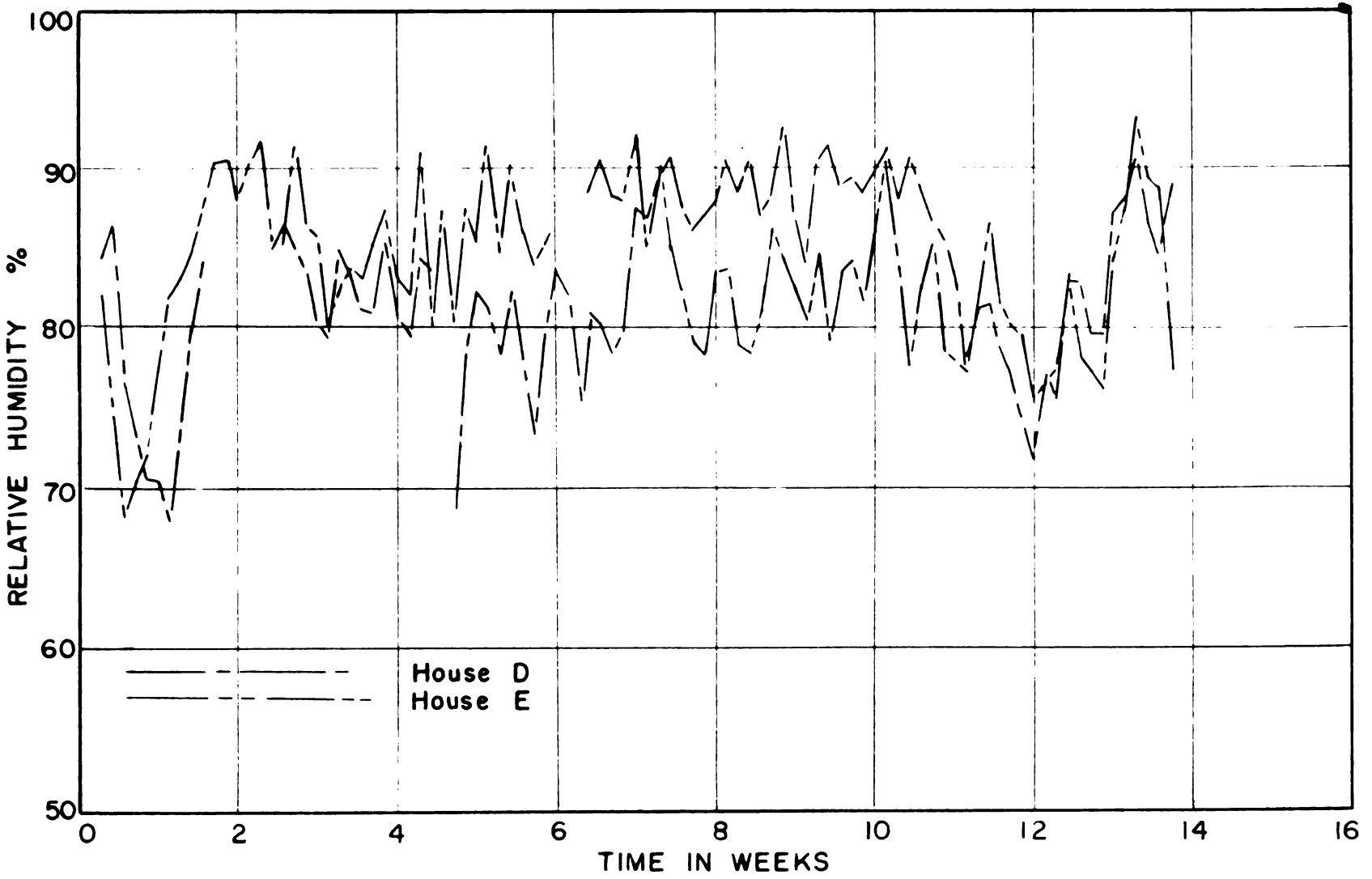

Figure 34. The mean daily relative humidity in Houses D and E from May 27, 1955 to September 2, 1955.

TABLE III

SUMMARY OF THE RESULTS FOR THE HOG FEEDING TRIAL OF THE SUMMER STUDY OF 1955

	Treatment				
	House A	House B	House C	House D	House E
Number of pigs	6	6	6	6	6
Average initial weight in pounds	36.2	35.8	35.5	36.2	36.2
Average final weight in pounds	181.3	195.9	195.2	198.5	193.3
Average daily gain in pounds	1.48	1.63	1.63	1.66	1.61
Average daily feed consumption per pig in pounds	5.61	5.72	5.78	5.84	5.50
Pounds of feed consumed per pound of gain	3.79	3.49	3.55	3.53	3.42

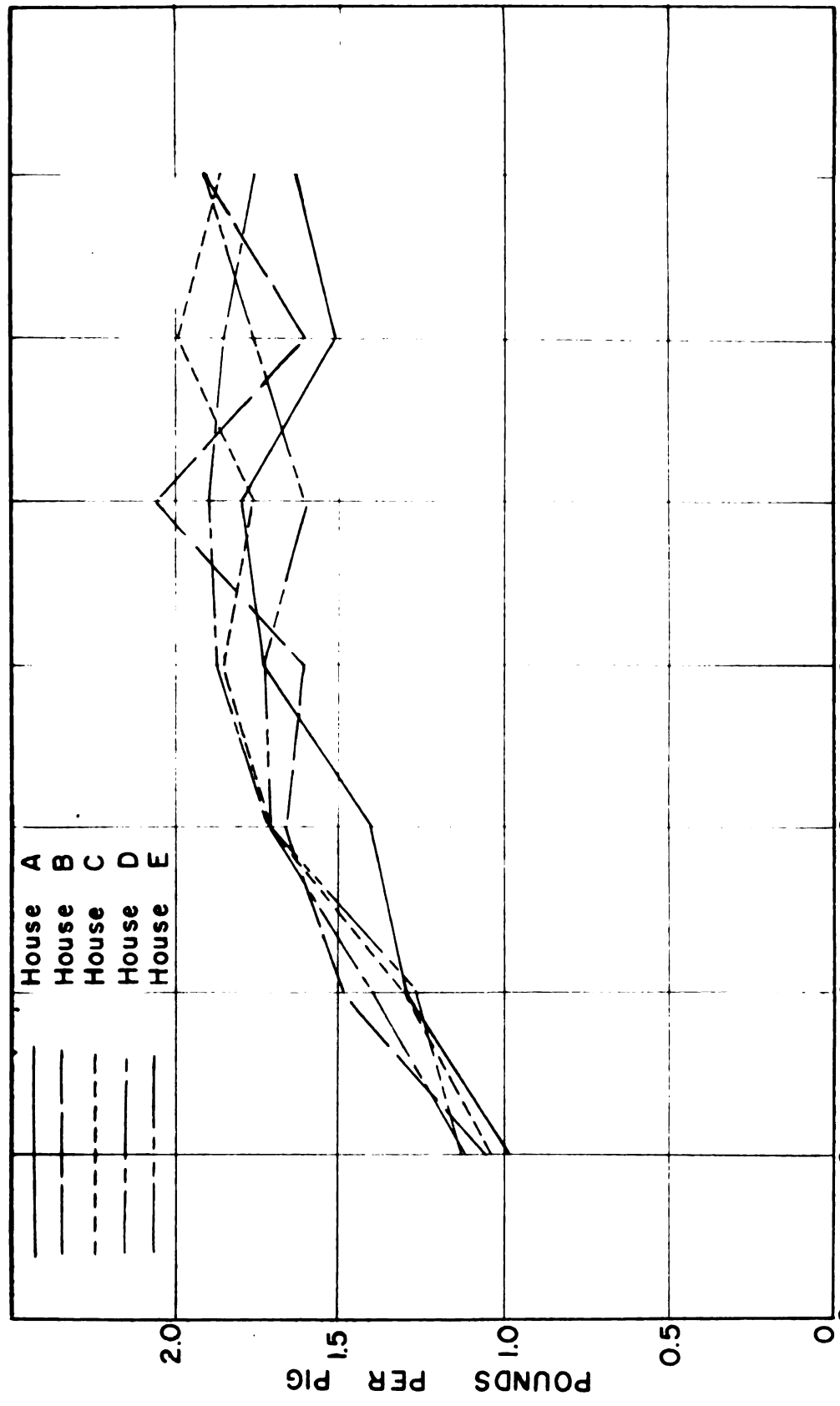

Figure 35. The average daily gain per hog for each two week period of the summer study of 1955.

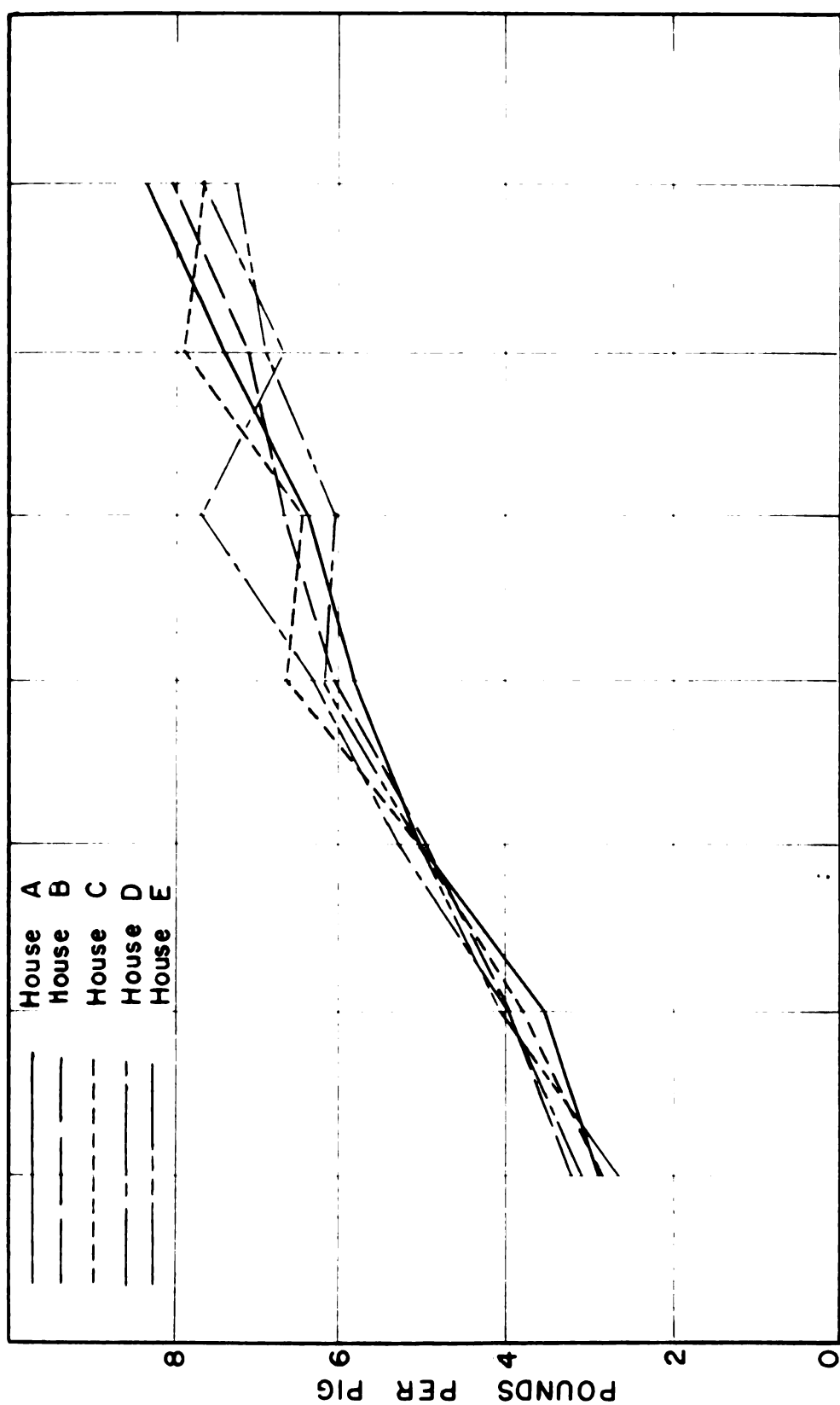

Figure 36. The average daily feed consumption per hog for each two week period of the summer study of 1955.

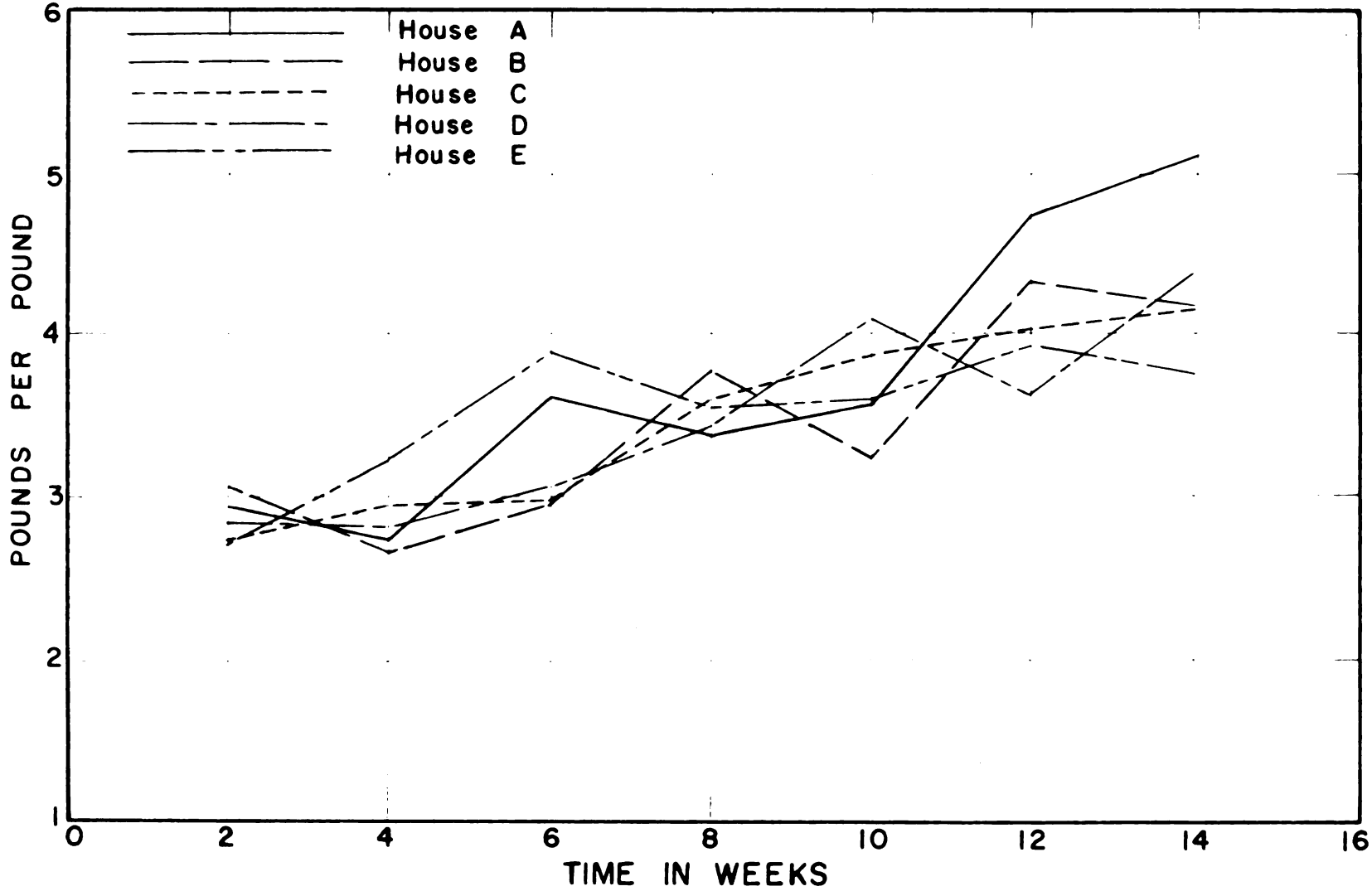

Figure 37. The amount of feed consumed per pound of gain for each two week period of the summer study of 1955

Part IV - Analysis of the Winter Study of 1955 - 1956

This winter trial started on December 21, 1955 and ended February 28, 1956. Duration of the feeding trial was ten weeks. Average initial weight of the hogs was 81 pounds.

The thermostat controlling the heat lamps in House E was set at 60°. An air temperature of 60° was assumed to give an effective environmental temperature to the surroundings of 65 to 70°.

Daily maximum, minimum and mean outside temperatures and inside temperatures of Houses A, B, C, D and E are shown in Figures 38, 39, 40, 41, 42 and 43 respectively. The mean daily relative humidities in Houses A, B and C are shown in Figure 44 and the mean humidities in Houses D and E are shown in Figure 45.

Temperature. Temperatures in House A were higher than the outside temperatures due to the heat production of the heavier hogs used in this trial. Maximum, minimum and mean temperatures in Houses B and C averaged 10 to 20 degrees higher than in House A. A comparison of the Houses B and C shows that maximum and mean temperatures were generally greater in House C. Daily variation in temperature was greatest in House C.

Temperatures in House D, which was heated, ranged from approximately 46° to 70° averaging 58° for most of the trial.

Attainment of a constant temperature was best approached by House D.

Except for a few days the temperatures in House E were 3 to 8 degrees higher than in House B. It was also noted that the daily maximum temperature in House E occurred at approximately the same time as in House B and not earlier as was expected. No explanation could be found for the above statement.

Relative humidity. The mean relative humidity in House A was consistently higher than in the other houses. No other marked trend was noticeable.

Ventilation. A minimum ventilation rate of 16 cubic feet per minute per hog was maintained in the test houses until the hogs average 100 pounds in weight. For the remainder of the trial a minimum rate of 25 cubic feet per minute per hog was maintained.

The initial thermostatic setting of 75° was reduced to 70° when the hogs reached an average weight of 125 pounds.

Ventilation records showed very little fan operation beyond the minimum rate.

Feeding trial. Results of the hog feeding trial are summarized in Table IV. The hogs in House E made the highest daily gain of 1.94 pounds while the hogs in House A had the lowest daily gain of 1.77 pounds. Hogs in Houses B, C and D

had very similar daily gains of 1.88, 1.87 and 1.85 pounds respectively.

The hogs in House E also made the most efficient gains consuming 3.76 pounds of feed per pound of gain while the hogs in House A had the poorest efficiency of 4.47 pounds of feed per pound of gain. Respective efficiencies for the hogs in Houses B, C and D were 3.91, 3.90 and 3.79 pounds of feed per pound of gain.

Feed consumption and efficiency for each two week period are shown in Figures 47 and 48 respectively. Except for one period the hogs in House A had the highest daily feed consumption and accordingly the poorest feed efficiency. The only noticeable pattern was that the hogs in House D had the lowest daily feed consumption.

Conclusions. Better environmental conditions as existed in Houses B, C, D and E compared to House A, improved the growth rate of the swine by 7 percent. The hogs in Houses D and E had 17 percent better feed efficiencies than the hogs in House A, while the hogs in Houses B and C had 15 percent better feed efficiencies than the hogs in House A. The degree of attainment of the ideal conditions was not measurable in the performance of the swine.

Absence of sunlight in House D did not affect the performance of the swine.

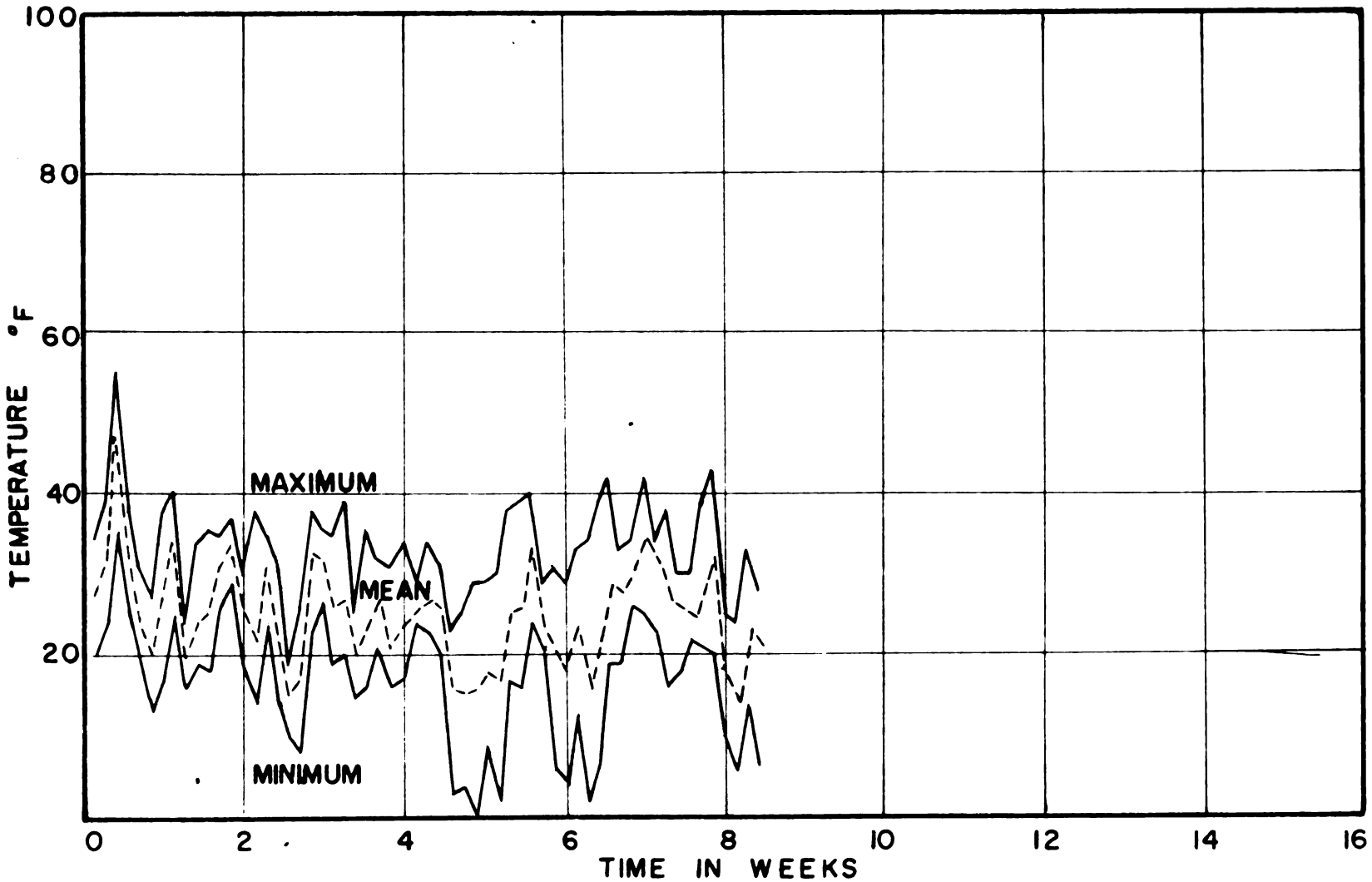

Figure 38. The maximum, minimum and mean daily outside temperatures from December 21, 1955 to February 28, 1956.

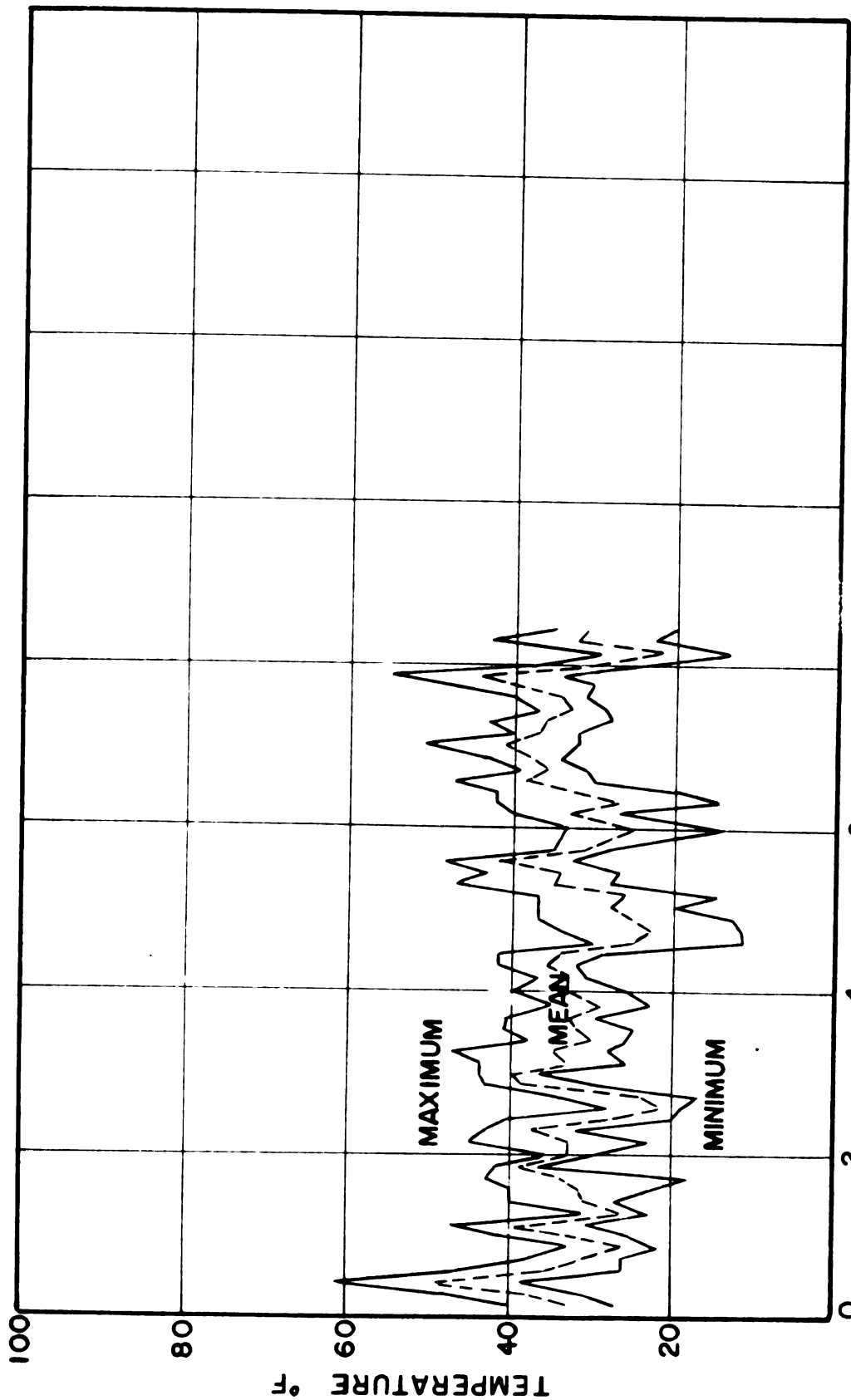

Figure 39. The maximum, minimum and mean daily temperatures in the conventional house from December 21, 1955 to February 28, 1956.

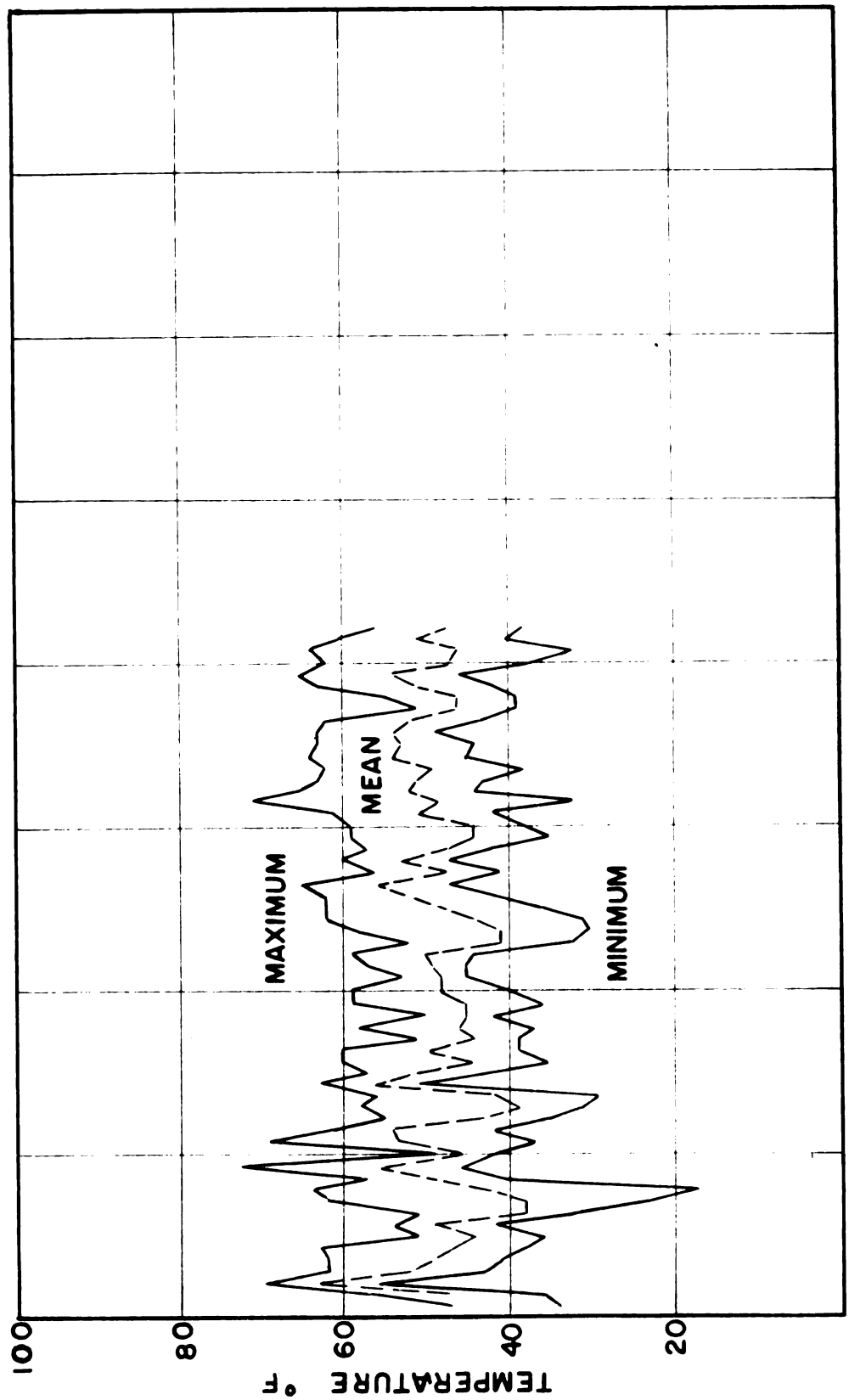

Figure 41. The maximum, minimum and mean daily temperatures in the single pane house from December 21, 1955 to February 28, 1956.

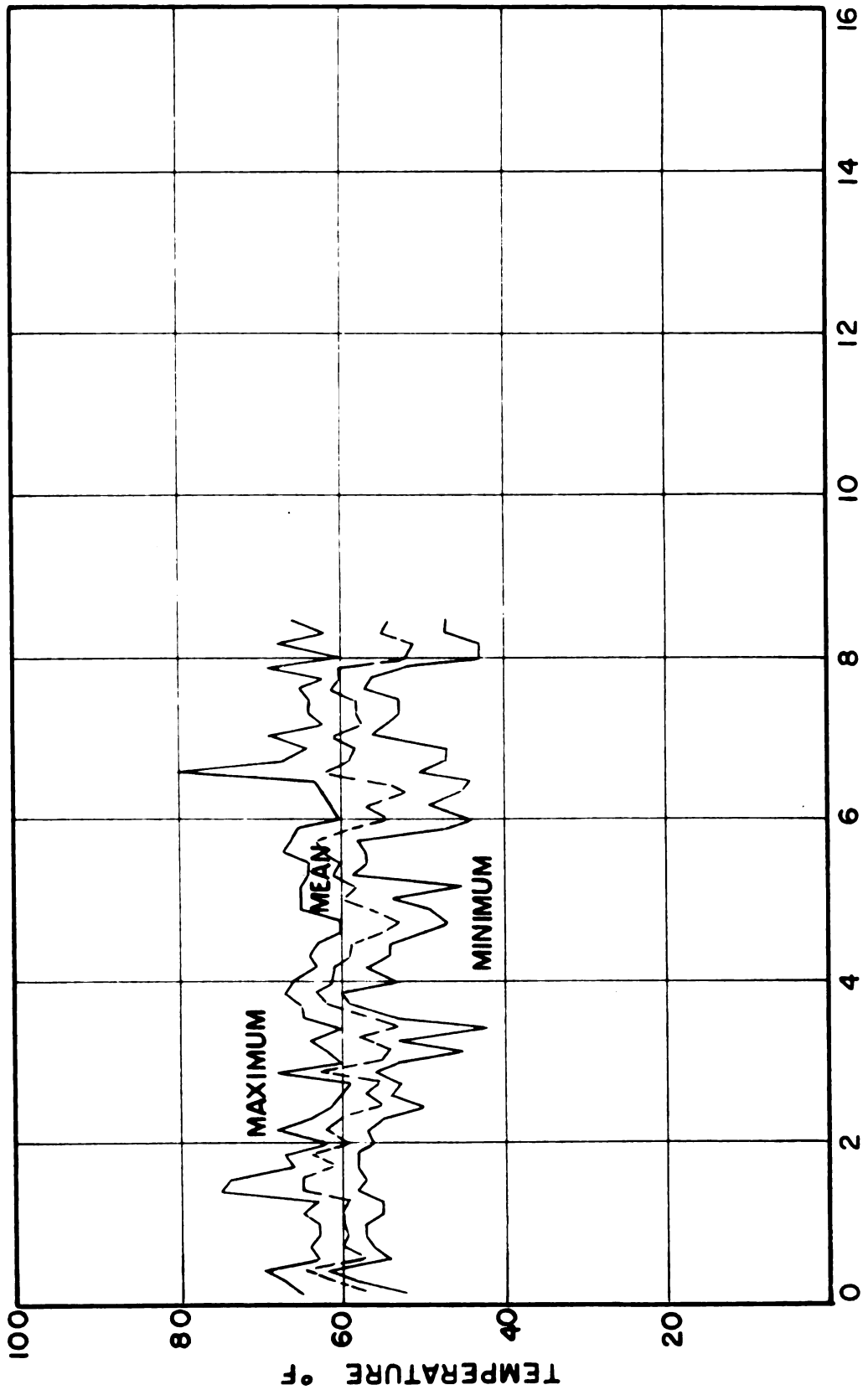

Figure 42. The maximum, minimum and mean daily temperatures in the dark house from December 21, 1955 to February 28, 1956

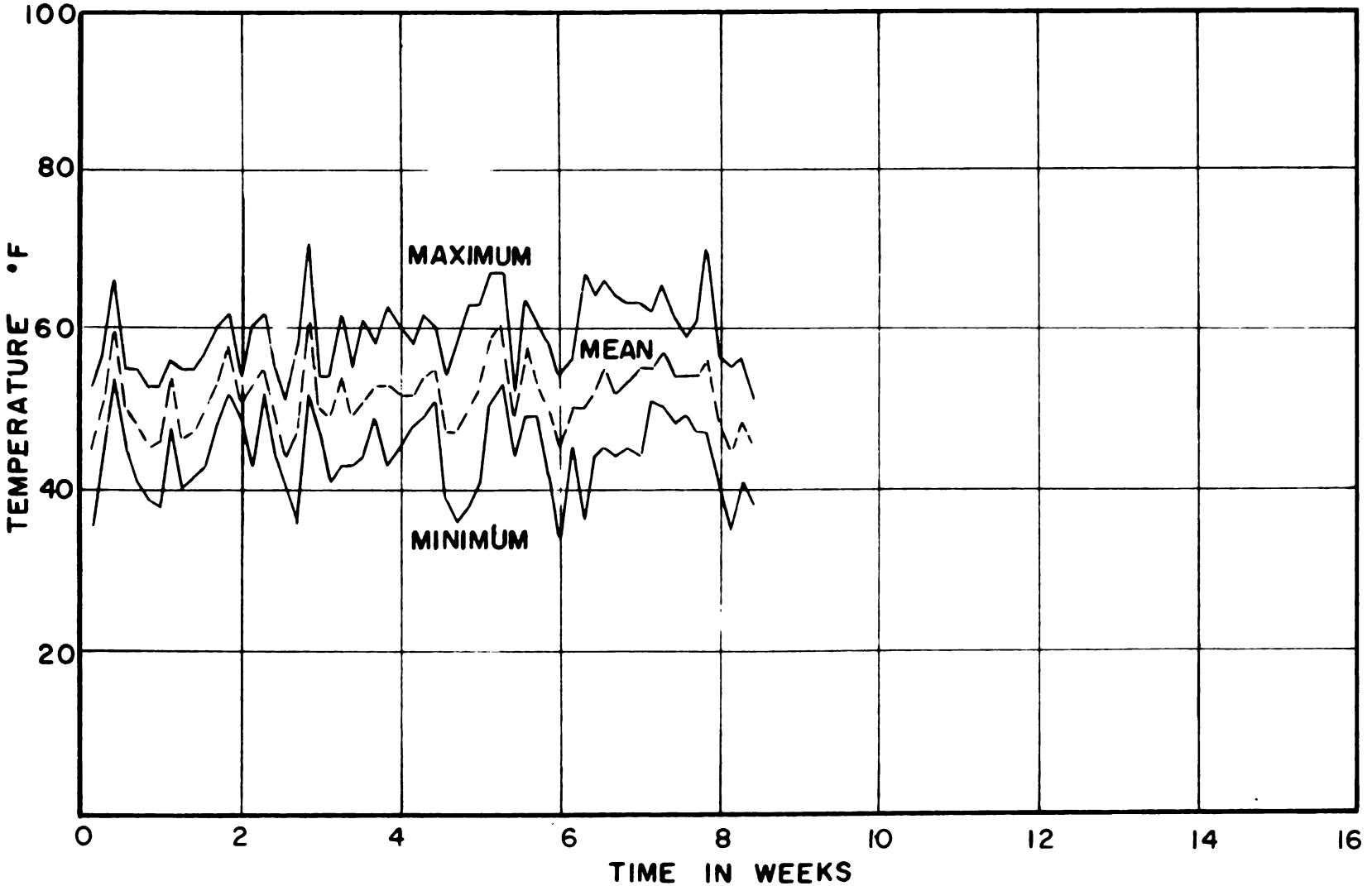

Figure 43. The maximum, minimum and mean daily temperatures in the east facing double pane house from December 21, 1955 to February 28, 1956.

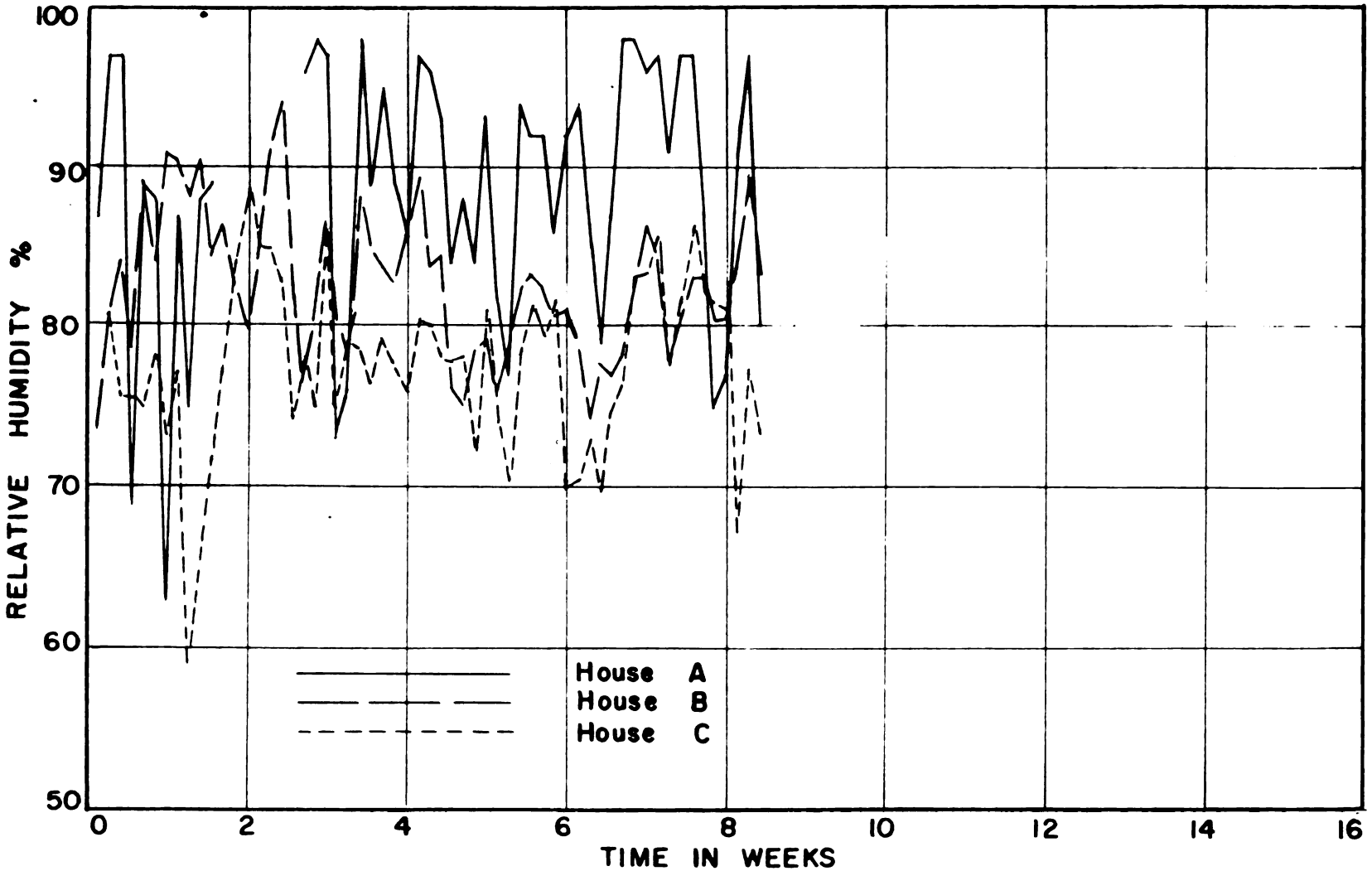

Figure 44. The mean daily relative humidity in Houses A, B and C from December 21, 1955 to February 28, 1956.

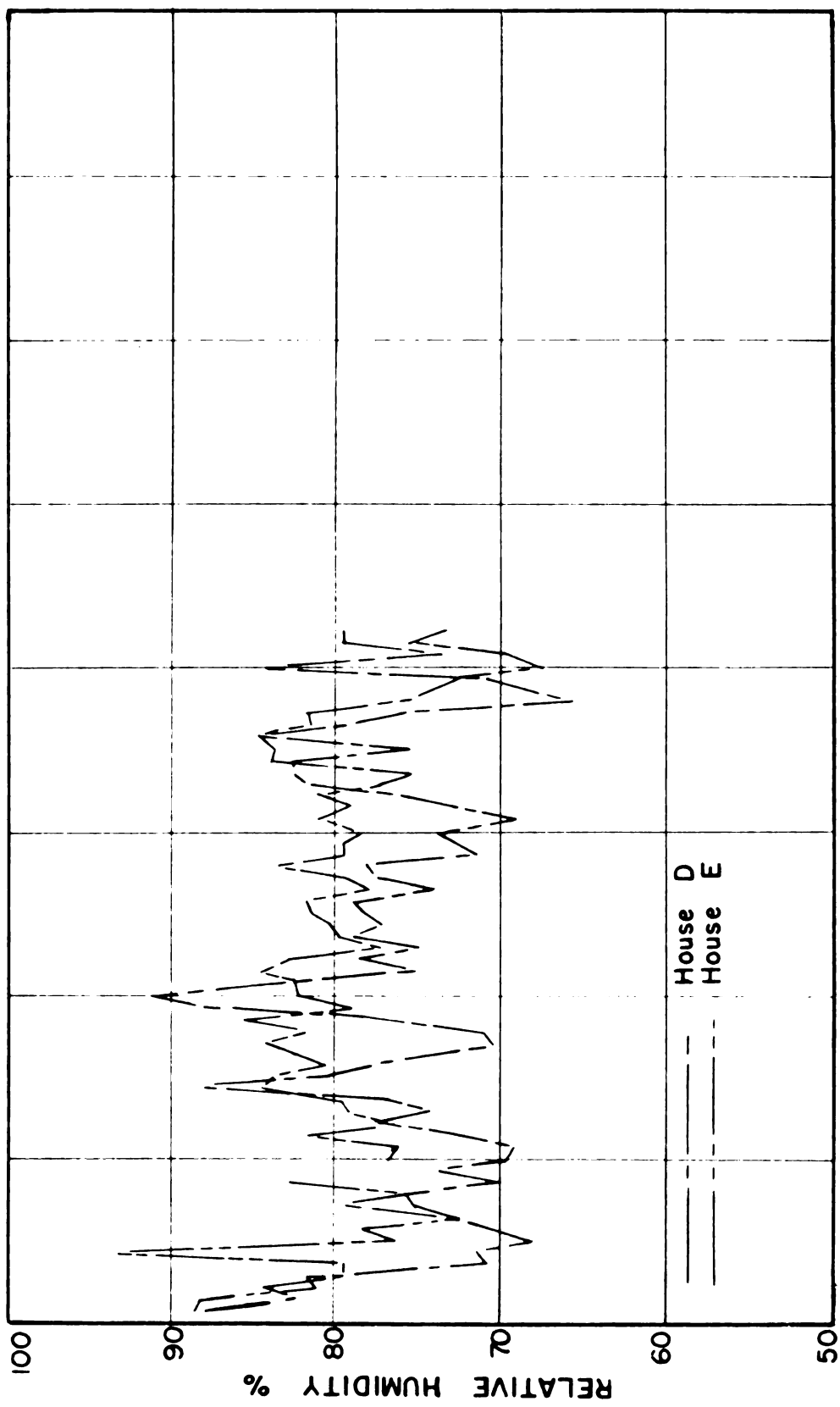

Figure 45. The mean daily relative humidity in Houses D and E from December 21, to February 28, 1956.

TABLE IV

SUMMARY OF THE RESULTS FOR THE HOG FEEDING TRIAL OF THE WINTER STUDY OF 1955-1956

	Treatment				
	House A	House B	House C	House D	House E
Number of pigs	6	6	6	6	6
Average initial weight in pounds	81.2	81.4	81.4	81.3	81.3
Average final weight in pounds	203.3	210.7	209.9	208.7	215.4
Average daily gain in pounds	1.77	1.88	1.87	1.85	1.94
Average daily feed consumption per pig in pounds	7.91	7.32	7.25	7.00	7.29
Pounds of feed consumed per pound of gain	4.47	3.91	3.90	3.79	3.76

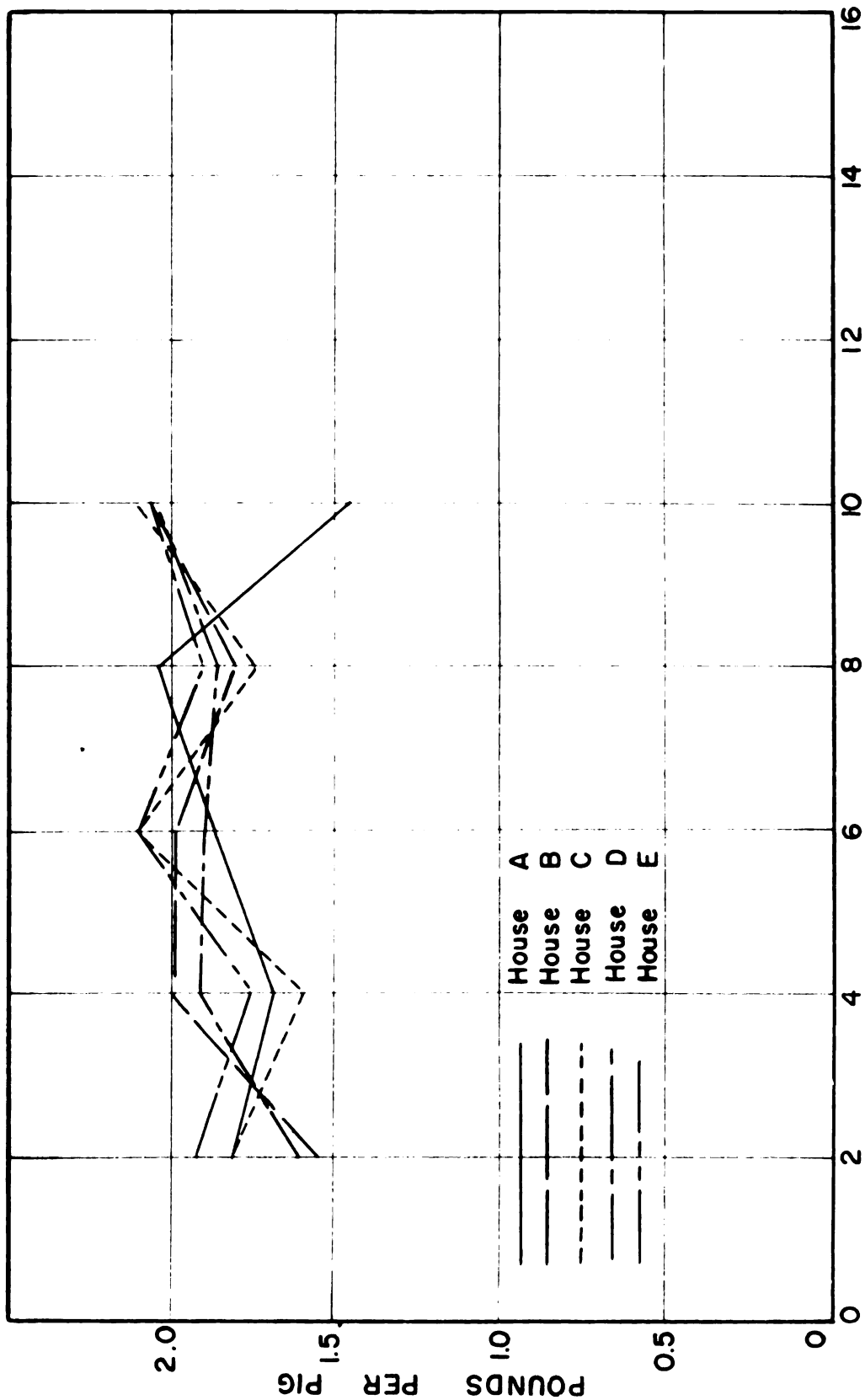

Figure 46. The average daily gain per hog for each two week period of the winter study of 1955-1956.

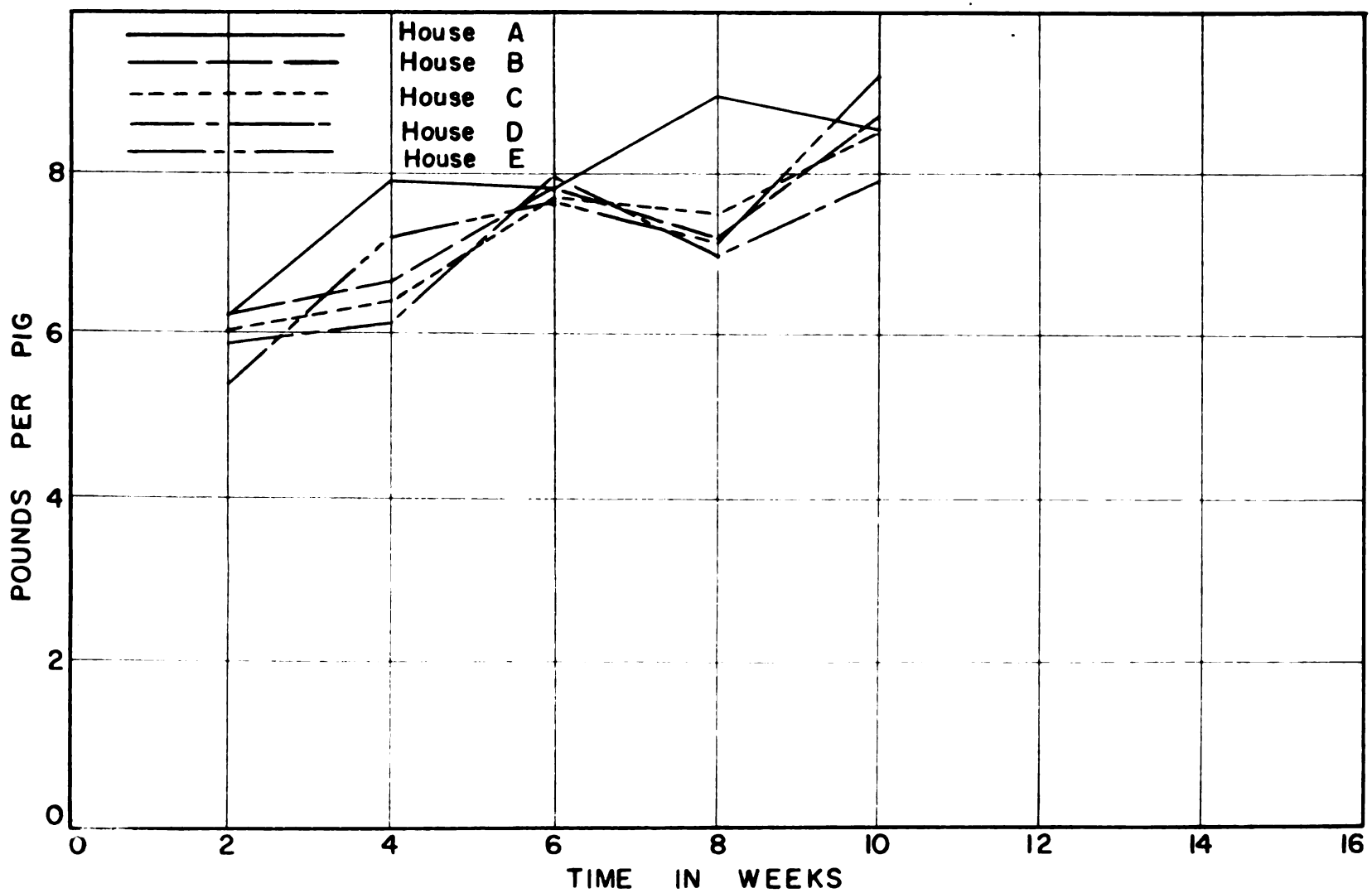

Figure 47. The average daily feed consumption per hog for each two week period of the winter study of 1955-1956.

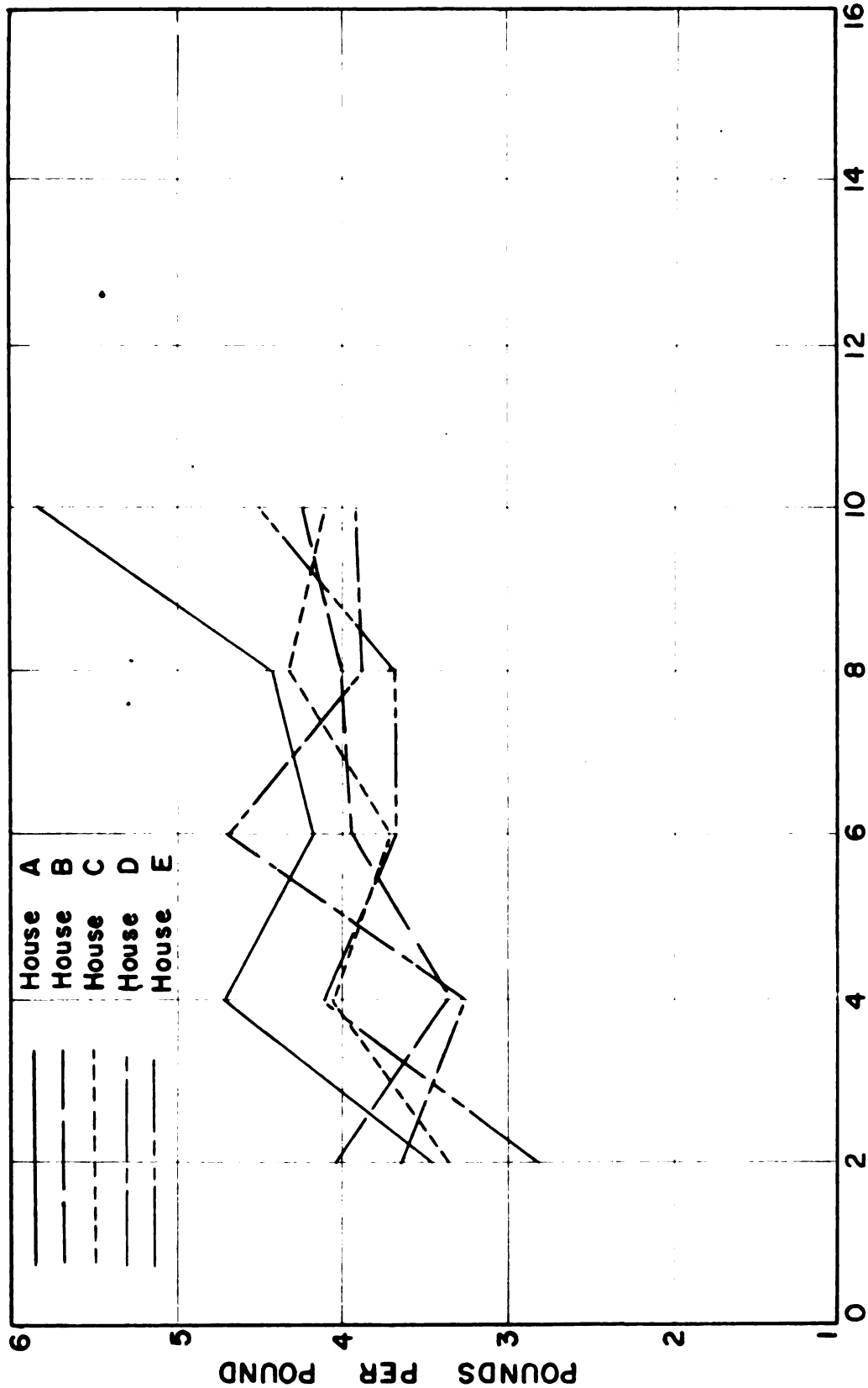

Figure 48. The amount of feed consumed per pound of gain for each two week period of the winter study of 1955-1956.

EVALUATION OF METHODS USED TO IMPROVE ENVIRONMENTAL CONDITIONS IN THE HOUSES

Double Pane Windows

A complete evaluation of using double pane windows was made by Brandt (3) and the following points were verified by this study.

The use of double pane windows as compared to single pane windows made more efficient use of available solar energy in the heat gain of the building during the winter.

The temperature variations in the double pane house were smaller than in the single pane house.

Air Conditioning

Clogging of the filter and coating of the cooling coils with dust greatly hampered the cooling capacity of the air conditioner. In order to minimize the amount of dust reaching the unit, a washable air filter was installed next to the air intake. The washable filter was washed with water weekly and the filter inside the unit was replaced about every two weeks.

The temperature sensing ability of the thermostat was also affected by dust in that the rate of heat transfer to the bulb was reduced. This resulted in a greater lag in

sensing a difference in temperature and consequently wider fluctuations of temperature in the house.

Another difficulty encountered in the air conditioned house was the presence of strong ammonia odors. It was presumed that as the air conditioner removed moisture from the air the ammonia present in the building became more concentrated. This condition was aggravated because room air was recirculated through the unit to obtain the desired cooling capacity. Ventilation was necessary to remove the odors.

Artificial Heat

The use of infrared heat lamps to provide heat to the house was successful. Occasionally high humidities during the day were present because of the vaporization of moisture from the litter.

CONCLUSIONS

Since the performance of the hogs in the hog feeding trial for the winter of 1954 - 1955 was affected by disease, and the data reported using air conditioning and artificial heat were from one trial each, the following conclusions must be tentative and subject to revision.

1. Improved environmental conditions in swine housing were conducive to better growth and feed efficiency of market swine.

2. Practical attainment of improved environmental conditions were realized by the use of double pane windows.

3. Attaining a constant temperature by using air conditioning was not feasible.

4. The use of artificial heat in swine housing was feasible and was conducive to better feed efficiency of swine.

5. The absence of sunlight did not affect the gain and feed efficiency of swine.

SUGGESTIONS FOR FURTHER STUDY

1. Since the data reported using air conditioning and artificial heat were from one trial each, the project should be continued to verify the results. Data from one trial does not represent a sufficient sample of climatic variability.

2. Results from the east-facing double pane house indicate that research is needed to determine the best orientation for houses with large glass areas.

3. The possibility of using radiant cooling and heating should be investigated in order to eliminate the dust problem.

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