RESEARCH BULLETIN 846 NOVEMBER, 1963

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE

AGRICULTURAL EXPERIMENT STATION

E. R. KIEHL, *Director*

Environmental Physiology and Shelter Engineering

With Special Reference to Domestic Animals

LXVI. TEMPERATURE-HUMIDITY EFFECTS INCLUDING INFLUENCE OF ACCLIMATION IN FEED AND WATER CONSUMPTION OF HOLSTEIN CATTLE

H. D. JOHNSON, A. C. RAGSDALE, I. L. BERRY AND MILTON D. SHANKLIN
WITH TECHNICAL ASSISTANCE OF SANDRA MCLARNEY

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

(Publication authorized November 19, 1963)

COLUMBIA, MISSOURI

CONTENTS

ACKNOWLEDGEMENTS

This project is part of a broad cooperative investigation between the Departments of Dairy Husbandry and Agricultural Engineering of the Missouri Agricultural Experiment Station, University of Missouri, and the Agricultural Engineering Research Division of the U.S. Department of Agriculture. This bulletin is a report on the Department of Dairy Husbandry research project No. 125, "Climatic Factors".

Acknowledgements are due to M. M. Jones for cooperation on the engineering phase of the work; to Sam Barrett for assistance in water measurements; to the Veterinary Clinic staff for veterinary care; to Harry Ball, Roy Rumans, and Shirley Sturm for care and feeding of animals; to Ed Paschang for assistance in taking measurements; and to George Gruner of the State Church Farm in Jefferson City for use of several Church Farm cows in this experiment.

Environmental Physiology and Shelter Engineering

With Special Reference to Domestic Animals

LXVI. TEMPERATURE-HUMIDITY EFFECTS INCLUDING INFLUENCE OF ACCLIMATION IN FEED AND WATER CONSUMPTION OF HOLSTEIN CATTLE

H. D. JOHNSON, A. C. RAGSDALE, I. L. BERRY AND MILTON D. SHANKLIN*
WITH TECHNICAL ASSISTANCE OF SANDRA MCLARNEY

INTRODUCTION

Various combinations of temperature and humidity above a comfort temperature of 65°F influence milk production, feed intake, water intake, body weight and other functions associated directly with production in dairy animals. This is the first report describing these relative effects of numerous combinations of temperature and humidity on food and water intake. Temperature-humidity combinations on milk production have been reported by Johnson *et al.* (1962).

It is the purpose of this report to provide extensive data on feed and water intake as influenced by temperature-humidity conditions on lactating Holstein cows. Data of this nature are essential and fundamental for specific shelter requirement indexes as pertains to the two most important factors of an environment above the animal's comfort zone: temperature and humidity. An additional purpose was to analyze the "short-term" acclimation trends and express them mathematically for each exposure period. A further objective was to relate these to responses in milk production.

Orientation

Since the days of Rubner and Voit, agriculturists have been increasingly concerned with the controlling influence of the environment and the needs of energy for production (milk, meat, etc.). Feed intake in cattle is utilized for milk production, maintenance of body cells, and production of body heat. With declining temperature gradients between the animal and its environment (above 65°F), cattle have extreme difficulty in dissipating sufficient body heat by vaporization or by non-evaporative cooling to maintain normal body temperatures.

Any increase in body temperature depresses feed intake and milk production (Worstell and Brody, 1953), therefore, it is appropriate to concern ourselves with the mechanisms of feed intake and factors controlling feed intake which are actively being investigated on laboratory animals. Brobeck (1960) described his

*Departments of Dairy Husbandry, Agricultural Engineering, Univ. of Mo., Columbia, USDA, ARS.

thermosensitive theory of appetite regulation by presenting evidence of heat acting either on the heat-sensitive neurons of the rostral hypothalamus and preoptic region, or upon the neurons of the appetite center. Other excellent reviews of this subject were presented at the 22nd International Congress of Physiological Sciences by H. D. Janowitz, P. J. Morgane, and others (1962). Factors controlling water intake are also believed to be located primarily in the preoptic and rostral regions of the hypothalamus (B. Andersson, 1962).

In view of this increased emphasis on body temperature (more specifically, hypothalamic) as a controlling influence on feed and water intake, the data in this report will be expressed in relation to a temperature-humidity index as well as rectal temperatures at the various temperature-humidity conditions. Since a higher environmental temperature without its relation to humidity of the air does not fully express the severity of the environmental condition, we will use the temperature-humidity index .

PROCEDURES

Experimental Animals

A total of 40 lactating Holstein cows** were used during the two years devoted to this study (as described by Johnson *et al.*, 1962). The daily milk production of these cows when they were placed in the Climatic Laboratory ranged from approximately 25 pounds per day to about 70 pounds per day, depending on their stage of lactation and milk potential.

Individual cows were arbitrarily classified on the basis of stage of lactation. Cows in the first three months of lactation were considered to be in the early stage of lactation; cows in their four to six month stage of lactation were referred to as the mid-lactation group; and the cows which had been producing milk for about six months or more represented the late-lactation group. Cows in each stage of lactation were matched as nearly as possible with respect to productive capacity, persistency, size, and age.

Experimental Design

The experimental design used for this study was a reversal or "switch-back" plan. Two groups of animals were used; one group being exposed consecutively to a control (65°F, 50% relative humidity) condition, experimental condition, and control (65°F, 50% relative humidity) condition in that order, while the other group was exposed to an environmental condition followed by a control condition, etc. (Table 8 and 9). The animals were exposed to each condition, experimental or control, for a period of two weeks. As there are two test rooms in the Climatic Laboratory, the two groups of animals were tested simultaneously. A period of six weeks was necessary to complete a test for each experimental condition.

**In addition 6 lactating Holstein cows were placed in the laboratory Nov. 20, 1961, to determine the effects of humidity below 65°F on milk production, feed and water intake and related physiological measurements. The milk, feed, water and body temperature data are included in the appendix of this manuscript, Tables 11, 12, and 13.

Statistical Analysis

The design of this investigation permitted the use of several methods in analyzing the effects of temperature and humidity on hay and water consumption data. One procedure was a comparison of the effects of the various experimental conditions. In this analysis, student's "t-test" was used to compare the hay, TDN, and water to the previous control of 65°F and 50% R.H. The averages of the second-week data were used to determine the differences for the 12 cows.

Another method (Brandt, 1948 and Lucas, 1956, 1957) tested treatment differences in the switch-back design. The consumption during each experimental period was compared to the normal hay and water consumption. This method was more sensitive than the standard "t-test" and eliminated variation due to both error and the treatment variance values.

Because of individual cows' differences in levels of intake and acclimation trends of hay and water consumption, a more complex analysis procedure was designed especially for the evaluation of individual animals. The hay and water consumption of each cow during a six-week period was tested for significant differences due to the experimental conditions. This procedure was desirable because it did not mask the individual differences in heat tolerance. The first step was the computation of a least-squares regression line versus time in days for the second- and sixth-week data. The average of the second- and sixth-week data was then compared to the average of the fourth-week data, with the differences being attributed to the differences between the control and experimental condition. The sum of squared deviations about the regression line through the second- and sixth-week data is a "t-test" of the difference in hay and water consumption during control and experimental periods. The primary purpose in computing the regression line of hay consumption, versus time during the second and sixth weeks was to eliminate squared errors due to the normal decline from the error term in the "t-test".

The probabilities obtained by the "t-tests" cannot be applied to other cows, but they do indicate the probability of some factor other than day-to-day variation influencing the tested animal during the time of a test. (The level of significance is defined as the probability of a greater "t" value being obtained with a random sample, or by chance, from a population of this particular standard deviation. There were 18 degrees of freedom, [(14-2) + (7-1)].

Acclimation trends for each cow during two-week periods were estimated by computing "b" values for hay and water consumption versus time in days, (equation, $Y = a + bX$). Standard errors of estimate and correlation coefficient were also determined to indicate the significance of such acclimation trends.

Measurements

Water Intake: In the climatic chambers, water, at 60° to 70°F, was available *ad libitum* in drinking cups. The daily frequency of drinks and the quantity of water consumed were recorded automatically. (For methods see Ragsdale, *et al.*, 1950). Both a.m. and p.m. data were obtained in volume and frequency of drinks for individual cows.

Feed Consumption: The cows were fed grain and beet pulp before milking and alfalfa pellets† following each milking. Individual a.m. and p.m. feed measures were made for each cow. The alfalfa pellets were available *ad libitum.* The amount of alfalfa pellets or grain left over was recorded and deducted from the quantity fed. The grain and alfalfa pellets refused were air-dried before the "weight-back" was deducted. The composition of the milk ration (Table 10) and alfalfa pellets and quantity of beet pulp were previously reported by Johnson *et al.* (1962).

Rectal Temperatures: These measures were recorded daily with a clinical bulb thermometer at 1:30 p.m. Monday through Friday of each week.

A summary of the unpublished data of H. H. Kibler is presented in Table 7.

Body Weights: Each cow was weighed before feeding twice weekly on Wednesday and Thursday at approximately 4:00 a.m.

RESULTS AND DISCUSSION

Temperature-Humidity Effects on Feed and Water Consumption

Feed Consumption. The differences in hay consumption values (2nd week average) from the previous 65°F base values are represented by bar graphs in Figures 1a and 1b.

Data for 1958-59 (Fig. 1a) showed that the hay consumption decreased for all the animals at two temperatures, 80°F-80% and 90°F-40%; for all animals except Cow 855 at 90°F-50% R.H., and for most of the animals at 80°F-30% and 80°F-50% R.H. To further demonstrate the effects of the higher temperatures and humidity combinations observe the lower humidity at 90°F-20% R.H. Apparently the lower humidity offset the effects of the high temperature and there were actually increases in hay consumption differences in all but three cows (474, 818, 440). Cow 818 was the highest producer of milk (50 lbs.), which may account for its decline in feed intake.

Hay consumption decreases for 1959-60 (Fig. 1b, Table 1) were significant at 95°F-25%, and 85°F-70% R.H. Hay intake differences had decreased from 65°F values in all animals but one, (C-818). At 90°F-25% R.H., hay consumption decreases were of greater magnitude than those of the previous year at 90°F-20% R. H.

---

†Manufacturers guaranteed composition not less than 17% crude protein; crude fat not less than 1.75%; crude fiber not more than 27%; nitrogen free extract not less than 35% per hundred pounds. Approximately 100,000 I.U. of Vitamin A. Pellets obtained during the first four months of study (in 1958-59) were from Reimer Dehydrating Co., Wakenda, Mo. The pellets for the remaining period of the first year's experiment came from Midwest Alfalfa Blenders, Inc., Topeka, Kans. During the 1959-60 study all pellets were obtained from the W.J. Small Co., Kansas City, Mo., a division of Archer Daniels-Midland Co.

The "t-tests" on individual animals in Figure 1b and Table 1 indicate significant decreases ($P<.01$) for all 12 animals at 95°F-25% R.H. At 85°F-70% R.H., decreases for 10 of the 12 animals were significant at $P<.01$ and one of the 12 was significant at $P<.02$, making a significant decline in hay consumption for 11 of the 12 animals.

The 75°F-90% R.H. condition was the mildest treatment. Significant increases were shown by two of the 11 cows while five of the 11 had significant decreases (Table 1).

In considering all the temperature-humidity conditions, significant depressions in hay consumption were observed at 0.01 level for 95°F-25%, 90°F-40% and 50%, 85°F-50 and 70%, and 80°F-80% R.H. by student's "t-test" (Table 2).

Further observations of Figures 1a and 1b showing relative comparisons of individual cows' response to the temperature and humidity effects reveal that a lower humidity of 20% at 90°F was almost completely devoid of heat stress. In fact, increases occurred in hay consumption. The same temperature but higher humidity, 90°F-40% or 90°F-50% R.H. caused severe hyperthermia (See Table 7) in the cows and great losses in hay consumption. Obviously, a high humidity at high temperature is a distressing factor and interferes critically with heat dissipation in a presumably "non-sweating" cow. It is also very apparent that evaporative and non-evaporative cooling can maintain thermal balance in most cows at 90°F-20% R.H., but an increase of *only* 5% humidity causes extreme losses. Also, an 85°F-70% R.H. condition is almost as stressful as 95°F-25% R.H., which suggests the critical importance of maintaining a low humidity at higher temperatures.

TDN consumption declines were about the same as those in hay consumption, showing the hay consumption to be a good indicator of temperature effects on feed intake (Table 2). Student's "t-test" for significance of difference revealed about the same temperature effect on TDN as on hay consumption (Table 2).

TDN pertains to the complete ration which consists of grain, beet pulp, and alfalfa. TDN conversion values are as follows: beet pulp 72.40%, hay 53.50%, and grain 71.61%.

Hay consumption and TDN values based on second-week average are shown in Table 3.

Additional information on feed consumption at temperatures and humidities below 65°F is found in Table 12. Tables 11 and 13 contain information at these temperatures and humidities on milk composition and body weight respectively.

Water Consumption: Water consumption differences were expressed by bar graphs in the same manner as the hay. Seven of 12 cows increased water consumption significantly ($P>.05$) at 90°F-20% and 90°F-25% R.H., while considerable variation was observed at 90°F-40% and 90°F-50% R.H. At 90°F-50% R.H. all cows in the early stages of lactation increased and other animals in the mid and late stages decreased. (Fig. 2 and Table 1).

Exposure of lactating cows to higher temperature and humidity conditions usually elicits variable responses in water intake. This is due to many factors among which are heat tolerance, effect on milk flow, feed intake, and animal vaporization. Figure 2 shows consistently that most lower producers or animals in the late stage of production increase water intake at conditions above 65°F. (A partial explanation is the compensation in water intake due to greater water losses in milk output of high producers.) Table 2 presents average values of the 12 cows at each temperature-humidity condition.

In further consideration of water consumption, the student's "t-test" based on difference from previous 65°F-50% R.H. average of 12 cows showed a significant increase at 90°F-20% ($P > .01$), 90°F-25% ($P > .05$) and 80°F-30% ($P > .10$), (See Table 2). Changes in water consumption at other conditions were non-significant.

Additional information on water consumption at temperatures and humidities below 65°F is found in Table 14.

Comparison of Hay and Water Consumption

To facilitate this comparison a three-point moving average (Fig. 3) was calculated from the daily hay and water data for eight cows. Four cows of each year's trial were subjected to all of the environmental conditions of that particular year, starting as the early stage of lactating group and finishing in the late stage of lactation group. Treatments were of two weeks' duration with switch-back exposures to the base condition of 65°F-50% R.H.

"Short-term" acclimation effects of the temperature-humidity exposures are shown graphically (Fig. 3) on daily feed and water consumption of the eight cows. In most instances, at 65°F the water intake gradually increased as the hay intake resumed. This is readily apparent at 90°F-50% R.H. as well as most other conditions. The trend or temperature adjustment changes in the ratio of feed intake to water intake upon exposure to the various temperature conditions may also be visualized from this plot.

The delayed or lag effects on feed and water intake were very impressive on the cows. For example, at 95°F-25% R.H. it was almost a week before some cows showed minimum levels of feed intake for that period. Upon return to 65°F, a week was apparently necessary for the major recovery to be accomplished. These "short-term" acclimation effects are expressed numerically (for slope "b" values, correlation, and significance of change; see Table 5).

Note the greater relative water values (gal/day), compared with hay consumption (lbs/day) for Cow 523, until the late stage of lactation when hay intake began to increase (Fig. 3). At 90°F-50% R.H., the greatest decreases were noted for all cows.

In the upper section of the data, Cow U-830 shows marked increases in hay consumption during the 65°F exposure and like decreases upon exposure to the various treatments.

Heat Tolerant and Heat Intolerant Cows

Daily milk production, feed and water consumption data, and body temperature are shown (Fig. 4) for typical heat tolerant and heat intolerant cows. Figure 4 shows some of the typical gross responses of two cows which we have designated as heat tolerant and heat intolerant to a particular temperature-humidity treatment. Two of the four cows in the 1959-60 experiment have been referred to in an earlier bulletin (Johnson *et al.* 1962) as heat tolerant (C-829) and heat intolerant (C-623) (lower section of Figure 3). Cow C-829 leveled off in feed consumption at 85°F-70% R.H. and began a general increase with some drop at higher temperatures. The feed consumption of Cow C-623 showed more variability than that of C-829. Normally the animals, relatively speaking, consumed more hay (lbs./day) than water (gals./day); however, at 85°F-50% R.H. the reverse was true. Both cows consumed more water than hay at 85°F-50% R.H.

Remarkably consistent responses were obtained in body temperature, milk production, hay, and water consumption of C-623 and C-829. The X-axis showed time, in days, at each successive environmental treatment.

These two cows produced about the same quantity of milk at 65°F but at 95°F an obvious difference existed. At 95°F-25% R.H. there was a drop of approximately 13 pounds in hay consumption for C-623 while hay consumption remained about the same for C-829.

Relationship of Water Consumption and Milk Production

Absolute data values are presented in Figure 5 for individual animals, various stages of production-level of milk production, and different temperature-humidity conditions.

At the higher temperatures the cows produced lower volumes of milk and tended to increase water consumption. This observation would suggest an inverse relation of water intake and milk production. This is further observed by noting that at high levels of milk production the water consumption was not too much greater. This was due again to the higher levels of milk production being associated with the lower temperatures (animals drank less).

Relationship of TDN Consumption and Milk Production

There appears to be a gradual increase in TDN consumption with rising milk production. Animals in the cooler condition (75° to 90°F-20% R.H.) ate more TDN and produced more milk. Animals at the stressing conditions of 85°F-70%, 90°F-50%, etc. ate less TDN and produced less milk.

Fig. 5 suggests that most of the animals were milking between 20 and 40 pounds per day and consuming between 10 and 25 pounds of TDN per day.

Data suggest greater increases in TDN consumption per quantity of milk production, which is similar to the general concept seen in recent data presented by Reid (1961), where the TDN value or availability of ration decreased with increase in milk production. Similarily, the TDN graph and the water graph displayed less of a trend, since minimum TDN values are permissable for body maintenance.

TDN, FCM, Milk, and Body Weight Changes

Some insight into physiological adjustments in dairy cows may be provided by viewing in a gross manner a comparison of responses in TDN consumption, FCM, and body weight change of individual cows at various temperature-humidity conditions. Milk responses in terms of weight change in four animals may be observed at 90°F-20%. (Fig. 6)

A decline in TDN is associated with a simultaneous decline in FCM and body weight change. Some "heat tolerant cows" such as C-794 (Fig. 6b) apparently can use or devote relatively more of body weight for milk production at the more stressing conditions. However, another "heat tolerant" (based on rectal temperature changes) cow, C-829, may actually have increased body weight since her TDN declined very slightly. This cow lost about the same as C-794 in milk production. The "heat intolerant" cows, U-830 and C-623, made the greater declines in TDN and FCM and the data suggest that the two heat intolerant cows may have declined in milk flow. However, one cow may decline in TDN consumption much more and lose body tissue (U-830), whereas another heat tolerant cow (C-623) may show about the same milk decline with relatively less effect on TDN and weight loss.

These data re-emphasized that estimates of heat tolerance should consider the relative TDN and body weight changes in evaluating the stress responses per unit of milk decline at the higher environmental temperatures.

Data in Figure 6b are not as consistent as those in Figure 6a and the extreme differences in heat tolerance or intolerance were not apparent.

Generally speaking, if a particular temperature-humidity condition is considered, changes in TDN consumption are associated with changes of relative magnitude in FCM and body weight gain or loss.

Body weight change was calculated by taking the average body weight of the first week and second weeks (Table 6) of a specific period and subtracting to find the difference. Difference in body weight was then divided by 7 giving the difference per day in body weight. Difference per day times 2.1 (TDN factor) provides the TDN. This was then multipled by 1814 for Caloric equivalent in body weight. Then to find differences caused by temperatures 65°F-50% R.H. body weight (Calories) and treatment period (Calories) were compared to obtain these differences.

The conversion factors and values used were:

K Cal = 1000 large (C); example 3000 Cal or 3 K Cal
1 lb. of 4% FCM = 340 Calories
1 lb. of TDN = 1814 Calories
1 lb. in Body Weight Calories = 21.1 lb. of TDN X 1814 large Calories

Relationship of Water, TDN Consumption, and Milk Production to Rectal Temperature

To adequately describe the environmental effect on the animal, various expressions were used—vapor pressure, dew point, etc. and, since body temperature is a common expression of an animal's response and a good indicator of the environmental stress, the milk, TDN, and water consumption data were plotted as a function of rectal temperature (Fig. 7 and Table 7). Further evidence suggests that body temperature and, particularly, hypothalamic temperatures are involved in control of feed and water intake (Brobeck 1962, Andersson 1962).

It is easy to observe the extreme variability in milk production response to a stressing temperature-humidity condition. For example, note the 95°F-25% R.H. points may be observed for cows ranging from essentially normal body temperature (101.3°F) to above 105°F. For most of the individuals the decline in milk production was greater at the higher temperature-humidity condition. Table 1 shows the number of cows displaying significance at each condition.

Milk Production (lbs./day) vs. Rectal Temperature

Most values are grouped around 102.0°F for the rectal temperature with a one to six pound drop in milk production at this body temperature. As the rectal temperature for individual cows continued to increase, further decreases in milk production occurred. There were decreases in all animals' milk production averages at 103.5°F body temperature and above. If a mean line were visually estimated for decline in milk production vs. body temperature, each degree rise in body temperature (above 101.5°F) resulted in approximately 4 pounds decline in milk production.

TDN vs. Rectal Temperature

Again, most values grouped around 101.5-102°F. In this range an approximate drop of 1-2 pounds in TDN consumption is observed with a decrease in all averages with rectal temperature above 103.5°F. TDN and milk production followed the same general pattern. TDN consumption declines varied markedly with rising rectal temperatures. This variability is an important genetic and physiological factor and should be pursued when sufficient data are available. If an average decline in TDN vs. rise in rectal temperature is visually estimated from the data (Fig. 7), each degree rise in rectal temperature results in approximately 3 pounds decline in TDN intake.

Water Consumption vs. Rectal Temperature

There was an apparent gradual increase in water consumption at the lower rectal temperatures but at the higher rectal temperatures there was a gradual trend for the water consumption to decrease; that is, at the higher temperatures the greater losses in milk production provided greater water compensation factor (less water needed for synthesis of milk).

Water consumption showed no consistent change with body temperature in lactating dairy cattle as was explained earlier in this report. The lactating animals increased or decreased water intake depending on the degree of heat tolerance, individual ability for greater or less water consumption, the decline in milk production, or other unknown factors.

Milk Production, TDN, and Water Consumption vs. Temperature-Humidity Index (THI)

Water intake, milk production, and TDN intake differences were plotted vs. THI. Each symbol represents 12 cow averages which are based on the difference from previous 65°F-50% R.H. values. The visually estimated curves generally represent the trends with increasing THI (Fig. 8).

On the THI scale, 77 suggests the upper level of the comfort zone when considering temperature and humidity only; that is, the approximate THI where obvious decreases in TDN, milk, and water began to occur. The TDN and milk differences were negative values (less than previous 65°F values) while not until 79 on the THI scale did the water consumption show a decline below the zero line.

For purposes of estimation or calculation of the THI values, refer to the original data (Table 2). As indicated before, the higher humidities above 80°F become an increasingly critical factor in maintenance of heat balance and the expression (.2X Dew Point) of the THI formula provides a manner of expression of this factor (Fig. 8 and Table 2).

It is also very apparent that evaporative and non-evaporative cooling mechanisms could maintain thermal balance in most cows at 90°F-20% R.H. but an increase of only 5% R.H. causes greater losses in hay and TDN consumption (Table 2).

Also, an 85°F-70% R.H. condition is apparently as stressing as 95°F-25% R.H., again suggesting the importance of maintaining a low humidity even at temperatures as low as 85°F.

SUMMARY

The responses in feed intake, water intake, and body weight of 40 lactating Holstein cows to various combinations of temperature and humidity above 65°F are reported. Utilizing a switch-back procedure, the following environmental combinations were studied: 75°F, 90% R.H., 80°F, and 30% R.H., 50% R.H., and 80% R.H.; 85°F and 50% R.H. and 70% R.H.; 90°F and 20% R.H., 25% R.H., 40% R.H., and 50% R.H.; and 95°F and 25% R.H.

Significance of temperature and humidity on each individual animal as well as group statistics are presented. Significant effects on TDN consumption were displayed at 80°F, 50%, 80%; 85°F, 50%, 70%; 90°F, 25%, 40%, 50%, and 95°F, 25% R.H.

The time required for adjustment, "short term acclimation", on feed and water intake during the two-week exposure periods is reported. Graphic relationships of water intake and feed intake and milk production at various combinations of temperature and humidity are presented.

Expressions of average milk production and TDN intake versus rectal temperatures of cows subjected to the various temperature-humidity combinations suggested approximately 4 pounds loss in milk production for each degree (°F) rise in rectal temperature, and a 3 pounds loss in TDN consumption for each degree rise in rectal temperature.

Generally speaking, the humidity above 65°F (particularly above 80°F dry bulb) becomes a critical factor in the maintenance of heat balance and thus feed intake and milk production.

TDN consumption, water consumption, and milk production were related to a temperature-humidity index (THI = .55 X D.B. + .2 X D.P. + 17.5).

REFERENCES

1. Andersson, B., Hypothalamic Mechanisms Concerned with the Regulation of Water Intake. International Congress of Physiological Sciences XXII Vol. I, Part II. Symposium XV. The Regulation of Food Intake, p. 661, Leiden, Netherlands, (1962).
2. Brandt, A. E., Test of Significance in Reversal or Switch-back Trials. Agr. Exp. Sta. Iowa State College of Agr. Res. Bull. 234. (1938).
3. Brobeck, J. R., Food and Temperature. Recent Progress in Hormone Research XVI, Hormones and Metabolism IV, p. 439 (1960).
4. Brody, S., Bioenergetics and Growth. New York: Reinhold Publ. Corp. (1945).
5. Janowitz, H. D., The Role of the Gastro-Intestinal Tract in the Regulation of Food Intake. International Congress of Physiological Sciences XXII, Vol. I, Part II, Symposium XV, The Regulation of Food Intake, p. 690, Leiden, Netherlands, (1962).
6. Johnson, H. D., Ragsdale, A. C., Berry, I. L. and Shanklin, M. D. with technical assistance of Sandra McLarney. Effects of Various Temperature-Humidity Combinations on Milk Production of Holstein Cattle. Mo. Agr. Exp. Sta. Res. Bull. 791. (1962).
7. Lucas, H. L., Extra-Period Latin Square Change-Over Design. J. Dairy Sci., Vol. XL, 225-239. (1957).
8. Lucas, H. L., Switch-back Trials for More than Treatments. J. Dairy Sci., Vol. XXXIX, 146-154. (1956).
9. Morgane, P. J., Hypothalamic and R.H. in Encephalic Mechanisms in the Regulation of Caloric Intake. International Congress of Physiological Science XXII, Vol. I, Part II, Symposium XV, The Regulation of Food Intake, p. 670, Leiden, Netherlands (1962).
10. Ragsdale, A. C., Worstell, D. M., Thompson, H. J. and Brody, S., Influence of Temperature, 50° to 0°F and 50° to 95°F on Milk Production, Feed and Water Consumption and Body Weight in Jersey and Holstein Cows. Mo. Agr. Exp. Bull. 449 (1949).
11. Ragsdale, A. C., Thompson, H. J., Worstell, D. M. and Brody, S., Influence of Increasing Temperature, 40°F to 105°F on Milk Production in Brown Swiss Cows, and on Feed and Water Consumption and Body Weight in Brown Swiss and Brahman Cows and Heifers.
12. Ragsdale, A. C., Thompson, H. J., Worstell, D. M. and Brody, S., Milk Production and Feed and Water Consumption Responses of Brahman, Jersey and Holstein Cows to Changes in Temperature, 50°F to 105°F and 50° to 80°F. Mo. Agr. Exp. Sta. Res. Bull. 460 (1950).
13. Ragsdale, A. C., Thompson, A. J., Worstell, D. M. and Brody, S., The Effect of Humidity on Milk Production and Composition, Feed and Water Composition and Body Weight in Cattle. Mo. Agr. Exp. Sta. Res. Bull. 521, (1953).
14. Reid, J. T., Problems of Feed Evaluation Related to Feeding of Dairy Cows. J. Dairy Sci. 44:(11). 2122, (1961).
15. Weather Bureau, Instructions to Field Stations for Experimental Use of "Discomfort Index." March 2, 1959.
16. Worstell, D. M. and Brody, S., Comparative Physiological Reactions of European and Indian Cattle to Changing Temperatures. Mo. Agr. Exp. Sta. Res. Bull. 515, (1953).

APPENDIX
Tables and Figures

TABLE 1 -- LEVEL OF SIGNIFICANCE* FOR INDIVIDUAL ANIMALS' HAY AND WATER CONSUMPTION AT THE ENVIRONMENTAL TEMPERATURE CONDITIONS

		Hay Consumption						Water Consumption					
Level of Significance		.01		.02		.05		.01		.02		.05	
		Number of Animals**						Number of Animals**					
°F.	% R.H.	+	-	+	-	+	-	+	-	+	-	+	-
75	90	1 of 11	2 of 11	1 of 11	2 of 11		1 of 11	1 of 12	1 of 12		2 of 12		
80	30	2 of 12	4 of 12					2 of 12				1 of 12	
80	50	1 of 12	4 of 12		1 of 12		2 of 12	1 of 12	1 of 12			2 of 12	
80	80		3 of 12					1 of 12		1 of 12			
85	50		8 of 12		1 of 12			2 of 12	2 of 12			1 of 12	
85	70		10 of 12	1 of 12	1 of 12			2 of 12	4 of 12	1 of 12			
90	20	1 of 12	4 of 12	1 of 12				6 of 12				1 of 12	
90	25		6 of 10		1 of 10		1 of 10	5 of 12	1 of 12			1 of 12	
90	40		9 of 12					4 of 12					
90	50		12 of 12					3 of 12	2 of 12				
95	25		12 of 12					2 of 12	3 of 12		1 of 12		1 of 12

*Brandt's "t" test for individual animals based on the switchback design on individual differences in hay and water consumption.
**Number of animals showing significant increase (+) or decrease (-) in hay and water consumption from the normal 65°F. - 50% R.H. base.

TABLE 2 -- TEMPERATURE - HUMIDITY EFFECTS ON HAY, TDN, AND WATER CONSUMPTION
(Based on Average Differences for 12 Cows at 65°F., 50% R.H. as Compared to Treatments)

Environmental Conditions				Hay			TDN			Water		
Dry Bulb °F.	Relative Humidity %	Vapor Pressure mm Hg	Dew Point °F.	Mean Diff.	$S_{\bar{x}}$	Level of Sig.*	Mean Diff.	$S_{\bar{x}}$	Level of Sig.*	Mean Diff. gal./day	$S_{\bar{x}}$	Level of Sig.*
75	90	20.0	71.8	+ .07**	.60	n.s.	- .47**	.38	n.s.	- .42**	.59	n.s.
80	30	8.0	45.7	-2.37	1.20	.10	-1.40	.83	n.s.	+1.30	.69	.10
80	50	13.0	59.5	-2.48	.89	.02	-1.30	.51	.05	+ .50	.87	n.s.
80	80	21.0	73.2	-1.95	.45	.01	-1.00	.27	.01	- .10	.52	n.s.
85	50	15.5	64.2	-4.65	1.40	.01	-3.10	.80	.01	+ .21	1.11	n.s.
85	70	21.5	74.0	-5.83	1.38	.01	-4.13	.94	.01	- .30	1.44	n.s.
90	20	7.0	43.5	+1.72	.95	.10	+ .50	.60	n.s.	+3.90	.81	.01
90	25	9.0	49.4	-3.65	1.44	.05	-2.58	.89	.02	+2.80	1.05	.05
90	40	14.5	62.3	-9.98	1.40	.01	-5.90	.72	.01	-1.40	.98	n.s.
90	50	18.0	68.7	-7.81	1.09	.01	-4.20	.58	.01	+1.80	1.90	n.s.
95	25	10.0	53.5	-8.17	1.30	.01	-5.30	.80	.01	+ .35***	.93	n.s.

*Significance determined by Student's "t" test
**Cow 844 omitted due to acute mastitis (75°F. - 90% R.H.)
***11 cows (95°F. - 25% R.H.)

TABLE 3. HAY CONSUMPTION AND TDN CONSUMPTION, LB./DAY, BASED ON 2ND WEEK AVERAGE

1958 - 1959

Group A

Temperature °F.	% R.H.	Cow Number 793	523	474	440	484	473	820	823	855	852
Hay Consumption											
65	50	19.8	7.6	21.7	17.2	19.7	17.6				
80	50	24.1	6.8	14.9	16.4	15.5	14.8				
65	50	23.5	10.4	24.1	21.6	15.8	18.2				
90	40	8.5	6.5	6.1	11.5	9.8	10.1				
65	50	17.5	6.7	13.7	15.6	11.5	13.9				
90	40	12.5	6.0	9.5	11.5	8.5	10.9				
65	50	19.3	11.5	18.8	18.3			21.4	20.1		
80	30	12.5	7.1	11.9	14.0			19.0	11.0		
65	50	17.8	11.2	16.7	19.0			15.2	15.7		
90	20	19.3	11.2	12.1	18.2			19.6	18.2		
65	50	23.3	13.1	21.0	27.1			20.1	25.9		
90	20	24.1	14.8	17.0	21.8			20.8	22.8		
65	50	26.4	18.2					24.5	23.5	14.5	18.4
80	80	23.3	18.0					22.8	20.6	14.0	18.0
65	50	25.5	18.3					24.1	21.2	12.5	19.9
90	50	16.7	11.1					18.5	14.5	12.8	12.9
65	50	25.8	19.2					21.7	21.1	15.7	20.4
90	50	14.8	12.3					19.0	15.0	12.5	16.2
TDN Consumption											
65	50	22.8	15.8	20.2	19.3	18.3	17.6				
80	50	25.1	15.9	16.1	18.8	16.2	16.6				
65	50	24.8	16.3	21.5	21.7	16.4	18.4				
90	40	16.3	14.2	12.8	14.8	13.1	12.0				
65	50	20.9	13.7	16.8	17.0	14.1	14.6				
90	40	16.8	13.3	14.4	14.8	12.3	13.0				
65	50	21.7	16.3	19.4	18.4			21.0	22.2		
80	30	18.2	13.9	15.7	16.1			20.1	14.3		
65	50	20.3	16.1	18.2	18.8			15.9	16.6		
90	20	18.9	14.6	15.1	18.3			18.0	17.8		
65	50	22.6	15.6	19.8	23.1			20.9	23.5		
90	20	22.3	16.5	17.7	20.3			21.2	20.3		
65	50	24.2	18.3					23.2	21.9	17.9	22.7
80	80	22.5	18.2					22.3	19.6	17.6	22.5
65	50	23.2	18.4					23.1	21.1	16.8	23.4
90	50	19.8	14.5					20.0	16.4	16.9	18.8
65	50	22.8	18.9					21.7	20.9	18.5	23.8
90	50	17.1	15.2					20.3	17.7	16.8	21.6

Group B

Temperature °F.	% R.H.	Cow Number 713	856	807	804	499	487	814	818	849	858
Hay Consumption											
80	50	20.4	13.4	17.0	15.8	16.3	24.8				
65	50	18.0	16.3	19.1	16.2	17.5	26.2				
80	50	16.8	15.6	13.1	14.2	11.6	23.3				
65	50	21.8	14.5	16.3	15.2	17.5	22.4				
90	40	9.8	10.6	9.6	8.2	5.3	5.5				
65	50	9.5	10.4	11.3	11.3	13.1	15.9				
80	30	20.6	19.3	16.6	15.3			17.7	20.4		
65	50	12.0	11.4	15.1	11.9			13.1	19.7		
80	30	15.4	16.2	14.3	11.5			11.3	20.0		
65	50	18.4	16.6	14.4	14.8			13.1	20.0		
90	20	22.3	21.5	19.1	19.5			16.1	16.4		
65	50	23.9	23.4	17.2	19.1			23.2	29.2		
80	80	20.2	21.3					23.3	25.3	15.0	9.4
65	50	19.7	23.6					23.2	26.6	22.4	17.7
80	80	17.4	19.2					21.5	25.3	17.7	17.5
65	50	17.4	21.3					28.2	24.9	23.4	22.0
90	50	11.6	13.8					12.8	15.9	14.8	10.1
65	50	15.7	19.7					28.7	24.8	23.9	18.7
TDN*Consumption											
80	50	23.1	15.8	18.4	19.3	15.9	23.4				
65	50	21.8	19.5	19.5	19.5	16.6	24.1				
80	50	21.2	19.1	16.3	18.4	12.9	22.6				
65	50	23.2	18.7	18.0	18.9	14.2	22.1				
90	40	16.7	15.1	13.0	13.8	9.9	11.6				
65	50	16.6	14.9	13.9	15.3	11.8	17.1				
80	30	22.5	19.6	16.8	17.5			19.6	21.0		
65	50	17.9	15.4	16.0	15.7			17.1	20.6		
80	30	19.7	18.0	15.6	15.5			16.1	20.8		
65	50	19.9	16.8	14.9	15.8			15.6	20.8		
90	20	22.0	19.4	17.4	18.3			17.2	18.7		
65	50	22.9	20.4	16.4	18.1			21.0	25.7		
80	80	20.9	19.3					21.1	23.6	15.8	16.0
65	50	20.6	20.5					21.0	24.3	22.1	20.3
80	80	19.4	18.2					20.1	23.6	20.1	20.9
65	50	19.4	19.3					23.7	23.4	23.1	23.3
90	50	16.3	15.3					15.4	18.3	18.7	16.9
65	50	18.5	18.4					24.0	23.4	23.6	21.5

*TDN = Grain, beet pulp and hay

TABLE 3 (CONT'D). HAY CONSUMPTION AND TDN CONSUMPTION, LB./DAY, BASED ON 2ND WEEK AVERAGE

1959 - 1960

Group A

Temperature °F.	% R.H.	C-794	U-830	C-818	U-450	U-852	C-842	U-809	U-864	U-844	U-473
		Hay Consumption									
65	50	19.8	28.6	15.4	27.1	26.8	18.2				
85	50	11.2	13.5	15.7	12.2	21.6	12.6				
65	50	17.7	22.1	14.2	19.9	23.0	17.7				
85	70	13.6	13.7	17.2	15.2	21.3	15.1				
65	50	20.5	22.6	20.8	25.1	23.8	21.1				
85	70	15.2	17.0	21.0	18.7	23.1	17.6				
65	50	24.6	29.6	23.5	24.5			19.9	10.7		
95	25	16.6	12.1	20.8	15.7			9.8	5.1		
65	50	26.2	32.1	29.4	25.4			20.4	16.4		
90	25	18.2	18.9	24.1	24.2			21.5	11.1		
65	50	24.0	31.1	29.3	29.4			27.4	19.7		
90	25	20.8	17.2	24.6	25.6			25.9	18.5		
65	50	22.1	32.0					24.2	23.5	16.4	23.2
75	90	22.3	33.3					26.2	21.9	8.0	20.3
65	50	23.5	37.7					28.5	24.4	14.4	9.0
		TDN*Consumption									
65	50	21.8	26.4	18.7	25.2	22.9	17.0				
85	50	17.5	12.5	19.2	17.3	20.2	13.9				
65	50	21.7	21.1	17.7	18.9	20.3	16.0				
85	70	19.5	12.0	18.5	16.0	19.3	14.6				
65	50	22.5	20.7	19.7	21.5	19.9	17.8				
85	70	19.3	13.7	20.3	17.1	19.6	15.9				
65	50	23.5	23.9	21.2	23.1			23.6	17.2		
95	25	19.4	12.0	18.7	16.1			16.8	12.2		
65	50	24.1	24.4	22.9	22.9			23.7	19.6		
90	25	19.8	15.1	20.1	17.9			22.6	17.4		
65	50	22.4	23.8	22.2	24.6			25.3	21.3		
90	25	20.4	16.4	19.0	19.1			23.1	20.7		
65	50	20.4	24.3					25.1	23.4	22.9	26.3
75	90	20.5	24.7					24.3	22.5	10.6	24.0
65	50	19.8	26.7					25.9	23.8	13.2	26.9

Group B

Temperature °F.	% R.H.	C-829	C-623	U-829	C-880	C-895	U-853	U-813	U-847	U-818	U-820
		Hay Consumption									
85	50	13.5	10.8	24.5	14.1	9.2	14.7				
65	50	15.1	17.7	25.7	18.0	14.2	27.0				
85	50	15.9	15.8	22.9	17.9	12.3	16.1				
65	50	20.1	25.7	31.3	23.9	14.5	26.3				
85	70	17.4	15.9	19.8	10.0	9.9	17.3				
65	50	25.7	28.9	27.7	26.8	16.3	28.5				
95	25	24.0	12.9	28.0	13.2			4.3			
65	50	28.3	27.5	33.4	27.2			11.3	17.7		
95	25	27.2	15.2	26.3	16.3			7.1	8.0		
65	50	31.9	28.3	26.8	26.4			20.1	18.9		
90	25	31.5	18.5	31.1	25.7			15.7	17.7		
65	50	33.8	28.8	28.3	27.4			24.4	22.0		
75	90	31.4	26.3					25.4	21.4	29.1	26.0
65	50	32.9	28.5					27.2	22.4	25.8	23.6
75	90	32.8	25.7					25.7	24.8	27.7	25.5
		TDN Consumption									
85	50	17.3	13.7	23.4	16.0	13.5	16.2				
65	50	21.0	20.6	22.5	18.2	15.5	24.5				
85	50	20.7	17.9	20.8	18.2	12.4	16.4				
65	50	23.0	24.8	25.2	21.4	13.6	22.3				
85	70	21.2	17.3	17.9	13.1	11.0	16.0				
65	50	24.5	24.1	22.2	21.8	14.5	23.1				
95	25	23.6	16.5	22.8	14.7			12.0			
65	50	25.9	22.8	24.4	21.9			17.6	23.4		
95	25	25.2	17.8	20.3	15.4			13.7	17.7		
65	50	27.2	22.9	19.6	20.6			20.3	21.6		
90	25	26.2	18.5	21.8	20.2			16.6	22.6		
65	50	27.2	22.7	20.6	20.5			20.2	23.6		
75	90	25.4	22.0					21.4	22.9	27.9	26.1
65	50	25.9	22.2					24.2	23.2	26.0	24.8
75	90	25.4	20.3					22.0	24.1	27.0	25.8

*TDN = Grain, beet pulp and hay

TABLE 4. WATER CONSUMPTION, GAL./DAY, BASED ON 2ND WEEK AVERAGE

1958 - 1959

Group A

Temperature $^{\circ}$F.	% R.H.	793	523	474	440	484	473	820	823	855	852
		Water Consumption									
65	50	18.9	16.2	19.0	13.8	14.1	13.3				
80	50	23.3	22.6	17.0	15.3	13.5	12.5				
65	50	21.7	18.6	22.1	15.3	10.3	12.5				
90	40	17.7	22.0	13.2	16.7	12.8	10.0				
65	50	17.7	14.4	14.6	13.2	10.2	10.4				
90	40	15.1	18.2	15.2	14.5	10.6	12.7				
65	50	15.1	14.5	13.4	12.0			16.6	16.7		
80	30	17.3	12.7	17.5	17.5			17.2	15.2		
65	50	16.4	14.8	14.9	13.7			15.4	14.5		
90	20	18.0	15.9	15.5	16.4			17.8	17.0		
65	50	18.2	13.1	16.9	17.9			18.0	18.6		
90	20	21.1	19.4	17.9	20.3			20.1	20.0		
65	50	19.2	16.9					19.7	17.5	12.9	16.8
80	80	17.5	17.2					19.7	16.2	13.2	18.6
65	50	18.3	15.9					18.5	16.3	10.6	17.6
90	50	16.3	12.6					17.7	15.2	14.0	23.4
65	50	17.5	15.4					16.2	15.6	13.5	18.1
90	50	16.3	14.2					18.8	16.7	14.4	24.3

Group B

Temperature $^{\circ}$F.	% R.H.	713	856	807	804	499	487	814	818	849	858
		Water Consumption									
80	50	21.4	13.2	17.0	19.2	14.6	25.5				
65	50	17.9	15.7	16.9	18.5	14.9	23.5				
80	50	19.3	14.8	15.6	16.1	14.5	24.0				
65	50	20.6	14.5	14.6	18.2	15.3	23.8				
90	40	14.8	14.1	14.1	13.9	11.6	17.9				
65	50	14.0	11.0	8.7	12.1	9.7	14.4				
80	30	17.4	14.0	13.0	14.9			18.8	20.1		
65	50	14.0	11.8	11.8	12.4			17.4	20.1		
80	30	15.9	15.8	12.8	13.8			15.4	20.4		
65	50	14.4	11.7	9.8	11.7			12.4	16.9		
90	20	22.2	18.6	16.1	17.0			20.3	18.3		
65	50	18.3	16.2	10.8	15.0			16.6	21.9		
80	80	16.2	15.7					18.2	19.8	24.9	20.0
65	50	17.7	17.0					17.2	19.0	19.5	16.9
80	80	15.6	15.2					16.3	20.4	23.2	18.8
65	50	15.7	14.3					19.0	19.6	20.2	20.0
90	50	14.9	14.0					18.7	15.2	40.2	25.8
65	50	14.0	13.2					19.9	18.7	19.4	17.5

1959 - 1960

Group A

Temperature $^{\circ}$F.	% R.H.	C-794	U-830	C-818	U-450	U-852	C-842	U-809	U-864	U-844	U-473
		Water Consumption									
65	50	14.75	21.2	14.67	19.75	15.9	12.7				
85	50	13.8	13.3	17.4	15.7	24.1	11.9				
65	50	15.6	16.7	14.0	15.0	15.3	12.2				
85	70	16.2	13.0	16.0	14.4	27.7	11.4				
65	50	18.0	15.9	17.1	17.4	14.9	13.3				
85	70	17.7	14.1	19.2	16.2	25.9	13.0				
65	50	19.9	18.8	17.4	17.3			21.0	14.1		
95	25	21.1	14.8	19.2	18.8			17.1	13.8		
65	50	20.0	20.5	18.8	17.5			18.8	16.3		
90	25	21.2	18.1	21.3	21.3			23.3	18.7		
65	50	18.0	18.4	19.0	20.3			21.0	17.9		
90	25	17.9	18.1	21.4	22.0			25.6	21.6		
65	50		20.4					20.1	21.9	20.5	24.7
75	90	17.5	19.8					20.8	19.0	13.0	20.5
65	50	17.4	22.3					21.8	19.6	11.8	22.4

Group B

Temperature $^{\circ}$F.	% R.H.	C-829	C-623	U-829	C-880	C-695	U-853	U-813	U-847	U-818	U-820
		Water Consumption									
85	50	18.6	14.3	18.6	14.8	11.7	14.6				
65	50	17.5	17.0	18.5	16.1	11.3	18.4				
85	50	18.2	16.7	19.2	17.3	12.9	19.8				
65	50	18.7	20.9	20.4	18.8	10.0	17.4				
85	70	18.5	16.7	17.5	13.0	11.7	22.8				
65	50	20.1	21.4	16.6	20.1	10.1	14.2				
95	25	23.3	18.4	22.6	16.4			13.8			
65	50	19.8	20.2	18.4	19.2			15.0	19.8		
95	25	25.7	19.9	22.7	16.9			15.0	18.0		
65	50	17.0	22.5	19.9	13.8			17.7	16.9		
90	25	24.8	19.3	22.0	22.4			18.1	23.1		
65	50	22.8	18.0	14.9	17.7			16.3	17.9		
75	90	20.5	17.2					19.5	18.3	23.0	23.4
65	50	19.9	17.0					19.8	18.8	21.4	19.0
75	90	21.9	16.9					18.1	19.0	22.1	20.8

TABLE 5. INDIVIDUAL TRENDS AND RELATIONSHIPS IN HAY CONSUMPTION FOR EACH

2 WEEK PERIOD AT A SPECIFIC TEMPERATURE CONDITION

1958 - 1959

Temperature °F.	% R.H.	Week	Group A $\bar{x}$	b	Syx	r*	$\bar{x}$	b	Syx	r*
			Cow 793				Cow 523			
65	50	1 & 2	20.77	- .3011	1.919	.5641	6.18	.4473	1.452	.8017
80	50	3 & 4	22.81	.2952	1.702	.6026	6.42	.1774	1.021	.1774
65	50	5 & 6	23.26	.1147	1.404	.3353	9.53	.2462	9.529	.2462
90	50-40	1 & 2	12.91	-1.316	4.459	.7892	6.99	-.1886	1.654	.4446
65	50	3 & 4	14.61	.7754	2.794	.7704	6.98	-.0165	1.463	.0490
90	40	5 & 6	13.69	- .3756	2.147	.6060	6.24	-.1437	1.119	.4648
65	50	1 & 2	17.74	.5336	1.657	.8142	10.46	.3277	1.484	.6930
80	30	3 & 4	16.08	-1.1660	2.889	.8691	8.81	-.5270	2.241	.7154
65	50	5 & 6	14.83	.7160	5.179	.5157	9.74	.3549	2.37	.5467
90	20	1 & 2	18.51	.1387	2.048	.2829	11.27	-.0690	1.904	.1559
65	50	3 & 4	22.17	.2826	2.502	.4414	11.15	.2095	4.344	.2055
90	20	5 & 6	25.36	- .3780	3.834	.3945	15.37	-.2022	1.586	.4854
65	50	1 & 2	25.42	.3262	1.758	.6283	17.44	.1943	1.066	.6217
80	80	3 & 4	24.78	- .4952	2.945	.5907	17.68	.1633	2.100	.3205
65	50	5 & 6	25.41	.0026	1.926	.0060	18.44	.0409	2.224	.0798
90	50	1 & 2	20.10	- .9431	1.971	.9015	12.89	-.6551	2.415	.7632
65	50	3 & 4	23.40	.7095	2.314	.8003	18.58	.2868	1.707	.5904
90	50	5 & 6	19.46	-1.278	1.205	.9382	15.19	-.7490	1.717	.8848
			Cow 474				Cow 440			
65	50	1 & 2	22.86	- .1846	3.818	.2060	18.07	-.4637	2.236	.6701
80	50	3 & 4	16.42	- .3681	2.717	.5082	16.19	.1123	2.412	.1987
65	50	5 & 6	22.99	.2538	1.370	.6278	20.47	.2576	1.567	.5816
90	50-40	1 & 2	9.54	-1.1378	4.521	.7386	12.94	-.5509	3.587	.5570
65	50	3 & 4	12.14	.4938	3.111	.5686	15.02	.2763	3.183	.3535
90	40	5 & 6	9.54	- .1637	2.934	.2361	14.16	-.8371	2.523	.8222
65	50	1 & 2	15.70	.8787	3.362	.7512	17.40	.3066	4.165	.3052
80	30	3 & 4	14.63	- .9960	5.332	.6310	17.24	-1.190	4.258	.7728
65	50	5 & 6	13.76	.7090	4.814	.5398	16.54	.7363	4.584	.5731
90	20	1 & 2	12.98	- .4064	4.167	.3909	17.38	.0668	4.601	.0631
65	50	3 & 4	18.52	.6890	2.833	.7271	24.68	.7400	2.710	.7653
90	20	5 & 6	19.19	- .6187	2.054	.7951	24.81	-.7409	1.528	.9038
			Cow 484				Cow 473			
65	50	1 & 2	19.59	- .1473	3.278	.1920	19.82	-.6385	1.609	.8655
80	50	3 & 4	13.75	.3914	3.989	.3929	15.84	-.0279	2.957	.0411
65	50	5 & 6	14.35	.3989	2.010	.6539	17.49	.1018	1.503	.2829
90	50-40	1 & 2	11.49	- .3778	2.323	.5780	13.44	-.7752	2.144	.8441
65	50	3 & 4	11.41	.1562	2.413	.2713	12.81	.1301	2.831	.1962
90	40	5 & 6	8.96	- .2699	2.100	.4882	12.07	-.4250	1.441	.7890

Temperature °F.	% R.H.	Week	Group B $\bar{x}$	b	Syx	r*	$\bar{x}$	b	Syx	r*
			Cow 713				Cow 856			
80	50	1 & 2	19.36	.1231	4.085	.1301	15.75	- .584	4.162	.5210
65	50	3 & 4	14.78	.7879	3.087	.7433	15.47	.329	1.863	.6010
80	50	5 & 6	16.87	- .1235	2.451	.2143	16.46	- .288	1.466	.6500
65	50	1 & 2	21.14	.0598	2.259	.1145	14.64	- .0668	2.658	.1088
90	40	3 & 4	11.78	- .5097	4.724	.4252	11.10	- .1870	2.364	.3257
65	50	5 & 6	9.50	- .1547	2.979	.2206	10.36	- .1848	2.865	.2704
80	30	1 & 2	18.44	.5567	2.898	.6415	16.22	.8314	3.493	.7196
65	50	3 & 4	14.99	-1.005	4.420	.7035	14.59	- .9345	2.747	.8288
80	30	5 & 6	12.61	.7455	4.501	.5850	13.78	.6819	2.240	.7982
65	50	1 & 2	16.39	.4182	5.747	.3021	15.72	.1967	3.213	.2575
90	20	3 & 4	20.52	.4864	2.411	.6600	20.93	.2164	2.763	.3229
65	50	5 & 6	24.04	- .1182	2.313	.2173	22.79	.2151	1.903	.4417
80	80	1 & 2	20.93	- .2000	1.253	.5708	22.02	- .1230	1.838	.2798
65	50	3 & 4	19.84	- .0855	1.741	.2090	22.84	.1756	1.981	.3599
80	80	5 & 6	17.55	- .1101	1.166	.3803	20.74	- .4997	1.514	.8208
65	50	1 & 2	17.84	- .1358	1.253	.5708	20.76	.0481	1.943	.1072
90	50	3 & 4	12.82	- .2587	1.741	.2090	16.59	- .7184	1.585	.8920
65	50	5 & 6	15.56	.0433	1.166	.3803	18.29	.3545	1.997	.6115
			Cow 807				Cow 804			
80	50	1 & 2	17.64	- .1582	1.415	.4379	16.30	- .7189	4.820	.5445
65	50	3 & 4	18.54	.2470	2.353	.4158	15.11	.4429	3.066	.5324
80	50	5 & 6	15.84	- .6453	2.057	.8069	14.65	- .1655	1.948	.3469
65	50	1 & 2	15.86	.0505	1.358	.1599	15.78	- .1369	3.161	.1853
90	40	3 & 4	10.89	- .3393	2.191	.5590	9.49	- .3327	2.537	.4960
65	50	5 & 6	11.12	.0248	1.998	.0540	11.53	- .0791	1.994	.1702
80	30	1 & 2	15.73	.2182	1.343	.5776	14.72	.1396	2.081	.2803
65	50	3 & 4	15.84	- .3162	1.754	.6175	13.14	- .5400	3.701	.5363
80	30	5 & 6	14.49	- .1470	2.396	.2580	10.26	.2765	4.140	.2793
65	50	1 & 2	14.26	.0096	3.188	.0132	13.47	.2413	2.851	.3458
90	20	3 & 4	17.70	.2929	2.412	.4675	18.35	.3853	.878	.8860
65	50	5 & 6	17.85	- .2055	1.239	.5854	19.14	- .0299	2.006	.0648
			Cow 499				Cow 487			
80	50	1 & 2	17.92	- .4154	2.100	.6535	25.04	- .1791	2.629	.2844
65	50	3 & 4	17.01	.2448	2.080	.4560	25.63	.1171	.993	.4569
80	50	5 & 6	14.58	- .8242	2.006	.8728	24.42	- .4169	1.427	.7860
65	50	1 & 2	15.54	.3793	2.577	.5396	22.53	- .2407	3.661	.2752
90	40	3 & 4	8.60	- .9367	1.886	.9076	9.06	- .9895	6.361	.5607
65	50	5 & 6	12.59	.0624	3.108	.0871	15.21	.0984	2.777	.1525

*Level of significance: .05 = .5324   .01 = .6614

TABLE 5 (CONT'D). INDIVIDUAL TRENDS AND RELATIONSHIPS IN HAY CONSUMPTION FOR EACH 2 WEEK PERIOD AT A SPECIFIC TEMPERATURE CONDITION

1959 - 1960

Temperature			Group A							
°F.	% R.H.	Week	$\bar{x}$	b	Syx	r*	$\bar{x}$	b	Syx	r*
			Cow U-450				Cow C-818			
65	50	1 & 2	28.30	-.2120	4.091	.2277	17.22	-.5628	2.961	.6376
85	50	3 & 4	13.91	-.5398	2.489	.6865	14.89	.2233	1.825	.4702
65	50	5 & 6	18.54	.3325	3.381	.3937	14.44	-.0505	1.001	.2147
85	70	1 & 2	16.31	-.2160	1.385	.5619	17.51	-.0244	1.060	.0997
65	50	3 & 4	23.61	.4767	2.020	.7168	19.79	.3248	2.289	.5257
85	70	5 & 6	21.46	-.6481	1.403	.8954	21.54	-.1314	1.560	.3445
65	50	1 & 2	23.37	.2321	3.182	.3026	22.66	.2648	2.532	.4144
95	25	3 & 4	18.93	-.7670	2.878	.7576	22.43	-.4413	1.450	.7983
65	50	5 & 6	22.92	.6719	3.197	.6750	25.93	.8549	2.365	.8440
90	25	1 & 2	25.23	-.1973	1.622	.4681	26.16	-.5281	2.394	.6928
65	50	3 & 4	27.56	.4719	1.860	.7414	27.59	.4688	.993	.8992
90	25	5 & 6	26.19	-.4086	3.672	.4360	25.80	-.3103	2.107	.5398
			Cow C-842				Cow U-852			
65	50	1 & 2	17.48	-.0684	4.015	.0739	27.43	-.2760	3.144	.3570
85	50	3 & 4	12.66	-.0597	1.682	.1529	21.80	-.0866	1.568	.2338
65	50	5 & 6	17.56	.0703	.9526	.3060	22.19	.2156	1.666	.4909
85	70	1 & 2	16.87	-.3719	1.697	.6903	23.44	-.4945	1.335	.8499
65	50	3 & 4	19.09	.6174	1.532	.8687	22.30	.5874	2.870	.6653
85	70	5 & 6	18.71	-.2367	2.440	.3891	24.71	-.4556	1.328	.8310
			Cow U-809				Cow U-864			
65	50	1 & 2	20.76	-.1180	4.280	.1192	11.42	-.1945	3.111	.2626
95	25	3 & 4	10.54	-.3589	3.796	.3807	5.24	-.1015	2.464	.1766
65	50	5 & 6	17.66	.6640	2.767	.7224	14.39	.5075	2.686	.6353
90	25	1 & 2	21.51	-.0081	1.986	.0178	12.76	-.4565	2.105	.6865
65	50	3 & 4	24.90	.6347	1.923	.8209	18.37	.3543	2.801	.4824
90	25	5 & 6	26.46	.0004	2.426	.0008	17.99	.0813	2.059	.1694
65	50	1 & 2	24.32	.0424	1.742	.1055	22.47	.3284	2.136	.556
75	90	3 & 4	26.34	.0118	1.530	.0337	23.96	-.5233	2.671	.6490
65	50	5 & 6	26.89	.3657	1.156	.8091	21.54	.7653	1.457	.9162
			Cow U-473				Cow U-844			
65	50	1 & 2	25.00	-.4780	1.564	.7994	21.61	-1.293	2.667	.9036
75	90	3 & 4	21.38	-.2086	1.792	.4520	7.82	-.0217	4.245	.0223
65	50	5 & 6	24.26	.3807	1.400	.7639	10.48	.8763	3.274	.7589

Temperature			Group B							
°F.	% R.H.	Week	$\bar{x}$	b	Syx	r*	$\bar{x}$	b	Syx	r*
			Cow U-829				Cow C-880			
85	50	1 & 2	25.76	-.2930	3.386	.3525	17.74	-1.012	2.935	.8322
65	50	3 & 4	24.81	.4295	3.399	.4820	19.00	-.2189	2.475	.3594
85	50	5 & 6	24.10	-.4044	2.862	.5239	18.04	-.0341	1.334	.1105
65	50	1 & 2	29.18	.6886	2.049	.8256	23.09	.3800	4.238	.3637
85	70	3 & 4	24.41	-.1166	2.817	.8745	15.14	-1.413	2.202	.9416
65	50	5 & 6	26.55	.3914	2.468	.5682	23.03	1.135	2.864	.8653
95	25	1 & 2	28.14	-.2936	3.473	.3454	19.54	-1.743	2.380	.9542
65	50	3 & 4	30.05	.8367	3.445	.7266	25.59	.5873	2.907	.6605
95	25	5 & 6	28.91	-.4446	3.131	.5259	20.78	-1.072	2.814	.8565
65	50	1 & 2	28.72	-.4424	2.181	.6618	24.55	.4921	2.541	.6446
90	25	3 & 4	30.58	.1725	.9735	.6109	26.01	-.0270	1.277	.0917
65	50	5 & 6	29.65	-.2670	2.902	.3719	26.54	.2934	1.594	.6254
			Cow C-895				Cow U-853			
85	50	1 & 2	13.00	-1.255	4.040	.8041	17.43	-.7895	2.627	.7945
65	50	3 & 4	13.63	.213	1.696	.4800	24.75	.4881	3.766	.4915
85	50	5 & 6	13.14	-.1978	1.390	.5266	16.99	-.3629	3.386	.4228
65	50	1 & 2	14.84	-.1229	1.728	.2958	23.98	.4609	2.959	.5612
85	70	3 & 4	10.23	-.0105	1.536	.0298	17.59	-.3262	3.688	.3594
65	50	5 & 6	14.32	.6591	4.606	.5289	26.62	.6407	2.104	.7984
			Cow U-847				Cow U-813			
95	25	1 & 2	8.00	.2347	2.900	.332	5.77	-.7112	3.941	.6178
65	50	3 & 4	21.70	-.6031	5.757	.4150	9.06	.6969	.8502	.9629
95	25	5 & 6	9.76	-.4103	3.179	.4900	7.29	-.0734	2.619	.1211
65	50	1 & 2	17.31	.6430	2.085	.8020	17.28	.7149	1.793	.8665
90	25	3 & 4	19.75	-.5721	2.628	.6879	17.57	-.4246	2.599	.5796
65	50	5 & 6	20.98	.3514	1.766	.6549	22.22	.6373	.6205	.9759
75	90	1 & 2	22.16	-.3598	3.614	.3977	23.14	.6523	1.603	.8709
65	50	3 & 4	22.12	.1752	1.549	.4418	26.09	.2200	1.904	.4494
75	90	5 & 6	24.59	.0123	2.048	.0262	26.16	-.1059	1.461	.3011
			Cow U-818				Cow U-820			
75	90	1 & 2	30.87	-.3666	2.240	.5802	26.80	-.1607	1.591	.4024
65	50	3 & 4	25.42	.1176	1.595	.3057	23.69	-.0230	2.152	.0467
75	90	5 & 6	28.00	-.0859	1.538	.2364	24.95	.2064	1.009	.6649

*Level of significance: .05 = .5324 .01 = .6614

TABLE 6. BODY WEIGHT, LBS. - WEEKLY AVERAGE

1958 - 1959

Group A

Temperature °F.	% R.H.	793	523	474	440	484	473	820	823	855	852
		Cow Number									
65	50	1153	1146	1120	1182	1243	1162				
80	50	1160	1138	1124	1195	1228	1173				
		1177	1122	1122	1206	1217	1140				
65	50	1190	1129	1162	1206	1213	1142				
		1193	1142	1171	1224	1210	1166				
90	40	1204	1131	1190	1157	1197	1166				
		1155	1089	1076	1232	1188	1124				
65	50	1146	1098	1120	1217	1179	1140				
		1155	1100	1096	1186	1162	1129				
90	40	1162	1096	1091	1204	1157	1133				
		1142	1076	1118	1204	1160	1142				
65	50	1129	1068	1109	1171			1082	1226		
		1173	1078	1155	1248			1085	1213		
80	30	1177	1034	1168	1259			1098	1175		
		1151	1043	1142	1254			1096	1168		
65	50	1162	1082	1171	1230			1078	1135		
		1171	1085	1197	1252			1060	1140		
90	20	1175	1085	1160	1261			1076	1138		
		1190	1074	1109	1257			1074	1120		
65	50	1190	1074	1124	1281			1109	1122		
		1184	1067	1155	1314			1118	1157		
90	20	1208	1093	1206	1345			1120	1195		
		1219	1076	1186	1336			1118	1188		
65	50	1197	1091					1129	1193	1005	1142
		1224	1100					1113	1217	1014	1146
80	80	1272	1107					1120	1239	1016	1168
		1261	1120					1129	1215	1012	1131
65	50	1239	1135					1138	1182	1016	1131
		1237	1133					1157	1184	1005	1168
90	50	1281	1149					1173	1210	978	1182
		1270	1113					1135	1162	988	1142
65	50	1278	1146					1157	1171	999	1138
		1312	1142					1173	1188	1005	1151
90	50	1338	1195					1204	1246	1016	1171
		1303	1160					1202	1213	1025	1190

Group B

Temperature °F.	% R.H.	713	856	807	804	499	487	814	818	849	858
		Cow Number									
80	50	1340	1091	1131	1063	1360	1140				
65	50	1296	1105	1140	1034	1376	1142				
		1327	1131	1151	1043	1356	1160				
80	50	1340	1142	1160	1016	1373	1179				
		1314	1138	1127	1027	1365	1166				
65	50	1296	1135	1149	1032	1343	1179				
		1334	1168	1186	1069	1351	1193				
90	40	1274	1173	1171	1047	1380	1179				
		1294	1149	1116	1014	1367	1100				
65	50	1261	1149	1089	1001	1351	1113				
		1294	1140	1146	1012	1373	1118				
80	30	1290	1153	1171	1003			1274	1221		
		1321	1190	1184	1030			1259	1228		
65	50	1321	1228	1206	1052			1287	1228		
		1241	1210	1179	1034			1268	1190		
80	30	1250	1204	1175	1027			1228	1164		
		1276	1210	1166	1008			1230	1151		
65	50	1285	1239	1175	1038			1213	1173		
		1292	1217	1204	1023			1210	1173		
90	20	1287	1250	1246	1027			1202	1179		
		1329	1274	1254	1043			1204	1155		
65	50	1327	1265	1272	1058			1226	1140		
		1329	1303	1274	1038			1261	1195		
80	80	1305	1316					1276	1206	1091	1124
		1329	1321					1307	1204	1080	1071
65	50	1312	1327					1312	1327	1268	1146
		1325	1354					1287	1151	1100	1082
80	80	1329	1358					1316	1157	1118	1118
		1340	1380					1332	1188	1138	1116
65	50	1325	1378					1318	1182	1118	1098
		1329	1380					1362	1162	1131	1127
90	50	1345	1393					1342[1]	1166	1160	1153
		1332	1393					1323	1122	1146	1098
65	50	1345	1387					1358	1173	1140	1071
		1373	1407					1415	1224	1177	1133

TABLE 6 (CONT'D). BODY WEIGHT LBS. - WEEKLY AVERAGE

1959 - 1960

Group A

Temperature °F.	% R.H.	C-794	U-830	C-818	U-450	U-852	C-842	U-809	U-864	U-844	U-473
		Cow Number									
65	50	1146	1466	1140	1276	1173	1360				
85	50	1140	1400	1144	1263	1149	1345				
		1124	1343	1210	1210	1190	1332				
65	50	1133	1362	1135	1217	1151	1336				
		1162	1365	1140	1228	1160	1354				
85	70	1168	1373	1186	1232	1213	1376				
		1118	1347	1175	1202	1215	1365				
65	50	1151	1362	1164	1230	1179	1365				
		1157	1422	1182	1235	1219	1387				
85	70	1197	1448	1204	1263	1257	1422				
		1171	1378	1235	1199	1283	1431				
65	50	1164	1415	1213	1243			1252	1173		
		1195	1451	1219	1274			1263	1144		
95	25	1199	1418	1208	1252			1195	1116		
		1146	1345	1197	1182			1162	1056		
65	50	1164	1411	1208	1239			1175	1063		
		1188	1433	1228	1272			1210	1093		
90	25	1217	1464	1237	1294			1228	1111		
		1168	1404	1252	1259			1221	1109		
65	50	1150	1415	1268	1250			1224	1078		
		1186	1457	1265	1294			1230	1107		
90	25	1177	1490	1281	1334			1228	1135		
		1157	1420	1292	1259			1232	1131		
65	50	1160	1477					1221	1135	1248	1343
		1177	1508					1228	1149	1217	1310
75	90	1177	1537					1237	1153	1186	1299
		1177	1475					1239	1157	1144	1274
65	50	1175	1523					1228	1144	1047	1254
		1166	1543					1237	1171	1012	1274

Group B

Temperature °F.	% R.H.	C-829	C-623	U-829	C-880	C-895	U-853	U-813	U-847	U-818	U-820
		Cow Number									
85	50	1246	1093	1254	1226	1250	1122				
65	50	1228	1109	1228	1257	1241	1151				
		1252	1122	1268	1265	1265	1164				
85	50	1237	1120	1299	1279	1287	1175				
		1252	1122	1299	1296	1276	1138				
65	50	1252	1146	1285	1294	1294	1166				
		1276	1146	1340	1314	1332	1199				
85	70	1294	1164	1373	1312	1312	1210				
		1314	1146	1312	1239	1314	1173				
65	50	1310	1162	1316	1259	1307	1171				
		1314	1157	1351	1332	1358	1208				
95	25	1332	1177	1426	1351			1190			
		1294	1151	1367	1292			1076			
65	50	1329	1195	1407	1301			1076	1250		
		1340	1164	1440	1371			1091	1164		
95	25	1325	1166	1437	1362			1102	1140		
		1354	1173	1431	1314			1023	1069		
65	50	1365	1188	1468	1281			1058	1091		
		1378	1188	1486	1367			1105	1118		
90	25	1354	1177	1523	1367			1076	1102		
		1376	1186	1528	1387			1049	1096		
65	50	1398	1177	1541	1389			1056	1093		
		1422	1202	1570	1413			1091	1109		
75	90	1413	1215					1102	1102	1409	1219
		1444	1224					1135	1118	1371	1186
65	50	1451	1195					1142	1109	1354	1179
		1457	1213					1151	1133	1376	1208
75	90	1473	1271					1179	1215	1400	1217
		1493	1224					1179	1210	1415	1206

TABLE 7 -- RECTAL TEMPERATURE ^{o}F. BASED ON AVERAGE OF THE 2ND WEEK

1958 - 1959

Temperature		Group A Cow Number									
^{o}F.	% R.H.	793	523	474	440	484	473	820	823	855	852
65	50	101.6	101.4	101.5	101.3	101.4	101.4				
80	50	102.0	102.4	101.7	101.6	101.5	101.9				
65	50	101.6	101.5	101.6	101.2	101.5	101.4				
90	40	105.4	104.8	105.3	105.0	102.6	103.3				
65	50	101.4	100.9	101.3	100.8	101.5	100.8				
90	40	103.4	102.8	102.7	103.9	102.1	101.8				
65	50	101.5	101.2	101.3	101.0			101.5	101.4		
80	30	101.6	101.6	101.9	101.5			101.5	101.8		
65	50	101.6	101.3	101.2	101.3			101.5	101.4		
90	20	102.4	102.2	102.0	102.5			101.7	102.3		
65	50	101.8	101.2	101.2	101.2			101.4	101.3		
90	20	101.8	102.2	102.2	103.9			101.8	102.3		
65	50	101.5	101.3					101.5	101.3	101.2	101.4
80	80	101.9	101.9					101.8	102.1	102.0	103.6
65	50	101.6	101.4					101.5	101.3	101.5	101.3
90	50	103.7	104.1					102.6	102.9	102.8	104.8
65	50	101.7	101.3					101.9	101.4	101.6	101.4
90	50	104.1	104.2					102.6	103.3	103.8	104.1

Group B

Temperature °F.	% R.H.	713	856	807	804	499	487	814	818	849	858
		Cow Number									
80	50	102.0	102.2	101.8	102.0	101.6	103.2				
65	50	102.3	101.6	101.7	101.5	101.5	101.7				
80	50	101.7	102.4	101.8	101.9	102.0	102.6				
65	50	101.6	101.9	101.6	101.7	101.9	101.6				
90	40	102.5	103.0	102.4	103.0	103.1	104.6				
65	50	101.6	101.3	101.3	101.5	101.9	101.3				
80	30	101.8	102.0	101.7	101.6			102.3	102.0		
65	50	101.6	101.7	101.4	101.7			101.4	101.8		
80	30	101.8	101.9	101.5	101.5			101.7	101.8		
65	50	101.7	101.7	101.5	101.5			101.3	101.4		
90	20	101.9	102.4	102.0	101.9			102.6	104.2		
65	50	101.8	101.7	101.6	101.5			101.5	101.3		
80	80	101.9	102.4					102.5	102.5	103.9	104.5
65	50	101.9	101.7					101.2	101.6	101.4	101.6
80	80	101.9	102.4					102.7	102.1	102.3	103.4
65	50	102.0	101.8					101.5	101.6	101.3	101.5
90	50	101.9	103.3					104.8	103.1	103.2	105.2
65	50	101.9	101.6					101.3	101.6	101.2	101.2

1959 - 1960

Group A

Temperature °F	% R.H.	C-794	U-830	C-818	U-450	U-852	C-842	U-809	U-864	U-844	U-473
		Cow Number									
65	50	101.5	101.3	101.5	101.4	101.4	101.5				
85	50	102.5	104.4	102.2	103.3	102.9	101.7				
65	50	101.5	101.5	102.6	101.7	101.4	101.5				
85	70	104.1	105.0	102.6	104.8	103.3	102.2				
65	50	101.1	101.3	102.1	101.4	101.2	101.7				
85	70	103.7	104.8	102.5	104.4	103.1	101.8				

TABLE 7 (CONT'D) -- RECTAL TEMPERATURE °F. BASED ON AVERAGE OF THE 2ND WEEK
1959 - 1960

Group A

Temperature		Cow Number									
°F	% R.H.	C-794	U-830	C-818	U-450	U-852	C-842	U-809	U-864	U-844	U-473
65	50	101.5	101.3	102.0	101.7			101.7	101.6		
95	25	101.3	105.2	102.4	105.2			103.1	105.0		
65	50	101.5	101.1	102.0	101.3			101.4	101.3		
90	25	102.5	105.0	102.2	104.2			102.7	102.9		
65	50	101.5	101.3	101.9	101.3			101.4	101.9		
90	25	102.4	104.8	101.8	103.5			102.3	102.5		
65	50	101.3	101.1					101.7	101.3	101.6	101.2
75	90	101.5	101.8					101.5	102.8	101.6	101.6
65	50	101.3	101.4					101.6	101.8	101.1	101.4

Group B

Temperature		Cow Number									
°F	% R.H.	C-829	C-623	U-829	C-880	C-895	U-853	U-813	U-847	U-818	U-820
85	50	101.5	102.9	101.9	103.4	102.6	102.6				
65	50	101.6	101.5	101.3	101.7	101.5	101.6				
85	50	101.3	103.3	101.8	102.6	102.5	103.2				
65	50	101.6	101.4	101.3	101.5	101.6	101.6				
85	70	102.0	103.6	103.9	104.3	102.3	104.1				
65	50	101.4	101.5	101.4	101.4	101.5	101.6				
95	25	102.1	104.9	102.5	104.3			102.5	101.9		
65	50	101.7	101.6	101.5	101.8			101.4	101.7		
95	25	102.1	105.2	102.7	103.9			104.5	105.0		
65	50	101.7	101.4	101.6	101.6			101.5	101.2		
90	25	102.1	103.9	101.9	102.0			103.5	102.8		
65	50	101.6	101.4	101.6	101.6			101.5	101.3		
75	90	101.6	102.1					102.0	101.5	101.6	101.5
65	50	101.9	101.5					101.6	101.5	101.5	101.7
75	90	101.6	102.0					102.1	101.7	101.6	101.7

TABLE 8 -- ENVIRONMENT SCHEDULE FOR TEMPERATURE HUMIDITY STUDIES, 1958 - 1959

Date	Chamber I			Chamber II		
	°F.	R.H.	Group*	°F.	R.H.	Group*
10-20-58 to 11-02-58	80	50%	B	65	50%	A
11-03-58 to 11-16-58	80	50%	A	65	50%	B
11-17-58 to 11-30-58	80	50%	B	65	50%	A
12-01-58 to 12-14-58	90	50-40%**	A	65	50%	B
12-15-58 to 12-28-58	90	40%	B	65	50%	A
12-29-58 to 1-11-59	90	40%	A	65	50%	B
1-12-59 to 1-25-59	80	30%	B	65	50%	A
1-26-59 to 2-08-59	80	30%	A	65	50%	B
2-09-59 to 2-22-59	80	30%	B	65	50%	A
2-23-59 to 3-08-59	90	20%	A	65	50%	B
3-09-59 to 3-22-59	90	20%	B	65	50%	A
3-23-59 to 4-05-59	90	20%	A	65	50%	B
4-06-59 to 4-19-59	65	50%	A	80	80%	B
4-20-59 to 5-03-59	65	50%	B	80	80%	A
5-04-59 to 5-17-59	65	50%	A	80	80%	B
5-18-59 to 5-31-59	65	50%	B	90	50%	A
6-01-59 to 6-14-59	65	50%	A	90	50%	B
6-15-59 to 6-28-59	65	50%	B	90	50%	A

*Cows divided into groups of six cows each: A and B.
**First week 90°-50% R.H. and 2nd week 90°-40% R.H.

Stage of Lactation and Group Designation for Individual Cows

Date	Group	Stage of Lactation					
		Early		Mid		Late	
10-20-58 to 1-11-59	A	(793)	(523)	(474)	(440)	(484)	(473)
	B	(713)	(856)	(807)	(804)	(499)	(487)
1-12-59 to 4-05-59	A	(820)	(823)	(793)	(523)	(474)	(440)
	B	(814)	(818)	(713)	(856)	(807)	(804)
4-06-59 to 6-28-59	A	(855)	(852)	(820)	(823)	(793)	(523)
	B	(849)	(858)	(814)	(818)	(713)	(856)

TABLE 9 -- ENVIRONMENT SCHEDULE FOR TEMPERATURE HUMIDITY STUDIES
1959 - 1960

Date	Chamber I °F.	R.H.	Group*	Chamber II °F.	R.H.	Group*
10-26-59 to 11-08-59	65	50%	A	85	50%	B
11-09-59 to 11-22-59	65	50%	B	85	50%	A
11-23-59 to 12-06-59	65	50%	A	85	50%	B
12-07-59 to 12-20-59	65	50%	B	85	70%	A
12-21-59 to 1-03-60	65	50%	A	85	70%	B
1-04-60 to 1-17-60	65	50%	B	85	70%	A
**1-18-60 to 1-31-60	95	25%	B	65	50%	A
2-01-60 to 2-14-60	95	25%	A	65	50%	B
2-15-60 to 2-28-60	95	25%	B	65	50%	A
2-29-60 to 3-13-60	90	25%	A	65	50%	B
3-14-60 to 3-27-60	90	25%	B	65	50%	A
3-28-60 to 4-10-60	90	25%	A	65	50%	B
4-11-60 to 4-24-60	75	90%	B	65	50%	A
4-25-60 to 5-08-60	75	90%	A	65	50%	B
5-09-60 to 5-22-60	75	90%	B	65	50%	A

*Cows divided into groups of six cows each: A and B.
**Changed temperature of Chamber January 22, 1960.
I became experimental room
II became control

Stage of Lactation and Group Designation for Individual Cows

Date	Group	Early		Mid		Late	
10-26-59 to 1-17-60	A	(C-794)	(U-830)	(U-450)	(C-818)	(C-842)	(U-852)
	B	(C-623)	(C-829)	(U-829)	(C-880)	(U-853)	(C-895)
1-18-60 to 4-10-60	A	(U-809)	(U-864)	(C-794)	(U-830)	(U-450)	(C-818)
	B***	(U-847)	(U-813)	(C-623)	(C-829)	(U-829)	(C-880)
4-11-60 to 7-03-60	A	(U-473)	(U-844)	(U-809)	(U-864)	(C-794)	(U-830)
	B	(U-818)	(U-820)	(U-847)	(U-813)	(C-623)	(C-829)

***U-821 taken out of Lab and replaced January 22 by U-847.

TABLE 10 - HERD RATION - MILKING COWS

Feeding Stuffs	Crude Protein	Dig. Protein	Total Dig. Nutrients
800# No. 2 Yellow Corn (3/4" grind)	72.80	56.00	640.00
300# No. 2 Oats (3/4" grind)	36.00	28.20	210.30
300# Wheat Bran	49.20	39.90	200.70
300# Soybean Meal (44%)	137.10	126.00	234.00
250# Cane Molasses Feed*	11.28	4.28	147.28
30# Salt	-	-	-
20# Bone Meal	-	-	-
2000#	306.38	254.38	1432.28
Average Composition per cwt.	15.32	12.72	71.61

*The cane molasses feed shall contain a minimum of 80% cane molasses with 10% milo grain and 10% wheat grain.

TDN Estimates for Beet Pulp are 72.40% and 53.5% for Hay (Pellets).

TABLE 11 -- EFFECT OF TEMPERATURES AND HUMIDITIES BELOW 65°F. ON MILK PRODUCTION, PERCENT BUTTERFAT, SPECIFIC GRAVITY AND TOTAL SOLIDS

1961 - 1962

Date	Weeks Averaged	Temp. °F	%R.H.	Cow Number 46	895	851	910	921	867	Average
				MILK PRODUCTION, LB/DAY						
Nov. 20-Dec. 10	3	65	52	34.1	39.8	36.3	41.3	36.0	49.0	39.4
Dec. 11-Dec. 24	2	39	92	29.8	39.4	36.6	39.3	34.5	49.1	38.1
Dec. 25-Jan. 14	3	65	55	26.8	39.3	35.7	37.4	30.9	49.2	36.6
Jan. 15-Jan. 28	2	39	53	20.0	37.3	33.2	31.7	31.9	41.6	32.6
Jan. 29-Feb. 18	3	64	50	19.0	37.6	33.6	31.9	31.5	45.4	33.2
				PERCENT BUTTERFAT, LB/DAY*						
Nov. 20-Dec. 10	3	65	52	3.2**	4.2**	3.4**	3.6**	4.1**	4.1**	3.8
Dec. 11-Dec. 24	2	39	92	4.9	3.8	3.6	3.6	4.4	3.8	4.0
Dec. 25-Jan. 14***	3	65	55	4.1	3.8	3.5	3.4	3.8	3.6	3.7
Jan. 15-Jan. 28	2	39	53	4.4	4.0	3.8	3.6	4.1	4.4	4.1
Jan. 29-Feb. 18	3	64	50	4.0	4.0	3.8	3.4	3.8	4.3	3.9
				SPECIFIC GRAVITY*						
Nov. 20-Dec. 10	3	65	52	1.0332**	1.0328**	1.0322**	1.0339**	1.0334**	1.0319**	1.0329
Dec. 11-Dec. 24	2	39	92	1.0293	1.0313	1.0308	1.0319	1.0309	1.0312	1.0309
Dec. 25-Jan. 14***	3	65	55	1.0316	1.0320	1.0319	1.0326	1.0316	1.0324	1.0320
Jan. 15-Jan. 28	2	39	53	1.0305	1.0309	1.0311	1.0320	1.0314	1.0308	1.0311
Jan. 29-Feb. 18	3	64	50	1.0307	1.0310	1.0313	1.0321	1.0314	1.0307	1.0312
				TOTAL SOLIDS*						
Nov. 20-Dec. 10	3	65	52	12.68**	13.83**	12.61**	13.40**	13.87**	13.48**	13.31
Dec. 11-Dec. 24	2	39	92	13.82	12.93	12.54	12.80	13.58	12.91	13.10
Dec. 25-Jan. 14***	3	65	55	13.23	13.13	12.79	12.72	13.12	13.03	13.00
Jan. 15-Jan. 28	2	39	53	13.55	13.05	12.90	12.80	13.31	13.48	13.18
Jan. 29-Feb. 18	3	64	50	12.99	13.15	12.89	12.68	12.99	13.32	13.00

*Four readings per week (2 A.M. 2 P.M.)
**Average of one week (no data for first two weeks)
***Only two readings for week of Jan. 1-7
NOTE: Total Solids appear as measured by Taylor Lactometer and Babcock Fat Test.

TABLE 12 -- EFFECT OF TEMPERATURES AND HUMIDITIES BELOW 65° ON FEED CONSUMPTION, LB/DAY

1961 - 1962

Date	Weeks Averaged	Temp. °F.	R.H. %	COW 46				COW 895				COW 851			
				Grain	Beet Pulp	Hay	TDN*	Grain	Beet Pulp	Hay	TDN*	Grain	Beet Pulp	Hay	TDN*
Nov. 20 - Dec. 10	3	65	52	18	4	26.1	28.9	18	4	26.2	29.0	18	4	26.2	29.0
Dec. 11 - Dec. 24	2	39	92	18	4	24.2	28.0	18	4	25.0	28.4	18	4	29.2	30.5
Dec. 25 - Jan. 14	3	65	55	18	4	18.5	25.1	18	4	29.8	30.8	18	4	34.8	33.3
Jan. 15 - Jan. 28	2	39	53	18	4	21.3	26.5	18	4	45.3	38.6	18	4	59.1	45.5
Jan. 29 - Feb. 18	3	64	50	18	4	18.4	25.1	18	4	34.8	33.3	18	4	57.2	44.6

Date	Weeks Aver-aged	Temp. °F	R.H. %	COW 910				COW 921				COW 867				Average TDN
				Grain	Beet Pulp	Hay	TDN*	Grain	Beet Pulp	Hay	TDN*	Grain	Beet Pulp	Hay	TDN*	
Nov. 20 - Dec. 10	3	65	52	18	4	26.4	29.1	18	4	26.8	29.3	18	4	26.0	28.9	29.0
Dec. 11 - Dec. 24	2	39	92	18	4	27.3	29.5	18	4	28.0	29.9	18	4	31.9	31.8	29.7
Dec. 25 - Jan. 14	3	65	55	18	4	34.5	33.2	17.7**	4.6	35.6	33.9	18	4	41.5	36.7	32.2
Jan. 15 - Jan. 28	2	39	53	18	4	57.2	44.6	18	4	52.3	42.1	18	4	63.6	47.8	40.8
Jan. 29 - Feb. 18	3	64	50	18	4	38.4	35.1	18	4	42.5	37.2	18	4	44.3	38.1	35.6

*TDN estimates for grain, beet pulp and hay are 71.8%, 72.4% and 50.3% respectively.
**Mastitis

TABLE 13 -- EFFECT OF TEMPERATURES AND HUMIDITIES BELOW 65°F.

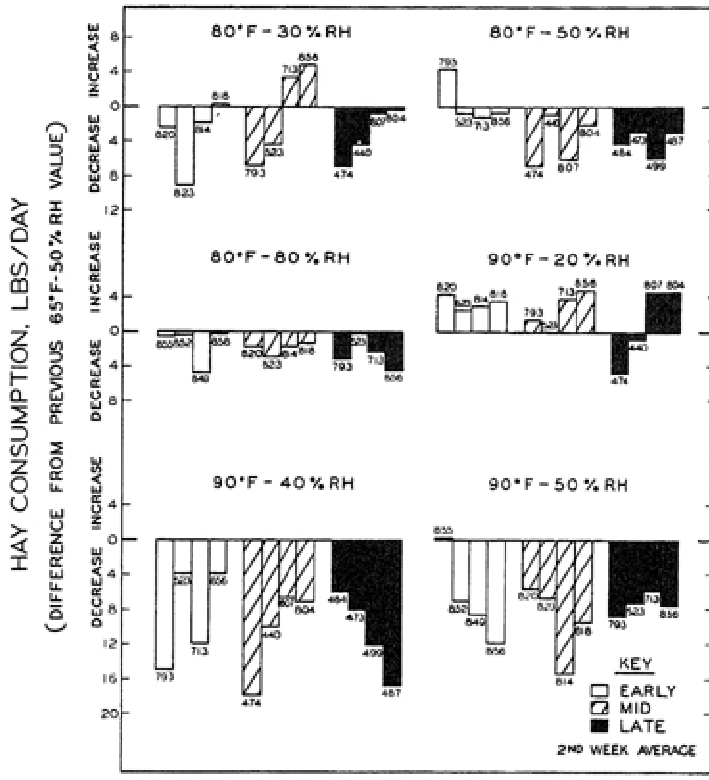
Body Weight in Pounds
1961 - 1962

Date	Week	Temp. °F.	% R.H.	Cow Number 46	895	851	910	921	867
Nov. 20 - 26	1	65	52	1075	1066	1281	1268	1035	1129
Nov. 30 - Dec. 3	2	65	52	1079	1195	1306	1247	1077	1114
Dec. 4 - 10	3	65	52	1067	1202	1279	1235	1089	1122
Dec. 11 - 17	1	39	92	1116	1229	1334	1258	1120	1138
Dec. 18 - 24	2	39	92	1113	1208	1354	1252	1135	1153
Dec. 25 - 31	1	65	55	1110	1213	1356	1256	1116	1159
Jan. 1 - 7	2	65	55	1140	1221	1356	1259	1118	1161
Jan. 8 - 14	3	65	55	1143	1224	1378	1252	1135	1163
Jan. 15 - 21	1	39	53	1166	1242	1396	1284	1144	1146
Jan. 22 - 28	2	39	53	1133	1230	1367	1279	1118	
Jan. 29 - Feb. 4	1	64	50	1182	895	1411	1281	1141	1175
Feb. 5 - 11	2	64	50	1160	1263	1418	1278	1141	1189
Feb. 12 - 18	3	64	50	1203	1240	1410	1286	1177	1188

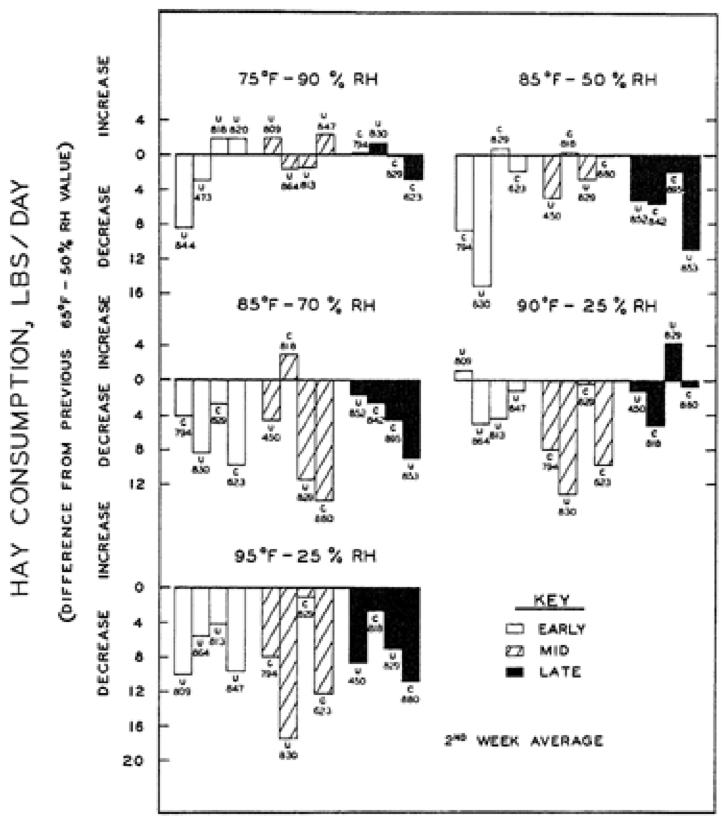
TABLE 14 -- EFFECT OF TEMPERATURES & HUMIDITIES BELOW 65°F. ON WATER CONSUMPTION, GAL/DAY

1961 - 1962

Date	Week Averaged	Temp. °F.	% R.H.	Cow Number 46	895	851	910	921	867	Average
Nov. 20 - Dec. 10	3	65	52	18.1	18.9	21.5	16.9	17.3	18.6	18.6
Dec. 11 - Dec. 24	2	39	92	14.8	17.8	19.8	15.6	16.6	18.8	17.2
Dec. 25 - Jan. 14	3	65	55	15.0	17.5	20.2	16.1	15.6	19.3	17.3
Jan. 15 - Jan. 28	2	39	53	13.2	15.6	17.3	15.1	14.6	18.0	15.6
Jan. 29 - Feb. 18	3	64	50	16.2	17.9	19.9	16.3	17.4	21.0	18.1

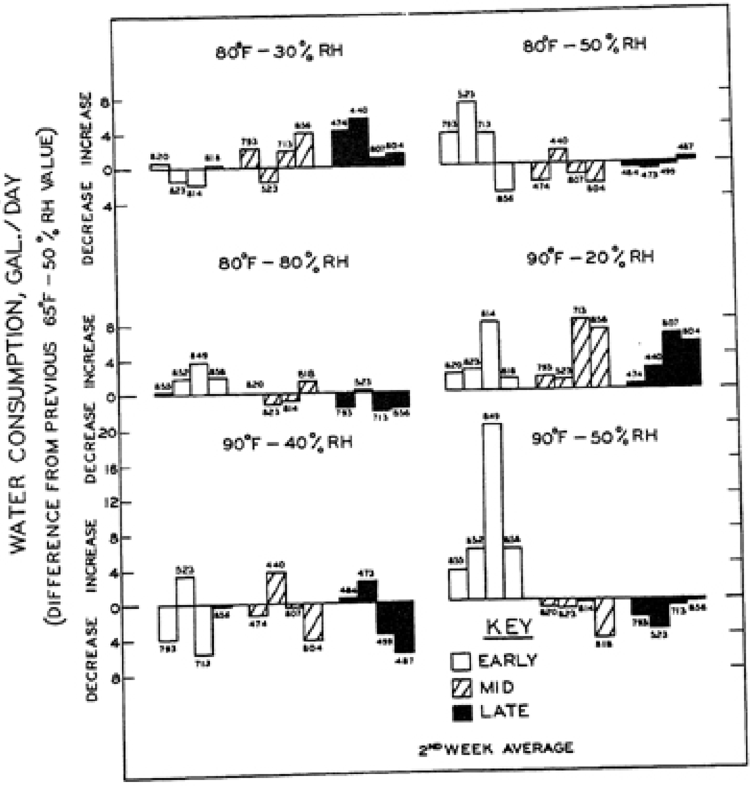


a

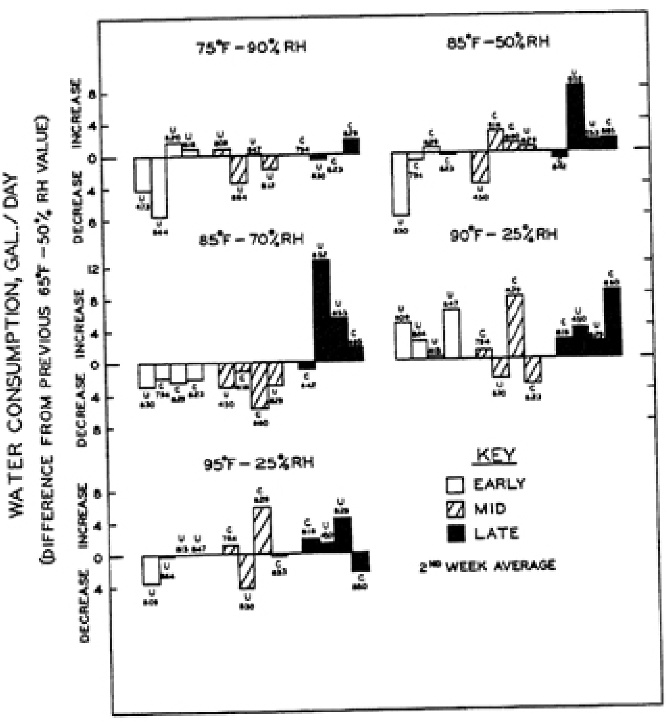


b

Fig. 1—Differences in hay consumption (2nd week average) from the previous 65°F base values. Figure (a) represents 1958-59 data. (b) 1959-60 data.



a



b

Fig. 2—Differences in water consumption (2nd week average) from the previous 65° F base values. Figure (a) represents 1958-59 data, (b) 1959-60 data.

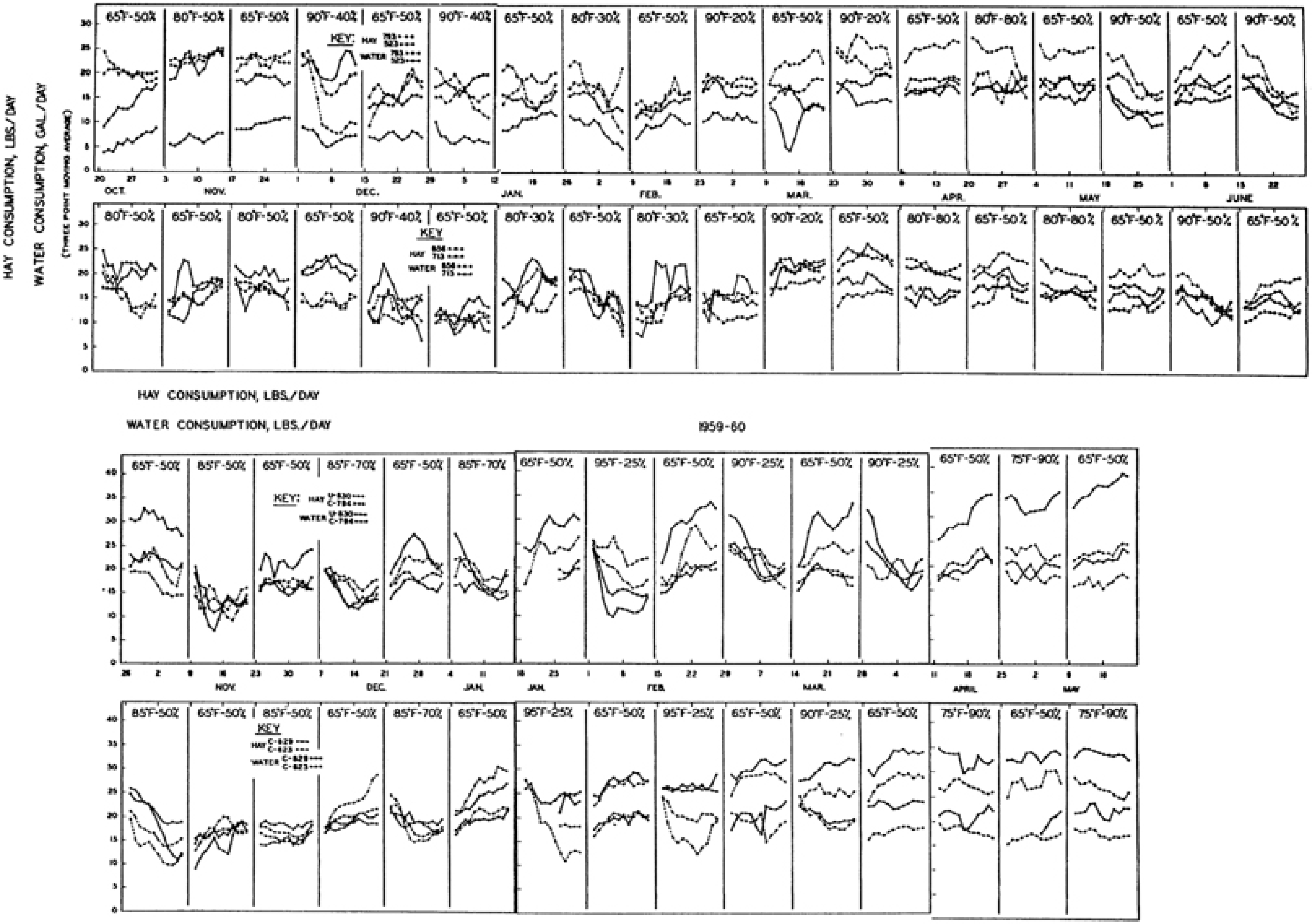


Fig. 3—3 point moving average for Hay Consumption and Water Consumption for 8 cows.

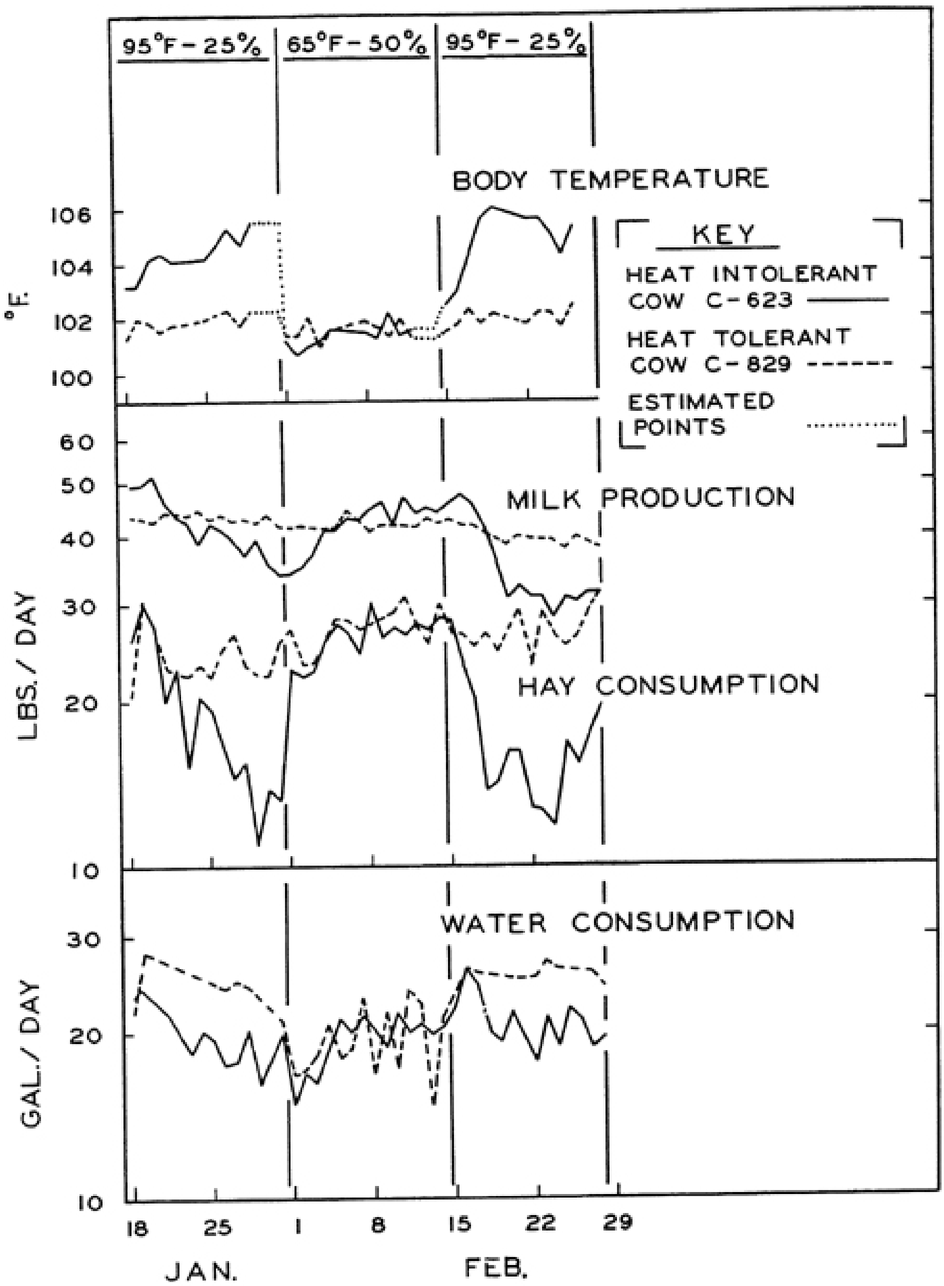


Fig. 4—Daily milk production, feed and water consumption, and body temperature on a typical heat tolerant and intolerant cow.

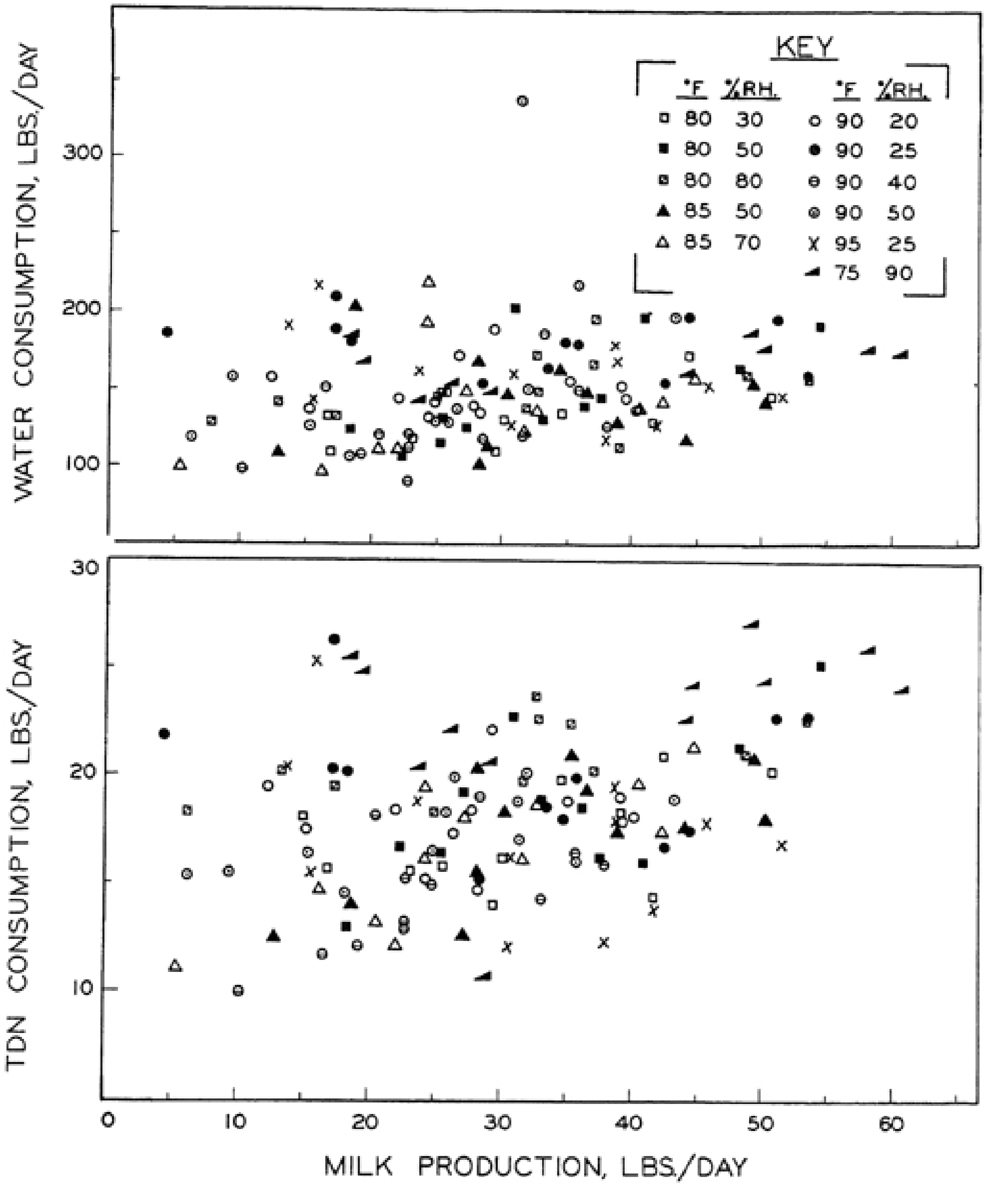
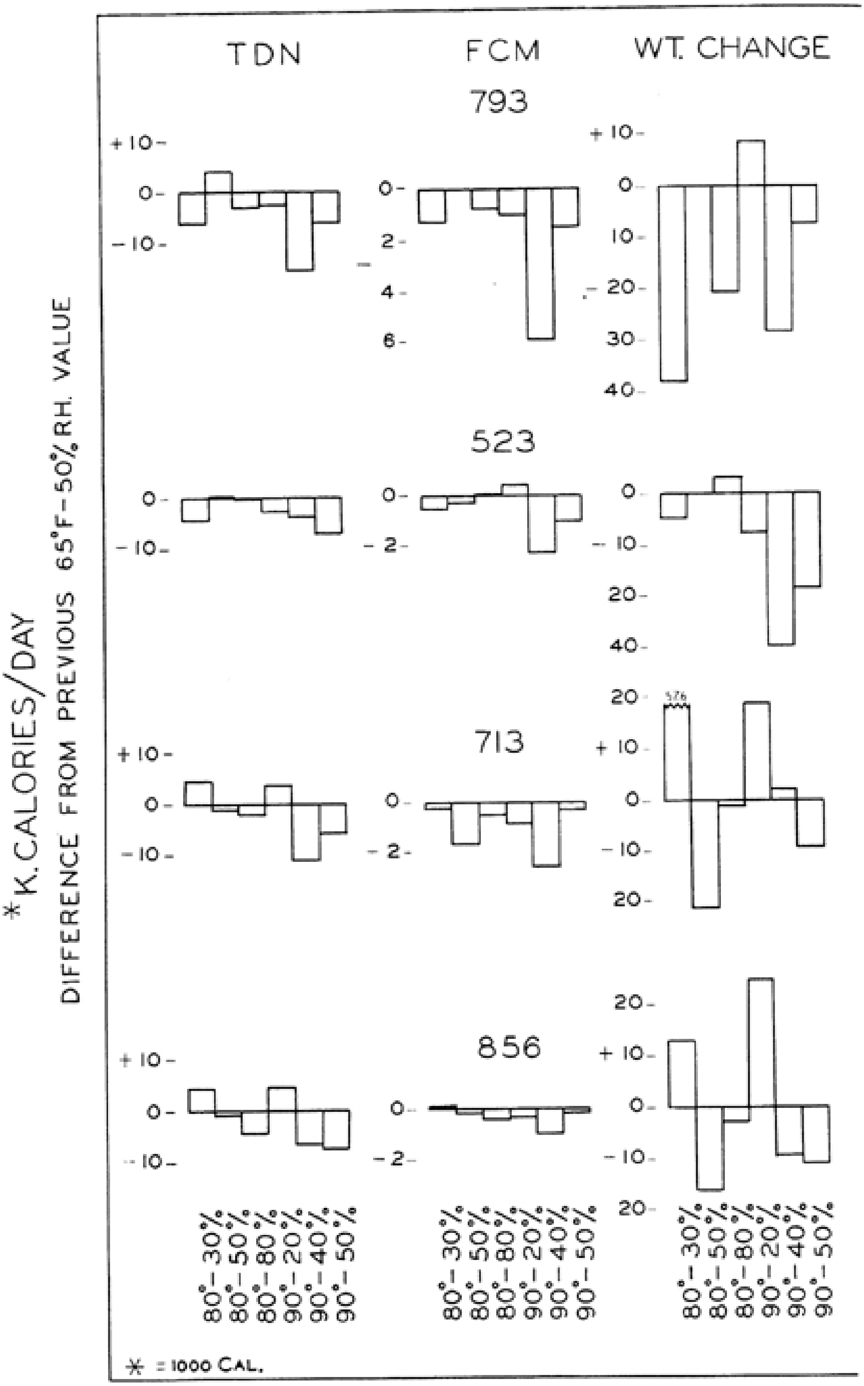
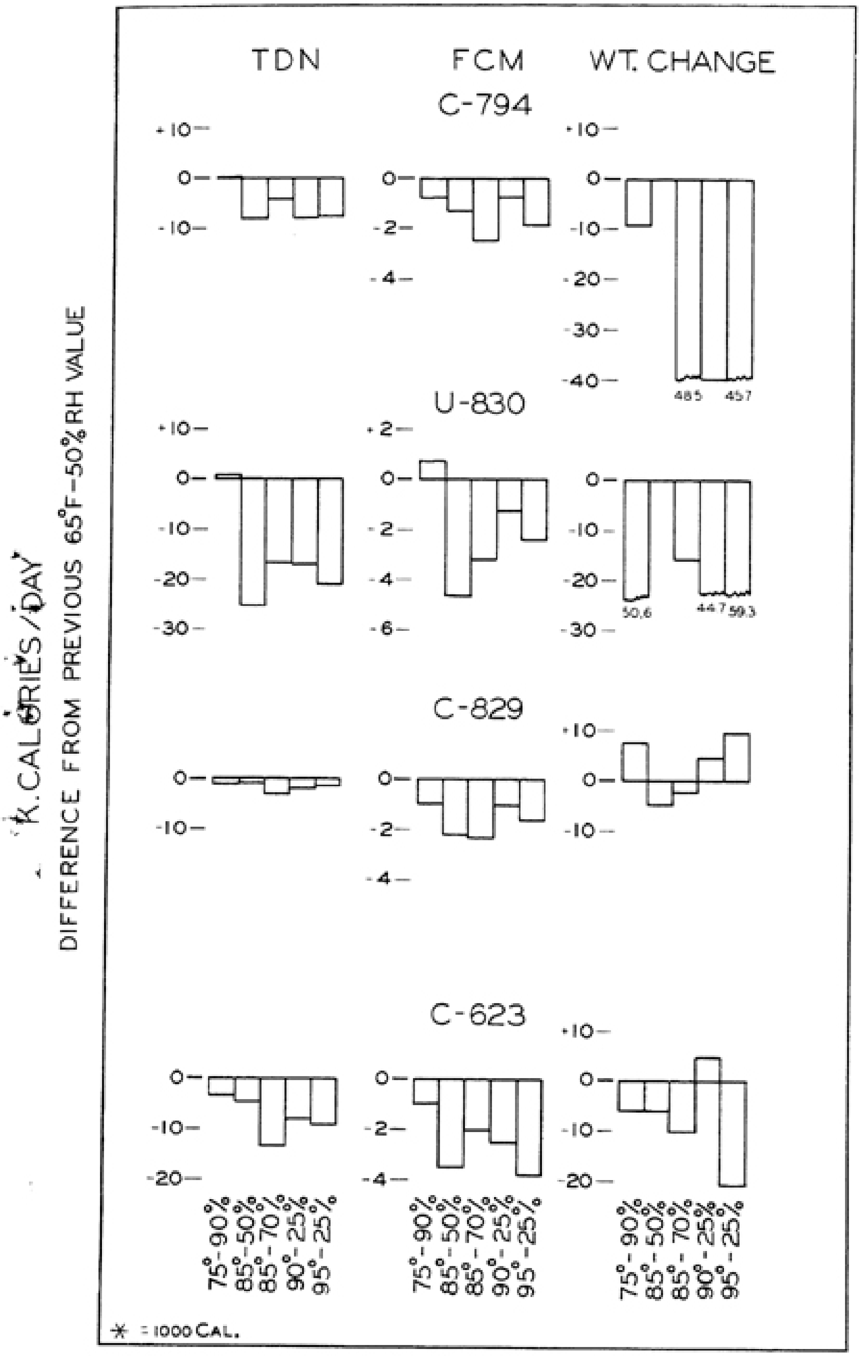


Fig. 5—Relationship of water and TDN consumption to milk production.



a

Fig. 6—TDN, Fat Corrected Milk, and weight change in K. ries. (a) 1958-59 (b) 1959-60.



b

Calories per day for 8 cows. K. calories = 1000 Large Calo-

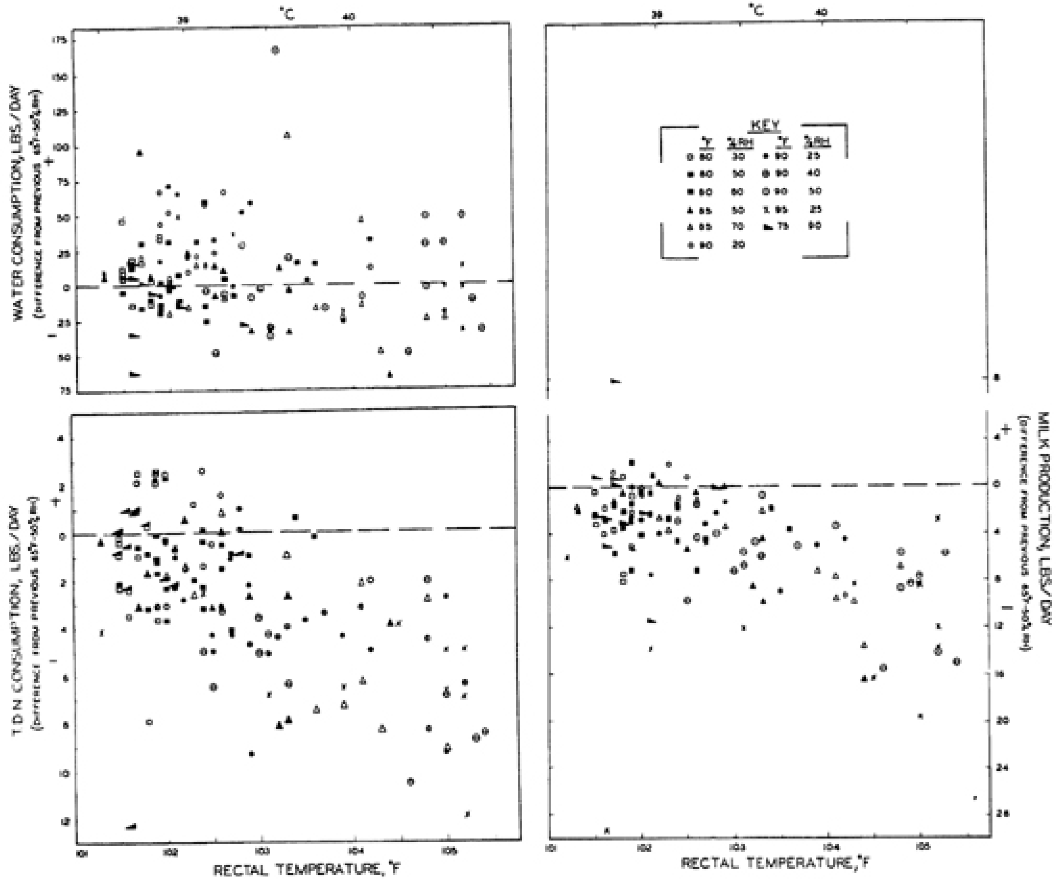


Fig. 7—Relationship of milk production, TDN and water consumption vs. rectal temperature.

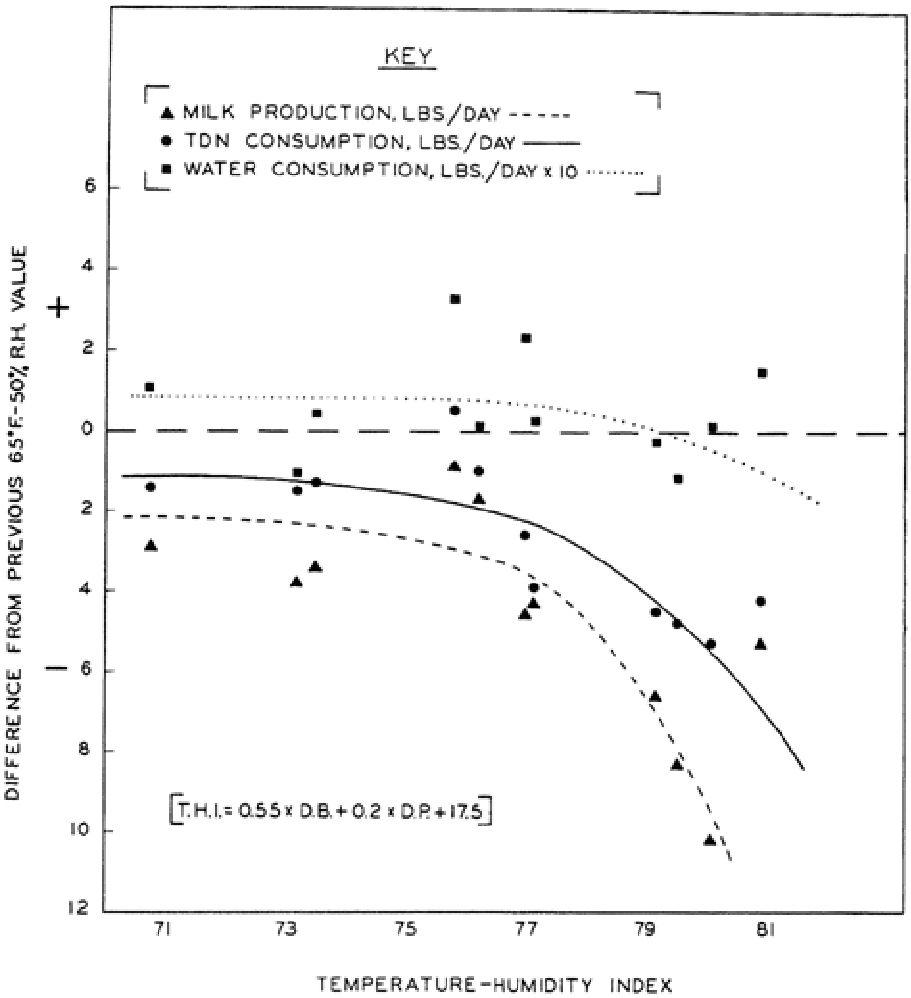


Fig. 8—Expression of milk production, TDN consumption and water consumption at various temperature humidity conditions vs. the THI index. 77 THI may be approximately 90°F-25% R.H. or 85°F-50% R.H. etc. Each data point is the difference from previous 65°F based on a 12 cow average.