THE EFFECT OF SHADE LOCATION ON SUMMER
GAINS OF FATTENING CATTLE

BY

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Director of Thesis   Date

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INTRODUCTION AND PURPOSE

The increase in the size and number of cattle feeding operations in Arizona has resulted in a local demand for comprehensive studies of all factors contributing to greater and more efficient production of finished stock. Year-long feeding is considered desirable by many operators engaged in the industry, and the reactions of feedlot cattle to the high temperatures of the Southwest have emphasized the need for proven practices and installations that will alleviate climatic stress during the summer months.

The test reported in this paper was designed to compare the rates and efficiency of summer gains made by yearling Hereford steers provided shade in the vicinity of the feed trough with the gains and efficiency of similar steers provided shade at a more distant or conventional location. The steers subjected to the above treatments were, in turn, compared with a similar group denied the benefit of shade during the fattening period.

LITERATURE REVIEW

The influence of shade location upon the rate and efficiency of summer gains in fattening cattle has not been found in the literature. However, considerable related work has been reported.

Keeping adult livestock cool in the summer is a greater problem in most parts of this country than keeping them warm in the winter, observed Brody (1). Concurring with this observation, Snapp (12) stated that too little attention is given to adequate shade provisions for cattle during hot weather.

Cattle moved from shade to an area exposed to strong sunlight in the summer, according to Rhoad (10), showed increased respiration rates and higher body temperatures, indicating increased difficulties in disposing of body heat. Further, Gaalaas (3) noted that less time was spent grazing on open bright days than on overcast days. Maynard (6) stated that physical regulation operates under conditions of increasing environmental temperature until the regulation is no longer able to cool the animal body. At this point, a super-normal body temperature and an increase in metabolism result.

Hot weather is a detriment to liberally fed fattening cattle, indicated Morrison (7). More heat is produced by chewing, digesting, and assimilating the feed than is required to maintain the body temperature. Physical regulation by the action of increased respiration rates, even to the point of panting, is characteristic of the animal effort to dispose of excess body heat when under high environmental temperatures. High animal temperatures and respiration rates are accompanied by increased metabolism and a greater demand for nutrients. Therefore, fattening cattle produce less rapid gains than would be expected in a more comfortable environment.

Discomforts of cattle, due to climatic stress, have been associated by Mullick et al. (8), with decreased feed intake. Working with dairy cows under controlled temperature conditions, Ragsdale et al. (9) found that increasing temperatures above the normal noticeably decreased feed consumption and milk production.

According to Dukes (2), animals remain comfortable under normal environmental conditions by means of radiation, convection, conduction and water vaporization. As a consequence, the body temperature and metabolism are not materially increased. The animal's condition shows great change, however, when the environmental temperature rises above the normal, and the animal system is no longer able to prevent rises in body temperature and increases in metabolism.

Winslow and Herrington (13) effectively charted the basic physical and physiological factors upon which heat interchanges depend:

	Evaporation	Convection	Radiation
Physical Factors			
Air temperature	X	X	
Air movement	X	X	
Relative humidity	X		
Mean radiant energy			X

	Evaporation	Convection	Radiation
Physiological Factors			
Du Bois surface area		X	
Effective radiation area			X
Area of evaporating surface	X	X	X
Mean skin temperature		X	X
Available moisture for evaporation	X		

Many workers agree that more effective control of radiation and mean radiant energy contributes much to the physical comfort and efficiency of cattle during hot weather.

Brody (1) recommended the reduction of solar radiant energy upon animals to permit greater animal-heat loss and a relative increase in animal efficiency.

The effective radiation of the sun, reported Kelly and Ittner (5), can be reduced considerably by the use of shades and other similar artificial means. An example from their work demonstrates the heat interchanges between an animal and its environment as follows:

	No Shade	Shade
Heat exchange by radiation (BTU/hr)	-2423	+ 340
Heat exchanged by convection (BTU/hr)	+1856	+ 437
	- 567	+ 777

Heat movement away from the animal body is represented by the positive values, while heat movement into the animal is represented by the negative values.

The effect of shade on physiological reactions of Hereford and Hereford-Brahman crossbred cattle has been studied and recorded by Ittner and Kelly (4) and Kelly and Ittner (5). Their results show that shade structures effectively reduce the heat intake of animals incident to the absorption of radiant energy from the sun. High shades (10-12 feet high) covered with straw adequately reduced the sun's radiant heat upon livestock.

EXPERIMENTAL PROCEDURE

Pre-test Procedure

Twenty-seven yearling Hereford steers were selected seventy-one days (April 19, 1951) prior to the official start of the test. The steers, previously number branded, were weighed and placed on a pre-test ration as a single group. The pre-test ration (fed free choice) consisted of chopped alfalfa hay, hegari silage, rolled barley, and cottonseed meal. Block salt was provided in abundance. The rolled barley and cottonseed meal were increased gradually until the concentrate level of the fattening ration was equalled. Records of feed consumption were kept for the entire group.

Forty-nine days after the beginning of the pre-test period, the steers were individually weighed and given condition scores. On the basis of these weights and scores, the steers were assigned to three groups of nine per unit.

Each group was placed in an individual pen and fed the experimental ration (Table II) free choice. All three pens received identical treatment and were fully exposed to the sun. During this period feed consumption records were kept for each individual pen. Observations of group feeding habits were made and respiration rates were recorded for animals selected at random within each pen.

On June 18, 1951, all steers were weighed individually and given condition scores, and the pre-test records were closed. The individual gains for the entire pre-test period of 60 days, and the feed consumption records for the last eleven days of the pre-test period, were used to determine the equality of the three groups to be used in the subsequent test.

During the eleven days following the conclusion of the pre-test period, shade structures were erected in two of the three pens. The shade structures (10 feet wide, 18 feet long and 10 feet high) were constructed of galvanized-iron roofing and were open on all sides with a vertical back-drop extending 4 feet and 8 inches from the top of the structure on the western exposure. At 1:00 p.m., each structure provided a shaded area of 10 x 18 feet at 24 and 42 inches above the ground surface. This provided a minimum of 20 square feet of shade per animal. As the afternoon progressed, each shaded area increased in depth. At 5:00 p.m., the shade cast by each structure offered an area of 15 x 18 feet at 24 and 42 inches above the surface of the ground. Diagrams of the shaded area are provided in Figures IIIa and IIIb.

The shade structure in Pen 1 was erected 54 feet from the feed trough. A similar structure was located at a distance of 10 feet from the trough in Pen 2. The shade was so located, in the latter case, that it cast a shadow in the vicinity of the feed during the hot afternoon periods. Pen 3 was provided no shade.

Test Procedure

With the beginning of the official test period, June 29, 1951, the allotment of the animals remained as in the last phase of the pre-test period. The groups were assigned to the test pens by random selection. Individual steer weights were taken at the start of the experiment, at intermittent intervals and also at the conclusion of the test. Feeder grades and conditions scores were assigned each steer at the beginning of the test and again at the end of the feeding period.

All three pens were fed free choice. Feed was supplied each morning and evening and feed consumption records were kept by pens for the duration of the test. The fattening ration (of constant percentage composition) consisted of hegari silage, chopped alfalfa hay, rolled barley and cottonseed meal (Table II). Salt was constantly available.

Temperature and humidity records (Table V) were obtained from the University of Arizona Weather Station. Environmental temperatures at the test location were frequently recorded from Maximum-Minimum thermometers. Atmospheric temperatures at the test location were recorded in the shaded areas and in the direct sunlight at both the height of the standing animal (approximately 42 inches above the ground surface) and at the height of the animal lying down (approximately 24 inches above the ground surface).

Frequent observations of the animal feeding habits and activity in each pen were recorded.

Respiration rates were determined at intervals by observation of flank movement. The respiration rates of several steers in each pen, selected at random, were observed and recorded under varying environmental conditions. The environmental temperatures were recorded at the time of the respiration counts.

Shade diagrams were made at the beginning of the test and at 30-day intervals thereafter, weather permitting.

The experiment was concluded after ninety-eight days. Individual weights and condition scores were again recorded and the excess feed was weighed back. Individual gains were analyzed statistically, and the efficiency of feed utilization was calculated by pens.

RESULTS

Pre-test Results

Average gains per head and average daily gains, based upon the pre-test period of 60 days, are shown on Table I. It may be noted in this table that Pen 1 gained 167.8 pounds as compared with 149.5 pounds and 153.4 pounds recorded for Pens 2 and 3 respectively. However, variance analyses based upon the methods of Snedecor (11) indicated that the differences were insignificant. Table I also shows the average daily consumption to be comparable for all lots.

Test Results

The results of the test period are summarized in Table III. The steers of Pen 2, provided shade at the feed trough, gained 2.4 pounds daily. The animals in Pen 1, with the shade located 54 feet from the feed trough, made average gains of 2.1 pounds which exceeded the 1.9 pounds recorded for the unprotected steers of Pen 3.

The daily feed consumed by Pen 2, shown as 35.7 pounds per head, was slightly greater than for Pen 1 (recorded at 35.3 pounds), while Pen 3 consumed only 34.3 pounds per day.

Observation of animal feeding habits (Figure I) revealed the tendency for all three groups to follow a similar trend in the morning and late afternoon. However, the habits during the mid-afternoon varied in that more steers of Pen 2 started feeding earlier than the steers in Pens 1 and 3.

The respiration rates (Figure II) showed that additional stress was suffered by the steers of Pen 3 as the environmental temperature increased. Increasing environmental temperatures affected the steers of Pens 1 and 2, but these animals didn't show the discomfort exhibited by the steers of Pen 3.

The feed per pound of gain, recorded for each pen, presented a trend opposing that observed for the daily feed consumed. Pen 3 required 18.3 pounds. Pen 1 utilized 16.8 pounds, and Pen 2 (requiring the least) consumed 15.1 pounds of feed per pound of gain.

The steers in Pen 2 made the most economical gains, as indicated on Table III. The cost of $0.26 per pound of gain for this group was appreciably lower than the $0.29 and $0.32 recorded for the animals of

Pens 1 and 3 respectively.

The net return of Pen 2 exceeded the others by returning $27.82 per head, while Pens 1 and 3 followed with returns of $19.14 and $13.05 per head respectively.

DISCUSSION AND CONCLUSIONS

Pre-test Period

The results of the pre-test period provided a means of evaluating the gains between the pens and the individual gains within pens. Upon comparison (Table I), it was noted that the steers of Pen 2 showed a lower individual gain than did the steers of Pens 1 and 3. Variance analyses of the mean-gains between pens (Table I) indicated no significant differences.

The feed record for the period June 7 to June 18, 1951 (Table I) provided a measure of the average daily feed consumption for the period, by pens. This record shows that the three pens consumed equal quantities of feed.

Feeding habits, animal activity, and respiration rates for the pre-test period showed that the three pens reacted the same under comparable environmental conditions.

When supplied the morning ration, all of the steers in each pen started to feed immediately. Thirty minutes after the feeding two or three animals remained at the feed trough. This was characteristic of all three pens. Usually around 10:30 a.m., all the steers were dispersed about their pens but none were feeding. During the day, the steers remained scattered about each pen taking water occasionally but they were indifferent to feed until after the evening feeding. In general, none of the animals of the three pens indicated any interest in the evening ration until 5:00 p.m. or later, at which time three or four steers of each pen would begin to feed.

During the time the steers were dispersed about the pens, the same degree of comfort and range of respiration rates was observed among the three groups. The respiration rates on June 16, 1951 were very much the same for all three pens. From 9:00 to 10:00 a.m., the average respiration rate of each pen was about 85 per minute, while between 10:00 and 11:00 a.m., the respiration rate average of each pen was 102 per minute. At 5:00 p.m., the respiration rate average of each pen was about 80 per minute. The maximum and minimum temperatures on record for that day were 103 and 60 degrees F. respectively at the University of Arizona Weather Station.

The pre-test observations, comparisons, and statistical analyses indicated that the steers were uniformly alloted; the evaluation of these data therefore strengthens the hypothesis that the differences in the test results were indicative of the differences in treatment.

Test Period

The effects of shade and shade location, for this experiment, assumed a definite trend as shown in Table III. Evaluation of the final results revealed outstanding differences between the three pens of steers for the test period of ninety-eight days.

Table III shows that the individual gain of 232.4 pounds, recorded for the steers in Pen 2 during the test, was the highest gain made under the three treatments compared. Shade was provided near the feed trough in this pen. The steers in Pen 1, with the shade provided at a more remote location, gained 205.6 pounds; those in Pen 3, without benefit of shade, gained only 183.4 pounds. It may be noted in Figure IV that the gain relationships indicated above were reasonably consistent throughout the feeding period. The gains in Pen 1, however, were somewhat erratic.

The differences in individual gains were analyzed by the methods of Snedecor (11), and the results of these analyses are shown in Table IV. As observed in this table, the gains of Pen 2 exceeded those of Pen 3 by a highly significant figure. The animals of Pen 2 made higher gains than did the steers of Pen 1, and the differences approached significance at the 5% level. All other comparisons proved insignificant.

The differences in the individual gains made by the steers, subjected to the three treatments previously outlined, can be associated not only with the presence or absence of shade and with the shade location, but more specifically with the differences in feed consumption, feeding habits, respiration rates and efficiency of feed utilization.

As shown in Table III, the steers in Pen 2 consumed 35.7 pounds of feed per head daily. This figure slightly exceeded the 35.3 pounds recorded for Pen 1 and the 34.3 pounds recorded for Pen 3. While these differences are small and will account for little difference in gains, they suggest some influence of treatment upon feed consumption.

Since the steers in Pen III were provided no protection from direct solar radiation, and since the animals of Pen 1 were subjected to the same conditions while feeding during the day, the above conclusion is in accord with the findings of Mullick, Murty and Kehar (8) and Ragsdale et al. (9). The former reported that discomfort due to climatic stress resulted in decreased feed intake, while Ragsdale found that increasing the body temperature above the normal affected both feed consumption and milk production adversely.

Not only were the differences in the three treatments of the experimental cattle associated with differences in daily feed consumption, but treatment also exerted an apparent influence upon the time of consumption. The latter is illustrated in Figure I which is a graphic record of the average number of steers observed feeding at various hours throughout the day.

It may be noted, in the figure described above, that the steers of Pen 2 were away from the feed trough for a somewhat shorter period during the heat of the day than were those in Pens 1 and 3. Of equal importance is the fact that an interchange of animals at the feed trough occurred frequently in Pen 2 during the periods in which only one or two animals were observed feeding at a given instant. This did not occur to an appreciable extent in the other two pens.

A rather striking difference was found in the feed consumption habits of the animals in Pens 1 and 3. Although the period of inactivity was of similar duration through the heat of the day, more animals in Pen 1 began feeding at 5:00 p.m., or shortly thereafter. This is apparent in Figure I.

The feed consumption habits observed in each of the three pens seemingly account for the differences in feed consumption. However, these data must be substantiated by further observations.

The feed intake and accompanying feed consumption habits under the various environmental conditions can be explained partially by the differences in climatic stress as reflected in the respiration rates recorded in Figure II.

Discomforts, due to climatic stress, were particularly outstanding among the steers of Pen 3, a condition which was not as evident in Pens 1 and 2. On clear bright days the respiration rates observed in Pen 3 consistently ranged higher than the rates of the other two pens. As shown on Figure II, the average respiration rates of Pen 3 ranged from 20 to 30 respirations per minute faster than the average of the two shaded groups. These differences are in accord with Rhoad (10), Gaalaas (3) and Morrison (7) who associated increased atmospheric temperature with increasing respiration rates. The difference in respiration rate is of profound importance when it is considered that the average respiration rate of cattle, at rest, is 10 to 30 respirations per minute, as has been indicated by Dukes (2).

It is concluded that the shade structures in Pens 1 and 2 effectively reduced the solar radiation to such an extent that the steers in these two pens disposed of body heat more efficiently than did the unprotected steers in Pen 3. This conclusion compares favorably with the reports of both Kelly and Ittner (5) and Brody (1).

Efficiency of feed utilization followed in the same order as feed consumption. The steers of Pen 2, with the shade close to the feed trough, were the most efficient, requiring 15.1 pounds of feed per pound of gain. Pen 1, with the more conventional shade location, and Pen 3, with no protection from the sun, required 16.8 pounds and 18.3

pounds of feed per pound of gain respectively.

The higher feed requirement per pound of gain in Pens 1 and 3 agreed with Ragsdale et al. (10) in that the higher environmental temperature decreased production. In addition, feed consumption was not as uniform throughout the day in Pen 1 as in Pen 2, since the animals in the former case were inclined to linger under the shade located at some distance from the feed supply. Based upon the report of Brody (1) these differences in feeding habits should account, to some extent, for the difference in the efficiency of Pens 1 and 2.

It naturally follows that feed cost per pound of gain should be correlated positively with efficiency of feed utilization. As recorded on Table III, the steers of Pen 2 showed the greatest economy of gain with a cost of $0.26 per pound. Pens 1 and 3 followed with costs of $0.29 and $0.32 per pound of gain respectively.

Net returns, as shown on Table III, indicate an interesting result of this test; the steers of Pen 2, with the shade near the feed trough, returned $27.82 per head, while the steers of Pens 1 and 3 averaged $19.14 and $13.05 per head respectively. These differences in net returns were attributed to the corresponding differences in gains and feedlot efficiency as shown on Table III.

The test described in this paper, while not entirely conclusive, indicates that protection from the sun is of importance during the summer feeding period and that shade location influences feedlot performance. Because of the differences in rate of gain, feed consumption, feeding habits, feedlot efficiency and net returns associated with the treatments described in this report, a repetition of this experiment should merit consideration.

SUMMARY

Twenty-seven yearling Hereford steers, in three pens of nine head each, were fattened under different environmental conditions for a period of ninety-eight days (June 29, 1951 to October 5, 1951). A shade structure was conventionally located in Pen 1 at some distance from the feed trough. A like structure, erected in Pen 2, provided shade in the vicinity of the feed trough during the hot afternoon period, and Pen 3 was fully exposed to the sun. Individual weights were taken and group feed consumption records were maintained.

The results of the test were as follows:

1. The steers of Pen 2 made a creditable daily gain of 2.4 pounds, while those of Pens 1 and 3 gained 2.1 and 1.9 pounds respectively.

2. Variance analyses of total gains indicated a highly significant difference between the gains in Pens 2 and 3. The difference between Pens 1 and 2 approached significance at the 5% level.

3. The average feed consumption between pens was rather close. However, the steers of Pen 2 consumed 35.7 pounds of feed per head daily, which slightly exceeded the 35.3 pounds recorded for Pen 1 and the 34.3 pounds recorded for Pen 3.

4. The highest feedlot efficiency was shown by Pen 2, requiring 15.1 pounds of feed per pound of gain, while Pens 1 and 3 required 16.8 pounds and 18.3 pounds of feed per pound of gain respectively.

5. The steers of Pen 2 showed the greatest economy of gain with a cost of $0.26 per pound. This figure compares favorably with the cost of $0.29 in Pen 1 and $0.32 in Pen 3.

6. With a net return of $27.82 per head the steers of Pen 2 surpassed the average net returns of Pens 1 and 3 by $8.68 and $14.77 respectively.

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A P P E N D I X

TABLE I

PRE-TEST PERIOD APRIL 19, 1951 - JUNE 18, 1951

(per head basis)

Lot number	1	2	3
Number of head	9	9	9
Final weight June 18, 1951 (lbs)	675.6	670.6	672.8
Initial weight April 19, 1951 (lbs)	507.8	521.1	519.4
Total gain (lbs)	167.8	149.5	153.4
Daily gain (lbs)	2.8	2.5	2.6
Daily feed consumption (lbs) June 17, 1951 - June 18, 1951	32.7	32.7	32.7

VARIANCE ANALYSES OF GAINS BETWEEN PENS

Variability due to:	DF	Sum of squares	Mean square	F*
1 vs 2				
Between individuals	16	14,577.8	911.1	1.66
Between groups	1	1,512.5	1,512.5	
1 vs 3				
Between individuals	16	9,355.6	584.7	1.61
Between groups	1	938.8	938.8	
2 vs 3				
Between individuals	16	11,822.2	738.9	0.09
Between groups	1	68.0	68.0	

* significance at the 5% level is 4.49

TABLE II

EXPERIMENTAL RATION

Composition	Percent	Average Daily Ration Per Head		
		Pen 1	Pen 2	Pen 3
Alfalfa Hay (Chopped)	9	3.2	3.2	3.1
Hegari Silage	60	21.2	21.4	20.6
Barley (Rolled)	28	9.8	10.0	9.6
Cottonseed Meal	3	1.1	1.1	1.0

TABLE III

SUMMARY OF FEEDING PERIOD

JUNE 29, 1951 - OCTOBER 5, 1951
(per head basis)

Lot number	1	2	3
Number of head	9	9	9
Weight Oct. 5, 1951 (lbs)	906.7	928.9	876.7
Weight June 29, 1951 (lbs)	701.1	696.7	693.3
Total gain (lbs)	205.6	232.2	183.4
Daily gain (lbs)	2.1	2.4	1.9
Total feed fed (lbs)	3,455.7	3,494.3	3,362.5
Feed fed per head per day (lbs)	35.3	35.7	34.3
Feed per lb. gain (lbs)	16.8	15.1	18.3
Feed cost per day ($)	0.61	0.62	0.59
Feed cost per lb. gain ($)	0.29	0.26	0.32
Purchase weight* (lbs)	673.1	668.6	665.6
Initial cost per head ($)	235.66	234.01	232.96
Total feed cost ($)	59.85	60.52	58.23
Total cost ($)	295.51	294.53	291.19
Sale weight ** (lbs)	870.4	891.7	841.6
Gross return ($)	314.65	322.35	304.24
Net return ($)	19.14	27.82	13.05
Slaughter grade			
Choice (number of head)	9	9	8
Good (number of head)	0	0	1

* initial weight less 4%
** final weight less 4%

TABLE IV

VARIANCE ANALYSES OF GAINS BETWEEN PENS

Test period June 29, 1951 - October 5, 1951

Variability due to:	DF	Sum of squares	Mean square	F
1 vs 2				
Between individuals	16	11,522.25	720.14	4.26*
Between groups	1	3,068.00	3,068.00	
1 vs 3				
Between individuals	16	13,422.25	838.89	2.65
Between groups	1	2,222.22	2,222.22	
2 vs 3				
Between individuals	16	14,100.02	881.25	11.93**
Between groups	1	10,512.50	10,512.5	

* approaches significance at the 5% level (4.49)

** highly significant, greater than 1% significance (8.53)

TABLE V

SUMMARY OF THE WEATHER CONDITIONS AT

UNIVERSITY OF ARIZONA WEATHER STATION

June

TUCSON, ARIZONA

June 29, 1951 - October 5, 1951

	Temperature *		Humidity **	
	High	Low	12:N	5:PM
<u>1st Period</u>				
June 29 - July 12	105.2	75.4	21.8	21.3
July 13 - July 26	105.6	75.6	31.2	33.9
<u>2nd Period</u>				
July 27 - Aug. 9	99.6	73.1	37.6	35.9
Aug. 10 - Aug. 24	102.5	72.9	29.4	24.0
<u>3rd Period</u>				
Aug. 24 - Sept. 7	97.2	67.8	31.6	33.4
Sept. 8 - Sept. 21	102.1	66.9	18.5	20.0
<u>4th Period</u>				
Sept. 22 - Oct. 5	95.7	61.4	29.1	25.6

* degrees Fahrenheit

** percent moisture

Figure I
Feeding Habits

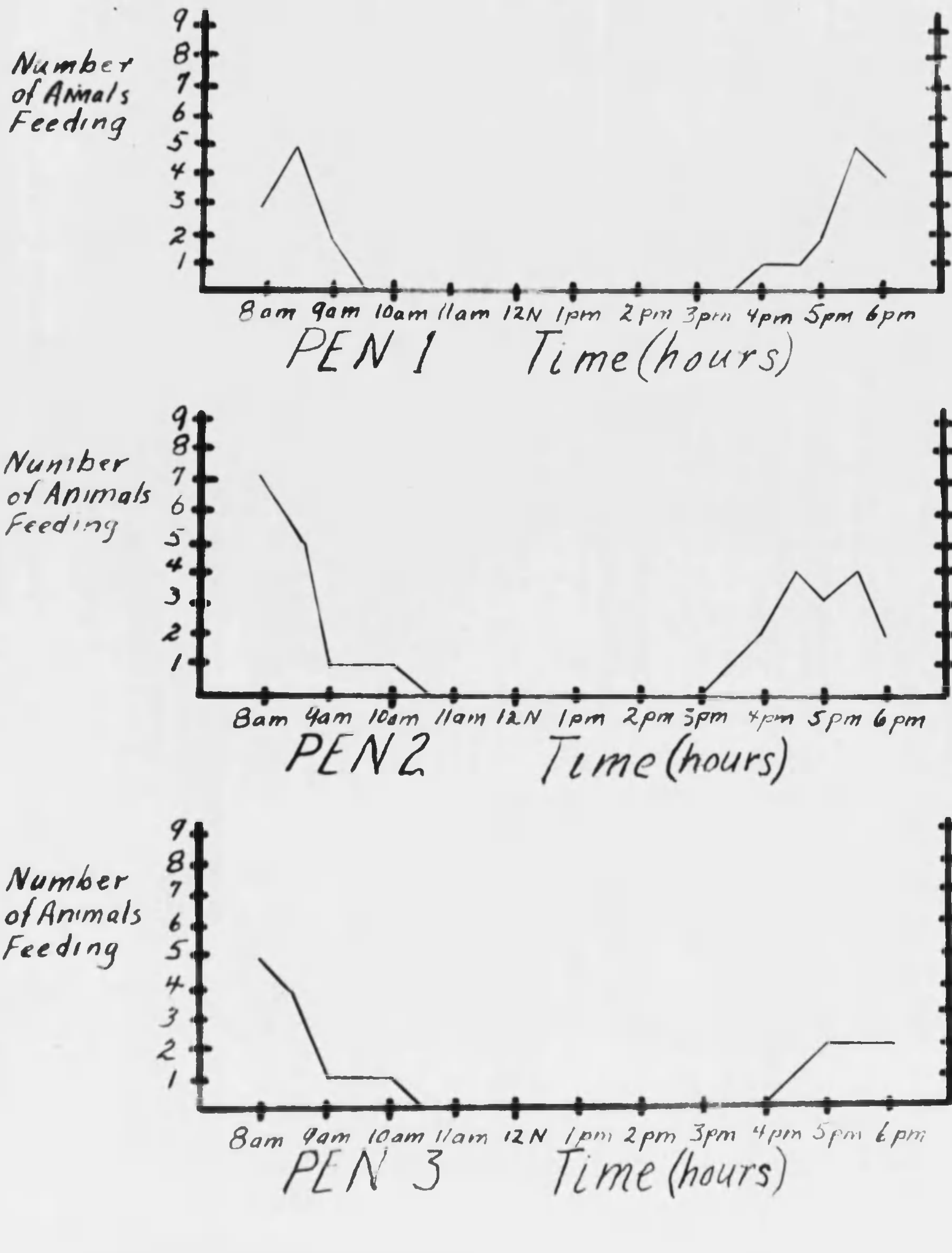
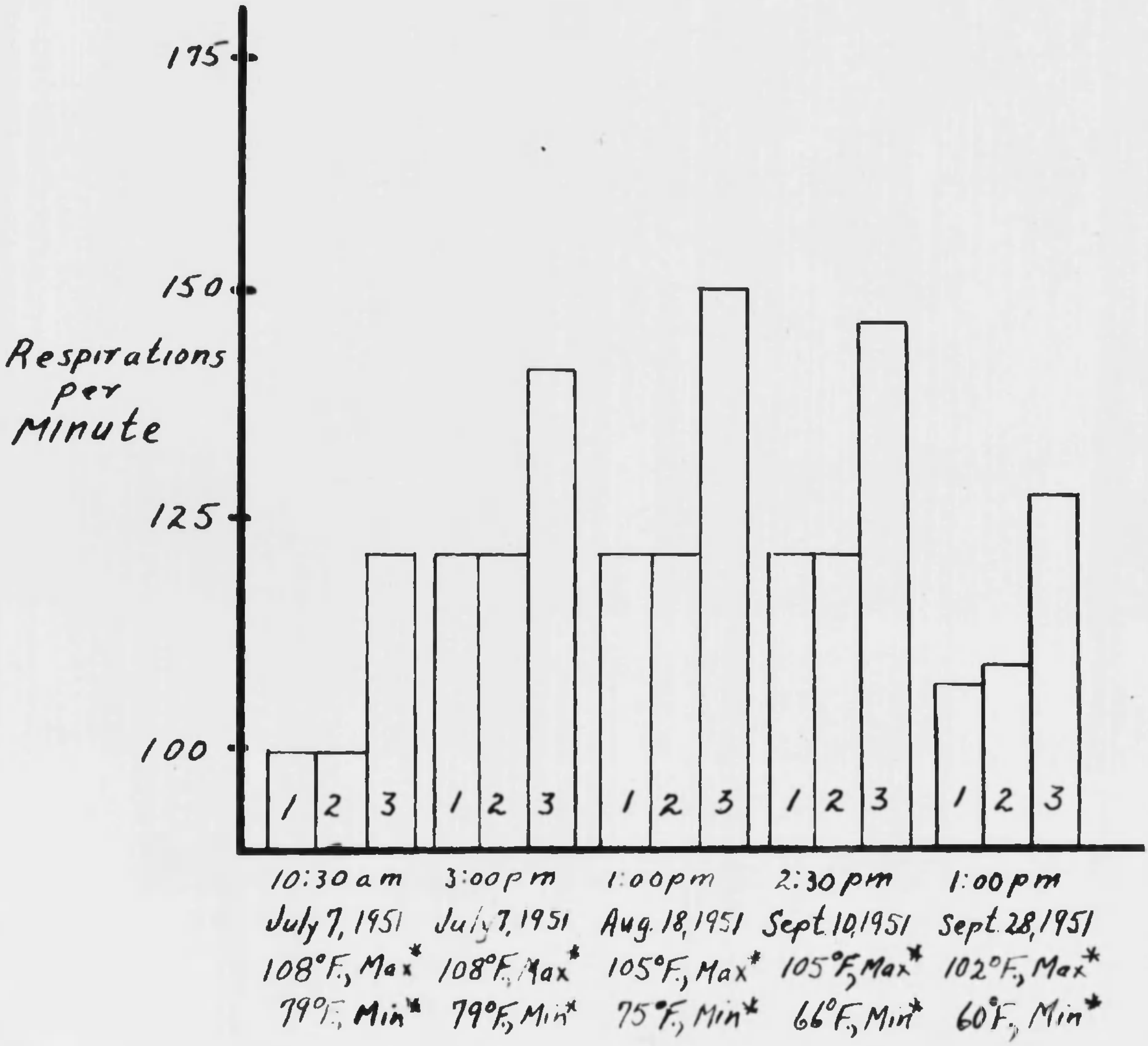
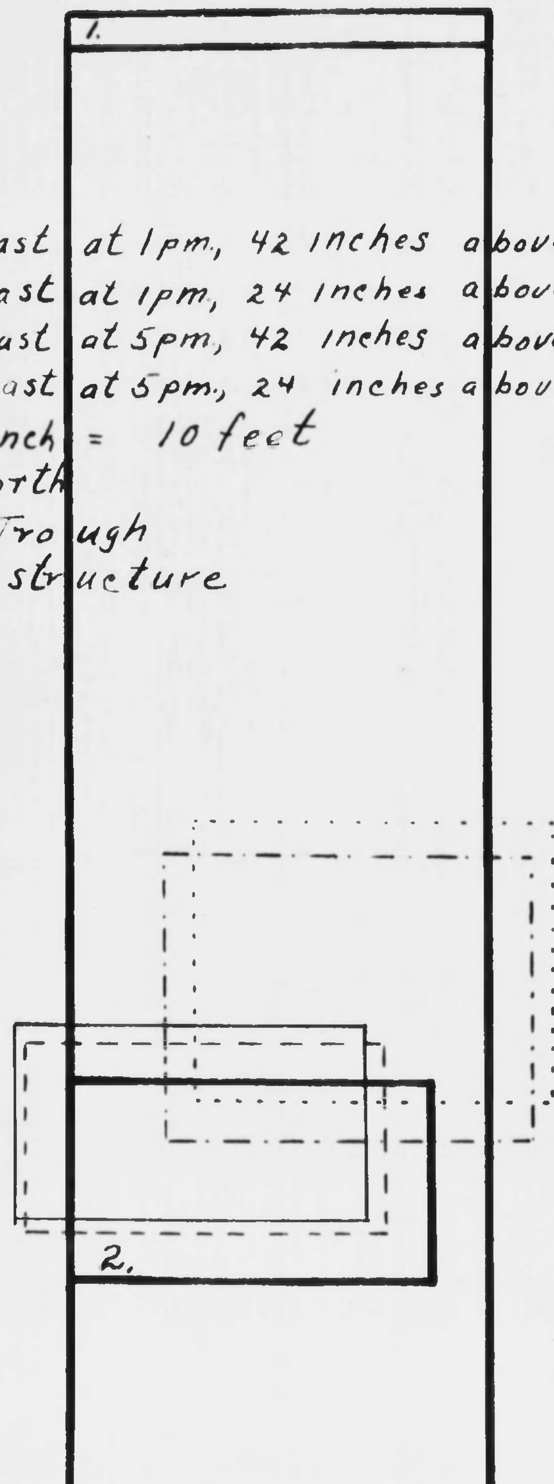


Figure II
Comparative Respiration Rates



* University of Arizona Weather station

Figure IIIa
Shade Cast In Pen 1



– – – –	shade cast at 1pm., 42 inches above the ground
———	shade cast at 1pm, 24 inches above The ground
–·–·	shade cast at 5pm, 42 inches above The ground
·······	shade cast at 5pm., 24 inches above the ground
—————	1 inch = 10 feet
←————	North
1.	Feed Trough
2.	Shade structure

Figure IIIb
Shade Cast In Pen 2

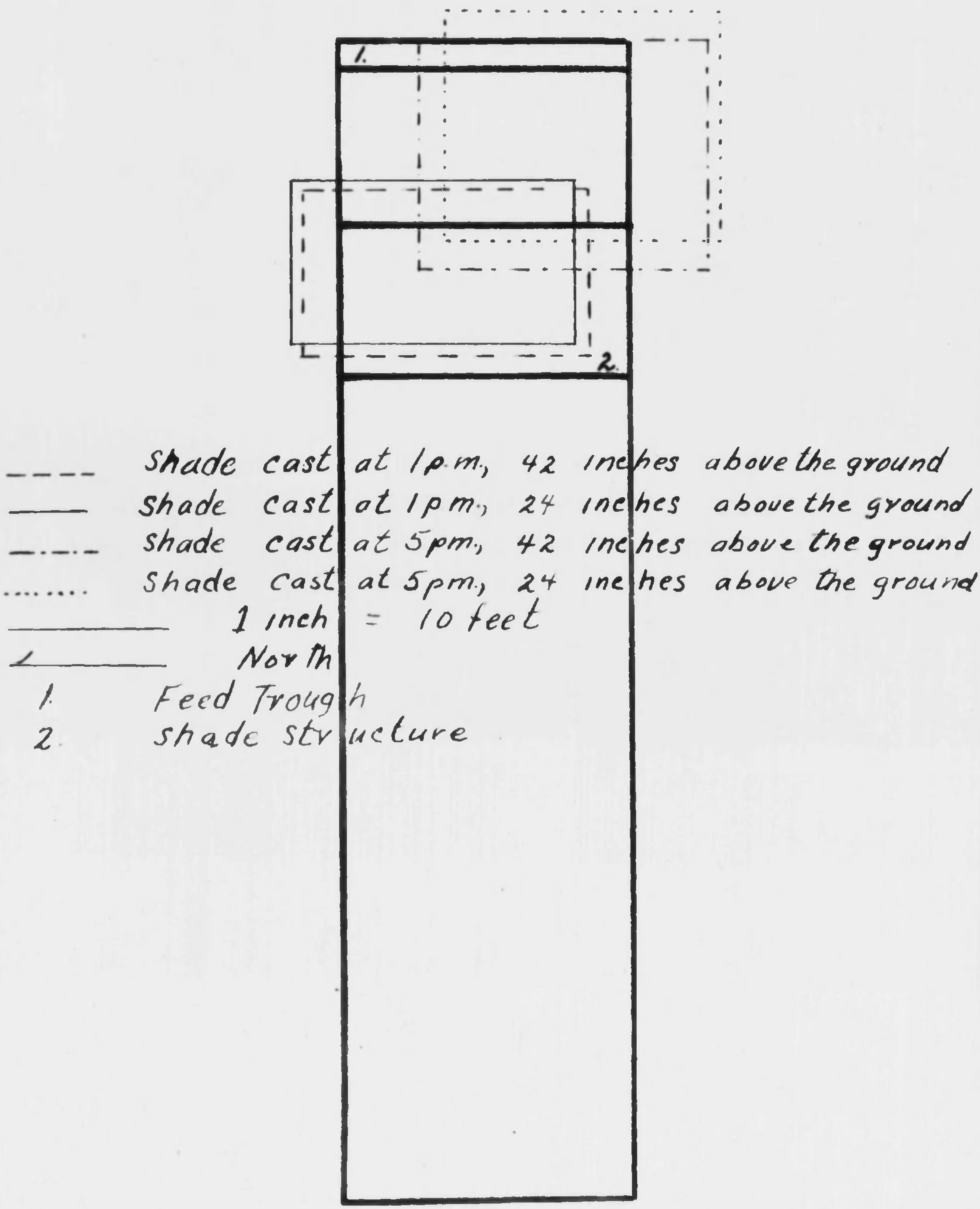


Figure IV
Average Weight During The Test Period