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Influence of Winter Housing Conditions on Growth Rates and Feed Consumption of Dairy Heifers

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INFLUENCE OF WINTER HOUSING CONDITIONS ON GROWTH RATES AND FEED CONSUMPTION OF DAIRY HEIFERS

BY

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This is to certify that, in accordance with the requirements of South Dakota State College for the Master of Science Degree, Mr. Emery Bartle has presented to this committee three bound copies of an acceptable thesis, done in the major field; and has satisfactorily passed a two-hour oral examination on the thesis, the major field, Dairy Husbandry, and the minor field, Poultry Husbandry.

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INTRODUCTION

It is important in dairy cattle management to maintain steady and continuous growth of heifers and thereby secure properly developed cows which will give the production that is expected of them when they are brought into the milking herd. In general, heifer calves during the first twelve months of their growing period are carefully managed as to feed, housing and care to promote normal growth. However, they are often neglected during their yearling stage to the point where growth is retarded because of environmental factors.

On many dairy farms in the North Central States the management of yearling dairy heifers in open outdoor sheds during the winter months has become a somewhat common practice. It is the concensus of many dairymen that managing heifers by this method has the advantage of growing larger size animals since they consume large quantities of feed. The costs of care and housing also are important factors, since labor can be reduced materially with the employment of mechanical methods and the housing requirements are kept at a minimum.

There is a lack of sufficient and conclusive data pertaining to some of the environmental conditions that affect growing heifers during the winter. To obtain additional information on this problem, a winter housing experiment was designed with two definite objects in mind. First: to ascertain whether dairy heifers housed in a cold barn will make as rapid growth and show as good physical condition as those housed in a warm barn, and second: to observe the feed consumption levels of the heifers housed in the two barns.

LITERATURE REVIEW

Early studies pertaining to problems of housing farm animals were conducted to determine costs and factors that influence growth, fattening and milk production. This review may readily be divided into two parts: one, studies in environment affecting beef cattle and two, those affecting dairy cattle.

Part I - Beef Cattle

Results of feeding and shelter studies conducted by Patrick and Smith (14) at the Iowa State College in 1889, showed that when steers were housed in a barn with temperatures from 37° to 49° F., the feed cost per pound of gain was 8.02 cents as compared to 10.22 cents for steers housed in a colder barn with a temperature range of 17° to 33° F. In 1895 at the Ohio Experiment Station, Thorne and Hickman (20) studied the effects of a warm barn vs. an open shed, in which the warm barn averaged 40° F. with a low of 10° F. and a high of 70° F., while the temperature in the open shed ranged from a low of 10° F. below zero to 60° F. While the results pertaining to the daily gain of animals in either group for two series of trials did not show any material difference, it was, however, observed that when temperatures fall below the zero point, there was a retardation in rate of gain even to the point where there were no gains until temperatures increased, even though the animals continued to eat on full feed. This same situation was also observed when abnormally high temperatures were reached.

Temperature influences on the fattening of steers were studied by

Mairs and Tomhave (13) at the Pennsylvania Experiment Station in 1908, in trials in which steers were selected as uniform as possible with respect to age, size, breeding, flesh and quality. They were divided into groups of 12 with one lot in closed box stalls and the other in an open shed. The steers in each group weighed about the same with a weight of 886.6 lb for the closed shelter steers as compared to 889.4 lb for the open yard group. The tests were conducted from November 13 to March 19, and during this period the steers housed in the warm barn gained 48 lb more than those in the open barn group. This may not be significant, since the animals in the warm barn ate slightly more feed.

In studies made by Sanborn (18) at the Utah Experiment Station in 1892, the results indicated that in comparing steers in protected sheds with a temperature averaging 40° F. to those in open sheds with the temperature averaging 23° F. with the lowest point reading 12° F. below zero, that even though the steers in the open shed consumed more feed, they gained more in weight, had heavier appetites, showed better physical condition, and had better general appearance than those in the closed shelter.

Feeding trials conducted by Waters (22) at the Missouri Experiment Station in 1907 indicated that animals maintained in outdoor pens made greater gains than those housed in warm barns. Conclusions were that cattle are able to generate sufficient heat in the body through mastication, digestion, assimilation and fermentation of the large quantity of food to maintain the normal temperature requirements for the animal body.

Corresponding conclusions were indicated in the investigations of Shaw (19) at the Minnesota Experiment Station in 1902. Steers fed

indoors gained an average of 1.74 lb per head daily as compared to those fed in the open shed at a gain of 2.26 lb per day per steer.

Cochel and Doty (3) at the Pennsylvania Experiment Station in 1910 observed that protection of animals from cold temperatures was not necessary, that steers receiving liberal amounts of silage had keener appetites and possessed somewhat smoother coats, and made greater gains than steers that were fed liberal grain rations. Of the two lots of steers that were on trial, one lot received 15 lb of silage per day, the other lot on full grain feed consumed 7.5 lb of silage per day. The lot on liberal silage feeding gained 20 lb per head more than those on full grain feed during the trial.

In experiments conducted by Potter and Withycomb (16) at the Oregon Experiment Station in 1921 the effects of feed and temperatures were observed on beef cattle. Temperatures in the sheltered barns averaged 42° F. as compared to 33° F. for the open barns. Hay consumption showed 25.38 lb per day for the sheltered steers as compared to 26.81 lb per day for steers in the open sheds. Silage consumption was 19.21 lb per day for sheltered animals while for the open yard group it was 15.19 lb per day. The average daily gain per animal was 1.54 lb for the sheltered group and 1.48 lb for the open shed steers. Conclusions from these studies suggest that there were no material differences in favor of one group over another.

Armsby (1) relates that since growth is a physiological process, largely synonymous with increase of protein tissue and rapidly growing cells, a liberal supply of protein is needed. The average rate of growth diminishes from birth onward. A deficient protein ration may limit growth. This may also be true of a deficiency of ash material in

the ration. While it may be an assumption that abundant protein and mineral supplies may stimulate growth, the effects are slight and thus the production of protein tissue is fundamentally a function of the animal, not the ration.

Part II - Dairy Cattle

From 1910 to 1913 at the Maryland Experiment Station three seasons trials were conducted to observe the effects of housing dairy cows in closed sheds vs. open sheds. Buckley (2) found an advantage for open sheds in lower building costs, less barn equipment, less labor required to manage the cows, and the effects of low temperatures did not seem to show any influence on milk production. In no case did there seem to be any decrease in milk production or physical effects on the animals, permanent or temporary that could be attributed to a low temperature or sudden fluctuation in temperature, unless because of a cold rain or sleet. This is in agreement with the dairy cattle housing studies made by Woodward et al (23) at the United States Department of Agriculture Experiment Station at Beltsville, Maryland in 1918. In trials that were observed from November through March, indications were that cows kept in the open shed, consumed somewhat more feed and produced slightly more milk than those kept in the closed barn, but the increase in production did not offset the extra feed cost.

Investigations of the effects of high environmental temperatures on dairy cattle were conducted by Reagan and Richardson (17) at the University of California in 1938. In this experiment studies were made in a temperature controlled room at levels of 40 to 100° F. Respiration rates, body temperatures, pulse rates and physical effects were studied. Their

results showed that as the air temperatures increased from 40 to 100° F., the respiration rates increased from 12 to 124 per minute, body temperatures increased from 101 to 105° F. and pulse rates decreased from 72 to 57. It was also observed that the upper limits of heat regulation for the dairy cow were between 80 and 85° F. When temperatures went above those levels for more than 24 hours, heat production overbalanced heat loss and the body temperature increased.

Shelter methods, temperature influences and feed consumption rates were studied at the North Dakota Experiment Station in 1926 by Dice (4) (5) (6) to determine the ability of cows to withstand exposure to low winter temperatures. Cows were kept in closed barns and open barns during November, December, February and March. The cows in the cold barn showed a slight advantage in milk production.

Studies pertaining to housing dairy cattle were conducted by Plumb (15) at the Purdue Agricultural Experiment Station. Two groups of six cows each were kept, one in a warm barn and the other in an open shed. Conclusions from these trials indicated that the protected cows produced 161.1 lb more milk on less feed per pound than those in the open shed and gained 231 lb in weight as compared to a loss in weight of 33 lb for cows in open sheds for the 48 day trial period. Results from these studies seem to indicate that other factors being equal dairy cows housed in warm shelters will eat less feed than cows not protected. Exposure to cold winter weather causes cows to produce less milk than these same animals would produce if protected. Also, it is more difficult to maintain their weight when they are exposed to cold weather.

Kelly and Rupel (12) in investigations of stable environments conducted at Genesee Depot, Wisconsin during the winter of 1930-1931 and 1931-1932 in cooperation with the Wisconsin Experiment Station and United States Department of Agriculture, observed that at a temperature reading of 60 to 65° F. milk production was maintained above the average, but butterfat was below the average for the experiment. At higher temperature levels the rate of respiration was correspondingly higher, the cows appeared less comfortable and cow pox problems became more apparent than at lower temperatures. Sudden changes of temperatures of 10° in the 45 to 65° F. ranges, affected the cows for the first three milkings. Sickness, lack of appetite, and pneumonia increased with sudden exposures to drafts. The rate of decline in milk production was greater when the temperature in the barns was variable than when it was fairly constant. Cows in open barns dropped sharply in milk production during cold periods, but recovered more quickly with the return of mild weather than cows in stanchions.

In studies pertaining to the wintering of dairy heifers on corn silage, Hunt (11) at the Virginia Experiment Station in work with dairy heifers found that heifer calves weighing 275 lb would eat approximately 20 lb of silage per day, those weighing 420 lb would eat 25 lb, and heifers weighing 650 lb would eat approximately 30 lb of silage.

Some factors influencing the rate of growth and the size of dairy heifers at maturity were studied by Eckles and Swett (9) at the Missouri Experiment Station. The results showed that skeletal measurements may be used as a method of determining growth, because the chances for experimental error are low and because of the ease with which it is

possible to secure the height at withers. This method is recommended as being sufficiently accurate to measure the development of a growing animal. The other unit of growth measure in animals is live weight. It was also noticed in these studies that there was a tendency for animals to recover from retarded growth if conditions are favorable later; however, if retardation of skeletal growth has proceeded too far, the animals will not obtain the normal size that is expected of them at maturity.

According to Eckles (8) the most favorable barn temperatures had not been determined experimentally, but the assumption was that it should range from 40 to 50° F. for well-fed cows and between 55 and 65° F. for growing heifers. Experimental work along with practical observations seems to indicate that fattening steers do not need as much, if any, protection from cold temperatures. Since the dairy cow is not protected by thick layers of fat, she cannot withstand exposure to cold weather, especially when wet or drafty conditions prevail. This coincides with the recommendations of Henry and Morrison (10) that beef steers adjust more rapidly to cold temperatures because of the layer of fat just beneath the skin. In the dairy cow the situation is different because her system is severely taxed through the annual drain of milk production. She does not build these layers of fat and does not have the insulating protection, consequently her body has more radiation than the beef steer per hundred pounds of live weight. Her hide is thinner and coat of hair not as heavy as on the beef animal. It is therefore believed necessary to provide a well ventilated barn with temperatures maintained above 40° F. for dairy cows. This temperature level can

easily be attained in a well built barn without artificial heat, since the animals produce enough heat energy to keep the barn warm, provided that the barn has enough animals in it.

To determine the effects of different methods of growing dairy heifers during the winter months Dice (7) carried out experiments with heifers in open and closed sheds. The results of these trials indicated that growth may increase with less feed consumption at higher temperatures than for heifers housed under lower temperature levels. It was also observed that those housed in closed sheds developed greater skeletal growth as measured by height at withers and that they consumed less protein and total nutrients per pound of gain than those in open sheds. Apparently more energy was needed to keep the heifers warm in the open shed. An explanation as to why heifers require warmer barns than cows is that cows consume more feed and therefore are able to produce greater body heat, and also heifers have larger body surface exposed to the atmosphere in proportion to their weight than cows. From this explanation it then seems plausible that a warm shelter is to be recommended for housing year old dairy heifers during winter months - especially when temperatures drop below zero accompanied with high wind velocity.

EXPERIMENTAL PROCEDURE

This experiment, as indicated, has been planned to study some environmental effects on the growth of dairy heifers and their feed requirements during the winter months. Many studies have been made by several agricultural research workers on feed requirements and milk production for dairy cows during the winter months, but these results are not conclusive with respect to the need for warm housing. Little work has been reported on housing requirements for heifers. The experiments herein reported were designed to obtain this type of information.

Three trials were conducted from November 1 to April 1 or for a period of approximately 22 weeks. The first of the trials was started on November 1, 1947 and then they were repeated in November 1948 and November 1949. Therefore, the experiment may be divided into three periods.

Since the information that was being sought pertained to dairy heifers about one year old or older, animals were selected as nearly alike as possible with respect to age, breed, breeding, size and general physical appearance. Heifers were arranged in pairs by breeds, age and size, with one heifer being housed in the warm barn and the other in the cold barn. They were registered heifers that were being retained in the college herd for replacements.

The barns in which these experiments were conducted are at the College dairy farm. The heifers were housed in two barns. The warmer barn is a part of the main college barn and the other is a more open and

colder barn which was originally built to house dairy sires. These barns each have box stalls averaging in size about 12 ft x 12 ft or an area of about 144 square feet of floor space per stall. Three heifers were placed in each pen, thus allowing about 48 square feet of floor space per animal. The barns have ample light, and the ceilings are approximately 10 feet high. The walls and ceilings of the main barn are constructed of wood, and are insulated with 4 inches of rock wool. The walls have building paper and sheathing on the outside and are lined on the inside with wood. This barn is always referred to as the warm barn. The walls in the sire barn are not insulated. They are lined inside with planks to a height of 4 feet and are covered with sheathing and siding. This barn is referred to as the cold barn. Each barn is equipped with cement floors, standard steel pen panels for the box stalls, feed mangers and water tanks that are not automatic.

Each of the barns has outside yards in which the animals could exercise. In the case of the heifers housed in the cold barn the doors were open at all times with the exception of a few nights when blizzard weather conditions prevailed which made it necessary to close these doors to keep the snow from blowing into the pens. The animals housed in the warm barn were allowed limited exercise, in the outdoor yard to the extent that these heifers were out for about two hours during the afternoon when outdoor temperatures were mild (40° F. or above); otherwise they were closely confined to their box stalls in the barn.

The animals were kept on a regular schedule by being fed at 8:00 o'clock in the morning and 4:00 o'clock in the afternoon. The feeding procedure was to feed silage first and after the silage was consumed

the hay was fed. The same personnel fed and managed the heifers throughout the three years of the trials.

In determining the amounts of feed the heifers should have, the literature on dairying indicated that 20 pounds of corn silage per heifer per day for this age was about the amount expected to be consumed during the winter months when temperatures ranged at lower levels. Any feed requirements above this amount were consumed as hay. Ensilage was kept constant at 20 pounds per day per heifer by being weighed daily. The hay was fed ad lib. and was weighed on the same day of each week. Corn silage was of excellent quality throughout the trials, but the hay varied to quite a degree from time to time. It was planned to feed a mixture of brome and alfalfa hay and this was strictly followed. No grain was included in the rations during the trials, thus making the feed an all roughage ration. Salt was available ad lib. in the form of block salt but no mineral supplements were supplied.

Growth rates were determined each week on the same day, by weighing the animals, measuring chest circumference and height at withers. Chest circumferences were obtained by using a cattle tape measure placed around the heart girth and readings were recorded in inches. Height at withers was measured by a caliper designed to be placed level at the point of withers and readings were reported in centimeters. According to Eckles and Swett (9) Touchberry and Lush (21) measurements obtained at point of withers are recommended for experimental procedures.

Temperature readings were secured with recording thermometers placed in a central location in the barn.

Health of the animals was under the supervision of a licensed

veterinarian who has charge of the veterinary work of the herd. During the course of the trials normal health prevailed.

Each heifer was designated by the herd number, that is, the registration ear tag or tatoo for the animal on the certificate of registration.

For the trial from November 1, 1947 to April 1, 1948, 18 heifers were selected consisting of 6 Holsteins, 6 Guernseys and 6 Brown Swiss. These were paired into two groups with 9 heifers being placed in the cold barn and an equal number in the warm barn. The group in the cold barn had an average age of 11 months and 24 days, and weighed 595 lb as compared to those in the warm barn which had an average age of 11 months and 9 days and weighed 596 lb. On November 1, 1948, 22 heifers were selected consisting of 4 Brown Swiss, 4 Guernseys, 2 Jerseys and 12 Holsteins. The average age for the 11 put in the cold barn was 1 year, 1 month and 27 days and the weight was 683 lb in comparison to the 11 heifers in the warm barn that averaged 11 months, 12 days, in age and weighed 656 lb.

Sixteen heifers were selected for the trial on November 1, 1949 and these consisted of 8 Holsteins, 2 Brown Swiss, 2 Guernseys and 4 Jerseys. The 8 heifers placed in the cold barn averaged 1 year, 1 month and 25 days in age and weighed 617 lb while the 8 heifers in the warm barn averaged 1 year, 1 month and 10 days in age and weighed 607 lb.

Thus a total of 56 animals were used in the experiment of which 26 were Holsteins, 12 Brown Swiss, 12 Guernseys and 6 Jerseys.

The data obtained from these trials consisted of growth rates, feed consumption levels, temperature ranges and differences between barns as well as differences between breeds.

RESULTS

During the first trial with a temperature difference of 17° F. in the two barns, the heifers in the warm barn showed greater gains in weight, chest circumference and height at withers. These data are presented in table 1.

The cold barn heifers made an average gain of 73 lb compared to 110 lb per heifer in the warm barn or a difference of 37 lb. The rate of growth in weight (Fig. 1) shows that the two groups started the trial at about the same weight, that growth trends were parallel to each other during the first nine weeks and after this time the group in the warm barn grew more rapidly.

Increase in chest circumference (Fig. 2) indicates that the two groups grew at the same rate until the twelfth week when the warm barn group began to develop more rapidly. Chest measurements for the two groups were essentially alike at the beginning of the trial. At the twelfth week the warm barn group had gained an inch more than the other group, and at the end of the trial the difference was 3.5 inches.

(Fig. 3) shows that each group started the trial with about the same height at withers. Growth rates were nearly alike during the first ten weeks, after which the warm barn heifers grew more rapidly during the remainder of the period. The warm barn heifers finished the trial with 126.2 cm in height as compared to 121.2 cm for the cold barn group, or a difference of 5.0 cm. Heifers in the warm barn gained an average of 10.8 cm compared to 5.7 cm for those in the cold barn.

Table I

Effect of temperature on growth rates of dairy heifers.
Trial 1. Nov. 1, 1947 - Apr. 1, 1948.

	Cold Barn (9 heifers)				Warm Barn (9 heifers)			
Weeks No.	Weights lb	Chest circumference in.	Height at withers cm	Barn temperature °F	Weights lb	Chest circumference in.	Height at withers cm	Barn temperature °F
1	595	56.7	115.5	44	596	56.8	115.4	57
2	602	56.8	115.8	25	599	57.2	115.8	45
3	605	57.0	116.3	30	607	57.5	116.3	44
4	619	57.2	116.6	22	613	57.8	116.7	33
5	620	57.6	116.9	23	619	58.0	117.4	37
6	625	57.9	117.3	15	621	58.3	117.8	35
7	630	58.2	117.6	20	627	58.6	118.2	39
8	633	58.3	117.9	25	633	58.9	118.5	43
9	636	58.4	118.1	20	638	59.0	118.8	38
10	638	58.6	118.5	27	645	59.2	119.3	48
11	643	58.6	118.6	19	650	59.5	120.0	40
12	645	59.1	119.2	16	660	60.2	120.0	32
13	648	59.4	119.5	17	669	60.8	121.3	36
14	649	59.6	119.8	16	677	61.0	121.7	37
15	654	60.0	120.1	11	677	61.5	122.3	31
16	656	60.1	120.2	29	684	62.0	123.1	46
17	661	59.9	120.4	33	687	62.5	123.7	50
18	661	60.5	120.6	29	692	63.0	124.0	47
19	664	60.7	120.7	16	697	63.5	124.6	35
20	666	60.9	120.8	40	697	63.8	124.9	52
21	667	61.1	121.0	45	699	64.3	125.4	59
22	668	61.4	121.2	32	706	64.9	126.2	46
Ave. gain	73	4.7	5.7		110	8.1	10.8	
Ave. temperature				25				42

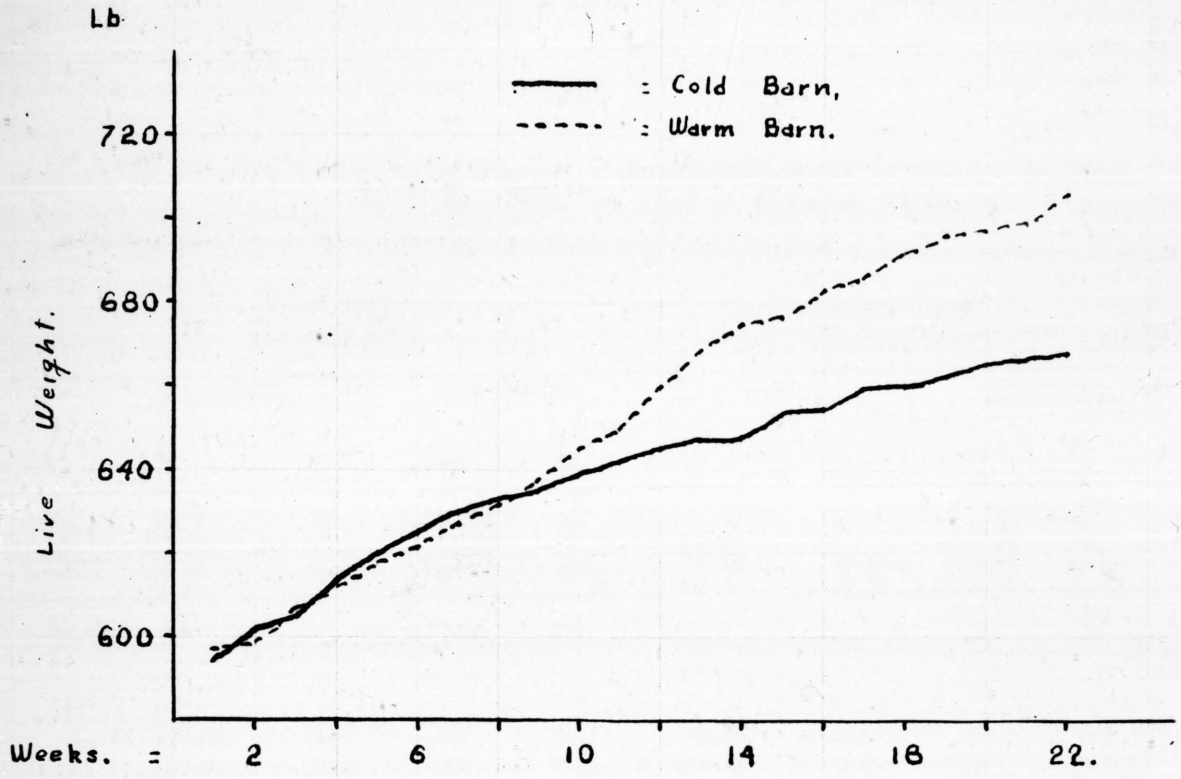

Fig. 1 Course of Growth in Weight.

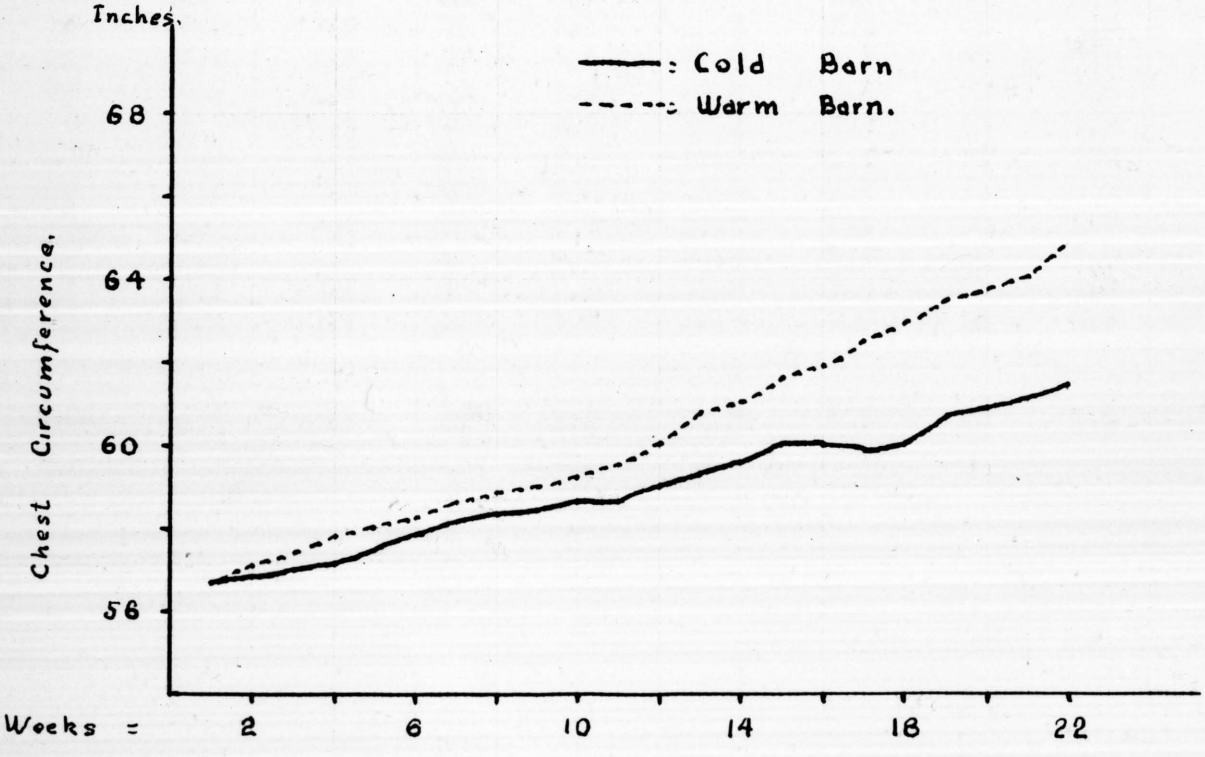

Fig. 2 Course of Growth in Heart Girth.

Table II

Effect of temperature on the feed consumption of dairy heifers.
Trial 1. Nov. 1, 1947 - Apr. 1, 1948.

	Cold Barn (9 heifers)				Warm Barn (9 heifers)			
	Hay		Silage		Hay		Silage	
Weeks	Daily per heifer	Daily per cwt	Daily per heifer	Daily per cwt	Daily per heifer	Daily per cwt	Daily per heifer	Daily per cwt
No.	lb	lb	lb	lb	lb	lb	lb	lb
1								
2	10.8	1.8	20	3.3	9.6	1.6	20	3.3
3	11.8	1.9	20	3.3	10.3	1.7	20	3.3
4	11.7	1.9	20	3.3	8.6	1.4	20	3.3
5	11.9	1.9	20	3.2	10.7	1.7	20	3.2
6	12.8	2.0	20	3.2	10.9	1.8	20	3.2
7	13.3	2.1	20	3.2	11.9	1.9	20	3.2
8	14.4	2.3	20	3.2	9.8	1.5	20	3.2
9	12.9	2.0	20	3.1	8.3	1.3	20	3.1
10	12.2	1.9	20	3.1	10.8	1.7	20	3.1
11	15.1	2.4	20	3.1	9.2	1.5	20	3.1
12	16.3	2.5	20	3.1	10.3	1.5	20	3.0
13	16.9	2.6	20	3.1	11.8	1.6	20	3.0
14	16.1	2.5	20	3.1	10.9	1.8	20	3.0
15	16.9	2.6	20	3.1	9.0	1.6	20	3.0
16	16.6	2.5	20	3.1	11.3	1.3	20	2.9
17	17.8	2.7	20	3.0	12.2	1.7	20	2.9
18	14.4	2.2	20	3.0	11.0	1.8	20	2.9
19	16.2	2.4	20	3.0	13.0	1.6	20	2.9
20	14.8	2.2	20	3.0	13.4	1.9	20	2.9
21	16.1	2.4	20	3.0	13.9	1.9	20	2.8
22	17.4	2.7	20	3.0	14.6	2.0	20	2.8
Ave.	14.5	2.3	20	3.1	11.0	1.6	20	3.0

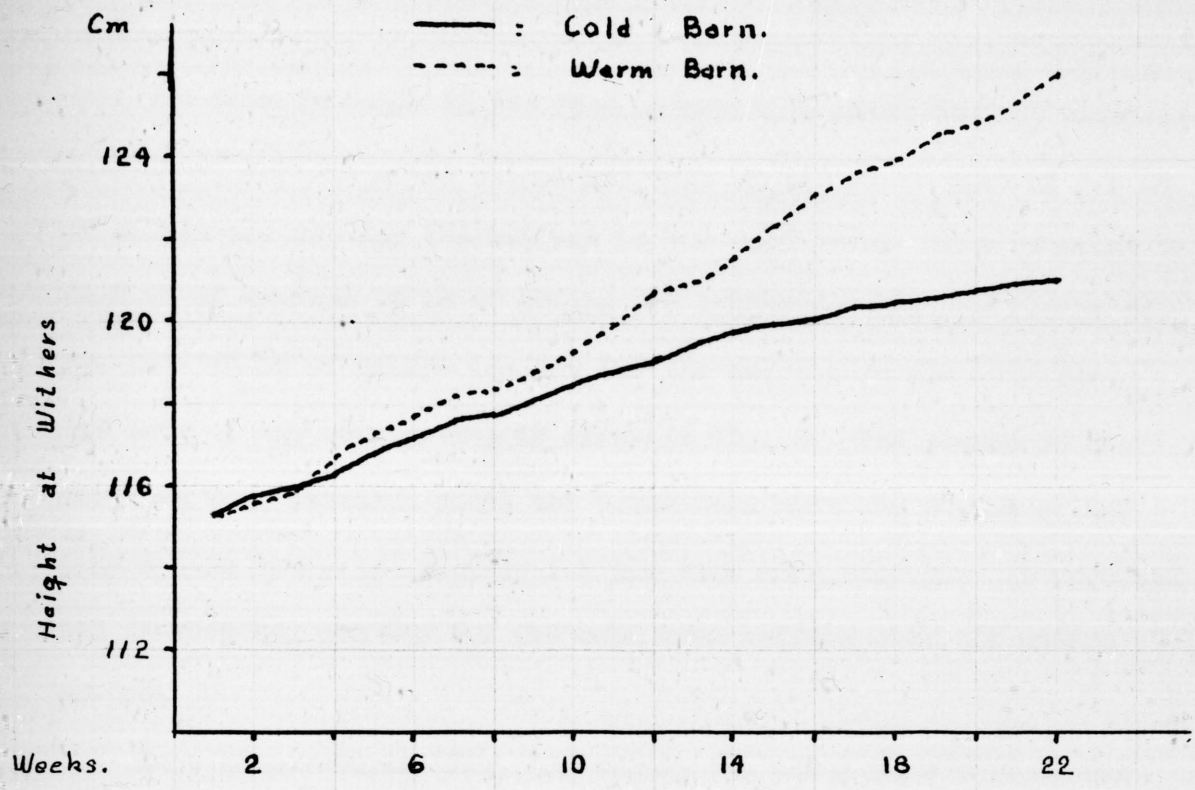

Fig. 3 Course of Growth at Withers.

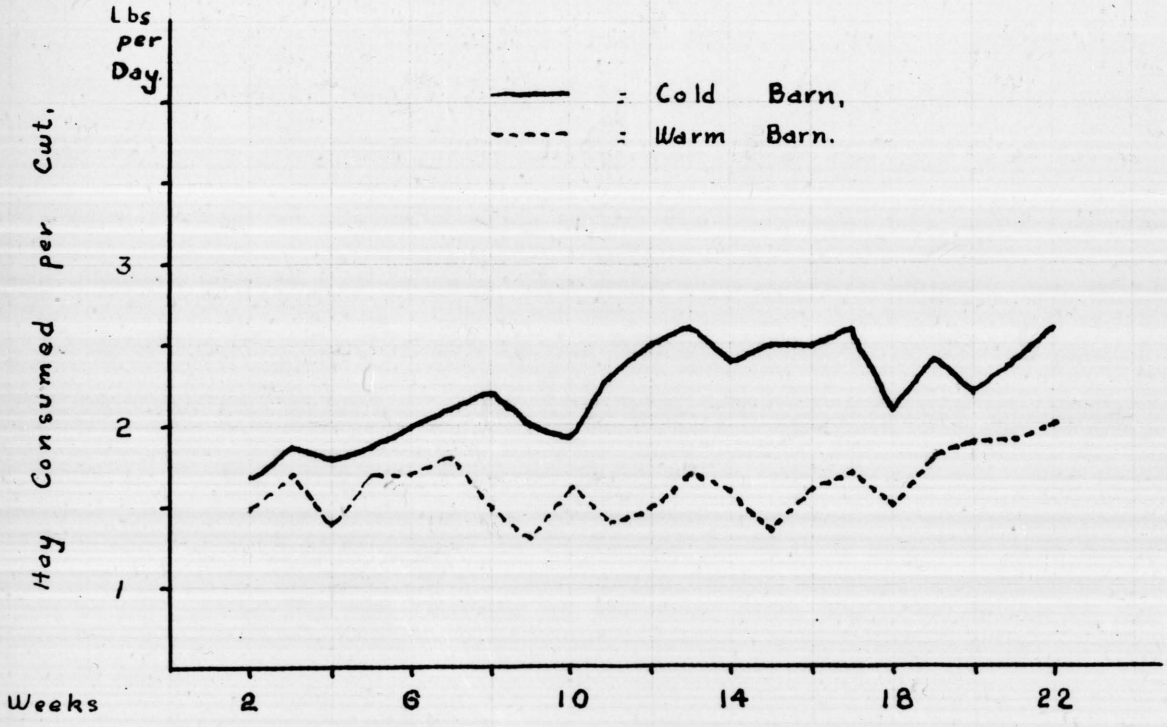

Fig. 4 Course of Hay Consumption.

The data in table II for feed consumption show that it required 14.5 lb of hay and 20 lb silage per day, or 2.3 lb of hay and 3.1 lb of silage per cwt for the heifers in the cold barn. This compares to 11.0 lb of hay and 20 lb of silage per heifer per day, or 1.6 lb of hay and 3.0 lb of silage per cwt for the heifers in the warm barn. The rate of hay consumption is shown in Fig. 4. The pounds of hay consumed were parallel until the tenth week when the course of hay consumption increased rapidly for the cold barn heifers. It required 3.5 lb more hay per day for the cold barn heifers over the entire period.

Barn temperatures (Fig. 13) during the trial show that as the trial continued, there was a greater daily variation of temperature in the cold barn than in the warm barn.

Results of the second year trial were similar to the first as is indicated in Table III. The cold barn heifers gained an average of 72 lb in weight compared to 112 lb for those in the warm barn. The rate of growth in weight is shown in Fig. 5. The weights were parallel for each group until the twelfth week, when the cold barn heifers began to grow at a slower rate, while the warm barn heifers maintained a steady, continuous growth. The cold barn heifers started the trial at an average weight of 683 lb per heifer, compared to 657 lb per heifer for the warm barn. The warm barn heifers finished the trial with an average weight of 769 lb compared to 755 lb for the cold barn heifers. Chest development as indicated in Fig. 6 shows a more rapid rate of growth for the heifers in the warm barn than for those in the cold barn.

Table III

Effect of temperature on growth rates of dairy heifers.
Trial 2. Nov. 1, 1948 - Apr. 1, 1949.

	Cold Barn (11 heifers)				Warm Barn (11 heifers)			
Weeks No.	Weights lb	Chest circumference in.	Height at withers cm	Barn temperature °F	Weights lb	Chest circumference in.	Height at withers cm	Barn temperature °F
1	683	60.7	120.7	48	657	56.6	115.8	57
2	672	60.9	120.7	38	648	56.0	116.3	50
3	690	60.3	120.8	36	651	57.2	116.6	49
4	695	60.6	120.9	32	670	57.4	117.0	45
5	705	60.1	121.1	48	665	57.6	117.4	49
6	701	60.2	121.3	37	679	57.7	117.5	41
7	710	60.2	121.5	42	691	57.8	118.3	45
8	712	60.4	121.6	36	692	58.2	118.5	41
9	724	60.7	121.7	34	698	59.4	119.1	39
10	737	61.7	122.2	30	714	59.6	119.4	31
11	730	61.4	122.5	33	710	60.0	119.7	37
12	742	61.1	122.8	20	716	60.2	120.0	33
13	742	61.8	122.9	22	728	60.4	120.7	30
14	741	62.0	123.0	21	728	60.8	121.7	44
15	747	62.1	123.1	21	740	61.1	121.2	43
16	745	62.0	123.3	13	739	61.7	122.0	37
17	751	62.1	123.4	18	746	61.0	122.5	42
18	749	62.3	123.6	32	751	62.3	122.9	50
19	751	62.4	124.0	15	760	62.6	123.0	39
20	751	62.6	124.2	21	757	62.7	123.7	42
21	751	63.0	124.6	21	768	63.7	124.2	44
22	755	63.2	124.6	30	769	64.5	124.7	50
Ave. gain	72	2.5	3.9		112	7.9	8.9	
Ave. temperature				30				42

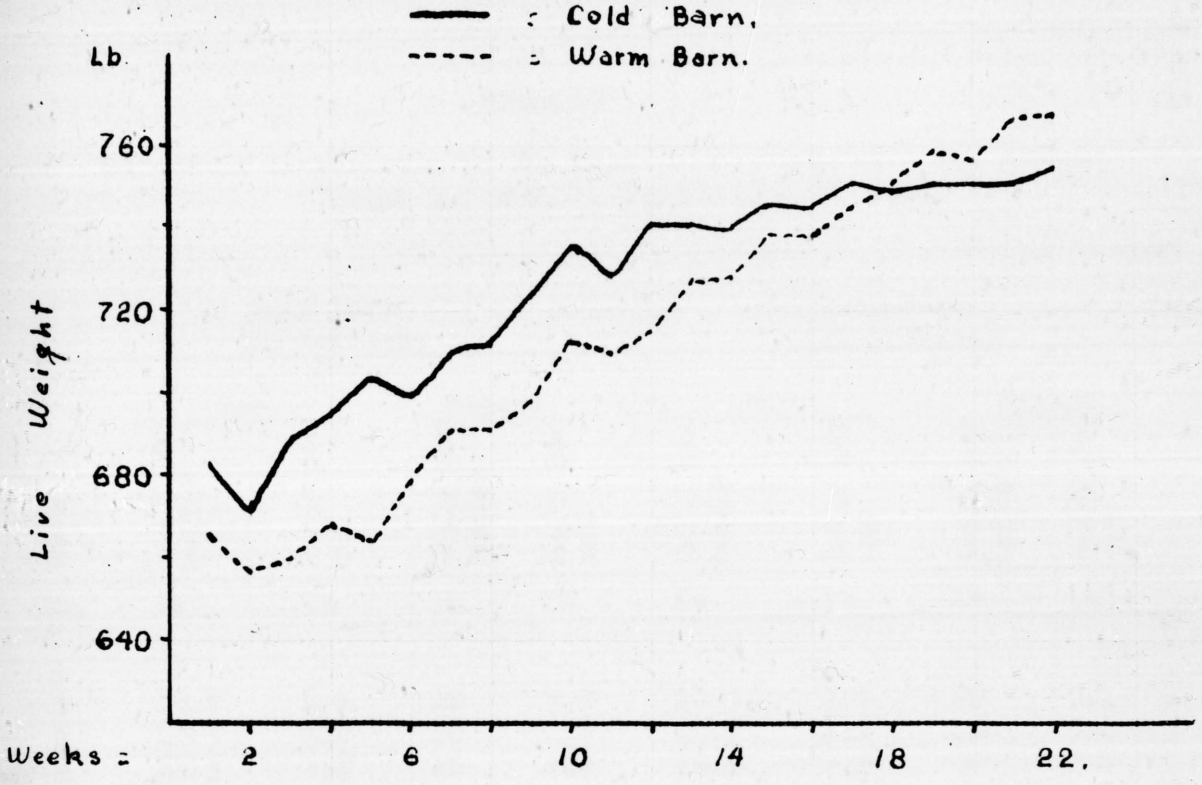

Fig. 5 Course of Growth in Weight.

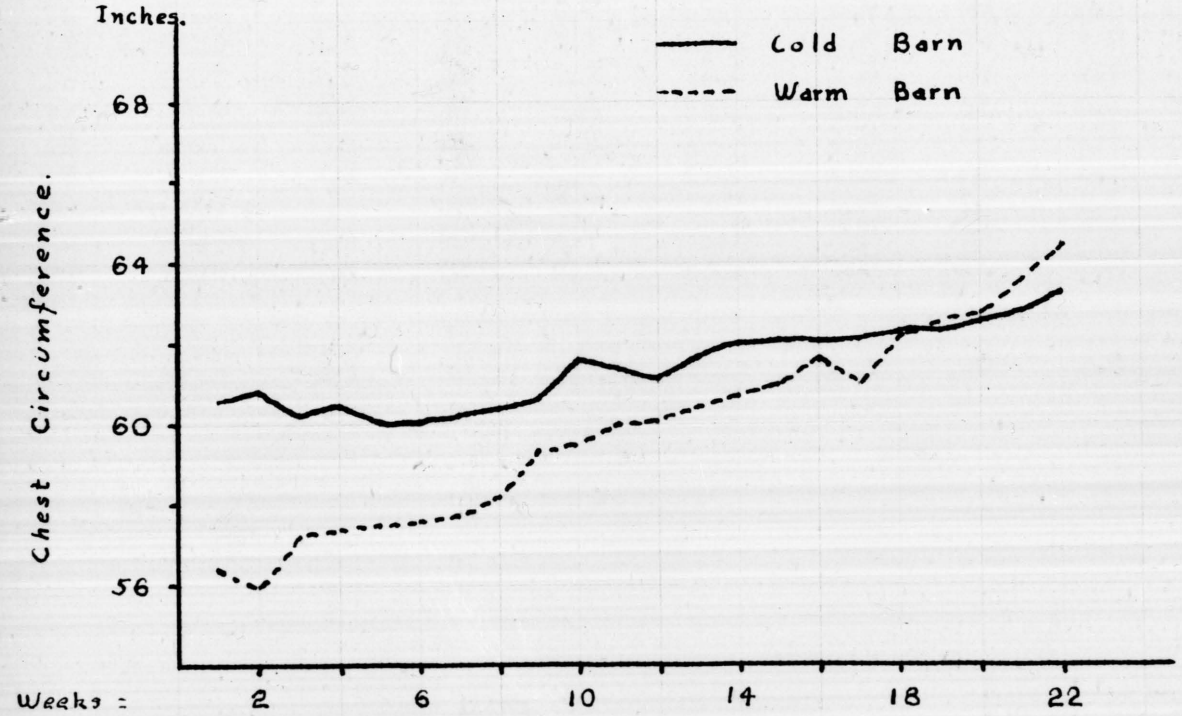

Fig. 6 Course of Growth in Heart Girth.

Table IV

Effect of temperature on the feed consumption of dairy heifers.
Trial 2. Nov. 1, 1948 - Apr. 1, 1949.

	Cold Barn (11 heifers)				Warm Barn (11 heifers)			
	Hay		Silage		Hay		Silage	
Weeks No.	Daily per heifer lb	Daily per cwt lb	Daily per heifer lb	Daily per cwt lb	Daily per heifer lb	Daily per cwt lb	Daily per heifer lb	daily per cwt lb
1								
2	10.9	1.6	20	3.0	10.5	1.6	20	3.1
3	11.5	1.7	20	2.9	10.7	1.6	20	3.1
4	12.6	1.8	20	2.8	10.2	1.5	20	3.0
5	13.0	1.8	20	2.8	10.3	1.5	20	3.0
6	15.4	2.2	20	2.9	9.6	1.4	20	2.9
7	16.2	2.3	20	2.8	10.0	1.4	20	2.9
8	16.5	2.3	20	2.8	10.1	1.5	20	2.9
9	16.8	2.3	20	2.8	10.8	1.5	20	2.9
10	17.7	2.4	20	2.7	10.1	1.4	20	2.9
11	16.9	2.3	20	2.7	11.0	1.5	20	2.8
12	17.2	2.3	20	2.7	11.6	1.6	20	2.8
13	17.8	2.4	20	2.7	11.9	1.6	20	2.8
14	20.0	2.7	20	2.7	11.7	1.6	20	2.7
15	21.0	2.8	20	2.7	13.5	1.8	20	2.7
16	20.7	2.8	20	2.7	13.0	1.8	20	2.7
17	20.0	2.6	20	2.6	12.0	1.6	20	2.7
18	18.7	2.5	20	2.7	13.6	1.8	20	2.7
19	21.0	2.8	20	2.7	13.0	1.7	20	2.7
20	20.4	2.7	20	2.7	13.3	1.8	20	2.6
21	20.0	2.7	20	2.7	12.9	1.7	20	2.6
22	19.8	2.2	20	2.6	13.4	1.7	20	2.6
Ave.	17.3	2.3	20	2.7	11.6	1.6	20	2.8

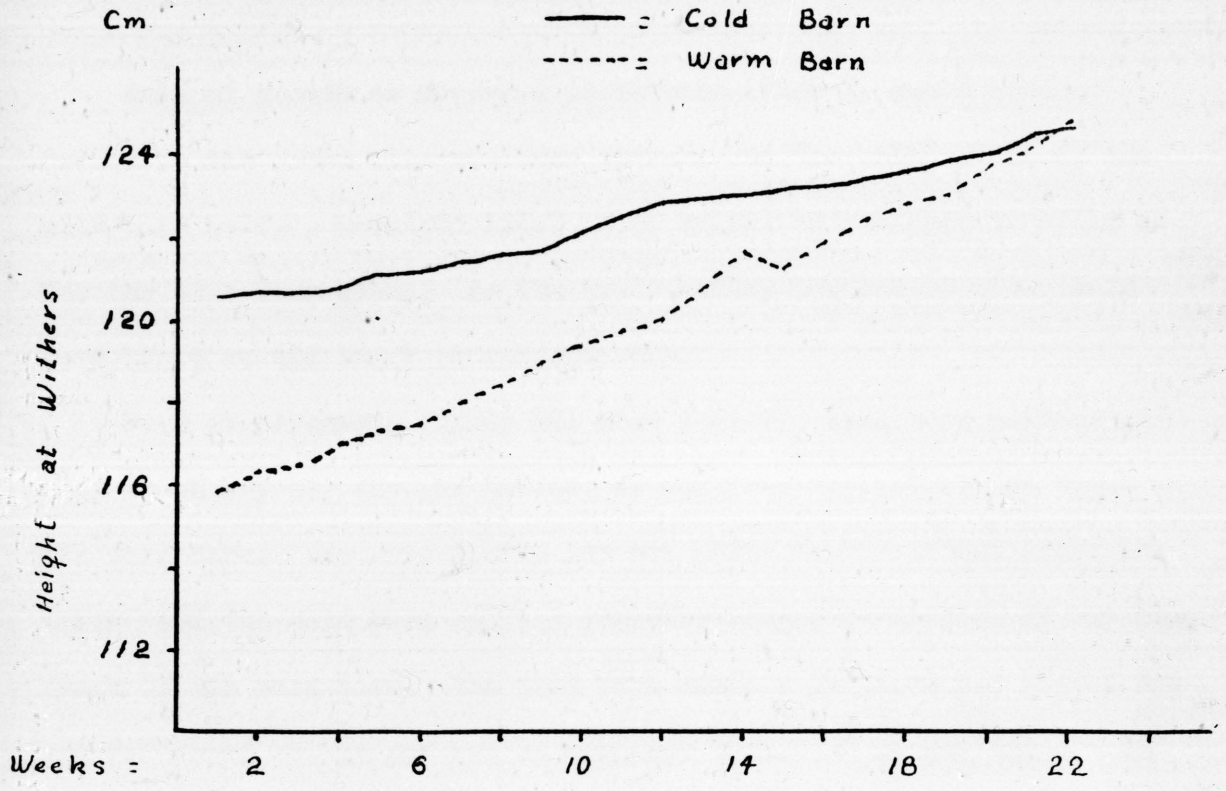

Fig. 7 Course of Growth at Withers.

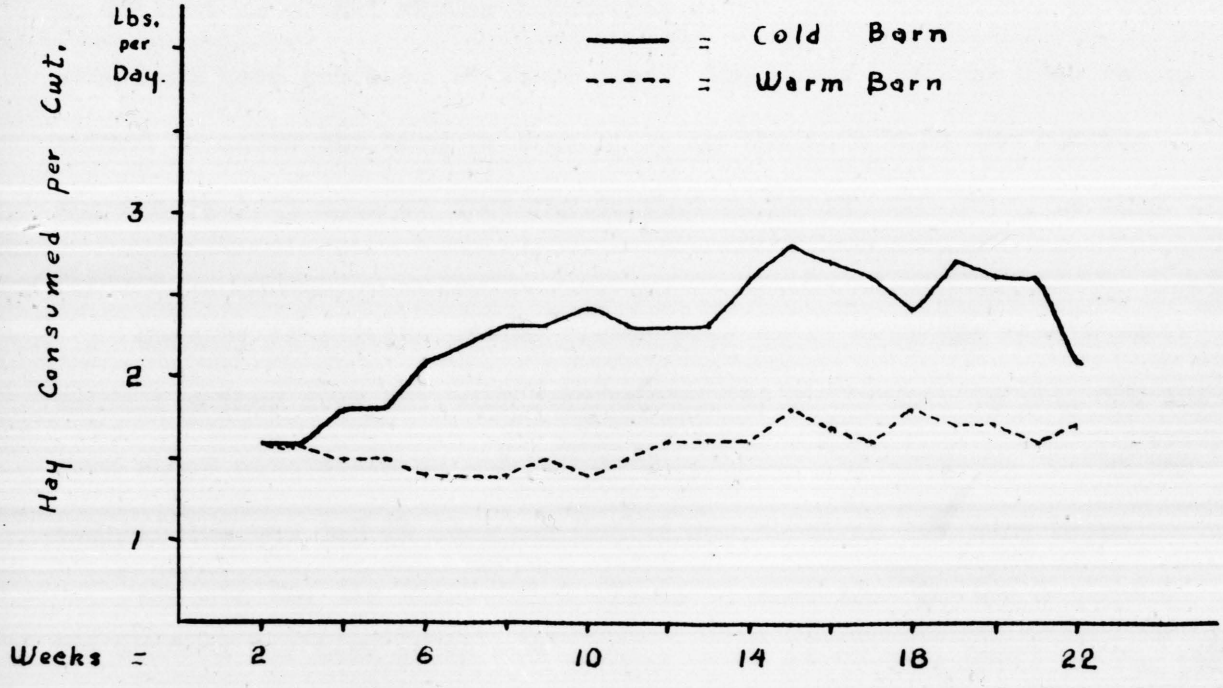

Fig. 8 Course of Hay Consumption.

Rate of growth as measured at withers (Fig. 7) shows similar trends to the chest circumference curves. As the trial started, the cold barn heifers measured 120.7 cm in height as compared to 115.8 cm for the warm barn group. As the trial ended, the height at withers were 124.6 cm and 124.7 cm respectively.

Feed requirements (Table IV) show that the cold barn heifers ate 17.3 lb of hay per day per heifer, as compared to 11.6 lb for those in the warm barn. Hay consumption per cwt (Fig. 8) shows that after the third week the cold barn heifers consumed larger quantities of hay than those in the warm barn. The cold barn heifers required 2.3 lb. of hay and 2.7 lb of silage per cwt as compared to 1.6 lb of hay and 2.8 lb silage per cwt for the heifers in the warm barn.

Barn temperatures (Fig. 13) were parallel until the twelfth and thirteenth weeks, when cold barn temperatures dropped rapidly while warm barn temperatures became warmer. The explanation for this seems to be that as normal winter temperatures dropped, the heifers in the warm barn were confined to their pens. The doors were not open to any extent to allow the barn to cool down; in the cold barn the outside doors were left open so that the heifers could run out doors as they wished.

Summary of results of the second year trial shows the warm barn heifers gained over the cold barn heifers by 40 lb more weight, 5.4 in. more chest circumference and 5.0 cm more height at withers. Daily hay consumption was 5.7 lb less per heifer for those in the warm barn.

Results for the third trial (Table V) show that in the beginning the heifers for each group were nearly equal in weight, heart girth, and

Table V

Effect of temperature on growth rates of dairy heifers.
Trial 3. Nov. 1, 1949 - Apr. 1, 1950.

	Cold Barn (8 heifers)				Warm Barn (8 heifers)			
Weeks	Weights	Chest circumference	Height at withers	Barn temperature	Weights	Chest circumference	Height at withers	Barn temperature
No.	lb	in.	cm	°F	lb	in.	cm	°F
1	625	59.0	115.9	48	628	58.1	112.6	59
2	628	59.7	116.2	50	628	58.3	113.2	60
3	637	60.1	117.6	37	629	58.3	115.6	44
4	647	60.0	118.2	38	633	59.1	116.2	48
5	658	60.8	118.5	36	638	59.5	116.6	40
6	659	61.0	118.9	23	647	60.0	116.8	29
7	664	61.1	118.1	27	653	60.3	116.8	34
8	666	61.3	118.2	23	658	60.6	117.1	34
9	670	61.6	119.2	32	664	61.0	117.5	37
10	671	61.8	119.6	20	670	61.4	118.1	36
11	678	62.3	120.0	9	675	61.8	118.7	34
12	683	62.2	120.1	11	683	62.0	118.7	34
13	683	62.4	120.6	7	691	62.2	119.3	32
14	682	62.6	120.7	19	701	62.7	119.9	35
15	680	62.8	121.3	27	709	63.0	120.5	45
16	683	62.7	121.8	25	725	63.4	121.5	42
17	686	62.7	122.1	21	741	64.0	122.1	41
18	692	62.7	122.5	31	751	64.0	122.7	42
19	699	62.9	122.8	13	758	65.1	123.4	38
20	706	63.0	123.3	28	768	65.7	124.0	41
21	713	63.1	123.6	37	775	66.2	124.4	51
22	721	63.1	123.6	37	785	66.6	124.8	51
Ave. gain	96	4.1	7.7		157	8.5	12.2	
Ave. temperature				27				41

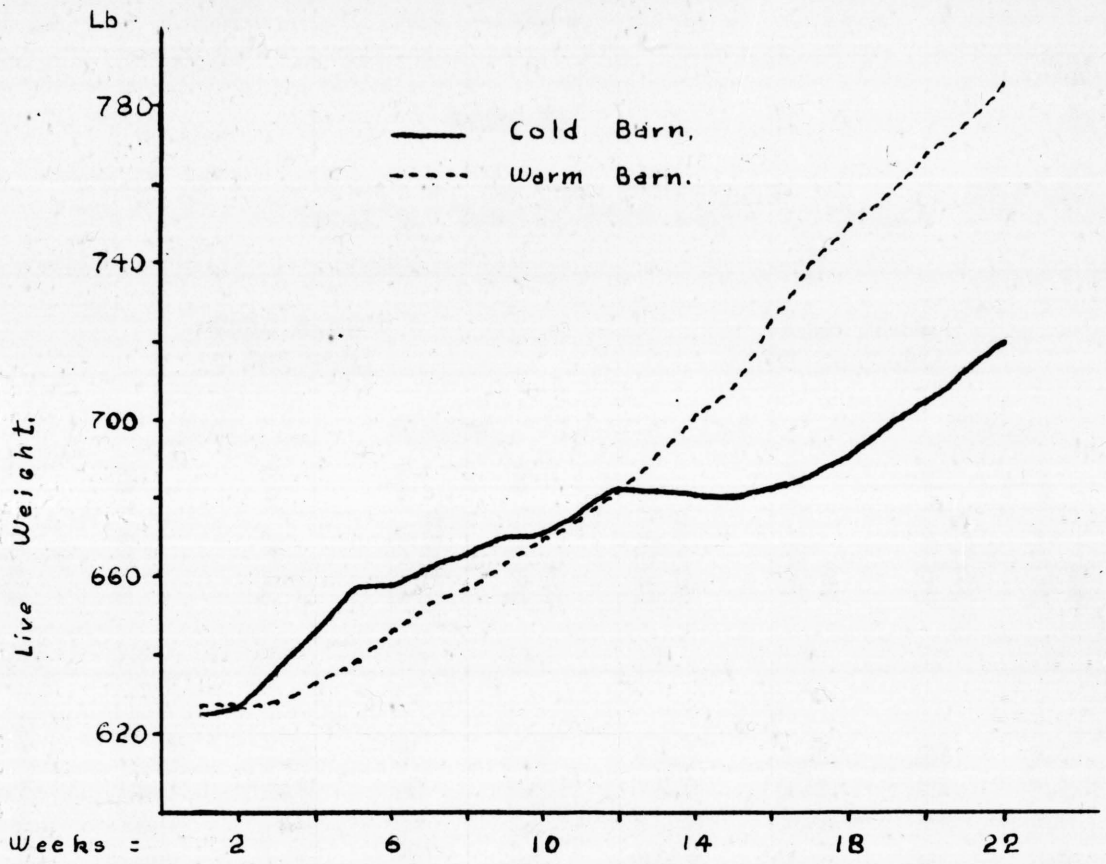

Fig. 9 Course of Growth in Weight.

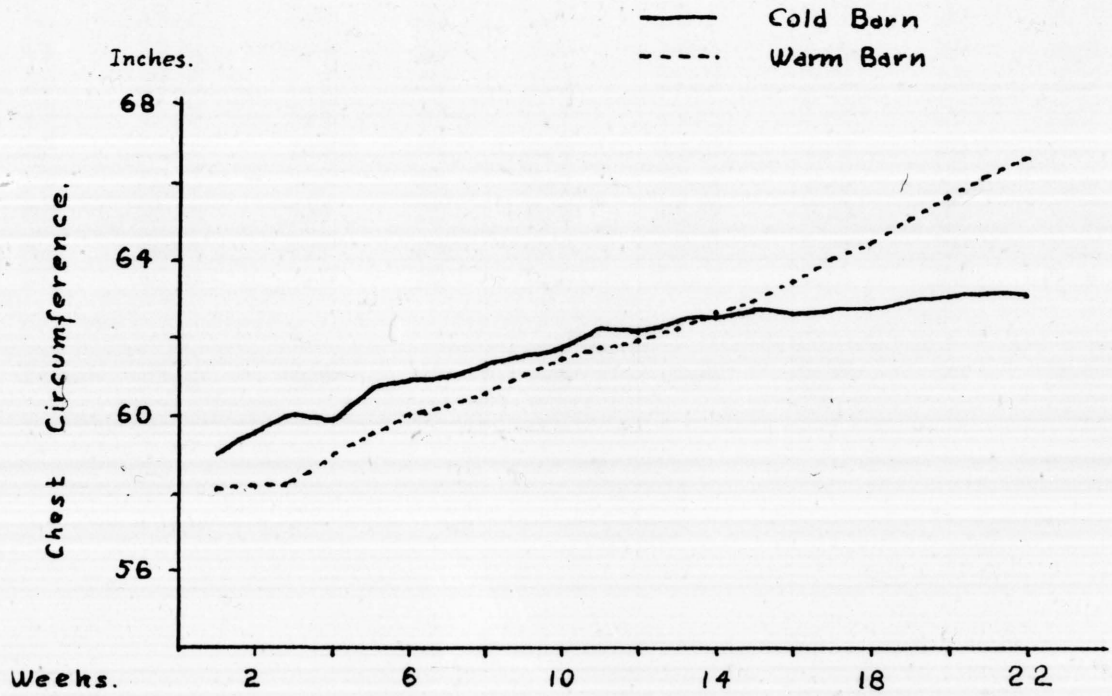

Fig. 10 Course of Growth in Heart Girth

Table VI

Effect of temperature on the feed consumption of dairy heifers.
Trial 3. Nov. 1, 1949 - Apr. 1, 1950.

	Cold Barn (8 heifers)				Warm Barn (8 heifers)			
	Hay		Silage		Hay		Silage	
Weeks	Daily per heifer	Daily per cwt	Daily per heifer	Daily per cwt	Daily per heifer	Daily per cwt	Daily per heifer	Daily per cwt
No.	lb	lb	lb	lb	lb	lb	lb	lb
1								
2	11.6	1.8	20	3.2	11.3	1.8	20	3.2
3	12.3	1.9	20	3.1	11.7	1.9	20	3.1
4	12.7	2.0	20	3.1	11.6	1.7	20	3.2
5	12.0	1.8	20	3.0	11.6	1.8	20	3.1
6	13.9	2.1	20	3.0	11.4	1.8	20	3.1
7	14.6	2.3	20	3.0	12.3	1.9	20	3.1
8	15.3	2.3	20	3.0	10.4	1.6	20	3.0
9	14.8	2.2	20	3.0	9.8	1.5	20	3.0
10	16.4	2.4	20	3.0	11.7	1.7	20	3.0
11	16.1	2.4	20	3.0	10.2	1.5	20	3.0
12	17.8	2.6	20	2.9	11.3	1.7	20	2.9
13	18.4	2.7	20	2.9	11.8	1.7	20	2.9
14	19.4	2.9	20	2.9	12.9	1.8	20	2.9
15	20.0	2.9	20	2.9	10.4	1.5	20	2.8
16	18.6	2.7	20	2.9	12.2	1.7	20	2.8
17	21.8	3.2	20	2.9	13.4	1.8	20	2.7
18	21.0	3.0	20	2.9	14.0	1.9	20	2.7
19	22.6	3.2	20	2.9	15.2	2.0	20	2.6
20	21.4	3.0	20	2.8	15.0	2.0	20	2.6
21	20.6	2.9	20	2.8	12.0	1.5	20	2.6
22	19.0	2.7	20	2.8	12.3	1.6	20	2.5
Ave.	17.2	2.5	20	2.9	12.0	1.7	20	2.9

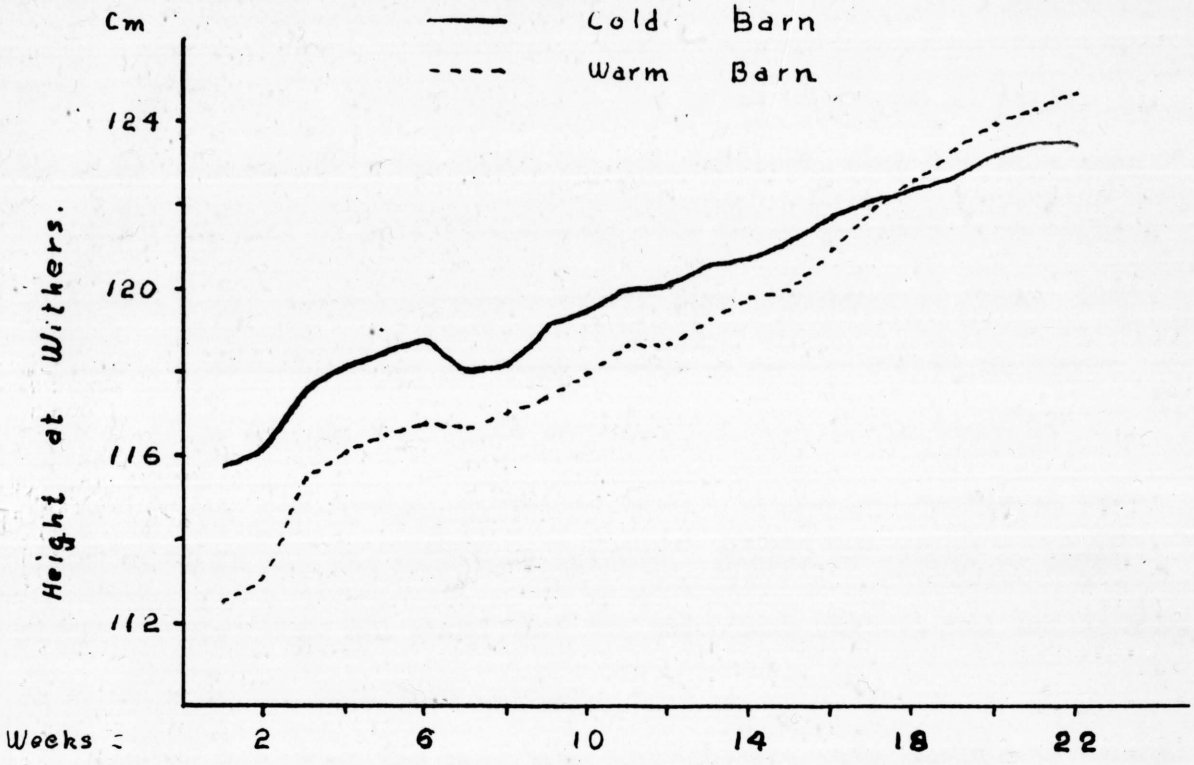

Fig.11 Course of Growth at Withers.

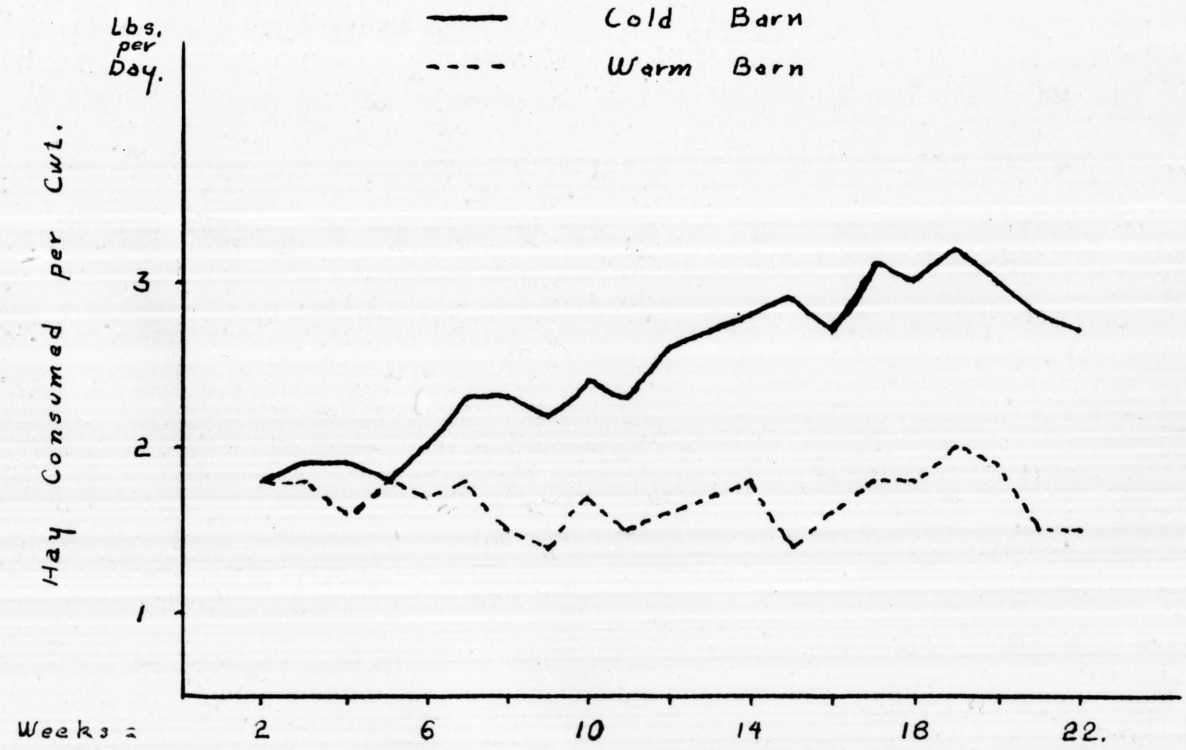

Fig.12 Course of Hay Consumption.

height at withers. During the trial the rates of growth in weight (Fig. 9) were nearly equal until the twelfth week, when the warm barn heifers continued to grow at a steady rate while the cold barn heifers lost weight for about four weeks before they continued to gain. The explanation for this loss in weight seems to be the effect of temperature (Fig. 13) which dropped very sharply during the tenth to twelfth week. The warm barn heifers gained 157 lb per animal as compared to 96 lb for the cold barn heifers. Course of growth in chest circumference (Fig. 10) shows that the cold barn heifers did not develop as rapidly as the warm barn heifers.

During the trial the warm barn heifers grew more rapidly in height as is shown in Fig. 11. At the beginning of the trial they were 3.3 cm less in height at withers but at the end of the period they were 1.2 cm taller.

Feed consumption (Table VI) shows that each heifer in the cold barn required 17.2 lb of hay per day per heifer, as compared to 12 lb of hay for those in the warm barn. Hay consumption per cwt (Fig. 12) shows that the hay requirements were 2.5 lb of hay per cwt for the cold barn heifers as compared to 1.7 lb for the warm barn heifers.

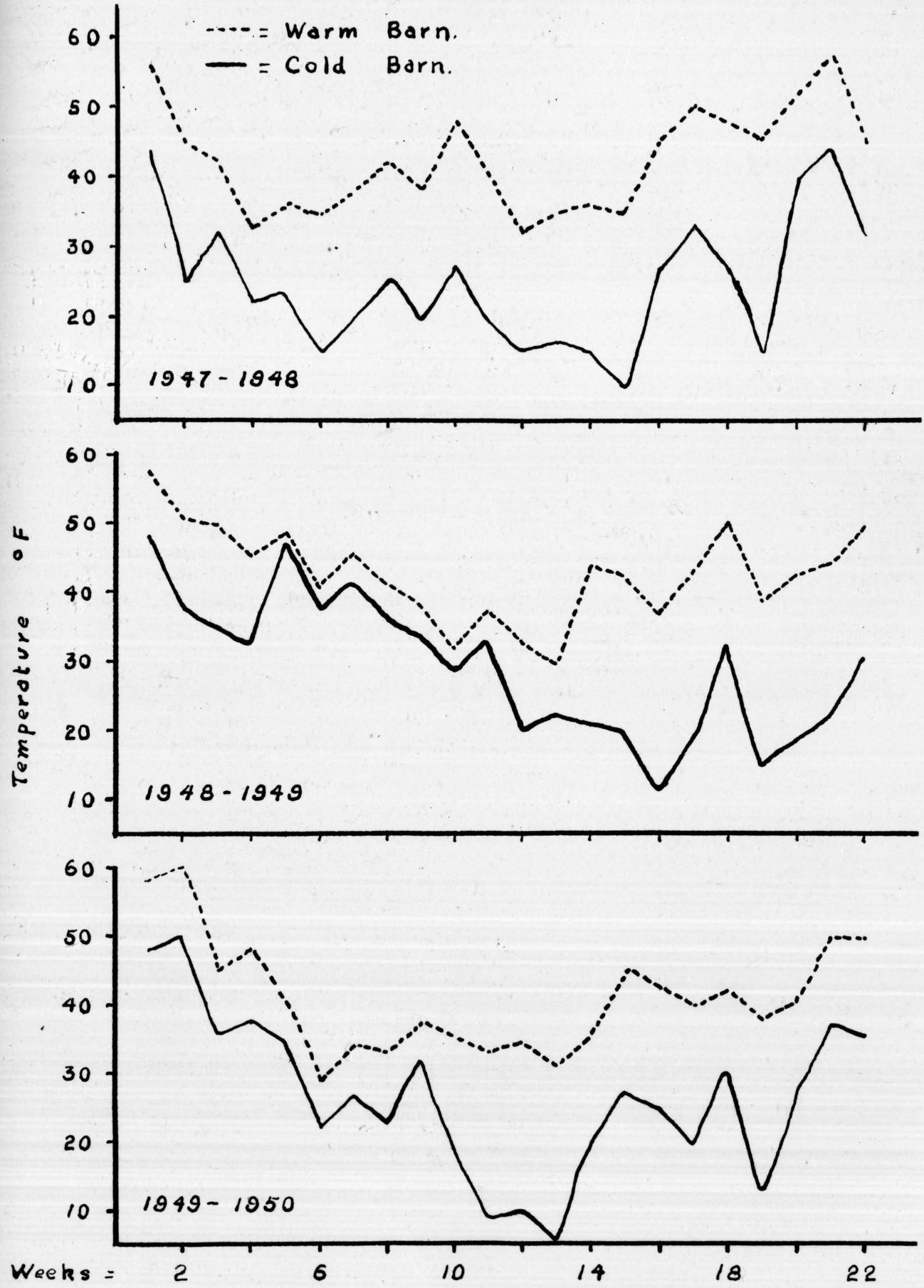

Fig. 13 Course of Barn Temperature

A summary of comparisons for each year and the average of the three trials is presented in Table VII. These results show that the heifers in the warm barn made average daily gains in weight of 0.83 lb compared to 0.52 lb for the group in the cold barn.

Total feed consumption, which includes hay and silage, is expressed as hay equivalent. This value is obtained by dividing the pounds of silage consumed by three and adding this to the pounds of hay. The average for the trials shows that the heifers in the cold barn consumed 4.7 lb more feed, as hay equivalent, than those in the warm barn.

To produce a pound of gain in the cold barn, feed requirements for the three trials averaged 31.1 lb hay and 38.4 lb silage or 43.8 lb as hay equivalent, compared to 13.9 lb of hay and 24.6 lb silage, or 22.2 lb as hay equivalent for the warm barn heifers. These differences calculated on a percentage basis show that to produce a pound of gain in the heifers housed in the cold barn, the feed requirements were greater by 123.7 per cent for hay, 56.1 per cent for silage and 97.3 per cent for total feed as hay equivalent than for those in the warm barn. The average temperature difference of the two barns was 14.5° F. for the three trials.

When the gains during the entire trial periods are averaged for the three trials and the results are expressed in terms of percentages, the data show that the heifers in the cold barn gained 12.6 per cent in weight, 6.4 per cent in chest circumference and 4.5 per cent in height at withers as compared to 20.1, 14.2 and 9.3 per cent respectively for the heifers in the warm barn.

Breed differences were observed (Table VIII) which indicated that

Table VII

Results of housing heifers in a cold barn versus a warm barn.

	1947-1948		1948-1949		1949-1950		3 yr. ave.		
	Cold barn	Warm barn	Cold barn	Warm barn	Cold barn	Warm barn	Cold barn	Warm barn	Difference of 3 yr. ave.
No. heifers included	9	9	11	11	8	8	9.3	9.3	
Daily weight gain per heifer (lb)	0.48	0.73	0.47	0.74	0.63	1.03	0.52	0.83	0.31
Daily hay equivalent per heifer (lb)	21.1	17.6	23.9	18.2	23.6	18.7	22.8	18.1	4.7
Feed Consumption per lb gain:									
Hay (lb)	30.1	15.2	36.2	15.1	27.0	11.5	31.1	13.9	17.2
Silage (lb)	41.6	27.6	42.2	27.1	31.5	19.2	38.4	24.6	13.8
Hay Equivalent (lb)	43.9	24.3	50.1	24.5	37.5	17.9	43.8	22.2	21.6
Percentage gain per group									
Weight (%)	12.2	18.4	10.5	17.0	15.3	25.0	12.6	20.1	7.5
Chest circumference (%)	8.2	14.2	4.0	14.0	6.9	14.6	6.4	14.2	7.8
Height at withers (%)	4.9	9.3	3.2	7.7	5.6	10.8	4.5	9.3	4.8

Table VIII

Effects of cold and warm housing on different breeds of dairy heifers.

	Holsteins		Brown Swiss		Guernseys		Jerseys	
	Cold barn	Warm barn	Cold barn	Warm barn	Cold barn	Warm barn	Cold barn	Warm barn
No. heifers included	13	13	6	6	6	6	3	3
Ave. gains per heifer								
Weight (lb)	78	127	75	104	75	106	102	153
Chest circumference (in.)	4.4	8.2	3.5	8.4	4.8	8.1	3.5	9.8
Height at withers (cm)	5.3	10.6	4.1	9.8	7.7	11.0	6.9	11.9
Percentage gain per heifer								
Weight (%)	11.0	17.7	12.3	16.1	12.6	18.5	20.9	34.5
Chest circumference (%)	7.2	13.7	6.0	14.6	8.5	15.1	6.4	19.4
Height at withers (%)	4.3	8.8	3.5	8.4	6.8	10.0	6.4	11.7

Holsteins in the warm barn gained 127 lb (17.7 per cent) in weight compared to 78 lb (11.0 per cent) gain for those in the cold barn. Brown Swiss in the warm barn gained 104 lb (16.1 per cent) in weight, while those in the cold barn gained 75 lb (12.3 per cent). Guernsey heifers in the warm barn gained 106 lb (18.5 per cent) in weight, while those in the cold barn gained 75 lb (12.5 per cent). Jersey heifers showed the greatest gain in weight with those in the warm barn making a gain of 153 lb (34.5 per cent) as compared to 102 lb (20.9 per cent) for the heifers in the cold barn.

Chest circumference measurements showed the Holstein heifers housed in the cold barn gained 4.4 in. (7.2 per cent) as compared to 8.2 in. (13.7 per cent) or 3.8 in. (6.5 per cent) more for those in the warm barn. Brown Swiss in the cold barn gained 3.5 in. (6 per cent) in chest circumference compared to 8.4 in. (14.6 per cent) for the warm barn heifers. Guernseys housed in the cold barn gained 4.8 in. (8.5 per cent) in chest circumference as compared to 8.1 in. (15.1 per cent), which is 3.3 in. (6.6 per cent) more for the heifers housed in the warm barn. Jersey heifers in the cold barn gained 3.5 in. (6.4 per cent) in chest circumference as compared to 9.6 in. (19.4 per cent) or 13.0 per cent more for those in the warm barn.

Growth efficiency as measured in height at withers showed that the cold barn Holstein heifers gained 5.3 cm (4.3 per cent) as compared to a gain of 8.2 cm (8.8 per cent) or 4.5 per cent more for those in the warm barn. Brown Swiss in the cold barn gained 4.1 cm (3.5 per cent) as compared to 9.8 cm (8.4 per cent) or 4.9 per cent more for the heifers in the warm barn. Guernseys housed in the cold barn gained

7.7 cm (6.8 per cent) as compared to 11.0 cm (10 per cent) or 3.2 per cent more for the warm barn heifers. Jerseys housed in the cold barn gained 6.9 cm (6.4 per cent) as compared to 11.9 cm (11.7 per cent) or 5.3 per cent more for the heifers in the warm barn.

The data just presented show that the rates of growth varied somewhat with the different breeds of dairy heifers. Some of these variations may be shown in a general way by a ranking of the breeds. Since the increase in weight is perhaps the most important single measurement used, the breeds are listed below in decreasing order of their average gains in weight for the three trials.

	Warm barn group		Cold barn group	
	Gain in wt.	Percentage gain	Gain in wt.	Percentage gain
1.	Jersey	Jersey	Jersey	Jersey
2.	Holstein	Guernsey	Holstein	Guernsey
3.	Guernsey	Holstein	Guernsey	Brown Swiss
4.	Brown Swiss	Brown Swiss	Brown Swiss	Holstein

It is evident that the Jersey heifers made the greatest gains both in actual weight and percentage wise under the conditions of these experiments. There are some factors which may explain these greater gains. The number of Jerseys in these trials was less than for the other breeds. Since the average age of the Jersey heifers was two months less than for the other breeds, they were smaller and in a more rapid stage of development. With each animal receiving 20 lb of silage the smaller Jerseys had more available feed in proportion to their size than did the other heifers. It is therefore believed that little importance should be placed in the greater gains made by the Jerseys.

SUMMARY AND CONCLUSIONS

A housing experiment for yearling dairy heifers was conducted over three winter seasons, using a warm, insulated barn for one group and a cold, uninsulated barn for the other. Growth rates and the amount of feed consumed were determined for each group.

Weekly average temperatures for the entire experiment ranged from 29 to 60° F. in the warm barn compared to a range of 5 to 48° F. in the cold barn. The lowest temperature recorded was 2° F. below zero in the cold barn. Temperature fluctuations were much greater in the cold barn than in the warm barn.

The heifers in the cold barn consumed 26.0 per cent more feed, as hay equivalent, than those in the warm barn.

The heifers in the warm barn made greater gains by 7.5 per cent in weight, 7.8 per cent in chest circumference and 4.8 per cent in height at withers than those in the cold barn.

Heifers in the warm barn made greater gains and consumed less feed than those in the cold barn. Calculations of total feed consumed, as hay equivalent, to produce a pound of gain show that 97.3 per cent more feed was required for the group in the cold barn.

Comparisons were made of growth rates and feed consumption of different breeds of dairy heifers housed in the cold and warm barns. Due to age differences and lack of sufficient numbers in some of the breeds, the results were not conclusive.

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