

To the Graduate Council:

I am submitting herewith a thesis written by Ronnie Ray Nease entitled "Complete Rations Utilizing Hay or Corn Silage for Dairy Calves." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

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Thesis

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COMPLETE RATIONS UTILIZING HAY OR CORN SILAGE
FOR DAIRY CALVES

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Ronnie Ray Nease

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ABSTRACT

Thirty-two Holstein and 13 Jersey heifer calves in 1974-1975 and 34 Holstein and 9 Jersey heifer calves in 1975-1976 were individually fed the following rations: (a) 1:1 ratio of hay to grain (16% crude protein), (b) 2:1 ratio of corn silage to grain plus soybean meal, and (c) 4:1 ratio of corn silage to grain plus soybean meal from birth until 29 weeks of age. The soybean meal was added to make all rations isonitrogenous. Average daily gains (lb) for the Jerseys and Holsteins on each treatment in 1974-1975 were: (a) 1.06, 1.73; (b) 1.12, 1.82; and, (c) 1.02, 1.74 and in 1975-1976 were: (a) 1.06, 1.60; (b) .95, 1.63; and, (c) .97, 1.53. There were no significant differences in height at withers, length, and paunch circumference in either year.

Also, nine Holstein bull calves were used to determine the digestibility and retention of the complete feeds at 4, 17, and 29 weeks. Within an age group, there were no significant differences in dry matter digestibility, acid detergent fiber digestibility, acid detergent lignin digestibility, nitrogen digestibility, and phosphorous and nitrogen retention. Over time dry matter digestibility and calcium and phosphorous retention at four weeks were significantly higher than at 17 or 29 weeks with calcium and phosphorous retention being significantly higher than at 29 weeks. Nitrogen digestibility and retention were significantly higher at four weeks than for later ages.

This data suggest that Holstein and Jersey calves may be raised successfully on complete feeds containing corn silage. Also as these heifers become older their rate of gain can be predicted by the amount of digestible dry matter consumed.

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CHAPTER I

INTRODUCTION

The concentration of dairy cattle into large herds has caused re-evaluation of many of the traditionally recommended methods of supplying nutrients to dairy cattle. This change has been responsible for dairy-men placing more emphasis on automation and specialization. To help reduce labor requirements and maximize automation, some dairymen and feed manufacturers are blending the concentrate and forage portions to form a complete or blended feed.

Complete rations are quantitative blends of all diet ingredients. These ingredients are mixed thoroughly to prevent separation and sorting, and may be formulated to specific nutritional requirements. These feeds are usually offered ad libitum. Intake of many different ration ingredients consumed by the animal can be controlled without the management difficulties encountered when the forages and concentrates are fed separately.

The objectives of this study were to determine whether complete feeds containing corn silage could be used for raising young calves and to determine what ratio of forage:concentrate the complete feed should contain.

CHAPTER II

REVIEW OF LITERATURE

As the limitations of conventional feeding systems become more widely recognized, alternatives and modifications are being sought which increase the accuracy with which diets are formulated and consumed. The desirable alternatives are labor efficient and facilitate the use of least cost formulation techniques. The usual procedure in the conventional stanchion or tie-stall barn was to offer cows forages free-choice plus a grain mixture fed individually according to feeding guides which reflect the quality and quantity of forage eaten by the herd. Also, individual requirements for nutrients based upon lactation number, body size, milk quantity, milk fat content and gestation were considered.

With the advent of automated milking parlors and group housing, new problems have arisen. Automation has reduced the time cows spend in the parlor, thus high producers do not have enough time to eat required grain. By adding a base amount of grain to the forage which was fed outside in a bunk, dairymen tried to alleviate this problem. This did not correct the problem because low producers sometimes consumed too much energy and high producers did not get the correct protein-energy ratio necessary for them to produce to their full genetic potential.

Various methods have been utilized in attempts to provide the right protein-energy ratio for all cows in a herd. Forages and concentrates

have been fed separately to groups or to individuals, feeding all the ration in a blended form either to groups or to individuals, and ensiling all feed ingredients together into a complete ration.

Much of the early research (McCoy, 31) on complete rations was conducted with by-product roughages including corn cobs, cottonseed hulls, and rice hulls. This study was conducted in the era of expensive forage, inexpensive grain and minimum forage.

In the past, dairy nutritionists were slow to recognize the advantages of complete feeds for dairy cattle. Reasons for this could be the large range in milk production and corresponding variations in nutrient requirements present within any herd. Reviews by Rakes (38) and Coppock (9) show several advantages and disadvantages of complete feeds. Included among the advantages are:

- I. No expression of choice was permitted among available feeds and each bite was a uniform, nutritionally complete diet.
- II. Free-choice of mineral supplements was unnecessary.
- III. Complete rations result in few digestive upsets early in lactation as cows are changed from a high forage to a high concentrate diet.
- IV. By using a specific and obligatory ratio of forage to concentrate, one can prevent cases of milk fat depression by insuring a minimal fiber level.
- V. The percentage of crude protein desired in total ration of the cow can be controlled.
- VI. Total diet of the cow can be quantitatively formulated.

Included among the disadvantages are:

- I. Hay stored as long form or in a bale must be chopped before blending.
- II. Mixer wagons are expensive.
- III. This method was not economical for small herds and herds on pasture, especially during the pasture season.
- IV. More calculations are necessary on the farm to implement the use of complete feeds.

The protein level of complete feeds which will give maximum production has been a major concern among dairymen. Rakes (38), in a review of complete feeds, indicates that the amount of protein consumed by dairy cattle can be controlled and that a 13 or 14% crude protein level will support milk production similar to that achieved with conventional rations.

One concern of dairymen in using complete feeds has been the health problems which may occur from prolonged feeding of these complete rations. Rumen parakeratosis (5, 10), liver abscesses (12), bloat (23), and joint stiffness (23, 25) have been associated with feeding ruminants complete rations that contain less than 50% forage.

There are many different kinds of forages which may be used in complete feeds. Some of the different forages which have been used are: hay (27, 26, 36, 40, 44, 53), pineapple hay and bran (25, 41), corn cobs (27, 31, 32), cottonseed hulls (27, 31, 32), straw (16), silage (16, 19, 34, 8, 20, 22), haylage (34, 22), waste paper (24), ground polyethylene (13), and oyster shells (57). Many dairymen encounter problems in obtaining a reliable and economical source of these ingredients.

Performance of Lactating Cows Fed Complete Feeds

Feed intake and milk production have been approximately the same for cows fed complete feeds as compared with the conventional method of feeding the forage and concentrate portion of the ration separately. Komkris et al. (25) compared the feeding of complete feeds with feeding of the concentrate and forage separately. No significant differences attributable to the feeding procedures were noted in 4% fat-corrected milk production. Stanley and Morita (44) reported that when cows were fed approximately the same amounts of individual feeds, either blended or separately, no significant differences in milk production or milk composition resulted.

Villavincencio et al. (53) fed ~~a conventional ration with the con-~~centrate and forages offered separately and three complete feeds containing one percent urea and different sources of forages. These rations were fed to four groups of lactating cows for a 120-day period. The milk production levels of the different groups were not significantly different, but a significantly larger amount of the ration containing cottonseed hulls was consumed. Using relatively low producing cows, Putnam and Davis (36) compared a conventional hay and concentrated ration with two pelleted complete feeds containing 25 and 80% hay. Milk production of the cows fed the low roughage pellets was higher than that of either of the other two groups. These differences, however, were not statistically significant. In another trial (36), cows fed the high roughage pellets produced slightly less milk than the control group.



Fosgate et al. (15) compared the ad libitum feeding of two blended rations, one containing 40% cottonseed hulls and Coastal Bermudagrass pellets and the other containing 30% of the same roughage, with either ad libitum feeding of both corn silage and concentrate, or ad libitum feeding of corn silage and controlled feeding of concentrate. Similar levels of milk production and feed consumption were reported for the cows on all of the treatments.

Leighton and Rupel (26) studied the effects of feeding complete rations containing 30% of several different forages. A control ration consisting of hay and corn silage plus 16% protein concentrate was also fed. Daily 4% fat corrected milk production of the cows fed the complete feed containing chopped alfalfa was not significantly different from the milk production of the control animals. The other groups produced significantly less milk than the control animals.

Thurmon et al. (48) fed lactating cows a complete ration containing 30% hay ad libitum. These animals produced significantly more 4% fat-corrected milk than either the cows fed both hay and concentrate ad libitum, or those fed hay ad libitum and concentrate at the rate of one kilogram to each two and one-half kilograms of 4% fat-corrected milk produced daily. The intake of the group consuming the complete ration was significantly lower than that of those receiving both hay and concentrate ad libitum.

Lactating cows were group fed corn silage containing 100, 50, and 0% of the concentrate portion of the ration as reported by Muller et al. (30). The remaining portion of the concentrate mixture for the latter two treatments was fed in the milking parlor. The method of feeding

had no significant effect on 4% fat-corrected milk production.

The depression of the fat percentage in cow's milk by feeding rations which contain high proportions of concentrates has been observed repeatedly. Complete feeds seem to be particularly noted for this adverse effect on fat percent. The inclusion of only 20% forage in a complete feed can be expected to cause the cow to secrete milk containing a relatively low percent of fat as reported by Emery et al. (13) and Leighton and Rupel (26). Although some exceptions have been noted even with complete feeds containing 40% roughage as reported by Welch and Maddux (55), 30% seems to be the level below which a definite drop in the fat content can be expected.

Researchers are concerned about the problem of low producers or non lactating cows becoming obese or too fat by consuming a high energy complete feed, while the energy might be needed by the high producing cows. Optimum ratio of forage to concentrate throughout the lactation has not been established because conflicting results are reported in the literature. It seems difficult to have a feed high in energy which would not cause body fat deposition in low producers or non lactating cows. Coppock et al. (8) conducted an experiment which compared the effect of four forage-to-concentrate ratios in complete rations on the ad libitum feed intake and the production performance of lactating cattle over an entire lactation. The four complete rations were fed from four weeks prepartum through 44 weeks of lactation. Average consumption of all four rations was essentially the same. These workers concluded that lactating cows do not regulate their intake according to their energy requirements. They suggest that rations composed of silage and relatively

large amounts of concentrates need to be modified during different stages of lactation to fit changing requirements.

Everson et al. (14) ~~studied~~ another type of feeding regime to use with complete feeds. They compared feeding one group of cows a constant 60:40 forage-to-concentrate complete feed while feeding another group a variable ration of 50:50 for the first 21 weeks of lactation, a 65:35 ration for the next 23 weeks, and an 85:15 ration during the 8-week dry period. These researchers reported that the group receiving the constant ration performed as well as the group receiving the variable energy ration. According to Van Dijk (51), it appears that a ratio of 50:50 to 60:40 forage-to-concentrate would be about optimum if a constant ratio complete feed must be used throughout a lactation. Various grouping systems have been used for more efficient management of a dairy herd while determining the optimum forage-to-concentrate ratio and efficiency of complete feeds during different stages of lactation.

Performance of Dairy Calves Fed Complete Rations

With the onset of the use of complete feeds for feeding dairy cattle, interest has increased in the use of complete feeds for dairy calves. By being able to use this type of feeding system, one could group feed calves at an earlier age and use more automation in feeding. This would curtail the amount of labor needed to feed calves, a very important expense item today; however, people have been reluctant to try this because there is little data on the growth of calves fed complete rations.

One question, which has been raised regarding feeding of complete feeds, was whether the rumen can develop enough at this early age to utilize this type of ration. According to Swanson and Harris (46), the

appearance of rumen contents of calves sacrificed at 12-22 days of age indicate that more than half of the 26 calves in their experiment were ruminating effectively at two weeks of age. These calves were also observed for a full day's time each two weeks from one-two to 15-16 weeks of age. Rumination had begun in 18 of the calves in the first two weeks, 25 in the second two weeks, and all calves in subsequent periods.

Researchers have cautioned against the use of silage for young calves. The Iowa Experiment Station (21) concluded that silage is desirable for calves as early as the calves will eat the silage. They found that silage gave increased weight gains, seemingly thriftier calves, and more economical advantages than with rations without silage.

Contradictory to this, Shepherd and Converse (43) concluded that silage is not a suitable feed for the young calf. They claim that the addition of this feed to the ration is likely to cause digestive disturbances and scours. Furthermore, according to Shepherd and Converse (43), it is desirable that the calf eat as much hay as possible during its first three months. After that, however, silage makes a desirable feed to supplement hay.

The only problem of feeding silage that both Shepherd and Converse (43) and the Iowa Experiment Station (21) found was that care should be taken not to feed any moldy or frozen silage, and to remove any uneaten silage from the manger each day.

Gardner (17) fed alfalfa hay, alfalfa silage, and corn silage to 21 new-born calves. He found that when the effect of birth weight differences was considered, the differences in gains were not significant.

Kesler and Spahr (23) also raised Holstein calves from birth to 20 weeks of age on ad libitum feeding of alfalfa-grass hay and corn silage. They found that differences in gains in body weight, chest circumference, and in height at withers of both groups were not statistically significant. He concluded that good-quality corn silage is a satisfactory roughage for young Holstein calves.

Grieve et al. (18) compared corn silage, corn silage-wilted hay silage, and blended corn silage-chopped hay fed to three week old calves. All the rations were isonitrogenous and the feed intakes between groups were not different. They found that the calves fed only corn silage had a slight weight advantage throughout the trial, which is probably due to the higher energy concentration of corn silage. Grieve et al. (18) also concluded that dairy heifers can be raised successfully on diets based on corn silage as the only forage supplemented with additional protein.

White and Kuelling (56) considered a gain of 1.25 pounds/day to be evidence of good growth. Thus, in an experiment where silage was fed as a supplement to skim milk, the gains of calves and their general good health at six months of age indicated that silage, grain, and hay were as desirable as supplements to skim milk as grain and hay are alone.

Adequate growth for young calves can also be attained by use of complete feeds that contain forages other than silage. Clifton and Fowler (6) fed Holstein and Jersey heifers from eight weeks to six months either hay and grain or an all-in-one ration ad libitum. The all-in-one mix contained 50% grain mix and 50% bulky, fibrous mix composed of equal parts citrus pulp, soybean hulls, Coastal Bermudagrass pellets,

and cottonseed hulls. The Holstein and Jersey heifers fed the hay and grain ration gained .81 and .46 kilograms/day, respectively, whereas those fed the all-in-one ration gained .99 and .68 kilograms/day, respectively. The all-in-one group, however, required more feed/kilogram gain than did the control groups.

Clifton and Fowler (7) fed Holstein and Jersey female calves four all-in-one rations from birth to 16 weeks. The rations contained either ground Coastal Bermudagrass, cottonseed hulls, pelleted corn cobs, or a combination of the above ingredients. Differences in weight gains approached significance, but total feed consumption did not vary significantly among treatments. The only problem encountered was that the pelleted corn cobs were sorted out and refused by some calves, particularly at early ages.

Waldern and Nelson (54) fed three-day-old calves rations which contained a complex 20% protein calf starter plus varying amounts of chopped alfalfa hay. Average daily gain (kg) and feed dry matter/kilogram gain of the calves in the four groups to 12 weeks were similar.

In work with young dairy calves, Bartley (4) self-fed a soft pelleted mixture of hay and starter (three parts starter:one part hay) which was compared with starter and hay fed separately in the conventional manner. Growth rate was measured by using the linear regression of weight/kilogram of birth weight on age. Calves fed the pelleted mixture grew significantly faster between eight and sixteen weeks than did the controls. There was no difference between birth and eight weeks. In another experiment Bartley (4) fed the pelleted ration at two protein levels. One ration contained 22% protein and the other 18% protein on a dry matter

basis. There was no significant difference between the two groups regarding amount of feed intake, but the calves receiving the 22% protein ration grew faster than those receiving the 18% protein ration.

Addanki et al. (1) compared the performance of pelleted high forage rations fed to heifer calves until 16 weeks of age. The Jersey and Holstein heifers were either fed free-choice ground alfalfa as 67% of forage, or beet pulp and soybran flakes as 57% of forage. All rations gave comparable data on growth, feed consumption, digestibility, and efficiency of feed utilization.

A complete starter of steam processed flaked milo and barley plus 20% alfalfa pellets was compared to steam rolled milo and barley and to steamed processed flaked milo and barley by Schuh et al. (42). The average daily gain of the groups was not significantly different, but in one trial the total feed/kilogram gain for the complete ration was less than the other rations.

Lima et al. (28) compared a complete feed consisting of steam processed flakes of milo and barley plus 20% dehydrated alfalfa pellets with rations of either steam rolled milo and barley and rations of steam processed flakes of milo and barley. The complete ration gave average daily gains comparable to the other rations, but it took fewer kilograms of feed/kilogram gain than the other rations to achieve this growth.

Miller et al. (29) investigated the effect of adding fiber (10% cottonseed hulls) to simplified and complex calf starters, fed as the only dry feed to four groups of eight calves each. Additions of fiber to both the simplified and the complex starters resulted in increased feed consumption and weight gains. Estimated net energy requirements

per unit of gain were similar. General appearance and incidence of diarrhea were not affected by the dietary differences. Results of this research suggest that when a starter is used as a complete feed for young calves, too low a fiber level reduces weight gains.

Digestion Trials Using Dairy Calves

A digestion trial is commonly used to determine the digestibility of chemical components of a feed. The simplest digestion trial consists of feeding animals a specific feed or feeds for a certain period so that the animal becomes accustomed to the feed, then feeding the specific feed for a collection period. The digestion trial can be used to measure the energy, protein, and other nutrient values of feeds.

Addanki et al. (1) using digestion crates, studied the digestibility of three forages with male calves. At 16 weeks of age, the calves were placed on a five day digestion, balance trial in which they were fed either ground alfalfa, beet pulp, and soybran flakes. From this trial it was concluded that beet pulp and soybran flakes can be used as a highly digestible source of energy in complete rations.

CHAPTER III

EXPERIMENTAL PROCEDURE

Objective

The objectives of this study were to determine whether complete feeds containing corn silage could be used for raising young calves and to determine what ratio of forage:concentrate the complete feed should contain. Dry matter intake, digestibility, growth, and weight change of dairy calves fed complete feeds containing corn silage and grain versus chopped hay and grain were measured.

Experimental Animals

The data used in this experiment were collected on 32 Holsteins and 13 Jerseys in 1974-1975 and 34 Holsteins and 9 Jerseys in 1975-1976. Also, 9 Holstein males were used for the digestion trial. These animals were from the Holstein and Jersey herds of the University of Tennessee located at Knoxville, Tennessee.

Design of Experiment

A continuous type feeding trial was conducted with the female calves being assigned to one of the experimental rations at birth. In 1974-1975 both Jerseys and Holsteins were assigned to blocks based on birth order within breed. Each block consisted of nine pens. Two Holsteins and one Jersey were randomly assigned to each ration. The assignment of calves to pens was also randomized within each block. Sufficient replication was utilized to allow the detection of a 10% difference in

means 80% of the time. The animals remained on the experiment for six months.

In 1975-1976 both Jerseys and Holsteins were assigned to pens based on birth order within breed. The assignment of calves to pens and rations was randomized. Sufficient replication was utilized to allow the detection of a 10% difference in means 80% of the time. The animals remained on the experiment for six months. Also, nine male calves were saved and used to determine ration digestibility at 4, 17, and 29 weeks of age.

Management-Growth Trial 1974-1975 and 1975-1976

The animals were housed in individual pens in the calf barn after remaining with the dam for two or three days. Care was taken to insure that each calf received ample colostrum during the first few hours post-parturition.

Milk replacer (one pound/nine pounds water) or unsaleable whole milk (from fresh or antibiotic treated cows) was fed to each calf individually at the level of 10% of body weight for six weeks. All calves were weaned at six weeks. Forage feeding (three experimental rations) was offered to each calf during the second week. Feed consumption data were collected beginning with the third week. The three treatments imposed were as follows:

- I. Mixed alfalfa-grass hay of medium chop and a 16% protein grain mixture mixed and fed in a one:one ratio to maintain approximately 16% crude protein (dry matter basis) for the total ration.

- II. Corn silage and a 16% crude protein grain mixture mixed and fed in a two:one ratio (as fed) plus sufficient soybean oil meal to maintain 16% crude protein (dry matter basis) for the total ration.
- III. Corn silage and a 16% crude protein grain mixture mixed and fed in a four:one ratio (as fed) plus sufficient soybean oil meal to maintain 16% crude protein (dry matter basis) for the total ration.

Digestibility Trial 1975-1976

The male calves were housed and managed as the heifers were until they reached 17 weeks of age. At this time they were moved to group pens. Feed intakes and growth rates were determined in the same manner as with the females. The male calves were fed the same ration as the females.

For the digestion trial, the male calves were moved to the Animal Science Metabolism room at 4, 17, and 29 weeks of age. A four day adjustment period was used prior to the digestion trial. Feces and urine were collected separately for determining nitrogen balance. Sheep crates were used at four weeks and cattle crates at 17 and 29 weeks of age.

Data Collection 1974-1975 and 1975-1976

Body weights were taken at birth, and at weekly intervals thereafter for the remainder of the experiment. Beginning at one week of age and each week thereafter to 29 weeks of age wither height, body length, and paunch circumference were determined for each animal. The individual feed weights of the rations fed and refused were recorded daily. Moisture determinations were run on the feeds weekly and saved for chemical analysis.

Chemical Analysis

Weekly samples of the three rations were collected and analyzed for dry matter content, crude protein, acid-detergent fiber, lignin, ash, calcium, and phosphorous. The fresh samples were dried in a 60°C drying oven for three days and air equilibrated for two days to give the air dry, dry matter content. Total dry matter was determined by placing the samples in a 100°C oven overnight. Feeds, feces, and urine were analyzed for nitrogen content by the Kjeldahl method (2). Acid-detergent fiber (ADF) and lignin were determined by the method of Van Soest (52). Calcium was determined by the method developed by Perkin and Elmer (39). Fiske and Subbarow (35) method was used for the phosphorous determination, ash was determined by ashing an air dry sample overnight at 500°C in an ashing oven.

Statistical Analysis

The data were analyzed statistically with appropriate statistical methods. The Statistical Analysis System (SAS) was utilized for computational purposes (3).

Statistical analysis for differences between treatments for the growth and digestion trials were determined by analysis of variance. If differences existed, as determined by F test, then means were separated using Duncan's Multiple Range Test (45).

The figures of the growth measurements were made by plotting best fitting polynomials across rations. Table 12* contains the intercept and regression coefficients used in plotting the growth measurement curves.

*All tables and figures may be found in the appendix.

CHAPTER IV

RESULTS AND DISCUSSION

Growth Trial. The chemical composition of the complete feeds is presented in Table 1. The hay and grain ration (Ration I) had the highest dry matter (89.0%) with Ration III having the lowest dry matter percentage (44.8%). Even though Rations II and III both contained corn silage the difference in the dry matter was caused by the forage:grain ratio. Ration III contained more corn silage and less grain than did Ration II. All rations were computed to be isonitrogenous by adding soybean meal and were similar in the amount of crude protein within years. The percent crude protein was less for 1975-1976, however. The hay and grain ration was higher in acid detergent fiber and Ration III was higher than Ration II because more silage was present. Ration I was highest in acid insoluble lignin because the hay used was primarily alfalfa, which is naturally high in lignin. In 1975-1976 the hay and grain ration contained 10.39 mg/gram of calcium, whereas, Ration III contained the smallest amount of calcium. The fact that alfalfa hay is fairly high in calcium while corn silage is lower in calcium accounts for this difference. Phosphorous content of the three rations was different, with Ration II being the highest and Ration III the lowest.

The daily dry matter consumed at various ages is listed in Table 2. Within years there was very little difference in the amount of dry matter consumed, but there was a difference between years. Also, the amount consumed by the breeds was different. The Holsteins consumed

more dry matter per day than did the Jerseys. The animals progressively consumed more dry matter as they became older.

The growth of the heifers increased at a consistent rate on all rations as shown in Table 3. The average daily gain (ADG) to date increased with age in both the Holstein and Jersey heifers. The Holstein heifers in 1974-1975 on Ration II had, at 8, 16, and 29 weeks of age, an ADG of .83, 1.36, and 1.82 lbs., which was comparable to Rations I and III. This ADG was lower than the Beltsville growth standards (49) and those reported by Davis (11), NRC (33), and Ragsdale (37) at 8 and 16 weeks, but exceeded the ADG of all standards by 29 weeks of age. This ADG was also less than that reported by Gardner (17), Kesler et al. (24), and Grieve et al. (18) at 16 weeks. In 1975-1976 the ADG of the Holstein heifers was again comparable between rations but was less than in the previous year. The ADG of the heifers was slightly less than the Davis (11), NRC (33), Ragsdale (37), and Beltsville (49) growth standards. The Jersey heifers had a lower ADG than the Holstein heifers, which was expected, but within years the ADG of the Jerseys was not very different. As with the Holstein heifers, the Jersey heifers in 1974-1975 had a higher ADG than those in 1975-1976. The ADG of the Jerseys did not achieve the Beltsville, NRC (33) and Ragsdale growth standards (50, 33, 37) in either year.

Table 4 lists the period average daily gain (PADG), which is the weight change difference between two consecutive weeks divided by seven days. This allows one to examine the ADG within a certain period to help determine the animal's growth progress. Both the Holstein and Jerseys displayed a PADG which increased until about 24 weeks, then

then started to decline slowly. These animals exhibited a PADG pattern similar to the Beltsville growth standards (49, 50) for both Holstein and Jerseys.

There were several other measurements examined to help determine whether silage can be used in a complete feed for young calves. Body weight of the Holsteins and Jerseys is listed in Table 5. There were no detectable significant differences between rations for either breed, with the Holstein heifers at 29 weeks weighing 435, 450, and 442 for Rations I, II, and III, respectively in 1974-1975. In 1975-1976 the Holstein heifers weighed less than they did in the previous year. The Jersey heifers also weighed less in 1975-1976 than they did in the previous year, with the weight of the Jersey heifers at 29 weeks of age on the three rations being I = 265, II = 278, and III = 257, whereas, in 1975-1976 the weight was I = 267, II = 246, and III = 242. The Holstein heifers in 1974-1975 exceeded the NRC (33), the Beltsville (49), and Davis (11) growth standards and Swanson's (47) proposed economical growth curve, while the Holstein heifers in 1975-1976 only exceeded Swanson's growth curve. The Jersey heifers in both years did not exceed the recommended growth curves (50, 33) and growth reported by Grieve (18), but did grow better than Swanson's (47) economic growth curves for Jerseys.

The growth curves for both breeds and years are shown in Figure 1. The heifers on all rations gained weight at the same rate within breed. After 50 days, the Holsteins and Jerseys ~~did not gain weight~~ at the same rate because the Holsteins were larger animals and had higher ADG than did the Jerseys. As in the previous year, the Holstein heifers in 1975-

1976 gained weight at a faster rate after 50 days than did the Jerseys.

Another parameter measured to help determine growth was wither height. There was no significant difference between rations for both breeds for either year as shown in Table 6. The Holstein heifers in 1974-1975 at 24 weeks of age had wither measurements of 41.0, 40.7, and 40.6 inches for Rations I, II, and III, respectively. Holsteins for both years exceeded the growth standards of Ragsdale (37) for wither height. Figure 2 illustrates that the Jerseys and Holsteins grew in wither height at the same rate, with the two breeds growth curves being paralleled. The Holsteins and Jerseys in both years grew at the same rate for all rations.

A third measurement taken to determine growth was the length down the topline from the anterior of the shoulder blades to the first caudal vertebra. There was no significant difference between rations for either breed as shown in Table 7. At 29 weeks of age the lengths of the Holsteins and Jerseys in 1974-1975 were I = B_1 40.5, B_2 36.0; II = B_1 40.9, B_2 36.1; and III = B_1 41.6, B_2 35.0 inches. In 1975-1976 the length measurements were similar to those in the previous year. When length is plotted against age (Figure 3), it indicates that the breeds grew at the same rate in length with their curves being parallel.

The final growth measurement was paunch circumference. It was felt that this was a very important measurement because it indicated whether the calves on the silage rations would develop what is commonly called "pot belly," or would be comparable to the conventional hay and grain ration. As shown in Table 8, the paunches circumferences of calves on all rations increased steadily from 4 weeks to 29 weeks, with the Holsteins

in 1974-1975 averaging about 67.5 inches at 29 weeks. Even at 12 weeks of age, the paunch circumferences of the Jerseys in 1975-1976 on Ration I were 41.0 inches, on Ration II 42.3 inches, and on Ration III 41.0 inches. There were no significant differences between rations for either breed for both years.

When the curves of paunch circumference are examined against time (Figure 4) at about 50 days, it can be seen that the rate of growth of the paunch increased much more rapidly. This could be because at this age the animals were depending solely upon the complete rations for their nutrients, since they were removed from milk at six weeks of age.

Digestion Trial. The composition of the complete feeds fed during the three digestion trials at 4, 17, and 29 weeks of age is listed in Table 9. The components of the feeds differ, with the main difference being in the dry matter content. In Table 10 is listed the composition of the milk fed during Trial 1. Listed in Table 11 is the digestibility and calcium and phosphorous retention of the complete feeds. The dry matter digestibility of the three rations, which are not significantly different are I = 82.03%, II = 83.00%, and III = 79.71%. There is also no significant difference between rations for acid detergent fiber digestibility, lignin digestibility, calcium and phosphorous retention, nitrogen balance, and nitrogen digestibility. Although there are some differences between rations, the number of animals available was not large enough to determine a difference.

In Trial 2, as in Trial 1, there were no significant differences between digestibilities and retention of calcium and phosphorous.

The complete feeds fed in Trial 3 were comparable to the rations fed in digestion Trials 1 and 2. In Table 11 is the digestibility and utilization of the rations, which were not significant between rations for dry matter digestibility, acid detergent fiber digestibility, lignin digestibility, phosphorous utilization, nitrogen balance, and nitrogen digestibility. Calcium retention, however, was significantly higher ($P < .05$) for Ration I than for either Ration II or III. The reason for this large difference in utilization of calcium was that Ration I contained mostly alfalfa hay which is higher in calcium than either of the two silage rations.

When the digestion trials were tested statistically at 4, 17, and 29 weeks of age, it was found that the digestibility and mineral retention of the feed components changed over time (Table 11). Dry matter digestibility of Trial 1 was significantly higher ($P < .05$) when compared with Trials 2 and 3. The dry matter digestibility of Trial 1 was higher because milk composed most of the diet at four weeks and a very limited amount of complete feed was consumed. Acid detergent fiber digestibility and lignin digestibility of the three trials were not significant at the three ages. This was caused by the variability which existed within each digestion trial. Calcium retention was the highest at 29 weeks and was significantly higher ($P < .05$) than Trials 1 and 2. Animals in Trial 2 retained significantly ($P = .05$) more calcium than did the animals in Trial 1. Phosphorous retention also increased as the animals became older, with those in Trial 3 utilizing significantly ($P < .05$) more phosphorous than did the animals in Trials 2 and 1. Also, in Trial 2 the bulls retained significantly ($P < .05$) more phosphorous than did those in Trial 1.

Trial 2 had the highest nitrogen digestibility while Trial 1 had the lowest.

The Holstein and Jersey heifers in both years on all rations grew at the same rate. The ADG, body weight, wither height, length, and paunch circumference of all heifers were similar. When the results of the digestion trial were applied to the growth trial, this same effect also showed up. The daily digestible dry matter consumed increased steadily from 4 weeks to 29 weeks, with no difference between rations. At 4 and 17 weeks of age, the animals which consumed the most digestible dry matter did not necessarily have the highest ADG or PADG. By 29 weeks, however, the heifers consuming the most digestible dry matter had the highest ADG and PADG. This suggests that as heifers become older, their rate of gain can be predicted by the amount of digestible dry matter consumed.

CHAPTER V

SUMMARY AND CONCLUSION

Thirty-two Holstein and 13 Jersey heifer calves in 1974-1975 and 34 Holstein and 9 Jersey heifer calves in 1975-1976 were individually fed the following rations: (a) 1:1 ratio of hay to grain (16% crude protein), (b) 2:1 ratio of corn silage to grain plus soybean meal, and (c) 4:1 ratio of corn silage to grain plus soybean meal from birth until 29 weeks of age. The soybean meal was added to make all rations isonitrogenous. Average daily gains (lb) for the Jerseys and Holsteins on each treatment in 1974-1975 were: (a) 1.06, 1.73; (b) 1.12, 1.82; and, (c) 1.02, 1.74 and in 1975-1976 were: (a) 1.06, 1.60; (b) .95, 1.63; and, (c) .97, 1.53. There were no significant differences in height at withers, length and paunch circumference in either year.

Nine Holstein bull calves were used to determine the digestibility and retention of the complete feeds at 4, 17, and 29 weeks. Within an age group, there were no significant differences in dry matter digestibility, acid detergent fiber digestibility, acid detergent lignin digestibility, nitrogen digestibility, and phosphorous and nitrogen retention. Over time dry matter digestibility and calcium and phosphorous retention at four weeks were significantly higher than at 17 or 29 weeks with calcium and phosphorous retention being significantly higher in Trial 2 than in Trial 3. Nitrogen digestibility and retention were significantly higher at four weeks than for later ages.

These data suggest that Holstein and Jersey calves may be raised successfully on complete feeds containing corn silage. Also as these

heifers become older their rate of gain can be predicted by the amount of digestible dry matter consumed.

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APPENDIX

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TABLE 1. MEANS AND STANDARD DEVIATION OF CONSTITUENTS OF COMPLETE FEEDS FED TO HOLSTEIN AND JERSEY HEIFERS TO 29 WEEKS

	Ration		
	I	II	III
Dry Matter (%)			
1974-1975	89.0 $\pm$ 2.23	50.7 $\pm$ 5.06	44.8 $\pm$ 3.30
1975-1976	88.7 $\pm$ 1.20	49.8 $\pm$ 4.44	44.0 $\pm$ 3.15
Crude Protein (%) DMB ^a			
1974-1975	17.2 $\pm$.63	17.3 $\pm$ 1.16	16.8 $\pm$.85
1975-1976	16.8 $\pm$.66	16.4 $\pm$.84	16.2 $\pm$.89
Acid Detergent Fiber (%) DMB			
1974-1975	26.4 $\pm$ 2.14	19.7 $\pm$ 1.73	22.1 $\pm$ 1.29
1975-1976	25.8 $\pm$ 2.09	19.4 $\pm$ 3.86	23.1 $\pm$ 2.85
Acid Insoluble Lignin (%) DMB			
1974-1975	5.2 $\pm$.56	2.9 $\pm$.62	2.7 $\pm$.23
1975-1976	6.4 $\pm$.89	3.8 $\pm$.94	3.8 $\pm$.51
Ash (%) DMB			
1975-1976	7.6 $\pm$.55	7.4 $\pm$.43	7.0 $\pm$.40
Calcium (mg/gram) DMB			
1975-1976	10.4 $\pm$ 1.10	7.2 $\pm$ 1.26	5.7 $\pm$.80
Phosphorous (mg/gram) DMB			
1975-1976	6.3 $\pm$.78	7.3 $\pm$.92	6.1 $\pm$.77

^aDMB = Dry Matter Basis

TABLE 2. DAILY DRY MATTER CONSUMPTION BY HOLSTEIN AND JERSEY
HEIFERS FED COMPLETE RATIONS

Age (wk)	Yr ^a	Ration					
		I		II		III	
		B ₁ ^b	B ₂ ^c	B ₁	B ₂	B ₁	B ₂
		lb					
4	1	.53	.20	.63	.27	.48	.33
	2	.59	-	.54	.41	.43	.28
8	1	3.48	1.75	3.11	1.66	3.25	1.79
	2	2.87	2.14	2.69	1.68	2.33	1.29
12	1	6.21	3.91	5.40	3.55	5.49	3.02
	2	4.87	3.22	4.53	3.28	3.80	2.45
16	1	7.61	5.30	7.00	5.12	7.07	3.96
	2	6.85	4.26	5.65	4.36	5.56	3.77
20	1	9.75	6.51	8.53	6.08	9.50	5.32
	2	8.34	5.99	6.95	5.97	7.05	5.54
24	1	11.53	7.40	10.93	7.27	10.16	6.63
	2	9.44	6.94	8.92	6.78	8.28	5.66
29	1	12.81	9.09	12.81	9.01	12.23	8.12
	2	11.87	8.65	10.42	8.11	10.43	7.62

^aYr 1 = 1974-1975
Yr 2 = 1975-1976

^bB₁ = Holstein

^cB₂ = Jersey

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TABLE 3. CUMULATIVE AVERAGE DAILY GAIN (ADG) OF HOLSTEIN AND JERSEY HEIFERS FED COMPLETE FEEDS

		Ration						III	
		I		II					
Age (wk)	Yr ^a	B ₁ ^b	B ₂ ^c	B ₁	B ₂	lb			
						B ₁	B ₂	B ₁	B ₂
4	1	.36 + .17 ^d	.01 + .24	.36 + .30	.09 + .19	.18 + .16	.10 + .27		
	2	.42 + .24	.10 + .03	.32 + .32	.21 + .24	.46 + .22	.31 + .29		
8	1	.79 + .15	3.7 + .03	.83 + .19	.39 + .09	.81 + .18	.40 + .17		
	2	.85 + .22	.33 + .27	.87 + .29	.49 + .17	.79 + .09	.46 + .15		
12	1	1.06 + .11	.56 + .03	1.10 + .16	.62 + .05	1.01 + .18	.48 + .08		
	2	1.02 + .24	.56 + .18	1.00 + .16	.57 + .20	.87 + .11	.49 + .07		
16	1	1.28 + .12	.69 + .04	1.36 + .18	.77 + .08	1.24 + .20	.64 + .13		
	2	1.18 + .23	.70 + .19	1.12 + .15	.66 + .14	1.07 + .14	.63 + .05		
20	1	1.45 + .13	.85 + .02	1.54 + .16	.93 + .05	1.41 + .27	.80 + .14		
	2	1.33 + .19	.81 + .21	1.27 + .19	.82 + .14	1.21 + .18	.78 + .03		
24	1	1.64 + .12	.95 + .01	1.68 + .21	1.06 + .08	1.55 + .27	.85 + .21		
	2	1.44 + .19	.92 + .18	1.40 + .15	.92 + .12	1.36 + .17	.85 + .03		
29	1	1.73 + .17	1.06 + .04	1.82 + .23	1.12 + .03	1.74 + .22	1.02 + .13		
	2	1.60 + .23	1.06 + .17	1.63 + .10	.95 + .05	1.53 + .18	.97 + .06		

^aYr 1 = 1974-1975 ^bB₁ = Holstein ^cB₂ = Jersey ^d = Standard Deviation
 Yr 2 = 1975-1976

TABLE 4. PERIOD AVERAGE DAILY GAIN (PADG) OF HOLSTEIN AND JERSEY HEIFERS FED COMPLETE FEEDS

Age (wk)	Yr ^a	Ration					
		I		II		III	
		B ₁ ^b	B ₂ ^c	B ₁	B ₂	B ₁	B ₂
		lb					
4	1	1.13 + .58 ^d	.64 + .38	.97 + .76	.39 + .27	.77 + .30	.23 + .30
	2	1.07 + .35	.71 + .00	1.25 + .37	.90 + .30	1.29 + .61	.86 + .29
8	1	.94 + .44	.64 + .44	1.17 + .64	.61 + .43	1.46 + .89	.60 + .66
	2	1.23 + .42	.62 + .64	1.25 + .85	1.24 + .50	.85 + .56	.43 + .57
12	1	1.55 + 1.16	1.04 + .24	2.04 + .85	1.18 + .32	1.57 + 1.05	1.06 + .58
	2	1.42 + .67	1.43 + .14	1.39 + .62	1.33 + 1.07	1.07 + .64	.38 + .50
16	1	1.21 + 1.38	1.50 + .78	2.47 + 1.39	1.36 + .85	2.54 + 1.12	1.80 + 1.03
	2	2.20 + 1.46	1.52 + .91	1.78 + 1.30	1.24 + .58	2.10 + .80	1.29 + .25
20	1	1.79 + 1.09	1.25 + .21	2.44 + .50	1.21 + .66	2.86 + 3.18	1.86 + .36
	2	2.15 + .74	1.48 + .50	1.74 + .90	1.71 + .62	2.07 + .42	1.43 + .38
24	1	3.42 + 2.81	.32 + .88	1.38 + 1.77	1.71 + 1.21	2.40 + 3.42	.49 + 2.48
	2	2.21 + 1.28	-.43 + 3.71	1.70 + 1.55	2.33 + .87	1.99 + 1.50	.91 + 1.80
29	1	2.13 + 2.68	.14 + .72	.95 + 3.18	1.04 + 1.11	3.47 + 3.26	2.37 + 3.57
	2	2.27 + 1.51	2.38 + 1.46	2.90+ 1.01	.19 + 2.16	2.55 + .75	1.14 + .94

^aYr₁ = 1974-1975
Yr₂ = 1975-1976

^bB₁ = Holstein

^cB₂ = Jersey

^d = Standard Deviation

TABLE 5. BODY WEIGHT OF HOLSTEIN AND JERSEY HEIFERS FED COMPLETE FEEDS

Age (wk)	Yr ^a ₁	Ration									
		I		II				III			
		B ₁ ^b	B ₂ ^c	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂	B ₁	B ₂
1	1	89.8 + 12.6 ^d	53.5 +	85.5 + 12.3	52.0 +	90.9 +	3.2	90.9 +	7.9	54.4 +	4.5
	2	80.6 + 10.3	49.0 +	85.6 + 11.9	53.0 +	80.6 +	2.0	80.6 +	8.1	48.0 +	4.0
4	1	97.4 + 11.45	53.5 +	95.9 + 14.68	55.0 +	99.3 +	1.83	99.3 +	8.59	54.0 +	.89
	2	94.8 + 12.5	56.5 +	95.8 + 11.6	62.0 +	97.3 +	.56	97.3 +	10.2	56.7 +	.21
8	1	130.6 + 15.62	72.5 +	130.5 + 19.01	73.8 +	137.3 +	8.42	137.3 +	15.24	73.4 +	11.06
	2	129.8 + 15.8	71.0 +	133.1 + 19.4	82.3 +	127.2 +	10.7	127.2 +	14.8	73.0 +	6.2
12	1	174.4 + 17.77	98.3 +	175.8 + 22.12	103.3 +	176.2 +	9.11	176.2 +	21.19	90.8 +	10.94
	2	167.3 + 24.2	98.7 +	167.6 + 18.3	102.3 +	155.3 +	17.6	155.3 +	15.0	88.3 +	1.5
16	1	228.7 + 19.34	128.3 +	234.3 + 27.61	136.8 +	229.8 +	10.11	229.8 +	28.22	122.0 +	18.43
	2	214.0 + 31.6	130.0 +	209.2 + 20.7	127.7 +	201.2 +	16.6	201.2 +	24.1	117.7 +	3.5
20	1	228.0 + 23.41	169.5 +	297.8 + 30.51	180.3 +	286.9 +	10.69	286.9 +	42.91	162.2 +	23.31
	2	267.4 + 33.6	164.3 +	260.7 + 31.1	167.3 +	250.3 +	21.0	250.3 +	32.7	155.0 +	5.2
24	1	360.0 + 23.8	209.0 +	363.0 + 40.72	227.5 +	350.1 +	12.92	350.1 +	52.08	193.0 +	35.83
	2	323.7 + 39.8	206.0 +	317.0 + 28.8	207.0 +	308.5 +	21.1	308.5 +	35.5	189.0 +	5.3

Table 5. (continued)

Age (wk)	Yr ^a ₁	Ration					
		I		II		III	
		B ^b ₁	B ^c ₂	B ₁	B ₂	B ₁	B ₂
1b							
29	1	435.2 ± 37.95	264.8 ± 6.65	450.1 ± 51.93	278.0 ± 11.31	441.5 ± 51.13	256.6 ± 29.24
	2	405.3 ± 51.5	266.7 ± 35.4	412.6 ± 23.9	246.3 ± 10.1	390.3 ± 42.6	241.7 ± 7.5

^aYr₁ = 1974-1975
^aYr₂ = 1975-1976

^bB₁ = Holstein

^cB₂ = Jersey

^d = Standard Deviation

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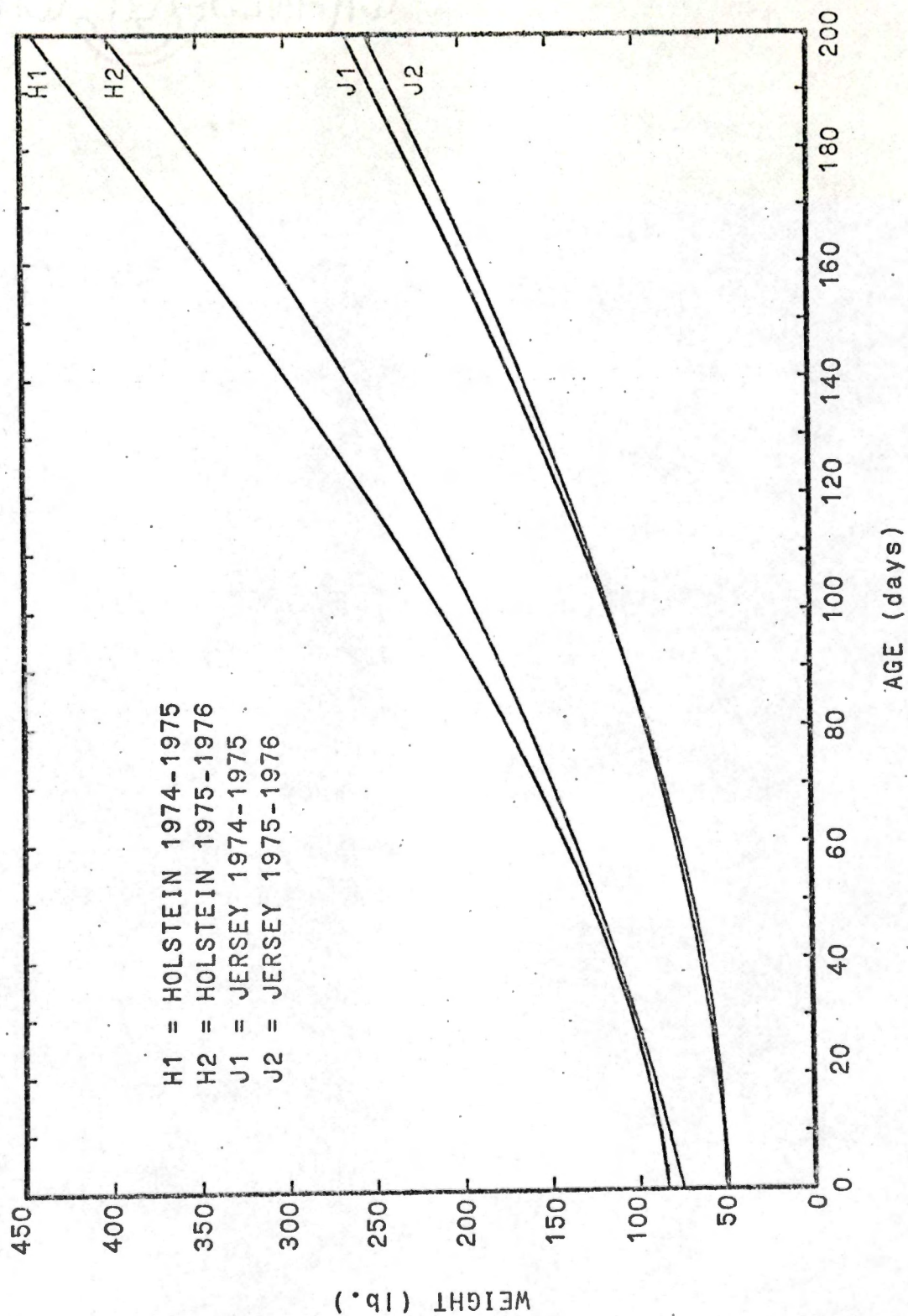


Figure 1. Weight of Holstein and Jersey Heifers Fed Complete Rations.

TABLE 6. WITHER HEIGHT OF HOLSTEIN AND JERSEY HEIFERS FED COMPLETE FEEDS

Age (wk)	Yr ^a ₁	Ration							
		I		II		III			
		B ^b ₁	b ^c ₂	B ₁	B ₂	B ₁	B ₂		
								in	
4	1	31.6 ± 1.57 ^d	27.3 ± 1.26	31.8 ± .81	27.4 ± .95	31.8 ± 1.21	27.6 ± .82		
	2	31.1 ± 1.1	28.0 ± .71	31.7 ± 1.0	29.2 ± 1.04	31.8 ± 1.4	27.7 ± 1.76		
8	1	33.0 ± 1.28	28.9 ± 1.55	32.9 ± 1.07	28.4 ± 1.70	32.7 ± 1.00	28.4 ± .55		
	2	32.9 ± 1.4	27.8 ± 1.04	33.0 ± 1.2	30.3 ± 1.04	33.1 ± 1.3	29.3 ± 2.02		
12	1	34.9 ± 1.83	30.1 ± .95	34.5 ± 1.01	30.0 ± 1.14	34.9 ± 1.05	29.5 ± 1.00		
	2	34.4 ± 1.4	30.2 ± 1.25	34.7 ± 1.2	29.7 ± 2.75	34.3 ± 1.2	30.2 ± 1.76		
16	1	37.1 ± 1.24	31.6 ± 1.31	37.7 ± 1.52	32.0 ± .71	36.8 ± 1.86	31.2 ± 1.35		
	2	36.5 ± 1.1	32.5 ± 1.50	36.2 ± 1.3	31.8 ± 1.61	35.8 ± 1.0	30.7 ± 1.53		
20	1	39.2 ± 1.52	33.9 ± 1.65	39.1 ± 1.29	34.6 ± 1.11	38.5 ± 1.85	33.3 ± .97		
	2	37.8 ± 1.3	34.2 ± 1.26	38.0 ± 1.4	34.2 ± 2.36	37.6 ± 1.4	33.2 ± 1.76		
24	1	41.0 ± 2.08	36.0 ± 1.41	40.7 ± 1.81	36.0 ± .71	40.6 ± 1.96	34.7 ± 1.48		
	2	39.5 ± 1.3	35.3 ± 1.04	39.6 ± 1.1	35.5 ± 2.29	39.3 ± 1.2	34.7 ± 2.25		
29	1	42.4 ± 2.03	38.3 ± .96	41.9 ± 2.12	38.3 ± 1.71	42.4 ± 1.75	37.5 ± 1.94		
	2	41.2 ± 1.4	37.3 ± 1.26	41.3 ± 1.1	37.0 ± 1.8	41.4 ± 1.1	37.0 ± 1.32		

^aYr₁ = 1974-1975
Yr₂ = 1975-1976

^bB₁ = Holstein

^cB₂ = Jersey

^d = Standard Deviation

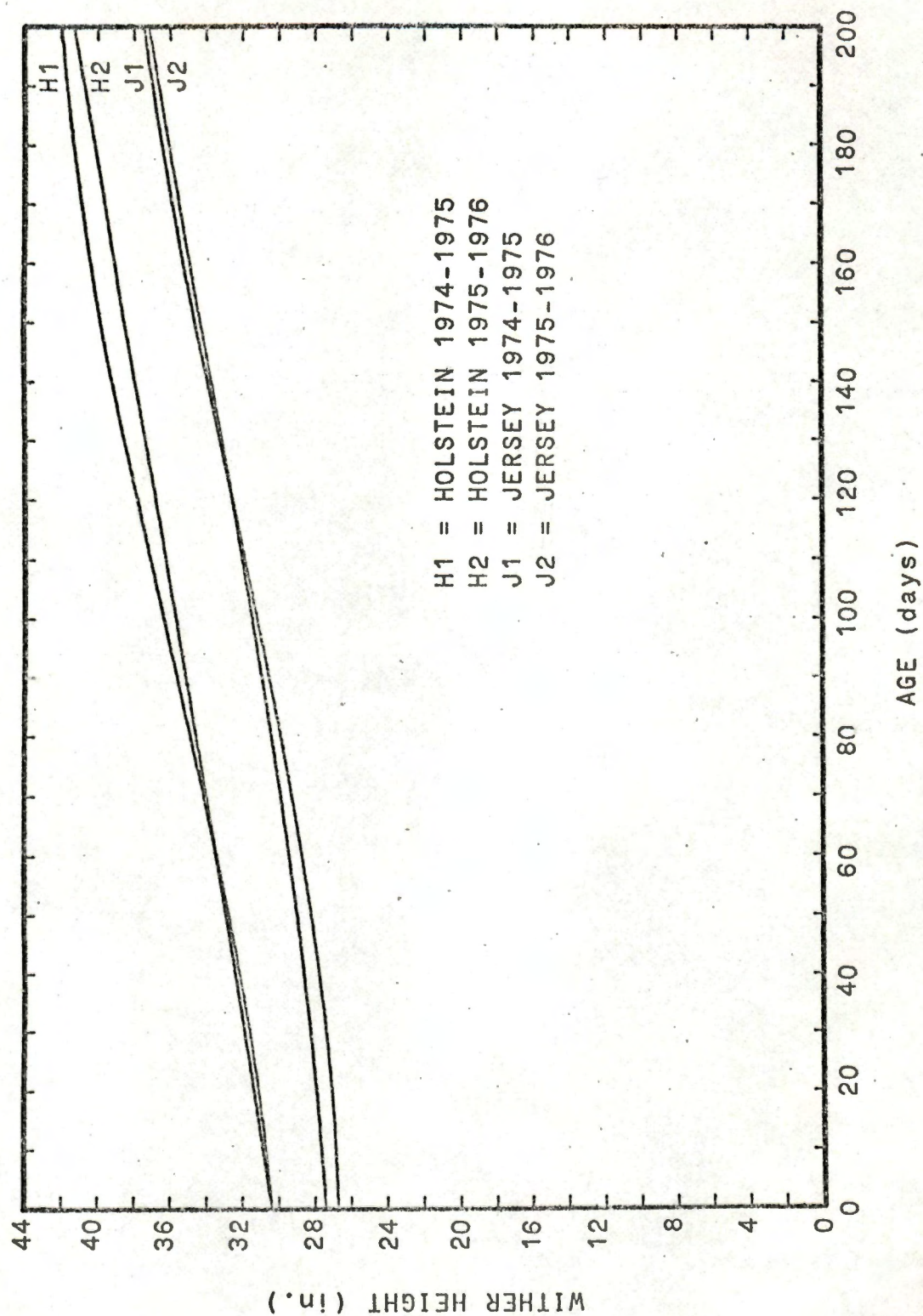


Figure 2. Wither Height of Holstein and Jersey Heifers Fed Complete Rations.

TABLE 7. LENGTH OF HOLSTEIN AND JERSEY HEIFERS FED COMPLETE FEEDS

Age (wk)	Yr ^a ₁	Ration					
		I		II		III	
		B ₁ ^b	B ₂ ^c	B ₁	B ₂	B ₁	B ₂
—in—							
4	1	23.0 ± 1.46 ^d	19.3 ± 1.19	22.5 ± 1.56	19.9 ± .85	23.7 ± 1.51	19.5 ± 1.58
	2	25.9 ± 1.3	23.0 ± .71	26.4 ± 1.5	23.8 ± .29	26.3 ± 1.4	23.2 ± 1.26
8	1	24.0 ± 1.18	21.0 ± .91	24.3 ± 1.75	21.1 ± 1.18	25.1 ± 1.41	22.3 ± 2.77
	2	27.7 ± 1.7	23.5 ± 1.32	28.3 ± 1.0	24.7 ± .29	28.1 ± 1.7	24.8 ± 1.76
12	1	27.4 ± 2.05	23.3 ± 2.10	27.1 ± 1.9	23.0 ± 1.58	27.8 ± 1.42	23.6 ± .55
	2	30.2 ± 1.4	27.7 ± 1.44	30.8 ± 1.4	27.2 ± .58	30.3 ± 1.1	25.5 ± 1.0
16	1	30.2 ± 1.9	26.3 ± 1.32	30.5 ± 2.15	26.9 ± 1.76	30.8 ± 1.7	26.2 ± 1.04
	2	33.3 ± 1.6	29.3 ± 1.61	33.5 ± .7	28.8 ± 1.04	32.7 ± 1.5	27.2 ± 1.15
20	1	35.0 ± 2.8	29.9 ± 2.7	34.5 ± 1.6	29.9 ± 1.3	34.5 ± 2.2	29.5 ± 2.1
	2	35.1 ± 1.6	31.5 ± 1.3	36.2 ± 1.1	30.7 ± 1.9	35.1 ± 1.1	31.0 ± .5
24	1	37.6 ± 1.9	33.4 ± 1.7	37.6 ± 1.5	34.1 ± 1.1	38.1 ± 1.8	32.6 ± 2.1
	2	37.6 ± 1.3	34.3 ± 1.3	38.6 ± 1.3	32.7 ± 2.4	37.4 ± 1.6	33.3 ± 1.0
29	1	40.5 ± 2.0	36.0 ± .8	40.9 ± 1.5	36.1 ± 1.0	41.6 ± 2.1	35.0 ± .4
	2	40.0 ± 1.1	36.8 ± 1.6	40.5 ± 1.1	35.7 ± 1.4	40.0 ± 1.5	35.0 ± .5

^aYr₁ = 1974-1975
^aYr₂ = 1975-1976

^bB₁ = Holstein

^cB₂ = Jersey

^d = Standard Deviation

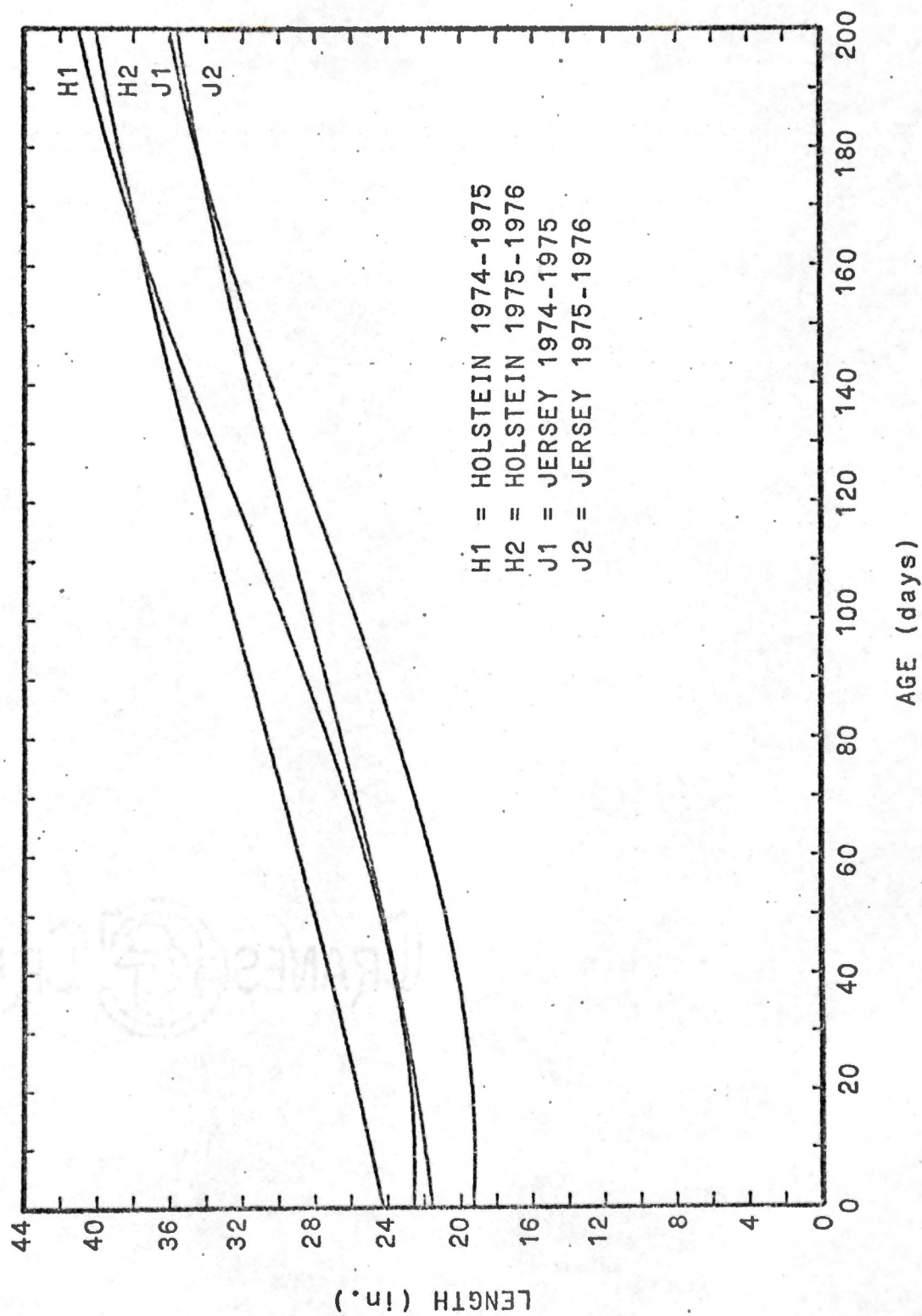


Figure 3. Length of Holstein and Jersey Heifers Fed Complete Rations.

TABLE 8. PAUNCH CIRCUMFERENCE OF HOLSTEIN AND JERSEY HEIFERS FED COMPLETE FEEDS

Age (wk)	Yr ^a ₁	Ration					
		I		II		III	
		B ₁ ^b	B ₂ ^c	B ₁	B ₂	B ₁	B ₂
in							
4	1	34.2 + 1.6 ^d	29.6 + 1.3	34.5 + 2.9	29.4 + 1.3	33.8 + 2.0	28.8 + 1.8
	2	34.8 + 2.0	30.3 + 1.1	34.6 + 2.2	31.2 + .3	35.0 + 2.0	29.8 + .3
8	1	42.1 + 2.7	34.6 + .8	43.2 + 2.8	35.5 + 1.8	43.4 + 2.4	35.9 + 2.3
	2	42.1 + 3.9	34.7 + 4.5	43.5 + 3.8	39.0 + 1.7	42.9 + 2.8	34.7 + 2.8
12	1	48.6 + 2.3	39.9 + 1.0	48.6 + 1.9	41.8 + 2.7	48.1 + 2.5	40.0 + 1.2
	2	48.5 + 2.6	41.0 + 2.5	48.3 + 2.7	42.3 + 3.1	47.8 + 2.2	41.0 + 2.3
16	1	53.7 + 2.6	44.5 + 1.3	53.6 + 1.8	46.0 + 2.6	53.6 + 2.9	44.2 + 1.6
	2	53.0 + 2.6	43.7 + 3.1	50.9 + 2.5	45.5 + 3.0	52.0 + 3.5	42.7 + 1.5
20	1	59.2 + 3.3	49.1 + .9	59.3 + 1.6	49.5 + 1.7	57.5 + 3.2	48.6 + 1.9
	2	56.4 + 2.5	46.5 + 2.3	54.5 + 2.7	48.5 + 2.5	54.3 + 3.4	44.0 + 3.5
24	1	63.0 + 3.0	53.3 + 1.5	63.0 + 2.4	54.4 + 3.5	61.4 + 4.1	51.8 + 3.0
	2	60.1 + 2.7	50.3 + 2.5	58.0 + 2.1	51.7 + 1.2	58.6 + 3.4	49.5 + 2.8
29	1	67.1 + 2.6	57.4 + .8	67.9 + 2.9	58.4 + 2.1	67.5 + 3.3	58.4 + 1.9
	2	64.3 + 3.7	55.3 + 4.5	64.5 + 1.9	53.5 + .87	64.1 + 4.2	54.7 + .58

^aYr₁ = 1974-1975
Yr₂ = 1975-1976

^bB₁ = Holstein
^cB₂ = Jersey

^d = Standard Deviation

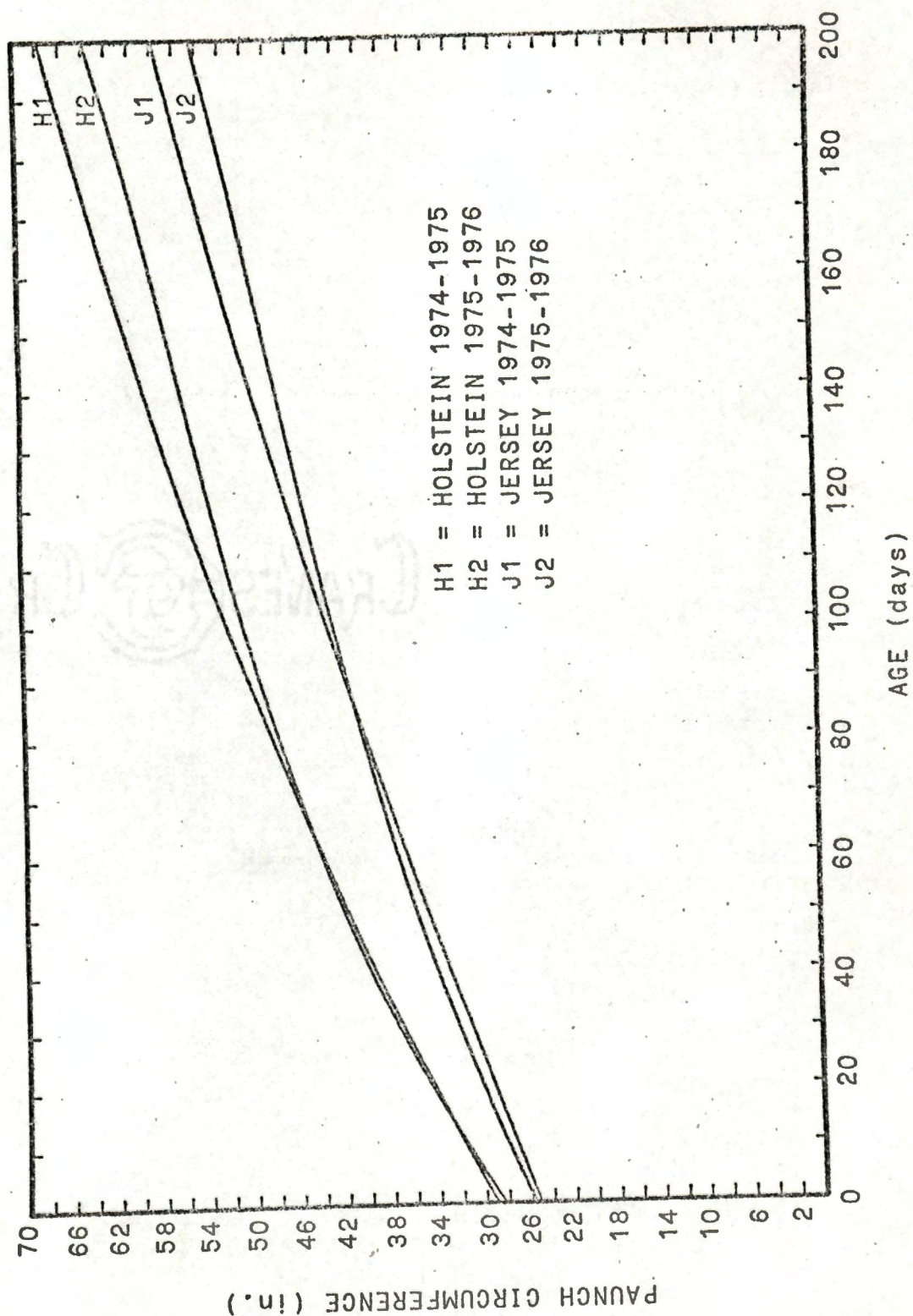


Figure 4. Paunch circumference of Holstein and Jersey heifers fed complete rations.

TABLE 9. COMPOSITION OF COMPLETE FEED FED TO HOLSTEIN BULL CALVES IN DIGESTION TRIALS AT 4, 17, AND 29 WEEKS OF AGE

	Ration		
	I	II	III
Dry Matter (%)			
Trial 1	88.61	49.44	43.07
Trial 2	87.26	50.33	45.52
Trial 3	89.90	48.80	45.60
Crude Protein DMB ^a (%)			
Trial 1	16.42	16.81	16.78
Trial 2	17.26	16.52	15.76
Trial 3	17.14	16.01	16.15
Acid Detergent Fiber DMB (%)			
Trial 1	26.30	17.97	23.72
Trial 2	26.57	19.92	19.75
Trial 3	25.76	20.44	23.38
Acid Detergent Lignin DMB (%)			
Trial 1	8.03	3.36	3.71
Trial 2	5.89	2.79	3.26
Trial 3	6.54	3.73	3.65
Calcium (mg/gram) DMB			
Trial 1	7.75	7.33	6.52
Trial 2	11.55	8.85	6.29
Trial 3	11.41	6.49	5.55
Phosphorous (mg/gram) DMB			
Trial 1	5.45	7.04	6.41
Trial 2	6.58	8.68	6.91
Trial 3	5.58	6.98	5.54

^aDMB = Dry Matter Basis.

TABLE 10. MEANS AND STANDARD DEVIATION OF MILK COMPONENTS FED TO HOLSTEIN
BULLS IN DIGESTION TRIAL 1

Dry Matter %	8.93 $\pm$.82 ^a
Gram Nitrogen/gram	.0061 $\pm$.0004
Ash (%) DMB ^b	.69 $\pm$.04
Calcium mg/gram DMB	10.13 $\pm$.50
Phosphorous mg/gram DMB	11.64 $\pm$.61

^a = Standard Deviation.

^b DMB - Dry Matter Basis.

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TABLE 11. DIGESTIBILITY AND MINERAL RETENTION OF COMPLETE RATIONS FED TO HOLSTEIN BULL CALVES
AT 4, 17, AND 29 WEEKS OF AGE

No. of Animals	Ration			Mean
	I	II	III	
	3	3	3	
Dry Matter Digestibility (%)				
Trial 1	82.03 + 2.96	83.00 + 6.20	79.71 + .71	81.58 ^b
Trial 2	69.25 + 3.42	71.69 + 7.06	72.33 + 5.02	71.09 ^a
Trial 3	66.39 + 2.55	70.22 + 2.41	71.19 + 1.38	69.29 ^a
Mean	72.56 ^a	74.97 ^a	74.41 ^a	
Acid Detergent Fiber Digestibility (%)				
Trial 1	54.02 + 28.63	47.93 + 11.08	51.36 + 11.67	51.10 ^a
Trial 2	54.93 + 6.75	42.76 + 15.17	49.25 + 8.50	48.99 ^a
Trial 3	42.52 + 2.74	48.17 + 8.64	51.90 + 3.51	47.53 ^a
Mean	50.50 ^a	46.29 ^a	50.84 ^a	
Acid Detergent Lignin Digestibility (%)				
Trial 1	47.99 + 36.80	17.20 + 46.58	21.10 + 2.51	28.76 ^a
Trial 2	23.65 + 10.26	19.37 + 20.00	26.01 + 14.72	23.01 ^a
Trial 3	22.03 + 10.18	12.39 + 17.02	15.87 + 12.29	16.76 ^a
Mean	31.22 ^a	16.32 ^a	20.99 ^a	
Calcium Retention (grams/trial)				
Trial 1	36.60 + 11.08	24.89 + 2.12	24.88 + 1.56	28.79 ^a
Trial 2	59.62 + 29.86	67.78 + 45.55	36.11 + 25.30	54.50 ^b
Trial 3	230.35 + 32.12	94.53 + 4.13	109.62 + 18.07	144.83 ^c
Mean	108.86 ^b	62.4 ^a	56.87 ^a	

Table 11. (continued)

	Ration			Mean
	I	II	III	
Phosphorous Retention (grams/trial)				
Trial 1	23.55 + 2.88	22.51 + 4.54	22.80 + 3.79	22.95 ^a
Trial 2	45.39 + 35.19	86.46 + 34.00	48.57 + 23.54	60.14 ^b
Trial 3	114.94 + 35.73	86.65 + 28.71	106.56 + 19.80	102.72 ^c
Mean	61.29 ^a	65.21 ^a	59.31 ^a	
Nitrogen Retention (grams/trial)				
Trial 1	12.41 + 41.78	- 24.07 + 6.12	- 4.26 + 7.88	- 5.30 ^a
Trial 2	174.18 + 16.87	194.88 + 118.95	97.19 + 131.16	155.42 ^b
Trial 3	179.01 + 95.31	61.52 + 36.94	183.05 + 20.62	141.2 ^b
Mean	121.87 ^a	77.44 ^a	91.99 ^a	
Nitrogen Digestibility (%)				
Trial 1	56.56 + 20.13	46.96 + 11.43	56.43 + 4.85	53.32 ^a
Trial 2	70.72 + 3.25	75.74 + 7.07	74.12 + 4.47	73.53 ^b
Trial 3	66.21 + 2.97	67.96 + 2.18	69.39 + 3.74	67.85 ^b
Mean	64.50 ^a	63.55 ^a	66.65 ^a	

^{a,b,c} Means within rows and columns with different superscripts were different ($P < .05$).

TABLE 12. INTERCEPT AND REGRESSION COEFFICIENT FOR HOLSTEIN AND JERSEY GROWTH CURVES

Breed	Year	Variable	Intercept	B ₀	B ₁	B ₂
Holstein	1974-1975	Weight	84.35915	.35407094	.0113444	-.0000206
		Height	30.369895	.0284031	.0004758	-.00000164
		Length	22.53211	-.01503097	.00120291	-.00000333
		Paunch	29.030886	.27900492	-.0005322	.00000054
Jersey	1974-1975	Weight	51.594577	-.03004491	.00826718	-.00001379
		Height	26.73330	.00974187	.00048389	-.00000132
		Length	19.22834	-.01763515	.00113736	-.00000315
		Paunch	25.26486	.19324677	-.00008812	-.00000031
Holstein	1975-1976	Weight	75.99496	.78952235	.00345101	.00000398
		Height	30.40484	.04864657	.0000538	-.00000012
		Length	24.23746	.06593015	.00025055	-.00000092
		Paunch	28.39552	.34093998	-.00153419	.00000036
Jersey	1975-1976	Weight	50.00805	.17812586	.00555524	-.00000668
		Height	27.43918	.02138011	.00024577	-.00000054
		Length	21.55442	.03431339	.00047733	-.00000149
		Paunch	25.70955	.23758394	-.00085161	.00000193

B₀ = Linear regression coefficient for day.

B₁ = Quadratic regression coefficient for day.

B₂ = Cubic regression coefficient for day.

VITA

Ronnie Ray Nease was born in Cocke County, Tennessee on June 19, 1953. He attended Cocke County Elementary and Secondary schools. In 1971, he graduated from Parrottsville High School and enrolled at The University of Tennessee, Knoxville.

He received the Bachelor of Science Degree with a major in Dairy Production in 1975. In 1975 he entered graduate school, majoring in Animal Science.

He was married to Julia Ann Marshall in September 1976.