THE RESPONSES OF DAIRY HEIFERS REARED ON A SELF-FEEDING REGIME DESIGNED TO ALLOW RAPID GROWTH AND SUBSEQUENT EARLY CALVING

by

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INTRODUCTION

In recent years cattlemen have shown increased interest in self-feeding cattle. Self-feeding of dairy heifers, with its advantages of saving labor, convenience and adaptability, could be useful to dairymen if the feeding regime produced dairy heifers that were of acceptable age and weight at calving and showed no ill effects on the subsequent milk and milk fat production.

Consequently, research was conducted to explore possible methods of self-feeding dairy heifers and the effects of self-feeding, rapid growth and early calving on performance of dairy heifers.

REVIEW OF LITERATURE

Factors Affecting Voluntary Feed Intake by Ruminants

Results of research have shown that there are many factors that control feed intake by ruminants. Prior to 1960, most research on this subject was conducted using all-roughage rations. These results have shown the importance of bulkiness and of undigestible matter in feedstuffs as controlling factors, but only since the early 1960's and the advent of high concentrate rations have other control mechanisms been studied in depth.

The relative importance of each regulating factor changes as the constituents of the ration are varied (high roughage vs. high concentrate) (Balch and Campling, 1962; Cowsert and Montgomery, 1969; Dinius and Baumgardt, 1970). An understanding of intake control is further complicated by the many ways that animals can use energy (growth, work, lactation, etc.) (Baumgardt, 1969; Brobeck, 1960). Although animals receive a wide variety of rations while performing many different activities, they normally voluntarily control their energy intake so as to grow, produce, and reproduce in a uniform manner (Baumgardt, 1969; Conrad *et al.*, 1964; Cowsert and Montgomery, 1969; Montgomery and Baumgardt, 1965a). Baumgardt (1969) stated that the central nervous system controls feed intake from signals triggered by digestive tract fill and/or from metabolites by way of chemical or thermal sensitive receptors.

Central Nervous System and Intake Control. Wyricka and Dobrzecka (1960) found that, in goats and sheep, electrical stimulation of the hypothalamus would either inhibit or induce eating, depending on the area of application. Bilateral lesions of the hypothalmus in rats caused hyperphagia or complete stoppage of food intake; depending on the region severed (Anand and Brobeck, 1951). Baile, Mahoney and Mayer (1968) induced electrolytic lesions in the hypothalamic region of goats and produced temporary aphagia and adipsia.

Other parts of the central nervous system that may be important in regulating intake are the neocortex portion of the brain, which controls habits and conditioning, and the limbic system, important in discriminative appetite (Anand, 1961).

Palatability and Feed Intake. Palatability is the degree of readiness with which a feed is consumed and is dependent on stimulation of the senses, primarily taste and smell (Baumgardt, 1969). From a review of the literature, Balch and Campling (1962) concluded that cattle and sheep are color blind, but have well developed senses of taste and smell. They further contended that palatability is more important in choosing between two or more feeds and initiating feed consumption than determining the amount eaten. Also, Welton and Baumgardt (1970), using sheep, showed that palatability had little effect on amount of feed consumed.

Intake Control by Thermal Mechanisms. Anderson and Larsson (1961) showed that, in goats, cooling of the preoptic areas of the hypothalamus increased feed intake, and warming of other areas stopped feed consumption. They warned, however, against accepting this as clear-cut evidence of thermal regulation because the temperatures used were outside of what are believed to be normal physiological extremes. Other workers (Dinius, Kavanaugh and Baumgardt, 1970; Grossman and Rechtschaffen, 1967) have since shown that an increase in hypothalamic temperature is more closely related to increased activity than food consumption. However, high ambient temperatures have been shown to decrease feed intake (Balch and Campling, 1962; Baumgardt, 1969; Conrad, 1966).

<u>Intermediate Metabolites and Intake Control.</u> In a literature review, Anand (1961) presented information indicating that intake might be influenced by blood levels of glucose, lipids, amino acids and volatile fatty acids (VFA). He also reviewed research showing an interrelationship between food and water intake (restricting water intake decreased feed intake) and intake control by hormones and pharmacological preparations. Although glucose is known to be important in controlling feed intake in monogastric animals, evidence shows that it is of little importance in regulating feed intake of ruminants (Anand, 1961; Balch and Campling, 1962; Conrad, 1966; Simkins, Suttie and Baumgardt, 1965). No work was found to support or reject the theory that amino acids worked as chemostatic regulators.

Although Kennedy (1953) reported research which indicated that lipostatic mechanisms may help control intake, other workers (Anand, 1961; Balch and Campling, 1962; Conrad, 1966) concluded that control by these mechanisms is minimal. However, in the last three to four years, new research again shows that lipids may play an important part in feed intake regulation (Baumgardt, 1969). Several workers (Baile, 1971; Balch and Campling, 1962; Reid and Robb, 1971) have reported that fat animals eat less than their thin contemporaries. Reid and Robb (1971) stated that with high-forage diets, body fat might restrict gastrointestinal capacity, thus curtailing appetite. They also stated that fat animals may release substances that depress appetite. Baile (1971) cited research that showed decreased intake in rats after they had been force-fed to a fat condition. In the future, probably more will be found about lipids and their role in regulation of feed intake.

Recently, much research involving fatty acids and their affect on intake has been reported. Dowden and Jacobson (1960), working with cows, found that acetic and propionic acids and sodium acetate, injected intravenously at a level of 12.5% of the calorie requirement for maintenance, reduced voluntary feed intake. Although blood levels of acetate and propionate are not normally as high as the above level, other research (Baile and Pfander, 1965; Montgomery, Schultz and Baumgardt, 1963; Simkins, Suttie and Baumgardt, 1965; Ulyatt, 1964) has shown that intraruminal infusions of acetate, proprionate and butyrate will depress feed consumption. Baile (1971) further showed with goats that anesthetizing the nerves of the dorsal area of the rumen at eating time increased feed intake and injecting acetate or propionate on a ruminal nerve at meal time depressed appetite. This was interpreted to mean that there are nerves sensitive to acetate and propionate in the rumen and that these nerves assist in regulating feed consumption.

Intake as Affected by Quality of Feedstuff. Protein or urea supplementation has been shown to increase intake of poor quality, all-roughage rations (Campling and Freer, 1966; Freer, Campling and Balch, 1962; Morris, 1958; Weston, 1966). Bond et al. (1962) showed that with high energy mixed rations, a deficiency of nitrogen (as protein or urea) would inhibit voluntary consumption. Crampton (1957) reported that lack of nitrogen, or other specific nutrients, inhibited microfloral growth, which in turn decreased rate of forage digestion and subsequently led to lower intake.

In all-roughage rations, as maturity of the forage increases, voluntary intake decreases (Blaxter, Wainman and Wilson, 1961; Colburn, Evans and Ramage, 1968; Conrad et al., 1962; Crampton, 1957). This decrease has been shown to be correlated with a decrease in digestibility (Blaxter et al., 1961; Conrad et al., 1962; Crampton, 1957; Troelson and Bibsby, 1964) and digestibility of forages is impaired as the plant matures and increases in lignin content (Crampton, 1957; Dehority and Johnson, 1961; Dehority, Johnson and Conrad, 1962).

Effect of Physical Form of Feedstuff on Intake. Physical form of a feed affects the rate at which it will be ingested. Although there were large variations among experiments, ground and pelleted rations were usually consumed at a slightly higher rate than were rations of long forage or long forage plus concentrate (Blach and Campling, 1962; Blaxter, McGraham and Wainman, 1956; Campling and Freer, 1966). Although Montgomery and Baumgardt (1965b) found that grinding oat straw decreased voluntary consumption, Campling and Freer (1966) found that grinding and then pelleting increased intake of oat straw. Many workers (Blaxter et al., 1956; Balch and Campling, 1962; Campling and Freer, 1966; Freer et al., 1962) have found that various types of feed processing increase the rate of digestion and/or the rate of passage, thus allowing greater feed intake. Even though pelleted hay and ground hay are usually consumed at about the same rate and long hay at a slightly lower level, different feeding methods or experimental conditions can give wide variations in results (Beardsley, McCormick and Southwell, 1959; Campling and Freer, 1966).

Metering Feed Through Mouth. It has been proposed that a certain amount of feed is metered through the mouth at each meal, but Campling and Balch (1961) showed otherwise when their experimental cows ate 77% more than normal when the meal contents were removed from the rumen as the cows ate. Weston (1966) gave sheep 140% of their voluntary normal daily intake intrarumenally and the sheep not only quit eating but digesta accumulated in the rumen until no more feed could be added.

Correlation Between Intake and Body Weight, Metabolic Weight, and Gastro-Intestinal (GI) Tract Capacity. Balch and Campling (1962) reviewed literature showing that fat ewes bearing twins had a marked decline in feed intake during the last month of pregnancy. They thought this decrease was caused by the decreasing amount of space for the GI tract as the reproductive tract increased in size. Campling and Balch (1961) found that feed consumption could be depressed by putting water-filled balloons in the rumens of cows, and Weston (1966) depressed intake by giving sawdust to sheep intrarumenally. Balch and Campling (1962) cited several articles that showed a relationship between body weight and feed consumption. However, other workers (Blaxter et al., 1961; Colburn and Evans, 1968; Colburn et al., 1968; Crampton, Donefer and Lloyd, 1960) have shown that metabolic weight (a logarithmic function of body weight) has a higher correlation with feed intake than does body weight.

Other Variations in Consumption Among Animals. Feed intake may be highly variable between individual animals that are handled under the same conditions (Blaxter and Wilson, 1962; Burt, 1957; Stone et al., 1960). Since this variation is believed to be genetic, little can be done to help those animals that consume small amounts of feed, but possibly selection could be used to increase feed intake of future generations of ruminants (Conrad, 1966; Stone et al., 1960). Attempts have been made to teach or condition cattle to eat more, but with little success (Balch et al., 1960). Group fed animals usually voluntarily consume more feed than individually fed animals (Baumgardt, 1969; Clark and Barth, 1968). Animals usually will consume more feed if fed several times a day, compared to once a day (Balch and Campling, 1962; Baumgardt, 1969; Blaxter et al., 1961).

Relative Importance of Each Controlling Mechanism as Rations Change. It is generally contended that when low-quality, high roughage rations are fed, intake regulation is controlled by an interaction between the "bulkiness" of the ration and the physical capacity of the animal. However, when low-bulk, high energy rations are fed, animals tend to consume only a certain amount of energy. Conrad, Pratt and Hibbs (1964) using cows fed all-roughage rations varying in digestibility from 52 to 80%, found that physical and physiological factors regulating feed intake change in importance with increasing digestibility. Therefore, one would conclude that in mixed rations as the ratio of concentrate (highly digestible) to roughage (low digestibility) changes, so would the importance of the different feed intake control mechanisms. Dinius and Baumgardt (1970) showed this to be true by feeding sheep pelleted concentrate rations that were diluted with sawdust at levels from 5 to 50% and as energy concentration (kcal DE/g) of the pellet increased from 1.8 to 2.5, dry matter intake (g/body weight$^{3/4}$) and total digestible energy intake increased. When the concentrate level was increased from 65 to 100% and the digestible energy concentration of the pellet increased from 2.5 to 3.6, the dry matter intake declined and the total amount of digestible energy consumed remained nearly constant.

Conrad (1966) reported that energy intake was constant when lactating cows received rations that were 67% or higher in digestibility. Montgomery and Baumgardt (1965b) reported that heifers consumed a constant amount of energy when the ration was 56% or more digestible. These differences may reflect differences in physical form of the feed and/or different physiological needs for growth vs. production.

Importance of Understanding Control Mechanisms, Methods of Controlling Intake. The information presented thus far is of importance if one is trying to formulate a ration that will allow only a certain level of energy to be voluntarily consumed (self-feeding). Salt has been used to control intake of concentrates (Wise, Barrick and Blumer, 1965; Pelissier, 1969) and gypsum has been reported to control intake of cottonseed meal (Barrentine and Ruffin, 1958). The levels of gypsum and salt used were low enough to infer that intake was restricted by some means other than fill or energy dilution of the ration. A possible ration diluent (something to increase bulk, and thereby decrease energy concentration) is sawdust (Dinius and Baumgardt, 1970; Cody, Morrill and Hibbs, 1972). In certain areas, sawdust is available in abundance as a waste product and therefore is inexpensive. In most cases it is not harmful to the animals (Cody et al., 1972) and there is a possibility that certain types may contribute some energy to the ration. Ground hay has also been used to dilute concentrate mixtures that were self-fed to cows (Wobker, personal observations).

Effect of Rapid Growth on Performance of Dairy Heifers

Rate of growth is quite variable and can easily be accelerated or restricted by the ration given (Eckles, 1915; Gardner and Garcia, 1966; Reid et al., 1964; Swanson et al., 1967; Swanson, 1971). Therefore, each dairyman should view his situation and decide on an appropriate rate of gain in order to have his heifers at an acceptable weight at the age he has chosen to have them freshen. Several considerations can be given as to what appropriate weight and age are.

Many dairymen like their herd to produce a majority of the yearly milk within a certain season of the year. If the herd continually achieves maximum production during the same season, it must have a 12-month calving interval. This means the heifers must freshen at 24 or 36 months to fit into the regime. Twenty-four months is usually chosen as the most desirable (Swanson et al., 1967). Although a 12-month calving interval (CI) is thought to be desirable (Swanson et al., 1967; Yates and Olds, 1969) research shows that in many herds only a 13 or 14 month interval is maintained (Norman and Thoele, 1967; Olds and Cooper, 1970; Yates and Olds, 1969). Other workers (Evans, Branton and Farthing, 1964; Wilcox et al., 1966) have found that 3.5 to 4 is the average number of lactations for a cow in a herd. If the CI is 13 months and a cow is going to have 4 lactations, then she must freshen at 22 months (2 months ahead of 24) of age in order to average calving at the same time of the year that she was born. If a cow was born late in the desired calving season, then it might be advantageous for her to calve at 20 to 21 months of age.

Factors involved in rapid growth and early calving have been studied by several workers. Evidence (Amir et al., 1967; Crichton, Aitken and Boyne, 1960; Reid et al., 1964) shows that rate of growth can vary considerably and not affect final mature size and performance of the cow. Wilk, Young and Cole (1963) found no correlation between body measurements at 3, 6, 12, and 16 months of age and subsequent milk production, while Blackmore, McGilliard and Lush (1958) reported that there was a slight negative relationship between body measurements at birth, 6 mo., 1 yr., and 2 yrs. of age and subsequent milk production. However, severe restriction of feed intake and subsequent growth (Swanson, 1960) or extremely rapid growth with fattening (Swanson and Hinton, 1964) has been shown to hinder productive performance of cows. If growth is restricted and cows are small at time of first calving it is important that they receive plenty of energy during the first lactation in order to attain normal mature size (Amir _et al._, 1967; Reid _et al._, 1964; Swanson _et al._, 1967).

Reid _et al._, (1964) using heifers reared on three different energy levels and weighing 384, 483, and 549 kg at parturition found no significant difference in milk production between these three groups. These workers contended that it was uneconomical to grow heifers rapidly and then have them calve as late as 28 months of age.

Effect of Age at First Calving on Heifer Performance

Although having heifers freshen at 24 months of age has advantages in certain situations, the most desirable age at first calving is still largely a matter of opinion. Eckles (1915) stated that calving heifers too young is detrimental because lactation uses many of the nutrients yet needed for growth. As stated earlier, to compensate for this large energy requirement, it is often recommended (Reid _et al._, 1964; Swanson _et al._, 1967) that small young heifers receive liberal amounts of grain during their first lactation. Turner (1932) concluded that most efficient milk and milk fat production (on basis of utilization of nutrients) could be obtained by breeding animals to calve at 20 to 24 months of age. Also, he found that maximum lifetime production was obtained from heifers calving at approximately 30 months of age and that within 5 to 10% of maximum lifetime production could be obtained by calving heifers at 23 to 28 months of age, depending on breed.

Lamb and Kopland (1963) reported that cows calving at 25 months of age had the highest production of milk and milk fat per day of life, but that cows calving at 30 months had the highest total lifetime production. Hargrove, Salazar and Legates (1969) found that Holstein cows that calved at 27 months of age gave maximum life production, but those calving at 24 months gave only 579 kg less in their lifetime. Clark and Touchberry (1962) found that as age of calving increased so did production, but the increase was slight. They further contended that weight at calving had a larger influence on production than did age. Wickersham and Schultz (1963) found that there were no significant differences in first lactation yields of heifers that calved at 27.9, 24.2, and 20.4 months of age. However, Amir et al., (1967) found that first lactation 4% fat corrected milk yields of three groups of heifers that calved at 21.4, 19.3, and 17.8 months of age were 3,739, 2,919, and 2,606 kg respectively.

Another consideration that must be given to early freshening is the effect it would have on generation interval. Reduction of age at first calving from reported averages of 29 to 32 months (Evans et al., 1964; Gaalaas and Plowman, 1963; Wilcox et al., 1966) to 24 months or lower would shorten generation interval considerably and produce more offspring.

Early calving, if not beset by other disadvantages, would decrease generation interval, give sooner return on investment, allow culling of animals with less invested (time and overhead, but not necessarily feed) in them, and fit in with a high-concentrate, rapid rate of growth feeding regime.

The major disadvantage of early calving age is difficult parturition. Schultz in Wisconsin and Hibbs in Ohio (Anonymous, 1966) both found this to be true with heifers. Reid et al., (1964) reared heifers on three different energy levels and found that the group that received the lowest level of TDN during growth and were the lightest at parturition had the most difficulty calving. Wickersham and Schultz (1963) found that heifers that calved at 20.4 months of age had significantly more severe parturition problems than did those calving at 24.2 and 27.9 months of age. Amir et al., (1967) also found that the younger their heifers were at calving, the more severe were the problems at parturition. Amir et al., (1967) and Reid et al., (1964) attributed the difficult parturitions experienced by the small heifers, not to the small size of the heifer, but that the calf weighed a larger percent of the dams calving weight.

Rate of Growth, Puberty and Breeding. Age at puberty is highly dependent on rate of growth as heifers tend to reach puberty at about the same stage of development (Eckles, 1915; Crichton, Aitken and Boyne, 1959; Gardner and Garcia, 1966). Sorensen et al., (1959) found that heifers showed signs of first estrus at about the same weight and skeletal size, but that there was less variation in skeletal size than body weight in heifers at first estrus. Gardner and Garcia (1966) found that their accelerated heifers reached puberty at an average age of 7.7 months and 273 kg body weight, while the control heifers were two months older but weighed only 281 kg at first estrus. Hawk, Tyler and Casida, (1954) found that inbreeding, calfhood scouring and season of birth affected the age of first estrus. Inbreeding and calfhood scouring retard growth, so delayed puberty was attributed to this. No reason was given why spring born calves reached puberty at earlier ages than did calves born during the other seasons.

Breeding efficiency seems to be best when the cattle are in good condition, not fat, and increasing in weight. King (Personal communication with Dr. E. P. Call, Department of Dairy Science, Kansas State University, Manhattan, Kansas) found that of 98 lactating cows that gained weight during a breeding period, 77.6% conceived on first service, and of 81 that lost weight, only 16% conceived on first service. Swanson and Hinton (1964) encountered both breeding and parturition difficulties when they raised heifers on 66% of normal TDN recommendations. Reid _et al._, (1964) found no difference in breeding efficiency between their three groups fed high, medium, and low levels of TDN, but in the group that was on the low energy level, puberty was delayed to such extent that the animals were not yet cycling when they were first scheduled to be bred. Wiltbank _et al._, (1962) found with beef cows receiving one half the recommended TDN after calving that breeding efficiency decreased and in some cases the animals stopped cycling.

EXPERIMENTAL PROCEDURE

Experiment 1

The purpose of this experiment was to observe responses when Holstein heifers, approximately four months of age, were placed on a self-feeding regime designed to allow rapid growth and subsequent early calving. Data were recorded for feed consumption, growth, estrus periods, breeding efficiency, parturition difficulties, postpartum problems (pyometra, metritis, etc.), condition and weight of offspring, and milk production during first lactation.

Management of Animals. Grade Holstein heifers from the Kansas State University dairy herd were used. Previous to the start of the experiment, the calves were given 1.8 kg per head per day of a concentrate mixture (Appendix--Table 1) and received good quality alfalfa hay free choice.

Thirty-two animals were divided into four groups of eight each (Table 1). Groups were made as homogenous as possible with respect to weight, age and sire, with weight and age receiving first priority.

Facilities were simple but adequate. Initially, the groups were in unpaved lots that provided 30 square meters of space per animal. The lots were adjacent to each other and connected to two barns that provided shelter. The barns had concrete floors and were bedded with wood shavings or wheat straw. Bunks for hay were inside the buildings. Groups 1 and 4 received the concentrate ration from self-feeders; Groups 2 and 3 from bunks inside the building. The animals had free access to unheated water.

Later the animals were moved to similarly size, unpaved lots with outside bunks, automatic, heated waterers, and unpaved, metal shelters.

Table 1. Age, weight, sire, and date of birth of heifers used in Exp. 1.

Animal number	Age at start of experiment[a] (days)	Weight at beginning of experiment (kg)	Sire of heifer[b]	Date of birth
(Group 1)				
13E	167	157	H42	9-15-68
160E	200	145	H42	8-13-68
161E	199	174	H42	8-14-68
162E	191	171	H42	8-22-68
165E	163	145	H42	9-19-68
166E	162	159	H42	9-20-68
B181	196	177	H42	8-17-68
B184	180	151	H42	9- 2-68
(Group 2)				
B185	156	132	H42	9-26-68
C109	137	121	H42	10-15-68
C117	125	111	H42	10-27-68
164E	170	121	H42	9-12-68
167E	157	136	H42	9-25-68
168E	157	120	H42	9-25-68
169E	144	124	H42	10- 8-68
170E	127	128	H42	10-25-68
(Group 3)				
C118	151	125	H42	10-29-68
C125	128	125	H44	11-21-68
C127	105	119	H42	12-14-68
C128	91	103	H49	12-28-68
171E	149	141	H43	10-31-68
175E	109	113	H49	12-10-68
178E	90	108	H42	12-29-68
B188	168	131	H43	10-12-68
(Group 4)				
C114	158	117	H44	10-22-68
C124	135	118	H43	11-14-68
C129	90	87	H49	12-29-68
173E	122	114	H43	11-27-68
174E	117	94	H42	12- 2-68
176E	105	92	H49	12-14-68
177E	94	106	H49	12-25-68
179E	71	83	H49	1-17-69

[a] Groups 1 and 2 started on experiment March 1, 1969, Groups 3 and 4 on March 29, 1969.

[b] Code for sire, Kansas Artificial Breeding Service Unit, Manhattan, Kansas

Feeding. The feeding plan was designed to allow all animals to make rapid growth and be of acceptable size to calve at 20 months of age. Groups 1 and 4 were designated treatment groups; 2 and 3 control groups.

Groups 1 and 4 could consume ad lib. a pelleted (.48 cm in diameter) mixture of (by weight) 35% sawdust and 65% concentrate mixture (Appendix Table 1). The sawdust was obtained by milling kiln dried short leaf pine (pinus echinata) and screening to a log mean diameter of 880 microns, with a log standard deviation of 1.83 microns (Headley and Pfost, 1966). Groups 2 and 3 received enough of the concentrate mixture to provide, along with hay consumed, 115% of the National Academy of Sciences--National Research Council, 1966 (NRC) requirements for TDN. Grain allowances were calculated biweekly. Average hay consumption for each biweekly period was determined and used, along with the projected average weight of the animals for the next period, to calculate the amount of concentrate mixture to be given. All groups received long alfalfa hay, free choice.

When control animals were receiving enough TDN from hay only, grain feeding was discontinued. Groups 1 and 4 were removed from the sawdust-grain ration when, by subjective evaluation, it was decided that the animals were fattening more than was desirable. Later, the animals were fed the concentrate mixture as needed to maintain desirable condition. Amounts fed were variable and will be discussed later.

Three weeks before expected date of parturition the animals were removed from their respective lots and put into a prematernity pen. Here their grain allowance was gradually increased until they were receiving 7.3 kg of concentrate mixture daily. They still received long alfalfa hay, free choice.

After calving, the heifers were placed with the main herd and no more data pertaining to feed consumption were recorded. The lot to which the animals were assigned provided a concentrate mixture, free choice, and limited quantities of alfalfa hay.

Throughout the duration of the experiment all animals had free access to plain and iodized salt, dicalcium phosphate, and water.

Reproduction. After the animals reached 227 kg they were checked twice daily for signs of estrus and age of puberty was established. Prior to breeding time, three of the animals in each group were randomly designated to be bred to freshen at 20 months of age, three for 21 months of age, and the remaining two at 22 months of age. Forty days before the heifers were to be bred, they started receiving 1 mg of melengestrol acetate (MGA) orally by capsule daily. The forty days were derived by allowing 14 days for feeding, an expected 5 days after termination of feeding to first estrus, and 21 days until second estrus. Animals were bred at the end of second estrus.

All animals were inseminated with frozen semen from the same bull; most of the semen was from the same ejaculation. Animals were bred twice per estrus at approximately 12 and 24 hours after the first signs of heat. Insemination was by the author. The animals were checked for pregnancy by rectal palpation at 50-60 days post-breeding.

Three days before expected calving, the animals were moved into the maternity barn to facilitate observations. While in the maternity barn, the longest that the animals were unobserved was approximately five hours. Problems associated with parturition were noted. Within 24 hours of parturition the calf was weighed and general appearance was noted.

Collection and Handling of Data. A core sample was taken from every sixth bale of hay and the samples composited. Monthly samples of hay, concentrate mixture and sawdust-grain pellets were ground and subjected to proximate analysis by methods of AOAC (1955).

Growth data collected included biweekly weights and monthly measurements of heart girth and height at withers. Heart girth was taken at the smallest circumference around the rib cage directly behind the front legs. Height at withers was taken at the highest point over the withers. The measurements were taken in a uniform manner throughout the experiment by the author.

The last weight for each animal was taken after the animal had calved and the placenta had passed.

Milk production data on the animals were collected and analyzed. The latest available D.H.I.A. 305 day, 2X, M.E. production figures were used.

In this experiment comparisons were made between groups, treatments and elsewhere as appropriate. One-way analysis of variance with the F-test was used to determine which means were significantly different (Fryer, 1966). When the F-test showed three or more means to be different, Fisher's LSD, as described by Fryer (1966), was used to determine which means were significantly different.

Experiment 2

Except that ground hay, instead of sawdust, was used to control intake, Experiment 2 was basically the same as Experiment 1.

Management of Animals. Animals were of the same origin and handled basically as those in Experiment 1 except as follows: Twenty-eight animals were assigned to four groups of seven each. Groups were determined on basis of age as shown in Table 2.

Table 2. Age, weight, sire, and date of birth of heifers used in Exp. 2.

Animal number	Age at start of experiment[a] (days)	Weight at beginning of experiment (kg)	Sire of heifer[b]	Date of birth
(Group A)				
001	198	189	H51	7-30-69
002	193	180	H51	8- 4-69
003	190	181	H51	8- 7-69
004	182	158	H42	8-15-69
005	169	153	H51	8-28-69
006	166	166	H51	8-31-69
007	163	159	H42	9- 3-69
(Group B)				
008	156	154	H51	9-10-69
009	155	148	H49	9-11-69
010	148	138	H51	9-18-69
011	146	146	H51	9-20-69
012	137	125	H49	9-29-69
013	111	106	H42	10-25-69
014	109	97	H51	10-27-69
(Group C)				
015	123	140	H51	10-27-69
016	119	113	H51	10-31-69
017	117	104	H51	11- 2-69
018	110	127	H49	11- 9-69
019	108	113	H51	11-11-69
020	104	106	H51	11-15-69
021	91	98	H49	11-28-69
(Group D)				
022	115	125	H42	12- 2-69
023	111	136	H51	12- 6-69
024	107	104	H49	12-10-69
025	99	102	H49	12-18-69
026	99	98	H49	12-18-69
027	97	92	H49	12-20-69
028	87	98	H51	12-30-69

[a] Groups A and B started on experiment February 13, 1970, Group C started February 27, 1970, and Group D started March 27, 1970.

[b] Code for sires, Kansas Artificial Breeding Service Unit, Manhattan, Kansas.

The facilities were the same as those used in Experiment 1, except that all groups received their concentrate from self-feeders.

Feeding. The feeding regime was designed to allow rapid growth and early freshening. Alfalfa hay (poor quality when available) was ground through a 1.6 cm screen with a Model 265 Allied mill-mixer operated at 540 RPM. Rolled concentrate (Appendix--Table 1) was mixed in different proportions with the ground hay as needed to fulfill the objectives of the experiment.

Groups A and D initially received a mixture of 65% ground hay and 35% concentrate, while Groups B and C started on 50% hay and 50% concentrate. All groups had free access to long alfalfa hay.

Throughout the experiment, subjective evaluations of the body condition of the animals were made. If the animals in a group showed excess fattening, the ratio of hay to grain for that group was increased. In most cases, when the animals were diagnosed pregnant they were placed on a ration of good quality, long alfalfa hay. However, special effort was made to prevent severe decreases in energy intake near time of breeding. Weight and feed intake were monitored biweekly to determine if heifers were receiving at least 115% of NRC recommendations for TDN.

Reproduction. Observations for estrus and establishment of puberty were as in Experiment 1. The animals were bred at the first estrus after they had reached 116 cm height at withers and 308 kg body weight, or 331 kg body weight, regardless of height. The animals were bred twice per estrus with frozen semen from a single ejaculation of a proven bull. At 32-35 and 45-60 days post insemination, the animals were palpated, per rectum, for pregnancy. The 32-35 day palpation was to diagnose early pregnancy and possible early embryoic abortion. The 45-60 day palpation was to confirm pregnancy.

Collection and Handling of Data. Except as previously indicated, feeding, collection of data and statistical analysis were as for Experiment 1. The hay that was ground was sampled just before grinding and the samples were kept separate from samples of the feeding hay.

In this experiment, length, measured from point of shoulder to posterior point of the pins, was recorded. Weight, height at withers, heart girth and length were measured biweekly until the animals reach 272 kg. Thereafter, all but weight (still taken biweekly) were taken monthly.

RESULTS AND DISCUSSION

Experiment 1

Feed Consumption and Growth. Feed consumption, daily gains, feed efficiency and calculated TDN intake per animal up to 475 kg body weight are given in Tables 3 and 4. Collection of data stopped after 475 kg body weight because the heifers were freshening and dropping out of their groups, making calculations unreliable. Appendix Table 2 gives feed consumption by eight-week periods. Total digestible nutrient (TDN) values for the feedstuffs were calculated using the average crude fiber (CF) (from proximate analyses, Appendix Tables 3 and 4) and the following equations: $\%\ TDN = 61.68 - .47\ (CF)$ for hay and $\%\ TDN = 80.49 - 1.17\ (CF)$ for grain.

Feed efficiency decreased ($P < .01$) as the animals grew (Table 5). Feed efficiency for the 425 to 475 kg range was slightly better than for the 375 to 425 kg range but the differences were not significant ($P > .05$). Average daily TDN consumption (Table 5) for all groups increased ($P < .01$) as the heifers grew.

Average daily gains (ADG) up to 475 kg body weight for Groups 1, 2, 3, and 4 were .78, .77, .76, and .77 kg/day (Table 6), respectively. Although ADG for the entire period were not significantly ($P > .05$) different, there were differences when the total time was divided into periods. Groups 1 and 2 were started on experiment at the same time. Groups 3 and 4 were placed on experiment a month later. Group 1 was self fed sawdust-concentrate pellets for 168 days, Group 4 for 210 days. It was decided, on the basis of body condition, to discontinue feeding of sawdust-concentrate at these times. During the 168 days that Group 1 was self-fed, they gained faster

Table 3. Average daily gain, feed efficiency and feed and TDN consumption for heifers in Groups 1 and 2, Exp. 1.

Weight range	Av. daily gain	Feed efficiency	Concentrate intake (Per animal)	Concentrate intake TDN from	Baled hay intake (Per animal)	Baled hay intake TDN from	Total TDN intake per animal	Av. daily TDN intake per animal
(kg)		(kg TDN / kg gain)	(kg)					
(Group 1)								
160-225	.98	3.63	165	129	219	107	236	3.58
225-275	1.14	4.33	147	115	207	102	217	4.92
275-325	.85	5.88	104	81	434	212	294	4.98
325-375	.76	6.64	00	00	677	332	332	5.04
375-425	.50	11.53	36	28	1119	549	577	5.71
425-475	.75	9.50	283	224	513	251	475	5.48
(Group 2)								
124-175	.86	3.81	112	88	218	107	195	3.29
175-225	.79	4.67	31	24	428	210	234	3.70
225-275	.77	5.47	00	00	558	274	274	4.21
275-325	.77	6.20	00	00	634	310	310	4.78
325-375	.63	8.46	22	17	828	406	423	5.29
375-425	.68	9.63	287	224	525	257	482	6.51
425-475	1.02	7.05	179	140	435	213	353	7.20

Table 4. Average daily gain, feed efficiency and feed and TDN consumption for heifers in Groups 3 and 4, Exp. 1.

Weight range	Av. daily gain	Feed efficiency	Concentrate intake (Per animal)	TDN from	Baled hay intake (Per animal)	TDN from	Total TDN intake per animal	Av. daily TDN intake per animal
(kg)		(kg TDN / kg gain)	(kg)					
(Group 3)								
121-175	.79	3.91	72	56	316	155	211	3.11
175-225	.75	5.31	01	01	540	265	266	3.96
225-275	.82	5.82	00	00	594	291	291	4.77
275-325	.57	8.76	00	00	893	438	438	5.03
325-375	.78	7.21	54	42	649	318	361	5.63
375-425	.86	7.43	104	82	592	290	372	6.40
425-475	.82	9.12	131	102	722	354	456	7.48
(Group 4)								
102-125	.66	3.62	48	38	93	46	83	2.38
125-175	.85	4.08	105	82	249	122	204	3.46
175-225	.94	4.53	69	54	352	173	227	4.27
225-275	.91	5.65	187	146	279	137	283	5.13
275-325	.78	6.46	40	31	597	292	323	5.05
325-375	.60	8.75	56	44	803	393	437	5.20
375-425	.77	8.09	118	92	631	312	404	6.21
425-475	.72	9.98	169	133	746	366	499	7.21

Table 5. Feed efficiency and daily TDN consumption by weight increments and groups, and with all groups averaged within each weight increment, Exp. 1.

Weight range	Group	Feed efficiency per animal	Average feed efficiency, all groups	TDN consumption per animal	Average TDN consumption all groups
(kg)		(kg TDN/kg gain)		(kg/day)	
125-175	2	3.81	3.93^{a}	3.29	3.29^{a}
	3	3.91		3.11	
	4	4.08		3.46	
175-225	1	3.63	$4.54^{a,b}$	3.58	$3.88^{a,b}$
	2	4.67		3.70	
	3	5.31		3.96	
	4	4.53		4.27	
225-275	1	4.33	$5.32^{a,b}$	4.92	$4.76^{b,c}$
	2	5.47		4.21	
	3	5.82		4.77	
	4	5.65		5.13	
275-325	1	5.88	$6.83^{b,c}$	4.98	4.96^{c}
	2	6.20		4.78	
	3	8.76		5.03	
	4	6.46		5.05	
325-375	1	6.64	$7.77^{c,d}$	5.04	5.29^{c}
	2	8.46		5.29	
	3	7.21		5.63	
	4	8.75		5.20	
375-425	1	11.53	9.17^{d}	5.71	6.21^{d}
	2	9.63		6.51	
	3	7.43		6.40	
	4	8.09		6.21	
425-475	1	9.50	$8.91^{c,d}$	5.48	6.84^{d}
	2	7.05		7.20	
	3	9.12		7.48	
	4	9.98		7.21	

[a,b,c,d] Means within column with different superscripts are significantly ($P < .01$) different.

Table 6. Performance of animals up to 475 kg body weight by periods, Exp. 1.[a]

Observation	Group 1	Group 2	Group 3	Group 4
Av. daily gain (kg) for entire period	.78	.77	.76	.77
Days to make gain	403	455	469	485
Av. daily gain (kg) when Groups 1 and 4 were on sawdust-concentrate mixture	.98	.84	.78	.87
Days to make gain	168	168	210	210
Av. daily gain (kg) after Groups 1 and 4 were removed from sawdust-concentrate mixture	.64	.73	.74	.69
Days to make gain	235	287	259	275

[a] Average daily gains between groups are not significantly ($P > .05$) different for entire period. However, Group 1 gained faster ($P < .01$) than Group 2 and Group 4 faster ($P < .01$) than Group 3 while Groups 1 and 4 were receiving sawdust-concentrate free choice. After Groups 1 and 4 were removed from sawdust Group 2 gained faster ($P < .05$) than Group 1, and the difference in gain between Group 3 and Group 4 was not significant ($P > .05$).

($P<.01$) than the hand-fed Group 2 (Table 6). Group 4 grew more rapidly ($P<.01$) than Group 3 for the first 210 days (Table 6). After Groups 1 and 4 were taken from the self-feeders their rates of gain for the rest of the experiment were less than for their contemporaries (Table 6). This difference was significant ($P<.05$) between Group 1 and 2 but not significant ($P>.05$) between Groups 3 and 4.

Figure 1 shows the average estimated net energy (ENE) consumed at various body weights. Estimated net energy was calculated using average crude fiber (Appendix Tables 3 and 4) and the following equations: ENE (megacalories/45.4 kg) = 52.85 - .56 (crude fiber) for hay and ENE (megacalories/45.4 kg) = 1.393 (%TDN) - 34.63 for grain. Figures 2 and 3 show the portion of the total ENE for each group that came from the hay or grain. Calculations were made biweekly so points on the graphs, in terms of time, are 14 days apart. Figure 1 shows that, initially, energy intake per unit body weight decreased slowly, was lowest when the animals received all hay and then increased when the animals were again fed grain. The animals were given concentrate mixture by hand when it was determined subjectively that proper body condition was not being maintained on an all-hay ration. Figures 2 and 3 show that hay intake was inversely related to grain intake. Although hay intake increased as grain intake decreased, the increase in hay intake was apparently not large enough to keep total ENE intake from declining as grain intake dropped.

Table 7 gives the amount of TDN consumed per animal for each group for their weight range and the recommended National Academy of Sciences--National Research Council, 1966 (NRC) amount of TDN needed to obtain this growth. Actual rates of growth, as a percent of the expected rate of growth that would be obtained by feeding NRC recommendations were 126,

THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.

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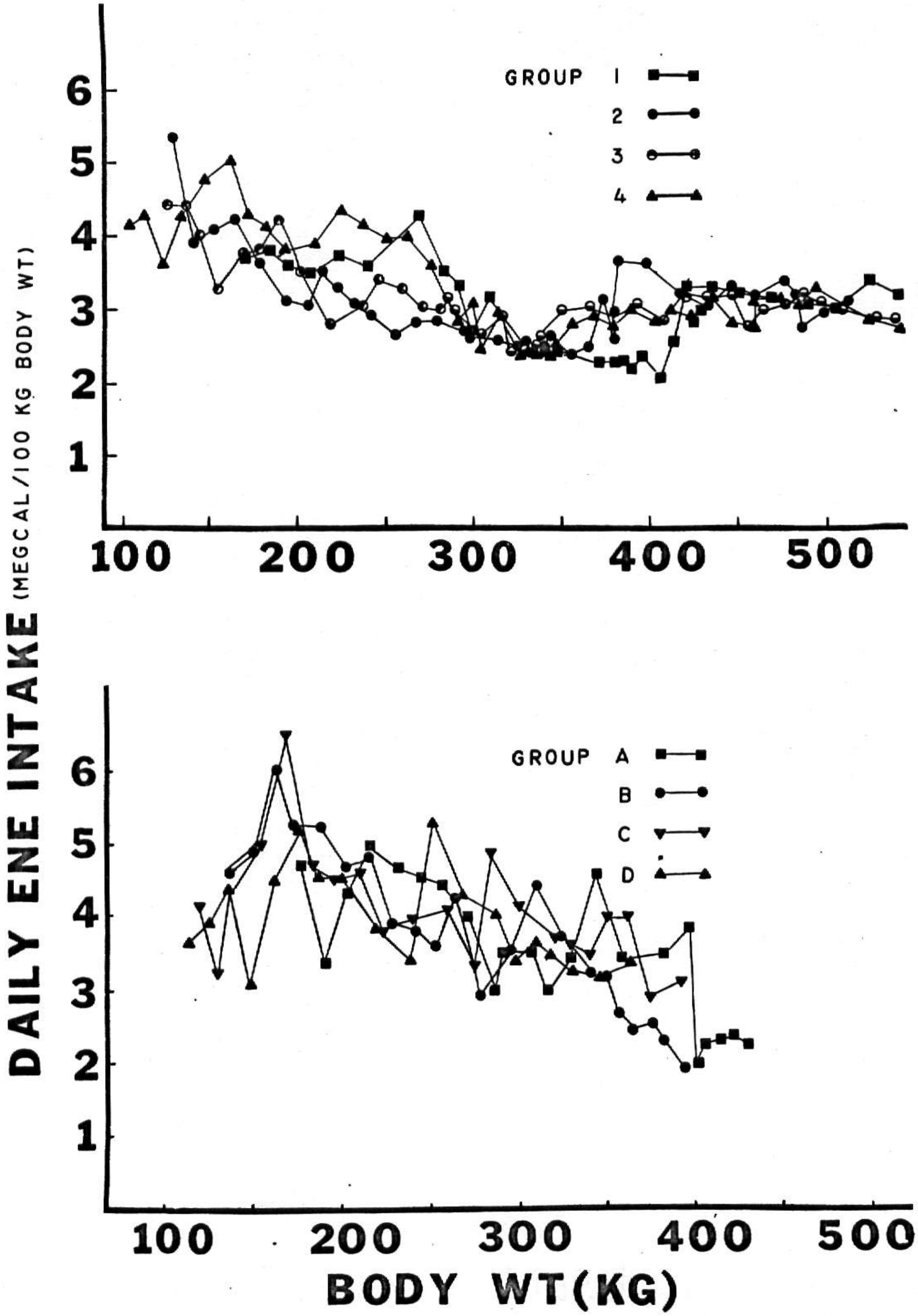

Figure 1. Daily ENE intake (Megcal/100 kg body wt) at various body weights for all groups in Exp. 1 and 2.

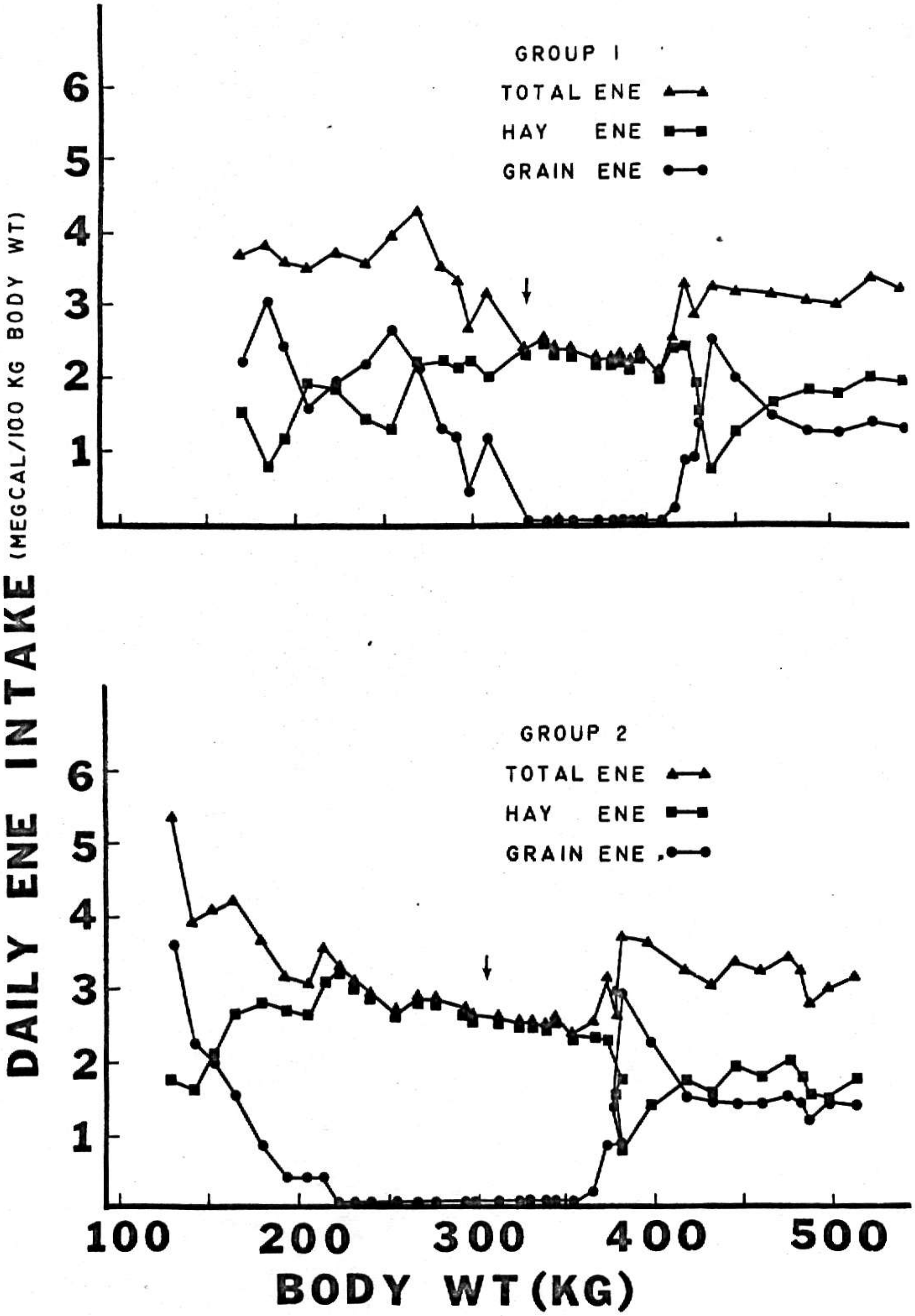

Figure 2. ENE intake (hay, grain and total) at various body weights for Groups 1 and 2, Exp. 1.
↓ Indicates average weight at which animals were first inseminated.

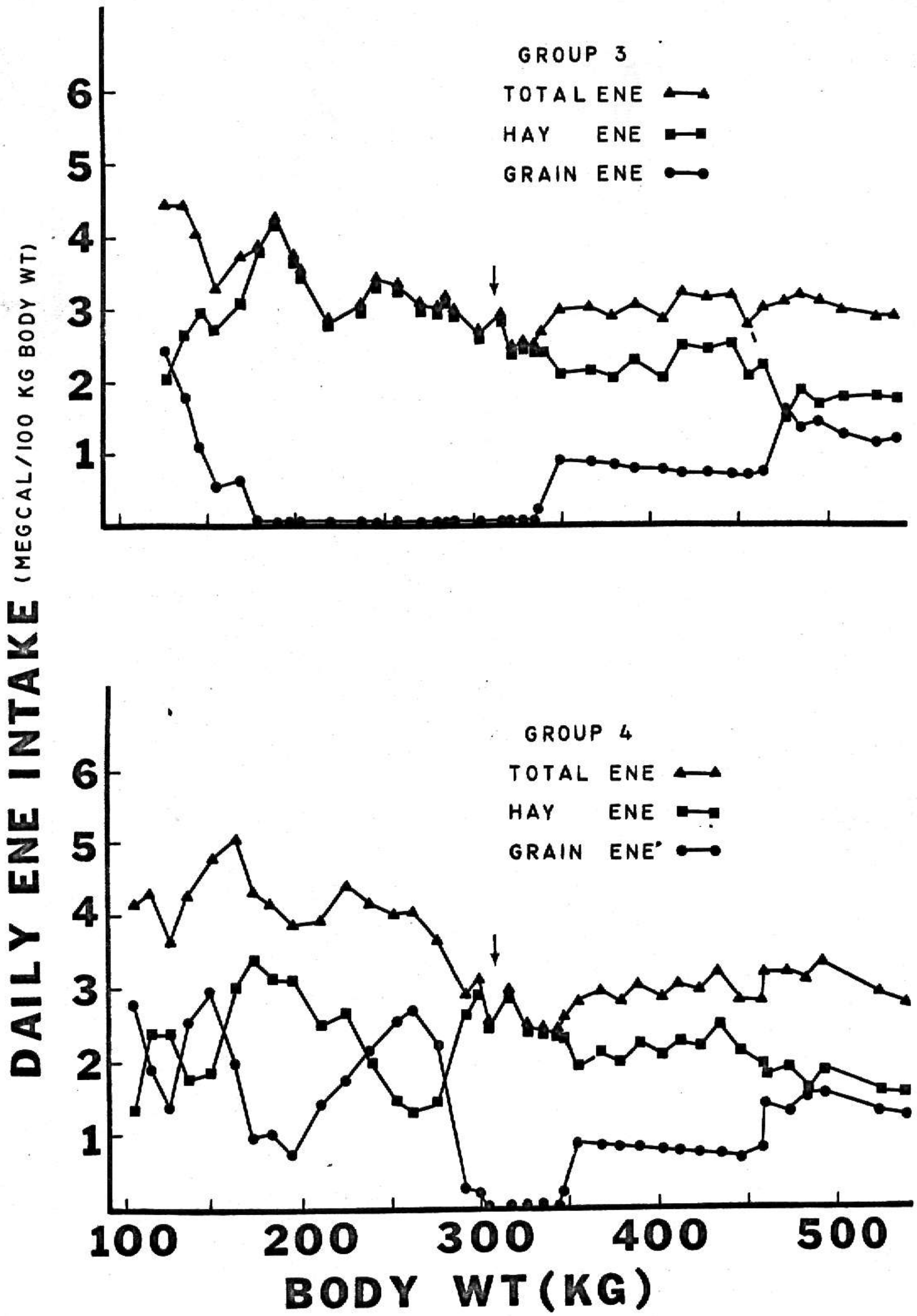

Figure 3. ENE intake (hay, grain and total) at various body weights for Groups 3 and 4, Exp. 1.
↓ Indicates average weight at which animals were first inseminated.

124, 123, and 124 for Groups 1, 2, 3, and 4, respectively.

Table 7. Comparisons between actual and recommended[a] TDN consumption and comparisons between actual rate of growth and that rate of growth that should be obtained by feeding NRC[a] recommendations for Groups 1, 2, 3, and 4, Exp. 1.

Group	Weight range	TDN intake per animal	TDN needed for growth (NRC)	TDN intake / TDN needed (NRC)	Rate of gain: Actual	Rate of gain: By feeding NRC recommendations	Actual rate of gain / NRC rate of gain
	(kg)			(%)	(kg/day)		(%)
1	160-475	2131	2117	101	.78	.62	126
2	124-475	2271	2253	101	.77	.62	124
3	121-475	2395	2262	106	.76	.62	123
4	102-475	2460	2317	106	.77	.62	124

[a] National Academy of Sciences - National Research Council (1966).

Consumption of TDN, as percent of NRC recommendations, was 101, 101, 106, and 106 for Groups 1, 2, 3, and 4. Although rates of gain were approximately 25% faster than those obtained by feeding NRC recommendation, it still required only approximately 100% of the NRC recommended amount of TDN to make that gain.

Puberty and Breeding. Initially, it was intended to watch the animals closely after 227 kg of weight in order to establish age of puberty. However, only six of the animals had shown estrus when administration of MGA was begun, so no attempt was made to obtain age of puberty.

Table 8 shows the number of heifers in each group that showed first estrus in specified time periods after MGA administration ceased. Only six animals showed estrus three to eight days post MGA treatment and only three of those had been in estrus before MGA was begun. All six were in

Groups 1 and 4, indicating that the self fed groups were reaching puberty before the control animals. This is further supported by the fact that of the nine animals that took 49 days or longer to show post MGA treatment estrus, eight were in Groups 2 and 3. It is apparent that heat synchronization with MGA was carried out under less than ideal conditions. The

Table 8. Number of days to first estrus after heifers were removed from MGA, Exp. 1.

Group	Number of heifers in heat before MGA was given	Number of days before heifers showed 1st post-treatment estrus 3-8	9-19	20-29	30-37	38-49	50 or more
1	2	3	0	3	0	1	1
2	0	0	0	3	1	1	3
3	1	0	0	3	0	0	5
4	3	3	0	2	1	2	0

heifers should have cycled at least once before MGA was given, but a majority of the animals had not reached puberty when MGA was first given. Further investigation (Figure 1) showed that ENE intake was decreasing for the groups during the 272 to 317 kg weight range. Gardner and Garcia (1966) and Reid et al. (1964) have reported that Holstein heifers first attain puberty around 272 kg body weight and Schuh (1971) found that decreasing energy intake, resulted in a reduced rate of growth and inhibited signs of estrus.

Appendix Table 5 gives, for each individual animal, breedings to first conception and age, weight, heart girth, and height at first breeding and first conception. Table 9 gives the group averages of the data presented in Appendix Table 5. Average weight, age, height at withers, and

Table 9. Reproductive data, averaged for each group in Exp. 1.[a]

Observation	Group 1	2	3	4
Wt. at first breeding, kg	330	304	313	306
Age at first breeding, days	363	370	379	356
Wt. at first conception, kg	350	330	328	320
Age at first conception, days	389	411	404	379
Services to first conception	2.00	2.50	2.00	1.88
Prepartum wt. at first calving, kg	559	552	574	551
Postpartum wt. at first calving, kg	487	481	507	501
Age at first calving, days	691	687	679	666
Height at withers (cm) - at first breeding	122	118	118	116
at first conception	123	120	120	118
at first calving	133	131	130	129
Heart girth (cm) -				
at first breeding	152	149	151	151
at first conception	156	152	155	153
at first calving	183	182	184	180

[a] None of the among-group means are significantly ($P<.05$) different.

heart girth at first breeding and conception are not significantly (P>.05) different between groups. However, Groups 2 and 3 are older than Groups 1 and 4 at first breeding and first conception. Services to first conception for the groups ranged from 1.88 to 2.50, but were not significantly (P>.05) different.

Table 10 gives the number of experimental animals conceiving on first, second, third or fourth or more breeding. Figures 2 and 3 show

Table 10. Number of animals and percent of total conceiving on first, second, third, or fourth and more breeding for Exp. 1.[a]

Number of breedings	Number conceiving	Percent conceiving	Cumulative percent conceiving
1st	13	42	42
2nd	8	26	68
3rd	7	23	91
4th or more	3	10	100

[a] Data are based on first conception. Three heifers (166E, C129, and 176E) aborted, but later conceived again.

that the heifers were on their lowest energy intake and in a period of least gain (for the experiment) when the average animal in each group was first bred, so this may explain the rather poor average of 2.12 breedings to first conception (all 31 animals) and 42% conception on first breeding. Apparently conditions were not best for maximum reproductive efficiency.

Observations at Parturition. Appendix Table 6 gives age, postpartum weight and measurements at first calving. No significant (P>.05) difference was found between groups for age, postpartum weight and body measurements (Table 9). Length of gestation, parturition difficulty and weight and sex of calf are also included (Appendix Table 6). Length of gestation and parturition difficulty were not significantly ($P > .05$) different between groups.

Of the 32 original animals, 29 had calved at time of this writing. One animal (168E) died from shock when given calcium gluconate. Post mortem examination revealed she was suffering from a severely pulled longissimus dorsi muscle. Another (C125) was removed from the experiment after reaching 408 kg body weight without exhibiting signs of estrus. A third heifer (C129), first conceived after two inseminations, later aborted after receiving sodium iodate for lumpy jaw, reconceived and then aborted again. Calving data were available for 166E but she had not been in milk production long enough to have a DHIA milk production record.

The 29 animals had an average gestation length of 278 days. Seventeen female (av. wt. 35 kg) and 12 male (av. wt. 42 kg) calves were born. Two of the bull calves and one heifer calf were born dead. If assistance had been given earlier, the heifer calf born to 176E would probably have been saved. None of the heifers died at parturition, but 170E had severe dystocia, developed severe uterine infection and was sold.

Postpartum uterine condition was followed by reviewing the herd records on each individual animal. The heifers were checked postpartum at regular intervals by a veterinarian. Summary of the results for the 29 experimental animals is given in Table 11. In order to see if the experimental animals were different than the rest of the university herd, records for other heifers calving during the same time period were obtained. Fifteen other heifers calved during this time and records were found for sex and condition of offspring, postpartum uterine condition, and breedings to first conception. These results are also shown in Table 11

Table 11. Postpartum reproductive performance of 29 experimental heifers and 15 other heifers calving during the same time interval.[a]

Group	Number of animals	Normal uterus 1st post-partum check	Fair uterine involution 1st postpartum check, normal uterus 2nd check	Pyometra cases	Metritis cases	Cases treated medically	Number of calves born dead
1	8	6	2	0	0	0	0
2	7	4	1	1	1	2	0
3	7	5	2	0	0	1	1
4	7	6	1	0	0	0	2
Total	29	21	6	1	1	3	3
%	100	72	21	3.5	3.5	14	10
Other heifers calving during same interval	15	10	3	2	0	4	1
%	100	67	20	13	0	27	7

[a] Data obtained from Kansas State University herd records. Postpartum reproductive checks made by Kansas State University veterinarians.

and Appendix Table 7. No differences between groups or between the experimental animals and the 15 others in condition of offspring or postpartum uterine condition were apparent. Breedings to first conception for the 29 experimental animals was lower (2.1 vs 2.9) than for the 15 other heifers.

Appendix Tables 8, 9, and 10 present data concerning parturition difficulties and postpartum conditions of uterus between treatment and control groups and groups determined by age at calving and postpartum weight at calving. Weight groups of 10, 10, and 8 animals were established (Appendix Table 9). Average parturition difficulty decreased as weight at calving increased. Also, postpartum uterine problems were more prevalent in the lightest group of heifers. The four lightest heifers at calving had postpartum uterine problems and three of the four postpartum cases that were treated medically were found in the eight lightest animals. In the middle weight group one heifer had pyometra which required treatment. The heifer (170E) was sold later. The two postpartum problems in the heaviest group were minor.

On the basis of age, the heifers were divided into groups of 10, 11, and 7 (Appendix Table 8). Parturition difficulty decreased as the age of calving increased. Averages for postpartum reproductive problems were about the same for all groups. Four of the eight reproductive problems occurred in the youngest group, 2 in the middle age group, and 2 in the oldest group. Two of the treated cases were in the youngest group, one in the middle group and one in the oldest group. Because of the larger difference in parturition difficulty and postpartum reproductive problems between the light group and the middle weight group as compared to the youngest group vs the middle age group, it appears that parturition-related problems may be more dependent on weight than age.

Milk and Fat Production During First Lactation. Twenty-eight of the 29 experimental animals that had calved at the time of this writing had partial DHIA records. Since few of the records were complete, 305 - 2X - ME values for production were used. Comparisons between the sawdust-concentrate groups (1 and 4) and the hand-fed groups (2 and 3) showed no significant ($P > .05$) difference in milk and milk fat production (Appendix Table 10). No significant ($P > .05$) difference was found for milk and milk fat production between the 29 experimental animals and the other 15 that freshened at a comparable time (Appendix Tables 7 and 10). Apparently, the early freshening did not affect milk producing ability of the experimental heifers. Milk and milk fat production were also compared by the previously described age and weight groups. No difference ($P > .05$) was found between age groups for milk and milk fat production. However, the heaviest of the weight groups had a significantly ($P < .01$) higher 305 - 2X - ME milk and milk fat production than did their lighter contemporaries.

Experiment 2

Feed Consumption and Growth. Feed consumption, daily gains, feed efficiency and calculated TDN intake per animal are given, by 50 kg weight increments, in Tables 12 and 13. Appendix Table 11 gives feed consumption by eight-week periods. Total digestible nutrient (TDN) values for the feedstuffs were calculated as in Experiment 1. Figures 4 and 5 show the different hay to concentrate ratios that were given each group throughout the experiment.

Feed efficiency decreased ($P < .01$) as the animals grew (Table 14).

Table 12. Average daily gain, feed efficiency and feed and TDN consumption for heifers in Groups A and B, Exp. 2.

Weight range	Av. daily gain	Feed efficiency	Concentrate intake (Per animal)	Concentrate intake TDN from	Ground hay intake (Per animal)	Ground hay intake TDN from	Baled hay intake (Per animal)	Baled hay intake TDN from	Total TDN intake per animal	Av. daily TDN intake per animal
(kg)	(kg)	(kg TDN / kg gain)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
(Group A)										
170-225	.96	4.70	139	109	259	127	47	23	258	4.52
225-275	1.02	5.60	144	112	281	138	62	30	280	5.72
275-325	.77	6.91	119	93	258	126	259	127	346	5.33
325-375	1.22	5.56	144	113	293	144	45	22	278	6.79
375-436	.64	9.47	79	62	312	153	740	363	578	6.01
(Group B)										
131-175	.88	4.64	148	115	148	72	34	17	204	4.08
175-225	.98	5.01	169	132	174	85	67	33	250	4.91
225-275	.88	5.79	115	90	214	105	193	95	290	5.08
275-325	1.11	5.28	126	99	243	119	94	46	264	5.87
325-375	.72	7.79	96	75	276	135	366	179	390	5.64
375-399	.67	7.40	00	00	00	00	363	178	178	4.93

Table 13. Average daily gain, feed efficiency and feed and TDN consumption for heifers in Groups C and D, Exp. 2.

Weight range	Av. daily gain	Feed efficiency	Concentrate intake (Per animal)	Concentrate intake TDN from	Ground hay intake (Per animal)	Ground hay intake TDN from	Baled hay intake (Per animal)	Baled hay intake TDN from	Total TDN intake per animal	Av. daily TDN intake per animal
(kg)	(kg)	(kg TDN / kg gain)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)	(kg)
(Group C)										
114-175	.90	3.74	155	121	155	76	65	32	228	3.35
175-225	1.00	4.77	134	105	134	66	139	68	239	4.77
225-275	1.25	4.11	98	76	121	60	142	70	206	5.14
275-325	1.04	6.10	139	109	309	151	92	45	305	6.35
325-375	.72	9.41	174	135	521	255	163	80	471	6.83
375-406	1.76	3.57	42	32	125	61	35	17	110	6.59
(Group D)										
108-125	.85	2.99	26	20	48	24	15	7	51	2.55
125-175	.91	3.49	77	60	142	70	91	45	174	3.16
175-225	1.06	4.39	93	73	172	84	128	63	220	4.68
225-275	1.19	4.63	117	91	231	113	55	27	232	5.52
275-325	.84	7.13	143	111	411	202	89	44	357	5.85
325-376	1.24	4.83	89	70	268	131	92	45	246	6.00

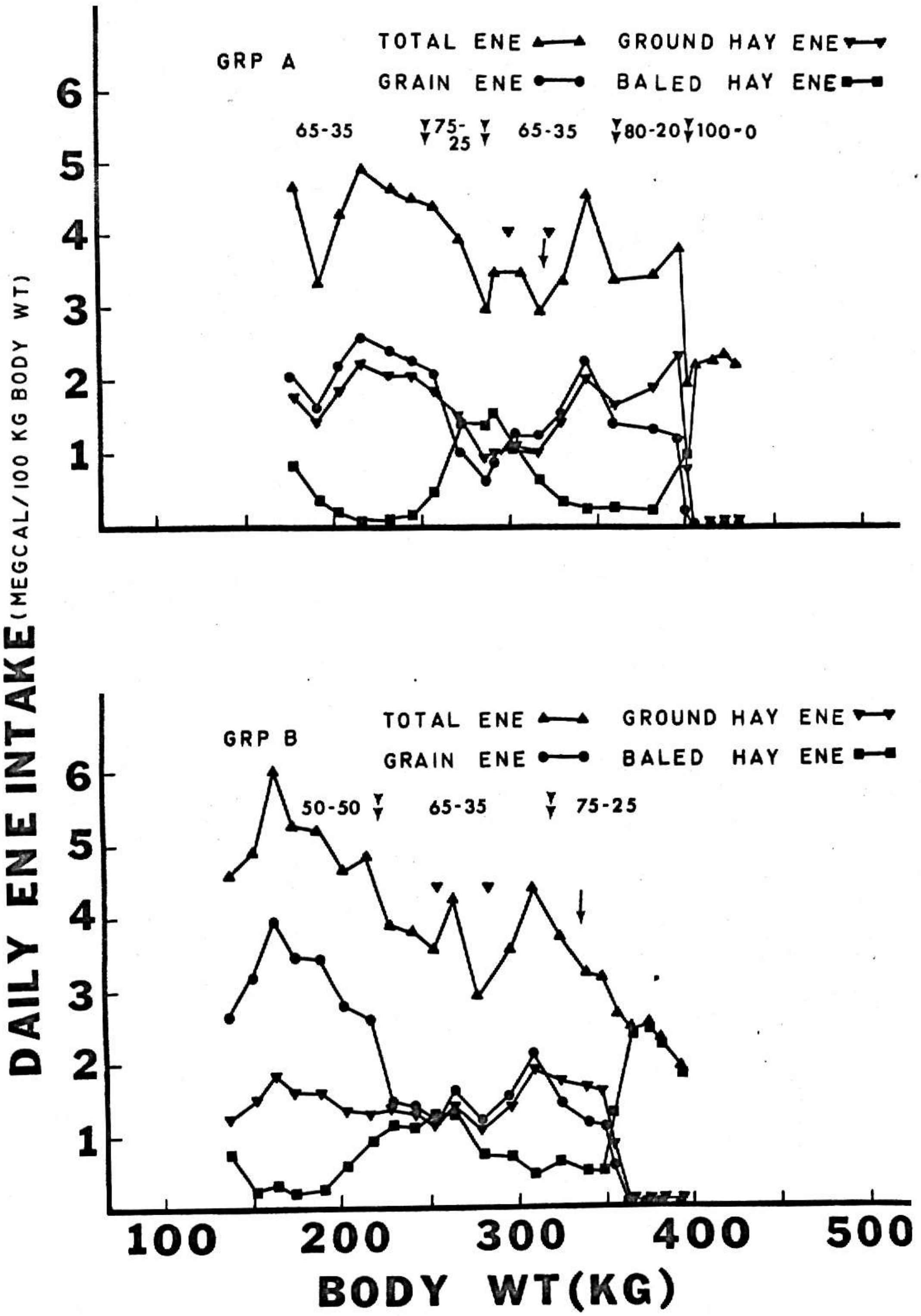

Figure 4. ENE intake and hay to grain ratio of self-fed ration at various body weights for Groups A and B, Exp. 2.
↓ Indicates average weight at which animals were first inseminated.
Numbers between ▼'s show ground hay to concentrate ratio given to heifers.
During the 4 week period between (▼▼) brome hay was given.

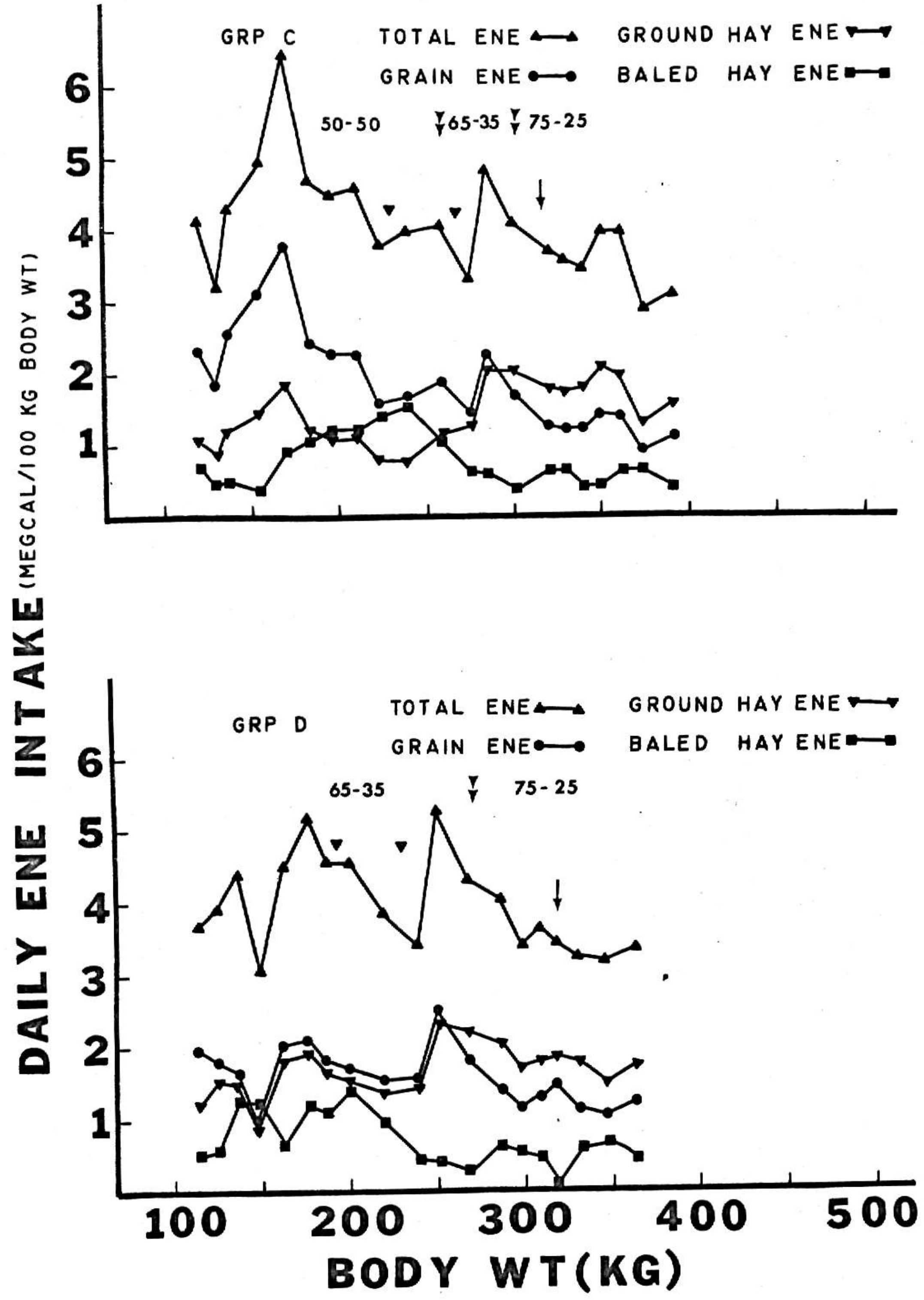

Figure 5. ENE intake and hay to grain ratio of self-fed ration at various body weights for Groups C and D, Exp. 2.
↓ Indicates average weight at which animals were first inseminated.
Numbers between ▼▲'s show ground hay to concentrate ratio given to heifers.
During the 4 week period between (▼▼) brome hay was ground.

Table 14. Feed efficiency and daily TDN consumption by weight increments and groups, and with all groups averaged within each weight increment, Exp. 2.

Weight range	Group	Feed efficiency per animal	Average feed efficiency, all groups	TDN consumption per animal	Average TDN consumption all groups
(kg)		(kg TDN/kg gain)		(kg/day)	
125-175	A	----	3.96[a]	----	3.53[a]
	B	4.64		4.08	
	C	3.74		3.35	
	D	3.49		3.16	
175-225	A	4.70	4.72[a,b]	3.35	4.43[a,b]
	B	5.01		4.91	
	C	4.77		4.77	
	D	4.39		4.68	
225-275	A	5.60	5.03[a,b]	5.72	5.37[b,c]
	B	5.79		5.08	
	C	4.11		5.14	
	D	4.63		5.52	
275-325	A	6.91	6.36[a,b,c]	5.33	5.85[c]
	B	5.28		5.87	
	C	6.10		6.35	
	D	7.13		5.85	
325-375	A	5.56	6.90[b,c]	6.79	6.32[c]
	B	7.79		5.64	
	C	9.41		6.83	
	D	4.83		6.00	
375-425	A	9.47	8.43[c]	6.01	5.47[b,c]
	B	7.40		4.93	

[a,b,c,d] Means within column with different superscript are significantly ($P < .01$) different.

Daily TDN consumption (Table 14) for all groups increased ($P<.01$) as the animals increased in weight, except during the 375 to 425 kg weight range. This decrease in daily intake at the 375 to 425 kg level can probably be attributed to the ration (all hay) that Groups A and B consumed during this period. Average daily gains (ADG) for Groups A, B, C, and D were .86, .87, 1.00, and 1.01 kg (Table 15), respectively. Rates of gain for Groups A and B were significantly ($P<.01$) lower than gains for Groups C and D over the entire period. However, until the time that Groups A and B were placed on an all roughage ration, rates of gain for all groups were not significantly ($P>.05$) different (Table 15). After Groups A and B were placed on an all-hay ration, their ADG were significantly ($P<.01$) lower than the gains for Groups C and D (Table 15).

Table 15. Average daily gain (kg) of heifers by various periods, Exp. 2.[a]

	Group			
	A	B	C	D
Entire period	.86 [b]	.87 [b]	1.00 [c]	1.01 [c]
Entire period minus last 8 weeks	.92 [d]	.89 [d]	.91 [d]	.93 [d]
Last 8 weeks of experiment	.62 [b]	.77 [b]	1.10 [c]	1.09 [c]

[a] Groups A and B were on all hay ration last 8 weeks of experiment.

[b,c] Average daily gains within rows with different superscript are significantly ($P<.01$) different.

[d] Gains were not significantly ($P>.05$) different.

Figure 1 shows the average amount of estimated net energy (ENE) consumed by each animal in each group at various body weights. Calculations were made biweekly so points on the graphs, in terms of time, are 14 days apart. Intake of ENE within groups is highly variable from one period to another. However, Figure 1 shows that after an initial increase there was a slight decline in ENE intake as body weight increased. This decline was probably related to experimental design because as the animals grew, the ratio of hay to grain in the self-fed mixture was increased. Other workers (Blaxter et al., 1961; Colburn and Evans, 1968) have also found that feed intake is not linearly related to body size.

When Groups A and B were placed on an all hay ration (last 5 periods) their ENE intake decreased, but was less variable than for previous periods.

Figures 4 and 5 show a division of the total ENE into that received from the grain, ground hay and baled hay. From the figures there appears to be an inverse relationship between the total ENE intake and the ENE derived from the baled hay. Perhaps the rumen load theory was applicable here and the animals ate to a certain "fill" level. If the baled hay was readily consumed perhaps there was less room in the rumen for the intake of the higher energy grain-ground hay mixture.

For a one-month period bromegrass hay was ground instead of alfalfa because it was more accessible. In the three lots that were receiving a 65% ground bromegrass hay mixture-35% grain, ENE per unit body wt. decreased during this period (Figures 4 and 5). The ENE intake of Group C, receiving 50% grain and 50% ground bromegrass hay ad lib., remained nearly constant (Figure 5). In all groups (Figures 4 and 5) there was an increase in ENE intake within ten days after the grinding of bromegrass hay was discontinued and alfalfa was used again. This indicates that low quality ground hays may be used in lesser quantities than alfalfa to control grain intake at a desired level.

Table 16 gives the amount of TDN consumed per animal for each group for their weight range and the NRC recommended amount of TDN needed to obtain this growth. Actual rates of growth, compared with the expected rate of growth when feeding NRC recommendations were 139, 134, 152, and 155% for Groups A, B, C, and D, respectively. Amount of actual TDN consumed the entire period as a percent of what whould be needed by NRC recommendations was 102, 101, 94, and 88% for Groups A, B, C, and D. respectively. Since the animals were group fed, it was not possible to show, statistically, if the group means were different, but the animals that gained fastest tended to require less TDN for their gain.

Table 16. Comparisons between actual and recommended[a] TDN consumption and comparisons between actual rate of growth and that rate of growth that should be obtained by feeding NRC[a] recommendations for Groups A, B, C, and D, Exp. 2.

Group	Weight range	TDN intake per animal	TDN needed for growth (NRC)	TDN intake / TDN needed (NRC)	Rate of gain: Actual	Rate of gain: By feeding NRC recommendations	Actual rate of gain / NRC rate of gain
	(kg)			(%)	(kg/day)		(%)
A	170-436	1740	1714	102	.86	.62	139
B	131-399	1576	1558	101	.87	.65	134
C	114-406	1560	1659	94	1.00	.65	152
D	108-376	1280	1450	88	1.01	.65	155

[a] National Academy of Sciences - National Research Council (1966).

Data from Experiment 1 and 2 shows that, within weight groups, those heifers that gained more rapidly were more efficient in energy utilization for gain. This is in agreement with work reported by Gardner and Garcia (1966). However, it must be remembered that often a more expensive feed must be given in order to increase energy intake and the added cost of the feedstuff may offset the increase in efficiency of gain. This figure also shows that as the heifers grew it took larger amounts of TDN to maintain the same rate of growth.

Gardner and Garcia (1966) suggested that the relationship between body measurements and weight is independent of rate of gain and that within the limits of their experiment those animals on high levels of energy intake had the same body dimensions at a given weight as those animals on the standard energy level. Figure 6 shows the graph presented by Gardner and Garcia (1966) along with the same information for Experiment 1 and 2. Height at withers at various body weights were exceptionally close between heifers used in Experiment 2 and heifers used by Gardner and Garcia (1966). The heifers used in Experiment 1 were taller at the various weights than were the other two groups but height at different weights followed the same trend as for Experiment 2 and Gardner and Garcia's heifers. Since the sire (H42) of a majority of the animals in Experiment 1 is known to produce tall offspring (Registered Holstein Sire Performance Summaries), the difference probably was genetic rather than nutritional.

Puberty and Breeding. Appendix Tables 12 and 13 give for each animal: breedings per conception and age, weight, heart girth, height and length at first observed estrus, first breeding, and first conception. The number (1st, 2nd, 3rd, etc.) of the estrus period on which the animals were first bred is also given. Table 17 gives the group averages of the data presented in Appendix Tables 12 and 13. Table 18 shows the percent of the heifers that had conceived after each breeding.

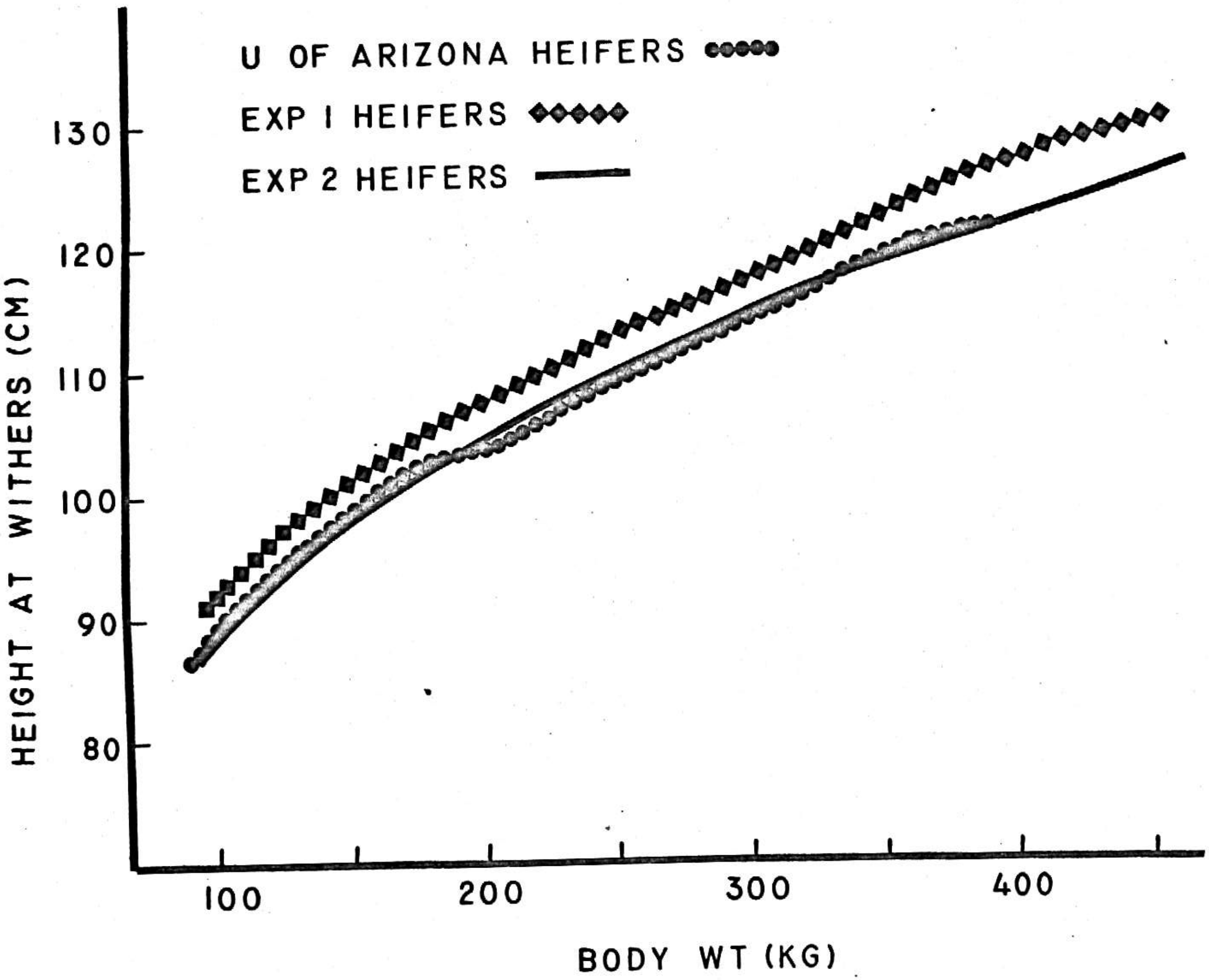

Figure 6. Height at withers at various body weights for heifers used in Exp. 1 and 2 and heifers used at University of Arizona by Gardner and Garcia (1966).

Table 17. Reproductive data, averaged for each group in Exp. 2.[a]

Observation	Group A	B	C	D
Wt. at first estrus, kg	299	296	299	284
Age at first estrus, days	321	303	296	278
Wt. at first breeding, kg	323	336	320	321
Age at first breeding, days	346[b]	344[b]	316[c]	317[c]
Wt. at first conception, kg	333	350	325	335
Age at first conception, days	354	355	322	332
Services to first conception	1.43	1.50	1.29	1.86
Number of times heifers showed estrus, up to and including first breeding	2.29	3.00	2.00	3.00
Height at withers (cm) - at first estrus	115	114	114	113
at first breeding	117	118	115	117
at first conception	118	119	116	118
Hearth girth (cm) - at first estrus	148	146	143	141
at first breeding	150	151	147	149
at first conception	152	153	147	151
Length (point of shoulders to pins) (cm) -				
at first estrus	143	142	139	138
at first breeding	144	145	143	143
at first conception	144	147	143	145

[a,b,c] None of the among group means are significantly ($P < .05$) different except age at first breeding. For age at first breeding, group means with different superscript are significantly ($P < .05$) different.

Table 18. Percent and number of heifers conceiving on first, second, third, or fourth and more breeding, Exp. 2.[a]

Number of breedings	Number conceiving	Percent conceiving	Cumulative percent conceiving
1st	17	63	63
2nd	8	30	93
3rd	1	4	97
4 or more	1	4	100

[a] Data are based on first conception. Three heifers (009, 017, 024) aborted but later conceived again on two or less breedings.

Data from Table 17 may be summarized as follows. Average weights at first estrus of animals in the four groups were not significantly different. Similar results have been reported by other workers (Gardner and Garcia, 1966; Sorensen et al., 1959). Although age at first estrus between groups was not significantly different ($P > .05$) there was a downward trend in age at first estrus from Group A through Group D. Group A was the oldest and Group D the youngest when the experiment started. Although the groups, while on experiment, gained at the same rate up to first estrus, the older animals had less time on experiment until they reached puberty. Their pre-experiment rate of growth was less than that while on experiment so it took them longer to reach first estrus than did the animals that started rapid growth when younger. Average weights at first breeding were not significantly ($P > .05$) different between groups. This was expected because the heifers were bred on the first estrus after reaching 304 kg body weight. Groups A and B had the same average age at first breeding; Groups C and D were also equal but significantly ($P < .05$) different from A and B. Again, this may be attributed to the fact that A and B were older when started on the experiment. Weight at first conception and services to first conception were not significantly ($P > .05$) different between groups. Weight at first conception between groups should not be different because the heifers were first bred after attaining 304 kg body weight, gained at the same rate and required equal number of services to first conception.

First conception was used because it was more complete. Three animals (009, 017, and 024) did abort in early pregnancy, but later conceived again on two or less services.

Average number of times heifers had been observed in estrus up to and including first breeding ranged from an average of 2.00 to 3.00 and were not different ($P > .05$) between groups. Again, this should be true if heifers reach puberty at a given weight and then are bred on first estrus after a given weight. The various body measurements at first estrus, first breeding and first conception were not significantly ($P > .05$) different between groups.

Table 19 groups the heifers according to the estrus at which they were bred and gives breedings to conception and percent conceived after first, second, and third breeding for each group. All animals were bred by the time of the fifth observed heat period. Except for those heifers bred on the fourth observed estrus, average breedings to first conception were approximately equal for each group. The 13 heifers bred on the first or second observed estrus required an average 1.31 breedings to first conception while the 14 animals that were bred on estrus three, four, or five required 1.71 breedings. However, these differences were not significant ($P > .05$). Although the numbers are small, these data indicate that it is not necessary to wait until any particular estrus to breed heifers for good conception if other conditions are right.

Table 19. Breedings to conception by groups that were determined by number of estrus on which heifers were bred, Exp. 2.

	Number of estrus on which heifers were bred				
	1	2	3	4	5
Number of animals	7	6	8	4	2
Breedings to first conception	1.28	1.33	1.25	2.75	1.50
Percent conceived after 1st breeding	72	83	75	00	50
2nd breeding	100	83	100	75	100
3rd breeding	100	100	100	75	100

GENERAL DISCUSSION AND CONCLUSIONS

Results of Experiment 1 showed that Holstein heifers can be reared to approximately 300 kg body weight on 35% sawdust-65% concentrate pellets and alfalfa hay given free choice. Health of the animals was excellent and rate of gain was above that rate supported by giving the control heifers 115% of the NRC recommendations for TDN. The heifers were removed from the sawdust-concentrate ration, at approximately 300 kg, because they showed signs of excess fleshing. Perhaps 35% sawdust will not control intake at the proper level above approximately 300 kg. Sawdust-concentrate pellets could be used to help control concentrate intake in areas where sawdust is inexpensive, labor is expensive and there is a need to handle feed mechanically.

Experiment 2 demonstrated the flexibility of using ground hay to control grain intake. The hay-to-concentrate ratio can be altered to obtain any desired rate of growth between that obtained from an all hay ration to that obtained by an all concentrate ration. In this experiment the heifers wasted none of the hay that was ground and self-fed with the grain. Poor quality hay that normally would not be readily consumed can be used as the grain diluent. Although the hay is an energy diluent it still contributes energy to the ration. This would be an advantage over an indigestible diluent. Any dairyman owning a grinder-mixer unit could adapt the system to his own individual needs.

Disadvantages are that grinding large amounts of hay can become time consuming, and wear on a grinder-mixer unit might become excessive, particularly if grass or grassy alfalfa is to be used.

Experiments 1 and 2 show that rate of gain is dependent on ration and daily energy intake. As the animals in both experiments grew, daily TDN intake increased and the efficiency of the utilization of TDN for gain dropped. Within the same 50 kg weight ranges, the heifers that grew the most rapidly made the most efficient gain (Figure 7). As the heifers grew from 175 kg to 425 kg, feed efficiency decreased at any given rate of gain (Figure 7).

The four groups of heifers from Experiment 2 had the same average weight and body measurements at first estrus, first breeding and first conception. There was no significant difference in breedings to first conception when heifers were grouped according to which estrus the heifers were bred on.

Average breedings to first conception were lower in Experiment 2 than in Experiment 1; this was attributed to the fact that in Experiment 2, energy intake levels were not reduced at or near time of breeding.

In Experiment 1, difficulty at parturition was more severe in the youngest, lightest animals. Although it was not possible to determine conclusively if age or weight was the most important factor associated with parturition difficulty, some indications were that weight as a measure of body size was more important.

No difference in postpartum uterine condition was found between the heifers used in Experiment 1 and 15 other Kansas State University herd heifers that claved during the same time interval. Postpartum uterine problems were more prevalent in the lightest, youngest animals in Experiment 1.

First lactation yields (305 day-2X-ME) between the Experiment 1 groups fed sawdust and those hand fed grain were not different. Milk and milk fat production were not different in the heifers used in Experiment 1

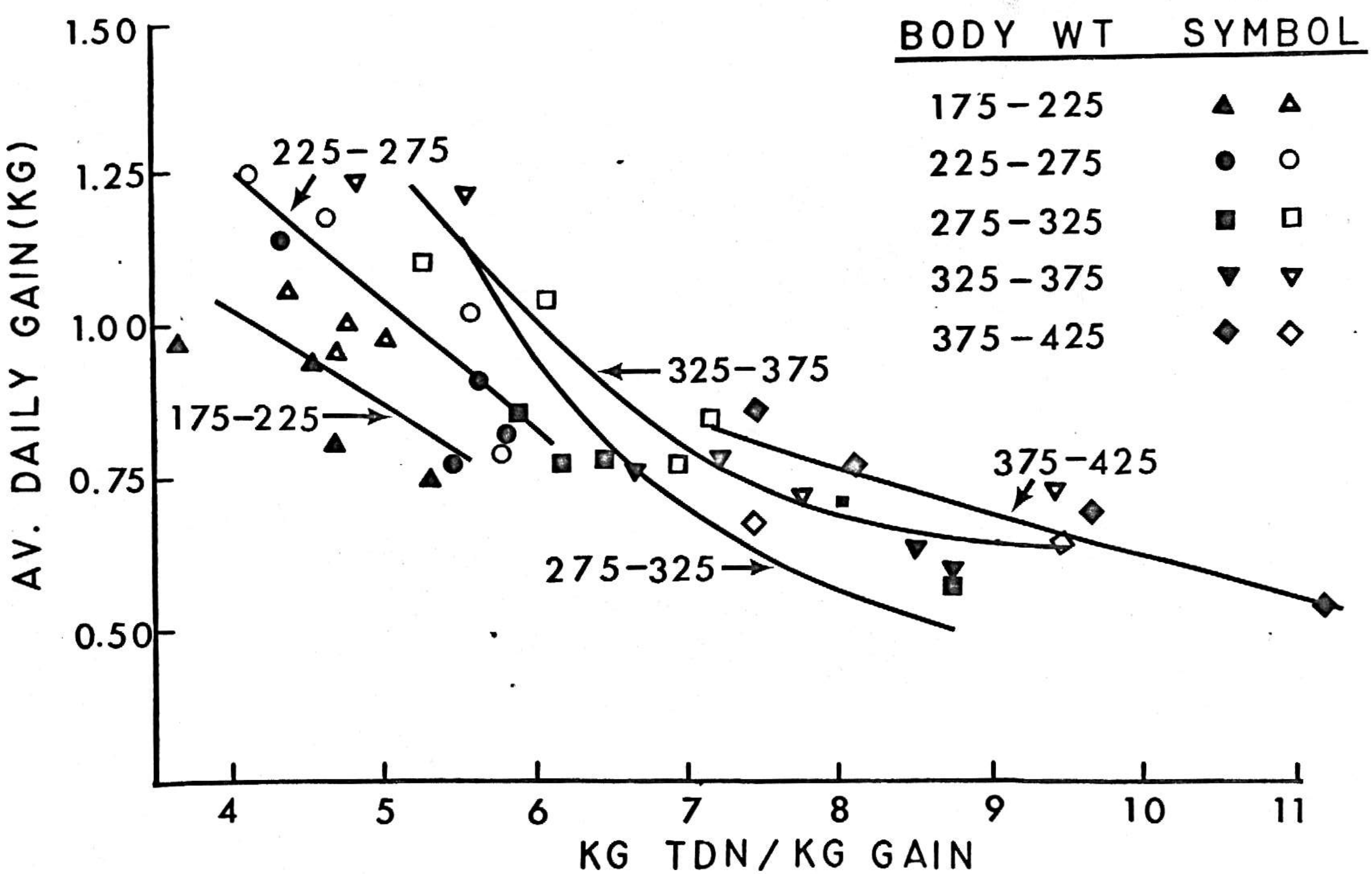

Figure 7. Feed efficiency at different rates of gain and weights for heifers in Exp. 1 and 2. Solid symbols indicate heifers used in Groups 1, 2, 3 and 4, Exp. 1; open symbols indicate heifers used in Groups A, B, C and D, Exp. 2.

and the other university dairy heifers calving at a comparable time. There was no significant difference in milk production between groups that calved at different ages. Grouping animals by weight at first calving showed that the heifers that were heaviest at first calving produced the most milk and milk fat.

The major disadvantage of early freshening was difficult parturition and increased postpartum reproductive tract problems. Milk production in Holstein heifers is apparently not impaired by early calving but at this writing it is still too early to tell what effects accelerated growth and early freshening may have on longevity.

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APPENDIX

Appendix Table 1. Composition of concentrate mixture used in Exp. 1 and Exp. 2.

	(kg)
Rolled sorghum grain	401
Soybean oil meal	45
Salt	5
Trace mineral mixture	2
	(gram)
Vit. A. (10,000 I. U./gm)	120
Vit. D. (15,000 I. U./gm)	10

Appendix Table 2. Feed consumption and body weight by eight week periods, Exp. 1.

Dates	Group 1			Group 2			Group 3			Group 4		
	Weight range	Conc. intake	Hay intake	Weight range	Conc. intake	Hay intake	Weight range	Conc. intake	Hay intake	Weight range	Conc. intake	Hay intake
	(kg)											
(1969)												
3- 1 to 4-25	160-213	2475	2995	124-171	1932	3534						
3-29 to 4-25							121-141	792	1802	102-118	729	1207
4-26 to 6-20	213-278	3141	4758	171-216	586	6422	141-181	494	5886	118-166	1813	3692
6-21 to 8-15	278-324	1723	7240	216-264	00	8084	181-235	00	8084	166-220	1105	6428
8-16 to 10-10	324-362	00	10140	264-300	00	9520	235-275	00	9804	220-268	3203	5331
10-11 to 12- 5	362-391	00	10311	300-342	00	9912	275-313	00	10157	268-306	1074	8251
12- 6 to 1-30	391-425	623	11410	342-379	476	9555	313-331	00	10085	306-343	00	10059
(1970)												
1-31 to 3-27	425-458	4213	7284	379-411	3537	5662	331-381	1440	9512	343-383	1440	9121
3-28 to 5-22				411-469	3164	7522	381-442	1680	10004	383-432	1792	9886
5-23 to 7-17										432-458	2320	10760
3-28 to 4- 8	458-475	786	1763									
5-23 to 6- 3				469-475	382	983						
5-23 to 7-11							442-475	1663	8766			
7-18 to 7-26										458-475	498	1495

Appendix Table 3. Proximate analysis of concentrate mixture fed from March, 1969 to November, 1970, Exp. 1 and 2.

Month	Dry matter	Ether extract	Crude fiber	Ash	Protein
	(%)				
(1969)					
March and April	87.90	2.66	2.19	2.66	12.64
May and June	87.43	2.03	2.09	2.75	14.58
(1970)[a]					
March and April	83.89	2.15	2.10	2.07	10.42
May	84.45	2.55	1.97	2.14	10.44
June	86.36	1.43	2.09	1.93	9.98
July	85.41	1.29	2.10	1.78	10.15
August	88.02	0.59	2.05	1.87	10.93
September	86.20	1.07	2.22	2.18	12.17
October	87.02	1.51	1.99	1.83	11.64
November	85.98	1.29	2.21	1.87	11.90

[a] No concentrate mixture was fed from July, 1969 through February, 1970.

Proximate analysis of sawdust-grain mixture fed from March, 1969 to August, 1969, Exp. 1.

Month	Dry matter	Ether extract	Crude fiber	Ash	Protein
	(%)				
(1969)					
March and April	89.95	3.35	22.54	2.53	9.43
May and June	90.00	2.79	23.76	2.64	8.42
July and August	87.89	1.37	25.50	2.39	8.54

Appendix Table 4. Proximate analysis of baled hay used from March, 1969 to November, 1970, Exp. 1 and 2.

Month	Dry matter	Ether extract	Crude fiber	Ash	Protein
	(%)				
(1969)					
March and April	88.01	1.58	25.94	8.94	17.25
May	90.37	2.55	26.02	8.12	15.62
June	89.28	1.85	22.53	9.99	17.51
July	90.90	2.07	20.61	10.02	18.48
August	90.69	1.79	29.40	8.52	17.31
September	90.45	1.61	27.02	8.47	18.94
October	89.82	1.57	27.83	8.06	17.95
November	88.92	1.57	26.42	9.70	17.92
December	87.65	1.56	26.81	9.85	17.97
(1970)					
January	90.10	1.85	28.81	9.73	17.04
February	90.19	1.11	28.50	9.37	15.85
March	89.41	1.12	27.48	8.66	15.57
April	88.10	1.89	23.71	8.17	17.63
May	86.45	2.12	21.36	8.65	19.45
June	91.76	2.10	25.90	8.73	18.18
July	91.03	2.08	26.60	8.41	17.63
August	92.60	1.26	28.74	8.62	19.16
September	92.25	1.56	26.50	8.76	18.76
October	92.40	1.58	28.09	8.64	17.79
November	89.44	1.38	27.28	9.56	17.65

Proximate analysis of ground hay used from March, 1970 to November, 1970, Exp. 2.

Month	Dry matter	Ether extract	Crude fiber	Ash	Protein
	(%)				
(1969)					
March and April	89.45	2.05	23.71	7.75	15.92
May	89.23	1.77	24.91	9.35	20.02
June	91.53	1.97	25.98	8.64	19.71
July[a]	92.69	2.34	30.46	6.20	9.28
August	92.29	1.21	25.96	10.13	20.86
September	91.42	1.46	26.34	9.50	20.73
October	92.68	1.39	26.48	11.61	19.99
November	91.92	1.21	28.17	10.44	18.31

[a] Bromegrass hay was ground during month of July.

Appendix Table 5. Age, weight, and body measurements at first breeding and first conception, and breedings to first conception, Exp. 1.

	First breeding					First conception			
Animal number	Age	Weight	Heart girth	Height at withers	Breedings to first conception	Age	Weight	Heart girth	Height at withers
	(days)	(kg)	(cm)			(days)	(kg)	(cm)	
(Group 1)									
13E	340	323	152	121	3	395	364	163	124
160E	327	269	140	116	1	327	269	140	116
161E	366	330	155	125	3	403	360	157	127
162E	399	364	160	126	3	437	397	168	128
165E	354	342	152	123	1	354	342	152	123
166E	359	347	155	122	3	434	403	165	126
B181	401	363	157	124	1	401	363	157	124
B184	358	302	147	117	1	358	302	147	117
(Group 2)									
B185	336	292	145	116	1	336	292	145	116
C109	419	343	157	122	5	540	400	168	129
C117	342	269	145	111	2	360	288	147	113
164E	381	274	142	112	3	429	320	147	117
167E	359	304	150	122	5	475	366	160	128
168E	389	293	147	120	2	412	312	150	121
169E	351	304	145	117	1	351	304	145	117
170E	386	356	157	122	1	386	356	157	122
(Group 3)									
C118	357	294	147	115	1	357	294	147	115
C125	Removed from experiment when she failed to show signs of estrus.								
C127	393	338	155	122	2	414	339	157	123
C128	418	330	155	123	3	498	402	168	126
171E	353	305	150	116	1	353	305	150	116
175E	386	322	152	120	2	399	338	155	121
178E	382	306	150	117	3	408	320	155	121
B188	366	297	145	116	2	401	296	150	118
(Group 4)									
C114	386	313	155	115	1	386	313	155	115
C124	322	283	145	108	5	444	366	160	117
C129	392	356	157	118	2	409	361	160	120
173E	361	304	150	117	1	361	304	150	117
174E	346	279	150	116	2	371	296	147	118
176E	341	288	150	121	1	341	288	150	121
177E	360	337	152	119	2	378	343	155	121
179E	339	285	145	113	1	339	285	145	113

Appendix Table 6. Age, weight, and body measurements at first calving, length of first gestation, parturition difficulty and sex and weight of calves of heifers on Exp. 1.

Animal number	Age	First calving: Postpartum weight	First calving: Heart girth	First calving: Height at withers	Length of gestation	Code[a] for parturition difficulty	Sex of calf	Birth-weight of calf
	(days)	(kg)	(cm)	(cm)	(days)			(kg)
(Group 1)								
13E	666	506	185	134	271	1	M	37
160E	606	388	168	128	279	4	F	44
161E	685	492	183	139	282	2	F	34
162E	711	526	196	133	274	2	M	39
165E	632	490	183	135	279	2	M	39
166E	920	574	201	138	293	2	M	46
B181	686	485	180	134	285	2	M	44
B184	624	433	168	124	267	1	F	34
				Average	279	2.0		
(Group 2)								
B185	610	449	173	130	274	3	F	34
C109	816	553	201	138	276	1	F	40
C117	633	431	183	125	274	3	F	34
164E	705	420	170	126	276	2	F	27
167E	753	549	185	138	278	2	F	35
168E	Died after conception and before parturition.							
169E	628	472	178	128	278	2	F	34
170E	667	490	183	135	281	3	M	46
				Average	277	2.1		
(Group 3)								
C118	631	451	180	126	274	3	M	38
C125	Removed from experiment when she failed to show signs of estrus.							
C127	683	538	191	135	270	2	F	39
C128	772	581	193	136	273	1	F	37
171E	630	449	180	125	278	2	M	38
175E	679	535	183	130	280	3	M[b]	44
178E	684	547	185	132	276	2	F	39
B188	671	451	178	127	271	2	F	36
				Average	274	2.1		
(Group 4)								
C114	655	440	178	126	269	2	F	29
C124	719	558	188	124	293	2	F	30
C129	Had not calved at time of writing.							
173E	633	458	173	128	272	1	M	43
174E	654	445	173	130	284	3	M[b]	c
176E	718	583	191	136	278	2	F[b]	c
177E	664	540	180	133	287	2	M	52
179E	616	485	180	128	278	2	F	38
				Average	280	2.0		

[a] 1 - Heifer was not assisted during parturition.
2 - Heifer was assisted--assistance slight and may not have been neede
3 - Much help given--dystocia.
4 - Calf taken by caesarean section.

[b] Dead at birth.

[c] No weight was recorded.

Appendix Table 7. Breedings to conception, length of gestation, age at calving sex of calf, postpartum uterine condition, days in lactation, milk and milk fat production for 15 other university herd heifers that calved during same time interval as heifers used in Exp. 1.

Animal number	Breedings to conception	Length of gestation	Age at calving	Sex of calf	Uterine condition postpartum[a]	Days in lactation	305 day-2X-ME Milk	Fat
		(days)					(kg)	
144E	5	283	821	M	1	315	5774	168
142E	4	276	913	M	2T	349	5915	215
B174	4	280	913	F	1	286	6822	200
B175	2	268	852	M	1	287	5511	177
B178	3	277	852	F	3T	280	7103	209
150E	3	275	882	M	1	288	7294	231
151E	4	266	1217	M	2T	281	6545	218
157E	1	271	882	F	2	172	6364	193
158E	2	278	882	F	1	176	7321	208
G18	1	280	913	M	1	100	5280	152
152E	3	279	1034	F	1	101	7103	203
G17	1	278	1034	M	3T	141	6550	220
156E	4	278	1034	M[b]	1	69	7657	249
154E	2	277	1065	F	1	74	7185	274
B177	5	280	1034	M	1	71	5702	174
Average	2.9	276	955		1.5	199	6542	206

[a] Data obtained from Kansas State University dairy herd records. Postpartum checks were made by Kansas State University veterinarians.

1 - Uterus normal first postpartum check.
2 - Uterus in fair condition first postpartum check, normal second check.
3 - Metritis or pyometra case.
T - Heifer treated medically.

[b] Calf born dead.

Appendix Table 8. Age at calving, postpartum weight, length of gestation, milk and milk fat production, number of days in lactation, parturition difficulty and postpartum uterine condition for Exp. 1, grouped according to age at calving.

Animal number	Age at calving	Post-partum weight	Length of gestation	305 day-2X-ME Milk	305 day-2X-ME Fat	Number of days in lactation	Parturition difficulty[a]	Uterine condition postpartum[b]
	(days)	(kg)	(days)	(kg)	(kg)			
(Youngest)								
160E	606	388	279	6,577	184	333	4	2
B185	610	449	274	6,391	213	285	3	1
179E	616	485	278	7,770	232	108	2	1
B184	624	433	267	5,874	136	294	1	2
169E	628	472	278	6,464	199	255	2	1
171E	630	449	278	7,698	219	230	2	3T
C118	631	451	274	6,868	182	231	3	1
165E	632	490	279	7,035	206	270	2	1
C117	633	431	274	4,854	157	231	3	2T
173E	633	458	272	5,144	175	200	1	1
Average	624	451	275	6,468	190	244	2.3	1.5
(Middle)								
174E	654	445	284	3,715	157	116	3	1
C114	655	440	269	5,507	193	215	2	1
177E	664	540	287	6,337	216	141	2	2
13E	666	506	271	5,039	145	239	1	1
170E	667	490	281	4,391	177	143	3	3T
B188	671	451	271	5,493	201	208	2	1
175E	679	535	280	5,820	218	143	3	1
C127	683	538	270	10,451	309	133	2	1
178E	684	547	276	7,199	224	115	2	1
161E	685	492	282	3,511	77	149	2	1
B181	686	485	285	6,237	204	249	2	1
Average	672	497	278	5,791	193	168	2.2	1.3
(Oldest)								
164E	705	420	276	3,951	152	204	2	3T
162E	711	526	274	6,382	176	219	2	1
176E	718	583	278	7,598	255	98	2	1
C124	719	558	293	7,239	233	127	2	1
167E	753	549	278	7,044	212	143	2	1
C128	772	581	273	7,203	237	91	1	2
C109	816	553	276	7,344	288	60	1	1
Average	742	539	278	6,680	222	135	1.7	1.4
Overall average	673	491	277	6,255	199	187	2.1	1.4

[a] Coded as in Appendix Table 6.

[b] Coded as in Appendix Table 7.

Appendix Table 9. Postpartum weight, age at calving, length of gestation, 305-2X-ME milk and milk fat production, number of days in lactation, parturition difficulty and postpartum uterine condition for Exp. 1, grouped according to weight at calving.

Animal number	Post-partum weight	Age at calving	Length of gestation	305 day-2X-ME Milk	305 day-2X-ME Fat	Number of days in lactation	Parturition difficulty[a]	Uterine condition postpartum[b]
	(kg)	(days)	(days)	(kg)	(kg)			
(Lightest)								
160E	388	606	279	6,577	184	333	4	2
164E	420	705	276	3,951	152	204	2	3T
C117	431	633	274	4,854	157	231	3	2T
B184	433	624	267	5,874	136	294	1	2
C114	440	655	269	5,507	193	215	2	1
174E	445	654	284	3,715	157	116	3	1
B185	449	610	274	6,391	213	285	3	1
171E	449	630	278	7,698	219	230	2	3T
B188	451	671	271	5,493	201	208	2	1
C118	451	631	274	6,868	182	231	3	1
Average	436	642	275	5,693	179	235	2.5	1.7
(Middle)								
173E	458	633	272	5,144	175	200	1	1
169E	472	628	278	6,464	199	255	2	1
B181	485	686	285	6,237	204	249	2	1
179E	485	616	278	7,770	232	108	2	1
165E	490	632	279	7,035	206	270	2	1
170E	490	667	281	4,391	177	143	3	3T
161E	492	685	282	3,511	77	149	2	1
13E	506	666	271	5,039	145	239	1	1
162E	526	711	274	6,382	176	219	2	1
175E	535	679	280	5,820	218	143	3	1
Average	494	660	278	5,779	181	198	2.0	1.2
(Heaviest)								
C127	538	683	270	10,451	309	133	2	1
177E	540	664	287	6,337	216	141	2	2
178E	547	684	276	7,199	224	115	2	1
167E	549	753	278	7,044	212	143	2	1
C109	553	816	276	7,344	288	60	1	1
C124	558	719	293	7,239	233	127	2	1
C128	581	772	273	7,203	237	91	1	2
176E	583	718	278	7,598	255	98	2	1
Average	556	726	279	7,552	247	114	1.8	1.3
Overall Average	491	673	277	6,255	199	187	2.1	1.4

[a] Coded as in Appendix Table 6.

[b] Coded as in Appendix Table 7.

Appendix Table 10. Age at calving, postpartum weight, length of gestation, 305-2X-ME milk and milk fat production, number of days in lactation, parturition difficulty and postpartum uterine condition for treatment and control groups, Exp. 1.

Animal number	Age at calving	Post-partum weight	Length of gestation	305 day-2X-ME Milk	305 day-2X-ME Fat	Number of days in lactation	Parturition difficulty[a]	Uterine condition postpartum[b]
	(days)	(kg)	(days)	(kg)	(kg)			
(Treatment)								
13E	666	506	271	5,039	145	239	1	1
160E	606	388	279	6,577	184	333	4	2
161E	685	492	282	3,511	77	149	2	1
162E	711	526	274	6,382	176	219	2	1
165E	632	490	279	7,035	206	270	2	1
B181	686	485	285	6,237	204	249	2	1
B184	624	433	267	5,874	136	294	1	2
C114	655	440	269	5,507	193	215	2	1
C124	719	558	293	7,239	233	127	2	1
173E	633	458	272	5,144	175	200	1	1
174E	654	445	284	3,715	157	116	3	1
176E	718	583	278	7,598	255	98	2	1
177E	664	540	287	6,337	216	141	2	2
179E	616	485	278	7,770	232	108	2	1
Average	662	488	278	5,998	185	197	2.0	1.2
(Control)								
B185	610	449	274	6,391	213	285	3	1
C109	816	553	276	7,344	288	60	1	1
C117	633	431	274	4,854	157	231	3	2T
164E	705	420	276	3,951	152	204	2	3T
167E	753	549	278	7,044	212	143	2	1
169E	628	472	278	6,464	199	255	2	1
170E	667	490	281	4,391	177	143	3	3T
C118	631	451	274	6,868	182	231	3	1
C127	683	538	270	10,451	309	133	2	1
C128	772	581	273	7,203	237	91	1	2
171E	630	449	278	7,698	219	230	2	3T
175E	679	535	280	5,820	218	143	3	1
178E	684	547	276	7,199	224	115	2	1
B188	671	451	271	5,493	201	208	2	1
Average	683	494	276	6,512	213	177	2.2	1.6
Overall Average	673	491	277	6,255	199	187	2.1	1.4

[a] Coded as in Appendix Table 6.

[b] Coded as in Appendix Table 7.

Appendix Table 11. Feed consumption and body weight by eight-week periods, Exp. 2.

Dates	Weight range	Conc. intake	Ground hay intake	Baled hay intake	Weight range	Conc. intake	Ground hay intake	Baled hay intake
	(kg)							
(1970)	Group A				Group B			
2-13 to 4- 9	170-224	953	1769	324	131-181	1179	1179	253
4-10 to 6- 4	224-283	1095	2216	616	181-235	1188	1352	665
6- 5 to 7-30	283-321	699	1479	1605	235-287	794	1474	1293
7-31 to 9-23	321-393	1318	2901	429	287-344	1091	2397	809
9-24 to 11-18	393-420	313	1456	2790	344-378	329	987	2890
11-19 to 12-16	420-436	00	00	2313	378-399	00	00	1907
	Group C				Group D			
2-27 to 4- 9	114-148	499	499	255				
3-27 to 4- 9					108-121	127	236	66
4-10 to 6- 4	148-205	1134	1134	677	121-171	519	959	583
6- 5 to 7-30	205-269	980	1061	1402	171-230	778	1445	1057
7-31 to 9-23	269-327	1102	2436	555	230-292	1070	2377	535
9-24 to 11-18	327-371	1032	3096	882	292-341	885	2586	612
11-19 to 12-16	371-406	442	1327	473	341-376	454	1361	452

Appendix Table 12. Age, weight, and body measurements at first estrus and first breeding, Exp. 2.

Animal number	First Estrus: Age	Body wt.	Heart girth	Height at withers	Length	First Breeding: Age	Body wt.	Heart girth	Height at withers	Length
	(days)	(kg)	(cm)			(days)	(kg)	(cm)		
(Group A)										
001	329	325	150	120	147	330	325	150	120	147
002	332	305	150	114	142	351	326	150	116	140
003	375	352	152	119	147	375	352	152	119	147
004	306	264	140	113	140	363	303	147	117	142
005	301	271	145	111	140	336	301	147	116	140
006	306	296	150	113	142	325	323	150	115	142
007	301	283	147	114	142	345	331	152	118	147
Average	321	299	148	115	143	346	323	150	117	144
(Group B)										
008	288	292	145	113	142	351	341	152	117	145
009	393	412	165	123	157	394	412	165	123	157
010	277	260	137	107	137	339	322	147	114	140
011	292	284	147	115	140	329	329	150	118	145
012	285	276	142	115	142	322	313	147	119	147
013	285	254	140	113	132	332	301	147	116	137
014[a]										
Average	303	296	146	114	142	344	336	151	118	145
(Group C)										
015	318	325	145	116	145	319	325	145	116	145
016	259	249	135	111	137	296	289	142	114	142
017	317	316	147	114	140	318	316	147	114	140
018	292	299	142	117	140	311	342	147	119	145
019	295	300	145	116	140	315	324	147	118	140
020	301	304	140	112	137	320	316	147	114	145
021	291	303	145	110	137	330	331	152	113	145
Average	296	299	143	114	139	316	320	147	115	143
(Group D)										
022	277	327	150	118	145	278	327	150	118	145
023	269	282	140	114	137	288	312	145	117	140
024	261	240	135	109	130	338	324	150	117	142
025	265	290	137	111	137	319	332	152	116	147
026	313	314	150	115	142	314	314	150	115	142
027	311	288	145	114	140	353	331	152	118	142
028	253	244	132	113	135	328	308	147	120	142
Average	278	284	141	113	138	317	321	149	117	143

[a] 014 was a freemartin.

Appendix Table 13. Age, weight, and body measurements at first conception, number of estrus on which heifer was bred, and breedings to first conception, Exp. 2.

Animal number	First Conception Age	Weight	Heart girth	Height at withers	Length	Number of estrus on which heifer was bred	Breedings to conception
	(days)	(kg)	(cm)				
(Group A)							
001	330	325	150	120	147	1	1
002	351	326	150	116	140	2	1
003	395	369	157	121	150	1	2
004	383	333	152	119	145	4	2
005	352	321	152	116	140	3	2
006	325	323	150	115	142	2	1
007	345	331	152	118	147	3	1
Average	354	333	152	118	144	2.3	1.4
(Group B)							
008	375	372	157	120	150	4	2
009	394	412	165	123	157	1	1
010	361	348	150	116	145	4	2
011	329	329	150	118	145	3	1
012	340	340	150	121	147	3	2
013	332	301	147	116	137	3	1
014[a]							
Average	355	350	153	119	147	3.0	1.5
(Group C)							
015	319	325	145	116	145	1	1
016	296	289	142	114	142	3	1
017	318	316	147	114	140	1	1
018	311	342	147	119	145	2	1
019	315	324	147	118	140	2	1
020	362	347	152	116	147	2	3
021	330	331	152	113	145	3	1
Average	322	325	147	116	143	3.0	1.3
(Group D)							
022	294	347	150	119	145	1	2
023	288	312	145	117	140	2	1
024	338	324	150	117	142	5	1
025	387	390	160	119	155	4	5
026	314	314	150	115	142	1	1
027	353	331	152	118	142	3	1
028	347	330	150	120	150	5	2
Average	332	335	151	118	145	3.0	1.9

[a] 014 was a freemartin.

THE RESPONSES OF DAIRY HEIFERS REARED ON A SELF-FEEDING REGIME DESIGNED TO ALLOW RAPID GROWTH AND SUBSEQUENT EARLY CALVING

by

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ABSTRACT

In Experiment 1, 32 Holstein heifers were divided into four equal groups. Two groups (1 and 4) received hay and concentrate-sawdust pellets free choice. The .48 cm pellets were 35% sawdust and 65% concentrate, and were fed until the animals weighed approximately 300 kg. Groups 2 and 3 received enough concentrate mixture to provide, along with the hay consumed _ad lib._, 115% of NRC requirements for TDN. Average daily gains up to 475 kg body weight for Groups 1, 2, 3, and 4 were .78, .77, .76, and .77 kg, respectively.

Twenty-eight Holstein heifers in Experiment 2 were divided into four equal groups, and concentrate intake was controlled by dilution with ground hay. Alfalfa hay was given free choice to all groups. Groups A and D initially received a mixture of 65% ground hay and 35% concentrate; Groups B and C started on 50% hay and 50% concentrate. On the basis of subjective observations, the ratio of ground hay to concentrate was altered to maintain proper body condition. Average daily gains for Groups A, B, C, and D were .86, .87, 1.00, and 1.01 kg, respectively.

Rates of gain for all groups in Experiment 1 were not significantly ($P>.05$) different up to 475 kg of weight. However, those animals that received the sawdust-concentrate pellets (Groups 1 and 2) gained more rapidly ($P<.01$) than their contemporaries while receiving the pelleted feed. After feeding of pellets to Groups 1 and 4 was discontinued, Groups 2 and 3 gained more rapidly.

Animals in all groups in Experiment 2 gained at rates not significantly ($P>.05$) different until Groups A and B were placed on the all-hay ration. After Groups A and B were placed on all-hay, their lowered ($P<.01$) rate

of gain was enough to make their daily gain for the entire period less ($P<.01$) than that obtained by Groups C and D.

For all groups in both experiments feed efficiency decreased ($P<.01$) and TDN consumption increased ($P<.01$) as the heifers grew.

Breedings to first conception were not significantly different ($P>.05$) for groups within the same experiment, but heifers in Experiment 2 averaged less breedings to conception than heifers in Experiment 1. This was attributed to the fact that energy intake for heifers was not lowered near time of breeding for Experiment 2 as had happened in Experiment 1.

Average height at withers at a given body weight was higher for Experiment 1 than for Experiment 2 animals. However, average height at a given weight for Experiment 2 was not different from that reported by University of Arizona workers.

Heifers in Experiment 2 conceived equally well regardless of the number of times they had shown signs of estrus prior to breeding.

Observations from Experiment 1 showed that those heifers that were the lightest, and youngest at calving experienced more difficult parturitions and had more postpartum reproductive problems. No differences between the groups fed sawdust and those hand-fed concentrate, or between all heifers used in Experiment 1 and 15 contemporary herdmates was observed for difficulty of parturition and condition of uterus postpartum.

Milk and milkfat production (305 day-2X-ME) was not different ($P>.05$) for the following comparison groups: sawdust-fed vs hand-fed, all of Experiment 1 heifers vs 15 other contemporary herdmates, and between three Experiment 1 age groups. However, those Experiment 1 heifers that were in the heaviest of the three weight groups produced more ($P < .01$) milk and milkfat (305-2X-ME) than their lighter contemporaries.