Growth, Body Composition and Costs of

Feeding Holstein Heifers

by

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Comparing Drylot, Pasture and Supplements to Pasture on Growth, Body Composition, Dry Matter Intake, and Costs of Feeding Holstein Heifers.

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(ABSTRACT)

Growth and body composition of 121 Holstein heifers (4.6 to 18 mo and 129 to 407 kg) reared on pasture, drylot and pasture-drylot systems were evaluated in 6 experiments. Heifers were switched from drylot to pasture or the reverse to study carry-over effects from previous treatments; both systems were satisfactory. Alternate 28-day periods of supplement feeding to grazing heifers did not affect final body weight nor wither height, but ADF and heart girth varied during 2 yr. When switching drylot heifers previously fed low and high TDN, to pasture, gains were best for heifers fed the lower TDN diet; also, gains on pasture were best for light heifers. Gains by all heifers grazing mainly orchardgrass-clover pasture were acceptable, but supplementing with a 19% CP concentrate or lasalocid, usually improved gains. Heifers with lowest BW during grazing made compensatory gains in drylot. Urea space estimation technique showed that compensatory gains were mainly fat. Lasalocid feeding increased daily gain and subcutaneous fat deposition but reduced feed intake and ribeye area. When moving grazing heifers to drylot a total mixed ration with fishmeal or soybean meal as protein sources gave similar responses. DM intake of grazing heifers ranged from 8.1 to 10.1 kg/d, vs 7.5 kg/d for drylot. Supplementing grazing heifers with degradable or undegradable protein gave similar responses in growth and body composition.

Based on growth and body composition, seasonal grazing of Holstein heifers may reduce costs for rearing replacement heifers. A corn silage-alfalfa silage-orchardgrass hay mixed ration without concentrates when fed ad libitum to heifers in drylot resulted in gain of 934 g/d. Pasture alone heifers gained from 368 to 755 g/d depending on drought and heifer age. Calculations of costs of rearing Holstein replacement heifers were prepared accounting for observations of response to grazing, supplements to grazing and drylot diets. Well managed grazing reduces costs of rearing.

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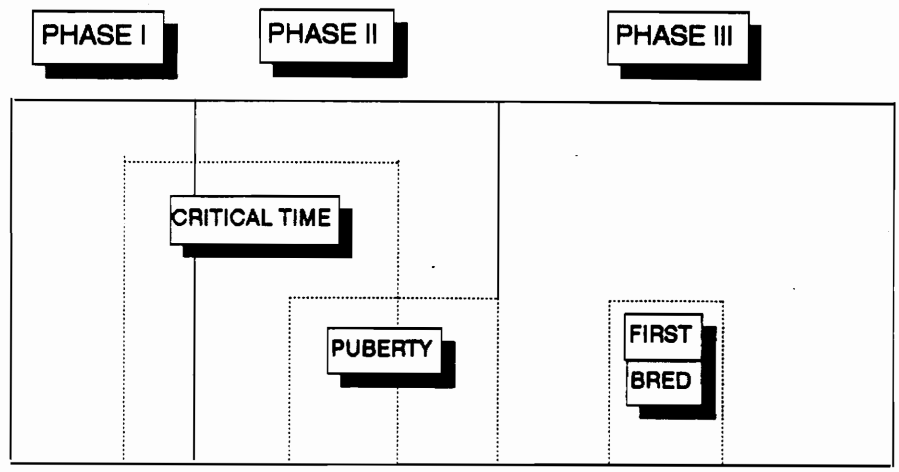
INTRODUCTION

Growing replacement dairy heifers to first calving is a significant cost. Estimated costs of this non-productive period in a heifer's life range from $750 to $1300 (43,126) varying with systems of rearing and feed ingredients. Feed costs alone account for 50-60% of the total rearing expenses (43,75).

A goal for Holstein cattle is to have well fed, growthy heifers bred at 350 kg (12-16 mo), calving at a weight above 500 kg and wither height (WH) of 133 cm yet reared at a modest expense (112,126,129,227,287,297). The diagram in Figure 1 illustrates a replacement program fitting this description. The rearing program is broken down into three distinct phases: birth to 4.5 mo of age, 4.5 to 12 mo, and 12 to 24 mo. Under experimental conditions, given adequate nutrition, dairy heifers have attained puberty at 7 to 8 mo of age (139,289) and calved at 18-21 mo (6,161,257). Phases I and II are the most likely to be affected by nutrition and feeding practices which may impair future milk production.

Excessive rates of gain (>800 g/day) if leading to fat tissue deposition prior to puberty (Phase II) may alter the ratio of parenchymal to fatty tissue in the mammary gland,



AGE-MONTH	BIRTH	3.0	4.5	7.0	9.0	12.0	14.0	16.0	24.0
RECOMMENDATION									
BW, kg	44	92			233	330	370		558
RATE OF GAIN, g/d									
CONTINUOUS					740				
DETRIMENTAL IF					>800				
IDEAL WITHER									
HEIGHT, cm	75				119				133

Figure 1. Phases of a dairy herd replacement program according to the current recommendation for feeding and managing a dairy heifer for optimum milk production.

and may cause permanent physiological damage, causing reduced milk production (87,182,206,297). Increased dystocia, reduced conception rates (137), reduced milking life, milk yield, and increased feeding costs due to faster rates of gain are also reported (239). Rearing dairy heifers for early breeding is desirable and economically sound because it increases the amount of milk produced due to a longer milking life. Shorter generation intervals result in more rapid genetic improvement, quicker return on capital, reduction in maintenance costs, and a smaller requirement at any one time for heifers reared as herd replacements (129,239,240).

Current diet recommendations for heifers reared in confinement may be excessive in energy (126,227,235). Few experiments have compared drylot-pasture systems for raising dairy heifers.

The objectives of this research were:

1. To investigate the growth responses and body composition of forage-fed heifers with or without supplements for rearing dairy heifers from 4.5 mo old until freshening at 24-27 mo.

2. To evaluate a nutritional management system that will reduce cost relative to traditional confinement systems without adversely affecting growth of Holstein heifers.

3. To study pasture as a healthful, cheap, and efficient alternative feed giving adequate structural growth and sound mammary gland development in dairy heifers.

Manuscript organization

This manuscript emcompasses seven chapters. Chapter One consists of Review of Literature. The other chapters describe the series of six experiments conducted from June, 1987 until October, 1990, where pasture, drylot and pasture-drylot combinations were used to feed Holstein heifers from 4.5 mo until 14 to 17 mo of age.

In Chapter 2, two experiments (1987-1988) were reported to compare the effects of different levels of energy on growth and body composition of grazing and drylot fed Holstein heifers.

Chapter 3 is a report on a series of experiments during 1989, where growth and body composition responses of Holstein heifers to lasalocid and supplemental protein-energy were compared to a drylot diet. Within this experiment an economic analysis determined differences between drylot and pasture-drylot combinations for feeding dairy heifers. Chapter 4 deals with intake of grazing Holstein heifers in response to lasalocid and supplemental protein-energy as compared to a drylot diet.

After drylot-pasture treatments (Chapter 5) heifers were brought to a drylot for 60 d to study growth and body composition responses of Holstein heifers to varying rumen degradable protein sources.

Chapter 6 reports the experiment conducted during 1990, where Holstein heifer growth on grass-legume pastures supplemented with rumen undegradable protein was investigated.

Finally, Chapter 7 is summary and conclusion of results from experiments conducted for this dissertation.

Chapter 1

REVIEW OF LITERATURE

Regardless of the source, purchased or homegrown, dairy replacements comprise 40 to 60% of the animals on the dairy farm (235,263). On Virginia dairy farms, about 30% of the cows are replaced each year (287).

These two facts per se are important in considering production costs and total milk production on a dairy farm. Genetic improvement has been a highly achieved goal in dairy cattle and research studies over 30 yr (163). Data show that mammary gland development and high potential of lactation in heifers are highly correlated (163,277). The amount of secretory tissue and its secretory activity allows the high producing dairy cow to manifest her genetic capability (144,289). Several factors have been reported to affect the normal growth and development of the mammary gland. Therefore, understanding this process is a key factor in any good heifer raising program.

Growth and development of the mammary gland

Mammogenesis may be divided into five stages or phases: conception to birth, birth to pregnancy, pregnancy, lactation, and the dry period (9,289). Figure 2 diagrams the stages of the reproduction cycle and the growth and development of the mammary gland in a female cattle.

The female reproductive tract has its major structures present at birth. Mepham (178) has outlined the details of their embryogenesis and fetal development. Tucker (289), McGrath (170), Silberstein and Daniel (261), Knight and Wilde (144) Anderson (9) also give details on all five phases of mammary development.

After birth, the reproductive tract and mammary gland continue to grow at the same rate as the body as a whole (115,170,289,297) and this occurs between 3 and 9 mo of age (115,296). This is the phase of a positive allometric growth, which lasts up to 2 or 3 mo before puberty (260).

This phase of a rapid prepubertal growth is under the influence of increasing concentrations of gonadotrophins from the anterior pituitary, steroids secreted from the ovaries (58) and peptides (170). Growth hormone secretion

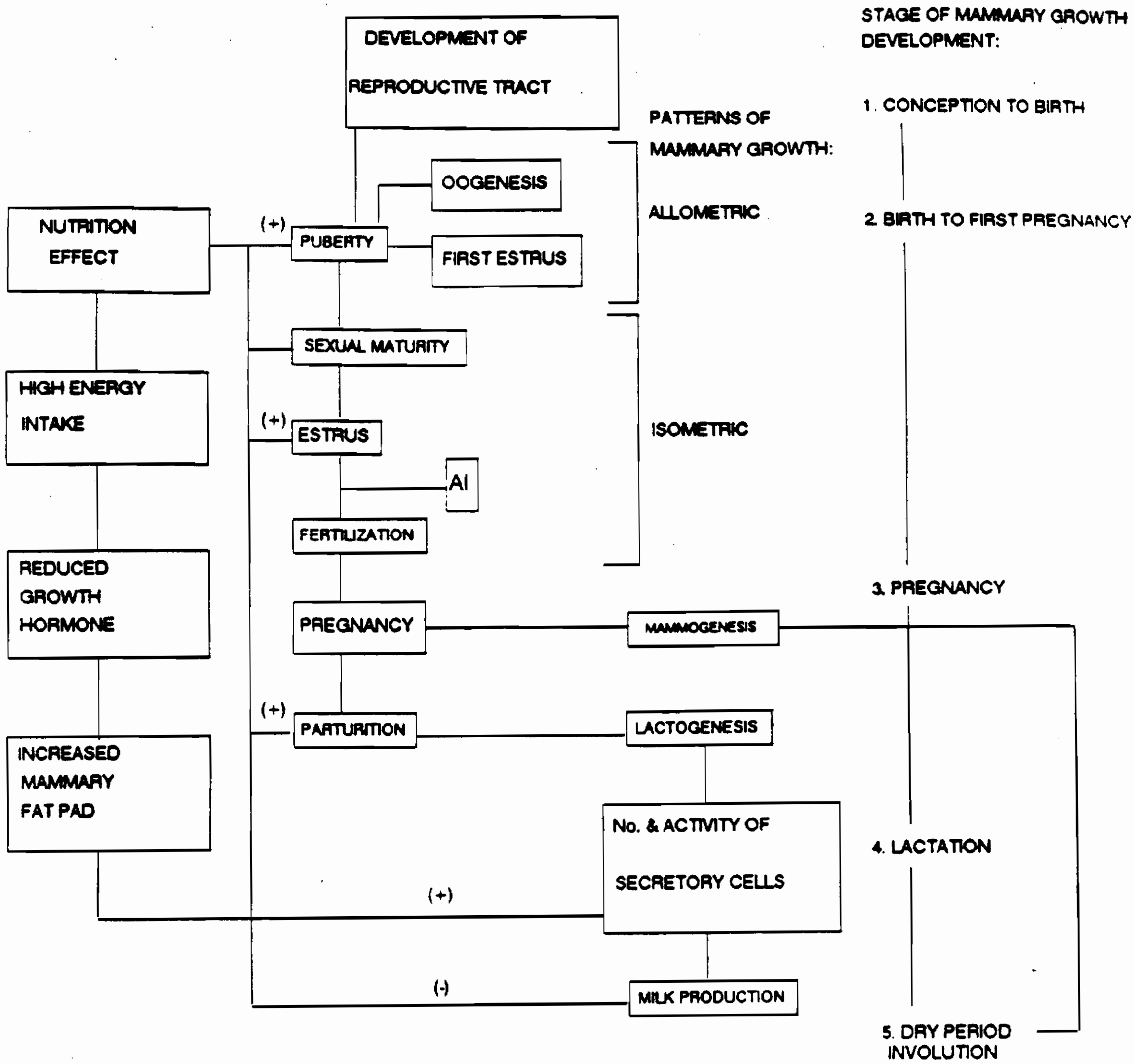


Figure 2. Stages of growth and development of the mammary gland in a bovine female and their association with nutritional status. Adapted from Holmes and Wilson (115) and Tucker (289).

and episodes of release are more discrete before puberty than after puberty (78). High energy intakes during the prepubertal period decreased concentrations of growth hormone in blood serum (253). Daily growth hormone injections in lambs (132) and in cattle from 8 to 12 mo of age increased mammary parenchyma by 18% (251).

During this allometric growth the mammary gland grows three or four times faster than the body as a whole. That growth seems to end at or near puberty (115,233,297,308). A live weight from 92 to 229 kg or an age from 3 to 9 mo appears to be the most critical time for influencing mammary growth of a Holstein heifer by nutrition (297).

Sinha and Tucker (260), found that mammary growth was 1.6 times faster during the 10 to 12 mo period (or 229 to 330 kg of live weight) than in any other growth period. Mean first estrus occurred at 7.4 mo. Estrus, achieved when a heifer ovulates, is a function of breed, age, and weight, with weight being directly dependent on nutrition. Amir and co-workers (6) demonstrated the variation of age, up to 5 mo, at which first estrus occurs (129). Amir et al.(6) fed heifers for 3 rates of growth: 1) control, fed according to Scandinavian feeding standards; 2) restricted forage, with concentrates ad libitum, and 3) milk feeding for 6 months (+

2000 kg of milk) and as 2 thereafter. First estrus occurred 11.7 mo (260 kg), 7.5 mo (227 kg) and 5.7 mo (226 kg), respectively. First lactation was 3,739, 2,919, and 2,606 kg of 4% FCM, respectively. Body weights at second calving were not different among treatments. Delay in estrus (115) in heifers is usually related to undernutrition.

Recently, Petitclerc et al., (218) found that prepubertal and postpubertal heifers when exposed to a photoperiod of 16L:8D (light:dark) had more mammary parenchymal development than heifers exposed to 8L:16D. One might speculate that some interaction response relative to season and nutrition could occur.

Prepubertal nutrition and lactation performance in dairy cows

Several factors such as genotype, sire, twinning, age of first calving, length of dry period, plane of nutrition, prepartum milking, induced calving and induced lactation, have been shown to have an effect on the mammary gland growth and development and its ability to produce milk (78,115,129,297). The amount and activity of the secretory tissue at parturition influences the above (115,144).

From the above factors, plane of nutrition is the factor reviewed for this study. Data from experiments with dairy (251,252,260) and beef heifers (130,166) and ewes (99,131,280) has demonstrated that high planes of nutrition, more specifically, high energy intake, before puberty can restrict the growth of the developing mammary gland. As an immediate consequence, there is a reduction in the size of the functional gland of the bovine female (248) with a reduction in the amount and activity of the secretory tissue at parturition, and therefore, milk output is reduced (125). Stelwagen and Grieve (270) reported that heifers gaining 903 g/d had fatter mammary glands and decreased concentration of DNA. However, total mammary DNA did not differ among treatment groups. However, some results do not indicate any consistent influence of nutrition on milk yield as measured by live weight gain of the calves (309).

Growth and growth components

Hammond (107), describes the growth patterns and the mode of nutrition for the intra-uterine and after birth periods for farm animals and cites the findings below. After birth, hormones from the anterior pituitary (264) and thyroid (262) can influence body size. However, plane of nutrition (77,211) imposed at certain stages of growth is the most common influence affecting body size. The differential rate of growth stated by Hammond (106), occurs in the different parts and tissues of the body. These alterations occur in a definite order and they are much the same in all species.

High planes of nutrition imposed at certain stages of growth after a period of feed restriction led scientists to observe that animals were able to make compensatory responses toward adult size (205). In evolution, the animal species has developed a flexible metabolic mechanism which reduces energy demand during periods of scarcity of nutrient supply and restoration of the energy stores during periods of nutrient abundance (155). Compensatory growth has been demonstrated in rats (169,205), pigs (168,173), lambs (172), and cattle (214,276,312,314).

The response achieved through compensatory growth reported in several studies reviewed by Reid and White (234) has been associated with: 1) increased feed intake relative to metabolic size, 2) increased efficiency of feed utilization for maintenance or production, and/or 3) a rearrangement of the chemical components of the body (differences in tissue deposition, in general, more fat and less protein) after full feeding is restored. However, Meyer and Clawson (179) and Meyer et al. (180) found an increase in energy utilization during compensatory growth with rats, independent of feed intake level .

Growth measurements

Estimation of in vivo body composition may represent a step to understand growth and development in farm animals. Body weight (BW) changes or body growth, average daily gains (ADG) and linear measurements such as wither height (WH), hip height (HH) and heart girth (HG) have been the measures used to evaluate and monitor the growth of domestic animals (32,68) either in research or in practical situations.

In ruminants, when body weight changes are used as a measure of growth (296), conclusions should be made with caution (14); especially when using infrequent measurements of live weight (62). The problem affecting interpretive conclusions is the rumen fill (110). However, Whiteman et al., (318) suggest standardized procedures for weighing cattle in order to minimize sources of variation due to gut fill and weighing errors. Increasing the number of animals per treatment when weighing them once has reduced the residual variation (118).

In general, experiments utilize weight change as a measure of response to an imposed condition or treatment. The weight taken at any time includes the actual tissue weight of the animal plus the contents of the digestive tract. Day to day variation in weight is prone to be influenced by gut fill, since tissue weight of an animal should not show large variation under normal conditions (62). The gut fill, which depends on type of diet, could contribute to appreciable errors. Rumen fill varying from 10 to 25% of the actual body weight has been reported (1,123,124,295). The lowest gut fill is associated with rations containing high energy density such as those using high levels of concentrates or corn silage, which also have short retention time in the rumen. Other forages, especially those of low quality, lead to an increased weight of contents in the intestinal tract of ruminants.

Jahn et al. (123) fed six diets at four protein levels (8.0, 11.5, 15.0 and 18.0% CP) and three levels of acid detergent fiber (11.0, 18.0 and 25.0% ADF) to calves 5 mo of age. Fill was 10.4, 12.7 amd 14.5%, respectively, for 11.0, 18.0 and 25% ADF rations, when the protein levels were averaged. A ration containing 18.5% CP and 11.5% ADF gave the lowest (8.8%) gut fill, whereas the diet containing 8.0% CP and 25.0% ADF resulted in a 16.9% gut fill. Their results also show that the diets containing lower CP levels (8.0 and 11.5%) associated with any ADF percentage resulted in higher gut fill. Changes in wet rumen fill of Holstein heifers were reported by Waldo (296). Heifers were fed a forage based diet at or near ad libitum, and fill was 10 to 15% for corn silage, 15 to 25% for alfalfa and 20 to 25% for orchardgrass hay.

The Agricultural Research Council (ARC; 1) considers a contribution of as much as 300 g per kg of BW for gut contents or fill in ruminants. Dietary and animal factors (age and physiological state) affect the weight of intestinal tract contents. Hay and dried grass promote a large gut fill as compared to silages made from the same herbage species. Green forages in grazing conditions are intermediate in gut fill weight. The ARC (1) also predicts the gut content's weight and its contribution to body weight gain if the diet is not changed. This prediction relates empty body weight (EBW, kg) to live BW (kg) and is obtained by the equation: BW= 1.09(EBW +a), where "a" is calculated from initial gut fill (g/kgEBW) at 75 kg EBW for cattle.

The values for a are 4, 14, and 25 for an initial fill of 150, 300, and 450 g/kg EBW, respectively. The ARC (1) emphasizes that the factor 1.09 should not be applied to animals subjected to changes in diet.

Using combined indices of measurements seems to be a more appropriate method of monitoring animal growth (318). For growing cattle, the linear size of the animal is better described by HG combined with BW (30). WH is the best reference to express the nutritional status in cattle, and it is one of the measurements least correlated with BW because over half of this index is completed by the time the animal is born (30). Also, in dairy cattle, WH provides a measure of inherent size, because it is almost independent of enviromental conditions.

In animals which are born at an advanced stage of development and have to follow their dam (horses, cattle and sheep), the maximum proportions of leg length occur at birth (107). However, BW, WH, and HG, do not give researchers any information on the composition of the gain achieved by the animal. Body weight gain in growing heifers is a function of growth, changes in rumen fill, and deposited reserves as body tissue (296,297). However, the composition of gain or energy storage varies with increasing weight, fatness, and age (142,191,193,194,304).

Body composition

Concepts

The earliest interest in body chemical composition of farm animals came from experiments conducted by von Berzold (294), von Hosslin (295), and Pfeiffer (219), all cited by Reid et al. (232). Mammals (cattle, sheep and swine), birds, amphibians, and fishes at all stages of development were analyzed. Soon these works led them to conclude and report a similar chemical body composition for animals of the same species. These authors found that the amount of water decreases and that protein and ash contents increase in the body as animals advance in age. A reduction in water content accompanying an increase in fat also was found. These determinations were attained by the classical method of chemically analyzing the entire carcass, which, according to Powell and Huffman (222), is the most accurate estimate of carcass composition.

Murray (194) stated that if the percentage of fat was known, the body composition could be determined, because the non fatty matter has an almost constant composition, and body condition (fatness) was not an effect or, because only slight variation is due to the age of the animals (Table 1).

Table 1 shows the empty body composition of dairy animals and illustrates the relationships above. Increase in body weight or size is due to deposition of fatty tissue, muscle or bone (215). For this reason, estimation of body composition becomes important if energy gained or lost by body tissues is a more significant measure of response than body weight changes alone (90,232).

Prediction of body composition

Prediction of body composition can be by direct or indirect methods. The direct method, is not acceptable in many cases. Another disadvantage of slaughter is that analysis of the complete animal body for chemical composition is expensive and laborious. Therefore, the indirect methods of dilution techniques and ultrasonic determination are preferable for living animals.

The constant relationship between empty body water and the other body components has been the basis for dilution techniques (232,254). Estimation of body composition in vivo is accomplished by tracer dilution or the so called dilution technique, which estimates total body water (210,268). Sheng and Huggins (255) cite Grenhant and Quinquand's (95) experiment which measured blood volume, as

Table 1. Empty body composition of dairy animals at several ages, determined by chemical analysis.

Age Mo	Components % Body Water	Dry Matter	Fat	Protein	Ash
Fetus (day 253)	77.0	23.0	4.5	16.5	3.9
Newborn	74.9	25.0	4.0	18.2	4.7
3	70.0	27.0	5.0	18.5	4.7
5	69.0	31.4	7.9	18.7	4.1
6	69.0	28.5	6.0	18.5	4.7
9	66.0	31.0	9.0	18.5	4.7
12	64.0	35.0	12.5	18.5	4.7
30-42	58.0	42.0	17.5	18.5	5.0
42-54	60.0	40.0	16.0	18.5	5.0
54-66	57.0	43.0	18.5	18.5	4.9
72-144	63.0	37.0	14.0	18.5	4.9

Adapted from: Ellenberger (1,73,123)

the first research using the dilution principle to measure a body fluid compartment. In the dilution technique, a water soluble tracer substance which can penetrate all compartments of the body, intracellular and extracellular, is injected into the blood stream. After removal and analysis of a number of samples over a period of time, the value is extrapolated back to zero time (215,225,243,268).

Then the water content of the body may be estimated and fat predicted (193,194,232). Body water dilutants such as antipyrine (146,213), N-acetyl-4-aminoantipyrine (23,213), potassium 40 (224), S-35 thiocynate (212), urea (18,19, 20,21,102,103,105,241), tritiated water (160,209,213) and deuterium oxide (32,34,201,237) have been used to predict body water in living animals. Of these dilutants, urea, deuterium oxide or tritiated water have been used sucessfully for the prediction of body water. The best estimators of water contents are either deuterium oxide or tritium because these isotopes distribute evenly. But the analytical technique is difficult, the cost is high (209) a large number of blood samples is required over a period of time, and disposal of the animals after injection is necessary. Urea space is a simple, accurate, and convenient method, because urea is cheap, easily infused, requires only two blood samples over a 12 min period (225) and does not require the disposal of the animal after injection.

Description of changes in body composition during growth can be derived by sequential observations or longitudinal data (250) on the same individuals, which will act as their own control. Therefore equations to predict body composition may be derived if some non-destructive method is used to determine or access the body components. Equations to predict the chemical composition in vivo from urea space have been developed for beef cattle (102,103,145,225,241), steers and heifers (18,23), dairy cattle, using cows and steers (133), bulls (137), Holstein steers (105), lambs (21,84,132) and pigs (186).

Recently, measurements of growth and body composition (back fat thickness and muscling) have been attained through ultrasound measurements in cattle and swine (138,274,275, 281,283) and in ponies (305). Limited application, however, has been reported, in determination of carcass composition in sheep (133). McLaren et al. (171) indicated the importance of operator effects on repeatability and image interpretations for cattle, sheep and pigs. Thus, using and improving the estimation of body composition under experimental and practical conditions to characterize the components of the gain and diet could be manipulated to improve animal growth performance and production data.

Target weights and structural scale

Target weights (kg) and other body measurements for replacement heifers calving at 24 mo of age are shown in Tables 2 and 3. Growth standards for Holstein heifers (i.e. BW at birth and 24 mo) differ among countries. For instance, in New Zealand, the rates of gain to achieve the desired weights are based on pasture feeding. In the USA, the heifer rates of gain may represent higher genetic potential with different diets and a feeding system based upon drylot situations. Averaging all recommended target weights (Table 2) for large dairy heifers in the USA (Table 3), a Holstein heifer should weigh 44 kg at birth, 370 kg at 15 mo and 558 kg at 24 mo old calving time.

To achieve this standard a continuous rate of gain should be around 700 g per day. Friesian heifers calving at 24 mo of age can easily be achieved by weaning calves at 5 wk of age when concentrate intake is about 500 to 700 g/d and an imposed rate of weight gain of 600 g/d is attained (240).

Table 2. Target body weight (kg) for replacement heifers calving at 24 mo of age.

	I	II	III	IV	V	VI
At birth	35	41	43	45[2]	45	45
At weaning	-	-	-	62	-	-
3 Mo	70	90	100	100	100	-
6	120	149	167	171	177	153
9	-	212	-	237	254	216
12	220	284	310	306	322	288
15	280	360	380	376	363	364
18	310	437	447	430	409	441
21	-	509	-	491	468	513
22	-	-	532	-	490	537
24	420	581	572[1]	526	504	585

Calculated values:
1. Rate of gain is assumed to be the same for the last 2 mo.
2. Body weights estimated from rates of gain (mean for next 90 d) as proposed by the authors.

Sources:

I. Holmes and Wilson (115)
II. Owen & Larson (207)
III. Crowley et al (59)
IV. Heinrichs & Hargrove (113)
V. Beltsville Standards
VI. Waldo et al. (297)

Table 3. Structural scale measurements for Holstein heifers from birth until freshening at 24 mo of age.

Age Mo	Weight kg	Heart Height cm	Girth cm
	44	75	76
At birth	63	81	72
1	102	86	91
2	116	90	na
3	145	94	112
4	162	102	127
6	236	112	145
9	283	119	157
12	374	124	166
15	402	128	173
18	429	130	180
21	493	133	182

Adapted from: James, 1988 (125)
James and Stallings, 1988 (266)
NRC, 1989 (198)
Etgen et al., 1987 (75)

na - not available

Eckles (71) concluded that energy accelerates body growth during the period of most rapid development. Fatness will occur in heifers receiving high energy levels, and heifers receiving low energy grow less rapidly but continue to grow for a longer period; and variations in nutrition have greater effects on BW than on rate of skeletal growth of growing heifers. His conclusions are still generally accepted and are under intensive evaluation through current heifer research in many countries.

Optimal feeding and management of replacement heifers

Growth rates

Growth patterns of growing animals can be varied (214, 278,279). Growing animals require an adequate energy and protein supply for maintenance and for the onset of puberty, (198). Therefore, manipulation of feeding practices (diets) may have either a positive or negative effect on heifer growth rate and age at first calving. An animal calving at 24 or 36 mo of age will require 40 and 30 percent of the total energy input for growth, respectively (239). The other 60 or 70 % will be used for maintenance. The pattern of growth during rearing is not critical, since compensatory growth is a normal process in cattle (115,214,234,283,312).

However, growth rates in excess of 800 g per day before and around puberty, which occurs at about 275 kg of BW in a Holstein heifer (233,260,308) may permanently reduce milk production (78,115,120,161,162,206,251). Amir et al. (6) reared Israeli-Friesian heifers under accelerated growth by means of high level feeding. Their study showed a reduced milk production in the first lactation, calving difficulties if calves were born weighing above 35 kg and an increased number of inseminations per conception. All of these studies reported a decrease in 305 day FCM production in first lactation as daily gain prior to puberty increased. However, Johnsson (129) points out that the detrimental effects of high planes of nutrition during rearing may be greater in breeds with a lower genetic potential for milk production.

Roy et al. (238) reported the growth rates required for several dairy breeds to attain the pre-calving weights. In general, for calving at 36, 30, 27, 24, 22 and 18 mo, the overall growth rates after birth of 467, 561, 650, 692, 765 and 935 g/d, respectively, are required (Table 4). Growth rates above 800 kg/day between 3 and 12 mo of age, induced by ad libitum feeding of pelleted diets (162) or other high density energy diets (252), have been found to be detrimental for heifers calving at 22 mo of age. The total

Table 4. Required continuous growth rates (ADG-g/d) for heifers from large breeds after birth to attain target weights at first service (15 mo) and first calving at 24 months.

Target BW/kg	Age at 1st calving		Rate of gain
	months	days	g/d
At birth=45	18	540	935
First service=350*	21	630	801
First calving=550	22	660	765
At maturity=800	24	730	692
	26	780	647
	28	840	601
	30	900	561
	34	1020	495
	36	1080	467

[1]Rate of gain accounts for 45 kg of calf at birth.

*Requires a continuous rate of gain of 678 g/day.

Adapted from: Roy and Smith, 1987 (239)
NRC, 1989 (198)

amount of dry matter (birth to conception) required for calving at 18 mo was 46% less than that for calving at 24 mo, but about 12% higher requirement per day was necessary in the same period, and also was more costly (240).

Age and body weight at first calving

With proper management and feeding levels, there is experimental evidence that heifers can calve successfully at 18 to 21 mo (7,161,256). There are rearing systems where heifers calve after 36 mo of age. Kliewer (145) and Roy (239) have reported a decrease in milk yield in the first lactation by about 40 kg per month for every month that heifers calve for the first time under 36 mo of age. Currently, the accepted goal is to rear heifers to calve at 24 mo of age with BW above 500 kg and 137 cm WH (112,287,297). Puberty and age at first calving are dictated by the rate of growth since puberty is related to BW (233). Nutrition is a major factor which can affect growth rate from birth to puberty. (6,7,89,239).

Mature body weight in a dairy cow is attained by about the 4th lactation and weight at first calving should be 75 or 80 % of that mature weight (238). However, if this weight is not achieved by the first parturition (low growth rates), live weight gains during first lactation may be enhanced if heifers are properly fed. In this case, milk yield is reduced only during the first lactation (78,238).

A quicker return on capital, reduction in maintenance costs, reduction in the number of heifers required for rearing as herd replacements, quicker assessment of the genetic value of a heifer, and longer herd life are advantages of reducing the age of first calving (43,129, 238). Possible disadvantages are the higher amounts of concentrates, greater management skills, the risk of dystocia, and an increased chance that a diet leading to fat deposition may negatively effect future milk production. Little and Kay (161) have shown some problems on heifers' subsequent performance when a "Barley beef" type diet was used. This type of diet uses high amounts of grain, so the effects are possibly associated with changes in rumen fermentation patterns, metabolic hormone concentrations, and fat deposition.

Conception rates also may be reduced with age of breeding (139). Lower conception rates have been reported by Leaver (154), for animals bred at 21 to 27 mo compared to those bred at 12 to 16 mo old. The number of inseminations per conception was reduced from 3.0 to 2.50, and 1.87, respectively, when Israeli-Friesien heifers were inseminated at first estrus at 5.6 mo (226 kg), or when estrus occurred either at 7.6 mo (227 kg) or 11.1 mo (260 kg) estrus. Heifers bred at younger ages had calves as large as those bred older but had more calving difficulties (248).

Essential Nutrients and Nutrition

Five major groups of chemical substances are critical nutrients for all body processes. Body tissues are comprised of water, proteins, fats, carbohydrates and minerals and vitamins. These nutrients are required for all metabolic processes: catabolism and anabolism in the animal's body. Similar in composition, although in different proportions, the feedstuffs supply the animal's nutrient requirements for maintenance, growth, reproduction and production. Therefore a good healthy program for dairy replacements requires energy, protein, vitamins and minerals. The rations used should be correctly balanced for these nutrients and the diet needs to stimulate early rumen development (133).

Energy nutrition: digestion and utilization

Fermentation in the rumen produces volatile fatty acids (VFA) primarily acetic, propionic and butyric acids which comprise a major source of nutrients supplied to ruminant tissues. The proportion of the VFA produced in the rumen is diet dependent. The ratio of acetate to propionate tends to increase as dietary fiber content increases and vice-versa. A negative relationship between acetate proportion in rumen liquor and efficiency of utilization of metabolizable energy for fattening (204), has been established and Table 5 shows the molar proportions of VFAs in rumen liquor of lambs.

The proportions of fat, protein, and water deposited in tissues is a reflection of the energy required for growth. The changes in body composition of cattle at different body weights can be compared with increased energy requirement. Data in Table 6 are for body composition of Holstein steers as determined by Hammond et al. (105). As BW increases, crude protein and ash contents are relatively static while fat content increases as that of water diminishes and energy content increases.

Table 5. Molar proportions of volatile fatty acids (%) in lambs sustained by intragastric infusion and the efficiency of energy utilization for growth.

	Molar proportion					
Acetic acid	35	45	55	65	75	85
Propionic acid	55	45	35	25	15	5
Butyric acid	10	10	10	10	10	10
k_f *	.78	.64	.57	.61	.61	.59

Lambs sustained by intragastric infusion of VFA's. Orskov et al. (204).

*Efficiency of energy utilization.

Table 6. The proportion (g/kg) of water, fat, crude protein, and ash and the gross energy content (Mcal/kg) in the empty body of Holstein steers at different weights.

Live weight (kg)	143	300	404
Empty body weight (kg)	101.2	244	349.1
Body composition (g/kg)			
Water	729	655	632
Fat	53	106	132
Protein	166	186	189
Ash	46	51	52
Gross energy (Mcal/kg)	1.41	2.0	2.3

Calculated data from Hammond et al., (105).

Energy density: Fat = 9.4 Mcal/kg
Protein = 5.5 Mcal/kg NRC (198)

Heifers fed from birth to first calving at 62, 100, and 146% of required total digestible nutrients (TDN) showed first heat at about 273 kg of BW but at different ages such as 20, 11, and 9 mo for 62, 100, and 146% of TDN requirement, respectively . TDN requirements above that recommended will allow heifers to be bred at earlier ages and to be heavier at first calving, but they will be more susceptible to calving difficulties (248), lower conception rates (154), more inseminations per conception (6), and future milk production may (252) or may not (129) be affected.

Protein nutrition: levels and quality

Early studies with calves fed concentrate rations revealed significant responses to dietary crude protein content. Wallace et al., (300), fed yearlings rations containing 5.5, 6.0, 9.0 and 12.0 % crude protein. Average daily gains were increased with each additional level of protein. Research on protein requirements for calves and heifers has shown an influence on rate of gain, body size, body tissue accretion, age, diet, and other factors (97,121, 123,124,240,271,272,278,279,282,322). Protein is a limiting factor of growth if the concentrate offered to young heifer calves contains below 22% CP. Protein requirements fall to

9% CP as BW increases to 700 kg of BW for heifers gaining 700 g/day. Researchers at Michigan State University have reported that dietary protein levels can affect weight gain, efficiency of gain and rate of gain in Simmental crossbred bulls (193). They concluded that these data support the NRC's recommended levels for feeding protein to beef cattle.

Protein utilization by calves between 2 and 10 mo of age was investigated (14). Rations were formulated to support gains of about 800 g/d. Body weight gain and WH were measured. Protein intake levels (80, 100 and 120% of 1978 NRC recommendations) fed between d 71 and 182 showed a quadratic growth response. Highest BW and WH were associated with medium protein ration. During 183 to 295 d the highest BW gain for calves was on the high protein treatment. No treatment differences were noticed for WH between the three protein levels. An increased digestibility of energy, OM, and DM also was reported. More recently, reviews (1,83,197,198,298) describing rumen protein utilization by ruminant animals (basis and concept) have indicated the importance of dietary protein quality (solubility and degradability) for dairy cattle and other ruminants.

Considerations for amino acid needs are becoming more important. Rumen microbial protein synthesis was lacking in four essential amino acids; methionine, lysine, arginine and histidine for sustaining high rates of gain in intensively reared lambs (273). Sources of bypass protein could potentially overcome limited amino acids.

Roasted soybeans, when replacing raw soybeans in diets of Holstein calves improved nitrogen digestibility and nitrogen retention (223). Cummins et al. (60) also reports more efficient nitrogen utilization by Holstein calves between 8 and 20 wk of age when a lower level of dietary rumen degradable nitrogen was fed. The authors also reported differences found in DM intake or weight gain among the three levels of rumen degradable nitrogen.

Average daily gains and feeding efficiency were improved when fish meal was substituted into rations for growing steers (284). Also, addition of fish meal to the ration of male Holstein calves resulted in elevated rumen microbial protein synthesis and increased the quantity of amino acids entering the duodenum (54).

Fast growing growth implanted steers had improved daily live weight gains of over 100 g/d when dietary undegradable protein was increased from 20 to 40 g/kg DM by incorporation of protected soybean meal (199).

Researchers at the University of Missouri (192) fed Holstein steers (318 kg) 3.5 kg (DM basis) of corn gluten plus ammoniated wheat straw and 2.0 kg DM alfalfa hay. They reported an ADG of 1270 g/head. Use of corn gluten to background steers is price dependent, however. Jaster et al. (127) reported that greater weight gains were attained by dairy heifers receiving rations containing wet corn gluten feed than similar heifers fed alfalfa haylage. Amos (8), also obtained improved gains for heifers and steers fed corn gluten meal when compared to similar animals receiving soybean meal.

Purdue University research studies have shown a positive growth response when bypass protein was fed to 6 to 9 mo old calves and yearlings (192). The same source has reported the results of a trial where Holstein calves were fed a pelleted all-concentrate diet (193). Dry shelled corn was the control diet. Treatments were 1) all soybean meal, 2) half soybean meal and half urea, 3) half urea and half feather meal, 4) half soybean meal and half feather meal and 5) meat and bone meal. Ad libitum feeding of a all-concentrate diet produced gains of 1330 g/d in young calves after 6 wk of age for the next 34 wk of the experiment, and required 5.5 kg of feed per kg of gain. The source of protein essentially did not affect either the rate of gain or carcass quality of steers. However, protein source combinations had some beneficial effect. Steers fed soybean meal and feather meal gained (7%) weight more rapidly than the steers fed other protein supplements. Soybean meal and feather meal or soybean meal plus urea required 6% less feed per 454 g of gain than steers fed the straight soybean meal supplements. Studies of lambs with ad libitum fed rations based on barley and fish meal containing 11.0%, 15.7% and 19.4% CP also showed increased growth rate, feed intake, and feed efficiency (feed/gain) with increasing dietary protein content (203).

Leibholz (156) used either urea or meat meal to supplement barley based rations for Holstein calves. When urea was substituted for meat meal, nitrogen flow to the duodenum was reduced, and apparent absorption of amino acids in the intestines was depressed also. The basis and methodology for determining the expressions of protein requirements in terms of undegraded intake protein (UIP) and degraded intake protein (DIP) have been described in detail by the NRC (198).

Several studies have shown the importance of considering protein and energy simultaneously to predict growth response in growing Holsteins (123,124).

Chandler et al. (41) have indicated an optimum digestible energy (Mcal) to digestible protein ratio (kg CP) of 17:1 at 146 kg BW. Ratios between 22:1 and 45:1 for growing calves not older than 25 wk have been reported (31,64,88,259,287).

Ration composition and rumen development

Liquid feeds lead to a less developed rumen even though the liveweight criteria is met for weaning purposes (139). Intake of solid feed and its fermentation products (VFAs) enhances early rumen development to adult characteristics (122,206), and rumination in calves was found to be functional by 6 to 8 weeks of age. Therefore intake of dry feed is a better guide to weaning than live weight in ruminants, and for early weaning programs (3 to 4 wk) a calf should be eating about 3% of its body weight (123). Fresh dry feed (i.g pellets) provided to young ruminants prior to weaning promotes early intake and also affects rumen development (118).

Daily nutrient requirement

Sufficient quantity and balanced amounts of nutrients should be provided to heifers in order to reach breeding weight between 13 and 15 mo and calving between 23 and 25 mo of age (126,287,297). The daily nutrient requirement for a non-lactating Holstein female is presented in Appendix 1. The National Research Council, 1989 (298) recommends growth rates lower than the maximal growth rates possible with ad libitum feeding. However, these rates allow calving at 24 mo with an acceptable mature body weight. Feeding allowances for this category are close to voluntary intake and allow the maximum use of forage. Reaching 250 to 300 kg of BW, dairy replacements can obtain enough energy for growth when fed only good quality hay, silage or pasture. Protein, minerals and vitamins may be needed to supplement forage based diets (198).

Theoretically the NRC (198) considers 800 kg a mature body size for a Holstein female. Metabolizable energy content of the diet is assumed to decrease in a linear fashion from 267 Mcal/kg of DM for animals at 12.5% (100 kg) of mature size to 2.0 Mcal/kg of DM for those at 75% (600 kg) of mature body size.

The NRC recommendations have produced well grown heifers and research supporting these allowances is extensive (14, 236,286,301,228,239). However, research at Virginia Tech (227,240,286,287) has shown that with more intensive feeding systems (Pinpointer computerized feeding) and either counter slopes or pen housing facilities, heifers gain more than the predicted rates of gain by NRC, 1978 (196,198).

FEEDING SYSTEMS FOR DAIRY CATTLE CONFINEMENT

Confinement

Improved genetic potential for milk production has changed practices for feeding dairy herds. A reduced number of dairy farms and increased number of dairy cows in herds, high labor costs, heavier usage of mechanization for milk, crop and feeding programs have led dairy farmers in the USA to change toward confinement facilities. This system demands a larger initial investment in facilities than pasture based feeding programs. However, confinement systems can result in a sound, labor efficient and an economical system for raising dairy heifers (235).

The system offers advantages such as grouping and more precise dietary alterations. If animal numbers are large enough, grouping heifers by size will reduce the range of nutrient requirements. Rations can be made to supply the animals with proper nutrition since the animal dominance problem is reduced (109). Also, primiparous cows can be properly fed, as a group apart from older cows improving management and potentially reducing spread of mastitis (267).

The use of total blended feeds (TMR), blending forages, concentrates, minerals and vitamins has been shown as a practical and labor saving method when grouping dairy herds (267). Advantages from this practice are said to prevent selective eating, hence a more balanced ration and better use of ingredients to formulate a ration, such as inclusion of fiber to restrict intake, masking off-flavor or odor of unpalatable feeds (53), and producing desirable effects on digestion through a distribution of feed intake (200,228).

PASTURE IMPORTANCE AND UTILIZATION

Worldwide, over 80% of the cattle are grazed for their entire life (49), and grazing lands provide the cheapest form of production (187). In British agriculture, pasture is the most important single crop (51). Most of the European countries rely on pasture to feed ruminants. In New Zealand, pasture is the main component in the diet of all cows (115). Tropical areas also rely on pasture to produce meat, milk and wool from ruminants. In the USA, essentially all feeds consumed by beef cow herds are forages, wastes and by-products (313), whereas, the dairy cattle industry has changed toward confinement feeding systems, mostly utilize more conserved feeds as silages, haylages and hays mixed with concentrates in TMRs.

The establishment of planned forage-livestock management systems for forage utilization and animal production is a must if optimization of land usage is intended (25,174, 175,190). Therefore, forage quality and quantity must be assured by practicing good management. Mixes of Kentucky bluegrass-white clover, tall fescue-red clover or orchardgrass-alfalfa have worked well for beef and dairy cattle in Northeast areas (28). When growth is depressed during hot summer weather, more area needs to be utilized for grazing, or grain should be used to supplement low pasture quality and quantity. Nitrogen fertilized grass pastures usually produce lower average daily gains than do grass legume combinations, but more animals per hectare are carried on well fertilized pastures (111).

Young, actively growing, well fertilized forages, can supply adequate nutrients for animal production (26,79,290). Grazing forages at this stage supply high energy (70 to 80 % TDN), and protein (25 to 35 %) content, and also allow maximum intake by the grazing animal (26,115,116,313) because bite size is increased (69,86). It is well known that forages increase DM yield as the plants reach maturity and that quality declines with plant age, except for the corn plant. Therefore, forage quality and quantity must be supplied to the grazing animal by adopting good management practices to achieve the optimum production level for both the animal and grasslands.

Feeding regimes for lactating dairy cows in the US have shifted from pasture to drylot feeding since 1960 in the United States. This trend is related to increased herd size, increased mechanization of cattle handling, and feeding management (49,53). Several studies have shown that despite the high genetic potential of cows in the US, lactating cows will produce about two-thirds of their maximum genetic capacity when fed good quality forages as the sole diet (26,86,202). The crude protein content of young actively growing temperate species is generally enough to support 20 kg of milk/day from a dairy cow and also assures good rates of gain, 349 to 755 g/d, for growing cattle (26,65). However, lactating cows can not consume enough dry matter to maintain high milk production and body weight, especially during the first third of their lactation. This is due to a relatively low energy concentration in most forages (49,115,116). Pasture forage may provide above 80% of the total dry matter consumed by dry cows and dairy herd replacements. In Georgia, Holstein heifers raised mainly with forage calved at 31 mo (182). James (126), stated that pasture should be a major source of nutrients for 3 to 5 mo per year. He also has developed a management scheme to utilize pastures for raising dairy replacements, if pasture is available. Some authors recommend that heifers should not be turned out onto pastures before they are 6 mo old (126,128,266). This recommendation is based on the potential of internal parasites infection.

Shumaker et al. (258) compared performance of unbred dairy heifers grazing either a cool season grass-legume mixture or a combination of cool season grasses fertilized with nitrogen. The mixtures were 1) oats (Avena sativa), ryegrass (Lolium multiflorum) in association with Crimson clover (Trifolium incarnatum) and 2) oats and ryegrass with "Mt. Barker" subterranean clover (Trifolium subterraneum).

The other treatment was oats and ryegrass topdressed ammonium nitrate. Average daily gains were 700, 910 and 850 g/day for heifers grazing the respective pastures. Since an average stocking rate of 450.8 kg BW/ha was used, the differences in gain may be attributed to differences in forage yield or quality in herbage consumed by the animals.

Growing heifers grazing improved permanent pastures will gain 660 g/day, and this rate of gain may be increased to 1000 g/day if a cereal grain is fed to Holstein heifers (49). However, when grain supplements are fed to grazing animals, the utilization of forages may (79,291) or may not (70) decline. Wise et al. (315) recommended that grain feeding to grazing animals be restricted to 1% of BW, which resulted in an increased rate of gain without depressing pasture utilization. In Virginia (28), gain was 730 g/d for beef steers with low grazing pressure.

PASTURE SUPPLEMENTATION

Pasture supplementation is a practice of providing various concentrates to grazing animals such as protein, energy, minerals and vitamins (291). Therefore, supplements should provide nutrient balance diets for any animal.

Supplementation for grazing dairy cattle usually refers to the use of concentrate feeds. Lusby and Wagner (165) give several reasons of why and how to supplement pastures. When forage is of low quality concentrates are effective buffers, but usually not if there is a lack or shortage in herbage availability (4). Otherwise, when enough forage is available for maximum intake, feeding a limited amount of concentrate will have two effects: additive and substitutive (256). However, under favorable conditions supplements have the tendency to provide additional carrying capacity. The extent of either additive or substitutive effects will depend on herbage quality (47,217). However, both effects may occur simultaneously if concentrates are fed (189). Substitutive effects resulting from decreased herbage intake depend on digestible energy intake (3,299) and degradation rate of cellulose in the rumen (37), which may be altered by grain feeding (72,183).

Any increase in production per animal indicates an additive effect from supplementation, if conversion of concentrate to gain is not too affected. An experiment by Coleman and associates (47) illustrates this aspect when steers grazed moderately high-quality St. Augustine grass pasture. They found that 4.5 kg concentrate per steer daily gave an increase in daily gain of .25 kg. An increased gain per animal indicates an additive effect, while the poor conversion of concentrate to gain indicates that the steers must have reduced herbage consumption.

Another problem with pasture supplementation, unless special precautions are taken, is that the amount of supplement consumed by different animals often is inversely related to animal needs (4,187). In general dominant animals consume more supplement than needed. This fact emphasizes the importance of adopting good management practices when supplementing grazing animals. Grazing animals should be supplemented only when the practice is profitable. Therefore, critical evaluation must be made of both to grazing animals (46). Practices for pasture supplementation and to achieve profits are specified by Vallentine (292).

POTENTIAL PROBLEMS WITH PASTURES

Several potential problems in pasture systems have been reported in literature. Difficulty of managing pastures, variable seasonal growth of forage plants and little winter grazing are common problems with pasture in the USA. It is also difficult to estimate DM intake from pasture. Supplying a forage that contains 15% protein and 69% TDN is attained for 3 to 5 mo in an average growing season (126). Heifer rearing systems which rely heavily on nutrients from pasture have slightly lower rates of gain than for drylot feeding, which delays first calving to 29 or 30 mo (126).

Loss of species or stands in mixed swards may occur from winterkill, dominance by a single species, or weedy growth and dominance (the latter occurring due to poor management). Cattle grazing legumes as the dominant forage commonly develop bloat (50). Losses caused by internal and external parasites are another problem. Other deleterious effects from pasture are described by Reid (230). Major inputs for reseeding, fertilizing the swards, fencing, barn access and moving a large number of cows on and out of pasture have been reasons against the use of pastures on dairy farms.

PASTURE MANAGEMENT INTEGRATED WITH DRYLOT FEEDING

Pasture feeding systems must be intensively managed to compete with or reduce the overall costs of managing confinement systems for rearing dairy herd replacements. The seasonal distribution of pasture forage production and seasonal changes in quality are overcome by using different classes of animals having different needs for digestible energy to meet the requirements for body maintenance, muscular activity, growth and production (26,116,313). A dairy cow producing 23 kg of milk per day will need above 75 percent digestible DM, whereas a dry pregnant beef cow to improve body condition, requires only 52% digestible dry matter (26,236). Intensive methods of grazing are used to control the responses of both animals and sward (27,174,175,190). Rotational grazing increased the production per hectare by grazing 8 to 10% but animal responses were similar, when compared to continuous grazing (26,27,175). However, individual animal performance was better with continuous grazing than rotational grazing systems (5).

The pasture-animal interrelationship may be altered to improve production per hectare or per animal to attain the best profit. The optimum balance between animals and pasture is important when utilizing pastures (26,115, 190,292). Within a farm the stocking densities should change during the season to avoid over or undergrazing. Excess of forage during the flush growth in spring should be harvested for hay or silage to improve pasture quality of the regrowth.

In situations where farmers want high output per animal, they will have to maintain a high availability of good quality forage. This option allows the animals to select young leafy material which is high in energy and protein. On the other hand, by increasing the stocking density giving better forage utilization results in higher output per land area. Maximum output per animal and unit of area can not be obtained simultaneously (26,167,290,313).

ESTIMATES OF HERBAGE QUALITY AND INTAKE

Under grazing conditions, the animal has access to many plant species to select from. The diet selected by the animal may vary in chemical and physical characteristics. Manually sampled forage from a sward may not be similar to that selected by the animal. Hardison et al. (108), found that the average diet selected by grazing animals from 23 swards representing a variety of plants and growth stages contained 23% more crude protein, 37% more fat, 26% more ash, and 17% less crude fiber than the grazable herbage from the same swards cut a height of 5 cm. Cable and Shumway (36) collected data on semiarid grassland range during a 2.5 yr period. The rumen protein varied from 1.5 to 2.9 times that of the clipped grass samples. Because of selective grazing, indirect methods to measure forage quality (chemical composition, digestibility of forage constituents and intake) may circumvent the manual sampling error (231), but also introduces other sources of error (12,56,57,149,150).

Reid (231) has proposed two indicator methods to measure forage digestibility. The ratio technique uses a naturally occurring, indigestible indicator which can be determined in both the herbage and feces. In the second method, the fecal -index technique, the indicator does not necessarily need to be indigestible and is measured only in the feces. Nitrogen (148,149,229) and plant chromogens (231) are employed as fecal indicators. Fecal nitrogen is directly related to both intake and digestibility of the forage and is generally correlated with dietary nitrogen (246). The basis for using nitrogen as an indicator of digestibility came from observations made by Gallup and Briggs (85), and Lancaster (148). They showed that there was a definite relationship between fecal N, forage nitrogen, and digestibility of dry matter. Forbes (80), however, could not find any significant relationship between the nitrogen excreted in feces and the protein content of freshly clipped Kentucky bluegrass fed to grade Hereford steers. Schneider et al. (247) with sheep grazing a permanent pasture containing predominantly orchardgrass with some cheatgrass (Bromus tectorum), found similar coefficients of DM digestibility for both fecal N as suggested by Lancaster (148) and chromogens technique (231).

Arnold and Dudzinski (12), point out two errors in the prediction of intake of grazing animals from regression equations relating fecal nitrogen and organic matter intake. Errors were associated with the regression equation and errors were involved in applying relationships to animals in the field. Ninety percent of the errors associated between digestibility and nitrogen for a wide range of herbages were attributed to variation in the feedstuffs due to the effect of species, season, stage of growth and fertilizer treatments. Only 10% of the error was associated with animal variation and experimental error (184). These sources of variation determine the precision of the prediction equation.

Recently, Kothmann and Hinnant (147) have concluded that fecal nitrogen shows great promise as a reliable, rapid, inexpensive indicator for monitoring nutrient intake of grazing animals. Anderson (10) suggested a dietary evaluation of forage quantity and quality for the grazing animal coming from an evaluation of the animal itself. The reasoning behind his theory was that dietary effects are expressed through the animal either as growth or production. Searle et al. (249) suggest that evaluations be based on continuous measurements on the same animal (longitudinal data). Statistical analysis for such evaluations can be made by repeated measurements in split-plot designs (93).

Herbage intake by grazing ruminants

Regulation of feed intake in ruminants is a consequence of complex mechanisms. Voluntary feed intake by ruminants usually is partitioned into physical and metabolic controls (48). Meijs (176) describes other factors that control feed voluntary feed intake of grazing animals are as from: 1) animal factors (age, BW, pregnancy, physiological state and animal condition); 2) plant factors (species, digestibility, chemical composition and stage of growth); and 3) management (DM allowance, supplementation, N fertilization, climate, season and grazing system). A review of mechanisms regulating feed intake in ruminants with emphasis on grazing dairy cows was made by Meijs (176) and Weston and Poppi (307) for herbivores in general. Meijs concluded that available forage influences herbage intake. Other features are the structure of sward, feces contamination and milk production. Concentrate supplements decrease herbage intake by about .4 to .6 kg DM/kg concentrate, at a supply of 2.4 kg concentrate, when the quantity of available herbage is not a limiting factor.

Estimation of herbage intake of grazing ruminants.

Different techniques have been used to estimate the voluntary feed intake of grazing ruminants. Direct methods use the herbage yields cut before and after a grazing period per unit land area. The difference is assumed to represent feed intake. Destructive or non-destructive techniques are used to quantify herbage yields.

Indirect methods make use of the animal to quantify organic matter (OM) or DM in feces or extrusa in a given period of time and the apparent digestibility (D) of the OM or DM of herbage ingested is estimated. Intake is dividing by fecal estimated production by the indigestibility (1-D). Extensive reviews have analyzed the factors affecting the precision and reliability of these techniques (3,56,57,116, 269).

The fecal index technique which predicts the digestibility from the composition of the feces has been used with success (12,149,150). Its reliability depends on the accuracy of the regression equations; errors with equations determined from indoors feeding, and getting representative fecal samples. A more precise technique uses grazing behavior method (179), where intake (I) by grazing animals is a function of time spent eating (T), number of bites per unit of time (R) and the average size of each bite (B) and intake is derived from the formula: I = BxRxT. However, measurement of each of these components is difficult and requires a special recording apparatus.

GROWTH PROMOTANTS FOR RUMINANTS

A survey of chemical agents and their effects on fermentative and hydrolytic digestion was conducted by Chalupa (40). Partially he concluded that: certain chemical agents increase carcass retention of energy and protein by decreasing losses in the rumen and increasing total tract digestibility. The rumen microbial population changes. Feed retention time in the rumen is increased, less methane is produced and high propionate formation increases food energy efficiency; ruminal digestion of protein and amino acids decreases and more dietary protein escapes the rumen. Responses in growth and feed efficiency may be additive when chemical agents are combined; and, nitrogen transactions in the rumen are affected and promote greater responses with diets containing marginal levels of protein (protein sparing effect).

Lassiter (153) found that antibiotics administered early in life benefit young dairy calves. The positive response is due to an increased feed intake and growth, and also by the prevention of diarrhea (153), Morrill et al. (188), cited in NRC, (198).

Ionophores became feed additives because they were anticoccidial and their use during a 30 d period resulted in almost zero coccidial loads (208). Ionophores enhance energetic efficiency by their microbial effect in the digestive tract (40,242). They increase feed efficiency and growth rates (96,317), increase cycling and improve pregnancy rate in beef cattle (313), and dairy heifers (17). Modes of action, metabolic effects, mineral interrelationships, and effects on performance have been extensively reviewed by 24,39,68,91,96,119,208,221,245,285.

Monensin and lasalocid were cleared by the Food and Drug Administration as new animal drugs for beef cattle in January, 1976, and October, 1982, respectively (94), and for dairy herd replacements since January, 1988 NRC, (198). Ionophores are produced by yeasts (208) and are carboxylic polyether antibiotics (24). By binding with a polar substance, they modulate the transport of mono or divalent ions across hydrophobic lipid membranes (24,74). Owens and coworkers (208) suggested that a change in electrical charge occurs across the surface of sensitive cells, altering the cell equilibrium (movement of nutrients and end product of metabolism) with an expenditure of energy to restore and maintain the cell equilibrium. Ionophores are methane inhibitors (24) reducing formate and hydrogen producing organisms in the rumen. Inhibition of substrates for methanogenesis and selection for succinate or propionate producing bacteria (44) alter the microbial population and endproducts of fermentation in the rumen (24). Data from in vivo and in vitro experimentation have shown decreases in ruminal digestion of protein and flow of microbial protein to the small intestine, and removed microbial growth when ionophores are fed to ruminants (40).

Russell and Strobell (242), suggest that monensin action in the rumen is probably due to its activity as a gram positive antibiotic. Their results agree with those obtained by Chen and Wolin (44), where monensin decreased methane production, increased the ratio of propionate to acetate and decreased the deamination of amino acids during in vitro ruminal fermentation. By reducing methane loss, energy was preserved and utilized by the host animal (40, 285,302).

Population and/or metabolism of rumen microorganisms (bacteria, protozoa and fungi) are altered when ionophores are fed to cattle (208). Such changes are measured by the alteration in concentrations of fermentation end products. Recently, O'Kelly and Spiers (202) suggested that bacterial lipid metabolism is influenced by ionophores, and monensin by increasing the lipid content of bacteria associated with both solid and liquid fractions of rumen digesta in Hereford steers by about 14%.

Owens et al. (208) compiled and statistically analyzed data from six different ionophores. They found an increased feed efficiency (four), increased rate of gain (five), tendency to increase incidence of liver abcesses (all), decreased dressing percentage and increased external fat cover (one), decreased carcass cutability (two), increased yield grade (two), increased marbling (one), and decreased quality grade (one). Little information on the effects of ionophores on carcass composition and meat acceptability was found. Table 7 shows the influence of monensin and lasalocid on performance and carcass measurements, as reported by these researchers.

Table 7. Influence of monensin and lasalocid on cattle performance and carcass composition.

	Control	Monensin	Lasalocid
Trial comparisons	156	137	33
No of head	5085	5244	1085
Mean level, ppm	0	30.02	32.88
Daily gain, kg	1.26	1.27[a,q]	1.31[a,g]
Daily feed, kg	8.97	8.47[a]	8.70[a]
Feed gain, kg	7.29	6.83[b,q]	6.74[a,g]
Liver abcesses, %	17.78	18.79	19.20
Ribeye area, cm2	77.88	77.68	77.93
cm2/100 kg carcass	26.02	25.05[a,q]	25.86
Rib fat cover, cm	1.34	1.36[c,g]	1.33
Kidney, pelvic and heart fat, %	2.63	2.62	2.70[c]

After Owens et al., 1990 (230).

[a]Linear change (P<.01) with level of ionophore

[b]Linear change (P<.05) with level of ionophore.

[c]Linear change (P<.05) with level of ionophore.

[q]Quadratic effect (P<.01) in addition to the above linear effect of ionophore level.

[g]Quadratic effect (P<.05) in addition to the above linear effect of ionophore level.

Lasalocid and monensin alter absorption and retention of minerals in growing ruminants (140,141). The site and extent of absorption of Ca, Na, K, P, and Cu were unaffected by monensin or lasalocid (66). Steers and heifers receiving ionophores improved the feed efficiency from 5 to 8% (94). Lasalocid increased growth rates by 13% or 77 g/d, while monensin showed a 10% increase in growth rate or 63 g/d (317).

Fiems et al. (76) fed monensin to grazing bulls and heifers. A significant increase in growth rate was obtained with monensin. Daily liveweight gain for bulls was 860 vs 730 g for the control group, and 680 vs 570 g for the heifers, respectively. At a similar stocking rate, feeding monensin increased the total liveweight gain per hectare from 1,336 to 1,612 kg with bulls and from 700 to 812 kg with heifers. In other experiments (317) they recommended that both monensin and lasalocid be used as dietary additives for dairy heifers and that these ionophores do not cause overconditioning. Monensin tended to increase WH gain as compared to control heifers.

Lasalocid can be used for any age or weight heifers, whereas monensin is restricted to animals above 181.0 kg of body weight. Monensin and lasalocid in feedlot diets are recommended at 20 to 30 ppm for optimal economic feeding level (208). With monensin, grazing growing steers and heifers had a maximum response when fed at 200 ng/day (76).

COSTS OF A DAIRY HERD REPLACEMENT PROGRAM

Twenty to 30% of the dairy herd is replaced yearly in the USA (75). Feeding costs alone for dairy replacements account for 50 to 70% of a total rearing program with total costs ranging from $700 to $1300 (43,75,126). In general, these costs are determined under drylot situations or simulation studies. Expenses charged to labor, buildings and equipment, bedding, veterinary and medical supplies, breeding, utilities, insurance, mortality, interest on capital invested and miscellaneous (fixed costs) are approximately $300 to $350 per heifer at 24 mo and relatively similar for pasture reared heifers versus confinement heifers (126).

Economic and nutritional evaluations have shown that either underfeeding or overfeeding a dairy heifer reduces profit. Underfeeding increases breeding age, reduces conception rates, and delays the age of first calving. Thus, daily feed costs are reduced but total costs increase due to an extended feeding period. Delaying calving beyond

24 mo of age necessitates an additional expenses per month in the range of $20 to $60 (125). Heifers calving at 26 mo will pay off their rearing costs at 54.6 mo of age with a net profit per day of life of $.43 (81). Furthermore, by delaying first calving until 32 mo of age, net profit per day of life is reduced to $.28 and 70 mo are required for a heifer to offset her rearing cost. Rearing costs included heifers who died or were culled involuntarily.

Chapter 2

Effects of Different Levels of Energy Supplementation on Growth and Body Composition of Grazing or Drylot Holstein Heifers.

ABSTRACT

Growth of Holstein heifers was studied for two grazing seasons (1987 and 1988) to evaluate pasture-drylot systems for raising dairy replacements. Pasture consisted of grass-legume mixture in six paddocks of 1.5 ha each. Grazing averaged 160 d per season. None or 2.0 kg/d of cracked corn were fed in addition to grazing in a changeover design (28 d) with repeated measurements. Average daily gain was greater when corn was fed (837 vs 581 g/d) in 1987.

In 1988, heifers were fed a high (HE) or low energy (LE) diets in confinement during 129 d period. During this phase, daily gains were 1190 (HE) and 990 g/d (LE) which were different.

After drylot, animals were equally allotted to pasture with or without 2 kg corn. On pasture, corn supplementation did not enhance weight gain overall, but did result in

greater gains in lighter animals that were previously fed the LE confinement diet. Heavy and light heifers on previously HE diet, gained 358 g/d contrasted to heifers previously on LE diet which had gains of 486 g/d.

Body composition, as determined from urea space was not different at the end of the drylot feeding. Body composition did change during the 155 d grazing season, a change normally associated with maturity.

INTRODUCTION

Research has demonstrated that given adequate nutrition, dairy heifers can reach puberty by 7 to 8 mo (6,260) and calve the first time at 18 to 21 mo, or even at a younger age (7). Usually reductions in time from birth to calving has been achieved with confinement feeding and feeding high energy diets (6,7,252,270,277).

A common approach to reduce age at first calving has been enough energy to attain daily gains between 600 and 800 g/d (297). However, energy feeding causing heifers to gain more than 800 g/d apparently decreases milk production potential (277).

The weight gain of growing animals alters content of water, fat and protein (186). Liberal feeding before or around puberty has altered the ratio of parenchymal to fat tissue in the mammary gland (251,252,260). The size of the fat pad in the mammary gland reduces duct growth (289), reducing potential milk production. However, accelerated feeding programs giving daily gains up to 1000 g/d from 3 to 12 mo of age produced heavier heifers calving at 24 mo, without excessive fattening (139). Moreover, diet recommendations (198) for heifers reared in confinement may be too high in energy (14,126,227,235).

Shortening the birth to conception period for dairy heifers reduces costs and monetary inputs with no return to the owner. Costs for this period ranged from $700 to $1300 (42,126). This cost reflects varying systems of rearing which may not utilize less costly feeds such as pasture. Feeding cost alone accounts for 50 to 60% of the total rearing expenses (42,75).

A simulation study by Toro (288) evaluated different contributions of pasture to the cost of rearing heifers. At calving, the estimated total feed costs per heifer were $441, $520 and $557 when 80%, 20% and zero% of required nutrients were supplied by pasture. In countries where grazed pasture is the main component in the diet of dairy herds, a common practice is to supplement pasture with energy, which is the most likely nutrient to be limiting production. Experiment I was conducted to measure growth responses of two groups of Holstein heifers each supplemented with energy during alternating 28 d switchback feeding while grazing pasture of temperate species.

Experiment 1. MATERIAL AND METHODS

Pasture

Nine hectares of a permanent pasture located at the Virginia Tech Dairy Center was subdivided into six paddocks of 1.5 ha each by three high tensile electric wires. Dactylis glomerata L. (Orchardgrass), Festuca arundinacea Schreb (tall fescue) , Poa pratensis L. (Bluegrass), and Trifolium repens L. and T. pratensis L. (White and Red clover) were the principal species grass-legume mixture. The legume stand was increased by overseeding white clover at the rate of 4 kg/ha in early spring 1987. Solanun rostratum (sand burs) and Franseria acantheicarpa (lambs quarters) were weeds present in pasture. Nitrogen, P_2O_5 and K_2O were applied at rates of 45, 45 and 54 kg/ha every other spring. Based on previous studies carrying capacity was estimated at six animals (3.1 animal unit; 1 AU = 450 kg BW) per hectare for the total grazing season.

Because of another experiment the heifers were not available for grazing until June 1, 1987. Thus the flush spring growth was harvested for hay in early May. The 6 paddocks were divided into 3 blocks of 2 paddocks for rotational grazing. The 2 treatment groups of 12 heifers were randomized to the 2 paddocks in each block each time the heifers were switched to a fresh pasture. The heifers were switched to a fresh pasture when it was estimated that the available forage had declined to a point to depress intake. At the time when animals were removed from a pasture being grazed, the ungrazed forage ranged from 5 to 25 cm in height (about 800 kg DM/ha). The tall fescue was rarely grazed except during autumn.

Animals, supplement and measurements

Twenty-four Holstein heifers with average BW of 295 kg and 13.2 mo old were paired into groups of 2 animals based on age and weight and airmates were then randomly split into two groups (G1 and G2). During the first 28 d grazing period G1 was fed cracked corn (2.0 kg/d) and G2 had only pasture forage. During each of 5 subsequent 28 d periods, the supplement was switched between groups. Because of drought during the 4th period, heifers were fed in drylot. Measurements taken were BW twice monthly, wither height (WH) and heart girth (HG) monthly.

Statistical analysis

Data were analyzed using the General Linear Model of SAS (244). Heifers response variables were analyzed as complete block design with heifers as block and nonrandom repeated measurements of the units (heifers) were taken following description by Gill (93). The model was:

Yijkl = u + Ti + Gj + (TG)ij + H(j)k + TH(j)ik + Pl + (TP)il + (GP)jl + (TGP)ijl + Eijkl, where:

Yijkl = dependent variable of heifer k in group j for treatment i in period l.

u = overall mean.

Ti = fixed effect of supplement i, i=1,2.

Gj = fixed effect of group j, j=1,2.

(TG) ij= interaction effect of group j, and treatment i.

H(j)k = random effect of heifer k, in group j.

TH(j)ik= random effect of interaction between treatment i and heifer k.

Pl = fixed effect of period (28 d) l, l=1,..5.

(TP)il = fixed effect of interaction between treatment i and period l.

(GP)jl = fixed effect of interaction between group j and period l.

(TGP)ijl= fixed effect of interaction among treatment i, group j and period l.

Eijklm = random residual.

Differences between treatments and treatment by group interactions were tested by treatment by heifer interaction as the error term; and H(j)k and TH(j)ik were used to test differences between groups. Period and period interactions were tested by the residual error term.

RESULTS AND DISCUSSION

Grazing began June 1 and lasted for 140 d to November 17, 1987. From August 24 to September 23 the heifers were removed from pasture due to extreme drought and were fed as one group in confinement. Appendix Table 2 contains the climate data for the period (195). During this 30 day period, the animals received a ration containing 10% CP from corn silage and soybean meal. Expected DM intake was 2.5% of BW, and average daily gain (ADG) was 571 g/d.

Initial BW, for both groups was 295.0 kg (Table 8). Final BW for Group 1 (G1) and Group 2 (G2) was 407 and 404 kg, respectively. Group 1 was fed supplement for 77 d and Group 2 for 56 d during grazing. Average daily gains were 710 and 708 g/d for G1 and G2, respectively, and did not differ (P>.05). These gains are similar to results of (263) but lower than 1000 g/d reported by (51) when Holstein heifers were supplemented with cereal grain while grazing.

Effect of corn supplementation on actual BW and daily gains (Table 9), show that supplementation increased ADG, except for period 6. However, at the end of the trial body weights were similar for groups because of alternate periods of supplementation. Means for WH were 123.2 and 124.7 cm and for heart girth 173.5 and 172.3 cm for G1 and G2, respectively.

Usually, the periods when feeding 2 kg/d of corn resulted in higher weight gains than for the alternate periods without corn (807 vs 551 g/d). Heart girth measurements (171.7 vs 174.2 cm) were different (P<.05) for periods of supplement versus no supplement feeding.

Table 8. Production measurements of two groups of Holstein heifers supplemented with cracked corn in alternate 28-d periods during a 140 day grazing period (1987) on a grass-legume mixture.

		Supplemented in alternate 28-d periods		Supplemented in alternate 28-d periods		
Item		G1	G2	NS	S	Overall
Age, mo	initial	13.4	12.9	12.9	13.4	13.1
	final	19.0	18.5	18.5	19.0	18.5
BW,kg	initial	295.0	295.0	295.0	295.0	295.0
	final	407.0	404.1	401.0	405.4	405.0
WH, cm	initial	118.4	119.4	119.4	119.1	118.9
	final	126.5	128.5	128.4	126.5	127.5
HG, cm	initial	163.1	160.5	162.0	164.4	161.8
	final	183.9	182.9	183.0	184.0	183.4
Least Square Means:						
BW,kg		356.0	346.8(3.0)	351.1	352.0(14.0)	
WH, cm		123.2	124.7(5.7)	123.7	124.2(6.3)	
HG, cm		173.5	172.7(5.9)	171.7	174.2(.4)	
ADG, kg/day		.710	.708(.02)	.581	.837(.20)	

Numbers in parenthesis are SE for n=12.

Table 9. Effect of alternate periods of corn supplementation on BW and daily gain of grazing Holstein heifers from June-October, 1987.

Period (28 day)	Zero Corn		Two kg Corn	
	Body wt (kg)	Gain (ADG) (kg/day)	Body wt (kg)	Gain (ADG) (kg/day)
0	295.0	-	295.0	-
1	300.1	0.209	310.7	0.695
2	327.5	0.574	318.1	0.885
3	336.0	0.506	352.7	0.858
4*	352.0	0.571	368.7	0.571
5	384.5	0.892	377.0	1.088
6	402.6	0.574	406.2	0.507
Mean	350.1+0.032[1]	0.551+0.118[1]	352.9+0.032[1]	0.807+0.118[1]

*Fed same diet in drylot during severe drought.

[1]S.E.

Significant supplement period interactions were observed for ADG (P<.01) and WH (P<.01). These interactions possibly could be explained by pasture availability and quality varying during the 28 d periods, especially since 1987 had an extended drought season (Appendix Table 2). Since it is known that energy supplements to grazing animals generally increases DM, changes in quantity or quality of forage among the periods could alter the relative responses of heifers fed or not fed grain among periods.

Experiment 2.

INTRODUCTION

Young heifers were used to evaluate combinations of a drylot feeding followed by grazing alone and with energy supplementation during the grazing season of 1988. Before start of grazing in May, Holstein heifers were wintered in confinement for 129 d between December, 1987 and April, 1988.

MATERIALS AND METHODS

Drylot phase

In the drylot phase, 16 Holstein heifers averaging 206 kg and 9.2 mo of age (heavies, H) and 16 averaging 129 kg and 5.6 mo of age (lights, L) were each divided again into two groups. Animals (H and L) were paired into similar groups of 2 and then randomized to one of two diets, high energy (HE) and low energy (LE) (Appendix Table 4). Thus the treatments each with 8 heifers (H) and (L) each with HE and LE diets were randomized into four pens and each treatment diet fed from a Pinpointer 4000-B. Diets were calculated to contain 85% (LE) and 105% (HE) of recommended TDN (198). Ingredients as percent of diet and chemical analysis of diets are in Appendix Table 4. Diets were mixed as TMR before noon and delivered to the feed bunk at 1300 h. Quantity of feed was offered to allow between 5 and 10% to remain after 24 h. Heifers had access to the feed at all times. Daily intake for individual heifers was recorded automatically by computerized weigh cell.

Pasture phase

Of the 8 heifers in each of the four drylot treatments, four animals were randomized to G1 and G2; hence 16 heifers in each group. Grazing, supplementation and measurements followed the routine of Experiment 1.

Statistical analysis for drylot phase

Heifer response was analyzed with randomized design by ANOVA. The model was:

Yijk = u + Si + Dj + (SD)ij + H(ij)k +Eijkl, were:

Yijk = dependent variable of heifer k in diet j and size i.

u = overall population mean.

Si = fixed effect of size i, i=1,2.

Dj = fixed effect of diet j, j=1,2.

(SD)ij= fixed effect of interaction between size i and diet j.

H(ij)k= random effect of heifer k in diet j and size i.

Eijkl = random residual.

Differences between sizes, diets and size by diet interaction were tested by heifer within diet and size as an error term.

Statistical analysis - pasture phase

Heifer response variables was analyzed as a repeated measurement split-plot with heifers as an incomplete block. The model was:

Yijklm = u + Si + Tj + (ST)ij + G(ij)k + H(ijk)l + Pm + (SP)im + (TP)jm + (STP)ijm + Eijklm, where:

Yijklm = overall response.

u = overall population mean.

Si = fixed effect of heifer size i, i= 1.2.

Tj = fixed effect of treatment (energy) j, j=1.2.

(ST)ij = fixed effect of interaction between treatment i and size j.

G(ij)k = fixed effect of group k in treatment j and size i.

H(ijk)l= random effect of heifer l in group k, treatment j and size i.

Pm = fixed effect of period m, m=1..6.

(SP)im = fixed effect of interaction between size i and period m.

(TP)jm = fixed effect of interaction between treatment j and period m.

(STP)ijm= fixed effect of interaction among period m, treatment j and size i.

Eijklm = random residual.

Differences between sizes, treatments (energy), interaction size by treatment and group within size by treatment were tested by heifer nested within group, treatment and size as an error term. Period and period interactions were tested by the residual error term Eijklm.

RESULTS AND DISCUSSION

Drylot phase

Least squares means (Table 10) for ADG in g/d were 1190 (HE) and 990 (LE), respectively, and were different (P<.01). Means for actual BW, HG and DM intake (DMI, kg/d) did not differ by diet (P>.05). WH (cm) were 112.3 (HE) and 109.8 (LE) and were influenced by diet (P<.05).

As expected, size of heifers had a significant effect on BW, ADG, DMI, WH and HG. There were no significant size-diet interactions. However, the higher DMI for LE diet as compared to HE diet, for both heifer sizes (H and L) caused similar rates of gains for H and L heifers. Baile and Della-Fera (15) found that growing animals regulate feed consumption to maintain a relatively steady rate of gain, even under different environmental and feeding conditions.

Table 10. Performance of Holstein heifers with low and high energy diets in confinement feeding from December 1987 until April 1988 before turning out on pasture (LS means).

	BW (kg)	ADG kg/d	DMI kg/d	WH (CM)	HG (CM)
Size:					
Heavies (H)	285.9**	1180*	7.7**	117.3**	157.7**
Lights (L)	192.0**	1000*	6.3**	104.5**	138.2**
Diet:					
High energy (HE)	244.2	1190**	6.7	112.3*	148.7
Low energy (LE)	233.8	990**	7.5	109.8*	147.2
Size*Diet:					
H*HE	290.9	1260	7.5	119.8	158.2
H*LE	281.0	1120	8.7	115.5	157.1
L*HE	197.5	1130	5.6	105.6	139.2
L*LE	186.6	880	6.3	104.1	137.2

* (P<.05)
**(P<.01)

Dry matter intakes and BW for HE and LE diets were higher than the 6.0 kg/d obtained for heifers of similar BW (226 to 275 kg, 235). Heavier heifers on LE diet consumed more DM (8.7) than heifers on HE (7.5 kg/d) diet. The difference in DMI was not similar (6.3 vs 5.6 kg/d), for light heifers fed low and high energy diets. Although not significant, heifers receiving LE diet had 10.7% (7.5 vs 6.7 kg/d) higher DMI than those on HE diet. Higher DMI of LE diets agrees with data of Quigley (227) and Baile and Pfander (16).

Although the rations were formulated for 800 g/d of ADG, heifers fed these rations ad libitum gained above 1000 g/d, except for light heifers on LE diet that gained 880 g/d. These results confirm previous studies of Quigley (227), Richardson (235), and those reported by James (124), that heifers in confinement gain more weight than expected by NRC (217).

Pasture phase

The grazing days were 184. Group one was supplemented for 4 periods of 28 d and the alternate group for 3 periods. Initial BW after balanced distribution into Groups (G1 and G2) were 316.4 and 315.5 kg at the start of grazing. At this time, heavy heifers averaged 353.7 and light heifers averaged 255.1 kg BW.

Heifers on both groups had weight losses during the first 14 d of grazing, but heavy animals lost the most weight. Even with a very high pasture availability such weight losses are normal and reflect changes in management and diet. During this period the heifers made adjustments in exercises, walking distances to graze, and altered contents of gastrointestinal tract. Pasture diets in spring are laxative, hence the losses in weight may be due partially to fill.

The results for supplementation, size, and previous diets are in Table 11; whereas Table 12 shows production measurements with interactions. Overall, corn supplementation did not increase BW nor ADG; however, corn supplementation tended to improve ADG of lighter animals that were previously fed the LE diet during wintering in confinement (Table 12). Although not significant, the heavier heifers, which were wintered on HE diet gained less (267 g/d) on pasture than those on LE diet (421 g/d). Similarly, heavy and light heifers on previously HE diet gained 358 g/d in contrast to heifers on the previously LE energy diet which had gains of 473 g/d. Similar results were obtained by Lewis et al. (158,159), when beef steers gained more than 280 g/d during the wintering phase.

Table 11. Least square means for BW, gain, wither height, heart girth of Holstein heifers grazing a grass-legume mixture with or without energy supplementation for alternate 28-d periods in 1988.

	BW (kg)	ADG g/d	WH (CM)	HG (CM)
Corn supplemented in alternate 28-d periods				
Periods with corn (S)	342.6	393	122.7	168.9
Periods with no corn (NS)	342.2	439	122.9	168.8
Size of heifers:				
Heavy (H)	374.9**	345**	125.9	174.5
Light (L)	309.9**	486**	119.8	163.2
Previous diet:				
High energy (H)	347.5	358**	124.3	169.7
Low energy (L)	337.3	478**	121.4	168.1

**(P<.01)

ADG-average daily gain, WH-wither height, HG-heart girth.

Table 12. Production measurements: BWT, ADG, H and HG of Holstein heifers, under supp*size, supp*diet, size*diet and supp*size*diet interactions (LS means).

	BWT (kg)	ADG g/day	WH (CM)	HG (CM)
Supplement x size:				
NS*H	374.9	459[1]	126.1	174.6
NS*L	309.5	421	119.9	163.3
SxH	374.8	235	125.8	174.5
SxL	310.3	550	119.7	163.2
Supplement*diet:				
NS*HE	347.3	400	124.4	169.9
NS*LE	337.2	478	121.6	167.9
S*HE	375.3	267	127.4	175.0
S*LE	337.4	469	121.3	168.2
Size*diet				
H*HE	375.3	267	127.4	175.0
H*LE	374.4	421	124.5	174.1
L*HE	319.7	450	121.2	164.4
L*LE	300.2	525	118.4	162.0
Supplement*size*diet				
NS*H*HE	375.4	382	127.6	175.1
NS*H*LE	374.5	537	124.5	174.1
NS*L*HE	319.1	419	121.2	164.8
NS*L*LE	300.0	419	118.6	161.7
S*H*HE	375.2	155	127.8	174.8
S*H*LE	374.4	307	124.4	124.1
S*L*HE	320.2	476	121.3	164.0
S*L*LE	300.4	632	118.1	162.3

Least square means without superscripts are not different at P>.05.

[1]Interaction=P<08

BW - body weight
ADG - average daily gain
WH - wither height
HG - heart girth
NS - nonsupplement
S - supplement

These ADG suggest that effects from previous treatments during wintering in drylot influenced the growth of heifers during the grazing period. The previous low energy diet with light heifers giving lower gains than for HE diets compensated by giving the greater heifer gains on pasture. Similar results were found by Beacom (22) with steers grazing oats in summer and fall to supplement pasture after being wintered. Rates of gains during winter were limited to 680 and 450 g/d. Steers that gained most during wintering gained 610 g/d less while grazing pasture supplemented with other forage crops. To explore compensatory gains for milk production or finishing steers for particular markets is not relevant but should be considered for grazing studies with dairy heifers, or other growing animals.

Period of supplementation and its interactions were significant (P<.01) in the model. Therefore, one can speculate that inferior pasture for supplemented animals in a particular period of the trial was the cause of less ADG.

Previous wintering diet or pasture supplemental periods had little or no influence on BW and HG measurements. There was a small but significant difference (2.9 cm) in WH favoring the heifers wintered on HE diet. The heavier heifers on both diets had lower ADG throughout the grazing period than light heifers (345 vs 486 g/d), respectively (Table 11).

Body composition

The first urea space measurement was at the end of drylot feeding and provided an initial body composition for the grazing period. This of course, indicates body composition of heifers after wintering on high or low energy diets.

Means for all heifers were 9.35 mg urea-N/dl of blood plasma (PUN), 60.1% urea space (US), 64.2% empty body water (EBWATER), 11.6% empty body fat (EBFAT), and 17.6% empty body protein (EBPRO). Least square means by size and diet are presented in Table 13. Table 14 shows calculated values for body components on a mass basis. The values for gross energy (Mcal/kg) at the end of the drylot period were similar in empty body weight (EBW), and were 2.3 (H), 1.9 (L) and 2.1 each for HE and LE diets, respectively.

Table 13. Least square means for PUN, EBWATER, EBFAT, EBPRO, and estimated empty body weight (EEBW) of Holstein heifers in drylot (129 d).

Item	PUN mg urea-N/dl	EBWATER	EBFAT %BW	EBPRO	EEBW* kg
Size:					
Heavy (H)	9.3	62.7[a]	13.0[a]	17.8[a]	248.2
Light (L)	9.4	65.6[b]	10.2[b]	17.3[b]	162.1
Diet:					
High Energy (HE)	10.0[c]	64.5	11.3	17.6[c]	210.0
Low Energy (LE)	8.7[d]	63.8	11.9	17.4[d]	200.5
Size*diet:					
H-HE	9.5[cd]	62.6[a]	13.1[ac]	17.9[a]	252.8
H-LE	9.1[cd]	62.8[a]	12.9[a]	17.7[ac]	243.8
L-HE	10.5[c]	66.5[b]	9.5[b]	17.4[abd]	167.1
L-LE	8.3[d]	64.8[ab]	10.9[abd]	17.2[b]	157.1

*Estimated from: EBW=(BW-15.3)/1.09, ARC, 1980. BW from Table 10. Means in the same column within main effect or interaction headings bearing different superscripts.

[abcd]Size x Diet = PUN (P<.05)

PUN - plasma urea nitrogen
US - urea space
EBWATER - empty body water
EBFAT - empty body fat
EBPRO - empty body protein

Table 14. Body composition (mass basis) of Holstein heifers fed either a high energy diet (105% NRC) or a low energy diet (85% NRC) at the end of drylot phase.

	Size		Diet	
Variable	Heavy	Light	High Energy	Low Energy
EBWATER, %	62.7**	65.6**	64.5	63.8
EBFAT, %	13.0**	10.2**	11.3	11.9
EBPRO, %	17.8**	17.3**	17.6*	17.4*
Ash,%	6.5	6.9	6.6	6.9
EBFAT:EBPRO	.73	.59	.64	.68
EEBW[1], kg	248.2	162.1	210.0	200.05
WATER, g/kg EEBW	627	656	645	638
FAT, g/kg	130	102	113	119
PROTEIN, g/kg	178	173	176	174
ASH, g/kg	65	69	66	69
GROSS ENERGY, Mcal/kg	2.3	1.9	2.1	2.1

* (P<.06)
**(P<.01)

Estimated empty body weights (kg) were 248.2 and 162.1 for heavy and light heifers, respectively. However, EBWATER, EBFAT, and EBPRO were different ($P<.01$) for different weight animals. Diet had a significant ($P<.06$) effect only on EBPRO. ANOVA mean squares for estimated components are in Appendix Table 5.

The measurements are in close agreement with those obtained by Hammond et al. (105) with Holstein steers, weighing 300 kg. Even though lighter in body weight (205 kg), our heifers had a much narrower percentage range of EBW components. Body components do differ between sexes (254) and among breeds (45,184). However the percentage of body components in their trial lies between those reported by Koch and Preston (145) for weanlings (Hereford and Swiss crosses), and for yearlings (Simmental), and data for mixed breeds and angus steers, used by Hammond et al. (102).

Prediction of body composition from US on percentage basis is advocated by Bartle and his coworkers (18), while Hammond (102) and associates conclude that a mass basis is the appropriate form to assess body composition on Holstein steers from US, because dairy breeds are leaner than beef breeds.

Neither previous wintering diets nor periods of energy supplementation while grazing had significant effects on body components of Holstein heifers (Table 15). Supplement interactions were also not significant; however interactions of heifer size by diet and diet by period were present (Appendix Table 6). Size, as it would be expected, had significant effects on body components ($P<.01$).

When considering only dates when urea space was performed (Table 16) a change in body components occurred for all heifers (P<01). After 48 d on pasture heifers had lower US, higher EBWATER, lower EBFAT and a slightly increased EBPRO. A lower fat-to-protein ratio was observed after grazing when compared to that at the end of drylot feeding (.59 vs .67), showing that heifers lost fat while gaining in BW during adjustment between drylot and grazing (Table 16). Sequential measurements by urea space revealed significant ($P<.01$) changes in EBWATER, EBFAT and EBPRO. The most likely factor affecting these changes are aging and for increased BW. Beyond 13.6 mo of age the EBFAT:EBPRO showed the effect of increased body weight and age, between June and November when fat was deposited (g/kg) at higher rates (45.5%) than protein (27.5%). The water content changed from 656 to 615 g/kg, comprising a reduction of 41 g/kg (Table 17). During the same period gross energy accumulated, increasing from 1.9 to 2.3 Mcal/kg of EEBW.

Table 15. Effects of supplementation, size and previous diet on PUN and body composition of Holstein heifers grazing a grass-legume mixture pasture.

Item	PUN mg urea-N/dl	EBWATER	EBFAT	EBPRO
		-----------	-%-	-----------
Supp. (SE)	.27	.26	.23	.04
Corn	10.4	63.8	12.0	17.8
No corn	10.3	63.5	12.2	17.8
Size (SE)	.26	.25	.23	.03
Heavy (H)	10.4	62.5**	13.2**	18.0**
Light (L)	10.4	64.8**	11.0**	17.6**
Previous diet(SE)	.27	.26	.23	.03
High energy	10.5	63.7	12.1	17.8
Low energy	10.3	63.7	12.1	17.8

**(P<.01)

[1]EEBW - Estimated empty BW

Table 16. Temporal changes in PUN and body composition of Holstein heifers before and during the grazing season, 1988 on a grass-legume mixture with or without energy supplementation.

Variable	End of Confinement April, 1988	48 d on pasture June, 1988	184 d on pasture November, 1988	P-value
No. heifers	19	17	25	
Age-mo[1]	12.6[1]	13.6	18.2	
BW-kg[1]	293.6[1]	314.6	417.2	
PUN, mg urea N/dl	9.3 (.36)[2]	11.2 (.34)	10.6 (.27)	P<.01
US, %BW	61.5 (1.89)	50.3 (1.79)	53.9 (1.42)	P<.01
EBWATER, %	64.0 (.34)	65.6 (.33)	61.5 (.26)	P<.01
EBFAT, %	11.7 (.31)	10.4 (.30)	14.2 (.24)	P<.01
EBPRO, %	17.5 (.04)	17.7 (.04)	18.2 (.04)	P<.01
Ash, by difference	6.8	6.3	6.1	
EBFAT:EBPRO		.67	.59	.78

[1]Range in: Age = April (9.8-15.6 mo), June (10.7-16.5 mo), November (15.3-21.1 mo)
BW = April (204.3-376.8 kg), June (242.9-397.2 kg), November (342.8-508.5 kg)

[2]SE

Table 17. Changes in empty body composition on mass basis for grazing Holstein heifers in 1988.

	April	June	November	Pasture diff.
BW, kg	293.6	314.6	417.2	102.6
EEBW, kg	255.3	274.6	368.7	94.1
EBWATER, kg	163.4	180.1	226.7	46.1
EBFAT, kg	29.9	28.5	52.3	23.5
EBPRO, kg	44.7	48.6	67.1	18.5
EBASH, kg	17.3	17.4	22.6	5.2
Deposition:				
Water, g/d	640	656	615	-41.0
Fat, g/kg	111	104	142	38.0
Protein, g/kg	175	177	182	50.0
Ash, g/kg	68	63	61	-2.0
Gross energy Mcal/kg	2.1	1.9	2.3	.4

Pasture effects per se could be detected by the US technique. After 184 d on pasture, the EBFAT:EBPRO was .78 when heifers averaged 18 mo of age weighing 417 kg.

Changes in body components may have occurred because of diet (pasture vs drylot), grazing activity or age associated with increase in BW. Body condition scores taken at the end of the grazing season were similar (3.3 vs 3.4) for G1 and G2, respectively.

Plasma urea N values (Table 16) were not influenced (Appendix Table 6) by supplement, size or previous diet. However, periods and interactions between size by diet and diet by period were significant ($P<.01$). This suggests that differences observed may be associated with differences in pasture quality, especially if these decrease in protein content of herbage when urea space was performed.

The significant differences in PUN at different dates when US was measured may be associated with diet quality at a particular time (Table 16). The previous diet at the end of drylot confinement had the lowest value (9.3 mg urea-N/100ml) as compared to values of 10.6 and 11.2 during grazing. The high PUN values for heifers while grazing may be caused by the high CP of the forage which may improve rates of availability and ruminal protein degradation. PUN values of this study agree with those of Preston et al. (226).

Plasma urea nitrogen associated with maximum animal performance ranges from 11 to 15 mg/100ml for growing steers (35) and 7 to 8 mg urea-N/100ml for finishing cattle (226). For maximum organic matter digestion in the rumen of lactating cows, a blood urea nitrogen concentration greater than 8 to 10 mg/100 ml is required (134). According to Carver et al. (38), growing steers grazing fertilized bermuda grass or an orchardgrass-ladino clover mixture require a range of 8 to 25 mg urea-N/100ml to attain BW gains of 500 g/d. Only animals grazing orchardgrass and ladino clover maintained a high enough PUN level during the grazing season to sustain an ADG of 500 g/d. Our heifers on pasture during this drought year (1988) had a PUN level ranging from 10.2 to 11.2 mg urea-n/100ml, the ADG range from 345 to 581 g/d.

Chapter 3

Growth and Body Composition Responses in Holstein Heifers to Lasalocid and Supplemental Protein-Energy as Compared to a Drylot diet.

ABSTRACT

Thirty-two growing Holstein heifers weighing from 155 to 241 kg (8 per group) were fed one of four diets: 1) a mixed diet containing corn silage, alfalfa silage and orchardgrass hay (DL); 2) pasture alone (PA); 3) pasture + lasalocid (PL); and 4) pasture + 2kg of a 19% CP concentrate (PG). Data obtained were daily gains, body weight, wither height, heart girth, backfat depth, ribeye area, body condition score and body composition. Daily gains for all treatments differed: DL 934, PA 755, PL 835 and PG 875 g/d. Body weight, wither height and heart girth did not differ. Ultrasound determinations for backfat and body condition scores generally agreed. Empty body water, empty body fat, and empty body protein were similar for heifers for all treatments. Supplementing heifers on pasture increased daily gains. Results suggest that energy needs of grazing animals are higher than housed animals. Economic analyses show that combinations of drylot (205d) and pasture (160 d) reduce dairy replacement costs compared to drylot alone.

INTRODUCTION

In a previous experiment, holstein heifers (12 to 18 mo old) attained average daily gains (ADG) from 400 to 851 g/d when 2 kg corn/d was fed in alternating 28 d periods while grazing. No significant differences in body weight (BW), wither height (WH), and heart girth (HG) occurred fort he groups alternately supplemented after a 160 d grazing period. In 1988 young heifers (5.6 to 9.4 mo, weighing 206 kg, heavies, H, and 129 kg, lights, L) were drylot fed before switching to grazing treatments. The drylot treatments for H and L heifers were high energy (HE, 105% TDN) and low energy (LE, 85% TDN). Subsequently while grazing, corn supplements in alternating 28 d periods did not enhance BW or ADG, but the L heifers fed the LE diet during drylot previous to grazing made the highest BW and ADG. Several authors recommend that heifers should not be turned onto pastures before 6 mo of age (49,125,266). In Virginia, Blaser et al., (28), reported gains for cattle allowed grazing only to be 410, 640, and 730 g/d under low, medium and high available pasture (forage), respectively.

Ionophores, like rumensin and lasalocid were cleared by FDA for use in beef cattle (94) and dairy replacements (110). Through microbial action ionophores enhance energetic efficiency by their microbial effect in the digestive tract (39,40,242). Thus, ionophores generally increase efficiency of growth rates (208,96), increase cycling and improve pregnancy in beef animals (317) and dairy heifers (17), and alter absorption and retention of mineral in growing ruminants (140, 141). Grazing bulls and heifers fed ionophores had faster growth rates than control animals, 860 and 680 g/d and 730 vs 570 g/d, respectively (71). Both monensin and lasalocid are recommended as dietary additives for dairy heifers as these ionophores did not cause overconditioning (317). Lasalocid can be used for any age or weight heifers, while monensin is restricted to animals above 181 kg of BW (208).

Pasture forages may provide 80% or more of the total DM for dry cows and for dairy herd replacements (25,70). In Georgia, Holstein heifers raised mainly on pasture calved at 31 mo with a total cost of $700 (182). In Virginia there is no information available on raising Holstein heifers on either pasture alone or pasture supplemented with ionophore or energy-protein concentrates.

Thus, the objectives of this research were: 1) to compare growth and body composition responses of Holstein heifers fed a drylot diet as compared to similar grazing heifers with only pasture and pasture supplemented with 19% CP concentrate or lasalocid; 2) To estimate pasture herbage intake; and 3) to estimate costs of combining drylot and pasture feeding for managing dairy heifers.

MATERIAL AND METHODS

Pasture

Six adjoining pasture paddocks of 1.5 ha, as described in Experiment 1 were used. However, to accommodate the 3 grazing treatments the paddocks were divided into 2 blocks of 3 paddocks. The heifers for the 3 treatments were randomized to the 3 paddocks in block I. After available forage declined (described in Experiment 1), the heifers were randomized to the paddocks in block II.

Because heifers were not available for grazing until May 9, one half of the area (3 paddocks) was cut for hay on the same day that heifers were turned into the other three paddocks.

With the flush spring pasture growth the heifers had a very high quality herbage to select from initially, meanwhile aftermath regrowth on the paddocks that had been cut for hay gave leafy growth for grazing. After the second grazing period, as heifers were switched to a fresh pasture, the paddocks were clipped, to assure leafy regrowth. Mowing removed mature growth and retarded weeds, if present; also competition from undergrazed tall fescue was reduced. Botanical components in paddocks were assessed visually by the DaFor method. Any time that heifers changed pasture, hand plucked samples were collected by following heifers during the first day of grazing. Herbage not grazed when heifers left the paddock was also collected by hand cutting from at least 20 locations in each paddock.

Animals and Treatments

In April 1989, 32 Holstein heifers weighing 155 (4.6 mo) to 241 kg (9.0 mo) were blocked by weight and age into 8 groups of 4 animals and randomized into four treatments. The heifers were wormed at the beginning and 30 d later. The heifers were weighed (not shrunk) biweekly on every other Tuesday beginning at 8:00 h. Heifers on pasture were brought to the scales at the same time. Wither height and heart girth were measured monthly.

Each diet was fed to eight heifers ranging in size from small to large. A TMR fed in drylot (DL) containing 55.8% corn silage, 25.6% alfalfa silage and 18.6% orchardgrass hay (55.9% DM, 14.3% CP, 32.0% ADF and 65% TDN). Pasture alone (PA) and pasture supplemented with either lasalocid (PL) and pasture with 2.0 kg of 19% CP concentrate (PG) were the other 3 treatments. Lasalocid was fed for daily intake at 200 mg/hd as free choice in a mineral-vitamin mixture (Bovamin - A: Southern States Cooperative, Richmond, VA). A similar mineral mixture Ca:P (2:1) was available (minus lasalocid) to the other 3 treatment groups.

The DL group was confined to conventional heifer-rearing pen with 12.5 m^2 per heifer. This provided outdoor space with shelter on one end and adequate feed bunk space at the other end. The pen was large enough to allow heifers to move freely inside. Diets were formulated for maximum forage use. Due to high quality forage available, concentrates were not added to formulate the DL ration. The TMR diet was mixed before 1200 h and delivered to the feeding bunk at 1300 h. Feed was offered in sufficient amounts to assure a residue of 5 to 10%. Heifers had access to feed at all times. Urea and body composition methods were described in the previous chapter.

Ultrasound Measurements

Backfat depth and Longissimus muscle area were estimated monthly by ultrasound measures. Determinations were made by the Scanogram Model Aloka 210 Real Time Machine (Cromo-metrics Medical Systems, Inc., Wallingford, CT) with a 5 MHZ general purpose probe. Measures of backfat depth and ribeye area (REA) were taken over the Longissimus muscle between ribs 12 and 13 (319,320,321) on each heifers' left side. A head-lock squeeze chute was used to restrain the animals and mineral oil was applied at the measuring site to ensure a good contact between the probe and skin of the animal (133).

A standard VHS video recorder was used to record scans for posterior sketching of REA. Direct measurement (cm) of the fat-lean boundary were obtained from the scans imaged on a TV monitor screen, because digitally displayed measurement from the face of the transducer was inappropriate due to a small fat-lean boundary on these heifers. Acetate paper was used to trace the ribeye areas directly from the video monitor. The Autosketch (Autodesk Inc, Sausalita, Ca 94965) Spatial Digitizer was used to determine the REA. Measured REA were then adjusted for scaling of the video display and recorded as square centimeters.

Body condition scoring (310) and urea dilution as described by Bartle et al. (20) were determined four times during the experimental period.

Urea and body composition

The urea dilution procedure followed the original outline of Preston and Koch (225), with modifications proposed by Bartle et al. (20), (full fed) and the precautions recommended by Hammond et al. (103,105). Urea solution was prepared on the day before infusion. Catheterization of heifers was not performed. Heifers were weighed on the morning (0800 h) of the established normal weighing date and urea infusion was performed the next morning. For infusion, heifers were restrained in scales with a head-catch mechanism and a 10 ml blood sample (blood urea-N base line) was obtained via venipuncture of the jugular vein through a 14 g x 2.5 cm needle attached to a stainless steel one-way stopcock. Eight centimeters of 4 mm ID Tygon tubing was connected to second one-way stopcock. Sixty ml syringes were attached to the second stopcock to administer the urea solution. The blood sample was collected into a heparinized tube (200 ul (143 units) Na-Heparin) and immediately placed on ice.

The same apparatus was used to infuse into the jugular vein 130 mg/kg BW of 20% urea solution dissolved in .9% saline solution. Twelve min later a second blood sample was collected from the jugular vein on the opposite side of the neck. Plasma urea nitrogen change was then measured by differences between these two samples and used to calculate urea space.

In the laboratory, blood was centrifuged at 3220 xg rpm for 15 min. One ml of plasma was processed according to Coulombe and Favreau, (55) for PUN determinations. Urea space (US) was calculated as percent of BW according to Bartle et al. (18):

Urea Space = [(mg urea-N/change in PUN)/BW]*10, where: mg urea-N= g of urea infused * %N in urea (46.7%) * urea DM (92.4). Change in PUN= Difference in PUN between the blood samples taken at zero and 12 min.

To estimate body components, the equations developed for Holstein steers by Hammond et al. (105), were used. Proportions as a percent of empty BW were estimated as follows:

% EBWATER = 83.5 - .160*US%BW - .0320*BW

% EBFAT = -5.9 + .140*US%BW + .030*BW

% EBPRO = 16.6 - .009*US%BW + .005*BW

% EBASH = by difference

Statistical analysis

Heifer responses to compare drylot and pasture treatments were analyzed as a complete block design with blocks of four heifers each, based on weight (Gill, 93). Anova was obtained with the GLM procedure of SAS (244).

RESULTS AND DISCUSSION

Growth

Various measurements describing growth are presented in Table 18. Least square means (g/d) for ADG were greatest for drylot, but not significantly greater than pasture plus grain (PG). Animals on PG gained more than PA ($P<.05$) but not significantly more than PL ($P>.05$). The difference between PA and PL was not significant.

Means for all treatments were BW (260 kg), WH (114 cm) and HG (148 cm) and values of these parameters were similar for treatments. Comparing body weights to standards in Table 3, DL heifers attained growth nearest to recommendations and PA fed heifers were below the recommendations in Table 3. Responses of pasture heifers supplemented PG and PL were intermediate. As a negative percentage of standard in Table 3, PA was 11.5% below in BW and 4.6% below in WH. The latter may be more important relative to structural standards.

Table 18. Treatment of effects on body weight, gains, wither height, heart girth, body condition score, backfat depth and ribeye area of Holstein heifers (LS means).

Item	Drylot	Alone	+Lasalocid	+Grain	SE
BW, kg	272.2	250.5	256.9	260.4	9.90
ADG, kg/d	.934[a]	.755[c]	.835[bc]	.871[ab]	.04
WH, cm	114.0	113.5	114.6	114.6	1.19
HG, cm	149.1	146.4	146.1	149.3	
BCS, units	3.5[a]	3.3[b]	3.3[b]	3.2[b]	.09
Backfat, mm	3.9[a]	2.9[b]	3.2[b]	3.2[b]	.01
REA, cm^2	41.5[a]	35.9[bc]	34.5[c]	37.8 [b]	1.88
cm2/100 kg BW	15.2	14.3	13.4	14.5	--
WH/BW, cm/kg	.42	.45	.45	.44	--
HG/BW, cm/kg	.55	.58	.57	.57	--

[a,b,c]Means in the same row bearing different superscripts differ by $P<.05$.
Means without superscripts do not differ ($P>.05$).

Except for the PA heifers the ADG was above the recommended 800 g/d by Amir et al. (7), Sejrsen (252), Swanson (277) and Waldo et al. (210). There was a linear increase in BW, WH, and HG from beginning to end of the experiment, indicating that the imposed treatments had not restricted growth of heifers.

Ultrasound determinations (Table 18) revealed that thickness of backfat was highest for DL heifers, lowest for PA and values for PH and PL were similar and not different from PA. There was a relationship in body condition scoring (BCS) and ultrasound measurement. Heifers fed pasture + grain (PG) had the lowest score (3.2) but did not differ from the other pasture treatments. The BCS value for DL heifers was 3.5 and differed ($P<.05$) from all pasture treatments. Similar observations are reported for mature cows (319,320) and sheep (100).

Lunt et al. (164) assessed carcass composition, comparing samples obtained from steers fed grain in drylot or pasture. At maintenance, steers weighing 169.1 kg at slaughter had 2.8 mm of backfat measured on the 12th rib. As weight gain increased above 169.1 kg, the grain fed animals showed progressive increases in separable fat as compared to pasture fed animals. Heifers on PA in this research had a 2.9 mm backfat depth and gained 755 g/d (Table 18).

Subcutaneous fat deposition measured 3.2 mm in animals with grain supplement, while DL heifers had the highest ($P<.05$) backfat deposition (3.9 mm). Work of Lunt and associates (164) does not mention the age of animals, but their results suggest that their animals were more mature than the heifers in this study. Backfat depth for PL was higher than for PA fed heifers which may be read as the same trend was reported by Owens et al. (208).

Longissimus muscle area (REA) measurement did not differ among treatments and averaged 37.4 cm^2, corresponding to 14.3 cm^2 per 100 kg of BW. However, lasalocid supplementation (PL) resulting in low REA (Table 18) similar to other pastured animals. Similar effects have been reported by Owens et al. (208, Table 7); with larger finishing animals.

Heifer growth was lowest with pasture treatments. Assessment of growth on individual animals by periodic weighing at 14 d intervals (temporal changes in BW) shows variable rates of gain among periods, but final BW was not significantly different for heifers on pasture treatments. Temporal changes in liveweight gains are a function of length of interval between weighings. Rumen fill influences ruminant weight and may affect interpretive conclusions of results (209,210). This fact explains the variable ADG values among period.

Body Composition

Blood measurements and body composition are shown in Table 19. No significant (P>.05) differences were found for body components or blood measurements, except for plasma urea nitrogen (PUN). Plasma urea nitrogen was not different (P>.05) for PA and PG heifers, but other comparisons differed significantly. The PUN values are well above the normal of 8 mg urea-N/100 ml of plasma (14) and 10 mg urea-N observed by Preston et al. (226); however, these values are in close agreement with those of Carver et al. (38). The high values of PUN for heifers on pasture may be caused by high forage protein before and after grazing 19.6% and 13.1% on dry basis, respectively (Appendix Table 7). The CP was 13.9% for the drylot diet.

Among pasture treatments, heifers supplemented with lasalocid (PL) showed the lowest PUN value (14.9) as compared to PA and PG heifers (16.4 mg urea-N/100ml; Table 19). Lasolacid might have changed protein metabolism in the rumen by shifting either the balance of microbial species or by shifting the balance of the digestive end-products or both.

Hematocrit count as a percent of packed cell volume (PCV) was reduced in blood samples after urea infusion (Table 19). The direct effect of infusing the urea dosing

Table 19. Least square means and standard errors for plasma urea nitrogen, change in plasma urea nitrogen, hematocrit, urea space and body components of Holstein heifers fed a total mixed ration in drylot or grazing a grass-legume mixture alone or supplemented with lasalocid or a 19% CP grain mixture in 1989.

	Treatments				
Item	Drylot	Alone	+Lasolacid	+Grain	SE
BW, kg	272.2	250.5	256.9	260.4	9.90
PUN, mg urea-N/dl	11.5[c]	16.4[a]	14.9[b]	16.3[a]	1.35
CHPUN,mg urea-N/dl	11.1	10.5	11.0	11.5	.37
HMTB, %PCV	31.2	33.4	31.7	32.9	1.05
HMTA, %PCV	30.9	32.8	31.2	32.8	1.07
US, %BWT	51.7	54.4	53.1	50.0	1.60
EBWATER, %	66.7	66.8	66.8	67.2	.40
EBFAT, %	9.3	9.1	9.2	8.9	.40
EBPRO, %	17.5	17.3	17.4	17.4	.05
EBASH, %	6.5	6.8	6.8	6.5	
EBFAT:EBPRO	.53	.52	.53	.51	

[a,b,c]Least square means in the same row bearing different superscripts differ by $P<.05$.
Least square means without superscripts do not differ ($P>.05$).

EBASH: by difference

HMTA - hematocrit after, 12 min, after urea infusion.

HMTB - hematocrit before, 0 min, before urea infusion.

solution (.65 ml/kg BW) could explain the slight reduction in PCV at the second sampling. Another factor which might have reduced hematocrit is hemolysis. Hemolysis consistently occurred with the second sample, contrasted with zero time samples. Bartle et al. (21), reported hemolysis in sheep when a 22% or higher urea solution was injected. In our research, hemolysis did not seem to change either PUN or cause a change in PUN after infusion, because the small differences in blood NH3 in samples (0 and 12 min). However, several papers reviewed on urea space do not report whether hemolysis occurred.

Using treatment means, empty body components (EB) calculated by the formula EBW= (BW - 15.3)/1.09 according to estimations of gut contents of grazing cattle (1) are shown in Table 20. Among pasture treatments of heifers, the EBW were similar, however, pasture supplementation had a tendency to increase empty body weight, EBFAT, and EBPRO compared to pasture alone.

Table 20. Effect of drylot, pasture alone, pasture plus lasalocid (PL) and pasture plus 19% CP (PG) on empty body composition of Holstein heifers on a mass basis (kg). LS means.

	Treatments			
Components	Drylot	Alone	+Lasolacid	+Grain
BW[1]	272.2	250.5	256.9	260.4
EEBW	235.7	215.8	221.6	224.9
EBWATER	157.2	144.1	148.0	151.1
EBFAT	21.9	19.6	20.4	20.0
EBPRO	41.2	37.3	38.5	39.1
EBASH	15.3	14.9	14.6	14.6
EBFAT:EBPRO	.53	.52	.53	.51
Deposition, g/kg:				
WATER	661	667	665	667
FAT	93	91	92	89
PROTEIN	175	173	174	174
ASH	65	69	66	65
Gross energy, Mcal/kg	1.83	1.80	1.82	1.80
Total gross energy,Mcal	432.5	373.6	387.7	387.3
Total gross energy as FAT, Mcal	205.9	176.7	184.2	180.5
Total gross energy as PROTEIN	226.6	196.1	203.5	206.8

Least square means were not significant at P>.05.

[1]Abbreviations Key in Appendix Table 3

The EBFAT:EBPRO ratio were similar for all heifers on four treatments (Table 20). The narrow ratio of fat to protein deposition suggests that the nutritional status was similar for DL and pasture treatments for Holstein heifers of this age and BW. The gross energy of gain was also similar for all treatments (1.81 Mcal/kg). The values as determined by urea dilution were near values obtained by Hammond et al. (105) with Holstein steers, and slightly different from results for beef cattle obtained by Hammond et al. (102), Bartles et al. (18), Preston and Koch (225), Koch and Preston (145), and Meissner et al. (177). However, the values obtained for US in this study were higher than those found by Jones et al. (132).

The sequential or longitudinal changes in body composition of heifers were measured four times during the experimental period (155 d) by urea dilution. The results in Table 21 show changes in BW, estimated empty body weight (EEBW) and percent of EBWATER, EBFAT and EBPRO; on a mass basis (Table 22); and as the energy content of gained weight in Table 23.

On a percent basis (Table 21), from beginning to end of the experiment, EBWATER for treatments decreased while EBFAT increased. Protein accretion also increased similarly among treatments. Body ash (Table 22) calculated by difference, decreased as protein increased. These trends support the

Table 21. Sequential changes in body composition of Holstein heifers fed either a TMR in drylot (DL), pasture alone (PA), pasture plus lasalocid (PL) or pasture plus a grain mixture, 19.0 % CP (PG).

Item		DATE May 5	June 21	August 16	October 10	Diff
BW[1] kg:	DL	195.0	233.6	292.7	339.5	144.0
	PA	195.0	217.0	267.4	311.3	116.3
	PL	195.1	220.9	275.4	323.5	128.4
	PG	195.0	223.4	279.4	329.4	134.4
EEBW, kg:	DL	174.9	210.3	264.5	307.5	132.6
	PA	164.9	185.0	231.3	271.5	106.6
	PL	165.0	188.6	238.6	282.7	117.7
	PG	164.9	190.9	242.3	288.2	123.3
EBWATER, %	DL	68.9	66.7	66.2	65.7	-3.2
	PA	69.1	67.7	65.7	64.8	-4.3
	PL	68.8	68.2	66.4	65.4	-3.4
	PG	68.8	68.2	66.4	65.4	-3.4
EBFAT, %:	DL	7.5	9.1	9.4	11.4	3.9
	PA	7.2	9.3	9.8	10.3	3.1
	PL	7.1	8.4	10.2	11.1	4.0
	PG	7.4	7.9	9.6	10.6	3.2
EBPRO %:	DL	17.1	17.3	17.6	17.8	.7
	PA	17.1	17.1	17.4	17.7	.6
	PL	17.1	17.3	17.5	17.8	.7
	PG	17.1	17.3	17.5	17.8	.7

[1]Abbreviations Key in Appendix Table 3.

Table 22. Sequential changes in body composition (KG) of Holstein heifers fed either a TMR in drylot (DL), pasture alone (PA), pasture plus lasalocid (PL) or pasture plus a grain mixture, 19.0 % CP (PG).

Item		May 5	June 21	DATE August 16	October 10	Diff
EBWATER[1]:	**DL**	120.0	140.0	176.4	198.0	78.0
	PA	113.6	123.4	157.9	185.7	72.1
	PL	114.0	127.7	156.8	183.2	69.2
	PG	113.4	130.2	160.9	188.5	75.1
EBFAT:	**DL**	13.1	19.1	24.9	35.0	21.9
	PA	11.9	17.2	22.7	28.0	16.1
	PL	11.7	15.8	24.3	31.4	19.7
	PG	12.2	15.1	23.4	30.5	18.3
EBPRO:	**DL**	29.9	36.4	46.5	54.7	24.8
	PA	28.2	31.6	40.2	48.0	19.8
	PL	28.2	32.6	41.7	50.3	22.1
	PG	28.2	33.0	42.4	51.3	23.1
EBASH:	**DL**	6.8	6.7	6.3	6.4	-.4
	PA	6.8	6.9	6.6	6.3	-.5
	PL	6.7	6.6	6.6	6.3	-.4
	PG	6.7	6.6	6.5	6.2	-.5

[1]Abbreviation Key in Appendix Table 3.

theory of constancy of body protein and fat (193,194, 232,303). Total energy gained in Mcal/kg of EEBW (Table 23) was highest for DL but not significantly different from animals in any pasture treatments.

Urea space and resulting body composition (water, fat, protein, ash and fat-to-protein ratios) are in the range of those reported in literature. Prior to grazing, values for US (Table 24) were 52.5% for 9.9 mo old heifers weighing 195.0 kg BW. Forty-two days later, US increased slightly to 54.7%. This change seems to be correlated with dietary changes and gastrointestinal tract fill, because slight changes in body components were detected. With all heifers, EBWATER and EBASH decreased while EBFAT and EBPRO increased. This trend was related to heifers growing towards mature body size. Although heifers grazed forage of excellent quality and abundance, the intake and gut fill varied due to selective grazing. Heifers on DL treatment were thought to have little variation in gut fill because of a constant supply of feed and ad libitum feeding. At the end of the experiment, the average values of all heifers were: BW 325.9 kg, US 49.8%, 65.1 EBWATER, 10.9 EBFAT, 17.8 EBPRO and 6.2% EBASH, respectively.

Table 23. Sequential changes in the energy contents of gain in Holstein heifers fed either a TMR in drylot (DL), pasture alone (PA), pasture plus lasalocid (PL) or pasture plus a grain mixture 19% CP (PG).

		Total Gain	Total Energy Gained	Total Energy Per kg	Fat & Protein Gained	Fat & Protein Gained
Item		kg	Mcal	Mcal	g/kg	g/d
EEBW:	DL	132.6	342.3[1]	2.58[1]	352[1]	301[1]
	PA	106.6	260.2	2.44	337	232
	PL	117.7	306.7	2.60	355	269
	PG	123.3	299.0	2.43	335	267
EBFAT:	DL	21.9	205.9	1.55	165	141
	PA	16.1	151.3	1.42	151	104
	PL	19.7	185.2	1.57	167	127
	PG	18.3	172.0	1.40	148	118
EBPRO:	DL	24.8	136.4	1.03	187	160
	PA	19.8	108.9	1.02	186	128
	PL	22.1	121.5	1.03	188	142
	PG	23.1	127.0	1.03	187	149

EBWATER and EBASH are not considered in the energy contents of the gain.

[1]EEBW energy or tissue gain = EBFAT + EBPRO energy or tissue gain.

Table 24. Changes in blood measurements, urea space, and body composition of Holstein heifers fed a TMR in confinement or pasture supplemented with lasalocid or a 19% CP.

Item	May 5	June 21	DATE August 16	October 10	SE	Diff
No. animals	28	31	31	27	na	na
Age, mo	9.9	11.3	13.2	15.0	na	5.6
BW, kg	195.0	229.8	278.9	325.9	na	130.9
PUN, mg urea N/dl	11.6	12.5	16.5	18.6	.93	na
CHPUN, mg urea N/dl	11.0	10.6	10.9	11.5	.62	na
HMTB, % PCV	--	30.1	33.0	33.8	4.53	na
HMTA, % PCV	--	30.0	32.4	33.4	4.46	na
US, %	52.5	54.7	52.2	49.8	2.11	-2.7
Body composition:						
EBWATER, %	68.8	67.4	66.2	65.1	.44	-3.7
EBFAT, %	7.3	8.7	9.7	10.9	.39	3.6
EBPRO, %	17.1	17.3	17.5	17.8	.7	.7
EBASH, % (by diff.)	6.8	6.7	6.6	6.2	na	- .6
EBFAT:EBPRO	.43	.50	.55	.61	na	.18

Least square means do not differ (P>.05).

na - not applicable.

The EBFAT to EBPRO ratio increased from .43 to .61 (Table 24). This represents a 33% increase in fat or 7.3 vs 10.9 as compared to a 3.9% increase in protein deposition (17.1 vs 17.8) during the experiment. These changes influenced by age are illustrated on a mass basis (Table 25). At the younger ages (9.9 mo), the heifers contained 267.9 Mcal based on EEBW; 112.8 Mcal were attributed to fat and 155.1 Mcal to protein accumulation. By the end of the 155 d period, heifers deposited 19.0 kg and 22.5 kg protein; rates were 122.6 and 145.2 g/d for fat and protein.

On a mass basis for all heifers, initial energy content was 267.9 Mcal as previously stated. At the end of the experiment energy content was 570.2 Mcal of which 291.4 Mcal was fat, and 278.8 Mcal was protein. At that date, the heifers were 13.0 mo old, when energy deposition as fat becomes higher than protein. The ARC (2), predicts protein concentration in empty body of 181 g/kg at 50 kg EBW to 140 g/kg at 500 Kg EBW for medium size steers growing at about 600 g/d. For bulls this factor is increased by 10% and for heifers it is decreased by 10%. The genetic potential, frame size and rates of gains of our heifers may explain the highest daily rate of protein accretion.

The estimated gross energy for heifers on the four treatments were (Mcal/kg; DL 1.83, PA 1.80, PL 1.82 and PG

Table 25. Sequential changes in body composition (KG) of Holstein heifers fed either a TMR in drylot (DL), pasture along (PA), pasture plus lasalocid (PL) or pasture plus a grain mixture, 19.0 % CP (PG).

Item	May 5	June 21	DATE August 16	October 10	Diff
No. heifers	28	31	31	27	--
Age, mo	9.9	11.3	13.2	15.0	5.1
BW	195.0	229.8	278.9	325.9	130.9
EEBW	164.9	196.8	241.8	285.9	120.0
EBWATER	113.4	132.6	160.1	185.5	72.1
EBFAT	12.0	17.1	23.4	31.0	19.0
EBPRO	28.2	33.8	42.3	50.7	22.5
EBASH	11.2	13.2	15.9	17.7	6.5
Gross energy stored: Mcal					
Total, Mcal	267.9	346.6	452.6	570.2	302.3
Per kg, Mcal/kg	1.62	1.76	1.87	2.0	.38
Energy as FAT	112.8	160.7	220.0	291.4	178.6
Energy as PRO	155.1	185.9	232.6	278.8	163.7
Daily deposition, g:					
FAT	115.9	112.5	138.2	122.6	
PRO	127.3	152.0	152.7	145.2	

1.80, Table 20). This energy deposition by heifers during this experimental period was similar to energy gained by heifers on the experiment of Waldo and associates (296), but was lower than 2.23 and 2.0 Mcal/kg of empty body estimated by (NRC) and from Hammond's steers (Table 6). During 155 d the high heifers on DL had 808.7 g/d EBW gain and 934 g/d of BW. The energy deposit of 1.83 Mcal/kg was 47.6% as fat and 52.3% as protein. Heifers on pasture alone had the lowest rate of gain , 650 g/d for EBW and 755 g/d for BW. The PA heifers deposited 1.80 Mcal/kg of which 47.4 % was fat and 52.6% protein.

These results suggest that supplementation to pasture heifers increase ADG and alters composition of these gains. Results also suggest that MEm requirements of grazing animals are likely to be higher than those of housed animals. DL heifers were 26.2 and 20.0% higher in fat and protein deposition than heifers fed pasture alone. These values indicated ME requirements for maintenance of grazing animals are in the range of 20 to 30 higher as compared to confined animals (115,116).

Chapter 4.

Intake of Grazing Holstein Heifers in Response to Lasalocid and Supplemental Protein-Energy as Compared to a Drylot Diet.

Abstract

Intra-ruminal release of Cr_2O_3 was used to estimate herbage intake by heifers (263 kg BW) grazing a grass-legume mixture with or without supplementation. Treatments were pasture alone (PA), pasture supplemented with either lasalocid (PL) or 2 kg 19% CP concentrate (PG). Fecal index was used to estimate fecal output. Dry matter intake was estimated from % N in feces according to Lancaster and by the coefficient of digestibility. No significant differences due to diet were found. Recoveries of Cr_2O_3, ug/g of feces DM, were 476 (PA), 506 (PL), and 498 (PG) with a 10% CV. Fecal output and herbage coefficient of digestibility were respectively, 3.0, 2.9, and 3.0 kg DM/d; and 67.0, 65.0, and 65.4%; for PA, PL, and PG. Intakes based on % N in feces were 10.8, 9.4 and 10.9 kg DM/d and digestibility determined by Cr_2O_3 ignoring fecal N caused lower estimated herbage DM consumption. Comparative daily intake for heifers in drylot was 7.5 kg of DM.

INTRODUCTION

Experimentally, the most precise estimation of voluntary feed intake by domestic animals is attained by measuring individual intakes with confined animals. The voluntary feed intake of grazing ruminants is difficult to estimate accurately because of yield, even with precautions. However, Arnold (11) assumed that principles derived from confined feeding apply to grazing animals. Direct and indirect methods are used to measure intake of grazing animals. Advantages, disadvantages, reliability and techniques for estimating intake have been extensively reviewed (176). For this research, the fecal index technique was chosen.

This technique predicts the apparent digestibility (D) from the composition of feces. The organic matter (OM) or dry matter (DM) in feces for a given period is estimated and then the OM or DM of the herbage ingested is estimated. By dividing the fecal production by the indigestibility (1-D) the intake is estimated (56). Indoor experiments have determined individual intakes like the heifers we used in Chapter 3 (287).

Because there is little information on forage intake of growing Holstein heifers in grazing conditions, this study was undertaken. The objective of this experiment was to compare rates of growth and group intake of grazing Holstein heifers on pasture alone (PA) with two supplements, protein-energy (PG) and lasalocid (PL) as compared to a drylot diet (DL) as described in Chapter 3.

MATERIALS AND METHODS

Dry matter intake

Dry matter intake (DMI) was measured for the four treatments as described in Chapter 3. For the TMR ration DMI was recorded for the group of eight heifers. Herbage intake of heifers on pasture was estimated by the fecal index technique. Measurements of herbage intake for the three grazing treatments were made from July 4 to September 26. To avoid differences in size (BW) two heifers of similar weight were selected from each of the 3 pasture treatments (groups). Thus there were 4 measurement periods to obtain data on all heifers. The measurements began with the largest heifers and ended with the smallest ones. Therefore, 6 heifers were dosed with chromic oxide $Cr_2 0_3$ during each period.

Chromium oxide was administered in an intra-ruminal controlled release device (CRD Captic Chrome, CSIRO, Australia, marketed by Quad-Five, Ryegate, MT). Manufacturers recommendations were followed for using CRDs.

Heifers were dosed at 0800 h, and one fecal grab sample was obtained from rectal stimulation on d 6, 13 and 20 after dosing. Batch quality control for the CRDs used had an expected Cr_2O_3 releasing rate of 1440 mg/d between 2 and 25 d dosing.

Forage intake was estimated by two methods. The Lancaster's formula uses fecal N concentration as an indicator. The formula was developed for sheep; however Soni et al., (269) using sheep and cattle, found no diurnal variation in estimates of digestibility. Hence, %N in feces is used to estimate the Y factor in the formula: Y=.97*%N in feces + 1.02 and the OM intake is estimated by the formula: DMI=fecal output (FO)*Y factor.

The second method used, recommended by Langlands (150,151) and Corbett (56), utilizes the digestibility coefficient of the diet. It is based on the estimation of FO and digestibility coefficient of diet (D). The formulas are: intake (I)=FO/(1-D) and digestible nutrient intake (DNI)=(FO*D/1-D). When FO and DNI are expressed on a DM basis, the I is DMI and DNI is the intake of digestible dry matter (DDM).

Fecal output and the digestibility coefficient were determined from CR_2O_3 concentration in a sample of feces. The formulas used were: FO=1000*CR_2O_3 dosed/CR_2O_3 in feces; and D=[(CR_2O_3 dosed - CR_2O_3 in feces)/CR_2O_3 dosed)]*1000. Hence the estimated intake by digestibility coefficient is calculated by: intake digestibility INTDIG=[100/(100-D)*FO].

Feces collection and analysis

Feces obtained by rectal stimulation were placed in Ziploc sealed plastic bags and kept for d 6, 13, and 20 after dosing. Bags containing fresh feces were stored after frozen at -20 C for later Cr determinations.

Feces DM was determined by freeze-drying to a constant weight. Dried samples were ground through a 1 mm mesh screen prior to analyses. All analyses were run in duplicate. Nitrogen was determined using the Kjeldahl procedure (13). Chromium was extracted from feces by wet washing, and Cr determinations made by atomic absorption spectrophotometer.

Approximately 500 $\pm$ 5 mg of dried feces were placed in 100 ml digestion tubes and 4 ml concentrated nitric acid was added to react overnight. The next morning, before digestion by heating, 3 ml 70% (v/v) perchloric acid and 3 drops of 20% hydrogen peroxide were added to each tube.

The digestion tubes were placed on a heating block with the temperature adjusted to 180 C for 3 h of digestion. Next the tubes were slowly heated to 300 C until complete digestion of samples. Digested samples were allowed to cool, then diluted to 50 ml with distilled deionized water and filtered through a Whatman #1 filter paper into acid washed plastic test tubes and stored at 4 C for elemental chromium (Cr) analyses. Five standard solutions, 1, 2,3, 4, and 5 ppm Cr, were prepared, digested and analyzed in the same manner as feces samples. These standards determined Cr in feces. The Cr contents in feces were used to calculate fecal output and DM digestibility coefficients, which were subsequently used to estimate DMI of pasture herbage.

Statistical analysis

Data were submitted to analysis of variance, using the General Linear Model procedures of SAS (244). A split-plot design (heifers as whole plots) was used to analyze DM intake responses by heifers due to treatments. Tests for differences among treatments were determined by the following model:

$$Y_{ijkl} = u + P_i + T_j + (PT)_{ij} + H(ij)_k + D_l + (PD)_{il} + (TD)_{jl} + (PTD)_{ijl} + E_{ijkl},$$ where,

Y_{ijkl} = dependent variable response.

u = overall population mean.

P_i = fixed effect of period i, i=1,..4.

T_j = fixed effect of treatment j, j=1,2,3.

$(PT)_{ij}$ = fixed effect of interaction between period i and treatment j.

$H(ij)_k$ = random effect of heifer k in treatment j and period i.

D_l = fixed effect of day l, l=1,2,3.

$(PD)_{il}$ = fixed effect of interaction between period i and day l.

$(TD)_{jl}$ = fixed effect of interaction between treatment j and day l.

$(PTD)_{ijl}$ = fixed effect of interaction among period i, treatment j and day l.

E_{ijkl} = random residual.

Differences among period, treatments and interactions were tested with $H(ij)_k$ as the error term.

RESULTS AND DISCUSSION

The Cr excreted in feces was not significantly different among heifers on the three pasture treatments ($P>.05$), however, interactions between period* treatment ($P<.05$) and period*day (P>.01) differed significantly. The ANOVA mean squares appear in Appendix Table 8 and the results are shown in Table 26. The average of Cr (ug/g) excretion in feces of all heifers was 493, with a 9.6% coefficient of variation, somewhat higher than the 8% suggested by the manufacturer but less than that reported by Brisson (29). The expected daily Cr2O3 released from the batch of CRD's used was 1440 mg/day. The amount of chromium recovered in feces represents a relative recovery of 1462 mg/day from 2.97 kg DM/heifer/d of fecal output (mean across treatments). This was a daily excretion of Cr_2O_3 averaging 101.5% of the daily dose. This indicates a different excretion pattern among individual heifers. Diurnal variations have been reported by several authors (29,56,57, 61,150,151,246,247).

Fecal output kg/dm of the grazing heifers was ~ 3 kg for the 3 treatments (Table 26) with a 10% CV. This is greater than the 5% suggested by Corbett (56). However, differences among the heifer treatments were small, 3.3%. Herbage digestibility was estimated as 67.0, 65.0, and 65.4% for PA, PL and PG, respectively. By Corbett's equation (61) which was derived for second growth of herbage, the values were 68.3, 66.6 and 70.9% for PA, PL, and PG, respectively. The equation by Holmes (116) for fecal index, gives similar results for estimated organic matter digestibility.

Table 26. Chromium recovery, fecal output, herbage digestibility, fecal N and intake of Holstein heifers grazing a grass-legume mixture with or without supplementation (lasalocid or a 19% CP grain mix).

	Alone PA	+Lasalocid PL	+Grain PG	SE of LSM	CV
Cr ug/g feces, DM	475.8	505.6	497.6	14.0	9.6
Fecal output, kg/DM	3.0	2.9	3.0	.08	10.0
Herbage digestibility,%	67.0	65.0	65.4	1.0	4.9
Fecal N, % N	2.6[ab]	2.4[a]	2.9[b]	.06	9.6
Intake-Lancaster,kg/DM	10.8[a]	9.4[b]	10.9[a]	.04	6.5
Intake-digest., kg/DM	9.5[c]	8.0[e]	8.8[bd]	.4	20.6

[a,b]Means in the same row bearing different superscripts differ by P<.01.

[c,d,e]Means in the same row bearing different superscripts differ by P<.05.

Fecal N (FN) for PG grazing heifers supplemented with the 19% CP concentrate was higher than for PA and PL heifers (Table 26). Interaction of protein and energy with digestion in the rumen is well documented (134,280) and a balance is required to support maximum feed intake and digestibility in the rumen (198). This may explain a possible enhancement of the excretion of metabolic FN for PG heifers, even though not significant (P>.05). Values for FN excretion of PG heifers were 17.2% and 10.3% higher than PL and PA, respectively, with a 9.6% CV. In several rectal grab samples taken at a specified time for grazing cows the CV for FN was 7.5% (29). Metabolic FN in ruminants averages about 0.5 to 0.6 g/100 g of DM when DM consumed is low in digestibility. Estimated FN for this study ranged from .25 to .30 g/100 g of DM consumed, which indicates the high digestibilityof pasture diets. Holmes (116), reports CV for a single estimation to be usually between 10 and 20%.

Herbage intake determined by the Lancaster (148) formula (INTLAN) was 10.8, 9.4 and 10.9 kg of DM for PA, PL and PG heifers, respectively (Table 26). Coefficient of variation for this determination was 6.5%. Estimated intakes by the coefficients of digestibility were lower with a CV of 20.6%. Both methods of estimating intake, although different in amount, resulted in lower intakes by PL. Similar values for PA and PG as evaluated by INTLAN method are due to higher values of FN for PG, which yielded a higher y factor. The coefficients of digestibility for these treatments had a pattern similar to % N excreted in feces.

Dry matter intake (DMI) per heifer and percent of BW, age and animal weights are in Table 27. The data are average values for the 8 heifers on the DL treatment since they were fed as a group. Data for the grazing heifers at each date are averages for two heifers. Appendix Table 9 shows age, BW gains, DMI by 14 d period for drylot group fed heifers during the whole experimental period.

Heifers on pasture treatments, had higher intake as compared to heifers in DL. Differences in diet densities can explain these results. Overall intake average for all heifers per treatment for the four-time intervals as percent of BW were also highest for heifers on pasture being 4.1%, 3.1% and 3.9% for PA, PL, and PG, respectively, as compared to 2.6 for DL heifers. The highest intakes for PA and PG appears to be associated with high digestibility of the herbage consumed, which may be caused by the lower retention time and increased ruminal turnover when compared to PL. Using Conrad's (48) formula, NRC (198) predicted DMI at varying digestibility, ranging from 2.25% of liveweight at 52% digestibility to 4.32% of live weight at 75% digestibility. In our study, intake of PA heifers was 4.1% BW at a digestibility coefficient of 66%. Gain was 755 g/d for PA and 871 g/d for PG heifers, (Table 18) support the

Table 27. Dry matter intake, body weight, and average daily gain of grazing drylot fed Holstein heifers.

Date	TRMT	Age days	BWT Initial[1]	BWT Final[1]	BWT X	DMI Estimated Total	DMI % BWT	ADG kg/d
			----------kg----------			------kg------		
7/5-7/18	DL	289	256.8	265.8	261.3[1]	6.9[1]	2.6	.640
	PA		231.3	243.5	271.3[2]	10.2[2]	3.7	.868
	PL		238.9	250.3	275.8[2]	6.7[2]	2.4	.811
	PG		240.6	252.8	263.3[2]	9.3[2]	3.5	.872
7/19-8/1	DL	303	265.8	282.0	273.9	7.4	2.7	1.160
	PA		243.5	254.2	248.6	10.3	4.1	.770
	PL		250.3	261.3	255.4	9.0	3.5	.789
	PG		252.8	263.0	266.7	10.0	3.7	.730
8/16-8/29	DL	331	293.4	302.8	298.1	7.5	2.5	.670
	PA		277.0	280.9	264.4	10.9	4.1	.278
	PL		276.1	288.9	265.6	8.2	3.1	.913
	PG		279.2	295.9	269.0	12.1	4.5	1.191
9/13-9/26	DL	359	319.4	333.4	326.4	8.2	2.5	1.000
	PA		284.9	301.6	246.3	11.1	4.5	1.197
	PL		294.5	312.7	263.3	8.9	3.4	1.297
	PG		304.7	313.3	264.5	10.6	4.0	.608

[1]Average BW for 8 heifers

[2]Average BW and DMI for the heaviest two heifers in each group

relatively higher herbage intake by these two groups as compared with DL heifers, which gained 934 g/d with an average DMI of 7.5 kg/d. Pasture supplemented with lasalocid (PL) gave an intake of 3.1% of BW and heifers gained 875 g/d. Feed efficiencies (kg feed/kg gain) were respectively, 8.0, 13.4, 10.4 and 11.0 for DL, PA, PL and PG treatments (Table 28).

The highest coefficient of digestibility for PA may have contributed to the enhancement of metabolic nitrogen in feces of the PG group. When intake was averaged for PA (10.2) and PG (9.8), a 3.9% substitution effect was found. This was an additional effect since ADG (755 vs 871 kg/d) and BW (250.5 vs 260.4 kg) were increased when heifers were grain supplemented on pasture.

Although not significant (P>.05), lasalocid supplementation reduced feed intake when compared with pasture alone with an increase of 9.6% in ADG, (835 versus 755 g/d). Pasture plus lasalocid had the most relative recovery in feces (505.6 vs 475.8 and 497.6 mg/g of DM, Table 26) FO, herbage digestion coefficient and FN. Feeding lasalocid to grazing heifers in this trial improved ADG, but not consistently, and reduced feed per gain over heifers fed pasture alone.

Table 28. Annual cost per treatment and drylot pasture systems combinations, pasture (160 d) and drylot (205 d) period.

Item	Drylot	Pasture Alone	Pasture + Lasalocid	Pasture Grain
Land & Facilities		.34	.34	.34
Pasture investment		.03	.03	.03
Pasture maintenance		.17	.17	.17
Truck and labor		.17	.17	.17
Supplement		.07	.10	.39
TOTAL COST/PASTURE TRMT		.78	.81	1.11
Housing pen	.17			
Diet: corn silage	.33			
orchardgrass hay	.22			
alfalfa haylage	.21			
2:1 mineral salt	.08			
Labor:mix & deliver feed	.23			
TOTAL COST/DRYLOT	1.25			
AVERAGE DAILY GAIN,kg/d	.93			
COST per kg of GAIN	1.35			
ANNUAL COST	457.53[1]	382.41[2]	387.13[2]	436.06[2]
HAY SALES		33.35[3]	33.35[3]	33.35[3]
NET ANNUAL	457.53	349.06	353.77	400.70
Intake, kg/d:				
per treatment	7.5	10.1	8.7	9.6
per system	8.0	8.8	8.1	8.5
Feed efficiency, feed/gain:				
per treatment	8.0	13.4	10.4	11.0
per system	8.0	10.4	9.1	9.5
ADG, g/d	934	884	810	850

[1]Cost accounts for 365 d in drylot.

[2]Cost accounts for 160 d on pasture and 205 d in drylot.

[3]Value of hay sale.

Period and day had slight but not significant differences in fecal Cr, FO, coefficient of digestibility, FN, INTAKE-LANCASTER and INTAKE-DIGESTIBILITY (Table 29). There were significant interactions between period by treatment for Cr, fecal output, digestibility and fecal N; and also between day by treatment for INTLANC (Appendix Table 8). Two heifers per treatment were dosed on a given day with Cr_2O_3 when they had reached desired BW (530 to 620 kg) for dosing. The heifers were dosed during various dates, beginning in mid season. The amount of available forage coupled with selective grazing varied because the decision was based on available forage rather than a set date. Therefore, the adopted pasture management contributed to the occurrence of those interactions.

Joyce et al. (135), using experimental data in New Zealand compared feeding requirements of growing animals and fattening beef cattle to NRC and ARC. They reported that stall fed animals had lower maintenance requirements compared to grazing animals (.127 vs .141 Mcal ME/kg BW 3/4). Also they report estimated values of 2.70, 2.47, and 1.99 Mcal ME/kg DM for spring pasture (75% DM digestibility), pasture other than spring (68% DM digestibility) and hay, respectively. The estimated coefficient of digestibility in our study was 67.0% for PA (Table 26). The heifers had an average intake of 10.2 kg DM and an ADG of 755 g/d averaging 250 kg of BW.

Table 29. Least square means by period and d for Cr, fecal output, digestibility coefficient, fecal nitrogen and intake for Holstein heifers grazing a grass-legume mixture with or without supplementation in 1989.

	Period					
Item	1	2	3	4	SE	P-value
Cr, ug/g feces DM	517.8	483.3	474.9	496.1	166	ns
Fecal output, kg	2.8	3.0	3.0	3.0	.09	ns
Digestibility, %	64.0	66.4	67.0	65.0	110	ns
Fecal nitrogen, %	2.7	2.7	2.6	2.6	.06	ns
Intake-Lancaster, kg DM	9.9	10.4	10.9	10.2	.44	ns
Intake Digestibility kg DM	7.9	8.6	9.5	8.4	.45	ns
	Day					
Item		6	13	20	SE	P-value
Cr, ug/g feces DM		496.8	477.4	487.9	14.0	ns
Fecal output, kg		2.9	3.0	3.0	.08	ns
Digestibility, %		65.5	66.8	66.2	.09	ns
Fecal nitrogen, %		2.6	2.7	2.6	.05	ns
Intake-Lancaster, kg DM		10.2	10.7	10.4	.61	ns
Intake Digestibility kg DM		8.5	9.1	8.8	41	ns

Requirements in NRC, (198) for a Holstein heifer of 250 kg BW gaining 800 g/d are: 6.0 kg DMI, 14.8 Mcal ME, and .857 kg CP per day. Assuming a ME of 2.23 Mcal/kg of pasture which is an average value for pasture other than spring pasture and hay, the total ME for pasture was 22.7 Mcal. This amount was enough to promote and support the growth achieved by heifers in this study. Heifers in drylot treatment received a diet containing 2.33 Mcal/kg of DM and have gained more BW (272.0 kg, Table 26) than did heifers in pasture alone. This difference in BW and ADG may be accounted for by higher maintenance requirements for heifers on pasture. Also, a lower energy density diet from pasture may explain the highest intake from heifers on PA, since animals are able to regulate feed consumption to maintain a relatively steady rate of gain, even under different environmental and feeding conditions (15). Fat animals also show a reduced intake as compared to leaner animals (116) and DL heifers had higher fat accretion than pastured heifers (Table 22).

Table 30 compares predicted (198) and estimated DM intake for heifers. Estimated DMI was higher than predicted. The differences between estimated and predicted values might suggest that DMI was overestimated by fecal index technique. However, there is evidence that heifers ad libitum fed in drylot consumed more DM and gained more BW than 800 g/d as predicted by (198). Fecal output of grazing

Table 30. Predicted (NRC, 1988) and estimated (fecal index) DM intake for heifers.

Treatment predicted: BW	$BW^{.75}$	Gain	DM intake			
----kg-----		g/d	kg	g/kg BW	g/$BW^{.75}$	
250	63	600	5.3	21.2	84.5	
		800	6.0	24.0	95.3	
300	72	600	6.3	20.9	86.8	
		800	7.1	23.5	97.9	
Estimated:						TMRT
267	66	934	7.5	28.1	114.0	DL
258	64	755	10.1	39.1	158.0	PA
265	66	835	8.7	32.8	136.0	PL
266	66	871	9.6	36.1	145.0	PG

heifers averaged 29.5 g/100 g DM which corresponds to an average DMI of 36 g/kg BW. On a metabolic weight basis DMI for pasture animals averaged 146.3 g/kg BW $^{.75}$ (Table 30). This output averaged 32% and 35% higher than the 20 g/kg BW and 110 g/kg BW .75 values reported by Weston and Poppi (307) for cattle.

The estimated intake data obtained through this experiment agree reasonably well with expectations based on the recommended allowances for growing heifers of large breeds like Holsteins.

ECONOMIC ANALYSIS

Introduction

The treatments imposed on heifers during this trial make it possible to assess costs and returns for heifers on pasture, with and without supplements as compared to drylot. In addition, data are available for economic evaluations of drylot with pasture systems for raising heifer replacements (Table 31).

Annual costs were determined for individual treatments and then added to drylot costs to project year around systems for comparative purposes. Costs for repairs, insurance, salvage value and property taxes were not considered. Investments, fixed and variable costs for each

Table 31. Cost-phase relationship of raising heifers to calve at 24 mo old under drylot and drylot-pasture combinations.

System	Cost phase relationship			Total cost per heifer	Cost per heifer per month
	Phase I Birth-4.5	Phase II 4.5-12	Phase III 12-24		
	$				
DL	148	286	457	891	37.10
DL + PA	148	218	349	715	29.80
DL + PL	148	221	354	723	30.10
DL + PG	148	250	401	799	33.30

system and combined systems are in Appendix Tables 10, 11 and 12.

Assumptions to estimate costs were as follows: Investments were pro-rated yearly at 6% interest. Established grass-legume stands will last a minimum of 5 y. Fences, corrals, chutes and head-lock mechanisms will have 7 y life, while the housing facility (barn) for total confinement has 20 y life. Annual cost of ownership was calculated by amortizing at 6% interest the purchase price over the years of life.

Commercial prices and market values for feeds are presented in Appendix Table 11. Labor expenditure for management of systems was not taken into account. Input feeds were purchased. Hay produced in the system was sold. Hay production yielded 5 metric tons per hectare and was round baled.

Budget prices for crop and livestock were adapted from West Central District Farm Management Agents 1989 (306) and estimates from records of costs at Virginia Tech Dairy Center (181). Ownership costs of machinery and equipment are included in budgets as fixed machine costs and the operating costs as part of the machinery equipment.

The annual cost per heifer per day in Table 28 assumes that heifers are on pasture for a 160 d grazing period and in drylot for 205 d in the combination treatment. Heifers are housed for 365 d in drylot for non-grazing management. Costs supporting growth until 4.5 mo of age are not considered.

Results and discussion

The current standards for raising dairy heifers are based on confinement programs. Therefore, the drylot treatment will be the control. Feed costs adopted from James (126), for early calfhood (birth to 4.5 mo Phase I) are $ 26 (23.6 kg of milk replacer), $47 (165.7 kg of calf starter), $59 (269.7 kg 18.1 CP concentrate) and $16 (165 kg of alfalfa hay), totaling $148 to 4.5 mo.

The diets consumed by heifers from 4.5 to 12 mo (Phase II) are based on total forage feeding, and are used for these comparisons. Diets produced satisfactory heifer growth.

Costs for phase I, II, III (12 to 24 mo), for raising heifer replacements with drylot and pasture systems are presented in Table 31. A Holstein heifer raised on standard drylot conditions calving at 24 mo of age costs $891.

Drylot-pasture systems will produce a replacement heifer at lower cost than the conventional DL system. As compared to drylot (DL) the calculated savings per heifer for pasture systems were respectively $176, $168 and $92 for PA, PL, and PG.

Miller and Amos (182), have determined a total cost of $700 for raising Holstein heifers from birth to 31 mo with heavy use of pasture systems in Georgia. Their conclusion was that slower rate of growth of heifers had no adverse effect on the animal. If raised to be sold, time value must be credited for an earlier sale. Consideration must be given to the expenses of raising and the value of money received when the heifer is sold. When the heifer is raised to be a herd replacement, milk production lost from 24 to 31 mo is nearly one complete lactation. This relationship of age at first calving and the overall profit on the farm has been studied. Reports by Gill and Allaire (92) showed the highest profit occurred when heifers calved at 25 mo of age and spent more time with the milking herd if calved between 22.5 and 23.5 mo of age. A six mo delay in age of first calving (26 vs 32 mo) will require approximately 15 mo of milking for a heifer to offset her rearing cost (81). Expense for delaying first calving ranges from $20 to $60/mo (125).

Calculated total costs in this study are in close agreement with those obtained by Toro (288), in a simulation study, when pasture was charged at $ .02/kg DM. His study evaluated three feed levels of pasture on the costs of heifer rearing. At calving, the estimated total feed costs per heifer were $441, $520 and $557 when 80%, 20% and zero% of required nutrients were supplied by pasture. Taking the estimates of James (126), the fixed costs in heifer rearing system range from $300 to $350 per heifer at 24 mo. Therefore costs estimated by the simulation study were $858 for no pasture (DL), $820 for 20% pasture and $741 when 80% of requirements were supplied by pasture.

In our study, daily cost per heifer on pasture (no supplement) was $ .35 and included land rental, investment for overseeding clover, herbicide to clean up fences and pasture maintenance. Intake was 10.1 kg DM/d, hence, pasture cost was $ .035/kg DM consumed. When total DM produced (16.2 kg DM/heifer + harvested hay) is considered in calculations, pasture cost is reduced to $ .022/kg DM produced, which is 9.1% higher than the cost charged in the simulation study (288).

Including facilities (corral, fences, etc.) and labor (mineral feeding, checking heat, etc.) the cost increases to $ .054/kg DM consumed and to $ .033/kg DM actually produced.

On a daily basis, pastured heifers had 37.6% lower cost than confinement feeding.

By comparing results of this and other studies one can conclude that pasture must be considered in any appropriate and economical heifer rearing program. Additional research is needed to improve utilization of pasture and pasture supplementation in drylot-pasture systems. Since most dairy and experimental farms have resources available, the price of ingredients will dictate the management of these supplemental ingredients to formulate cheap concentrate mixtures. (157).

Pasture supplementation improved daily gains and BW. However, daily cost/heifer was increased by 3.7% and 29%, respectively over pasture alone, when lasalocid or protein-energy was supplemented during 160 d. Drylot cost was the highest ($ 1.25) but only 12% above the cost of PG treatment. However, when pasture (160 d) and DL (205 d) were combined, any combination had reduced cost and increased feed efficiency. Thus, the use of protein-energy supplementation for pasture is price dependent and can affect the cost of both systems (pasture and drylot). Lewis et al. (157), Muirhead (192) and Larson (152) report similar results for beef steers.

Pasture supplementation, when properly used, may increase the carrying capacity and production per unit of land area. For instance, a lasalocid diet tended to decrease intake, but did not reduce animal growth or health. Another area needing research is extension of the grazing season. Wilson and Stringer (311), found averages of 221 d for West Virginia, Maryland and Pennsylvania and 160 days for some other states. They mention advantages of long grazing seasons including reduction in requirement for fuel and labor in forage harvesting and manure handling, but with improved conditions for maintenance of animal health.

Pasture in this experiment was managed in a way which could possibly extend the grazing season in Virginia. Flush growth early in spring in one half of the paddocks was harvested for hay, which in turn could be used to supplement pasture if needed during the summer months and/or mid and late fall. Tall fescue (Festuca arundinacia L.) yields a good quality forage in late summer and autumn (101). This forage can be stockpiled for use (25,316) in late fall or early winter. This practice has been successful for beef cattle. Extending the grazing season may also be a valid alternative to be tested within a dairy herd replacement program.

Chapter 5

Growth and body composition responses of Holstein heifers to varying rumen degradable protein sources fed in drylot.

ABSTRACT

Thirty-two Holstein heifers were divided into heavy and light groups and assigned to a forage diet with either fish meal or soybean meal (4 lots of 8 heifers) for 60 d. Heifers completing Experiment 3 (Chapter 3) were assigned to this experiment to determine the residual effects of the pretreatments, protein sources and heifer size. Data were obtained on daily gains, DM intake, wither heights, heart girth, backfat depth, ribeye area, body condition score and body composition. Feeding either fishmeal or soybean meal with a diet of corn silage-alfalfa silage and orchardgrass hay resulted in no significant differences in any measurements. The light heifers tended to gain more than the heavy heifers. The pretreatments influenced daily gains; heifers on previous grazing treatments gained more than heifers fed in drylot. DM intake was not influenced by pretreatments. Switching grazing heifers to drylot resulted in compensatory gains,

which were associated with fat deposition based on determination by urea space. Differences in backfat, ribeye area, and body condition score at the end of the 155 d pretreatment were maintained.

INTRODUCTION

Compensatory growth has been demonstrated in cattle (89,236,240). The pattern of growth can be altered without detrimental effect on growth or milk production (214). Lewis et al. (159) showed that steers that had gained above 280 g/d during the winter phase did not gain well while grazing in summer. They also point out that the finishing performance of steers was not influenced by compensatory gains on pasture after gains during the wintering phase. However, compensatory growth occurred during finishing when cattle went directly from restriction diets to finishing (82,217).

Protein requirements for calves and heifers has influenced rate of gain, body size, and body tissue accretion (193). A Michigan State University study reports that dietary protein levels can affect weight gain, efficiency of gain and rate of gain in Simmental crossbred bulls (193). Their data support the NRC's recommended levels for feeding protein to beef cattle. Bagg et al. (14) found that high BW and wither height (WH) were associated with a medium protein ration (100% of NRC) (197) for calves between 2 and 10 mo of age fed from 71 to 182 d. During 183 to 295 d the highest BW for calves occurred with the high protein level 120% of NRC (197), but WH did not differ among treatments. An increase in the digestibility of DM also was reported. More recently, reviews (1,2,83,197,198,298) on protein utilization by ruminants show that dietary protein quality (solubility and degradability) influence performance of dairy cattle and other ruminants. Average daily gains and feeding efficiency were improved when fish meal (FM) was substituted into rations for growing steers (293). Also, FM in the ration of male Holstein calves elevated rumen microbial protein synthesis and increased amino acids entering the duodenum (54). Recent work at Virginia Tech (286) evaluated diets that were formulated for 115% or 95% of NRC's recommendation for TDN in combination with 53% or undegradable intake protein (UIP) with dried brewers grains (DBG) as the source. The high energy protein combinations produced similar gains. However, at the lower TDN, rumen undegradable protein (RUP) was beneficial. Gains, structural scale, and feed efficiency were improved when dried brewers grains (DBG) was included. Intake with DBG was reduced, yet gains were higher and feed efficiency was improved. In trial 2, diets differed in percent RUP. Blood meal replaced soybean meal (SBM) to increase the UIP level in the orchardgrass hay-based diets. A linear response to increases in UIP resulted.

Since other sources of UIP were evaluated, the objective of this study was to compare FM vs SBM responses on growth and body composition of Holstein heifers fed in drylot after a 155 d grazing period.

MATERIAL AND METHODS

The thirty-two heifers used during 155 d in Experiment 3 (Chapter 3) were divided into two size groups, heavy (H) and light (L). In this trial, there were two treatments, fishmeal (FM) and soybean meal (SBM). Corn silage, chopped orchardgrass hay and alfalfa silage blended with the protein sources (Appendix Table 13 and 14) were fed ad libitum in confinement for 60 d with the Pinpointer 4000-B, which records intake.

The 32 heifers assigned to four treatments drylot (DL), pasture alone (PA), pasture + 19% CP concentrate (PG) and pasture + lasalocid (PL) were assigned to the trial reported here. The heifers in DL were divided into two groups of four light heifers (L) and four heavy heifers (H). Two L and two H heifers were randomized to the two protein treatments (FM and SBM). Similarly heifers in the other three treatments were assigned to the two protein treatments. Hence, there were four treatments of eight heifers each. All measurements were taken at the beginning of the trial and monthly thereafter except that heifers were weighed every 14 d as described in detail in Chapter 3. Body composition with urea space was obtained at the start and end of the trial.

Statistical Analysis

A split-plot design (heifers as whole plots) with repeated measurements was used to analyze this phase. Heifer response variables were obtained from ANOVA, and the model was:

$$Y_{ijklm} = u + C_i + S_j + (Cs)_{ij} + D_k + (CD)_{ik} + (SD)_{jk} + (CSD)_{ijk} + H(_{ijk})_l + T_m + (CT)_{im} + (ST)_{jm} + (DT)_{km} + (CST)_{ijm} + (CSDT)_{ijkm} + E_{ijklm},$$ where:

Y_{ijkl} = dependent variable of heifer i in diet k, for heifer size j and previous treatment i.

u = overall population mean.

C_i = fixed effect of previous treatment i, i=1...4.

S_j = fixed effect of heifer size j, j=1,2.

$(CS)_{ij}$ = fixed effect of interaction between previous treatment i and heifer size j.

D_k = fixed effect of diet k, k=1,2.

$(CD)_{ik}$ = fixed effect of interaction between previous treatments i and diet k.

$(SD)_{jk}$ = fixed effect of interaction between heifer size j and diet k.

$(CSD)_{ijk}$=fixed effect of interaction among previous treatments i, heifer size j and diet k.

$H_{(ijk)l}$= random effect of heifer l in previous treatment i, size j and diet k.

T_m2= fixed effect of date m.

$(CT)_{im}$ = fixed effect of interaction between date m and previous treatment i.

$(ST)_{jm}$ = fixed effect of interaction between date m and heifer size j.

$(DT)_{km}$ = fixed effect of interaction between date m and diet k.

$(CST)_{ijm}$=fixed effect of interaction among previous treatment i, size j and date m.

$(CSDT)_{ijkm}$=fixed effect of interaction among previous treatment i, heifer size j, diet k and date m.

E_{ijklm} = random residual.

Differences among previous treatment, between sizes, diets and among interactions of previous treatments, sizes and diets were tested using $H_{(ijk)l}$ as an error term.

RESULTS AND DISCUSSION

The data for heifer performance fed fishmeal (FM) or soybean meal (SBM) are combined in Table 32 to show the overall effects of previous treatments on responses of drylot feeding. The previous treatments did not alter BW, DMI, WH, backfat depth or body condition score (BCS) significantly. Heart girth, REA and average daily gain (ADG) measurements were significantly different. Heifers previously on Pasture + grain had the greatest HG. The highest ADG values occurred for PA and PG, the lowest ADG were for DL, the values for PL being intermediate.

It is difficult to account for the difference in ADG since intake values were similar. However, the ADG for heifers from the previous experiment were highest for pasture + grain and drylot, pasture alone was the lowest (Table 18). The 934 g/d previously gained in drylot for 155 d may account for the low 388 g/d during the 60 d period of this trial. Conversely the lowest gain (755 g/d) for pasture alone heifers may have caused compensatory gains of 756 g/d reported in the experiment. Also, after the previous treatments of 155 d the DL heifers were heavier,

Table 32. Effect of previous treatments (drylot, pasture alone, pasture + lasalocid and pasture + 19% CP concentrate) on BW, ADG, DMI, WH, HG, Backfat, REA and BCS of Holstein heifers (fed fish meal or soybean meal combined)[1].

	DL	PA	PL	PG	SE
BW, kg	363.8	373.2	379.6	375.6	7.00
ADG, kg/day	.388[c]	.756[a]	.650[b]	.736[a]	.18
DMI, kg/DM	7.6	7.8	7.8	7.3	.43
WH, cm	121.2	122.3	121.3	122.1	1.00
HG, cm	164.9[a]	165.0[a]	166.1[a]	161.5[b]	1.50
Backfat thickness, mm	3.6	3.4	3.3	3.2	.14
REA, cm^2	59.7[d]	51.8[f]	49.0[f]	55.1[e]	2.12
cm^2/100kg BWT	16.4	13.9	12.9	14.6	--
BCS	3.6	3.4	3.4	3.3	.05
WH/BW, cm/kg	.33	.33	.32	.32	
HG/BW, cm/kg	.45	.44	.44	.43	

[a,b,c]Means within a row bearing different superscripts are different (P<01).
[d,e,f]Means within a row bearing different superscripts are different (P<01).
[1]BW - body weight
ADG - average daily gain
DMI - dry matter intake
WH - wither height
HG - heart girth
REA - ribeye area
BCS - cody condition score
DL - drylot
PA - pasture alone
PL - pasture + lasalocid
PG - pasture + 18% CP concentrate

had more backfat, larger REA and lower WH to BW ratio as compared to PA heifers (Table 18). However, at the end of the 60 d trial reported here, backfat increased from 2 to 3.4 mm for PA heifers similar to DL heifers which had lost some backfat, meanwhile WH to BW ratio decreased from .45 to .33. Similarly, work by Ferris et al., (170) shows that steers making low pasture gains during summer made high ADG during finishing. Results from the previous treatments in Table 18, show that the height-to-weight (cm/kg) gain were 0.42 (DL), 0.45 (PA), 0.45 (PL) and 0.42 (PG). At the end of this 60 d feeding these values were lower (0.32 to 0.33, Table 32).

The influence of protein sources and BW on heifer performance appears in Table 33. When combining the data for L and H, the BW were similar for the two sources of protein (FM and SBM). However, HG was different (P<.01) but cannot be readily explained. When comparing heavy or light animal response, the values for BW, HG, backfat depth, BCS and REA differed significantly. The ADG were similar; 596 and 667 g, respectively, for H and L heifers. The intakes as percentage of BW were 2.03 and 2.14 for H and L heifers, respectively.

Table 33. Effect of body size and protein sources on performance of Holstein heifers in confinement.

	Body size		Protein source		
	Heavy	Light	Fish meal	Soybean meal	SE
BW, kg	400.0[a]	346.0[b]	375.3	370.9	4.9
ADG, kg/d	.596	.667	.658	.604	.06
WH, cm	122.6	120.9	122.1	121.3	.74
HG, cm	169.4[a]	158.5[b]	166.1[a]	161.8[b]	1.0
Backfat, mm	3.5[c]	3.2[d]	3.3	3.4	.10
BCS, unit	3.6[a]	3.3[b]	3.4	3.5	.04
REA, cm^2	59.0[a]	49.1[b]	54.5	53.6	15.0
REA, cm^2/100kg BW	14.7	14.2	14.5	14.4	-
BW/WH, cm/kg	.31	.35	.32	.33	-
BW/HG, cm/kg	.42	.46	.44	.45	-
Intake, kg DM	8.1	7.4	7.7	7.7	.31
Feed efficiency					
kg feed/kg gain	13.6	11.5	11.7	12.7	

[ab]Means within classifications bearing different superscripts are different (p<01).

[c]Means within classifications bearing different superscripts are different (p<05).

Compensatory growth was observed when cattle fed maintenance rations were switched to finishing rations (82,216). In this experiment, heifers that had been on pasture gained more BW than heifers on the previous DL treatment. An increased feed intake is commonly reported as the primary determinant of compensatory growth (234,312). Grazing heifers when brought into confinement reduced their feed intake by 22.7%, 10.3% and 23.9% for PA, PL and PG, respectively, (data in Table 26 vs Table 33) mainly due to increased diet concentration. Feed efficiency (kg feed/kg ADG) appeared higher for light heifers and heifers fed FM.

The tendency to improve growth and feed efficiency for heifers fed fishmeal agrees with the results of Hogue and Adam (117), when they added 3% fishmeal to the diets of growing lambs. Diets for this experiment had smaller amounts of fishmeal addition (2.2% and 2.6% as fed to L and H heifer respectively) to substitute for 4.3% SBM in both heavy and light heifer diets. Although heifers fed FM had gained more weight (Table 33), this difference was not significant.

Others (33,98,292,293) reported that FM fed to beef cattle may give the greatest benefits when (1) the animal is young and during the first 2 to 3 mo on feed, and (2) when FM is supplementing alfalfa, alfalfa silage or grass silage but not corn silage. These authors reported lowest responses with heifers which have the greatest potential for laying down fat tissue. In our trial the heifers were 13.6 mo old and alfalfa silage was a small (13.4%) part of the forage component in the diet and therefore, may have contributed to this low response to FM.

Quality forage usually provides nutrition for acceptable standards of heifer growth. In situations where poorly managed pastures or climate deter quality or quantity of pasture forage causing inadequate heifer growth; subsequent confinement diets provide an opportunity for heifers to make compensatory adjustments in growth. Thus, because of compensatory gains and lower costs for grazing than drylot feeding, combined pasture-drylot systems will reduce cost of raising replacements.

Plasma urea nitrogen ranged from 15.7 to 17.1 mg urea N/dl reflecting an adequate supply of protein from the diets (Table 34). Change in PUN (CHPUN) from across previous treatments differed moderately. Since calculation of US is dependent upon CHPUN before and after urea infusion, the

Table 34. Effect of previous treatments on blood measurements, urea space and body composition of Holstein heifers. (The data for FM and SBM protein are combined.)

	Treatments				
	Drylot	Pasture Alone	Pasture + Lasolacid	Pasture+19% CP concen.	SE
Age, mo	13.6	13.6	13.4	13.5	
BW, kg	363.8	373.2	379.6	375.6	
EEBW, kg[1]	319.7	328.3	334.2	330.0	
PUN, mg/dl	16.3	15.9	17.1	15.7	.75
CHPUN, mg/dl	12.5	11.8	11.3	11.2	.66
HMTB, %PCV	33.5	34.9	35.0	34.2	.84
HMTA, %PCV	32.6	34.0	33.8	33.5	.55
US, %BW	46.5	48.5	52.2	52.6	3.20
EBWATER, %	64.7	64.4	63.6	63.7	.50
EBFAT, %	11.2	11.5	12.2	12.1	.86
EBPRO, %	17.9	17.9	17.9	17.9	.04
EBFAT:EBPRO	.63	.64	.68	.68	
Mass basis, g/kg:					
WATER	647	644	636	637	
FAT	112	115	122	121	
PRO	179	179	179	179	
ASH	62	62	63	63	
Gross energy:					
Mcal/kg EEBW	2.0	2.1	2.1	2.1	

Least square means do not differ (P>.05)

[1]Abbreviations are in Appendix Table 3, abbreviation key

difference between PG and DL in CHPUN contributed to a difference in US values between the highest PUN change DL (46.5%) the lowest value PG (52.6%). Consequently, direct effects on EBWATER and EBFAT were in the range of 1.7% and 8.2%, respectively.

The data for heifers on body composition were combined for the pretreatments to show the influence of L and H heifers and protein sources (Table 35). Size of heifers influenced EBWATER, EBFAT and EBPRO (P<.01) as would be expected. Heavy heifers were closer to physiological maturity than light heifers. Significant (P< .02 and P<.05) differences (Appendix Table 15) were present for PUN and EBPRO, and CHPUN, EBWATER and EBFAT respectively, at beginning and end of the 60 d period.

Results at beginning of the trial for urea space when the heifers were still on pasture appear in Table 36 and also appear in Table 21. Thus diets (pasture vs TMR) caused differences in PUN, CHPUN and US. Aging and different composition of BW gain accounted for changes in body water, fat and protein.

Table 35. Effect of body size and protein sources on blood measurements and body composition of Holstein heifers in confinement (60 d period).[1]

	Body size		Protein source		
	Heavy	Light	Fish meal	Soybean meal	SE
Age, mo	14.2	12.8	13.4	13.8	-
BW, kg	400.1	346.0	375.3	370.9	-
EEBW, kg	352.9	303.4	330.3	323.3	-
PUN, mg urea-N/dl	15.5	16.9	16.5	15.9	.53
CHPUN, %	11.7	11.8	11.7	11.8	.46
HMTB, %	.0	33.8	34.7	34.1	.60
HMTA, %	34.1	32.9	33.7	33.2	.39
US, % live weight	49.3	50.6	50.0	49.9	2.00
EBWATER, %	63.3[a]	64.9[b]	64.1	64.1	.35
EBFAT, %	12.5[a]	11.0[b]	11.8	11.7	.32
EBPRO, %	18.1[a]	17.8[b]	17.9	17.9	.04
EBFAT:EBPRO	.69	.62	.66	.65	-
Water, g/kg	633	649	641	641	-
Fat, g/kg	125	110	118	117	-
Protein, g/kg	181	178	179	179	-
Ash, g/kg	61	63	62	63	-
Gross energy,Mcal/kg	2.2	2.0	2.1	2.1	-

[1]Data for pretreatments were combined.
[2]Abbreviation key in Appendix Table 3.
[3]Percentage of empty BW.

Table 36. Mean differences in blood parameters, urea space, and body components of Holstein heifers across treatments.

	Beginning	End
PUN[1], mg urea N/dl	14.0	18.5
CHPUN, mg urea N/dl	11.3	12.4
US, % live wt	50.3	46.8
EBWATER, %[2]	64.9	63.1
EBFAT, %	11.0	12.3
EBPRO, %	17.8	18.1

[1]Abbreviation key in Appendix Table 3
[2]Percentage of empty BW

Fat accretion was greater for heifers on previous pasture treatments than for those on previous DL. Therefore, the increased BW gain (compensated) was mostly fat accretion, since protein remained at the same percentage, 17.9% (Table 36).

Chapter 6

Holstein heifer growth on grass-legume pastures supplemented with sources of energy and rumen degradable and undegradable protein.

ABSTRACT

Thirty-three Holstein heifers (initially 5 to 9.4 mo old) grazing grass-legume pastures were allotted to three treatments: 1.5 kg of either dried brewers grains (DBG, 26% CP); soybean meal and cracked corn (26% CP); or cracked corn (CC 10% CP). Six paddocks of 1.5 ha each were rotationally grazed for 155 d. Average daily gains were not different (878 g/d). Hip height, wither height, and heart girth were similar among treatments and all met recommended growth standards. Ultrasound measurements of ribeye area and backfat depth, urea space estimations of body components and body composition scores did not differ by treatment. Plasma urea nitrogen was significantly greater in heifers fed dried brewers grains (14.5) and soybean meal (13.5) than cracked corn (11.6 mg/dl) during June only. Overall responses to degradable and undegradable protein sources were not different.

INTRODUCTION

Most of dairy heifer research in recent years has focused on confinement rearing. Recent work at Virginia Tech by Tomlinson (286,287) evaluated heifer gains in a Pinpointer Computer Intake facility. In his first study, diets were formulated for 115% or 95% NRC's recommended TDN level in combination with 30 % or 40% of CP as rumen undegradable intake protein (UIP), where soybean meal (SBM) was replaced with dried brewers grains (DBG). The high energy protein combinations produced similar gains of 940 g/d. However, in lower energy: protein diets gains structural scale, and feed efficiency were improved when DBG was included. In trial 2, diets differed in percent UIP. Blood meal replaced SBM in order to increase UIP level in the orchardgrass hay-based diets. A positive linear response in daily gain to increased UIP resulted.

Previously reported data indicate a potential improvement in gains with supplemental bypass protein in heifers under confinement feeding (286). Amos (8), reported increased weight gains in Holstein steers starting at 14 wk of age or 95 kg BW, and in heifers starting at 17 wk of age, or 100 kg BW when fed energy at 105% of 1978 NRC requirement and protein at 53% UIP (16.3 - 17.2% CP). No effect due to protein occurred in animals fed energy at 95% of requirement. Waldo and co-workers (296), indicated that feeding protein below requirement decreased protein deposition and growth but feeding protein above requirement was without effect. They concluded that feeding additional protein may not increase protein deposition as suggested by Johnsson (129), and may not increase daily gains as suggested by Kertz et al. (139). However Waldo (296) did not evaluate a bypass protein potential as a means of improving gains. The objective of this study was is to evaluate the potential of improving heifer growth rates and body composition by supplementing with a bypass protein source for pasture fed animals.

MATERIALS AND METHODS

The research was conducted in the pastures previously utilized by heifer grazing studies. Management of pasture and animals was also previously described. Animal measurements were the same with the inclusion of hip height (HH) measurements. Supplements compared were 1.5 kg/d cracked corn, and either corn + soybean meal (SBM) or dried brewers grains (DBG), each of the latter were 25% CP. Several body measurements including hip height were recorded as previously including tissue by ultrasound and body composition by urea space.

Statistical analysis.

Heifer response to treatments was analyzed as a complete block design with heifers as blocks and nonrandom repeated measurements of units (heifers) were taken (93) over time. Anova was obtained with the GLM procedure of SAS (244).

$Y_{ijk} = U + T_i + H_j + (DH)_{ij} + T_k + (DT)_{ik} + e_{ijk}$ where:

Y_{ijk} = dependent variable of heifer k in group j for treatment i

u = overall mean

T_i = fixed effect of treatment i, i = 1, 2, 3

H_j = fixed effect of heifer j, j = 1, 2,...

$(TH)_{ij}$ = interaction effect of heifers j and treatment i

T_k = fixed effect of time k

$(DT)_{ik}$ = fixed effect of interaction between treatment i and time k

e_{ijk} = residual

Test treatment effect with treatment x heifer

RESULTS AND DISCUSSION

Growth, body composition and changes in body composition during grazing are presented in Tables 37 and 38. Measurements describing heifer growth were not different across treatments and show a similar structural scale

Table 37. Growth of Holstein heifers grazing a grass-legume mixture supplemented with corn, corn plus soybean meal (26% CP) and dried brewers grains.

Variable	Pasture + Corn	Pasture + CSBM	Pasture + DBG	SE	CV
BW, kg	229.6	233.8	236.4	57.1	3.0
ADG, g/d	.858	.885	.890	.040	14.0
WH, cm	111.0	111.6	111.4	1.0	1.5
HH, cm	117.6	117.3	118.1	1.1	1.2
HG, cm	145.3	144.8	144.7	1.8	1.3
BCS, unit	3.0	3.0	3.0	.1	5.3
Backfat, mm	2.5	2.5	2.5	.003	17.8
REA, cm^2	32.8	31.9	33.7	1.1	10.0
REA, cm^2/100kg BWT	14.3	13.6	14.2	-	-
BW/WH, kg/cm	2.1	2.1	2.1	-	-
BW/HH, kg/cm	1.9	2.0	2.0	-	-
BW/HG, kg/cm	1.6	1.6	1.6	-	-

Least square means without superscripts do not differ at P>.01.

Table 38. Body composition of Holstein heifers grazing on grass-legume mixture supplemented with energy, energy-protein or rumen undegradable protein.

Variable	Pasture + Corn	Pasture + CSBM	Pasture + DBG	SE	CV
Age, mo				na	na
BW, kg	229.6	233.8	236.4	na	na
EEBW, kg[1]	196.6	200.4	202.8	na	na
PUN, mg/dl	11.3[a]	17.3[b]	16.9[b]	na	na
Urea space, %	60.7	60.0	60.6	2.6	17.6
EBWATER	67.0	66.9	66.8	.6	2.5
EBFAT	8.9	9.0	9.2	.5	16.3
EBPRO	16.2	16.2	16.2	.1	1.0
EBFAT:EBPRO	.55	.55	.57	na	na
Deposition: g/kg					
WATER	670	669	668	na	na
FAT	89	90	92	na	na
PROTEIN	162	162	162	na	na
ASH	79	79	79	na	na
Gross energy, Mcal/kg	1.7	1.7	1.7	na	na

Least square means with unlike superscripts differ at P<.01

[1]Abbreviations are in Appendix Table 3, abbreviation key

development on heifers in all three treatments (Table 37). The paddocks were remarkably similar in composition (Appendix Table 16 and 17) throughout an active grazing season. Actual kilograms of forage available were not measured. Visual estimations were the determining factor for changing heifers among paddocks.

There was abundant opportunity for heifers to select from a high quality herbage (Appendix Table 16 and 17). Visual observation of pastures indicated the normal shift in botanical composition towards the end of the grazing season. Late summer and early fall growth of orchardgrass, bluegrass and some clover declined and fescue increased, with this trend representing the typical production curves for these cool season grasses. However, quality did not decline based on data in Appendix Tables 16 and 17.

ADG were similar across treatments over the entire season (Table 37). Growth rates exceeded expectations and averaged 878 g/d for corn, corn + SBM and DBG supplements. Hill et al. (114), reported that pasture supplementation (energy or different sources of protein) and blood meal and fish meal (two ruminal undegradable proteins) may stimulate DMI more than other supplements by enhancing the amino acid profile in the gastrointestinal tract to the metabolic pool of the animal. Donaldson et al. (67) reported a linear tendency to increase total tract digestion when undegradable protein supplied by either fish meal or distillers dried grains with solubles were fed. They concluded that ruminal undegradable protein is an alternative way to increase post-ruminal protein flow without reducing fiber digestion. In our study pasture supplementation (Table 37) with energy or two forms of protein gave similar growth rates and subcutaneous fat accumulation based on body condition score or backfat measurements. Protein deposition was unaffected, as measured by ribeye area (REA). This agrees with Waldo et al. (297), that increasing protein level above requirements does not increase protein deposition. Crude protein in herbage from our pastures were above 15% throughout the season (Appendix Table 16).

Period by treatment interactions (P<.01) were detected for daily gains (Appendix Table 17). Cracked corn produced the highest gain during midsummer, but overall cracked corn gave the least gain (Table 37). This may be caused by shifts in botanical composition or growth of high quality tall fescue.

Body composition was not affected by treatments (Table 38). Changes in body components of those heifers with maturity followed the pattern of previous experiments (Table 39, 40). The body water declined as body fat increased.

Table 39. Effects of treatment and period of the year on urea space and body components of Holstein heifers receiving energy, energy-protein or rumen undegradable protein to supplement pasture.

	BW	US	EBWATER	EBFAT	EBPRO
	kg	------------------%------------------			
Cracked corn:					
Before grazing (5-1-90)	167.2	64.8	67.7	8.2	16.8
43 d after grazing (6-16-90)	198.6	61.2	67.6	8.4	17.0
135 d after grazing (9-16-90)	270.7	54.9	66.0	9.9	16.9
Corn + soybean meal:					
Before grazing	167.2	64.1	67.9	8.1	16.8
43 d after grazing	200.8	57.4	67.9	8.1	17.1
135 d after grazing	284.5	57.4	65.2	10.7	17.0
Dried brewers grains:					
Before grazing	167.2	68.0	67.0	8.8	16.8
43 d after grazing	204.7	62.7	66.9	9.0	17.0
135 d after grazing	284.6	51.9	66.1	9.9	16.2

Table 40. Sequential changes in body composition of Holstein heifers grazing on grass-legume mixture pastures in 1990.

Variables	Before grazing April	43 d after grazing June	135 d after grazing October
PUN, mg Urea-N/dl	9.2	17.5	12.9
US, %	65.7	60.8	54.7
EBWATER, %	67.6	67.8	65.8
EBFAT, %	8.3	8.6	10.2
EBPRO, %	16.9	17.0	16.2
EBASH, %	7.2	6.6	7.8
EBPRO:EBASH	.49	.50	.63
Mass basis: kg			
BW	167.2	201.4	280.0
EEBW	139.3	170.7	242.8
EBWATER	94.2	115.7	159.8
EBFAT	11.6	14.7	24.7
EBPRO	23.5	29.0	39.3
EBASH	10.0	11.3	18.9
Gross energy, Mcal	238.3	297.7	448.3
Gross energy, Mcal/kg	1.71	1.74	1.85

Cracked corn supplementation resulted in lower PUN (11.3 mg/dl) than corn soybean meal (CSBM) (17.3) and dried brewers grains (DBG) (16.9, $P<.01$), respectively. These values reflect an increase in protein levels over that of pasture and corn.

CONCLUSIONS

Protein or energy supplementation on well managed, high quality grass-legume pasture supplies nutrients to attain recommended rates of growth. There was no response to rumen undegradable protein supplementation compared to corn only or corn plus soybean meal.

Forage availability and quality were excellent during this study. One may speculate that the reason animals fed all supplements grew well is due to the overall protein quantity and quality available to the small intestine because of pasture regardless of whether supplemental protein was rumen degradable or not.

Chapter 7

SUMMARY AND CONCLUSIONS

Summary

Growth and body composition of 121 Holstein heifers reared under pasture, drylot and pasture-drylot systems were evaluated in a set of seven experiments. Heifers grazed a grass-legume mixture in six paddocks of 1.5 ha each. Excess forage in spring was harvested as hay. Repeated measurements in changeover, completely randomized block or split-plot designs were used. In 1987, 24 heifers 13.2 mo (295 kg BW) were allotted by size and weight and randomized into 2 groups. Corn (0 and 2 kg/d) was supplemented in alternate 28 d periods while grazing. ADG (837 vs 581 g/d) and heart girth increments 171.7 vs 174.3 cm were greater for supplement for all periods. In 1988, heifers with average weight of 205.9 kg (9.2 mo, heavies, H) and 129.0 kg (5.6 mo, lights, L) were assigned to a high energy (HE=105% TDN NRC) or a low energy (LE=85% TDN NRC) diet, in the drylot phase. Average daily gains (g/d) were 1190 (HE) and 990 (LE) respectively. Diet affected only WH, no effects on BW, HG, DM intake were present. While fed pasture, when supplemented with corn, there was no difference in body

weight nor increased gain. Gain was greater in light heifers that were previously fed LE diet.

In 1989, 32 heifers with weights varying from 155 (4.6 mo) to 241 kg (9.0 mo) were blocked by weight and age and randomized into four treatments. Urea space as percent of BW was the same (61.1%) for both sizes, but empty body composition was different at the end of the wintering phase. Neither previous wintering diets nor energy supplementation while grazing had significant effects on body composition determined via urea space. A lower fat-to-protein ratio was observed after grazing when compared to that at the end of the confinement (.59 vs .67) showing that heifers lost fat during adjustment to grazing. Plasma urea N (mg/dl) level ranged from 10.2 to 11.2 mg and ADG from 345 to 581 g/d during the summer months with alternated supplemental periods.

Thirty-two growing heifers were fed one of four diets in 1989. A total mixed diet containing 55.8% corn silage, 25.6% alfalfa haylage and 18.6% chopped orchardgrass hay was the drylot (DL) treatment. Pasture alone (PA) and pasture supplemented with either lasalocid (200 mg/d) or 2 kg of 19% CP concentrate (PL and PG) were compared. Rates of gain (g/d) were different when DL (934) was compared to PA (755) or PL (835), but not from PG (875). PA and PL differed from

PG, but no difference between PA and PL was detected. Subcutaneous fat cover as measured by ultrasound determinations and body condition scoring agreed with weight gain difference as expected, except for heifers in PL and PG. Lasalocid fed heifers had reduced ribeye area, increased subcutaneous fat in contrast to PA and had lower protein accretion (6.6% and 7.6%) respectively when compared to PA and PG heifers. Body composition, as determined by urea space, showed heifers fed DL compared to pasture deposited more fat and protein (21.9 and 24.8 kg vs 18.0 and 21.7 kg). However, the close ratio of EBFAT:EBPRO accretions, .53 (DL an PL), .52 (PA), and .51 (PG) along with with similar gross energy stored, 1.81 Mcal/kg, suggest similar nutritional status by heifers in both systems. Daily fat and protein accretions were higher for DL heifers than heifers fed pasture alone. Combinations of drylot (205 d) and pasture (160 d) can reduce cost of rearing dairy replacements.

Intake by grazing heifers were derived by the fecal index technique. Fecal output and herbage coefficient of digestibility were, respectively, 3.0 kg and 65.8%. Intakes based on %N in feces were 10.8, 9.4 and 10.9 kg DM/d for PA, P L, and PG, respectively. Coefficient of digestibility resulted in lower DMI; 9.5 (PA), 8.0 (PL), and PG (8.8) kg

DM/d. Comparative daily intake for heifers in DL was 7.5 kg of DM.

A 60 d confinement diet of corn, corn silage, orchardgrass hay and alfalfa silage containing either fish meal (FM, 3.7% DM) or soybean meal (SBM, 6.6% DM) was fed following grazing to evaluate growth and body composition of heifers. Responses in BW, DMI, WH, backfat depth, ribeye area and body composition score were not different regardless of previous treatment. However, during this period, heifers on previous PA diet maintained a similar rate of gain (765 vs 755 g/d) while the heifers on previous DL, PL and PG had a reduction in ADG. Daily gains decreased from 940 to 344 g/d for heifers on previous DL, even though intake by these heifers remained at 7.7 kg DM/d. Compensation made by PA heifers was mostly in form of fat deposition. This suggests a compensatory response since intake might have been regulated by energy requirements, and the height-to weight (kg/cm) gain were 2.4 (DL), 2.5 (PA), 2.2 (PL) and 2.3 (PG) and similar. This suggests higher ME requirement for grazing animals as compared to confined animals, because DMI was similar for all treatments. Body fat accretion as estimated by urea space was greater for heifers on previous pasture treatments than for those on previous DL.

In 1990, thirty-three heifers were allotted to three 1.5 ha grass-legume paddocks by age (5.0 to 9.4 mo) and weight (134.8 to 225.5 kg). Treatments included 1.5 kg/d of dried brewers grains (DBG, 26% CP), 57% corn and 43% soybean meal (CSBM, 26% CP) or cracked corn (CC, 10%). Daily gains (g/d) were not significantly different for DBG (890), CSBM (880), and CC (858). Hip height, wither height, and heart girth were not different, yet met recommended heifer growth size. Neither ultrasound (ribeye area, backfat depth) nor urea space or body condition score revealed differences in body composition. Overall responses to degradable and undegradable protein sources were not different.

General conclusions

The first year, 1987, was a preliminary experiment to establish management of pastures and get an indication of response to a 2 kg supplementation of corn to grazing heifers. Although heifers were large, average daily gains were greater during periods of corn supplementation.

In 1988, animals did not respond uniformly to corn supplementation. In that year, animals were allotted to pasture as heavy and light heifers after a period of confinement in which their diets were 85% or 105% TDN requirements (1978 NRC). Lighter heifers, previously fed

85% TDN diet seemed to gain more when supplemented with 2 kg corn. When averaged for 1987 and 1988 for all animals, average daily gains were 630 and 510 g/d with or without respectively.

Compared to 1989 and 1990, gains were lower in the 1987 and 1988 seasons. This may be attributed to several factors. In general, animals were larger and more mature, quality of pasture was lower because of drought and heat, and probably reduced grazing activity.

In 1989, when a drylot forage diet was compared to pasture, pasture plus lasalocid or pasture plus 2 kg of 19% CP concentrate, BW gains were greater for all treatments (than previously). With only pasture, gains were 755 g/d and ranged up to 934 for drylot diets. Lasalocid supplemented animals did not gain significantly more than pasture only, but 2 kg of concentrate increased gains. Based on urea space determinations, moving heifers from drylot wintering diets to pasture reduced empty body fat content.

When fishmeal and soybean meal were compared as protein sources in drylot diets of the grazing season, protein sources gave no differential response to heifers. However, some compensatory growth occurred in lower conditioned animals (grazed animals). Sequential changes in body composition indicated that the ratio of empty body fat to empty body protein began to increase substantially when body weight exceeded 334 kg or at approximately 14 mo of age.

In 1990, heifer gains were slightly but not significantly greater for soybean or dried brewers grains supplementation compared to cracked corn. All gained (average of 876 g/d) in excess of recommendations, but the pasture gre actively and was of exceptional quality. Other measures of growth and body composition were similar across supplemental treatments.

In general, pasture or pasture with modest supplement of corn or corn plus protein provided acceptable structural growth to Holstein heifers economically. When coupled with the opportunity to modify animal growth rates predictably in the non-grazing seasons, opportunities exist for more economical, healthful heifer growth by optimal use of pasture systems.

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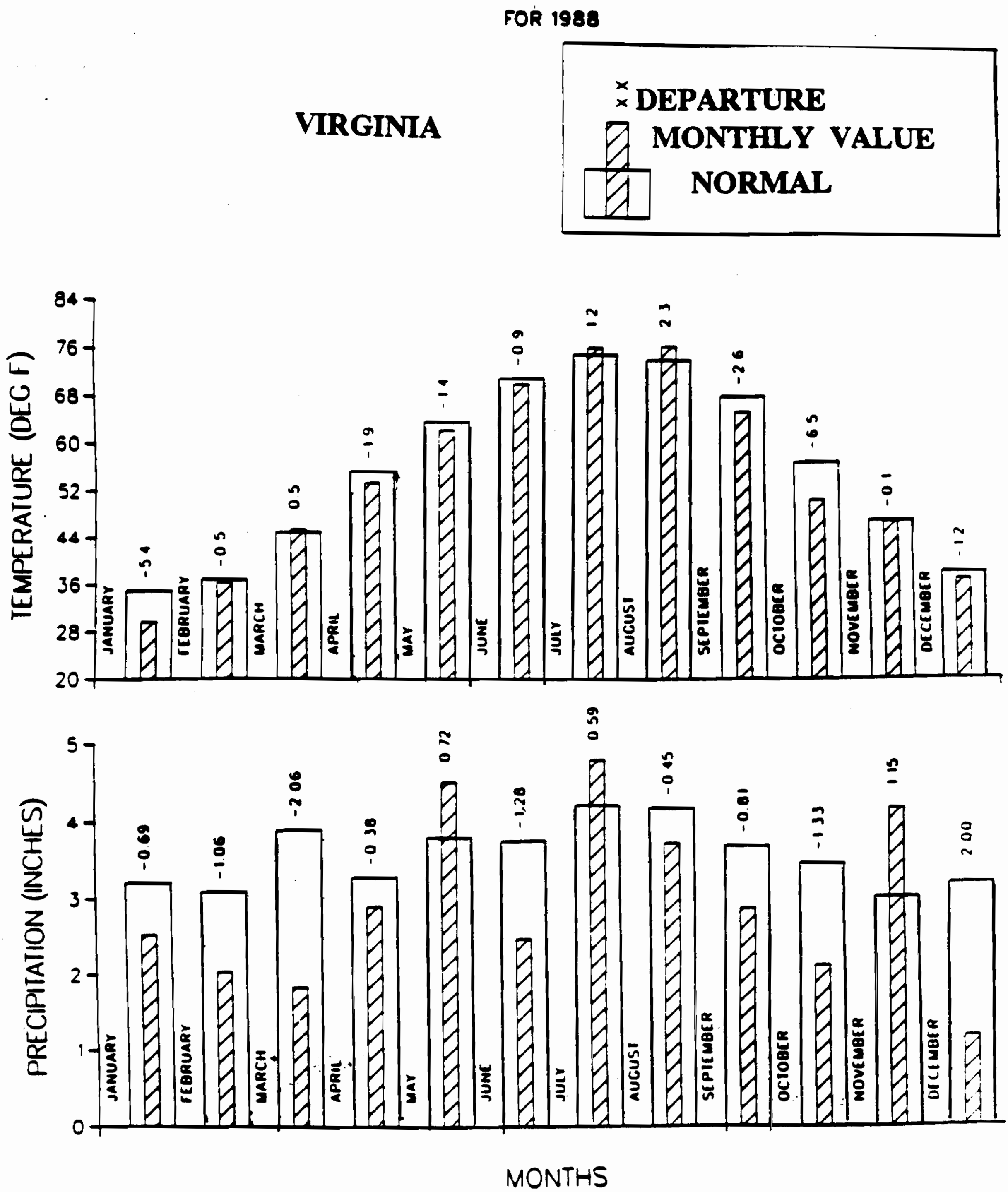
Appendix Table 1. Daily requirements of growing dairy cattle - large breeds. After NRC, 1989.

BW (kg)	Gain (g)	DMI (kg)	NEm	NEg	ME	DE	TDN	UIP	DIP	CP
			------------	------------	Mcal	------------	kg			
100	600	2.6	2.7	1.2	7.0	8.1	1.8	324	56	421
100	800	3.0	2.7	1.7	8.1	9.3	2.1	386	91	483
150	600	3.5	3.7	1.4	9.1	10.6	2.4	305	147	532
150	800	4.0	3.7	2.0	10.4	12.0	2.7	363	192	639
200	600	4.4	4.6	1.6	11.1	13.0	2.9	289	235	699
200	800	5.0	4.6	2.2	12.6	14.7	3.3	344	289	796
250	600	5.3	5.4	1.8	13.1	15.3	3.5	277	320	718
250	800	6.0	5.4	2.5	14.8	17.3	3.9	330	384	857
300	600	6.3	6.2	2.0	15.0	17.7	4.0	269	405	752
300	800	7.1	6.2	2.8	17.0	19.9	4.5	320	480	884
350	600	7.3	7.0	2.2	17.0	20.1	4.6	264	492	874
350	800	8.2	7.0	3.0	19.2	22.6	5.1	314	577	985
400	600	8.4	7.7	2.4	19.0	22.6	5.1	264	581	1,007
400	800	9.5	7.7	3.2	21.4	25.4	5.8	313	677	1,135
450	600	9.6	8.4	2.5	21.1	25.2	5.7	268	674	1,151
450	800	10.8	8.4	3.5	23.9	28.4	6.4	317	782	1,298
500	600	10.9	9.1	2.7	23.3	28.0	6.3	278	771	1,311
500	800	12.3	9.1	3.7	26.3	31.5	7.2	326	894	1,480

1. Abbreviations defined
NE_m = net energy maintenance; NE_g = net energy gain; ME - metabolizable energy; DE = digestible energy; UIP = undegraded intake protein; and DIP = degraded intake protein.

Appendix Table 2. Temperature and precipitation areally weighted state averages and departures from normal (1951-1980) (195).



Appendix Table 3. Abbreviation key used throughout this manuscript.

ADG - average daily gain
BCS - body condition score
BUN - blood urea nitrogen
C - cracked corn
CHPUN - change in plasma urea nitrogen
Cr - chromium recovery
CSBM - corn + soybean meal
DBG - dried brewers grains
DIG - digestibility coefficient
DL - drylot
DMI - dry matter intake
EBW - empty body weight
EEBW - estimated body weight
EBASH - empty body ash
EBFAT - empty body fat
EBPRO - empty body protein
EBWATER - empty body water
FM - fishmeal
FN - fecal nitrogen
FO - fecal output
G1 - group 1
G2 - group 2
H - heavy
HE - high energy
HG - heart girth
HH - hip height
HMTA - hematocrit after
HMTB - hematorcrit before
INTDIG - intake measured by digestibility coefficient
INTLANC - intake measured by Lancaster's formula
L - light heifer
LE - low energy diet
NS - nonsupplement
PA - pasture alone
PG - pasture + grain
PL - pasture + lasalocid
PUN - plasma urea nitrogen
REA - ribeye area
S - supplement
US - urea space
WH - wither height

Appendix Table 4. Low and high energy diets fed to Holstein heifers in drylot for the wintering period in 1988 at Pinpointer 4000-B.

1. Formulation:

	Diet							
	Low Energy				High Energy			
	% of DM							
Ingredients	DM	CP	ADF	TDN	DM	CP	ADF	TDN
Corn silage	70.7	4.95	21.99	45.96	51.0	3.57	15.9	33.2
Alfalfa silage	23.6	4.97	6.51	16.05	17.0	3.57	4.69	11.6
Soybean meal	5.7	3.08	.34	4.62	6.0	3.24	.36	4.9
High moisture corn	--				26.0	2.6	.78	23.4
Total	100	13.0	28.8	66.6	100.0	13.0	21.8	73.1

Trace mineral was available all times

2. Chemical Analysis:

	Low energy diet	High energy diet
DM %	47.7	53.3
CP %	13.3	12.1
ADF %	29.7	25.8
TDN %	67.0	70.0
NEm, Mcal	1.52	1.60
NEg, Mcal	.92	1.01

Appendix Table 5. ANOVA mean squares for PUN, US, EBWATER, EBFAT, and EBPRO for Holstein heifers at the end of the drylot phase in 1988.

Source	df	PUN	US[1]	EBWATER[1]	EBFAT[1]	EBPRO[1]
Size	1	.05	.03	38.70**	34.18**	.98**
Diet	1	7.24	288.95*	2.34	1.53	.16*
Size by diet	1	4.03	125.10	4.20	3.20	.00
Remainder	15	1.72	62.43	2.40	2.00	.04
R^2		.30	.30	.61	.61	.65

* P<.06
**P<.01

[1]Abbreviation key in Appendix Table 3.

Appendix Table 6. ANOVA mean squares for PUN, US, EBWATER, EBFAT, and EBPRO for Holstein heifers grazing a grass-legume mixture pasture with or without energy supplementation.

Source	df	PUN	US[1]	EBWATER[1]	EBFAT[1]	EBPRO[1]
Supplement	1	.15	7.81	1.00	.89	.01
Size	1	.01	.19	73.20**	64.90**	1.72**
Diet	1	.72	29.54	.01	.01	.04
Suppxsize	1	.44	3.89	2.45	2.33	.12
Suppxdiet	1	.33	12.60	.01	.01	.04
Sizexdiet	1	14.30**	369.00**	13.45**	10.74**	.00
Period	2	15.45**	499.90**	86.55**	75.93**	2.45**
SuppxPeriod	2	1.30	35.44	1.00	.85	.01
DietxPeriod	2	11.90**	360.14**	6.30*	4.54*	.08
Reminder	48	1.83	49.24	1.65	1.36	.03
R^2		.44	.47	.78	.79	.83
CV		13.00	12.80	2.03	9.30	1.0

* (P<.05)
**(P<.01)

[1]Abbreviation key in Appendix Table 3

US - urea space
EBWATER - empty body weight
EBFAT - empty body fat
EBPRO - empty body protein

Appendix Table 7. Chemical composition of TMR fed to DL group and of pasture quality offered to Holstein heifers in 1989.

	Drylot		Pasture	
	fed	refusal	Before grazing	After grazing[1]
DM, %	55.9	53.0	28.0	75.7
CP, %	14.3	13.6	19.6	13.1
ADF, %	32.1	35.0	22.7	22.0
TDN, %	65.0	63.0	64.1	59.3
NEm, Mcal/kg	1.4	1.4	1.7	1.1
NEg, Mcal/kg	.9	.8	1.7	1.1

[1]Excess herbage, clipped while wilting

Appendix Table 8. ANOVA mean squares of Cr recovery, fecal output (FO)[a], fecal N (FN)[b], digestibility (DIG)[3], and forage intake (INTLAN[+] and INTDIG[o]) for Holstein heifers on summer grazing grass-legume mixture with or without supplement.

Variable	df	Cr	FO[a]	DIG[c]	FN[b]	INTLAN[2]	INTDIG[3]
Period[1]	3	2787.3	.14	13.3	.08	3.1**	5.9
TRMT[1]	2	5450.0	.12	26.3	2.00**	12.9**	8.1*
Period*TMT[1]	6	7611.5*	.32*	36.6*	.22*	1.4	5.6
Heifer (Period*TRMT)	10	1902.1	.06	9.1	.05	1.1**	2.6
Day	2	1939.9	.03	9.3	.01	.9	2.1
TRMT*day	4	5279.4	.19	25.8	.13	1.8*	3.0
Period*day	6	11106.6**	.45**	53.7**	.34**	1.7	9.0**
Period*TRMT*day	10	2130.5	.08	10.4	.09	.8	2.3
Remainder	12	2193.0	.09	10.6	.06	.45	3.3
R^2		.89	.89	.89	.88	.93	.85
CV		9.6	10.0	4.9	9.6	6.5	20.6

[1]Heifer (Period*Treatment) as an error term

* P<.05

**P<.01

[a]FO = fecal output

[b]FN = fecal nitrogen

[c]DIG = coefficient of digestibility

[2]INTLAN = intake by Lancaster

[3]INTDIG = intake by coefficient of digestibility

Appendix Table 9. Age, BW gain, daily gains, DM intake of Holstein heifers group fed ad libitum, a total mixed ration for 160 days.

Age days	Period 14 d	BW/period Initial	Final	Mean	ADG kg/d	DMI per period kg/d	%BW
		------------	kg	------------			
233	5.9-23	195.0	212.5	203.7	1.27	6.3	3.1
247	5.24-6.6	212.5	224.9	218.7	.88	6.5	3.0
261	6.7-2.0	224.9	242.3	233.6	1.24	6.8	2.9
275	6.21-7.4	242.3	256.8	249.5	1.03	6.7	2.7
289	7.5-18	256.8	265.8	261.3	.64	6.9	2.6
303	7.19-8.1	265.8	282.0	273.9	1.16	7.4	2.7
317	8.2-15	282.0	293.4	287.7	.81	8.3	2.9
331	8.16-29	293.4	302.8	298.1	.67	7.5	2.5
345	8.30-9.12	302.8	319.4	311.1	1.18	7.8	2.5
359	9.13-26	319.4	333.4	326.4	1.00	8.2	2.5
373	9.27-10.10	333.4	339.4	336.4	.43	8.4	2.5
7.4-12 mo	155d		144.4 (gain)		.94	7.3	2.7

TMR - Chemical composition and gain

	DM	CP	ADF	TDN	DMI	NEm	NEg	Gain
Formulated for	49.3	12.7	30.4	63.8	5.5			.726
Actual	54.3	13.9	33.8	63.9	7.3	1.43	.84	.940

Appendix Table 10. Input information on investment, fixed and variable costs for housing Holstein heifers.

Item	Cost: Unit	Cost: Total	Annual	Per heifer	Heifer cost per day
1. Investment[1]	------	------	$	------	------
Heifer barn 223 sq.m	139.91	31200.00	2720.16	36.96	.10
Cost and equipments, total		10500.00	1880.92	25.56	.07
Total investments		41700.00	4601.08	62.51	.17
2. Fixed annual and variable costs[2]					
Building and equipment, yr[3]	96.00	96.00	101.76	1.38	.01
Feeding costs per day:					
Labor, d	4.00	1762.95	1868.73	58.40	.16
Truck, d	2.00	730.00	773.80	24.18	.07
Feeds, kg/heifer[4]:					
corn silage, 9		3679.20	3899.95	121.87	.33
alfalfa haylage, 4		2336.00	2476.16	77.38	.21
orchardgrass hay, 3		2452.80	2599.97	81.25	.22
2:1 mineral mixture, .158		922.72	978.08	30.57	.08
Total variable costs		11979.67	12968.45	395.03	1.08
3. Total costs		53679.67	17299.53	457.54	1.25

[1]Facilities will carry 73.6 heifers yearly. Heifer's cost/d is based on use of facility during 365 days. Initial cost amortized over 20 yr at 6% interest.

[2]Fixed animal and variable costs are for 32 heifers.

[3]Fixed animal maintenance cost.

[4]Individual feed cost is in Appendix Table 11.

Appendix Table 11. Commercial prices and market value for feeds in September 1989.

Commercial[a]	Unit	Price Cents
2:1 Mineral mix salt	kg	50
Lasalocid in 2:1 mineral mix	kg	60
Cracked corn	kg	14
Soybean meal	kg	20
Fishmeal	kg	41
Dried brewers grain	kg	14
Market[b]		Dollars
Pasture land unit	hectare	75.00
Orchardgrass hay	metric ton	70.00
Corn silage	metric ton	35.00
Alfalfa silage	metric ton	50.00

[a]Feedstuffs, September 1989 and Southern States Co.

[b]Charles N. Miller, Robert E. James and M. L. McGilliard, Personnel Communication

Appendix Table 12. Input information for fixed and variable costs necessary to feed 32 Holstein heifers on pasture for 160 days in 1989.

	Cost		Total	Annual per	Heifer	TRMT
	Unit	Total	annual	heifer	per day	per day
1. Fixed costs ($)						
· Land rental, ha	75.00	701.25	743.33	23.23	.15	4.65
· Facilities, total [1]	-	5567.00	997.24	31.16	.19	6.23
· Clover overseeding, ha	67.18	628.13	149.12	4.66	.03	.93
· Herbicide, total	-	50.00	53.00	1.66	.01	.33
· Pasture mainten., total[2]		790.00	837.48	26.17	.16	5.23
Total fixed costs		7736.38	2750.17	86.88	.54	17.37
2. Variable costs						
· Truck and labor, d	5.13	821.13	870.40	27.20	.17	5.44
· Supplement, total:						
Pasture + grain[3]		1902.08	2016.20	63.01	.39	12.60
Pasture + lasalocid[4]		485.38	514.50	16.08	.10	3.21
Pasture alone[5]		343.04	363.62	11.36	.07	2.27

[1]Corral, feeders, gates, head catch, and others

[2]Fertilizers, hay harvest, clipping after grazing (cost/yr) Supplement/TRMT: daily heifer

[3]1.5 kg cracked corn + 0.5 kg soybean meal + .123 2:1 mineral mixture

[4].158 kg Bovamin-A (lasalocid + 2:1 mineral mixture)

[5].134 kg 2:1 mineral mixture

Appendix Table 13. Ration formulation and ration nutrient content based on analysis fed to Holstein heifers in drylot for 60d period.

	FSM		SBM	
	Heavy	Light	Heavy	Light
Feed	------%-------		--------%-------	
Corn silage	40.2	39.7	42.8	42.0
Orchardgrass hay	43.9	45.6	46.2	46.0
Alfalfa silage	13.5	11.9	6.5	7.5
Fishmeal	2.2	2.6	.	.
Soybean meal	--	--	4.3	4.3
Salt minerals	.2	.2	.2	.2
DM, %	62.5	62.0	62.2	65.3
CP, %	14.4	13.1	13.6	13.0
ADF, %	36.2	36.9	34.7	37.7
TDN, %	61.7	61.0	63.3	61.0
Escape rumen protein, %	33.5	34.5	25.1	25.1
NEm, Mcal/kg	1.4	1.3	1.4	1.3
NEg, Mcal/kg	.8	.7	.8	.7

Appendix Table 14. ANOVA mean squares for blood components and body components of Holstein heifers, fed a diet containing fishmeal or soybean meal in confinement.

	df	PUN	CHPUN	B	A	US	EBW	EBFAT	EBPRO
PTT	3	1.6	6.0	8.0	6.5	17.3	1.1	.9	.0
WTG	1	19.7	17.5	8.7	10.2	38.7	35.6**	30.2**	.6**
PTT*WTG	3	4.1	3.7	5.6	6.5	61.9	2.6	2.1	.0
DIET	1	2.3	5.2	4.5	1.4	2.0	.0	.1	.0
PTT*DIET	3	21.6*	.6	1.7	.1	33.3	2.3	1.9	.0
WTG*DIET	1	3.6	1.9	1.1	2.1	6.1	.4	.2	.0
PTT*WTG*DIET	3	7.5	.2	.3	2.4	38.0	.8	.7	.0
HEFNO(PTT*WTG*DIET)	12	4.6	2.7	9.8	3.8	42.7	1.7	1.4	.0
DATE	1	193.0**	22.0*	12.1	.0	231.8	11.5*	10.8*	1.2**
PTT*DATE	3	21.0*	2.8	8.7	3.3	65.6	2.2	1.7	.0
WTG*DATE	1	9.4	6.3	.6	.0	35.3	1.4	1.1	.0
PTT*WTG*DATE	3	3.4	1.8	3.0	4.6	40.0	2.3	1.8	.0
DIET*DATE	1	1.4	2.0	.8	.7	20.8	.7	.5	.0
PTT*DIET*DATE	3	2.5	3.9	2.1	2.8	21.0	.6	.5	.0
WTG*DIET*DATE	1	23.2	.4	.3	6.8	36.2	1.1	.9	.0**
PTT*WTG*DIET*DATE	3	5.5	28.0**	4.1	4.7	419.6*	10.9*	8.3*	.0*
Remainder	51	5.5	3.5	3.4		67.8	1.6	1.2	.01
R^2		.93	.85	.90		.81	.91	.92	.96
CV		13.5	15.7	5.3		17.4	2.0	9.6	.6

* P<.05

**P<.01

PTT = previous treatment

Appendix Table 15. Pasture chemical composition before each grazing period in 1990.

		Date					
		May	May	June	July	August	September
TRMT		4	30	28	29	28	26
	DM	24.6	21.4	25.6	27.4	25.0	31.9
Corn	CP	17.9	18.9	17.1	17.1	20.4	17.1
	ADF	28.2	25.0	29.6	34.3	31.2	34.0
	TDN	62.8	63.6	62.2	62.2	64.7	62.2
	DM	24.1	21.2	24.6	28.5	23.1	31.3
Corn	CP	15.9	18.9	18.1	16.2	22.4	16.1
+ SBM	ADF	30.4	25.5	26.4	32.5	28.8	33.0
	TDN	61.4	63.6	63.0	61.6	66.1	61.5
	DM	21.2	21.5	26.8	27.8	24.7	33.7
DBG	CP	17.7	18.7	17.9	16.6	21.1	17.3
	ADF	29.1	25.2	27.8	32.0	28.4	31.2
	TDN	62.7	63.4	62.8	61.9	65.2	62.4

Appendix Table 16. Pasture chemical composition after each grazing period in 1990.

		Date					
TRMT		May 30	June 28	July 29	August 28	September 26	October 10
	DM	57.2	35.0	32.4	32.5	34.4	31.3
Corn	CP	11.0	12.3	15.9	14.3	15.7	16.6
	ADF	35.3	33.0	33.4	37.6	31.8	37.4
	TDN	57.8	58.7	61.4	60.2	61.2	61.9
	DM	61.8	33.1	31.9	33.2	35.2	34.2
Corn	CP	9.1	14.1	17.9	14.4	16.7	13.7
+ SBM	ADF	38.3	30.7	32.5	38.4	33.6	39.6
	TDN	58.8	60.0	62.8	60.3	62.0	59.8
	DM	59.7	34.7	30.8	32.3	34.7	32.8
DBG	CP	10.3	13.3	16.8	14.8	14.6	14.5
	ADF	37.4	31.9	32.4	35.8	32.0	39.4
	TDN	57.3	59.5	62.0	60.6	60.4	60.3

VITA

Luciano P. Novaes, the son of Mr. and Mrs. Jacintho Novaes of Ribeirao Vermelho, Minas Gerais, Brasil, was born March 3, 1947 in Ribeirao Vermelho, Minas Gerais, Brasil.

After graduating from Instituto Gammon, Lavras, MG, Brasil, he entered the Superior School of Agronomy, Lavras, MG, Brasil. He received the Bachelor of Science degree in Agronomy and was graduated in December, 1970. From January, 1971 to October, 1975 he served as a Extension Agent with the Minas Gerais State Cooperative Extension Service. In November, 1975 he entered EMBRAPA, National Research Organization serving at the National Dairy Cattle Research Center as a researcher.

In September, 1979 he enrolled in the graduate Dairy Science program at Virginia Tech under an EMBRAPA research scholarship and received a M.S. degree in Dairy Science in December 1981. From this time, he served as researcher and and in November 1984 he became the coordinator of the Dairy Cattle National Research Program with the National Dairy Cattle Research Center. At the same time, he was co-responsible for the organization of the first Holstein Dairy Cattle Experiment Station for total confinement.

In January, 1987 he began his doctoral program at Virginia Tech where he completed requirements for the Doctor of Philosophy degree in Animal Science (Dairy).

He is a member of the American Dairy Science Association, American Society of Animal Science and Society of Agronomist Engineers of Minas Gerais.

He married Darci Andrade Novaes in May 4, 1974 and is the father of Sabrina Andrade Novaes.

Luciano Patto Novaes.