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Environmental Physiology and Shelter Engineering

With Special Reference to Domestic Animals

XXVIII. The Thermal Effects of Radiation Intensity (Light) on Milk Production, Feed and Water Consumption, and Body Weight in Holstein, Jersey and Brahman Cows at Air Temperatures 45°, 70° and 80° F.

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Missouri Agricultural Experiment Station and the United States Department of Agriculture Cooperating

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ABSTRACT

Quantitative data are presented on the effects of exposing lactating Holstein, Jersey, and dry Brahman cows to six radiation intensities ("variable," 5, 40, 90, 130, and 180 Btu/ft^2/hr) obtained from combinations of incandescent and fluorescent lamps. Each intensity was of one-week continuous (24 hr/day) duration.

The effects here reported are on milk production, feed and water consumption, and body weight. Increasing radiation intensity did not appreciably affect these reactions at 45°F air temperature. At 70° an 80°F air temperature, however, the lactating Holstein and Jersey cows were increasingly affected by increasing radiation intensity. For example, on increasing the radiation intensity from 5 to 180 Btu/ft^2/hr (during a five week period of constant air temperature) the average milk yield of five Holsteins declined 10% at 45°F; 24% at 70°F; and 40% at 80°F; and average of four Jerseys declined 5% at 45°F; 14% at 70°F, and 30% at 80°F. Regardless of the air temperature, the greatest rate of decline occurred at the highest (180 Btu/ft^2/hr) radiation level. The non-lactating Brahmans showed no change in TDN consumption with increasing radiation at any of the three air temperature levels.

Factors contributing to greater heat tolerance are: large surface area per unit body weight; light, glossy, short (more radiation-reflective) hair; and lower heat production. These factors help to explain why the Jerseys are more heat tolerant than the Holsteins and Brahmans more heat tolerant than either of these two breeds.

In addition to the above, more advanced stages of gestation and lactation, greater age and larger size increased the intolerance to the higher radiation intensities at the higher heat exposures.

This is part of a broad cooperative investigation between the Departments of Dairy Husbandry and Agricultural Engineering of the Missouri Agricultural Experiment Staton, University of Missouri, and Agricultural Engineerng Branch, Agricultural Research Service, U. S. Department of Agriculture.

This bulletin is a report on the Department of Dairy Husbandry research project number 125—Climatic Factors.

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ORIENTATION

This and subsequent reports on the effects of radiation carried out during 1952-53 conclude the planned five-year survey on the effects of dry-bulb temperature, humidity, wind, and radiation on cattle. The preceding reports in this series[1] include data on the effects of changing dry-bulb temperature from 50° down to about 0°F and from 50° up to 105°F while holding relative humidity (65%) and air movement (½mph) approximately constant; the effect of humidity at environmental temperatures 12°, 40°, 75°, 85°, 95°, and 100°F; and the effect of wind at 0.5, 4 to 6, and 8 to 9 mph at temperatures 18°, 50°, 65°, 80°, and 95° F.

Radiation from the solar spectrum exert various effects on animals ranging from vitamin D production to photoperiodicity. This bulletin on the overall reactions of cattle as reflected by milk production and feed and water consumption is confined to the heating effects of various radiation intensities from incandescent and fluorescent lamps.

EXPERIMENT

The radiation intensity produced ranged from "visible" light, supplied by six 200-watt bulbs in the six-cow chamber, to "full" light, supplied by a combination of sixteen 300-watt incandescent reflection-type spot lamps and twelve 72-watt, 96-inch, fluorescent tubes mounted above each cow. The intensities, measured 52 inches above the floor, ranged from 5 to 180 Btu/ft^2/hr as shown in Table 1. The solar radiation on a clear summer day at noon in the Midwestern United States is of the order of 300 Btu/ft^2/hr.

Subsequent publications will give the method of installing the lamps and details concerning measuring their thermal energy and spectral composition.

Each of the three air-temperature levels (45°, 70°, and 80°F) was subdivided into six radiation intensity periods: "variable", 5, 40, 90, 130, and

TABLE 1 -- TEMPERATURE AND RADIATION CALENDAR

Weekly Periods 3 p.m. to 3 p.m.		Holsteins Air Temp. °F	Holsteins Radiation† Btu/ft²/hr	Holsteins Relative Humidity, %	Brahmans & Jerseys Air Temp. °F	Brahmans & Jerseys Radiation† Btu/ft²/hr	Brahmans & Jerseys Relative Humidity, %
1953							
Jan. 9	Jan. 16	46	variable*	66			
Jan 16	Jan. 22	45	5	65			
Jan. 22	Jan. 29	46	42	60			
Jan. 29	Feb. 5	48	86	62	45	variable*	65
Feb. 5	Feb. 12	46	131	59	45	5	62
Feb. 12	Feb. 19	46	179	54	46	39	53
Feb. 19	Feb. 26	69	variable*	63	46	94	49
Feb. 26	Mar. 5	70	7	63	45	136	51
Mar. 5	Mar. 12	70	44	64	45	190	52
Mar. 12	Mar. 19	70	98	56	69	variable*	62
Mar. 19	Mar. 26	70	135	60	70	5	67
Mar. 26	Apr. 2	71	180	55	70	40	63
Apr. 2	Apr. 9	47-93	irregular**	61	48-67	irregular**	61
Apr. 9	Apr. 16	83	variable*	64	70	82	55
Apr. 16	Apr. 23	80	7	68	70	129	55
Apr. 23	Apr. 30	80	40	69	70	175	51
Apr. 30	May 7	80	95	64	80	variable*	62
May 7	May 14	80	138	58	80	12	69
May 14	May 21	80	161	57	80	40	63
May 21	May 28				80	90	61
May 28	June 4				80	130	56
June 4	June 11				80	156	54

†Radiation values (net amounts of energy that would be absorbed from overhead by a flat horizontal black surface) were taken 52 inches from the floor along each stall divider. These readings were representative of the average radiation of the stall platform 36 inches from floor. For convenience, the radiation levels are sometimes referred to as follows:

Level	Btu/ft²/hr	Cal/m²/hr
visible	5	14
1/4	40	108
1/2	90	244
3/4	130	352
Full	180	488

*Variable period in which the radiation was changed during the day:

5-7 a.m.	5 Btu/ft²/hr	2-3 p.m.	130 Btu/ft²/hr
7-8 a.m.	40 Btu/ft²/hr	3-4 p.m.	90 Btu/ft²/hr
8-9 a.m.	90 Btu/ft²/hr	4-5 p.m.	40 Btu/ft²/hr
9-10 a.m.	130 Btu/ft²/hr	5-6 p.m.	5 Btu/ft²/hr
10-2 p.m.	180 Btu/ft²/hr	6 p.m.-5 a.m.	dark

**Irregular period in which the temperature as well as the radiation were varied to determine the highest temperature at full radiation intensity the Holstein cows would be able to endure for a week without serious consequences.

180 Btu/ft²/hr (see Table 1). With the exception of the "variable" period in which the radiation followed a set daily light rhythm of different intensities (see footnote to Table 1), each intensity level was constant throughout the 24-hour day for a period of one week. All other environmental factors were maintained as constant as possible—the relative humidity 60% and air movement ½ mph.

Pertinent information on the experimental animals is given in Table 2. The six Holsteins occupied one chamber and the four Jerseys and two Brahmans the other. All cows were lactating except the Brahmans.

As in the preceding experiments, the cows were machine-milked twice daily at 5 a.m. and 3 p.m. Water was available in individual drinking cups and the total amount supplied to the water cups was recorded automatically.

Alfalfa hay chopped in approximately three-fourths to one-inch lengths was fed *ad libitum;* the left-over hay was air dried before weighing back and deducted from the amount fed. The cows received 2 lbs. dry beet pulp twice daily. The grain mix, including cod liver oil supplement, was the same as in previous studies (see Table 3, p. 10, Res. Bul. 425). The amount fed the lactating cows was based on the previous week's milk production (Jerseys received 1 lb. grain per 3 lbs. milk and Holsteins 1 lb. grain per 4 lbs. milk). The dry Brahmans received 4 lbs. grain daily. Butterfat determinations were made three times weekly from a composite sample of the morning and evening milkings.

DATA AND DISCUSSION

The data are summarized graphically in Figures 1 to 7, based on the numerical values in Tables 3 to 7.

Figure 1 shows that at 70° and 80°F increasing radiation intensity increases the depression in feed consumption and in milk production. This result was expected from reports in the literature. For instance, Blum[2] reported that solar radiation on man may increase his heat load two to three times the resting heat production in the shade; and Adolph and associates[3] observed that exposing man to sunlight at 90°F approximately doubles his sweating rate over that in the shade; that is, it doubles his heat dissipation burden. As the thermal intensity of our lamps on the cows approached that of solar radiation, the results on cows indicates fair agreement with those reported [2 3] on man.

The relative effects of increasing radiation intensity at 70° and 80°F are brought out more impressively in Figure 2 by the curves for the individual Holstein cows, and Figure 3 for individual responses of Jersey and Brahman cows.

Milk and Butterfat Production: As in the preceding reports,[1] there were considerable individual differences because even if the cows were of the same size and age, they differed in their stages of gestation and lactation. Gestation has a depressing influence on milk yield at the advanced stages. The greater decline in milk production of H-357 at 80°F may have resulted from her advanced stage of gestation (sixth month). Although H-197 was a month later in her stage of gestation than H-357 she was removed from the laboratory during the last week of the test and aborted a sixth-month fetus. On the other hand, H-330, in the second month of gestation, showed the least decline of any of the Holsteins.

At air temperature 45°F no effect of radiation was observed except possibly at the highest (180 Btu/ft^2/hr) level in some of the Holstein cows (Figure 2). On increasing the radiation intensity from 5 to 180 Btu/ft^2/hr during a given constant air temperature, the average milk yield of the five Holsteins declined 10% at 45°, 24% at 70°, and 40% at 80°F; the average milk yield of the four Jerseys declined 5% at 45°, 14% at 70°F, and 30% at

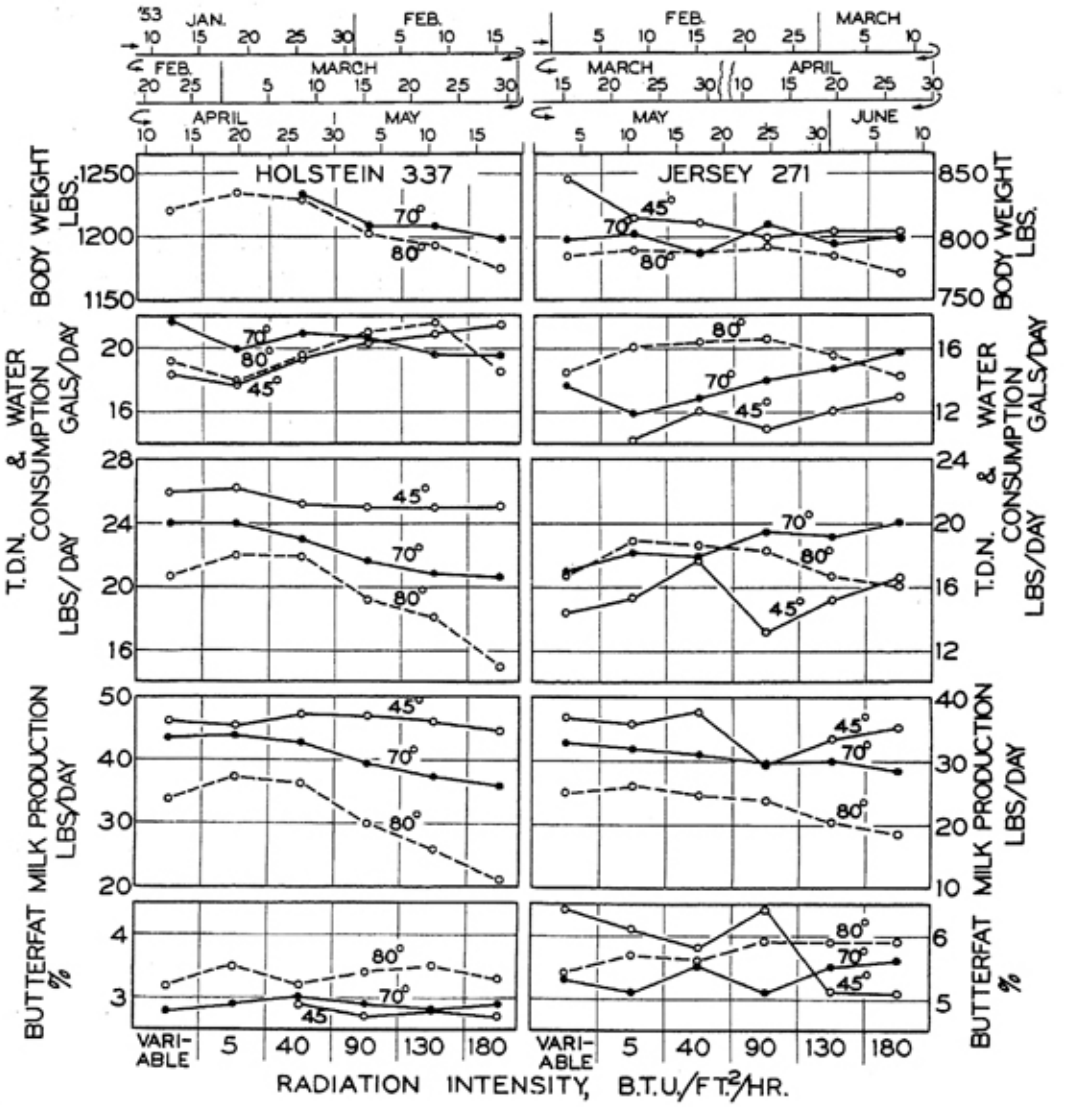

Figure 1. The responses of Holstein and Jersey cows in their milk yield, feed and water consumption and body weight on exposure for one week to each of the radiation intensities (given on axes of abscissa) at three air temperatures (given on the curves of the chart). No appreciable effect at 45°F is indicated. (J-271 was sick during the 90 Btu level which accounts for the "dip" in the curves at this point.) In Holstein 337 the rate of decline in milk production and feed consumption increased following radiation intensity of 40 Btu at 70°F; and at 80°F the rate of decline was still greater. Jersey 271 seemed to be unaffected by radiation until 80°F at the 130 Btu level.

80°F. These percentage declines include the usual 6% monthly decline[4] in milk yield with the advance in the period of lactation.

The butterfat percentage increased slightly with increasing radiation intensity at 80°F, that is, with decreasing milk yield.

Feed Consumption: Declines in TDN (total digestible nutrients) consumption roughly paralleled declines in milk production at 70° and

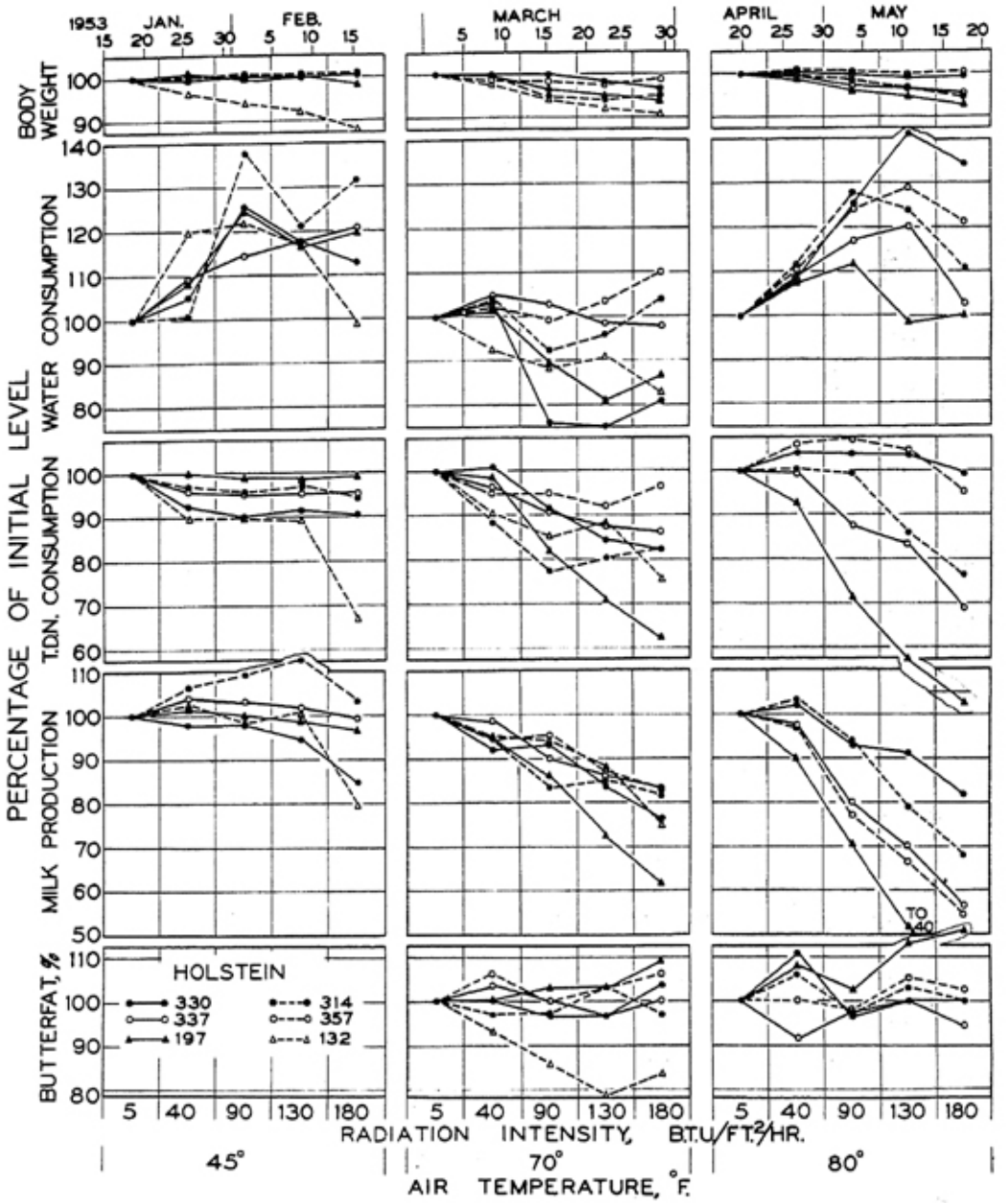

Figure 2. The effect of increasing radiation intensity on milk production, feed and water consumption, and body weight expressed in terms of percentages of the initial level (5 Btu/ft²/hr) for 45°, 70°, and 80°F (lower axis of abscissa) in individual lactating Holstein cows. Note the increasing steepness of decline in milk production and feed consumption on increasing the temperature from 45°, to 70°, to 80°F. Holstein 132 was removed from the chamber at the beginning of the 80°F level due to heat stress.

80°F. The average decline in TDN consumption on increasing radiation intensity from 5 to 180 Btu/ft²/hr for a given constant temperature were for Holsteins, 10% at 45°F, 20% at 70°F, and 24% at 80°F; for the Jerseys, 6% at 45°F, 3% at 70°F, and 15% at 80°F. The Jerseys were less affected by

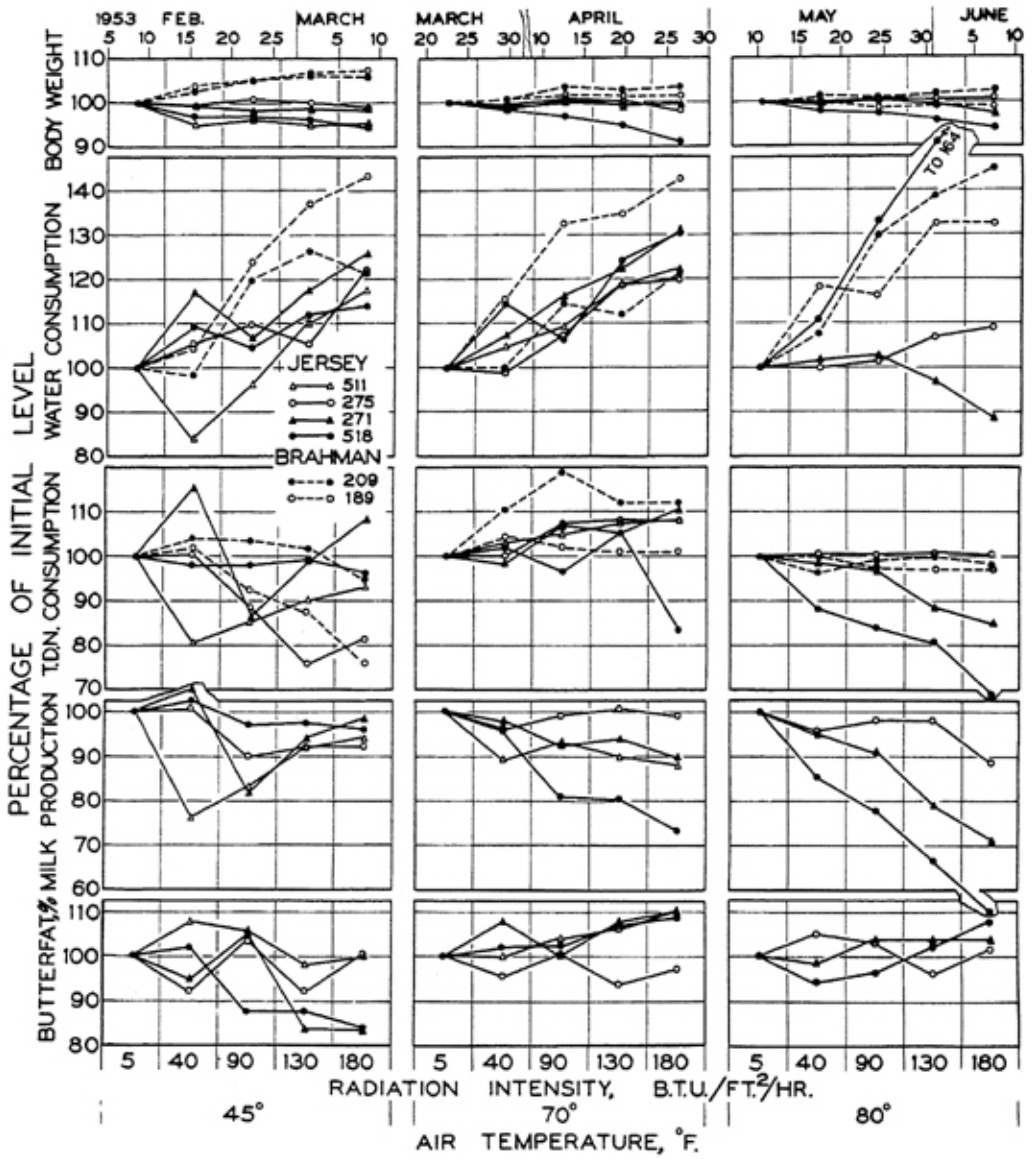

Figure 3. Continuation of Figure 2 but for lactating Jersey (continuous line) and dry Brahman (broken line) cows. The fluctuations in the data at 45°F are due to two cows being "off feed": J-511 at the 40 Btu level and J-271 at the 90 Btu level. J-511 had mastitis during the beginning of 80°F; therefore, is not shown at 80°F. J-518 was "off feed" at the 90 Btu level at 70°F.

increasing radiation intensity than the Holsteins; and the Brahmans appeared to be unaffected.

Body Weight: With exception of the Brahman cows, slight decreases in body weight occurred with increasing radiation intensity at 70° and 80°F (Figures 2 and 3). Although a few individual animals (H-132 and J-518) decreased their body weight 10%, the average decline was only about 3% during the five weeks that the radiation intensity increased from

TABLE 2 -- HISTORY OF THE COWS

Cow No.	Birth Date	Date of Last Calving	Number of Previous Lactations	Date of Last Breeding	At Beginning of Expt. Approx. Age Years	At Beginning of Expt. Approx. Body Weight lbs.	Average During January 1953 Milk lbs/day	Average During January 1953 Butterfat %
Holsteins								
330	Apr. 2, 1949	Oct. 16, 1952	1	Feb. 21, 1953	4	1200	39	3.0
337	May 7, 1949	Oct. 29, 1952	1	Dec. 17, 1952	4	1200	47	2.9
197*	Nov. 2, 1947	Aug. 22, 1952	2	Nov. 14, 1952	5	1200	45	3.3
314	June 4, 1948	Sept. 25, 1952	2	Nov. 19, 1952	4½	1200	32	3.4
132**	Sept. 14, 1944	Jan. 5, 1953	5	----------	8	1400	51	4.8
169+	July 30, 1946	Jan. 9, 1953	4	Apr. 11, 1953	6½	1400	70	3.5
Replacements								
357	Jan. 24, 1950	Aug. 2, 1952	0	Oct. 6, 1952	3	1200	26	3.5
144	June 11, 1945	Feb. 2, 1952	5	Nov. 26, 1952	7½	1300	dry	
Jerseys								
275	Nov. 3, 1948	Nov. 5, 1952	2	----------	4	800	25	5.5
511	Jan. 19, 1945	Dec. 22, 1952	5	Feb. 21, 1953	8	900	29	5.9
271	Aug. 22, 1948	Dec. 28, 1952	2	Mar. 26, 1953	4½	850	38	6.7
518	Dec. 22, 1945	Jan. 2, 1953	5	----------	7	875	29	5.8
Brahmans								
209	May 6, 1947	June 29, 1950	2		5½	1100	dry	
189	Feb. 13, 1947	June 19, 1951	2		6	1100	dry	

*Removed from chamber. Aborted May 17.

**Removed from chamber April 13. Replaced by H-144.

+Removed from chamber Feb. 16 -- operated and found hardware in rumen. Replaced by H-357.

5 to 180 Btu/ft²/hr. The decline might have been greater if the cows had not been pregnant and normally gaining weight (see Table 2).

The larger size (1400 pounds at start) of H-132 may have been a contributing factor in her greater heat stress (she was removed from the test at the beginning of the 80°F level). Another factor in the greater weight decline (as well as greater decline in milk and feed) of H-132 and J-518 could have been their more advanced age. Although a cow is considered to be in her "prime" in regard to milk production at 6 to 8 years, this age may not be the "prime" for tolerance to high temperature.

Water Consumption: There were great individual differences in the effects of radiation intensity and high temperatures on water consumption. The data presented here are for the water supplied to the water bowls; this includes spillage and evaporation. The greatest differences were not in the amounts actually drunk but in the amounts of water spilled or slobbered at the high temperatures. The weight difference in the refused hay before and after drying as shown in Figure 4 is an indication of the great difference in individual water spillage with increasing heat stress.

The water consumption curves shown in Figures 2 and 3 indicate an increase in water intake with increasing temperature and increasing radiation intensty with exception of the Holsteins at 70°F air temperature. This exception at 70°F in the Holstein is rather puzzling. However, the ratios of water consumption to milk production, and water consumption to TDN consumption, show no decrease at 70°F but rather a slight increase with increasing radiation at all temperatures (Figure 5). Could this decline in water consumption at 70°F in the Holsteins be explained by an adjustment to correspond to the decline in feed consumption and milk production of the Holsteins (but not the Jerseys)?

The two Brahman cows showed consistent increases in water consumption and in the ratios of water to TDN consumption with increasing temperature.

Hair Color: Several of the cows were chosen for their differences in hair color. Holsteins 169 and 357 (replacement of 169 when removed from the laboratory during the 45°F level) were mostly white in contrast to the others which were mostly black. Jersey 518 had a dark fawn hair coat; Jersey 511 was light fawn and the other two Jerseys were "in-between." The Brahmans were light gray. It is generally known that white or light-colored hair coats reflect a greater amount of the solar radiation in the visible spectrum than do dark hair coats.[5] Does this greater reflectance render the animals more heat tolerant as indicated by changes in milk yield?

At 80°F the decline in milk yield on increasing radiation intensity from 5 to 180 Btu/ft²/hr was 45% for the dark Jersey 518, as compared to 29 and 11% for the two medium-fawn Jerseys. (It was unfortunate that the light-colored Jersey 511 developed mastitis at the beginning of the 80°F temperature level.) Likewise, the decline in feed consumption and also body

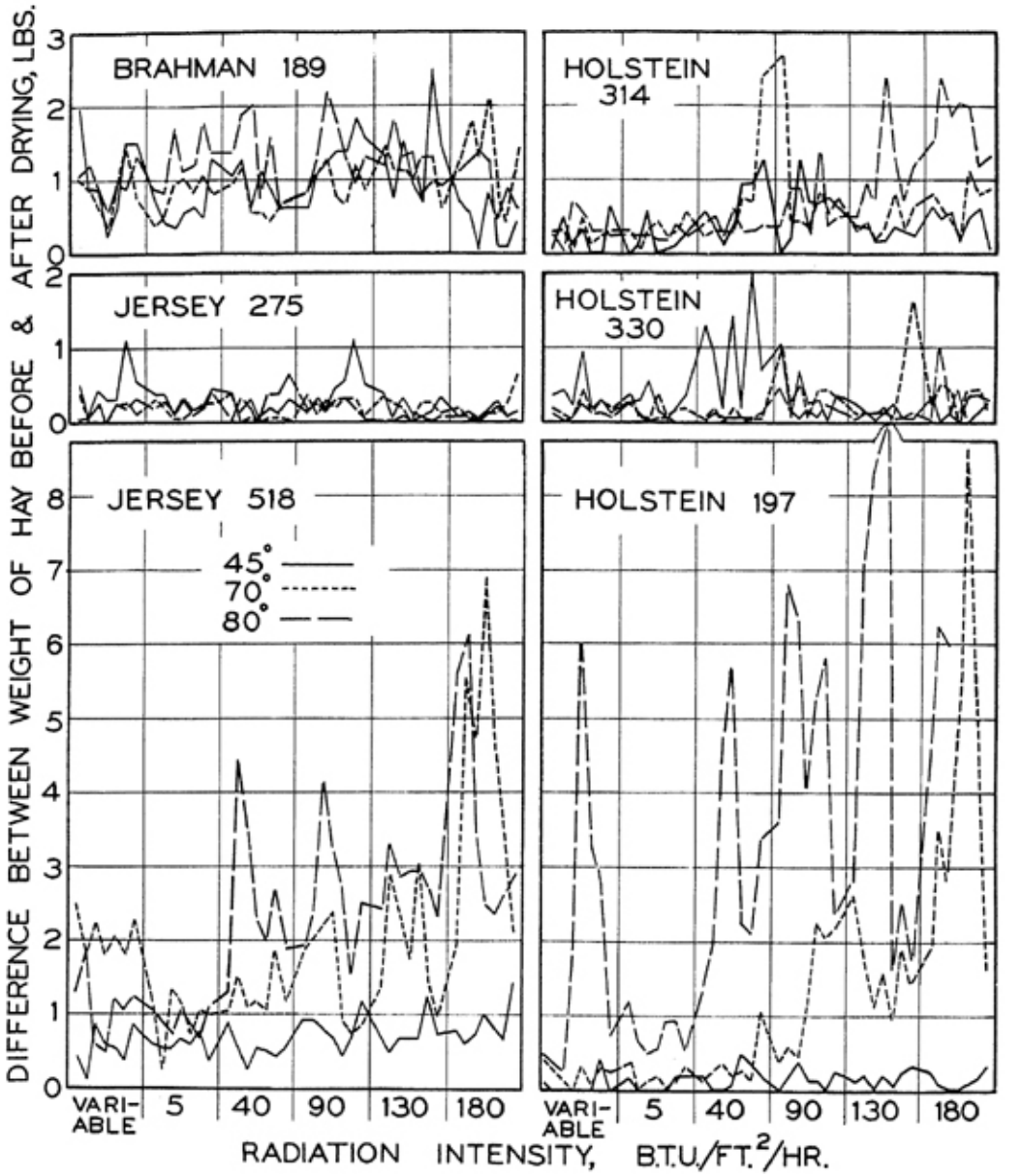

Figure 4. Individual differences in weight between the refused hay before and after air drying provides a rough index of the amount of water spilled into the mangers by slobbering and lapping at the water. High water spillage indicates, in part, the restlessness and heat stress of the cow and, in part, to individual differences in "temperament," "nervousness, and perhaps ingenuity in searching for a way to relieve the heat stress. Jersey 275 had very little spillage (less than ½ pound) at any temperature or radiation level whereas J-518 and H-197 increased their water spillage with increasing temperature and increasing radiation. Brahman 189 seemed to have spilled from ½ to 2 pounds of water at all times regardless of the radiation or temperature.

weight were greater in the dark Jersey 518, as compared to the other Jerseys. However, J-518 was three years older than either J-271 or J-275 (Table 2) and her age may have been a contributing factor to the greater decline in milk yield and feed intake. Much of the increase in water intake

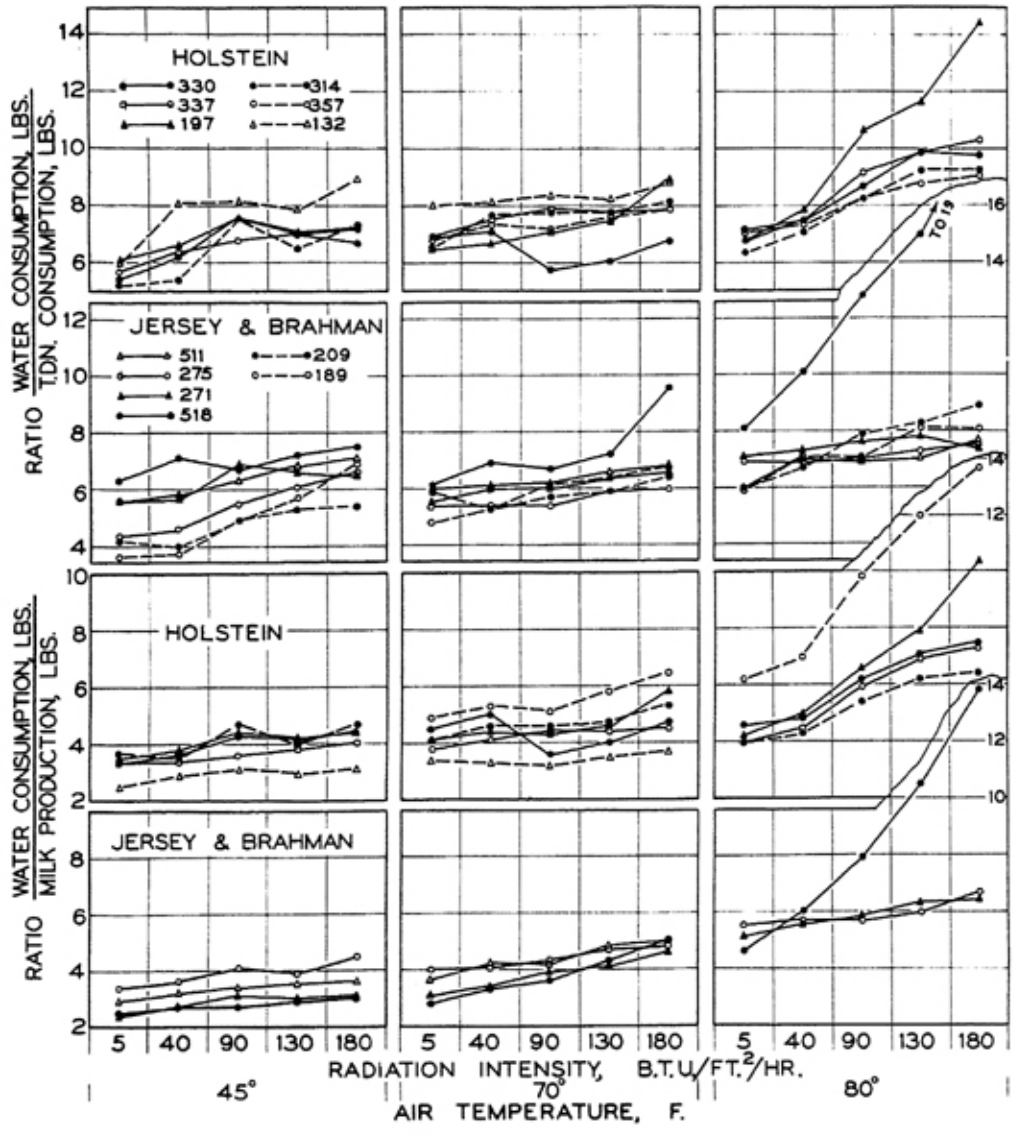

Figure 5. The ratios of water consumption to milk production and TDN consumption increase with increasing radiation and increasing temperature, especially at the higher air temperatures. The high water spillage of J-518 and H-197 (see Figure 4) accounts for the high values of the ratios. The high value for the ratios of water consumption to milk production of H-357 at 80°F is due to the decline in milk production but not feed consumption.

of J-518 (Figure 3) is explained by the increase in water spillage through slobbering and/or lapping at the water at 70° and 80°F (Figure 4). This greater increase in water spillage of J-518 over the other Jerseys indicates that this darker-colored cow was probably more restless, and trying to find a way to relieve her heat stress by increased water lapping.

Although the milk yield of the mostly white Holstein 357 declined rapidly at 80°F (probably due to advanced stage of gestation), no appreci-

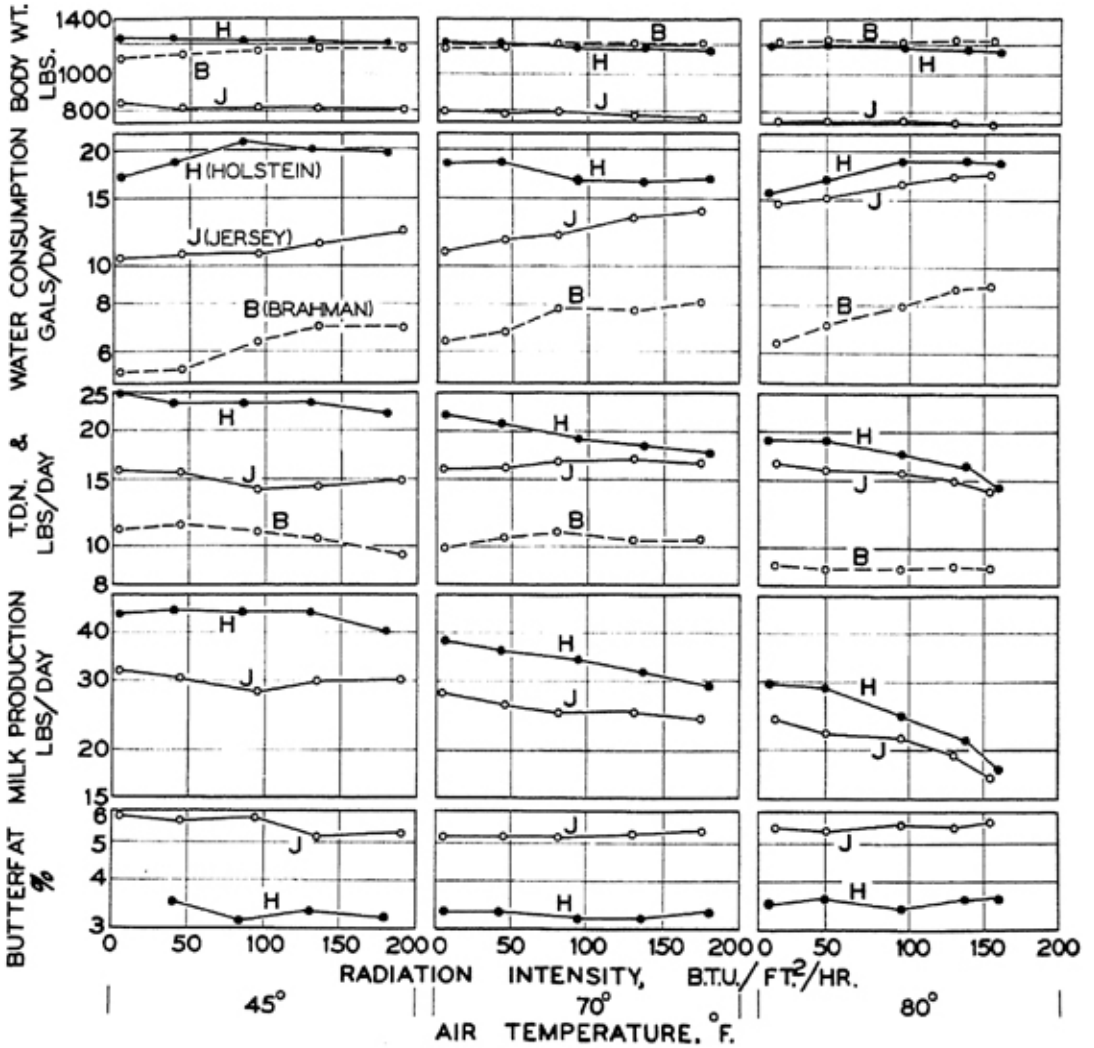

Figure 6. A comparison on a semi-log grid of the average curves of the three breeds. On semi-log paper equal slopes show equal percentages changes regardless of the absolute values. The curve for the Holstein represents the average of 5 (at 45° and 80°F) or 6 (at 70°F) cows; the curve for the Jerseys the average of 4 (except at 80°F only 3); and the two Brahmans were averaged together.

able decline occurred in TDN consumption nor in body weight at any temperature. Here, again, age may be a contributing factor as H-357 was the youngest Holstein.

Data on rectal and surface temperature, vaporized moisture, and heat production to be presented in following publications may throw more light on this subject of hair color in regard to heat tolerance. However, there are too few animals differing in hair color yet of the same age, breed, and of the same stages of gestation and lactation to make conclusive statements.

Breed Differences: In comparing the results of the different breeds, the Jerseys appear to be more tolerant of high temperatures and high ra-

diation levels than the Holsteins, and the Brahmans more tolerant than the Jerseys (Figure 6).

Several factors probably contribute to the greater heat tolerance of the Jersey: 1) they have lighter, more radiation-reflective hair in the visible spectrum than do the Holsteins; 2) they are smaller and therefore have a greater heat dissipating surface per unit weight, which is not proportionately exposed to the radiations.

Figure 7 shows that the feed cost of milk (FCM) production is higher in the Holsteins than in the Jerseys. On the average, it required about 0.7 lb. TDN to produce one lb. FCM in the Holsteins (with exception of H-132 which lost considerable weight) and only about 0.4 lb. in the Jerseys. This ratio increased with increasing temperature and radiation.

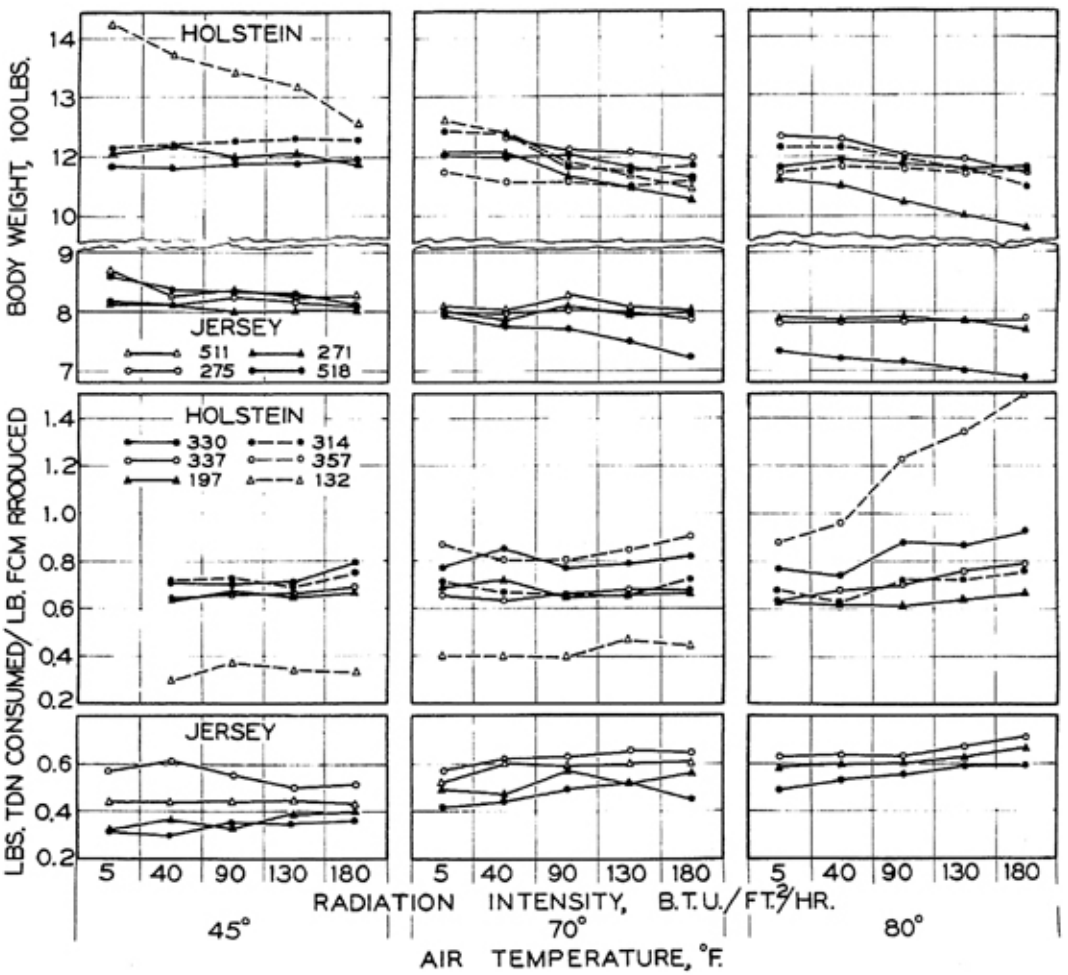

Figure 7. The apparent feed cost of milk production (represented by the pounds of TDN consumed per pound FCM produced) tends to increase with increasing radiation intensity, especially at 80° F. (FCM represents milk corrected to 4% fat and TDN total digestible nutrients.) If correction were made for loss in body weight the curves would be somewhat higher for some of the cows, especially for H-132. Body weights are given in the upper sections. The high feed cost of H-357 probably reflects her advanced stage of gestation.

The reasons for the higher radiation tolerance of the Brahmans over the Jerseys (of virtually equal body weights) are: 1) they had a lower heat production, being dry they were spared the burden of dissipating the heat increments of lactation and of the extra feeding that goes with lactation; 2) their light, glossy, short, hair reflected much better the radiations in the visible spectrum; 3) they have more extensive heat-dissipating surface areas in their ample naval flap, dewlap, and ears, only parts of which were exposed to direct radiation.

REFERENCES

[1]Preceding reports in this series published as University of Missouri Agricultural Experiment Station Research Bulletins include:

Physiological Reaction(s)	Temperature 1948-50	Humidity 1950-51	Wind 1951-52
Milk production, feed and water consumption	425, 436, 449, 460, 471	521	545
Heat production and cardio-respiratory activities	435, 450, 464, 473	522	548
Respiratory and skin vaporization	461, 497		
Insensible weight loss and total moisture vaporization	451, 479		
Surface temperature	481, 489	531	552
Blood composition	433, 488		
Carotene and Vitamin A	457		
Milk composition	485		
Integration	515		
Reflection of visible radiation		484	

[2]Blum, H. F., The physiological effects of sunlight on man. Physiol. Rev. *25,* 483-530, 1945.

[3]Adolph, E. F., and associates, Physiology of man in the desert. New York, Interscience, 1947. Adolph, E. F., The nature of the activities of the human sweat glands. Am. J. Physiol. *66,* 445-452, 1923.

[4]Brody, S., Bioenergetics and Growth, Reinhold Publishing Corp., New York, 1945, pp. 683 and 704.

[5]See Missouri Agricultural Experiment Station Research Bulletin Nos. 423 and 484.

APPENDIX

TABLE 3 -- MILK PRODUCTION, LBS/DAY, OF HOLSTEIN AND JERSEY COWS FOR SIX RADIATION LEVELS AT AIR TEMPERATURE 45°, 70°, AND 80°F.

Cow No.	Air Temp. °F	Radiation Level: Variable	Visible	1/4	1/2	3/4	Full
H-330	45	41.0*	39.2	38.4	38.4	37.1	33.2
	70	34.0	34.1	31.4	31.8	28.5*	26.1*
	80	28.2	30.0	30.7	27.9	27.4	24.6
H-337	45	46.3	45.5	47.3	46.9	46.3	44.8
	70	43.7	43.8	43.1	39.4	37.5	36.2
	80	33.8	37.3	36.3	29.9	26.1	21.2
H-197	45	45.0	44.7	45.3	44.6	44.0	43.1
	70	41.7	41.3	39.1	35.5	30.0	25.5
	80	28.4	32.3	29.1	22.7	16.7	13.0+
H-314	45	Sick	32.7	34.8	35.8	36.9	33.8
	70	34.0	34.8	32.9*	29.1*	29.6	28.3
	80	29.0	30.6	31.7	28.8	24.2	20.8
H-169	45	----	67.6	71.0	71.9	Sick-removed from Chamber	
H-357	70	23.6	23.4	22.0	22.3	20.4	19.5
	80	16.3	17.6	17.1	13.6	11.7	9.6
H-132	45	----	60.6	62.1	59.5	61.0	48.3
	70	50.5	50.7	48.1	47.6	44.8	38.1
	80	Removed from Chamber					
J-275	45	23.3	22.3	22.4	20.1	20.5	20.5
	70	19.8	20.1	19.3	19.9	20.2	19.9
	80	20.2	20.1	19.2	19.7	19.7	17.8
J-511	45	34.4	31.0*	23.6*	25.8	28.6	29.2
	70	29.2	26.8	24.0	24.9	24.2	23.6*
	80	0.3**	0.7*	1.4	2.3	2.1	1.9
J-271	45	36.8*	35.9*	37.7	29.5*	33.7	35.3
	70	32.9	32.0	31.3	29.6	30.0	28.7
	80	25.2	26.1	24.8	23.8	20.6	18.6
J-518	45	37.1	38.2	39.1	37.1	37.2	36.6
	70	34.2	33.3	32.0	26.9*	26.8	24.4
	80	25.0	26.5	22.6	20.6	17.6	14.6

*Off feed one or two days this period; these days are not included in the average. However, the following days may be affected as, for example, the cows have tendency to eat more for a few days following sickness.

+Average for three days. Removed from chamber May 17.

**Had mastitis.

TABLE 4 -- BUTTERFAT PRODUCTION, %, OF HOLSTEIN AND JERSEY COWS FOR SIX RADIATION LEVELS AT AIR TEMPERATURE 45°, 70°, AND 80°F

Cow No.	Air Temp. °F	Radiation Level					
		Variable	Visible	1/4	1/2	3/4	Full
H-330	45	---	---	2.7	2.7	2.9	2.9
	70	2.9	2.9	2.9	2.8	2.8*	3.0*
	80	2.8	2.8	3.1	2.7	2.8	2.8
H-337	45	---	---	2.9	2.7	2.8	2.7
	70	2.8	2.9	3.0	2.9	2.8	2.9
	80	3.2	3.5	3.2	3.4	3.5	3.3
H-197	45	---	---	3.3	3.1	3.3	3.3
	70	3.3	3.4	3.4	3.5	3.5	3.7
	80	4.0	3.8	4.1	3.9	4.3	4.4†
H-314	45	---	---	3.4	3.0	3.2	3.1
	70	3.3	3.3	3.2*	3.2*	3.4	3.2
	80	3.2	3.4	3.6	3.3	3.5	3.4
H-169	45	---	---	3.7	3.3 Sick-removed from Chamber		
H-357	70	3.5	3.2	3.4	3.2	3.3	3.4
	80	3.8	3.9	3.9	3.8	4.1	4.0
H-132	45	---	---	5.3	4.1	4.4	4.2
	70	3.8	4.2	3.9	3.6	3.3	3.5
	80	Removed from Chamber					
J-275	45	5.6	6.3	5.8	6.5	5.8	6.3
	70	5.6	5.9	5.6	5.9	5.5	5.7
	80	6.0	5.7	6.0	5.9	5.5	5.8
J-511	45	6.0	5.2*	5.6*	5.5	5.1	5.2
	70	4.9	5.0	5.0	5.2	5.3	5.5*
	80	No samples taken					
J-271	45	6.4*	6.1*	5.8	6.4*	5.1	5.1
	70	5.3	5.1	5.5	5.1	5.5	5.6
	80	5.4	5.7	5.6	5.9	5.9	5.9
J-518	45	5.7	5.6	5.7	4.9	4.9	4.7
	70	4.4	4.6	4.7	4.7*	4.9	5.0
	80	4.9	5.1	4.8	4.9	5.2	5.5

*Off feed one or two days this period; these days are not included in the average. However, the following days may be affected as, for example, the cows have tendency to eat more for a few days following sickness.

†Average of three days. Removed from chamber May 17.

**Had mastitis.

TABLE 5 -- TDN# CONSUMPTION, LBS/DAY, OF HOLSTEIN, JERSEY, AND BRAHMAN COWS FOR SIX RADIATION LEVELS AT AIR TEMPERATURE 45°, 70°, AND 80°F.

Cow No.	Air Temp. °F	Radiation Level					
		Variable	Visible	1/4	1/2	3/4	Full
H-330	45	22.2*	24.0	22.2	21.6	22.0	21.8
	70	21.9	22.0	22.2	20.1	18.6*	18.1*
	80	18.7	18.9	19.7	19.7	19.6	18.8
H-337	45	26.0	26.2	25.2	25.0	25.0	25.0
	70	24.0	23.9	23.1	21.7	20.9	20.7
	80	20.7	21.9	21.8	19.2	18.3	15.1
H-197	45	26.2	26.0	26.0	25.8	25.7	25.9
	70	26.0	26.0	25.7	21.3	18.4	16.3
	80	17.8	19.6	18.2	14.0	11.3	9.3+
H-314	45	Sick	23.2	22.5	22.2	22.5	21.9
	70	22.0	22.0	19.5*	17.0*	17.7	18.2
	80	18.3	18.8	18.9	18.7	16.2	14.4
H-169	45	----	22.0	21.4	22.3	Sick-removed from Chamber	
H-357	70	17.7	16.7	15.9	15.9	15.4	16.1
	80	15.4	15.2	16.1	16.3	15.9	14.5
H-132	45	----	24.8	22.3	22.3	22.2	16.6
	70	20.9	21.1	19.1	18.0	18.7	15.9
	80	Removed from Chamber					
J-275	45	17.0	17.2	17.3	15.2	13.1	14.0
	70	14.3	14.8	14.8	15.9	16.0	16.0
	80	15.7	15.9	16.0	16.0	16.1	16.0
J-511	45	15.6	16.1*	13.0*	13.8	14.5	15.0
	70	15.4	16.2	16.7	17.0	17.4	17.5*
	80	4.8**	11.0*	13.4	13.9	14.4	12.7
J-271	45	14.4*	15.3*	17.7	13.2*	15.2	16.6
	70	17.0	18.2	17.9	19.5	19.2	20.1
	80	16.8	18.9	18.6	18.3	16.7	16.1
J-518	45	15.4	15.0	14.7	14.7	14.9	14.4
	70	13.6	15.1	15.4	14.6*	15.9	12.6
	80	14.0	15.2	13.4	12.8	12.3	10.5
B-209	45	11.0	11.8	12.3	12.2	12.0	11.2*
	70	10.2*	10.6	11.7	12.6	11.9	11.9
	80	11.2	11.1	10.7	11.0	11.1	10.9
B-189	45	9.2	10.5	10.7	9.7	9.2	8.0
	70	8.8	9.0	9.4	9.2	9.1	9.1
	80	8.3	6.9	6.9	6.7	6.7	6.7

#Total Digestible Nutrients, computed with the aid of F. B. Morrison's "Feeds and Feeding", 21st Ed., 1948.

*Off feed one or two days this period; these days are not included in the average. However, the following days may be affected as, for example, the cows have tendency to eat more for a few days following sickness.

+Average for three days. Removed from chamber May 17.

**Had mastitis.

TABLE 6 -- WATER CONSUMPTION, GALS/DAY, OF HOLSTEIN, JERSEY, AND BRAHMAN COWS FOR SIX RADIATION LEVELS AT AIR TEMPERATURE 45°, 70°, AND 80°F

Cow No.	Air Temp. °F	Radiation Level					
		Variable	Visible	1/4	1/2	3/4	Full
H-330	45	14.5	15.6	16.4	19.6	18.4	17.6
	70	18.4	18.3	18.9	13.9	13.7*	14.8*
	80	17.7	16.4	17.8	20.6	23.2	22.1
H-337	45	18.4	17.8	19.4	20.4	21.0	21.5
	70	21.7	20.0	21.0	20.6	19.7	19.6
	80	19.1	18.0	19.6	21.1	21.7	18.6
H-197	45	19.3	18.9	20.5	23.6	22.0	22.7
	70	21.1	20.3	20.7	18.2	16.5	17.6
	80	17.6	16.1	17.3	18.0	15.9	16.2+
H-314	45	Sick	14.5	14.6	20.0	17.6	19.1
	70	18.2	17.3	18.0*	16.0*	16.6	18.0
	80	15.6	14.5	16.2	18.6	18.0	16.1
H-169	45	----	19.3	21.8	22.4	Sick-removed from Chamber	
H-357	70	14.7	13.8	14.1	13.7	14.3	15.2
	80	14.9	13.0	14.4	16.2	16.8	15.8
H-132	45	----	18.0	21.6	22.0	21.1	17.9
	70	21.5	20.4	18.9	18.1	18.6	16.9
	80	Removed from Chamber					
J-275	45	11.0	9.1	9.6	10.0	9.6	11.1
	70	11.0	9.6	9.5	10.3	11.4	11.5
	80	12.4	13.2	13.2	13.4	14.1	14.4
J-511	45	12.6	10.8*	9.1*	10.4	11.9	12.7
	70	12.9	11.6	12.2	12.7	13.8	14.2*
	80	7.5**	7.9*	11.2	11.5	12.1	11.8
J-271	45	----	10.3*	12.1	11.0*	12.1	13.0
	70	13.7	12.0	12.9	14.0	14.7	15.8
	80	14.5	16.1	16.4	16.6	15.6	14.3
J-518	45	13.9	11.4	12.5	11.9	12.8	13.0
	70	12.8	11.1	12.7	11.8*	13.8	14.5
	80	14.7	14.7	16.3	19.6	22.2	24.1
B-209	45	7.0	6.0	5.9	7.2	7.6	7.3*
	70	7.9*	7.5	7.5	8.6	8.4	9.1
	80	9.0	8.0	8.6	10.4	11.1	11.7
B-189	45	4.2	4.6	4.8	5.7	6.3	6.6
	70	6.0	5.2	6.0	6.9	7.0	7.4
	80	6.9	4.9	5.8	5.7	6.5	6.5

*Off feed one or two days this period; these days are not included in the average. However, the following days may be affected as, for example, the cows have tendency to eat more for a few days following sickness.

+Average for three days. Removed from chamber May 17

**Had mastitis.

TABLE 7 -- BODY WEIGHT, LBS, OF HOLSTEIN, JERSEY, AND BRAHMAN COWS FOR SIX RADIATION LEVELS AT AIR TEMPERATURE 45°, 70°, AND 80°F.

Cow No.	Air Temp. °F	Radiation Level: Variable	Visible	1/4	1/2	3/4	Full
H-330	45	----	1184	1180	1187	1190	1197
	70	1204	1203	1199	1205	1183*	1168*
	80	1177	1185	1195	1190	1183	1184
H-337	45			No Weights			
	70	----	----	1234	1209	1208	1199
	80	1221	1234	1230	1203	1194	1177
H-197	45	----	1207	1219	1200	1208	1187
	70	1196	1207	1207	1167	1150	1130
	80	1169	1164	1154	1124	1102	1082+
H-314	45	----	1216	1220	1226	1229	1228
	70	1228	1243	1240*	1184*	1178	1186
	80	1216	1215	1214	1197	1180	1152
H-169	45	----	1426	1425	1377	Sick-removed from Chamber	
H-357	70	1170	1174	1157	1158	1151	1162
	80	1165	1174	1186	1182	1174	1179
H-132	45	----	1423	1372	1343	1319	1258
	70	1256	1262	1238	1193	1171	1148
	80		Removed from Chamber				
J-275	45	829	817	812	825	816	807
	70	798	799	795	806	799	788
	80	788	783	783	785	786	790
J-511	45	895	869*	827*	838	828	829
	70	814	810	804	814	808	801*
	80	737**	718*	766	769	780	779
J-271	45	848*	815*	812	800*	805	805
	70	798	802	788	811	796	800
	80	786	790	788	793	785	772
J-518	45	878	860	836	834	829	812
	70	802	792	775	770*	751	722
	80	740	735	722	716	705	691
B-209	45	1090	1124	1153	1182	1191	1191*
	70	1184*	1201	1213	1241	1237	1241
	80	1254	1265	1283	1276	1289	1299
B-189	45	1080	1084	1127	1140	1154	1164
	70	1168	1168	1179	1188	1186	1187
	80	1188	1201	1201	1184	1192	1190

*Off feed one or two days this period; these days are not included in the average. However, the following days may be affected as, for example, the cows have tendency to eat more for a few days following sickness.

+Average for three days. Removed from chamber May 17.

**Had mastitis.