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# Environmental Physiology and Shelter Engineering

*With Special Reference to Domestic Animals*

XLVIII. Effects of Growth and Environmental  
Temperature on Surface Temperatures of  
Beef Calves

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# Effects of Growth and Environmental Temperature on Surface Temperatures of Beef Calves

R. E. STEWART AND M. D. SHANKLIN

## INTRODUCTION

The dissipation of heat from the animal surface by convection and radiation must necessarily take place in accordance with the temperature difference between the animal surface and the surrounding surfaces, assuming that conduction is minimized by the standing position. Therefore, prediction of the convection and radiation heat transfers from and to animals at various environmental temperatures will depend on knowledge of surface temperatures.

The surface (hair and skin) temperatures of mature dairy cows and dairy heifers as affected by environmental temperature have been reported by Thompson *et al.* in previous bulletins of the Environmental Physiology and Shelter Engineering Series (1, 2). The present report is the first one in which effect of growth on surface temperature is considered.

The data reported in this publication were obtained under the controlled conditions of the Psychroenergetic Laboratory, as part of a study of the effect of environment on calf growth.

## MATERIALS AND METHODS

Brahman (Zebu), Shorthorn, and Santa Gertrudis breeds were used. Three of each breed were placed in each test room of the laboratory. One test room was held at constant temperature of 50° F and about 62 percent relative humidity; the other test room was held at constant temperature of 80° F and about 54 percent relative humidity. Duration of the exposure to the constant condition was about thirteen and a half months (5). The calves weighed 115-160 pounds initially and were about 8 to 10 weeks old.

During the constant-temperature phase (in which most of the growth took place) the surface temperatures were taken approximately every week. The animals were weighed periodically by the Dairy Husbandry Department collaborators (7).

After completion of the constant-temperature phase, the animals were subjected to a series of environmental temperatures ranging from 65° to about 110° F. The duration of time at a given temperature was somewhat variable, but the surface temperatures were obtained at least twice during a given temperature

period. Table 1 shows the schedule of environmental conditions which was followed during the variable-temperature phase.

Complete details as to laboratory arrangements and conditions were given by Yeck (5).

TABLE 1--SCHEDULE OF ENVIRONMENTAL CONDITIONS

Psychroenergetic Laboratory 12/28/55 to 3/31/56					
Test Room I 50° F calves (all breeds)*			Test Room II 80° F calves (all breeds)**		
12/28-2/2	65° F	70% r.h.	1/4 -2/9	65° F	70% r.h.
2/3 -2/26	80° F	42% r.h.	2/10-2/19	80° F	42% r.h.
2/27-3/2	90° F	31% r.h.	2/20-3/2	90° F	31% r.h.

50° and 80° F calves were interchanged 3/2/56 and primary attention was given to the calves in Test Room II.

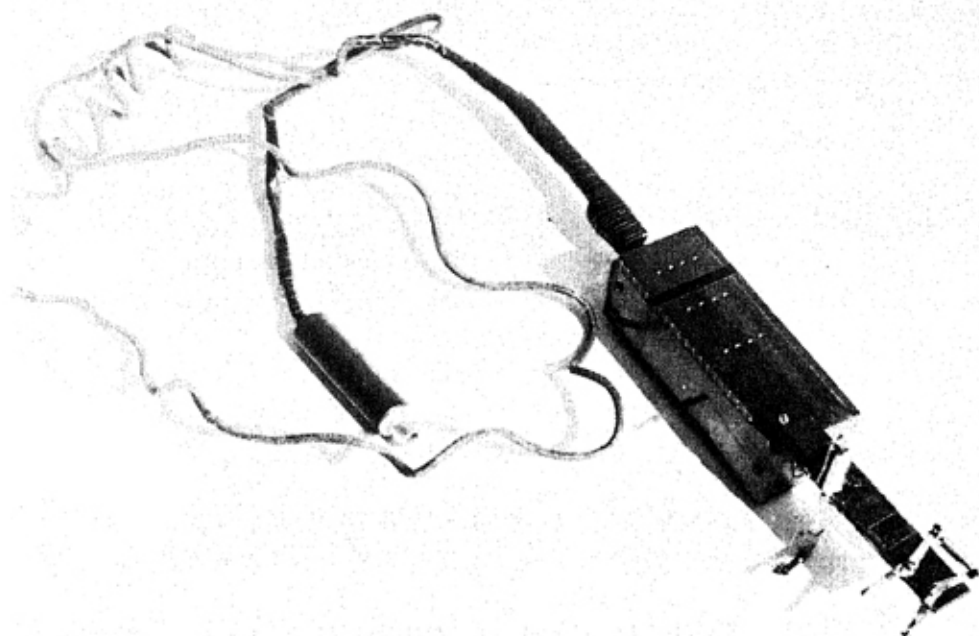
\*50° F calves represent those raised at 50° F in Test Room I from 11/17/54 to 12/28/55.

\*\*80° F calves were raised at 80° F in Test Room II from 11/17/54 to 12/28/55.

Test Room II					
	Day		Night		
	50° F calves (all breeds)				
3/2 -3/9	90° F	31% r.h.	90° F	31% r.h.	
3/10-3/11	82° F	33% r.h.	82° F	33% r.h.	
3/12-3/16	100° F	23% r.h.	94° F	30% r.h.	
	50° and 80° F Santa Gertrudis and 50° F Brahman				
3/17-3/18	94° F	28% r.h.	94° F	28% r.h.	
3/19-3/21	110° F	23% r.h.	104° F	26% r.h.	
3/22-3/23	106° F	26% r.h.	93° F	28% r.h.	
3/24-3/25	80° F	35% r.h.	80° F	35% r.h.	
	50° and 80° F Brahman				
3/26-3/27	105° F	25% r.h.	100° F	27% r.h.	
3/27	Dropped to 65° F at night				
3/28-3/30	105° F	52% r.h.	95° F	26% r.h.	

Test Room I	
	80° F calves
3/2 -3/16	Variable 70° - 80° F and about 50% r.h.
	50° and 80° F Shorthorn - 80° F Brahman
3/16-3/24	Variable 65° - 80° F and 45 to 75% r.h.
	50° and 80° F Santa Gertrudis - 50° F Shorthorn (80° F Shorthorn moved out of laboratory)
3/24-4/1	Variable 65° - 80° F and 45 to 80% r.h.

Two major differences may be observed between the above schedule and previous test schedules. One, the dew point was held approximately constant at 55° F in the above tests instead of the relative humidity. At 110° F air temperatures the dew point was elevated to about 65° F. With 52% humidity at 105° F air temperatures, the dew point temperature was about 85° F.



*Fig. 1—Photograph of instrument used for measurement of skin and hair temperatures of cattle. The short thermocouple on the end of the arm was used for skin temperature; the long thermocouple near the box was used for hair temperature. The box served as handle and also as mount for a switch. Thermocouples were of copper-constantan composition. In use, this instrument was connected to a continuous-balance, electronic-amplified, indicating potentiometer. See Reference 3 for details. This instrument was constructed by the senior author.*

The instrument used for taking skin and hair temperatures was described by Stewart and Brody (3). The instrument is shown in Figure 1. The instrument consisted of two copper-constantan thermocouples: a short one (No. 30 A.W.G.) used for measuring skin temperature and a long one (No. 24 A.W.G.) used for measuring hair temperature. The two thermocouples were connected through a switch to an automatic-balance, temperature-compensated recording potentiometer used as an indicator and calibrated for copper-constantan. The scale range was 0°-50° C, with an accuracy of 0.5° C and a sensitivity of less than 0.1° C. The calibration was checked frequently against appropriate standards.

The instrument was used as follows: the thermocouple used for skin temperature is the shorter one (see Figure 1). At a selected spot on the animal this thermocouple was inserted gently beneath the hair and moved very slowly while in contact with the skin. On attainment of the equilibrium temperature on the potentiometer the instrument was switched to the longer thermocouple. The longer thermocouple was brushed lightly on the hair surface to obtain hair temperature.

The same areas were measured on the animals as previously reported in (3).

These areas were top of back, right side, belly, and left side, which form the *main body*. Dewlap surface temperatures were taken on all breeds, but navel flap surface temperatures were taken only on the Brahman breed.

## DATA AND DISCUSSION

### Effect of Growth at Constant air Temperature.

The tables of original data for the constant-temperature phase are in the Appendix, numbered 3 through 9. The *main body* temperatures in the tables were formed by averaging the four main body temperatures for each animal and then averaging the same figures for the three animals of each breed. The *dewlap* and *navel flap* temperatures were averaged for each breed. The weights associated with the surface temperatures represent averages for each breed for the given date.

The data in the Appendix tables were formed into least-squares relationships using the equation

$$Y = A + BX,$$

$$Y = \text{Surface Temperature,}$$

$$X = \text{Body Weight,}$$

$$A \text{ and } B = \text{Constants.}$$

For each least-squares line the coefficient of correlation,  $r$ , and standard error of estimate,  $S_y$ , were determined by the usual procedures. These values are listed in Table 2, the summary of statistical data for the constant-temperature phase.

Body weight was chosen for correlation rather than age because previous work has shown that age, of itself, has little effect on surface temperatures of cattle (1, 2).

TABLE 2--SUMMARY OF STATISTICAL DATA FOR RELATIONS BETWEEN WEIGHT AND SKIN AND HAIR TEMPERATURES

Equation	r	Sy <sup>1</sup>	Breed	Location <sup>2</sup>	N
Y=98.5-.0037X	-.61	1.0	Brahman	Skin, Main Body, 80 <sup>0</sup> F	38 (Avg. of 4 places on 3 animals 38 times)
Y=92.4+.0019X	+.26	1.1	Brahman	Hair, Main Body, 80 <sup>0</sup>	38 (Avg. of 4 places on 3 animals 38 times)
Y=94.5-.012X	-.85	1.4	Brahman	Skin, Main Body, 50 <sup>0</sup>	36 (Avg. of 4 places on 3 animals 36 times)
Y=76.9-.0046X	-.36	2.1	Brahman	Hair, Main Body, 50 <sup>0</sup>	36 (Avg. of 4 places on 3 animals 36 times)
Y=87.8-.029X	-.75	4.6	Brahman	Skin, Dewlap, 50 <sup>0</sup>	36 (Avg. of one place on 3 animals 36 times)
Y=73.5-.018X	-.64	4.0	Brahman	Hair, Dewlap, 50 <sup>0</sup>	36 (Avg. of one place on 3 animals 36 times)
Y=97.1-.0037X	-.49	1.3	Brahman	Skin, Dewlap, 80 <sup>0</sup>	38 (Avg. of one place on 3 animals 38 times)
Y=92.9+.00005X	+.20	1.3	Brahman	Hair, Dewlap, 80 <sup>0</sup>	38 (Avg. of one place on 3 animals 38 times)
Y=97.9-.0021X	-.46	1.0	S.G. <sup>3</sup>	Skin, Main Body, 80 <sup>0</sup>	38 (Avg. of 4 places on 3 animals 38 times)
Y=91.4+.0037X	+.59	1.0	S.G. <sup>3</sup>	Hair, Main Body, 80 <sup>0</sup>	38 (Avg. of 4 places on 3 animals 38 times)
Y=94.6-.0063X	-.51	2.5	S.G. <sup>3</sup>	Skin, Main Body, 50 <sup>0</sup>	37 (Avg. of 4 places on 3 animals 37 times)
Y=77.9-.0013X	-.24	4.0	S.G. <sup>3</sup>	Hair, Main Body, 50 <sup>0</sup>	36 (Avg. of 4 places on 3 animals 36 times)
Y=99.1-.0043X	-.35	1.0	Sh. <sup>4</sup>	Skin, Main Body, 80 <sup>0</sup>	38 (Avg. of 4 places on 3 animals 38 times)
Y=91.7-.0014X	-.15	1.4	Sh. <sup>4</sup>	Hair, Main Body, 80 <sup>0</sup>	38 (Avg. of 4 places on 3 animals 38 times)
Y=93.6-.0033X	-.46	1.3	Sh. <sup>4</sup>	Skin, Main Body, 50 <sup>0</sup>	37 (Avg. of 4 places on 3 animals 37 times)
Y=77.0-.0042X	-.30	2.7	Sh. <sup>4</sup>	Hair, Main Body, 50 <sup>0</sup>	36 (Avg. of 4 places on 3 animals 36 times)
Y=97.7-.00019X	-.21	.9	Sh. <sup>4</sup>	Skin, Dewlap, 80 <sup>0</sup>	38 (Avg. of one place on 3 animals 38 times)
Y=91.7+.0043X	+.38	1.6	Sh. <sup>4</sup>	Hair, Dewlap, 80 <sup>0</sup>	38 (Avg. of one place on 3 animals 38 times)
Y=92.7-.0020X	-.24	1.5	Sh. <sup>4</sup>	Skin, Dewlap, 50 <sup>0</sup>	36 (Avg. of one place on 3 animals 36 times)
Y=79.8+.0033X	+.19	3.5	Sh. <sup>4</sup>	Hair, Dewlap, 50 <sup>0</sup>	36 (Avg. of one place on 3 animals 36 times)
Y=96.8-.0038X	-.15	1.0	S.G.	Skin, Dewlap, 80 <sup>0</sup>	38 (Avg. of one place on 3 animals 38 times)
Y=92.4+.0035X	+.53	3.5	S.G.	Hair, Dewlap, 80 <sup>0</sup>	38 (Avg. of one place on 3 animals 38 times)
Y=88.8-.0063X	-.31	4.6	S.G.	Skin, Dewlap, 50 <sup>0</sup>	37 (Avg. of one place on 3 animals 37 times)
Y=79.8-.0042X	-.16	6.1	S.G.	Hair, Dewlap, 50 <sup>0</sup>	36 (Avg. of one place on 3 animals 36 times)
Y=96.1-.0094X	-.03	1.2	Brahman	Skin, Navel Flap, 80 <sup>0</sup>	37 (Avg. of one place on 3 animals 37 times)
Y=92.4+.0082X	+.15	1.4	Brahman	Hair, Navel Flap, 80 <sup>0</sup>	37 (Avg. of one place on 3 animals 37 times)
Y=85.8-.023X	-.62	5.2	Brahman	Skin, Navel Flap, 50 <sup>0</sup>	35 (Avg. of one place on 3 animals 35 times)
Y=77.9-.022X	-.61	5.1	Brahman	Hair, Navel Flap, 50 <sup>0</sup>	35 (Avg. of one place on 3 animals 35 times)

<sup>1</sup>Standard error of estimate in <sup>0</sup>F.

<sup>2</sup>Main body measured on back, right and left sides and belly. Dewlap and navel flap measured on one side only.

<sup>3</sup>Santa Gertrudis.

<sup>4</sup>Shorthorn.

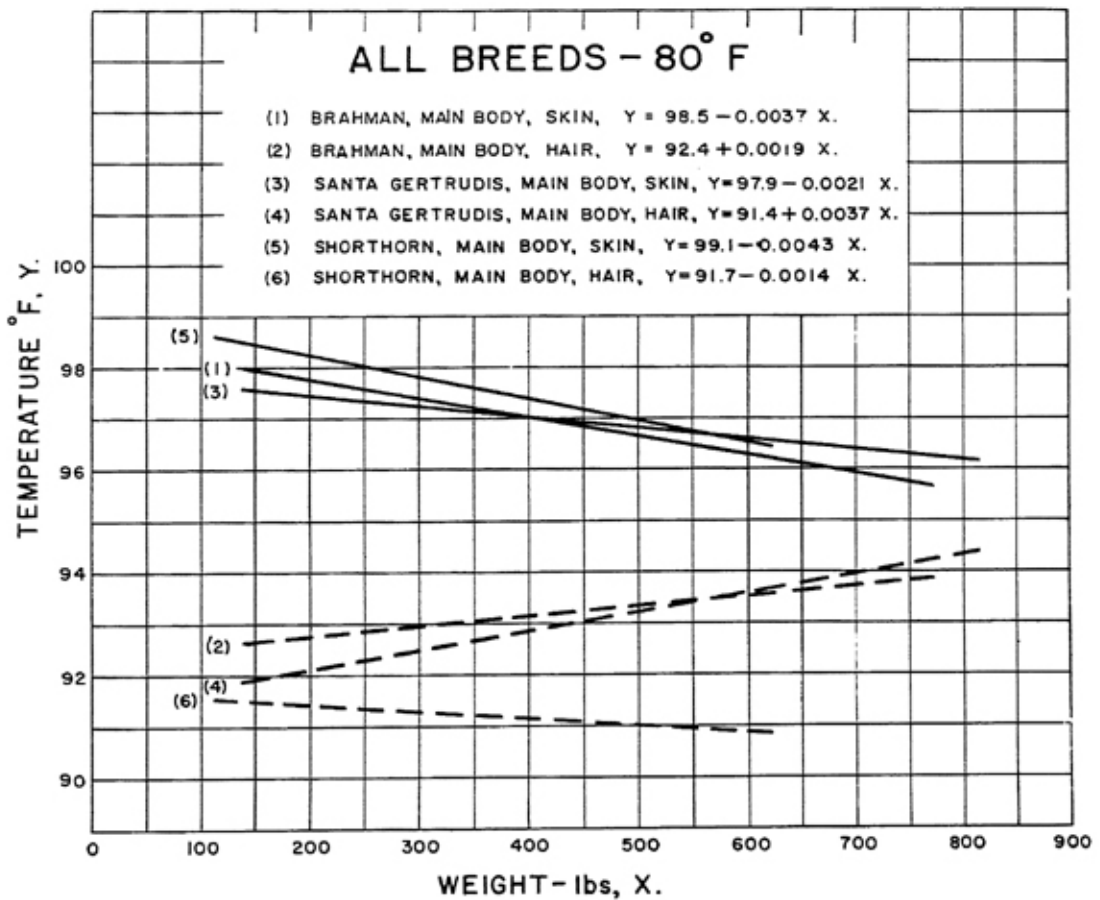


Fig. 2—Main body skin and hair temperatures of all three breeds at 80° F constant air temperature. The regression lines were determined from the data shown in the Appendix. The decreasing hair temperature of the Shorthorn was associated with longer hair in comparison with the other two breeds.

The least-squares lines are plotted in Figures 2 to 6. Figure 2 shows the plotted data for main body skin and hair temperatures of all breeds at 80° F constant air temperature. This figure indicates that skin temperature of all breeds decreased with increasing body weight. Hair temperatures of Brahman and Santa Gertrudis increased with increasing body weight, but main body hair temperature of the Shorthorn decreased. This could be associated with the comparatively long hair maintained by the 80° Shorthorn calves.



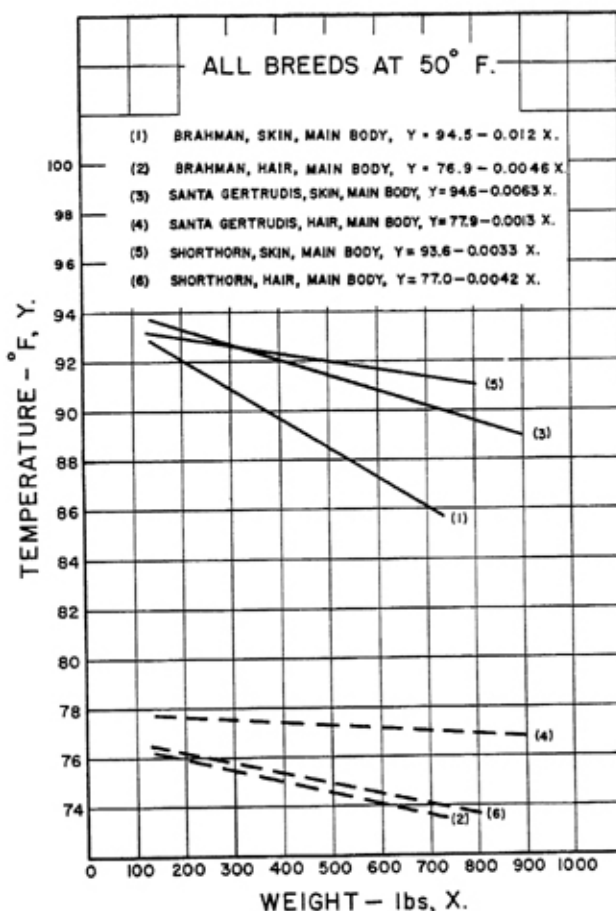
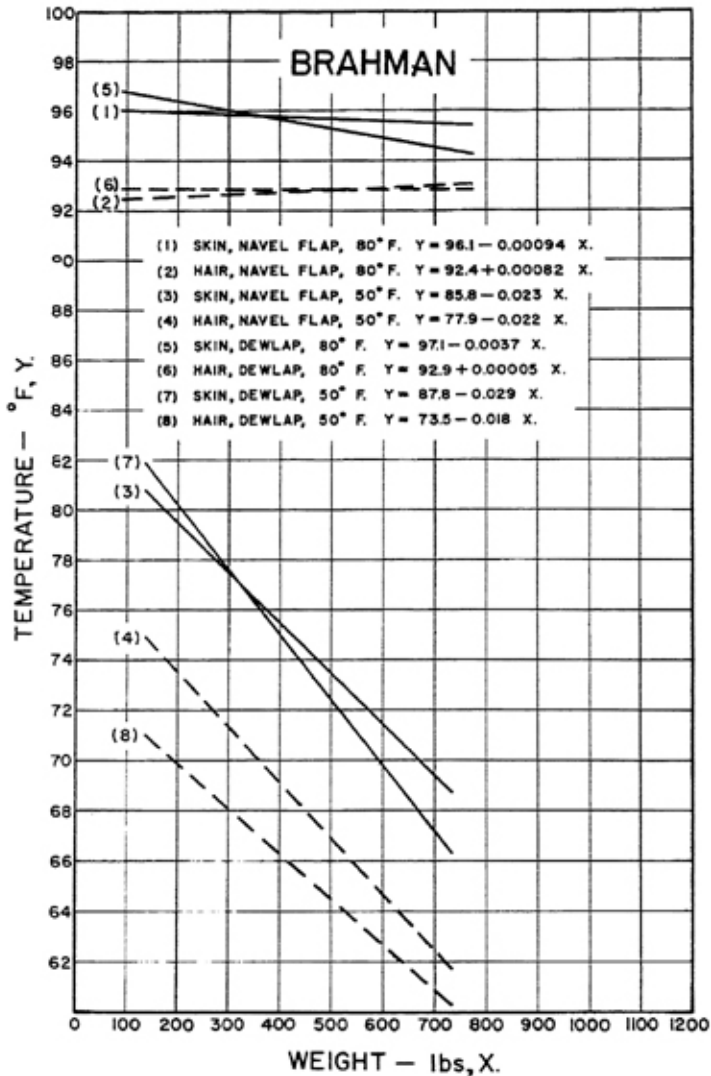


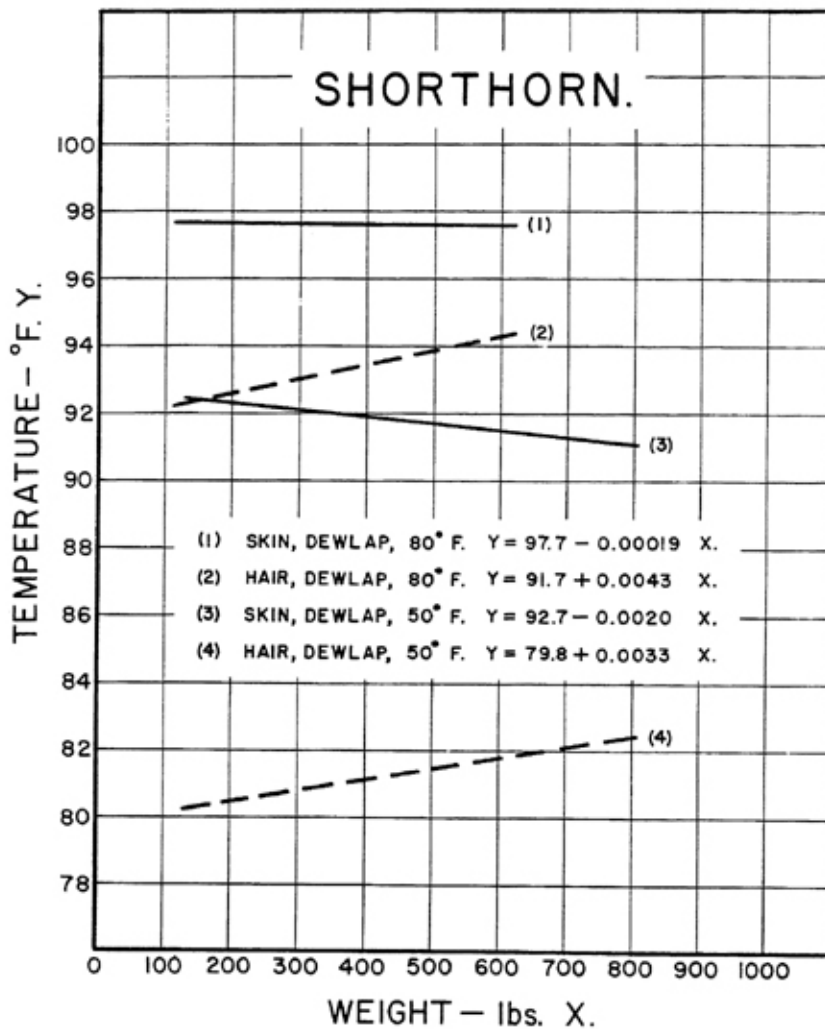
Fig. 3—Skin and hair (main body) temperatures of all three breeds at 50° F constant air temperature. The regression lines were formed from the data in the Appendix.

Figure 3 shows the least-squares lines plotted for main body surface temperatures of all breeds at 50° F constant air temperature. Figure 3 reveals that at 50° the average trend of surface temperature was downward with increasing weight. The Brahman skin temperature was significantly lower than that of other breeds, with the difference increasing with increasing weight. The Brahman hair temperature was likewise lower than that of the other breeds.



*Fig. 4—Skin and hair temperatures for the Brahman breed, navel flap and dewlap, at 50° and 80° F constant air temperature.*

Figure 4 illustrates the regression lines for the Brahman appendage (dewlap and navel flap) temperatures. These regressions indicate a remarkable decrease in skin and hair temperature of the appendages with increasing weight at 50° F. The fact that the Brahman dewlap and navel flap became quite pendulous with increasing maturity may account for the tendency to approach environmental temperature. At 80° there was little change in surface temperature with weight, although the typical downward trend in skin temperature and rising trend in hair temperature was observed.



*Fig. 5—Skin and hair temperatures for the dewlap of the Shorthorn breed at 50° and 80° F constant air temperature.*

Figure 5 illustrates the regression lines for the Shorthorn dewlap temperatures at 50° and 80° F. At 80° the skin and hair temperatures tended to intersect with increasing weight, an effect usually observed at the 80° F air temperature. At 50° F the dewlap hair and skin temperatures of the Shorthorn behaved in a similar fashion, although with lower temperatures. This behavior of the 50° F Shorthorns is unlike the dewlap temperature behavior of either the Brahman or Santa Gertrudis. The Santa Gertrudis' dewlap temperatures (Figure 6) have the typical intersection characteristic at 80° F but at 50° F both hair and skin temperatures decreased with increasing weight similar to the Brahman.

In examining the data in general, several conclusions may be drawn:

1. At 80° F constant temperature, increasing weight is associated with de-

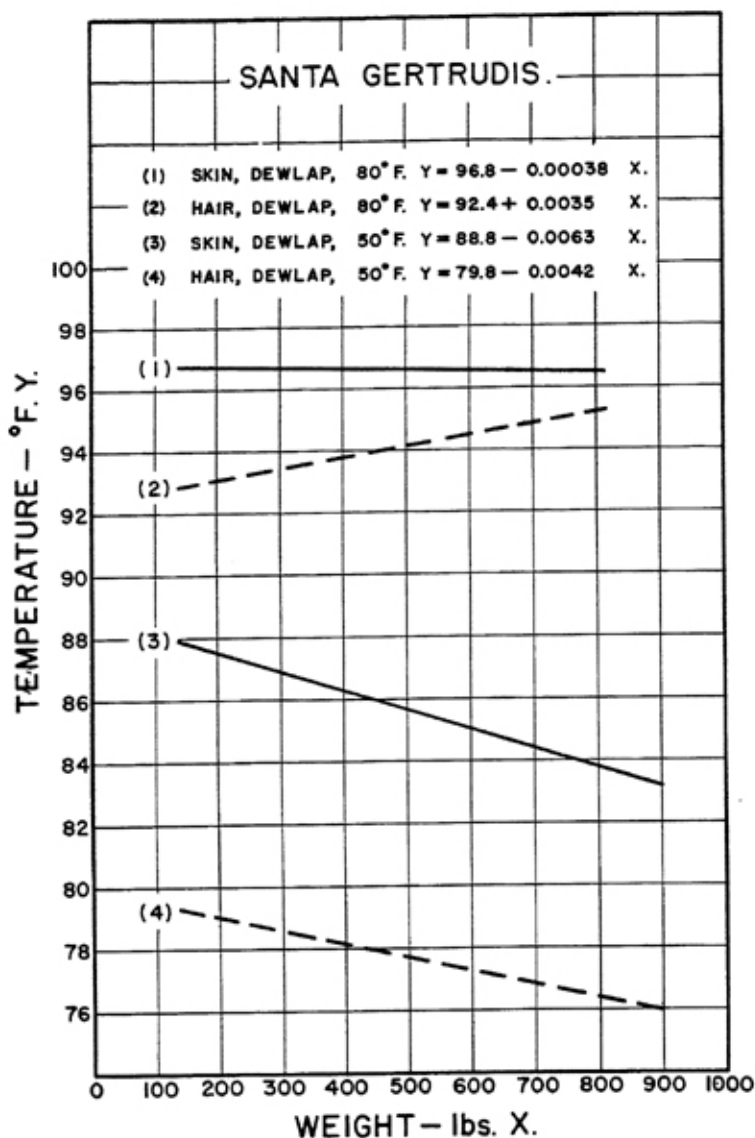


Fig. 6—Skin and hair temperatures for the dewlap, Santa Gertrudis breed, at 50° and 80° F constant air temperature.

creasing skin temperature and increasing hair temperature, except for Shorthorn main body hair. This is apparently true of the entire body, including dewlap and navel flap.

2. At 50° F constant temperature, the skin and hair temperature both decrease with increasing weight. This is apparently true for all parts of the body, with the sole exception of the Shorthorn dewlap. In the Brahman, the decrease in dewlap and navel flap temperatures with increasing weight is remarkably steep.

Similar effects were observed by Kelly *et al.*, (4) with swine surface temperatures as measured by dermal radiometer.

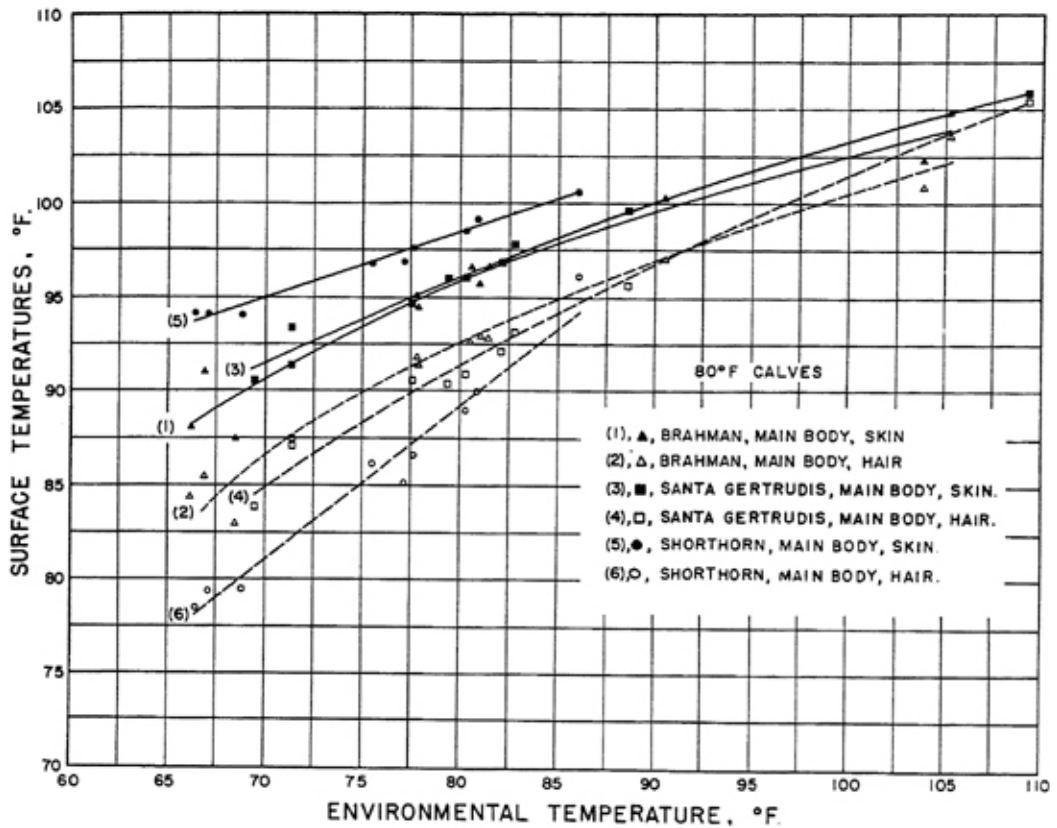


Fig. 7—Main body skin and hair temperatures of the calves raised at 80° F. Each plotted point represents an average of four measurements on each calf, averaged for the three individuals within each breed; therefore, each plotted point is an average of twelve temperature measurements. In most cases, at least two different sets of measurements were made at each environmental temperature. Curves drawn by inspection. Dashed curves are hair temperatures.

### Effect of Various Environmental Temperatures.

After completion of the constant-temperature phase, the calves were subjected to various air temperatures ranging from approximately 65° F to 110° F, as shown in Table 1.

In considering this portion of the data it is necessary to define the meaning of the terms "50° F calves" and "80° F calves". The 50° F calves were those which were raised at 50° F constant air temperature and the 80° F calves were raised at the constant 80° F air temperature.

The data are presented in Figures 7 to 10, inclusive. Average surface temperature values were plotted and then connected by inspection. Comparison of Figures 7 and 9, data for main body skin and hair temperatures of the 80° F and 50° F calves, shows little difference between the two temperature groups. The

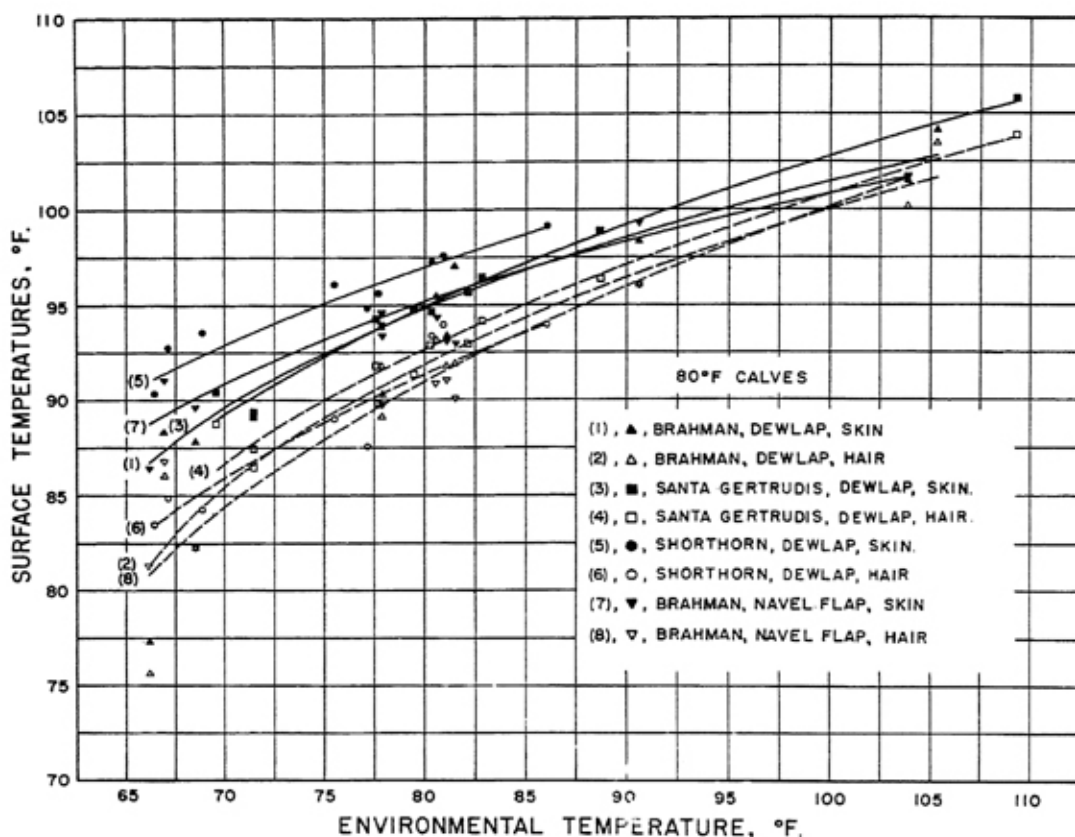


Fig. 8—Skin and hair temperatures of 80° F calves as a function of environmental temperature. The temperatures are those taken on the dewlaps of all breeds and the navel flap of the Brahman. Curves drawn by inspection. Dashed curves are hair temperatures.

Shorthorns had the highest skin temperatures and the lowest hair temperatures of both groups (main body location), an effect probably associated with longer hair coats.

Skin and hair temperatures for the dewlaps of all calves and the navel flaps of the Brahman are shown in Figures 8 and 10. As with the main body temperatures, there is little difference between the behavior of the 50° F and 80° F calves.

After reviewing the above data it must be concluded that the temperature at which a calf is raised has little or no effect on subsequent surface temperatures.

Reference to preceding surface temperature work (1, 2, 3, 6) shows that the surface temperatures of our calves after reaching 750-900 pounds in body weight were very similar to those measured previously on mature stock.

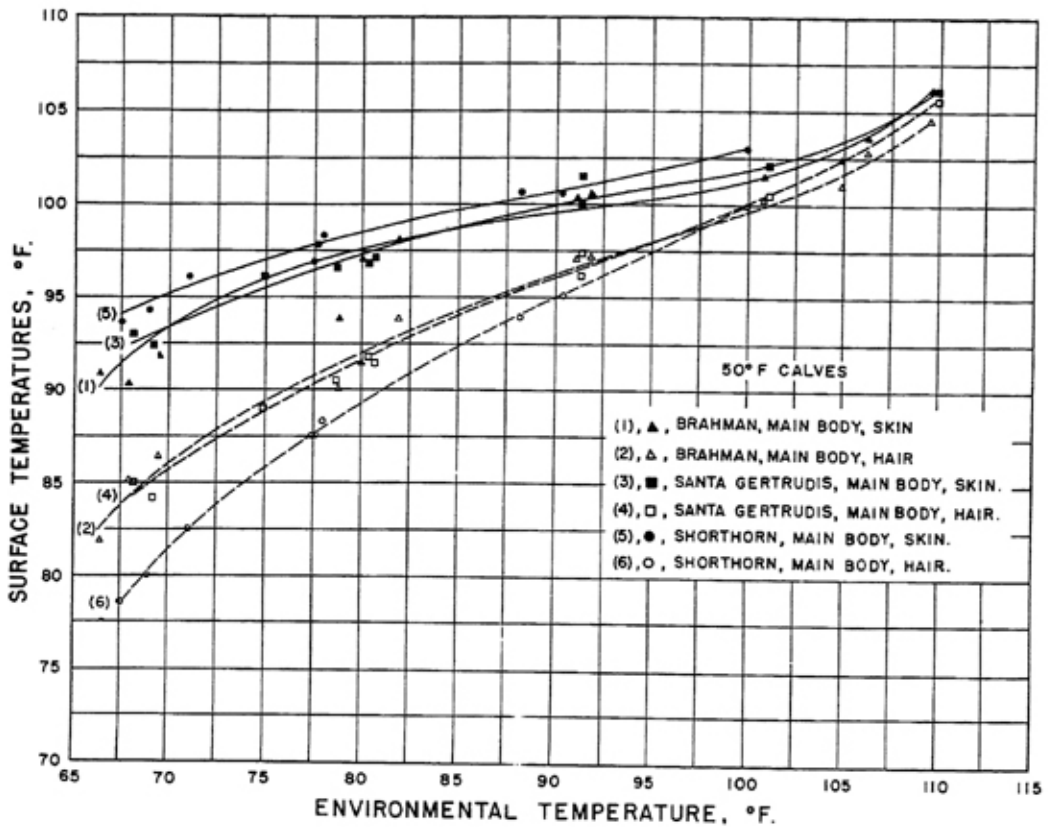


Fig. 9—Main body skin and hair temperatures of 50° F calves as affected by environmental temperature. Curves drawn by inspection. Dashed curves are hair temperatures.

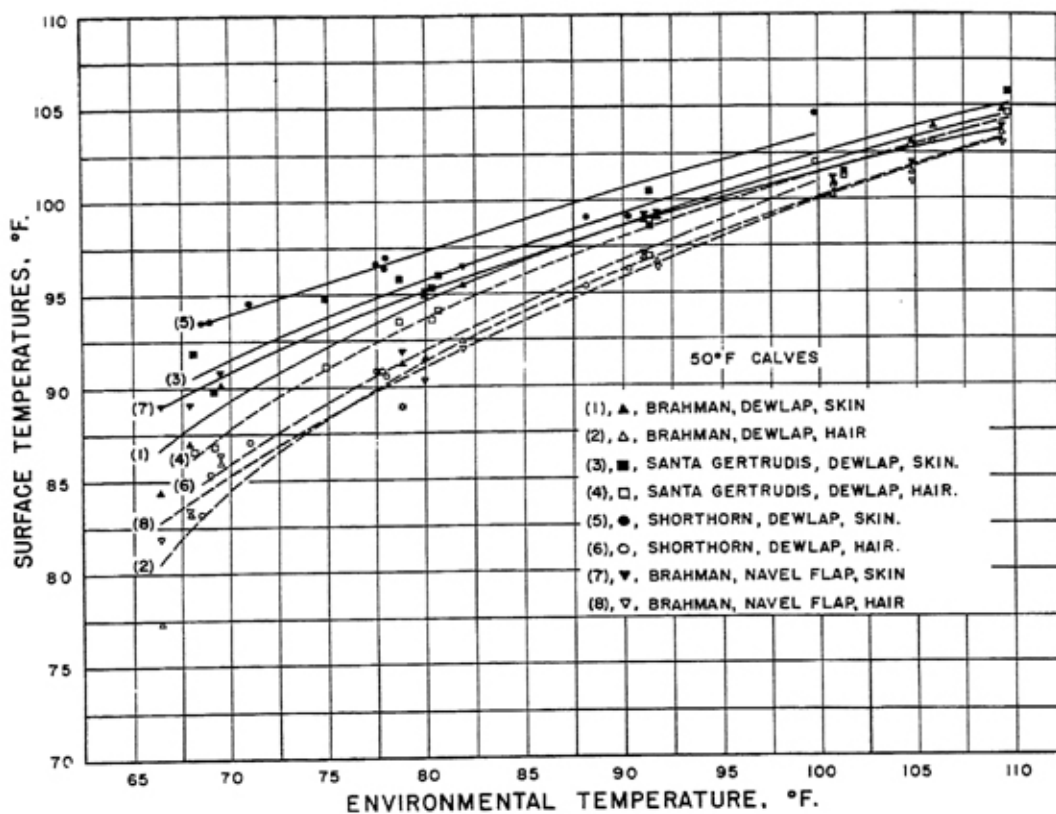


Fig. 10—Skin and hair temperatures for the appendages of the 50° F calves, as affected by environmental temperature. Curves drawn by inspection. Dashed curves are hair temperatures.



## APPENDIX

TABLE 3--BRAHMAN MAIN BODY SKIN AND HAIR TEMPERATURE AT 50° F AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F		80° F			
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54	139	90.5	72.9	145	97.8	92.5
12- 3-54	160	92.0	74.7	165	97.1	91.3
12-10-54	170	92.3	76.5	177	97.5	91.4
12-17-54	183	91.7	75.6	190	98.0	92.2
12-23-54	198	92.3	73.9	201	97.5	92.2
12-31-54	203	91.6	72.9	211	97.5	92.7
1- 7-55	217	92.5	76.1	230	97.1	92.2
1-14-55	230	92.0	73.4	247	97.2	91.9
1-21-55	244	92.6	76.7	262	99.1	93.8
1-28-55	256	91.1	75.4	277	96.1	91.4
2- 4-55	267	91.0	75.8	292	98.8	94.6
2-11-55	285	90.7	76.6	310	98.4	94.1
2-25-55	314	91.0	76.5	343	97.1	93.9
3- 4-55				362	98.1	95.1
3-11-55	349	90.7	78.3	378	96.2	93.6
3-18-55	363	89.8	77.4	393	97.9	94.7
3-25-55	377	90.7	76.9	406	96.5	93.0
4- 1-55	390	89.7	73.9	420	96.9	93.5
4-15-55	416	89.2	74.4	454	97.1	94.4
4-22-55	428	87.9	76.1	470	95.6	92.4
4-29-55	440	91.1	78.7	485	98.1	95.5
5-13-55	463	89.4	78.0	507	97.7	94.7
5-20-55	475	88.2	74.7	518	95.2	92.3
5-27-55	486	88.1	74.5	528	96.1	93.0
6-20-55	525	90.5	77.7	557	95.6	93.0
6-27-55	536	90.1	76.6	564	96.5	93.3
7-11-55	552	87.8	75.0	583	98.2	94.4
7-26-55	567	92.0	77.9	604	97.8	95.1
8- 8-55	583	89.8	75.4	619	95.6	92.1
9- 1-55	603	88.5	72.3	644	96.4	93.1
9-21-55				664	95.8	93.8
9-28-55	640	87.5	73.1	671	96.3	94.0
10-14-55	658	84.4	72.3	689	95.3	93.0
10-28-55	670	85.5	74.2	703	94.9	92.6
11-11-55	685	84.5	73.5	720	94.8	92.9
11-25-55	700	85.0	74.0	737	93.2	91.4
12-10-55	715	84.1	67.8	752	96.7	94.3
12-23-55	728	84.6	69.6	765	97.4	95.2

TABLE 4--BRAHMAN DEWLAP SKIN AND HAIR TEMPERATURE AT 50° F  
AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F			80° F		
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54	139	73.4	66.7	145	96.5	93.4
12- 3-54	160	85.0	67.3	165	94.9	91.7
12-10-54	170	79.3	69.7	177	94.5	91.5
12-17-54	183	82.3	72.4	190	95.5	92.0
12-23-54	198	85.9	74.9	201	95.7	93.6
12-31-54	203	84.9	69.1	211	96.9	91.9
1- 7-55	217	82.5	73.5	230	95.7	92.1
1-14-55	230	86.3	75.1	247	95.7	92.9
1-21-55	244	83.7	70.0	262	97.4	93.4
1-28-55	256	89.0	79.3	277	94.7	91.0
2- 4-55	267	80.1	61.5	292	98.3	94.6
2-11-55	285	83.8	67.5	310	97.1	93.5
2-25-55	314	72.3	66.3	343	96.9	93.5
3- 4-55				362	97.3	95.0
3-11-55	349	81.6	70.3	378	96.2	93.1
3-18-55	363	79.8	65.8	393	97.1	94.4
3-25-55	377	83.7	71.0	406	94.5	92.7
4- 1-55	390	68.1	61.3	420	95.5	93.2
4-15-55	416	69.9	60.1	454	97.0	95.1
4-22-55	428	72.5	61.2	470	94.6	93.3
4-29-55	440	71.0	67.5	485	97.4	95.7
5-13-55	463	71.5	62.1	507	96.0	92.8
5-20-55	475	63.9	59.5	518	93.1	91.1
5-27-55	486	67.6	57.3	528	94.7	91.7
6-20-55	525	72.5	62.8	557	95.0	93.3
6-27-55	536	76.6	65.6	564	94.6	92.5
7-11-55	552	73.1	63.7	583	96.6	94.8
7-26-55	567	74.7	67.1	604	96.9	93.9
8- 8-55	583	77.0	60.3	619	93.7	90.8
9- 1-55	603	73.7	58.1	644	93.9	92.3
9-21-55				664	94.9	93.9
9-28-55	640	71.6	64.1	671	94.9	93.7
10-14-55	658	65.5	58.6	689	94.3	92.0
10-28-55	670	69.2	64.7	703	92.9	91.9
11-11-55	685	67.8	64.1	720	93.7	92.6
11-25-55	700	69.4	64.6	737	91.7	89.7
12-10-55	715	65.3	59.5	752	95.1	93.8
12-23-55	728	67.3	63.1	765	95.4	94.4

TABLE 5--BRAHMAN NAVEL FLAP SKIN AND HAIR TEMPERATURE AT 50° F AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F			80° F		
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54						
12- 3-54	160	77.2	69.3	165	94.9	90.8
12-10-54	170	81.3	74.0	177	94.3	87.9
12-17-54	183	82.5	78.5	190	94.9	92.6
12-23-54	198	86.0	76.9	201	96.5	92.7
12-31-54	203	82.9	72.6	211	95.9	92.8
1- 7-55	217	78.1	72.2	230	95.3	92.3
1-14-55	230	85.1	76.9	247	96.1	93.0
1-21-55	244	82.0	76.4	262	97.1	93.3
1-28-55	256	84.3	74.5	277	95.6	92.6
2- 4-55	267	66.7	57.3	292	96.9	95.3
2-11-55	285	82.4	74.8	310	96.3	93.3
2-25-55	314	69.2	63.2	343	95.5	92.6
3- 4-55				362	97.1	95.3
3-11-55	349	82.5	73.4	378	95.4	92.5
3-18-55	363	80.5	70.5	393	96.3	94.1
3-25-55	377	77.3	68.9	406	94.9	92.9
4- 1-55	390	71.0	67.3	420	95.4	92.7
4-15-55	416	73.7	67.6	454	97.0	94.5
4-27-55	428	76.7	70.0	470	94.4	92.2
4-29-55	440	81.2	75.3	485	97.8	95.7
5-13-55	463	73.5	66.5	507	96.8	93.2
5-20-55	475	68.5	64.7	518	93.3	90.5
5-27-55	486	70.3	63.9	528	95.4	93.1
6-20-55	525	84.0	76.9	557	95.0	93.3
6-27-55	536	77.5	68.1	564	95.7	92.5
7-11-55	552	70.0	64.7	583	97.2	93.3
7-26-55	567	85.9	77.5	604	97.2	94.2
8- 8-55	583	71.2	60.2	619	92.6	89.8
9- 1-55	603	70.3	57.9	644	96.1	92.7
9-21-55				664	96.1	93.4
9-28-55	640	72.2	64.1	671	95.8	93.4
10-14-55	658	62.8	57.0	689	95.5	92.9
10-28-55	670	73.4	67.5	703	93.7	91.3
11-11-55	685	71.2	65.4	720	94.8	93.5
11-25-55	700	64.0	57.7	737	92.8	91.9
12-10-55	715	65.3	59.7	752	96.6	93.7
12-23-55	728	70.5	63.4	765	96.3	92.5

TABLE 6--SANTA GERTRUDIS MAIN BODY SKIN AND HAIR TEMPERATURE AT 50° F AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F			80° F		
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54	142	92.5	74.5	142	97.4	91.6
12- 3-54	162	93.3	74.7	158	96.8	91.0
12-10-54	175	93.5	79.1	170	96.6	90.3
12-17-54	190	92.4	74.1	183	96.9	90.4
12-23-54	201	94.3		193	97.0	90.9
12-31-54	213	93.5	73.4	204	98.1	92.3
1- 7-55	230	93.7	77.0	221	98.2	92.0
1-14-55	250	94.3	77.4	240	96.2	91.8
1-21-55	266	93.8	79.0	257	99.3	93.9
1-28-55	282	92.9	79.7	273	97.7	93.1
2- 4-55	297	91.2	80.3	287	98.9	94.2
2-11-55	315	93.8	81.2	307	98.2	93.4
2-25-55	348	91.3	78.8	339	97.6	94.3
3- 4-55	369	90.3	77.3	358	97.6	93.5
3-11-55	386	93.8	82.2	375	96.4	93.0
3-18-55	402	92.8	79.7	388	97.5	94.2
3-25-55	417	93.7	79.1	402	97.2	93.3
4- 1-55	431	90.9	76.0	414	96.6	92.9
4-15-55	463	91.6	74.9	443	96.5	92.4
4-22-55	477	90.6	76.5	457	95.0	91.6
4-29-55	490	91.6	80.0	470	97.6	94.4
5-13-55	523	92.5	77.4	495	96.7	93.4
5-20-55	540	90.7	75.8	508	95.7	93.5
5-27-55	557	91.0	77.5	518	95.3	92.8
6-20-55	604	93.3	78.8	559	96.5	93.3
6-27-55	617	90.9	77.0	569	96.8	92.9
7-11-55	640	90.5	77.0	589	97.6	93.7
7-26-55	663	91.9	77.4	609	99.5	96.2
8- 8-55	680	91.0	75.4	623	96.2	93.4
9- 1-55	714	90.2	74.3	649	96.7	93.4
9-21-55				690	95.7	93.3
9-28-55	766	89.3	78.6	703	97.0	94.5
10-14-55	789	90.0	76.1	723	96.6	94.0
10-28-55	807	88.3	76.7	737	96.8	93.4
11-11-55	828	89.7	79.7	755	96.3	94.0
11-25-55	848	87.0	77.2	773	94.4	93.5
12-10-55	870	88.6	74.8	792	96.4	94.4
12-23-55	890	88.1	73.4	808	96.5	93.6

TABLE 7--SANTA GERTRUDIS DEWLAP SKIN AND HAIR TEMPERATURE AT 50° F AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F			80° F		
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54	142	73.7	66.1	142	95.9	91.6
12- 3-54	162	88.2	74.7	158	96.0	91.1
12-10-54	175	80.6	68.5	170	94.2	91.6
12-17-54	190	84.0	71.2	183	95.6	92.0
12-23-54	201	86.0		193	96.1	94.1
12-31-54	213	84.2	74.0	204	96.7	92.7
1- 7-55	230	82.5	82.0	221	97.1	92.0
1-14-55	250	86.3	79.9	240	96.7	93.3
1-21-55	266	91.0	87.4	257	98.4	94.5
1-28-55	282	93.4	85.2	273	97.3	93.9
2- 4-55	297	87.9	81.8	287	98.1	95.1
2-11-55	315	92.4	83.8	307	98.2	95.4
2-25-55	348	89.7	83.4	339	97.8	95.5
3- 4-55	369	89.0	81.3	358	97.8	94.7
3-11-55	386	92.5	87.9	375	96.2	95.0
3-18-55	402	85.1	71.2	388	96.3	94.8
3-25-55	417	90.1	85.9	402	97.1	94.2
4- 1-55	431	86.5	79.5	414	97.1	93.5
4-15-55	463	89.7	75.8	443	96.8	93.9
4-22-55	477	90.9	82.9	457	94.3	91.9
4-29-55	490	90.6	83.5	470	97.4	94.7
5-13-55	523	85.3	76.6	495	96.8	93.8
5-20-55	540	81.3	74.5	508	95.4	93.5
5-27-55	557	86.9	81.5	518	94.4	93.0
6-20-55	604	91.2	79.3	559	96.5	93.7
6-27-55	617	87.5	84.6	569	97.0	94.9
7-11-55	640	87.5	78.5	589	97.3	94.5
7-26-55	663	88.9	78.0	609	99.2	96.7
8- 8-55	680	82.7	64.6	623	96.3	93.0
9- 1-55	714	84.7	66.6	649	96.9	93.5
9-21-55				690	95.7	94.8
9-28-55	766	84.9	77.3	703	96.8	95.6
10-14-55	789	77.6	70.9	723	96.7	95.1
10-28-55	807	79.2	78.6	737	96.7	94.9
11-11-55	828	84.7	83.1	755	96.0	95.4
11-25-55	848	81.3	72.3	773	95.0	93.8
12-10-55	870	78.3	73.8	792	96.2	96.1
12-23-55	890	75.2	71.9	808	96.3	94.6

TABLE 8--SHORTHORN MAIN BODY SKIN AND HAIR TEMPERATURE AT 50° F AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F			80° F		
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54	133	93.3	73.1	115	99.3	90.6
12- 3-54	156	93.4	74.8	128	98.5	89.9
12-10-54	167	91.9	75.0	137	98.1	92.4
12-17-54	180	93.4	73.7	146	99.0	91.8
12-23-54	190	95.2		154	98.9	91.6
12-31-54	202	94.7	74.1	162	99.4	92.1
1- 7-55	220	92.2	75.6	170	98.3	91.9
1-14-55	240	92.6	75.4	177	97.3	90.9
1-21-55	258	94.2	79.1	185	97.8	92.6
1-28-55	277	92.9	78.7	192	97.9	88.0
2- 4-55	291	92.6	76.4	200	99.6	95.0
2-11-55	309	93.3	82.1	210	97.6	92.2
2-25-55	342	92.1	78.2	227	97.9	91.9
3- 4-55	362	88.4	70.7	238	96.5	90.8
3-11-55	377	93.0	80.2	247	98.0	91.8
3-18-55	390	89.6	73.9	255	97.2	92.0
3-25-55	404	92.0	78.2	262	96.3	90.5
4- 1-55	417	91.1	74.4	270	97.4	90.6
4-15-55	444	92.6	73.7	293	95.4	89.4
4-22-55	457	90.7	75.0	303	96.0	91.5
4-29-55	470	91.6	74.4	313	97.1	93.0
5-13-55	497	92.2	76.4	336	96.8	91.3
5-20-55	510	90.7	73.3	348	95.9	89.4
5-27-55	522	91.7	75.1	358	96.2	89.7
6-20-55	562	92.4	76.5	386	98.3	90.0
6-27-55	573	92.8	74.7	394	97.8	94.2
7-11-55	593	93.0	74.7	410	97.1	91.7
7-26-55	613	94.4	74.5	428	99.4	93.8
8- 8-55	631	91.8	70.7	442	97.0	90.8
9- 1-55	655	92.1	73.7	467	97.9	91.5
9-21-55				492	98.8	90.9
9-28-55	694	93.2	75.8	500	97.9	91.4
10-14-55	715	91.5	74.0	523	98.9	90.4
10-28-55	733	91.2	76.2	543	97.4	90.3
11-11-55	750	91.8	78.7	556	98.2	92.0
11-25-55	761	89.4	75.2	569	95.9	90.9
12-10-55	782	90.1	69.4	591	97.2	89.7
12-23-55	798	90.4	68.1	612	97.7	90.3

TABLE 9--SHORTHORN DEWLAP SKIN AND HAIR TEMPERATURE AT 50° F AND 80° F AIR TEMPERATURE (AVERAGE OF THREE CALVES)

Date	50° F			80° F		
	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F	Weight, Lbs.	Skin Temp. °F	Hair Temp. °F
11-19-54	133	88.9	76.3	115	98.1	91.1
12- 3-54	156	92.2	75.0	128	97.7	88.4
12-10-54			76.1	137	97.0	92.9
12-17-54	180	93.1	83.5	146	98.6	93.0
12-23-54	190	93.7		154	98.0	93.7
12-31-54	202	93.3	76.3	162	99.6	92.3
1- 7-55	220	92.2	79.7	170	98.1	91.9
1-14-55	240	93.3	76.2	177	96.7	90.8
1-21-55	258	94.2	85.7	185	98.1	93.7
1-28-55	277	94.2	85.2	192	97.8	92.8
2- 4-55	291	92.1	83.3	200	99.2	94.7
2-11-55	309	93.1	86.4	210	97.4	93.1
2-25-55	342	92.4	85.8	227	97.9	93.1
3- 4-55	362	91.4	81.0	238	96.9	91.8
3-11-55	377	89.1	83.6	247	97.9	93.8
3-18-55	390	88.7	84.4	255	96.8	93.7
3-25-55	404	91.9	84.4	262	96.2	91.4
4- 1-55	417	90.7	80.0	270	97.5	95.5
4-15-55	444	91.7	77.9	293	95.9	92.5
4-22-55	457	90.5	79.9	303	96.6	91.5
4-29-55	470	92.6	83.2	313	97.5	96.0
5-13-55	497	89.7	79.3	336	97.9	95.4
5-20-55	510	89.5	77.8	348	96.8	92.2
5-27-55	522	91.4	81.2	358	96.5	92.8
6-20-55	562	92.6	79.6	386	98.3	90.7
6-27-55	573	92.0	82.5	394	97.9	94.8
7-11-55	593	92.3	82.7	410	96.9	93.1
7-26-55	613	94.9	84.9	428	99.9	94.7
8- 8-55	631	93.1	79.5	442	98.5	90.7
9- 1-55	655	93.1	81.8	467	98.5	91.1
9-21-55				492	98.2	90.9
9-28-55	694	92.9	83.9	500	97.7	95.2
10-14-55	715	90.8	85.3	523	98.2	95.5
10-28-55	733	91.6	85.5	543	97.5	93.8
11-11-55	750	91.3	86.5	556	98.2	96.1
11-25-55	761	88.9	81.5	569	95.9	92.9
12-10-55	782	90.3	78.9	591	97.6	95.0
12-23-55	798	89.9	73.4	612	97.7	94.9

## SUMMARY

Heifer calves of the Shorthorn, Brahman (Zebu), and Santa Gertrudis breeds were raised for thirteen and one-half months at constant air temperatures of 50° and 80° F. Three individuals of each breed were used at each temperature. During this time hair and skin temperatures of the main body, dewlap, and navel flap (Brahman only) were taken about once a week. The data, when plotted against body weight, show that:

1. At 80° F constant temperature, increasing body weight is associated with decreasing skin temperature and increasing hair temperature, except for Shorthorn main body hair. The effect is probably due to decreasing hair length in Brahman and Santa Gertrudis breeds.

2. At 50° F constant temperature, the skin and hair temperatures both decreased with increasing weight, except for the Shorthorn dewlap.

After completion of the constant-temperature (or growth) phase, both the 50° and 80° F groups of calves (average weights ranged from 750-900 pounds) were subjected to environmental temperatures ranging from about 65° to 110° F for varying periods of time. The hair and skin temperatures measured during this phase indicated that the previous constant-temperature phase had little or no effect on subsequent measurements at other air temperatures. The data showed that the surface temperatures were very similar to those taken in previous years on mature cows.

Tables and graphs are presented which summarize the numerical results.

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