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LXVIII. AGE AND TEMPERATURE EFFECTS ON TDN, WATER CONSUMPTION AND BALANCE OF DAIRY CALVES AND HEIFERS EXPOSED TO ENVIRONMENTAL TEMPERATURES OF 35 TO 95°F

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Acknowledgements are due to M. M. Jones and M.D. Shanklin for cooperation on the engineering phase of the Climatic Laboratory portion of the work; to A. C. Ragsdale for general council and management programs, to Dr. Homer E. Dale for veterinary care; to Harry Ball and Leonard Ayres for care and feeding of the animals; to Samuel Barrett, as an engineering aid; and to Joan F. Jones for assistance in data analysis.

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Limited information is available on homeothermic responses of dairy calves and heifers to higher environmental temperatures, particularly when animals are maintained at the higher temperatures for approximately two weeks or more. This publication and others (Johnson and Ragsdale, 1960; Kamal et al., 1962; and Kibler, 1962) describe numerous indices of environmental influence on yearling heifers, Phase I, and on small calves, Phase II.

The first phase of the investigation is a report on the responses of TDN, water consumption, and body weight of two groups of heifers (one group raised at a 50° and the other at a 80° F environmental temperature*) when exposed to a series of constant temperature conditions increasing from 35° to 95° F. An objective of this phase of the experiment was to determine acclimation effects that may have occurred from 12 months' growth at either 50° or 80° F. These acclimation effects were observed by recording TDN and water intake and other physical and physiological adjustment of three breeds of dairy heifers to various constant temperature conditions. The duration of exposure to each condition ranged from 5 to 9 days. (See Table 2 for sequence).

An additional objective was to provide quantitative information on heifers which were uncomplicated by effects of lactation or any pronounced growth changes during the experimental period.

This investigation permitted the opportunity to collect considerable water intake and output information on heifers at various temperatures. Research by Ragsdale, et al., (1950, 1951, 1953), and more recently by Harbin et al., (1958), has demonstrated that among both lactating and non-lactating Holsteins and Jerseys, positive correlations occur between environmental temperature and water consumption. Winchester and Morris (1956) reported that from 10° to 40° F environmental temperature, the rate of water consumption per unit of dry matter remained fairly constant; thereafter, with increasing environmental temperature, it increased at an accelerating rate. For 800 pound dairy heifers (pooled data on several breeds), water intake increased from 6.3 gallons at 40° F to 15.0 gallons at 90° F.

Bailey and Broster (1958), investigating dairy heifers, determined that within a temperature range of 30° to 90° F, water consumption increased by 0.0355 gallons per °F rise in temperature and by 0.0142 gallons per pound increase in live weight.

The second phase compares responses of young calves (approximately two months of age) in TDN and water consumption to exposures similar to those of Phase I. See Table 1 for sequence and duration of

*Growth studies on these animals were initiated September 27, 1956, and concluded in September, 1957. Eighteen calves (6 of each breed) remained in the Climatic Laboratory from about one month to approximately one year of age (Johnson et al., 1959). The experiment reported here began on September 16, 1951, when these calves were approximately one year of age.

exposure to each condition. Another objective was to obtain information useful in interpreting and providing insight into concepts regarding size, age, and heat tolerance.

EXPERIMENTAL CONDITIONS

Light, air movement, air exchange, and management conditions of both Phase I and the preceding 50° and 80° F rearing conditions were practically identical (Johnson and Ragsdale, 1958; Johnson et al., 1951). From 35° to 80° F the humidity was approximately 65 percent, and at 90° and 95° F, it was approximately 50 percent. Feed concentrate per day was limited to 3.3 pounds for the Jerseys and 4.6 pounds for the Holsteins and Brown Swiss. The following heifer ration was fed during this phase, and alfalfa hay and water were available *ad libitum.* The following is the ration fed to heifers:

	Percent
Ground oats	20
Wheat middlings	30.5
Linseed oil meal	5
Soybean oil meal	11
Calcium carbonate	5
Defluorinated phosphate	5
Trace mineral and salt mix	1
Vitamin D_2 premix	2.5
Vitamin A oil premix	20
	100.0%

Complete guaranteed analysis:

Crude protein	-	not less than 12.5%
Crude fat	-	not less than 2.5%
Crude fiber	-	not more than 12.0%
NFE	-	not less than 50.0%

Feed and water consumption were measured per pen per day.

At the inception of this temperature series investigation, the Holsteins raised at 50° F were approximately 80 to 90 pounds heavier than those raised at 80° F, and the 50° F Jerseys were about 20 pounds heavier than the 80° F Jerseys. The 80° F Brown Swiss, in contrast, were approximately 18 pounds heavier than the 50° F Brown Swiss.

Light and management conditions of the small calf study(2nd phase) were similar to those of the Phase I studies. The small calves were fed hay on an *ad libitum* basis. The following Calf Starter Ration was fed according to body weight; approximately 3.4 pounds of grain daily for each 100 pounds live weight. Table 1 gives actual pounds of grain, hay, and milk consumed by the growing calves at the various temperatures. Skim milk was given to the calves at both A.M. and P.M. feedings and water was available *ad libitum.*

The small calf starter ration composition was as follows:

	Crude Protein	Dig. Protein	Total Dig. Nutrients
300 lb. Ground Corn (No. 2)	25.80	19.80	240.30
300 lb. Ground Oats	36.00	28.20	210.30
100 lb. Wheat Bran	16.90	13.70	67.20
50 lb. Gr. Alfalfa (choice leafy green)	8.05	5.90	26.80
150 lb. Soybean Meal (44%)	68.10	57.15	118.35
27 1/2 lb. Soluble Blood Flour	23.29	22.36	23.07
50 lb. Dried Feeding Skim Milk	17.35	15.60	40.35
10 lb. Steamed Bone Meal	1.46	1.01	1.01
10 lb. Salt	-	-	-
2 1/2 lb. Reinforced Cod Liver Oil	-	-	-
1000 lb.	196.95	163.72	727.38
	19.70	16.37	72.73

Alfalfa hay was available ad libitum.

RESULTS

Phase I: Responses of Dairy Heifers Raised at 50° and 80° F to Other Environmental Temperatures

TDN Consumption and Water Consumption of Heifers vs. Environmental Temperature. The TDN and water consumption at each temperature level (Fig. 1) is based on the average per calf per day at each temperature. The tabular values are given in Tables 2, 3, and 4.

Regardless of the temperature level at which the animals were raised, TDN consumption of each of the breeds declined similarly as the temperature increased. The effect of rising environmental temperature on TDN consumption was significant at the 0.01 level (Table 5). Among the animals raised at 50°, Figure 1 indicates that below 90° F, the Holsteins displayed the highest level of TDN consumption, the Brown Swiss showed intermediate consumption, and the Jerseys had the lowest. At 95°F the Holsteins declined to a level similar to that of the Brown Swiss. The 50°F reared Jerseys showed the greatest total decline from 35 ° to 95° F. Among the heifers raised at 80° F the Holsteins consumed the greatest quantities of TDN throughout the temperature series. They were followed by the Brown Swiss and Jerseys, respectively. Breed differences were statistically significant at the 0.01 level of probability. Fig. 1 shows that the declines at 50° and 80° F are very closely paralled.

From 50° to 95° F water consumption increased sharply and was significant at the 0.01 level. Among the 50° F reared heifers, the Jerseys increased their water consumption (gallons per calf per day) to the greatest extent, from 5 to 16 gallons, the Holsteins increased

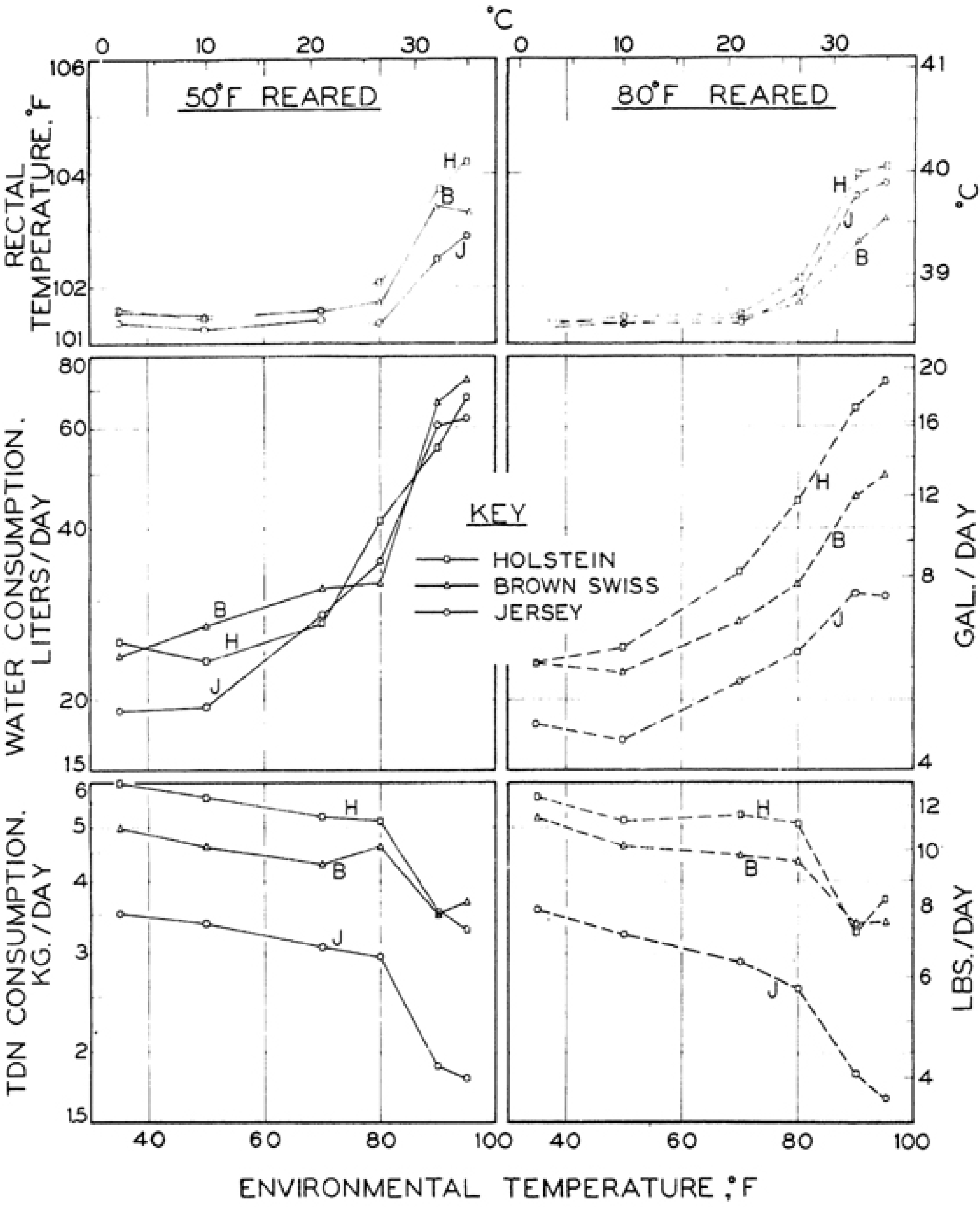

Fig. 1—TDN consumption, water consumption, and rectal temperature of heifers vs. increasing environmental temperature. Data on rectal temperatures from H. H. Kibler (1960).

their water consumption from approximately 6 to 18 gallons; and the Brown Swiss consumption rose from approximately 7 to 20 gallons. The increases of the 80° F reared Holsteins, Brown Swiss, and Jerseys, respectively, were 7, 12, and 3 gallons per heifer per day. The greatest quantity of water drunk by the 50° F reared heifers was that of the Brown Swiss, followed by that of the Holsteins and the Jerseys in that order.

With respect to heifers raised at 80° F, the Brown Swiss consumed the most water, the Holsteins an intermediate amount, and the Jerseys consumed the least. Breed differences in response to rising environmental temperatures were statistically significant at the 0.01 level of probability.

Rectal Temperatures: Fig. 1 also depicts the average rectal temperatures of each breed (raised at each temperature) vs. rising environmental temperature. For more information see Kibler (1962). The rectal temperatures of both groups increased at about 70° F environmental temperature and were significantly ($<$ 01) affected by rising temperature. Among the 50° F reared heifers, the Holsteins showed the greatest rise in rectal temperature, i.e., 2.6° F as the environmental temperature progressed from 35° to 95° F. They were followed by the Brown Swiss with a rise of 1.7° F and the Jerseys with an increase of 1.5°. The increases of the 80° F reared heifers were similar. They were 2.7°, 1.7°, and 2.5°, for the Holsteins, Brown Swiss, and Jerseys, respectively.

It was of interest to observe that while the 50° F reared Holsteins and Brown Swiss appeared to be affected more by the high temperatures than the corresponding 80° F reared animals, rectal temperature of the 50° F reared Jerseys rose less than that of the 80° F reared Jerseys. Perhaps the excessive water consumption of the Jerseys (particularly #633) allowed greater regulation of rectal temperatures (Table 5). However, these effects due to temperature acclimation and/or genetic variability were not significantly different. These will be discussed in more detail later.

Effects of acclimation at 50° and 80° F on TDN and water consumption at rising evironmental temperatures: The effect of acclimation temperatures on the feed and water responses at rising environmental temperatures may also be observed in Figure 1. The 80° F reared Jerseys, which reduced their TDN consumption (Fig.1) by the greatest amount, consumed slightly less TDN than the 50° F reared Jerseys throughout the range of temperatures. The 80° F reared Holsteins consumed less until they reached 90° F, but they consumed more than the 50° F reared Holsteins when the temperature was raised to 95° F. The 80° F reared Brown Swiss, on the other hand, consumed more than the 50° F reared Brown Swiss up to 80° F. Thereafter, the 50° F reared Brown Swiss consumed more. Generally, as shown by the all-breed averages, acclimation temperature had little effect on TDN responses to increasing temperature; the apparently greater TDN consumption of the 50° F reared heifers above that of 80° F reared heifers was not significant.

There are some apparent acclimation differences in water consumption. The "all-breed" average showed a higher value for the 50° F reared animals than for those reared at 80° F. This difference may be largely due to the influence of the greater average consumption of the 50° F reared than of the 80° F reared Jerseys. In fact, one Jersey animal displayed an unusual ability to drink water.

"J-633" Water Consumption and Urinary Excretion. "J-633", similar to J-212, which was in the laboratory several years ago, (Ragsdale, et al., 1950), displayed unusual drinking behavior. Figure 2 shows J-633 to have an approximately three-fold greater water intake than other Jerseys under the same conditions throughout the temperature series (Table 6). Furthermore, on exposure to higher temperatures (above 80° F), J-633 increased her water intake more sharply than did the other two Jerseys. Tables 6 and 7 show individual values for all breeds at the various temperatures.

Urinary volumes tended to parallel water consumption in J-633. Again the urinary value differed markedly from that of other heifers at temperatures above 80° F. These differences in values may possibly be due to lesser amounts of anti-diuretic hormone (ADH) in the blood of J-633. Data by Kamal et al. (1959) showed ADH to inhibit urine flow and water intake following injection. The specific gravity of the urine was considerably less for J-633 than for the other heifers though all heifers showed decline with rising environmental temperature.

Ratios of water intake to urine output for J-633 were 8:1 and 3.3:1 at 50° and 90° F, respectively, whereas similar values for J-636 were 3.3 and 4.6. These values re-emphasize the greater desire of J-633 to drink at the cooler temperature; however, the urine volumes seem rather low for J-633 at the lower temperatures. The increase in the urine volume at 70° F which precedes the increase in water intake at 80° F for J-633 suggests a possible temperature depression of the anti-diurectic hormone.

Average rectal temperatures at 80° F and above for J-633 were 101.8° F, compared to other Jersey animals which averaged 102.5° F, which suggested the possibility of greater heat tolerance due to the greater rate of urination by J-633 (For individual rectal temperatures see Kibler, 1962)

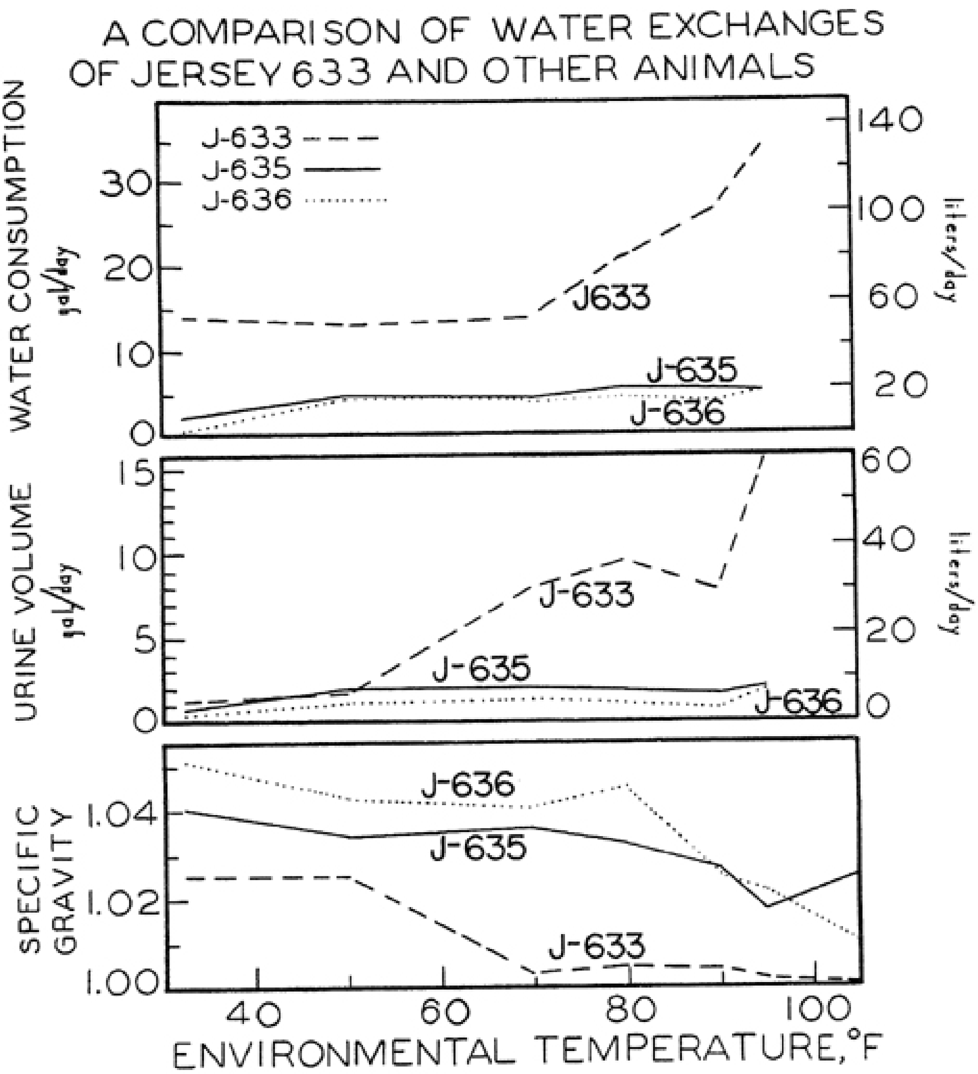

Fig. 2—A comparison of water exchange of Jersey 633 and other animals. Individual data at each temperature were obtained as one day measurements of water intake as recorded when each animal was offered water 3 times daily. Urine volumes were collected during one day of each temperature period. Other water data in the bulletin are based on group measures.

Estimation of Water Balance at Various Environmental Temperatures. Since little information is available regarding water balance of non-lactating cattle under controlled environmental conditions, it was considered desirable to accumulate all available data on these animals for an estimation of water balance. All sources of water intake and output were measured except feces-water. These values were obtained by difference and also based on the assumption that the animal was in water balance. Data are shown in Table 9.

Feed-water, estimated from dry matter values of feed, declined with rising environmental temperatures due to lowered feed intakes. Water consumption increased dramatically as shown earlier. Metabolic water decreased at higher temperatures due to declining levels of oxygen consumption (Kibler, 1962). Thus total intake values approximately doubled for all breeds from 35° to 95° F. Total vaporization (respiratory and surface) as measured by the tent method (Yeck, 1960) increased with rising temperatures as did the urine volumes. (24-hour urine volumes were obtained by external catheters fastened to the animals.)

Based on indirect estimations, the feces-H_20 is, for example, approximately 80 percent of total intake for Brown Swiss at 35° F and only approximately 40 percent at 95° F. Values are similar for other breeds at these temperatures. The increased water content of feces at the higher environmental temperatures is in general agreement with data of Rhoad (1940). These data are generally in agreement with those of Schmidt-Nielsen (1962) and suggest that the cow lacks conservation of either urine-H_2O or feces-H_2O, which is desirable for hot arid zones.

FEED AND WATER CONSUMPTION PER UNIT BODY WEIGHT

Water Consumption: The Jerseys, which are relatively light in body weight and high in proportion of surface area to body weight, theoretically, should be the more heat tolerant animals. Yet when they have been acclimated to the environmental temperature of 50° F, they have consumed much more water per unit body weight than the other two breeds with rising evnironmental temperature (Fig. 3). Again, as shown previously in Fig. 2, the unusual J-633 has greatly influenced the interpretation of this 50° F reared Jersey ratio. The values (gal/lb body weight) of the Holsteins were of intermediate magnitude, and those of the Brown Swiss were the lowest. At each temperature of the rising series, the water to body weight ratios of the Brown Swiss heifers raised at 50° F were higher than the ratios of the corresponding heifers raised at 80° F. The Holsteins raised at 80° F displayed higher ratios than those of the Brown Swiss and Jerseys after the environmental temperature of 70° F had been reached. The magnitude of these ratios was principally influenced by the relatively low body weights of the 80° F reared Holsteins.

At 80° F, the Holstein ratio was highest, the Jersey one was intermediate, and that of the Brown Swiss was the lowest. The Brown

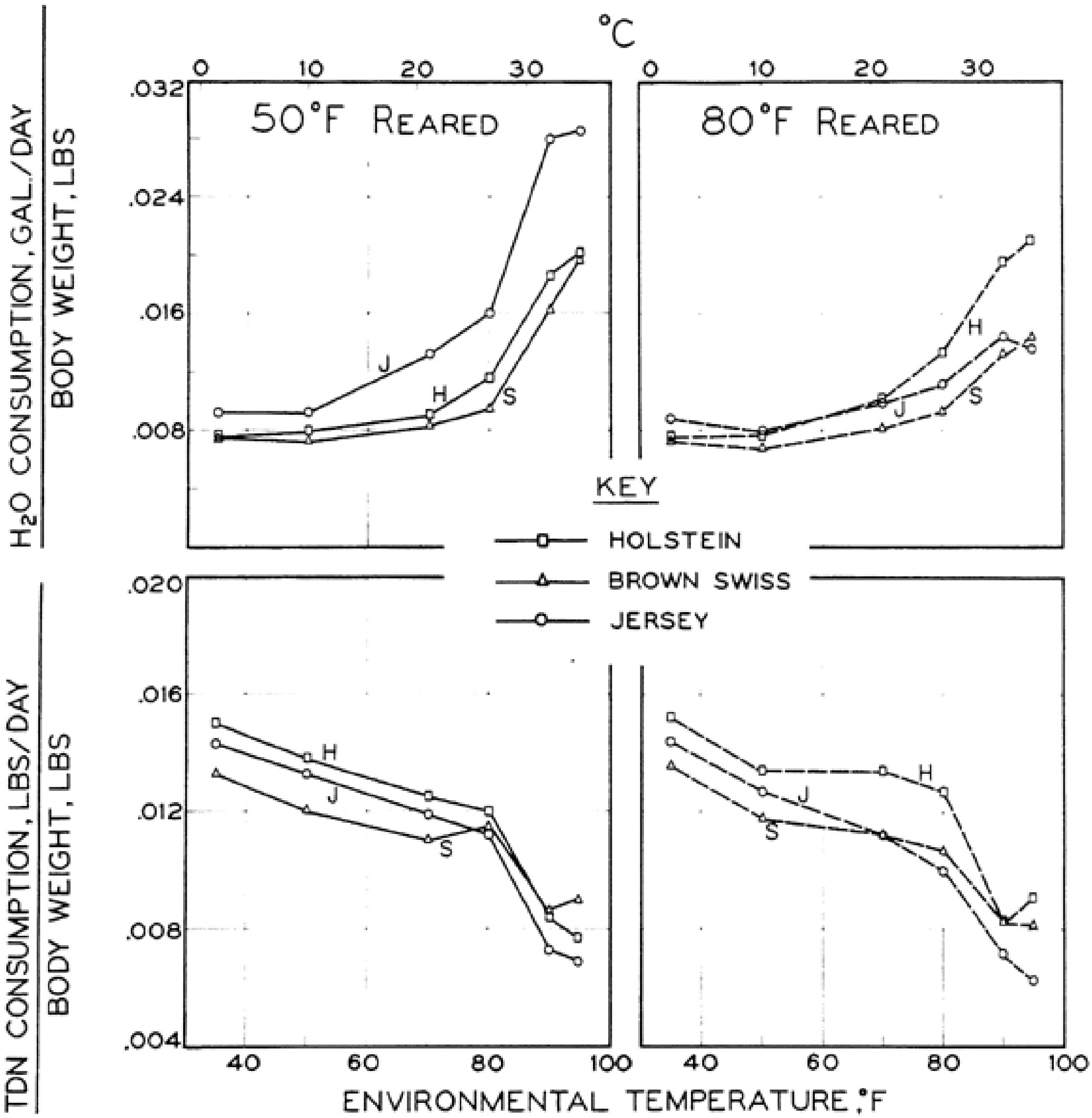

Fig. 3—The influence of increasing environmental temperatures on the ratios of TDN and water consumption to weight in heifers raised at 50° F and 80° F.

Swiss appeared to be most capable of acclimation, if a low ratio of water consumption to body weight can be regarded as a reflection of greater heat tolerance.

TDN Consumption: Without exception, the amount (lbs) of TDN consumed per unit (lbs) body weight decreased as environmental temperature increased. The animals raised at 50° F showed continuous declines, with the greatest drop occurring between 80° F. and 90° F, but the 80° F reared animals, i.e., Holstein and Brown Swiss, exhibited a plateau between 50° and 70° F, with their greatest declines also occurring between 80° and 90° F. At both temperatures the Holsteins displayed the highest ratios; they were followed by the Jerseys and Brown Swiss, in that order, until the environmental temperature exceeded 70° F, after which the Brown Swiss and Jerseys reversed their positions.

Apparently, the relatively greater drop in the Holstein and Jersey ratios as compared to that of the Brown Swiss was caused by the similar decrease in the Holstein and Jersey TDN consumption; while the Jerseys and Holsteins decreased their TDN fairly rapidly, the Brown Swiss decreased theirs somewhat more slowly. That is, the Brown Swiss at both temperatures reduced their TDN consumption per unit weight at a lesser rate than did the Jerseys or Holsteins. Although absolute differences were very small, the 80° F reared Holsteins and Jerseys showed slightly higher ratios than the 50° F reared animals, whereas, the 50° F reared Brown Swiss showed slightly higher ratios than their 80° F reared counterparts.

Ratio, Water Consumption (lbs) to TDN Consumption (lbs)

Figure 4 indicates that as the environmental temperature rose there was a marked increase in water consumption per unit TDN consumption. The elevation of the ratio began at about 70° F but showed its greatest increase from 80° to 90° F. Among the heifers acclimated at 50° F the pounds of water per pound TDN consumed rose for Holstein animals from 4.8 at 50° F to 22.0 at 95° F. For the same temperature interval, the Brown Swiss ratio rose from 5.1 to 18.3 and the Jerseys climbed from 5.7 to 34.2 pounds water per pound TDN. The 80° F reared animals displayed ratios of the same relative magnitudes until the environmental temperature exceeded 80° F, after which the Holstein, Jersey, and Brown Swiss ratios were high to low in order of magnitude. Water consumption per unit TDN increased to 14.4, 8.5, and 12.9 pounds for the 80° F-reared Holsteins, Brown Swiss, and Jerseys, respectively.

Again the Brown Swiss (both 50 reared and 80 F reared heifers) showed the lowest ratios of pounds of water/lb of feed at higher environmental temperatures (above 80° F). When considering only 80° F reared heifers at 90° and 95° F, the Holstein showed the highest ratios, Jerseys next, and Brown Swiss the lowest values. Water consumption expressed as a ratio to feed intake is a useful

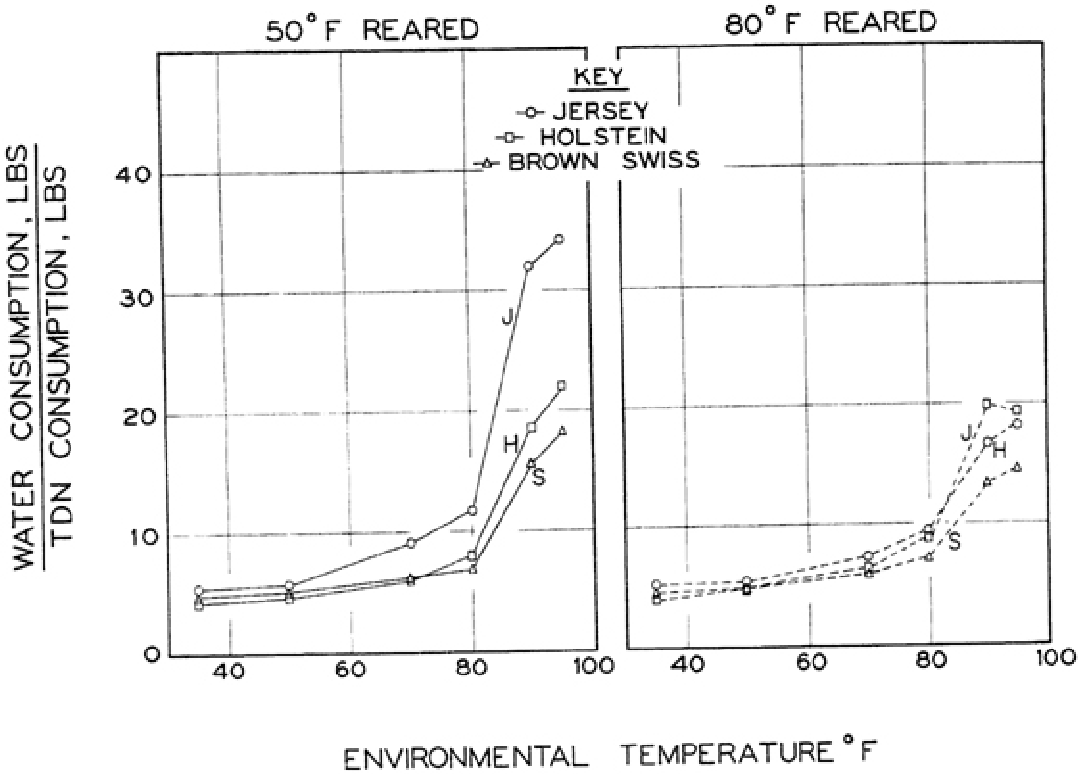

Fig. 4—Ratio of pounds of water consumed to pounds of TDN consumed as influenced by increasing environmental temperatures.

expression since it may logically contribute to the expression of degree of heat stress in animals.

Diurnal Trends in Water Consumption. Whether raised at 50° or 80° F, all breeds increased both day and night water consumption as the environmental temperature rose (Fig. 5). As the environmental temperature increased from 35° to 95° F, the difference between day and night water consumption decreased from a factor of approximately five to a factor of about two. Day water consumption was invariably greater than night consumption. The sharpest rises, day and night, occurred at a temperature above 70° F. Probably the most significant contribution here is that day consumption in all breeds increased only two to three times; whereas night consumption rose six to seven times from 35° to 95° F.

Heifers raised at 50° F exhibited greater percentage increases both day and night than the 80° F heifers. In descending order of magnitude, the day and night consumption was Holstein, Brown Swiss, then Jersey. This increase in night frequency and volume at higher temperature reflected the apparent necessity of the heifers to drink more at night to allay the distressing environmental temperature.

Diurnal Trends in Frequency of Drink. The number of drinks taken by the animals was recorded automatically. The monthly averages (derived from daily records) were plotted on a semi-logarithmic grid and are presented in Figure 5. The 50° F reared and 80° F reared Holsteins, Brown Swiss, and Jerseys all went from high to low, in the frequency of day drinking from 50° through 90° F. At night, however, the heifers acclimated at 50° F displayed an order of drinking frequency which differed from that of the 80° F reared heifers. Among the heifers raised at 50° F, the Holsteins drank most frequently; the Brown Swiss had the lowest frequency above 70° F. Below 70° F the positions of the Brown Swiss and the Jerseys were reversed. Among the 80° F reared heifers, the Holsteins again displayed the highest freqnency, but the Jerseys followed in order of magnitude until an environmental temperature of 80° F was reached after which their frequency was exceeded by that of the Brown Swiss.

Day frequency was invariably higher than night frequency for all breeds regardless of acclimation temperature. Interesting, however, the rate of increase in night frequency after the environmental temperature rose to 70° F was greater for the 50° F reared heifers (with the exception of the Holsteins) than for the 80° F heifers. As the environmental temperature rose, the similarity between day and night frequencv increased.

The frequency of drinks, both night and day, increased with rises in environmental temperature for all three breeds in each acclimation group. The most impressive daytime increases occurred above 70° F, and the 80° F reared Holsteins and Brown Swiss heifers showed a slightly steeper rise than the corresponding 50° F heifers. With respect to the frequency of night drinking, sharp rises began at 70° F for the 50° F reared heifers and at 50° F for the heifers reared at 80° F. Between 70° and 95° F, the 50° F reared heifers increased their frequency two to three-fold, and between 50° and 95° F, the 80° F reared heifers increased theirs similarly.

Phase II. Responses of Small Calves to Rising Environmental Temperature

Results. Figures 6 and 7 provide a comparison of small calves to heifers of the same breeds at similar ambient temperature. (Tabular data are in Tables 10 and 11). Water consumption of Brown Swiss small calves was generally lower than that of the other breeds at both ages.

TDN consumption patterns at the various temperatures were similar for both age groups. Holstein calves had the highest TDN consumption/unit weight and Brown Swiss the lowest. Rectal temperatures (Table 4) of the two age groups also showed the same breed relations. For example, the Holsteins at two months and one year displayed higher body temperatures and higher TDN intakes per unit body weight.

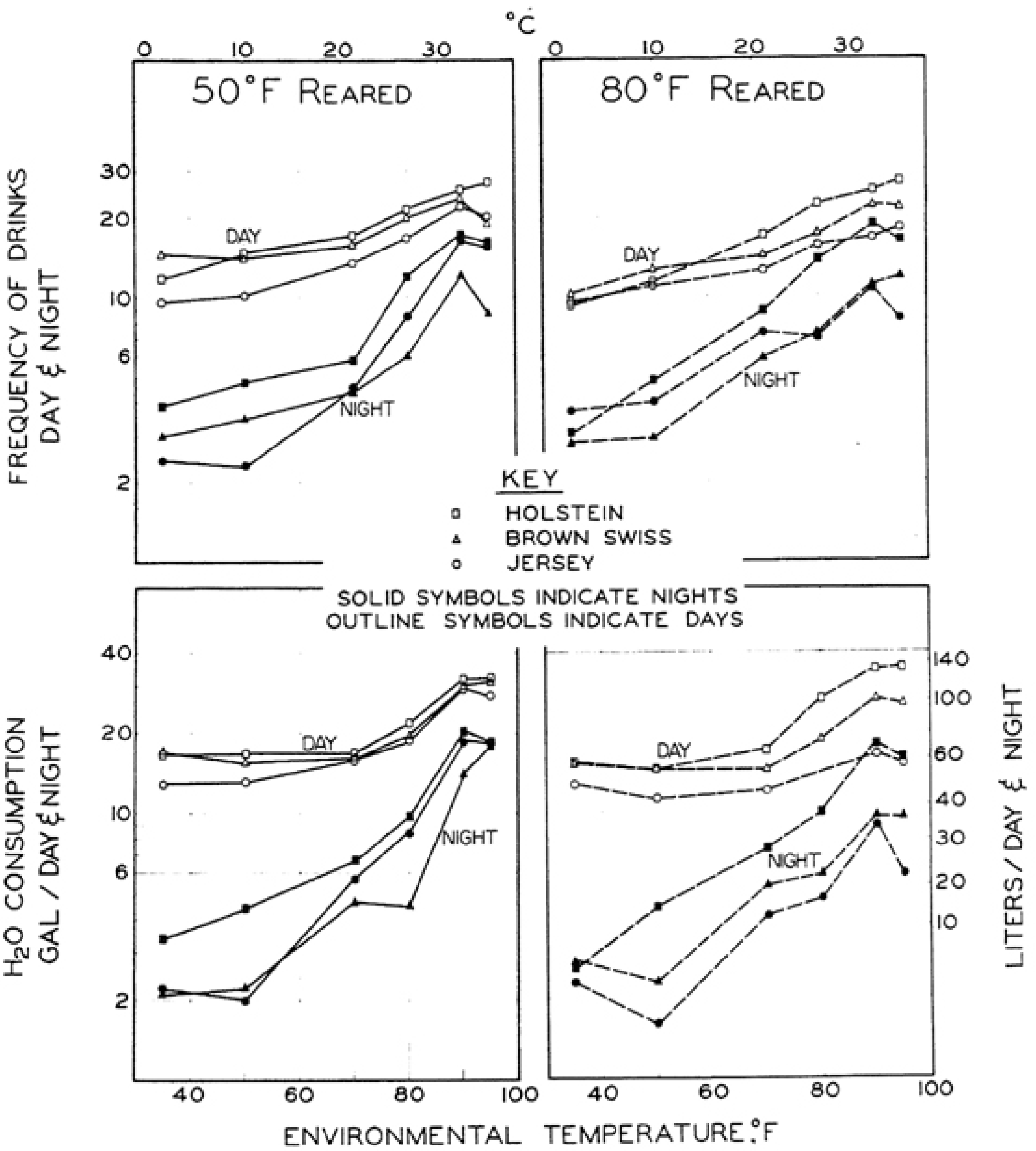

Fig. 5—Effects of environmental temperatures on frequency and volume of water consumption of heifers.

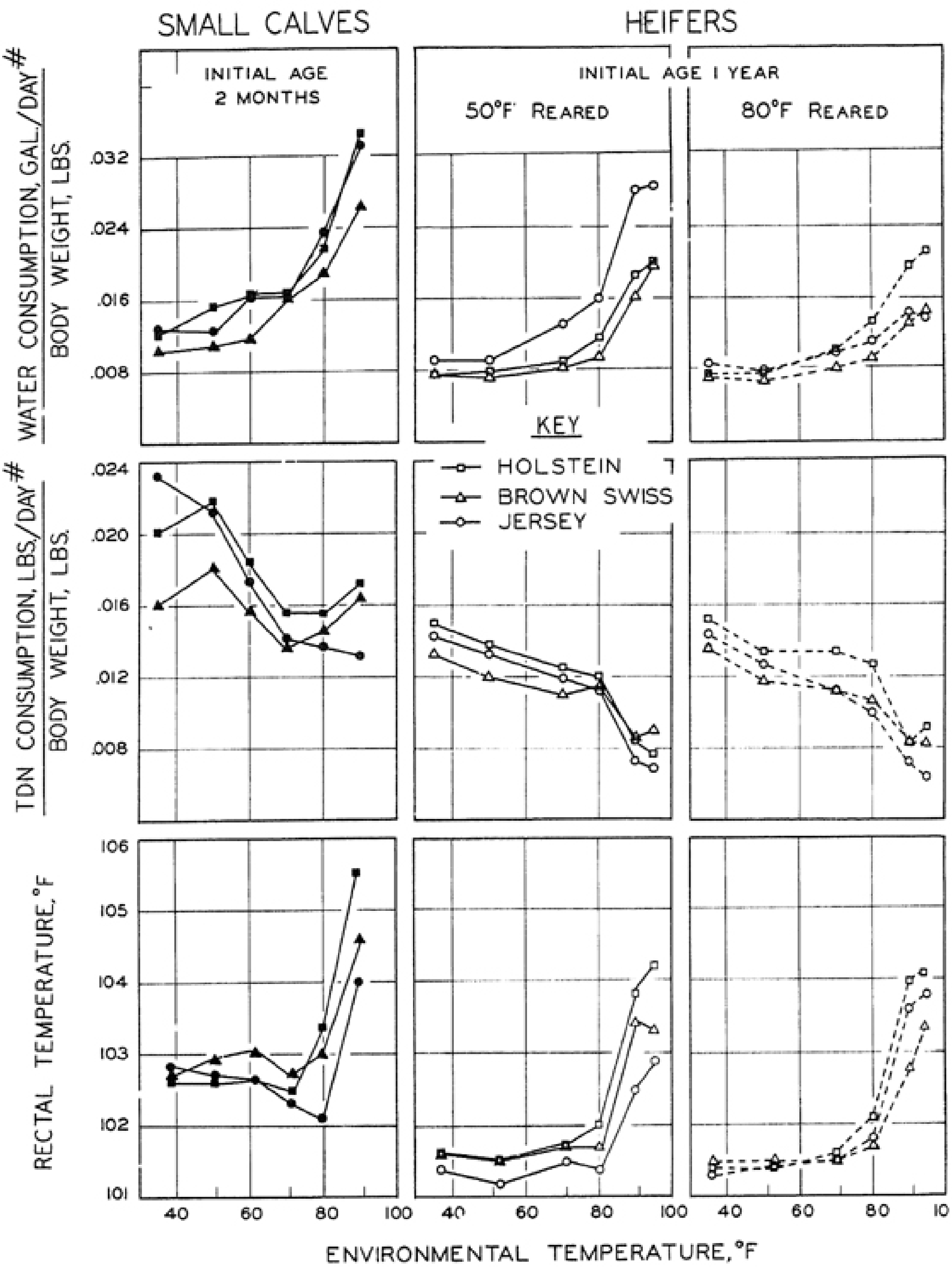

Fig. 6—Comparison of the responses of Holstein, Brown Swiss, and Jersey calves and heifers to rising environmental temperatures.

#Refers to small calf correction values for increased TDN and Water Consumption values due to growth during the experimental procedure. Data on heifers and calves raised at 50° F (Figs. 6 & 7 of Environ. Physiol. Series, Res. Bul. 786) were used as a normal or standard. Data at 35°F for the small calves were plotted on the Figs. 6 and 8 and the exponents of Figs. 6 and 8 were used to predict the increase in TDN and Water Consumption due to increase in body weight rather than environmental temperature. The small calves (3 of each breed) were exposed for 7 days at each temperature. The heifers (3 of each breed) were exposed for 21 days as 35°F, 5 days at 95°F, and 14 days at each of the other temperature conditions.

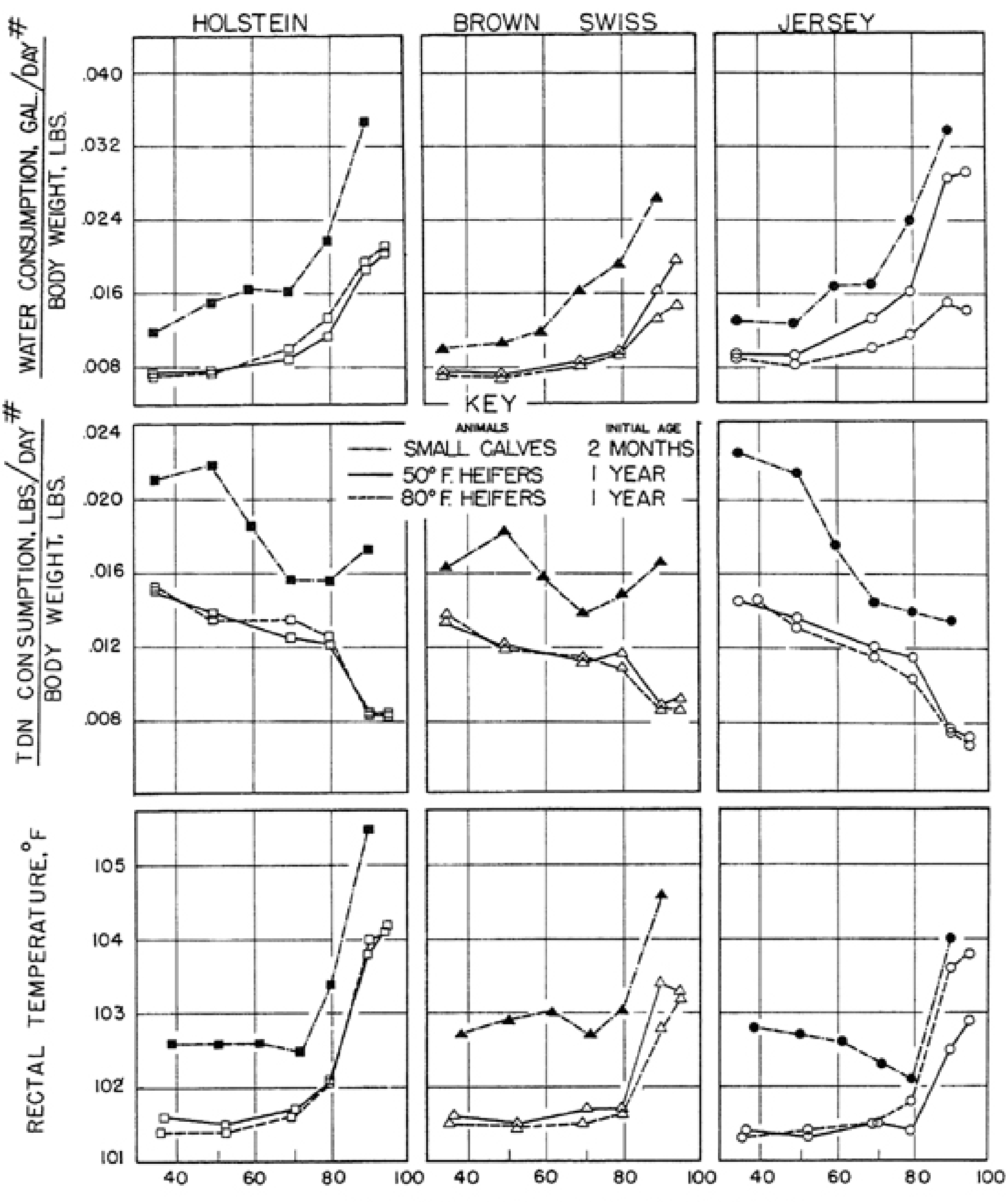

Fig. 7—Comparison of age effects on the responses of Holstein, Brown Swiss, and Jersey heifers and calves to rising environmental temperatures. (See Fig. 6)

An important observation is that, regardless of body size (age), at higher ambient temperatures the Holstein calves tend to have a higher body temperature and TDN intake, relatively speaking, than the other breeds. Figure 7 shows the same data but is plotted so an age comparison is graphically clear.

For water consumption and feed intake/unit weight and rectal temperatures, the calves displayed higher values at all temperatures.

The relative rate of increase in these measurements with rising temperatures is similar for both age groups.

These data emphasize the need to consider the age when making comparisons of heat tolerance. For example, is a Holstein calf more heat intolerant than a Holstein heifer at 90° F? They show about the same relative increases with rising temperature, which suggests the heat tolerance is similar, but we do not know that the small calves can tolerate a 1 1/2° F higher rectal temperature safely (See Fig. 7 and Table 4).

Comparison of Small Calves to Heifers. Tables 12 and 13 provide comparative response values of two-month old calves, the 50° F reared heifers, and the 80° F reared heifers of each breed. Differences in water consumption/unit body weight in temperature range of 35° -70° F are presented. These changes are also expressed per °F rise in environmental temperature. The same presentations are made for the environmental temperature range of 70°-90° F. In Table 13 the differences of water intake per °F change in rectal temperature are shown for each group of animals at the 35°-70° F and 70°-90° F environmental temperature ranges. Increase in water intake/body weight was greater in calves at the temperature range of 35°-70° F than in heifers.

Generally speaking, between 70° and 90° F small calves increased water consumption at a greater rate with respect to increasing environmental temperature or body temperature than animals raised at 50° or 80° F.

The small calves usually increased water consumption more per unit weight than the heifers. (Water consumption corrected for growth and milk intake.)

Changes in rectal temperature at the 70°- 95° F range was greater in calves than in heifers. Also, the changes in H_2O intake/ F rise in rectal temperature were higher for small calves, with the exception of 50° F reared Jersey and Brown Swiss.

The small calves did not decrease their TDN intake per °F rise in rectal or environmental temperature as much as heifers at the temperature range of 70-95° F.

Ability to eat at the higher environmental temperatures was about the same for 50 F reared and 80° F reared heifers; however, the rate of decrease in TDN was slightly higher for the 50° F reared heifers (Table 12).

DISCUSSION

These data are in agreement with work reported earlier by Ragsdale et al. (1951) on responses of lactating Brown Swiss and dry Brahman cattle. They concluded "the decline in water consumption with rising temperature in the milking Brown Swiss was caused by their decline in milk production; and if these Brown Swiss had been dry they would probably not have declined in water consumption with rising temperature."

In this study, above 80° F the water consumption of the 50° F reared heifers increased at a greater rate than that of the 80° F reared Brown Swiss and Holsteins, using greater water intake as a reflection of heat stress. The 50° F reared Jersey values were so strongly influenced by J-633, a heifer with an unusual (perhaps inherited) capacity to drink larger quantities of water at all conditions, that this interpretation would not apply .

A relatively low TDN consumption per unit weight (Fig. 3) at temperatures below 80° F) may suggest the desirability of a certain breed for hot climates. A greater TDN intake/unit body weight (or a less relative decline above 80° F) is a desirable expression of heat tolerance for animals of agricultural importance. The Brown Swiss did well in this regard.

Figure 4, showing the ratio of water to TDN consumption vs. temperature, expresses the rising trend with rising temperature--similar to data presented earlier by Ragsdale et al. (1951) and Winchester (1956) on European and Indian cattle. It is of particular importance to observe that, above 70° F, the Brown Swiss heifers require less water per pound of feed than either the Jerseys or Holsteins.

It seems the relative rate of change of the ratio of water intake to feed intake above 80° F may give a fairly clear picture of an animal's state of stress. For example, one may observe in the 80° F reared heifers the greater rate of increase in water intake for the Holstein (relatively more stressed) than for the Brown Swiss or Jersey. This would, in all probability, occur in the 50° F-reared heifers if J-633 values were not included. With rising environmental temperatures the 50° F reared heifers increased their night water consumption tenfold while the 80° F reared heifers increased at least threefold compared to only an unimpressive increase of day consumption. Does this suggest that some heat stress factor overcomes the diurnal rhythm at higher temperatures or, more probably, that the cattle are forced to work (drink) at a nearly constant rate for 24 hours a day to prevent serious dehydration? This is an important reaction and should be observed closely in future diurnal rhythm studies.

The age comparisons of small calves and heifers provide needed information for development of concepts regarding heat tolerance, age, and size relationships.

SUMMARY

Data are presented to show the effects of one year's acclimation to two fixed environmental temperatures (one group raised at 50 and the other at 80° F) on the responses of yearling Brown Swiss, Holstein, and Jersey heifers when they are exposed to environmental temperatures ranging from 35° to 95° F. Regardless of temperature level at which they were raised, or the breed, TDN consumption showed a significant decline as the temperature was increased and water consumption showed a significant increase as the temperature increased. Breed differences were significant at the 0.01 level of probability in respect to both TDN and water consumption. The rectal temperatures of both groups began rising at 70° F environmental temperature and were significantly ($< .01$) affected by rising temperature. Acclimation temperature had little effect on TDN and water responses to increasing temperature. Water consumption vs. unit body weight increased with increased environment with all heifers regardless of breed and to a greater extent with the 50° F. acclimated group. Without exception, the amount of TDN consumed per unit/lb of body weight decreased as environmental temperatures increased. The Brown Swiss at both temperatures reduced their TDN consumption per unit weight at a lesser rate than did the Jerseys or Holsteins. For both groups, as environmental temperature rose there was a marked increase in water consumption required per unit of TDN consumption. Day water consumption in all breeds increased two to threefold. Night consumption rose six to seven times from 35° to 95° F with the increase greater for heifers reared at 50° F than for those reared at 80 F.

The frequency of drinks increased with each rise in environmental temperature for all three breeds in each acclimation condition, with day frequency invariably higher than night frequency.

Small calves subjected to a similar pattern of temperature change had higher values at all temperatures than the 50° and 80° F reared heifers. The TDN and water consumption and the rectal temperatures of the calves followed a pattern similar to that of the heifers and had the same breed relations, and similar rates of increase.

Numerous suggestions throughout the bulletin refer to possible acclimations of the animal raised at either 50° or 80° F. From an over-all view the ability acquired from growth at 50° or 80° F to tolerate either a relativly low or high (35° or 95° F) air temperature was not markedly different. However, this is not to say that the 50° or 80° F constant environmental temperature did not induce various physiological adjustments and growth responses in these growing animals (Johnson and Ragsdale, 1959), especially since Kamal et al., (1962) demonstrated some acclimation in various blood constituents.

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APPENDIX

TABLE 1 - COMPLETE RATION (GRAIN, MILK, ALFALFA HAY) FOR SMALL DAIRY CALVES
(Average Value for Each Temperature Condition)

		BROWN SWISS			HOLSTEIN			JERSEY		
°F.	Days at each Temp.	Grain Av./lbs./calf/day	Hay	Milk	Grain Av./lbs./calf/day	Hay	Milk	Grain Av./lbs./calf/day	Hay	Milk
35	6	.88	1.59	13.33	1.09	2.28	14.0	.75	1.56	10.0
50	8	.96	2.13	13.33	1.19	2.36	14.0	.69	1.84	10.0
60	5	1.17	2.20	12.73	1.33	2.28	14.0	.83	1.70	10.0
70	7	1.50	2.65	12.88	1.67	2.68	14.0	1.17	2.03	10.0
80	7	1.50	3.56	13.33	1.67	3.17	14.0	1.17	2.45	10.0
90	7	2.52	3.02	13.33	2.53	2.21	14.0	1.88	1.78	10.0
50	9	2.78	3.79	13.78	2.78	3.16	14.0	2.04	2.36	12.1

TABLE 2 - TDN CONSUMPTION AND BODY WEIGHT OF BROWN SWISS, HOLSTEIN AND JERSEY HEIFERS REARED AT CONSTANT ENVIRONMENTAL TEMPERATURES OF 50°F AND 80°F AT RISING ENVIRONMENTAL TEMPERATURES.

°F Temp.	50°F			80°F		
	Brown Swiss	Holstein	Jersey	Brown Swiss	Holstein	Jersey
	TDN Consumption (lbs/heifer/day)					
35	10.95	13.13	7.74	11.43	12.44	7.87
50	10.15	12.42	7.42	10.18	11.29	7.11
70	9.46	11.49	6.77	9.81	11.53	6.38
80	10.19	11.29	6.48	9.57	11.13	5.71
90	7.79	7.83	4.17	7.44	7.17	4.04
95	8.13	7.27	3.97	7.46	8.18	3.67
	Body Weight (lbs)					
35	819.2	871.9	537.9	839.5	814.2	546.3
50	840.8	895.7	555.1	858.9	840.6	558.6
70	857.6	914.2	565.7	875.2	858.0	568.3
80	883.6	935.0	573.6	889.1	870.4	568.3
90	895.5	936.3	568.3	895.5	867.7	560.4
95	903.3	934.6	573.7	894.7	879.7	572.3

TABLE 3 - WATER CONSUMPTION OF BROWN SWISS, HOLSTEIN, AND JERSEY HEIFERS AT RISING ENVIRONMENTAL TEMPERATURES OF 35° F to 95° F.

TEMP. °F	50° F Heifers (Gal./Heifer/Day)			80° F Heifers (Gal./Heifer/Day)		
	BROWN SWISS	HOLSTEIN	JERSEY	BROWN SWISS	HOLSTEIN	JERSEY
35	6.8	6.3	5.03	6.16	6.15	4.81
50	7.1	6.2	5.12	6.53	5.88	4.49
70	8.3	7.2	7.43	8.81	7.25	5.67
80	10.9	8.4	9.23	11.75	8.42	6.38
90	17.5	14.6	16.02	17.13	11.98	8.12
95	19.2	17.8	16.3	18.8	13.1	8.0

*Gallons x 8.337 = lbs.

TABLE 4 - RECTAL TEMPERATURE °F OF DAIRY HEIFERS AT RISING ENVIRONMENTAL TEMPERATURES*

(Heifers 1 Year of Age)

	50°F. Reared			80°F. Reared		
°F.	BROWN SWISS	HOLSTEIN	JERSEY	BROWN SWISS	HOLSTEIN	JERSEY
35	101.6	101.6	101.4	101.5	101.4	101.3
50	101.5	101.5	101.3	101.5	101.4	101.4
70	101.7	101.7	101.5	101.5	101.6	101.5
80	101.7	102.1	101.4	101.7	102.1	101.8
90	103.4	103.8	102.5	102.8	104.0	103.6
95	103.3	104.2	102.9	103.2	104.1	103.8

Small Dairy Calves 2 Months of Age

°F.	BROWN SWISS	HOLSTEIN	JERSEY
35	102.7	102.6	102.8
50	102.9	102.6	102.7
60	103.0	102.6	102.6
70	102.7	102.5	102.3
80	103.0	103.4	102.1
90	104.6	105.5	104.0

*(Kibler, H. H., 1962)

TABLE 5 - TESTS OF VARIANCE ANALYSIS FOR ALL DATA AT 50° TO 95° F

TDN Consumption of the Three Breeds (Brown Swiss, Holstein, Jersey)

Variation	d.f.	Sum of Squares	Variance	F	p
Between breeds	2	1733.4174	866.7087	334.6105	.01
Within breeds	447	1157.8209	2.5902		
Total	449	2891.2383			

TDN Consumption of the 50°F and 80°F-Acclimated Heifers

Variation	d.f.	Sum of Squares	Variance	F	p
Between chambers	1	8.0003	8.0003	1.2430	ns
Within chambers	448	2883.2899	6.4359		
Total	449	2891.2092			

TDN Consumption at Rising Environmental Temperatures

Variation	d.f.	Sum of Squares	Variance	F	p
Between temperatures	4	817.4023	204.3505	43.8480	.01
Within temperatures	445	2073.8879	4.6604		
Total	449	2891.2902			

Water Consumption of the Three Breeds (Brown Swiss, Holstein, Jersey)

Variation	d.f.	Sum of Squares	Variance	F	p
Between breeds	2	538.0011	269.0000	18.0167	.01
Within breeds	444	6629.2014	14.9300		
Total	446	7167.2024			

Water Consumption of the 50°F and 80°F-Acclimated Heifers

Variation	d.f.	Sum of Squares	Variance	F	p
Between chambers	1	231.8001	231.8001	14.8731	.01
Within chambers	445	6935.4023	15.5851		
Total	446	9246.2024			

Water Consumption at Rising Environmental Temperatures

Variation	d.f.	Sum of Squares	Variance	F	p
Between temperatures	5	4187.8400	837.4000	123.9754	.01
Within temperatures	441	2979.3624	6.7559		
Total	446	6985.2024			

TABLE 6 - BREED AND TEMPERATURE COMPARISON OF WATER EXCHANGES OF 50°F REARED ANIMALS WITH SPECIAL REFERENCE TO JERSEY 633

	Temp. °F						
	35	50	70	80	90	95	105***
	Date 1957 - 58						
	11/5	11/19	12/3	12/17	12/31	1/16	2/12
Calf No.			Water Intake, liters/day*				
J - 633	54.09	49.92	52.72	79.99	101.81	129.53	
J - 635	8.64	18.18	16.59	21.82	20.45	19.99	
J - 636	2.73	16.82	15.23	15.91	14.99	19.99	
H - 845	17.27	22.50	31.36	31.82	34.54	37.27	
H - 847	15.91	22.27	24.77	28.18	29.54	30.00	
H - 848	59.09		35.91	74.99	72.27	89.50	
B.S. - 17	12.27	20.00	24.09	33.63	45.45	59.54	
B.S. - 18	8.64	21.36	24.09	28.18	37.72	52.27	
B.S. - 23	44.09		43.18	36.36	45.45	42.72	
			Urine Volume, liters/day				
J - 633	4.92	6.42	30.34	36.19	29.88	58.95	3.05
J - 635	3.32	7.72	7.72	7.04	5.98	7.73	.80
J - 636	1.99	4.57	5.06	3.91	3.10	7.69	1.04
H - 845	4.59	8.64	8.63	8.39	33.94	24.43	2.35
H - 847	3.68	6.72	6.07	6.34	14.77	14.63	7.34
H - 848	4.22	5.88	9.33	31.57	20.01	41.65	1.78
B.S. - 17	2.61	6.98	6.82	7.97	19.84	33.05	2.48
B.S. - 18	4.19	5.75	7.44	6.91	15.72	21.99	2.16
B.S. - 23	4.64	10.29	11.21	10.57	24.51	13.10	
			Urine, Specific Gravity **				
J - 633	1.0254	1.0257	1.0037	1.0048	1.0040	1.0023	1.0012
J - 635	1.0403	1.0342	1.0360	1.0322	1.0265	1.0173	1.0250
J - 636	1.0512	1.0427	1.0405	1.0449	1.0249	1.0219	1.0102
H - 845	1.0395	1.0391	1.0370	1.0298	1.0004	1.0138	1.0057
H - 847	1.0418	1.0496	1.0477	1.0387	1.0093	1.0160	1.0033
H - 848	1.0444	1.0447	1.0433	1.0078	1.0040	1.0050	1.0229
B.S. - 17	1.0441	1.0419	1.0467	1.0416	1.0079	1.0110	1.0093
B.S. - 18	1.0404	1.0439	1.0390	1.0389	1.0121	1.0148	1.0090
B.S. - 23	1.0380	1.0342	1.0303	1.0321	1.0142	1.0235	

* Pounds converted to liters by multiplying times 0.4545

** Corrected to 15°C.

*** 4 hours collection of urine at 105°F; animals fasted 46 hours and temperatures were raised from 65°F to 105°F at 10 a.m.

TABLE 7 - BREED AND TEMPERATURE COMPARISON OF WATER EXCHANGES OF HEIFERS RAISED AT 80°F.

	Temp. °F						
	35	50	70	80	90	95	105***
	Date 1957 - 58						
	11/12	11/27	12/10	12/23	1/8	1/22	2/18
Calf No.	Water Consumption, liters/day*						
J - 631	25.91	22.27	24.09	40.90		23.18	
J - 634	21.36	16.82	15.00	18.63	20.91	20.23	
J - 637	14.54	20.00	20.00	10.45	15.68	17.27	
H - 846	20.45	19.09	29.77	28.18	38.86	33.63	
H - 849	24.09	30.00	27.72	33.63	36.81	36.13	
H - 850	36.81	37.27	17.73	72.27		88.63	
B.S. - 19	32.04	27.72	33.63	35.91	26.82	44.31	
B.S. - 20	24.54	22.27	16.36	31.36	21.36	27.72	
B.S. - 21	27.27	36.81	29.54	40.00		43.63	
	Urine, liters/day						
J - 631	6.57	7.24	6.74	8.83	14.57	17.13	.49
J - 634	3.48	6.36	5.89	4.62	9.96	7.63	1.40
J - 637	12.46	9.37	9.35	8.22	4.87	11.24	
H - 846	10.50	6.53	8.10	14.93	26.17	20.29	2.39
H - 849	12.15	7.40	8.16	10.66	18.90	4.94	1.90
H - 850	9.20	8.88	6.59	17.46	29.32	35.54	2.39
B.S. - 19	10.02	7.88	7.88	8.45	18.79	13.47	3.39
B.S. - 20	5.87	6.09	5.64	5.68	8.42	10.83	.54
B.S. - 21	10.05	5.66	5.25	4.81	4.59	3.94	.50
	Specific Gravity**						
J - 631	1.0377	1.0355	1.0312	1.0290	1.0136	1.0134	1.0137
J - 634	1.0470	1.0444	1.0430	1.0322	1.0042	1.0136	1.0050
J - 637	1.0220	1.0236	1.0210	1.0226	1.0262	1.0187	1.0187
H - 846	1.0394	1.0446	1.0378	1.0227	1.0092	1.0078	1.0075
H - 849	1.0376	1.0440	1.0416	1.0275	1.0102	1.0129	1.0047
H - 850	1.0380	1.0288	1.0353	1.0194	1.0077	1.0054	1.0070
B.S. - 19	1.0430	1.0382	1.0367	1.0301	1.0159	1.0126	1.0049
B.S. - 20	1.0460	1.0447	1.0483	1.0408	1.0257	1.0283	1.0248
B.S. - 21	1.0399	1.0445	1.0387	1.0386	1.0384	1.0383	1.0075

* Pounds converted to liters by multiplying time 0.4545

** Converted to 15°C.

*** 4 hours collection of urine at 105°F., heifers fasted 46 hours and temperatures were raised from 65°F to 105°F at 10 a.m.

TABLE 8 - DAY AND NIGHT WATER CONSUMPTION AND FREQUENCY OF DRINKS OF BROWN SWISS, HOLSTEIN, AND JERSEY HEIFERS AT RISING ENVIRONMENTAL TEMPERATURES OF 35°F TO 95°F*

°F	50°F						80°F					
Temp.	Brown Swiss		Holstein		Jersey		Brown Swiss		Holstein		Jersey	
	day	night	day	night	day	night	day	night	day	night	day	night
	Water Consumption (Gal/pen)											
35	16.9	2.1	16.8	3.4	12.9	2.2	15.1	2.8	15.4	2.6	11.8	2.3
50	15.6	2.4	16.9	4.4	13.1	2.0	14.5	2.3	14.5	4.4	11.3	1.6
70	16.1	4.7	16.9	6.7	16.0	5.7	14.5	5.3	17.1	7.3	11.5	4.1
80	19.8	4.5	22.0	9.8	18.8	8.5	18.7	5.8	25.9	9.9	14.0	4.7
90	30.1	14.0	32.2	20.5	29.5	18.7	26.8	9.6	34.9	18.3	16.5	8.9
95	30.7	17.9	32.2	18.6	27.8	18.2	25.7	9.0	35.0	16.0	15.2	5.8
	Frequency of Drinks (Av./pen)											
35	14.6	3.0	11.7	3.9	9.6	2.4	10.2	2.8	9.2	3.0	9.5	3.7
50	14.1	3.5	14.8	4.8	10.2	2.3	12.6	2.9	11.3	4.8	10.9	4.0
70	15.7	4.4	17.2	5.8	13.6	4.5	14.3	5.9	17.0	8.8	12.5	7.3
80	20.0	6.0	21.7	12.0	16.7	8.4	17.2	7.3	22.2	13.8	15.5	7.0
90	23.7	12.1	25.4	17.4	22.0	16.3	22.1	11.1	25.1	18.5	16.6	10.9
95	19.2	8.6	27.0	16.0	20.6	15.4	21.7	11.7	27.3	16.2	18.0	8.2

* Each value represents total values for 3 heifers of the same breed.

TABLE 9 - ESTIMATIONS OF WATER BALANCE AT VARIOUS ENVIRONMENTAL TEMPERATURES

	°F	Feed H_2O Kgm	Drink H_2O lit/day	Metabolic H_2O Kgm/day	Total	Vaporization lit/day	Urine H_2O lit/day	Total	Estimated Feces H_2O by Difference (In - Out)
	35	.54	23.8	2.61	26.96	4.07	3.39	7.46	19.50
	50	.50	23.2	2.45	26.15	6.02	6.85	12.87	13.28
	70	.46	27.0	2.22	29.69	6.93	7.61	14.54	15.15
50°F. Br. Swiss	80	.50	31.8	2.42	34.72	13.35	7.62	20.97	13.75
	90	.37	55.1	1.77	57.24	12.58	19.43	32.01	25.23
	95	.39	67.2	1.90	69.49	18.32	21.74	40.06	29.43
	35	.66	25.5	3.17	29.28	4.57	3.67	8.24	21.04
	50	.62	26.2	2.98	29.81	7.17	6.23	13.40	16.41
	70	.57	31.2	2.74	34.52	10.23	7.09	17.32	17.20
50°F Holstein	80	.56	41.0	2.70	44.27	14.66	14.40	29.06	15.21
	90	.38	66.1	1.81	68.29	11.92	22.61	34.53	35.76
	95	.35	72.4	1.67	74.42	18.36	26.04	44.40	30.02
	35	.38	19.0	1.84	21.23	2.69	3.06	5.75	15.48
	50	.37	19.3	1.78	21.45	3.46	5.68	9.14	12.31
	70	.33	28.0	1.60	29.93	5.61	13.34	18.95	10.98
50°F Jersey	80	.32	34.8	1.53	36.65	7.92	14.58	22.50	14.15
	90	.20	60.4	.99	61.59	7.65	12.37	20.02	41.57
	95	.18	61.6	.88	62.67	12.08	24.31	36.39	26.28

	35	.57	23.2	2.73	26.51	4.28	7.66	11.94	14.57
	50	.50	22.2	2.41	25.12	4.67	5.79	10.46	14.66
	70	.48	27.4	2.31	30.20	7.69	5.55	13.24	16.96
80°F Br. Swiss	80	.47	31.8	2.26	34.53	11.41	5.69	17.10	17.43
	90	.36	45.2	1.71	47.26	15.46	9.84	25.30	21.96
	95	.36	49.3	1.71	51.37	17.15	8.76	25.91	25.39
	35	.62	23.2	2.99	26.81	4.27	9.55	13.82	30.99
	50	.56	24.6	2.70	27.87	5.07	6.81	11.88	15.99
	70	.58	33.2	2.75	36.53	9.21	6.85	16.06	20.47
80°F Holstein	80	.55	44.3	2.66	47.52	11.47	13.47	24.94	22.58
	90	.34	64.6	1.65	66.59	15.09	24.21	39.30	27.29
	95	.40	71.1	1.90	73.40	14.55	19.78	34.33	39.07
	35	.39	18.1	1.88	20.37	3.12	6.78	9.30	11.07
	50	.35	16.9	1.69	18.94	2.90	6.95	9.68	9.26
	70	.31	21.4	1.50	23.22	6.70	6.71	13.41	9.81
80°F Jersey	80	.27	24.1	1.32	25.70	7.94	6.68	14.62	11.08
	90	.18	30.6	.90	31.68	8.99	9.41	15.67	16.01
	95	.17	30.3	.80	31.27	9.36	11.52	20.88	10.39

TABLE 10 - TDN CONSUMPTION PER CALF PER DAY AND CORRECTION VALUES AT RISING ENVIRONMENTAL TEMPERATURES FOR SMALL DAIRY CALVES

°F.	Body Weight Lbs.	TDN kg	Correction* kg	TDN* kg	TDN* Lbs.	TDN, Lbs.* Body Weight, 100 Lbs.
			BROWN SWISS			
35	161	1.18		1.18	2.60	1.61
50	162	1.33		1.33	2.93	1.81
60	174	1.39	.15	1.24	2.73	1.57
70	198	1.62	.40	1.22	2.69	1.36
80	205	1.84	.48	1.36	2.99	1.46
90	209	2.05	.50	1.55	3.42	1.64
			HOLSTEIN			
35	150	1.43		1.43	3.15	2.10
50	150	1.49		1.49	3.29	2.19
60	163	1.52	.15	1.37	3.20	1.85
70	189	1.72	.38	1.34	2.95	1.56
80	196	1.83	.45	1.38	3.04	1.55
90	191	1.90	.41	1.49	3.29	1.72
			JERSEY			
35	99	1.00		1.00	2.21	2.23
50	103	1.04	.05	.99	2.18	2.12
60	111	1.05	.17	.88	1.94	1.73
70	128	1.24	.42	.82	1.81	1.41
80	134	1.34	.51	.83	1.83	1.37
90	140	1.42	.58	.84	1.85	1.32

*Corrected TDN (Corrected from Dairy Calf Regression - 50°F. - reared animals. Res. Bul. 786)

TABLE 11 - WATER CONSUMPTION PER CALF PER DAY AND CORRECTION VALUES AT RISING ENVIRONMENTAL TEMPERATURES FOR SMALL DAIRY CALVES

°F.	Body Weight Lbs.	Total Water Intake	Correction* Gallon	Water Intake	Water, Gallon* Body Weight 100 Lbs.
			BROWN SWISS		
35	161	1.63		1.63	1.01
50	162	1.76	.03	1.73	1.07
60	174	2.24	.19	2.05	1.18
70	198	3.69	.50	3.19	1.61
80	205	4.49	.59	3.90	1.90
90	209	6.09	.61	5.48	2.62
			HOLSTEIN		
35	150	1.82		1.82	1.21
50	150	2.29		2.29	1.53
60	163	2.90	.19	2.71	1.66
70	189	3.57	.50	3.07	1.62
80	196	4.83	.55	4.28	2.18
90	191	7.13	.53	6.60	3.46
			JERSEY		
35	99	1.28		1.28	1.29
50	103	1.38	.08	1.30	1.26
60	111	2.06	.24	1.82	1.64
70	128	2.65	.55	2.10	1.64
80	134	3.84	.69	3.15	2.35
90	140	5.45	.79	4.66	3.33

*Corrected water (corrected from Dairy Calf regression on -50°F. - reared animals) (R. B. 786)

TABLE 12 - CHANGE IN TDN, LBS/BODY WEIGHT, 100 LBS/DEGREE (°F) RISE IN ENVIRONMENTAL TEMPERATURE

Temperature Differences		Brown Swiss			Holstein			Jersey		
		Small Dairy Calves	50°F Reared	80°F Reared	Small Dairy Calves	50°F Reared	80°F Reared	Small Dairy Calves	50°F Reared	80°F Reared
35°-70°F	Difference in TDN/B. Weight	-.250	-.230	-.240	-.540	-.250	-.180	-.820	-.240	-.320
	Change in TDN/Body Wt./°F.	-.007	-.007	-.007	-.015	-.007	-.005	-.023	-.007	-.009
70°-95°F*	Difference in TDN/B. Weight	+.280	-.200	-.290	+.160	-.480	-.420	-.090	-.500	-.480
	Change in TDN/Body Wt./°F.	+.014	-.008	-.012	-.008	-.019	-.017	-.005	-.020	-.019
Change in TDN, lbs/Body Weight, 100 lbs/Degree (°F) Rise in Rectal Temperature										
35°-70°F	Difference in Rectal Temp.		+0.1			+0.1	+0.2		+0.1	+0.2
	Change in TDN/°F Rise in R. Temp.		-2.3			-2.5	-0.9		-2.4	-1.6
70°-95°F*	Difference in Rectal Temp.	+1.9	+1.6	+1.7	+3.0	+2.5	+2.5	+1.7	+1.4	+2.3
	Change in TDN/°F Rise in R. Temp.	+0.15	-0.13	-0.17	+0.05	-0.19	-0.17	-0.05	-0.36	-0.21

*90°F in small dairy calves.

TABLE 13 - CHANGE IN WATER CONSUMPTION, GAL/BODY WEIGHT, 100 LBS/DEGREE (°F) RISE IN ENVIRONMENTAL TEMPERATURE

Temperature Differences		Brown Swiss			Holstein			Jersey		
		Small Dairy Calves	50°F Reared	80°F Reared	Small Dairy Calves	50°F Reared	80°F Reared	Small Dairy Calves	50°F Reared	80°F Reared
35°-70°F	Difference in H_2O/Body Weight	+0.60	+0.07	+0.09	+0.41	+0.13	+0.27	+0.35	+0.38	+0.11
	Change in H_2O/Body Wt./°F.	+0.017	+0.002	+0.003	+0.012	+0.004	+0.008	+0.010	+0.011	+0.003
70°-95°F*	Difference in H_2O/Body Weight	+1.01	+1.14	+0.64	+1.84	+1.15	+1.11	+1.69	+1.53	+0.40
	Change in H_2O/Body Wt./°F.	+0.051	+0.046	+0.026	+0.092	+0.046	+0.044	+0.085	+0.061	+0.016
	Change in Water Consumption, gal./Body Weight, 100 lbs./Degree (°F) Rise in Rectal Temperature									
35°-70°F	Difference in Rectal Temp.		+0.1			+0.1	+0.2		+0.1	+0.2
	Change in H_2O/°F. Rise Rect. Temp.		+0.7			+1.3	+1.35		+3.8	+0.55
70°-95°F*	Difference in Rectal Temp.	+1.9	+1.6	+1.7	+3.0	+2.5	+2.5	+1.7	+1.4	+2.3
	Change in H_2O/°F Rise Rect. Temp.	+0.53	+0.71	+0.38	+0.61	+0.46	+0.44	+0.99	+1.09	+0.17

*90°F in small dairy calves.