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Effects of lasalocid and protein degradability on growth and development of Holstein replacement heifers

Todd M. Steen

To the Graduate Council:

I am submitting herewith a thesis written by Todd M. Steen entitled "Effects of lasalocid and protein degradability on growth and development of Holstein replacement heifers." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

J.D. Quigley III, Major Professor

We have read this thesis and recommend its acceptance:

J.C. Waller, L.W. Vantassell

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Accepted for the Council:

Associate Vice Chancellor
and Dean of the Graduate School

EFFECTS OF LASALOCID AND PROTEIN DEGRADABILITY ON GROWTH AND DEVELOPMENT OF HOLSTEIN REPLACEMENT HEIFERS

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

Todd M. Steen

December 1990

DEDICATION

This thesis is dedicated to my daughter, Brittany Carol Steen, with the hope that the information gained will be helpful when she raises her cattle.

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ABSTRACT

Two experiments were conducted to examine effects of ionophores on body composition in replacement heifers. In experiment 1, 32 Holstein heifers (250 kg initial BW) were assigned randomly to a 2 x 2 factorial arrangement of low undegradable protein in concentrate (L, 30% of CP) vs high undegradable protein (H, 38% of CP) and lasalocid (0 or 200 mg/hd/d). Animals were housed in an open barn in 8 pens of 4 animals and fed 12.7 kg/pen/d of experimental concentrate once daily with medium quality fescue hay for ad libitum consumption. Body measurements were taken every 28 d while ultrasonic fat thickness (F) and muscle depth (M), urea space (US), body fat % (BF), body protein % (BP) and coccidia (C) were measured every 84 d. There were no significant differences (P >.05) in dry matter intake, feed efficiency, weight gain, height, length, hook width, forearm length, US, BF and C; however, heifers fed L0 and H200 had decreased body circumference (BC), F, M and BP. Means for L0, L200, H0 and H200 were: BC (cm), 173.3, 174.6, 177.3, 171.6; F (mm), 7.4, 8.5, 8.7, 8.0; M (mm), 54.1, 57.3, 56.3, 53.9; BP, 17.9, 18.1, 18.2, 18.0.

Experiment 2 utilized 20 Holstein heifers assigned randomly to 1 of 2 experimental supplements containing 0 or 200 mg/hd/d lasalocid. Animals were placed on 9.7 ha of

permanent fescue divided by portable electric fence and offered 13.6 kg of cracked corn and 5.9 kg of supplement/group/d once daily. Body measurements, F, M, US, BF, BP and C were measured as in experiment 1. There were no significant differences ($P > .05$) in body measurements, weight gain, F, US, BF, BP; however, heifers fed lasalocid had decreased ($P < .05$) coccidia and M. Means for 0 and 200 mg/hd/d lasalocid were: C (oocyst/g), 60.8, 36.6; M (mm), 52.5, 49.0. Data from both experiments suggest that lasalocid did not affect rate or composition of body gain in heifers weighing 250 to 430 kg.

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CHAPTER I

INTRODUCTION

The application of ionophores to finishing diets of beef cattle to increase performance and feed efficiency has been widely accepted. Bartley and Nagaraja (1982), Berger and Ricke (1980), Brethour (1979), Brown and Davidovich (1979) and Thonney (1981) documented increased rates of gain and feed efficiency in beef cattle fed lasalocid. Carboxylic ionophores appear to shift ruminal fermentation patterns toward increased concentrations of propionate and decreased concentrations of acetate (Reffert-Stabel, 1989). Others have suggested that ionophores inhibit microbial production (Bartley and Nagaraja, 1982 and Dinus, 1976) and decrease protozoal numbers (Bartley and Nagaraja, 1982).

Although there is little evidence that lasalocid significantly increases carcass fat content or carcass composition in feedlot cattle, Meinert (1987) suggested that ionophores may effect composition of gain in replacement heifers. Heifers fed ionophores tended to contain a greater proportion of fat relative to control animals (Meinert, 1987). Swanson (1967) indicated that heifers fed for rapid growth deposit intramammary adipose tissue instead of secretory tissue resulting in decreased milk production.

Also, excessively conditioned heifers are subject to dystocia and other metabolic disorders (Littledike, 1981). Because ionophores increase rate and efficiency of gain, it is possible that these compounds may alter composition of gain during the rearing period. Our objective was to determine effects of lasalocid on rate and composition of growth in replacement heifers reared in confinement (experiment 1) or pasture (experiment 2). Experiment 1 also evaluated the effect of protein degradability of the supplement on rate and composition of body weight gain.

CHAPTER II.

REVIEW OF LITERATURE

1. IONOPHORES IN RUMINANT DIETS

Ruminal Fermentation

The synergistic relationship between the functional rumen and associated microorganisms results in fermentation which converts portions of the diet to beneficial (VFA, microbial protein, B - vitamins), useless (methane, carbon dioxide) and even harmful (ammonia, nitrate) products to the host animal (Church, 1988). Van Soest (1970) estimated that 50 to 85% of the metabolizable energy used by ruminant animals consuming a forage-based diet was provided by VFA from fermentation, and Church (1988) reports 66 to 80% of the total energy was derived from fermentation in the rumen.

Rumen fermentation can influence feed utilization efficiency by: (1) affecting efficiency of VFA utilization by the animal;(2) affecting the partitioning of dietary energy or (3) by affecting the efficiency of hydrogen capture by the fermentation process (Orskov, 1975). Feeding ionophores to ruminant animals has been shown to increase performance and improve feed conversion efficiency. A

considerable quantity of literature has documented a shift in the proportions of fermentation end-products without affecting total VFA production. This shift in fermentation patterns toward an increase in the propionate : acetate ratio (Fuller and Johnson, 1981) and the interaction and alteration with cations and their transport across biological membranes (Reffett - Stabel, 1989) appears to account for the increased responses observed. Ionophores or polyether antibiotics such as monensin sodium and lasalocid sodium inhibit gram positive bacteria (e.g., *Ruminococcus albus*, *Ruminococcus flavefaciens* and *Butyrivibrio fibrosolvens*) and allow selection for gram negative bacteria (e.g., *Bacteroides succinogenes* and *Bacteroides ruminicol*) (Dennis, 1981; Church, 1988). This suggests that ionophores promote succinate-producing bacteria, which produce propionic acid from succinate precursors, and impede hydrogen and formate-producing bacteria which would decrease methanogenisis (Dennis, 1981; Church, 1988). Dennis (1981) reported that ionophores inhibit the growth of *Streptococcus bovis* and *Lactobacillus* species which are considered major lactic acid producers. Shaw (1960) suggested that the efficiency of ruminal fermentation may be limited by the efficiency of acetic and butyric acid metabolisms. Thus, the propionic acid fermentation pathway would be more energetically efficient.

This, in turn, would reduce loss of methane associated with the production of acetic and butyric acid (Wolin, 1960; Prangle, 1978; Potter, 1976). Prangle (1978) reported a 29.3% increase in molar percentage of propionic acid associated with monensin supplementation and estimated a 3% increase in feed efficiency associated with the application of monensin to supplements due to efficiency of conversion of hexose energy into VFA's. As well as energy savings associated with fermentation yielding propionic acid, efficiency of utilization of propionic acid in the tissues of ruminants may be higher than that of acetic acid (Blaxter, 1962). Further, propionic acid appears to increase nitrogen retention more than either acetic or butyric acid; if this is the case, responses to propionic acid may be mediated through a sparing of protein from gluconeogenesis (Richardson, 1976; Leng, 1967), or propionic acid could be preferred to acetic or butyric acid as the major energy source for protein synthesis (Richardson, 1976).

Ruminal Microbial Protein Synthesis and Crude Protein Degradability

Since ingested feed passes into the rumen before the abomasum, feed materials are subjected to microbial fermentation prior to host animal digestion. By relying on

a fermentative-type digestive process, ruminant animals are able to utilize low quality or dietary non-protein nitrogen (NPN) efficiently and can convert to a higher quality microbial protein (Satter and Roffler, 1975; Leng and Nolen, 1984). Energy conservation would occur if dietary nutrients could be digested in the small intestine instead of being fermented in the rumen. Cummings (1982) found that calves fed rations with minimum amounts of fermentable and degradable nitrogen, retention of nitrogen was greater per unit of metabolic size and nitrogen utilized more efficiently than calves fed rations containing higher fermentable nitrogen. However, when protein quality or quantity is poor, fermentation is essential (Church, 1988). Also, microbial activity is necessary to release energy trapped within plant cell walls (Church, 1988). Hume (1970) demonstrated that if intake energy is adequate and not limiting for maintenance of the animal, the ruminal microbial population has the capacity to satisfy the host's requirement for protein. Growth and regulation of the synthesis of bacteria is apparently associated with the rate or phase of growth in the rumen (Bergen, 1980). Harmeyer (1976) found that molar protein growth yield is related to microbial growth rate. Satter and Slyter (1974) estimated that the minimum amount of ammonia-N required for maximum microbial growth and protein production is 5 mg /100ml of

rumen fluid. This can be achieved under normal feeding with dietary crude protein content between 11 to 14% of dry matter (Satter and Roffler, 1975). Bacteria included in ruminal fermentation are found to be bound to the rumen wall, bound to the particle phase and unbound in the small particle liquid phase (Bergen, 1980). Microbial crude protein is flushed to the omasum, abomasum and then to the small intestine in association with other residual materials from the rumen (Church, 1988). Bacteria and protozoa represent not only a major portion of the animals diet but the largest portion of protein nitrogen supplied to the animal (Van Soest, 1982). This is accomplished by proteolysis which includes hydrolysis of peptide bonds and degradation of amino acids (deamination) (Tamminga, 1979). Church (1988) reported that microbial nitrogen represents 40% of the non-ammonia nitrogen entering the lower tract. Since larger organisms with less surface to total mass are generally more digestible, the digestibility of protozoa is higher than bacteria (Van Soest, 1982).

Most ruminal microbes utilize or require ammonia-N as a source of nitrogen (Bergen, 1980). Poos (1981) reported that production of amino-N *in vitro* decreased linearly with an increase in levels of the ionophore monensin. With ionophores altering the microflora of the rumen (Dennis, 1981), microbial protein synthesis can be expected to

decrease somewhat (Richardson, 1976), which leads to an increase in escape of dietary protein. Further, inhibiting key enzyme systems (NAD- and NADP-linked glutamate dehydrogenase) could reduce microbial protein synthesis and possibly inhibit microbial degradation of other dietary ingredients, such as cellulose (Chalupa, 1975; Tamminga, 1979).

Most feedstuffs, particularly forages, are composed of relatively insoluble, complex polymers (Russell and Hespell, 1981). Through mastication during both eating and rumination, rumen movements, and microbial activity, breakdown of feed materials can be achieved (Murphy and Nicoletti, 1984). Hungate (1966) suggested that particle size was important to fermentation rate, as extracellular enzymes of rumen bacteria act on smaller feed particles. Retention of feed materials in the reticulo-rumen was influenced by the physical characteristics of the feed particle, level of intake and associative effects of other ration ingredients (Satter, 1977). Tyrrell and Moe (1975) suggested that ration digestibility was negatively correlated with consumption per unit of time.

Ingested protein is divided into soluble versus insoluble, and degradable versus undegradable (Chalupa, 1984). According to Russell and Hespell (1981), protein solubility is dependent upon the distribution of hydrophobic

and hydrophilic amino acids on the periphery of the protein. When protein solubility is high, hydrophilic structures are exposed while hydrophobic residues are contained in the interior of the tertiary protein structure (Russell and Hespell, 1981). Proteins without terminal amino or carboxyl groups are less accessible to proteolytic enzymes and are less degradable (Chalupa, 1984). Species of *Bacteroides*, *Butyrivibrio* and *Selenomonas* appear to be more potent proteolytic bacteria (Chalupa, 1975). Degradation by bacteria and protozoa appears to be somewhat different (Tamminga, 1979). Bacteria hydrolyze the protein chain into smaller components outside the cell and are transported across the cell membrane where peptides are hydrolyzed further to amino acids, while protozoa appear capable of engulfing small feed particles as well as bacteria and proteolysis takes place inside the cell (Tamminga, 1979). Proteolytic protozoa include species of *Entodinium*, *Isotrichia*, *Eudiplodinium* and *Ophryoscolex* (Chalupa, 1975). Despite the protein-splitting capabilities of the rumen microflora, substantial amounts of ingested protein are resistant to degradation and bypass the rumen (Chalupa, 1975). Thus, amino acids introduced to the lower tract are supplied by microbial protein and dietary protein undegraded in the rumen (Clark, 1975; Church, 1988; Chalupa, 1984; Chalupa, 1975; Van Soest, 1982). Under normal conditions,

20 to 60% of dietary protein is not degraded in the rumen (Church, 1988; Chalupa, 1975). Wohlt (1976) found that feeding diets with protein sources that normally have slower rates of ruminal protein degradation decreased amino acid deamination in the rumen. Production and performance in ruminants have been improved when feedstuffs low in fiber and high in protein escape rumen fermentation and are digested post-ruminally (Chalupa, 1975; Clark,1975; Hedde, 1974; Little, 1967; Orskov, 1970). Black (1973) found gains in body weight, wool growth and retention of nitrogen and energy were greater for lambs provided with abomasal infusion of diet versus ruminal infusion. The efficiency of converting dietary protein to microbial protein is approximately 50% (Black, 1971; Chalupa, 1975). Chalupa (1975) reported that some plant protein is more digestible than microbial protein.

For ruminants, consideration should be given to two protein requirements; for the animal and for the microbes in the rumen (Tamminga, 1979). These two protein requirements may differ in terms of quantity and quality (amino acid composition) (Tamminga, 1979). The protein requirement absorbed from the small intestine appears to be related to the level of production (e.g., milk production, rapid growth) (Tamminga, 1979).

The value of escape protein increases as the protein

requirement of the animal increases (Clark and Davis, 1980). If the protein requirement is not met, intestinal flow of ruminally undegraded dietary protein should be increased (Tamminga, 1979). By increasing dietary protein content, poor utilization of the extra protein results due to the degradation in the rumen (Tamminga, 1979). Increasing dietary protein flow to the lower tract can be seen by protection of the protein from treatment or by application of an ionophore (Chalupa, 1975). However, ammonia-N levels may fall below minimum requirements for the rumen microbes (Beever, 1972).

Effects of Ionophores on Coccidia

Coccidiosis is a protozoal disease resulting in reduced feed intake and substantial weight loss and, in some cases, death of the animal (Fitzgerald and Mansfield, 1979). Horton (1982) found lasalocid to be an effective anticoccidial for cattle and sheep. Kuhl (1980) reported similar results by reducing oocysts passing in the feces form 97 to 17% by the 39th day when lasalocid was given at 44mg/kg of feed.

Conclusions

Ionophores appear to effectively shift ruminal fermentative patterns resulting in a lower acetate :

propionate ratio. By increasing molar concentrations of propionic acid, an increase in performance and feed efficiency has resulted. This shift is generally due to the selection of certain gram negative bacteria which produce propionic acid precursors. As well, ionophores appear to cause a protein sparing effect on ruminal fermentation by allowing more escape protein to the small intestine. A significant amount of data suggest that ruminants have two protein requirements with one being for the microflora in the rumen and the other for the animal itself. As the protein requirement of the animal increases, dietary protein to the lower tract also should increase. This can be accomplished by increasing amounts of undegradable protein or through other methods such as chemical treatment or the application of ionophores. Not only do ionophores appear to increase escape protein but they also appear to aid in the prevention of coccidiosis.

2. MEASURES OF BODY COMPOSITION

Linear Body Measurements

The relationship among three major body tissues (bone, muscle and fat) is not only of great importance to the meat industry (Jones, 1978) but also in the selection of prospective breeding stock (Busch, 1969). Of the three, fat

is the most variable (Jones, 1978 and Elsley, 1964). There is a long history of attempting to predict these tissue relationships or body composition through subjective measurements (Reid, 1955; Busch, 1969; Jones, 1978). However, actual measurements obtained from the live animal or linear body measurements have the advantage over subjective, human judgement because these measurements remain constant over time and are objective (Lush, 1928; Black, 1938; Guilbert and Gregory, 1952; Lush, 1932). Using Jersey cows and yearling heifers, Lush and Copeland (1930) obtained different body measurements and reported close agreement for repeatability in the two groups of cattle. Although research has shown conflicting results in performance and carcass characteristics in beef cattle, Black (1938) suggested that corrections for fat, bodyweight and age is critical if ratios of linear body measurements are the basis for prediction of performance and carcass traits. Yao (1953) suggested that height and length are measures of skeletal size, while heart girth and width are measures of thickness and heaviness.

In estimating performance and carcass characteristics utilizing linear body measurements, two categories exist: (1) those that increase with conditioning more rapidly than weight (e.g., heart girth, chest width and flank girth), and (2) those that increase with conditioning less rapidly than

weight (e.g., head body height and trunk) (Hawkins, 1979).

Height measured at the withers and hooks or hip are repeatable and accurate (Lush, 1928) and Kidwell (1955) reported that hip height was more closely associated with carcass traits than wither height in beef cattle. Black (1938) reported performance traits and wither height to be negatively correlated, which was in contradiction to Lush (1932) that height at the withers was positively correlated with higher gains based on linear measurements of steers.

Correlations between body length and average daily gain and feed conversion efficiency have been found to be negatively associated in beef cattle (Black, 1938 and Kohli, 1951). Lush (1932) reported higher body weight gains for steers longer from point of shoulder to pins. However, Ternan (1959), Kidwell (1955) and Cook (1951) reported no correlation between body length and animal performance in beef cattle.

Butts (1980) suggested that deep ribbed beef cattle tended to be early maturing and finished at lower weights. Black (1938) and Lush (1932) reported that deep bodied steers were less feed efficient and yielded less valuable carcasses.

Prediction of Body Composition From Dilution Techniques

Powel and Huffman (1968) reported that the most accurate estimation of body composition is chemical analysis of the entire carcass. However, with potential replacements and economic constraints, this is not feasible. Along with linear body measurements, dilution techniques *in vivo*, based on the constant relationship between weight of water in the empty body and the weight of water in the fat-free empty body have been suggested (Preston and Kock, 1973; Shebaita, 1977; Bartle, 1983; Odwongo, 1984; Arnold, 1985; Hammond, 1984; Rule, 1986). Although water and fat contents are highly variable, together they constitute 75 to 79% of the whole empty body (Reid, 1955). Thus, the fattening process appears to be largely replacement of water with fat (Reid, 1955). Moulton (1922) described the age at which concentrations of water, protein and mineral matter in fat-free cells become practically constant as chemical maturity. Shebaita (1977) suggested that the animal is chemically mature at birth. Although proportions of water decreases and proportions of protein and bone increase as animals age, water content of lean body mass apparently is constant (approximately 73%) (Reid, 1955). Shebaita (1977) suggests that the most often observed change in chemical composition of animals related to age and development is an increase in fat content. Thus, body weight alone does not appear to be

a standard of reference for body composition (Shebaita, 1977).

Garrett (1971) and Shebaita (1977) reported a sex difference in body water content. Reid (1955) reported that in beef cattle, cows have a higher water content in the fat-free body than steers. Garrett (1971) reported that beef heifers contain a significantly higher ash content than steers on a fat-free basis. Shebaita (1977) concludeed that mathematical corrections should be taken into account for sex of animals tested.

Dilution techniques involve infusion of a known quantity of material containing a biological tracer into the animal. After equilibration with body water, total body water is estimated from dilution of the tracer (Arnold, 1985; Bartle, 1983; Hammond, 1984; Rule, 1986; Preston and Kock, 1973). Specifications of tracers to measure body water include: (1) an even or rapid distribution throughout the body water; (2) should be without toxic manifestation or physiological effect; (3) should not be selectively stored, secreted, or metabolized; (4) an accurate and convenient estimation of its concentration in plasma or blood should be available; and (5) should not be a substance foreign to the body (Preston and Kock, 1973; Arnold, 1985).

In developing mathematical models, the dilution procedure should take into account diuretic effect of water

in the body (Preston and Kock, 1973). With ruminants, amount of water in the gastrointestinal contents appears to be higher than nonruminants (Arnold, 1985). This is accounted for by analyzing tracer concentrations before and after equilibrium which allows for two distinct distributions of body water (Arnold, 1985).

Deuterium Oxide Dilution

Isotope dilution involving the nonradioactive deuterated water as the tracer has been considered (Arnold, 1985; Odwongo, 1984). Ferrell and Jenkins (1984) utilized deuterium oxide with the Byers (1979) model with nonpregnant, nonlactating aged cows to create prediction equations by regressing empty body weight or empty body water on empty body composition. Arnold (1985) applied these equations to predict composition in 30 beef steers and concluded that predictions were inaccurate resulting in an overestimation of body water. Odwongo (1984) reported that deuterium oxide space overestimated total body water. It is possible that isotopes exchange with nonaqueous hydrogen not attached directly to carbon atoms (e.g., amino, carboxyl, imino and sulfhydryl groups) (Culebras and Fitzpatrick, 1977; Odwongo, 1984) thereby inflating estimates of body water. Lewis and Phillips (1972) reported that hydrogen exchange does occur. Culebras and Moore (1977) calculated

that hydrogen exchange would account for 5.2% of the overestimation of total body water. However, Odwongo (1984) reported that hydrogen isotope bonding to carbon atoms would be a significant source of error associated with rapidly growing animals or in late lactation when fat deposition normally occurs. Odwongo (1984) concluded that all body components, except body fat which requires total body weight as an additional parameter, may be estimated by deuterium oxide kinetic parameters.

Urea Dilution

Urea has been shown to be a substance suitable for use as a tracer for body composition estimation in similar fashion with deuterium oxide (Rule, 1986; Preston and Koch, 1973; Koch and Preston, 1979; Hammond, 1983; Bartle, 1983; Hammond, 1990). However, costs associated with urea and relative ease of urea N analysis appear to make this compound more applicable (Rule, 1983). Bartle (1983) reported that deuterium oxide requires several hours to determine body water turnover rate, which in turn is affected by the physiological state of the animal, making urea, which has rapid dilution, more usable. Models predicting body composition from urea dilution have been developed for steers (Preston and Koch, 1973; Rule, 1983; Hammond, 1983). However, if a relatively constant body

protein percentage is assumed, estimates may be imprecise when predicting body composition in younger, light-weight cattle. (Kelly, 1968 and Gil, 1970). Because differences exist in prediction of body composition from urea space with different breeds and types of cattle (Chigaiu and Holness, 1983), different equations are required for each cattle type. Hammond (1990) has reported models for predicting body composition in Holstein steers and concluded that urea dilution method can be used effectively for live body composition predictions.

Ultrasonic Measurements

Ultrasonic measurements, utilizing high frequency sound, has been found to be a promising estimator of fat thickness and protein deposition in live cattle (Temple, 1956). McReynolds and Arthard (1970) reported reasonable accuracy and repeatability in measuring body components in beef cattle by ultrasonic evaluation. Reynolds (1968) and Williams (1965) concluded that accurate predicitions of muscle : fat ratios can be achieved using ultrasonic measurements, while Leymaster (1985) concluded a lack of accuracy for lambs. Butts (1980) found that fat thickness measured by ultrasound was more accurate than subjective observations of fat depots. Watkins (1967) reported repeatable predictions of ultrasonic measurements when

evaluating subcutaneous fat thickness at the 12th rib.

For evaluating body fat, techniques have been described using cross-sectional outlines of the *l dorsi* muscle and calculating fat thickness associated (Stouffer, 1961). Significant repeatabilities, however, have been greater for swine than for cattle (Butts, 1980; Stouffer, 1961; Williams, 1965; Reynolds, 1968; Kempster, 1981). Possible sources of error include: positional variation of instrument and variability in pressure of transducer against the hide during probing (Stouffer, 1961 and Williams, 1965).

Conclusions

Linear body measurements, being objective and repeatable, have been shown to be better estimates of body composition than subjective observations. Body weight alone, however, is not the standard measurement due to varying degree of conditioning. Application of dilution techniques to measure empty body water has been shown to be effective as an indirect measurement of fat thickness and content. Although varying degrees of success have been reported, models accounting for differences among cattle types have produced promising results. Also, ultrasonic measurements have seen similar success in measuring fat deposition. Through the use of applicable models and measuring and sampling techniques, live body composition can

be predicted with reasonable confidence and accuracy.

3. SUMMARY AND OBJECTIVES

Existing data suggests that addition of ionophores will enhance ruminant animal performance and feed efficiency by altering ruminal fermentation. Monensin and lasalocid have been documented to be effective coccidiostats. Also, protein undegraded by the rumen has been shown to increase performance by providing higher levels of dietary protein to the lower digestive tract. Age at breeding could potentially be decreased in heifers by applying ionophores to the diet or increasing rumen escape protein to promote increased growth. However, data suggests that heifers fed for rapid growth tend to compromise later milk production by depositing adipose tissue instead of secretory tissue in the mammary gland. Data regarding body composition in heifers fed lasalocid and varying degrees of protein degradability is limited. Body composition predictions have been shown to be somewhat reliable from linear body measurements, dilution methods and ultrasonic evaluations.

The objectives of this study were to identify effects of lasalocid and protein degradability on composition of weight gain in replacement Holstein heifers.

CHAPTER III

MATERIALS AND METHODS

1. EXPERIMENT 1

Animal assignments and feed management

Thirty-two Holstein heifers (initial BW = 250 kg) were randomly assigned to a 2 x 2 factorial arrangement of undegradable intake prtoein (UIP) (calculated from tabular values) in supplement (30% (L) or 38% (H)) and lasalocid (0 or 200 mg/hd/day). Supplements (table 1) were commercially prepared supplements. Heifers were housed in an open barn in eight pens of four heifers per pen. Each pen was offered 12.7 kg/day of experimental growers once daily while medium-quality fescue hay was offered for ad libitum consumption. Hay refusals were weighed daily and feed samples were obtained weekly and composited monthly for analysis of total DM (AOAC, 1980), ADF (AOAC, 1980), NDF (Goering and Van Soest, 1970), Ca (atomic absorption spectrophotometry) and P (Hawk, et al,1948) (table 2). Experimental supplements were always consumed completely. Fresh water was accessible at all times.

Table 1. INGREDIENT COMPOSITION OF EXPERIMENTAL FEEDS

	Treatment[1]			
Item, % of DM	L0	L200	H0	H200
Corn, gr	31.4	31.3	49.3	48.9
Wheat midds	30.0	30.00	3.1	3.1
Soybean meal, 48%	5.1	5.1		
Cottonseed meal			9.5	9.5
Meat and bone meal			3.1	3.1
Fish meal			1.7	1.7
Urea	0.5	0.5		
Soy mill feed	24.1	24.2	25.3	25.8
Molasses	2.5	2.5	2.5	2.5
Fat	1.0	1.0	0.9	0.9
Minerals	5.4	5.4	5.4	5.4
Lasalocid		0.04		0.04

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

Body measurements

At the beginning of the study and every 28 days afterwards, BW, height (at the withers), length (point of shoulder to pins), circumference (at withers), hook width (exterior measurement of the tuber coxae) and forearm length (from elbow joint to the carpal joint. Ultrasonic fat thickness at the 13th rib (F13), between the hooks and pins, flank, brisket and muscle deposition (M13) at the 13th rib were measured at the beginning of the study and every eighty-four(84) days afterward. Measurements were taken using General Electric Dataline, 3.5 mghz scanning ultrasound.

Body composition

Body composition estimations were made for each animal at day 0 and every 84 days thereafter by a modification of the urea dilution procedure described by Koch and Preston (1979). A 20% solution of urea N (specific gravity=1.057 g/ml) in 9% saline was infused via jugular catheter at a rate of 130 mg/kg live BW during a 2-minute period with a peristaltic pump[1]. Blood was collected via jugular catheter at 0 (pre-infusion) and 12 min after mean infusion time (minutes of infusion/2 + starting time of infusion).

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[1]S-series veristaltic pump, Manostat, Inc.

Samples were added to 2 ul sodium heparin and placed on ice until plasma was separated in the laboratory. Plasma was frozen (-20^{0}c) until analyzed for urea-N by urease/Berthelet determination[2]. Change in urea-N concentration from 0 to 12 min was used to determine urea space percent body weight (US%LW), percent empty body water (%EBH_2O), percent empty body fat (%EBFAT), percent empty body protein (%EBPRO) using calculations of Hammond (1990). The models include:

%EBH_2O = 83.5 - 0.16US% x LW[3] - 0.32 x LW,

%EBFAT = -5.9 + 0.14US% x LW + 0.30 x LW,

%EBPRO = 16.6 - 0.009US% x LW + 0.005 x LW.

Fecal sampling and analysis

Fecal grab samples were taken at the beginning of the study and every 84 days afterward. A 4 g fecal sample was prepared with 28 ml of sodium nitrate and placed under a microscope for fecal coccidia oocyst count.

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[2]Urea nitrogen kit, Sigma Chemical Co.

[3]Live weight

2. EXPERIMENT 2

Animal assignments and feeding management

Twenty Holstein heifers were randomly assigned to one of two experimental, commercially formulated supplements containing 0 or 200 mg/hd/day lasalocid. Animals were placed on approximately 9.7 hectares of permanent fescue which was divided by portable electric fence. Each group was offered once daily 19.5 kg of the ration which consisted of 13.6 kg of cracked corn and 5.9 kg of supplement. When pasture could not support adequate growth, which was determined by season change, heifers were moved to a confinement lot where corn silage and supplemental fescue hay was provided for ad libitum consumption in addition to the concentrate. Pasture, forage (when necessary) and concentrate samples were taken weekly and composited monthly for analysis of DM, CP, ADF, NDF, Ca and P.

Body measurements

Heifers were measured at the beginning of the study and every 28 days afterward for BW, height, circumference, length, hook width and forearm as in Experiment 1. In addition ultrasonic fat measurements were taken at the beginning of the study and every 84 days afterward as in Experiment 1. Body composition was measured at the beginning

of the study and every 84 days by urea dilution method as in Experiment 1.

Fecal sampling and analysis

Fecal grab samples were taken at the beginning of the study and every 84 days afterward. Each sample was analyzed for fecal coccidia oocyst by sodium nitrate method.

Statistical

As in experiment 1, body measurements, fecal oocyst counts, estimations of body composition and pen feed efficiency were analyzed by split-plot design using the model: $Y_{ijk} = u + T_i + H_{(i)j} + P_{(k)} + (TP)_{ik} + e_{(ijk)}$, where:

Y_{ijk} = dependent variable,

u = overall mean,

T_i = effect of the ith treatment,

$H_{(i)j}$ = effect of the jth heifer within the ith treatment,

$P_{(k)}$ = effect of the kth period,

$(TP)_{ik}$ = effect of period x treatment interaction,

e_{ijk} = residual.

CHAPTER IV

RESULTS AND DISCUSSION

1. EXPERIMENT 1

Chemical composition of experimental growers and hay are listed in table 2. Crude protein was higher for lasalocid treatments (16.1 vs 15.2%). Neutral detergent fiber of hay (67.4%) was indicative of late vegetative stage cutting (NRC, 1988) possibly caused by drought conditions experienced in the Southeast during 1989.

Heifers were generally healthy throughout the experiment. Two cases of foul foot were reported and were treated by veterinarian.

Although total dry matter intake (hay + grain) was affected by period, DMI was similar between the four treatments (Table 3). Crude protein and acid detergent fiber intake was the same for each treatment averaging 1.1 and 3.0 kg, respectively. Also, NDF intake was not significantly different between treatments. Gain to feed ratio (Table 3) was similar for the treatments. Gain to feed ratio was lower and did not show the feed efficiency response to lasalocid reported by Thonney (1981) or Brown and Davidovich (1979). Final feed intake values (Table 4)

Table 2. CHEMICAL COMPOSITION OF FEEDS

	Treatment[1]				
ITEM[2]	L0	L200	H0	H200	Hay
DM	87.7	87.8	87.3	87.8	86.4
CP*	15.2	16.1	15.7	16.1	10.7
ADF*	16.4	17.2	16.6	14.2	42.0
NDF*	31.6	31.6	29.4	26.3	67.4
Ca**	11.0	11.6	9.8	10.8	6.1
P**	6.8	6.9	6.5	7.0	3.5

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

[2]Mean of 9 observations.

* % of DM. ** mg/g of DM.

Table 3. LEAST SQUARES MEANS OF FEED INTAKE

Item[3]	Treatments[1]				SE	contrasts[2]		
	L0	L200	H0	H200		1	2	3
DMI	8.8	8.7	8.8	8.7	0.1	NS	NS	NS
CPI	1.1	1.1	1.1	1.1	0.01	NS	NS	NS
ADI	3.0	3.0	3.0	3.0	0.1	NS	NS	NS
NDI	5.0	4.9	5.0	4.8	0.08	NS	NS	NS

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

[2]contrasts: 1=lasalocid vs. no lasalocid; 2=high UDP vs. Low UDP; 3=interactions; NS=P >.05.

[3]DMI=total dry matter intake,kg; CPI=crude protein intake, kg; ADI=acid detergent fiber intake, kg; NDI=neuteral detergent fiber intake, kg.

Table 4. LEAST SQUARES MEANS OF FINAL FEED INTAKE

	Treatments[1]					Contrasts[2]		
Item[3]	L0	L200	H0	H200	SE	1	2	3
DMI	9.3	9.4	9.4	9.4	0.005	NS	NS	NS
CPI	1.1	1.2	1.1	1.2	0.0006	NS	NS	NS
ADI	3.2	3.2	3.3	3.2	0.002	NS	NS	NS
NDI	5.4	5.4	5.4	5.3	0.004	NS	NS	NS
G:F	0.7	0.7	0.8	0.7	0.01	NS	NS	NS

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

[2]contrasts: 1=lasalocid vs. no lasalocid; 2=high UDP vs. Low UDP; 3=interactions; NS=p >.05.

[3]DMI=total dry matter intake,kg; CPI=crude protein intake, kg; ADI=acid detergent fiber intake, kg; NDI=neuteral detergent fiber intake, kg; G:F=gain to feed ratio.

were found to be similar between treatments. Heifers quickly adjusted to concentrate, however, each pen was required to consume all offered hay before receiving any increasing increment of hay. Because hay digestibility may have limited intake, gain may have been limited, which may explain the non-significant results.

Body weights and heights measured at the initiation of the study (period = 0) are shown in Table 5. These data, which did not vary among treatments, indicate relatively homogenous groups of similar weight and height. Heifers fed L0 were 6.8 kg lighter than other heifers, although this difference was not significant. Heifers averaged 8.5 months of age at the start of the study. According to the NRC (1988), body weights are consistent with expected values for animals this age.

Initial estimates of body fat taken by ultrasound (Table 5) did not vary by treatment and averaged 2.5 and 37.6 mm for fat and muscle depth, respectively. Estimates of initial body composition made by urea dilution (Table 5), on the other hand, indicated that heifers on low UIP diets began the study with less body water and fat than other heifers ($P < .05$). However, the differences in body water and fat were not reflected in increased body protein. It seems likely that these differences may be an artifact of the procedure, as the amount of bone in young animals does

Table 5. LEAST SQUARES MEANS OF INITIAL BODY, ULTRASONIC, UREA DILUTION AND COCCIDIA MEASUREMENTS

	Treatments[1]					Contrasts[2]		
Item[3]	L0	L200	H0	H200	SE	1	2	3
BW	247.9	254.2	256.6	253.2	4.0	NS	NS	NS
BH	110.2	111.3	111.5	110.5	0.6	NS	NS	NS
13F	2.3	2.6	2.6	2.4	0.1	NS	NS	NS
13P	38.1	37.5	37.3	37.4	0.8	NS	NS	NS
US	56.2	44.1	61.2	62.9	2.6	NS	*	NS
USF	9.3	7.7	10.3	10.3	1.0	NS	*	NS
USP	17.3	17.4	17.3	17.3	0.03	NS	NS	NS
Coc	112.5	71.9	115.6	128.1	20.1	NS	NS	NS

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

[2]contrasts: 1=lasalocid vs. no lasalocid; 2=high UDP vs. Low UDP; 3=interactions; NS=P>.05; *=P< .05.

[3]BW=body weight, kg; BH=body height, cm; 13F=fat over 13th rib, mm; 13P=protein depostition at 13th rib, mm; US=urea space, %; USF=body fat, %; USP=body protein, %; Coc= coccidia, oocysts/g.

not appear to vary markedly between animals of the same size and age (Reid, 1955). Initial coccidia estimates (Table 5), also, were found to be similar for each treatment.

Body measurements taken at the end of the experiment (period = 12) are shown in Table 6. Animals averaged 20.5 months of age, weighed 464 kg, were 132 cm tall and 154 cm long. No differences were detected in any variable measured at the end of the study. Body weights in Table 6 are slightly lower than those suggested by NRC (1988) for heifers this age.

Though not significantly different, final body weight, circumference, fat between hooks and pins and at brisket tended to be greater in heifers on L200 and H0 treatments than other heifers ($P < .17$). On the other hand, final measurements of fat and muscle at the 13th rib tended do be greater and urea space (i.e. total body water) less in heifers fed lasalocid, although these trends were not significant ($P < .17$). Coccidia (Table 6), as well, were similar across treatments.

Least squares means of body measurements across all time periods (Table 7) indicate few statistically significant differences between variables measured. Paterson (1983) reported lambs gained 35% faster when fed high UIP supplemental protein. Results from this study reveal that BW was not affected by treatment. There was,

Table 6. LEAST SQUARES MEANS OF FINAL BODY, ULTRASONIC, UREA DILUTION AND COCCIDIA MEASUREMENTS

	Treatments[1]					Contrasts[2]		
Item[3]	L0	L200	H0	H200	SE	1	2	3
BW	455.0	464.3	479.1	459.9	5.1	NS	NS	NS
BH	131.9	131.0	133.0	132.6	0.5	NS	NS	NS
CM	177.8	179.5	181.5	177.3	0.8	NS	NS	NS
LN	155.1	153.7	153.7	154.3	0.7	NS	NS	NS
FL	40.3	39.5	40.2	39.7	0.2	NS	NS	NS
13F	8.3	8.5	8.1	8.4	0.2	NS	NS	NS
13P	57.9	63.0	59.0	61.3	0.9	NS	NS	NS
HF	7.5	7.9	7.8	7.6	0.2	NS	NS	NS
BF	10.1	10.3	10.8	11.0	0.3	NS	NS	NS
FF	8.1	8.1	8.9	8.1	0.2	NS	NS	NS
US	50.0	48.8	49.3	45.6	1.7	NS	NS	NS
USF	14.7	14.7	15.4	14.3	0.3	NS	NS	NS
USP	18.4	18.5	18.6	18.5	0.02	NS	NS	NS
Coc	37.5	31.3	40.6	33.3	2.6	NS	NS	NS

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

[2]contrasts: 1=lasalocid vs. no lasalocid; 2=high UDP vs. Low UDP; 3=interactions; NS=P>.05.

[3]BW=body weight, kg; BH=body height, cm; 13F=fat over 13th rib, mm; 13P=protein depostition at 13th rib, mm; US=urea space, %; USF=body fat, %; USP=body protein, %; Coc=coccidia,oocyst/g.

Table 7. LEAST SQUARES MEANS OF BODY, ULTRASONIC AND UREA DILUTION MEASUREMENTS AND COCCIDIA

	Treatments[1]					Contrasts[2]		
Item[3]	L0	L200	H0	H200	SE	1	2	3
BW	369.1	378.7	388.8	377.0	8.7	NS	NS	NS
BH	124.6	123.9	126.1	124.3	0.9	NS	NS	NS
CM	173.3	174.6	177.3	171.6	1.3	*	NS	**
HW	43.2	44.0	44.4	43.5	0.5	NS	NS	NS
LN	145.2	143.7	143.7	145.2	1.1	NS	NS	NS
FL	37.0	36.6	37.0	36.9	0.2	NS	NS	NS
13F[4]	7.4	8.5	8.7	8.0	0.4	NS	NS	*
13P[4]	54.1	57.3	56.3	53.9	1.2	NS	NS	*
HF	7.8	7.9	8.1	7.8	0.2	NS	NS	NS
BF	11.1	12.1	12.0	11.7	0.3	NS	NS	NS
FF	9.3	9.7	9.5	9.0	0.3	NS	NS	NS
US[4]	64.2	54.3	49.4	60.4	6.7	NS	NS	NS
USF[4]	14.5	13.2	13.0	14.1	1.0	NS	NS	NS
USP	17.9	18.1	18.2	18.0	0.1	NS	NS	*
Coc	46.1	43.0	38.3	42.2	6.1	NS	NS	NS

[1]treatments: L0=low UIP, 0mg lasalocid; L200=low UIP, 200mg lasalocid; H0=high UIP, 0mg lasalocid; H200=high UIP, 200mg lasalocid.

[2]contrasts: 1=lasalocid vs. no lasalocid; 2=high UDP vs. Low UDP; 3=interactions; NS=P >.05; *=P <.05; **=P <.01.

[3]BW=body weight, kg; BH=body height, cm; 13F=fat over 13th rib, mm; 13P=protein depostition at 13th rib, mm; US=urea space, %; USF=body fat, %; USP=body protein, %; Coc=coccidia,oocyst/g.

[4]significant period x treatment interaction (P <.05)

however, a significant period x treatment interaction (Figure 1). This phenomenon may have been due to unusually hot and cold temperatures experienced during the course of the study. Body circumference, fat and muscle depth at the 13th rib and body protein percentages were greater in heifers fed L200 and H0 than other treatments. A significant period x treatment interaction was observed with these two variables, as well as for flank fat, and are shown in Figures 2, 3 and 4. However, other variables (body weight, hook width, fat between hooks and pins, brisket fat depth and flank fat depth) tended to be greater in these heifers, supporting the observations that heifers receiving L200 and H0 were heavier, with a somewhat greater circumference, greater muscle and fat thickness and reduced body water as a percent of total body weight.

Coccidia oocyst count was similar for each treatment (table 7). With the low oocyst counts experienced throughout the trial, animals were apparently not stressed from coccidia and a lack of response from lasalocid could be expected.

Results suggest that total protein introduced to the lower tract with animals fed lasalocid may have been limited. Poos (1979) suggested that ionophores may exhibit a protein or N-sparing effect. Ionophores have been shown to decrease microbial protein synthesis as much as 42%

Figure 1. Body Weight (Experiment 1)

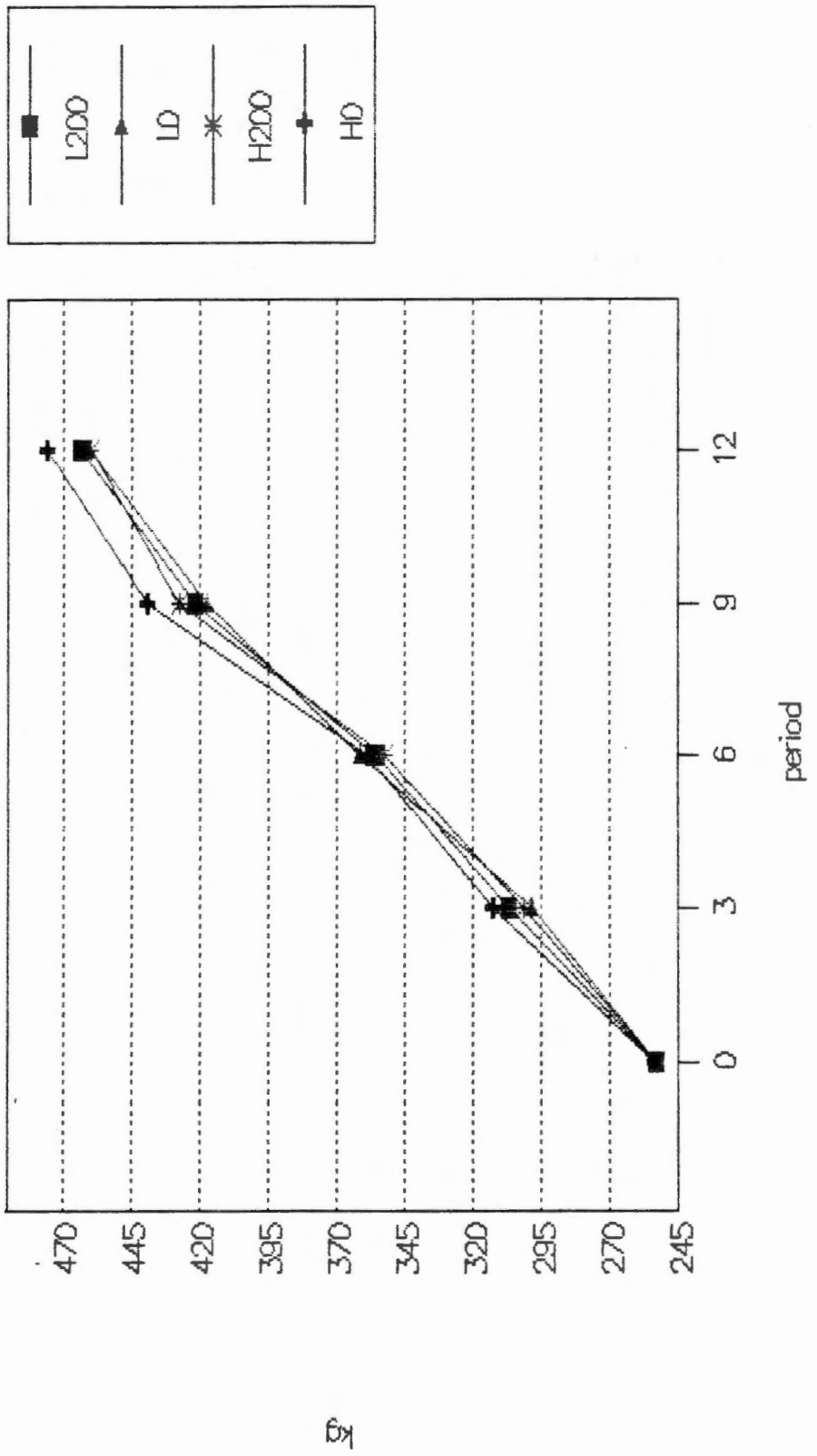


Figure 2. 13th Rib Fat (Experiment 1)

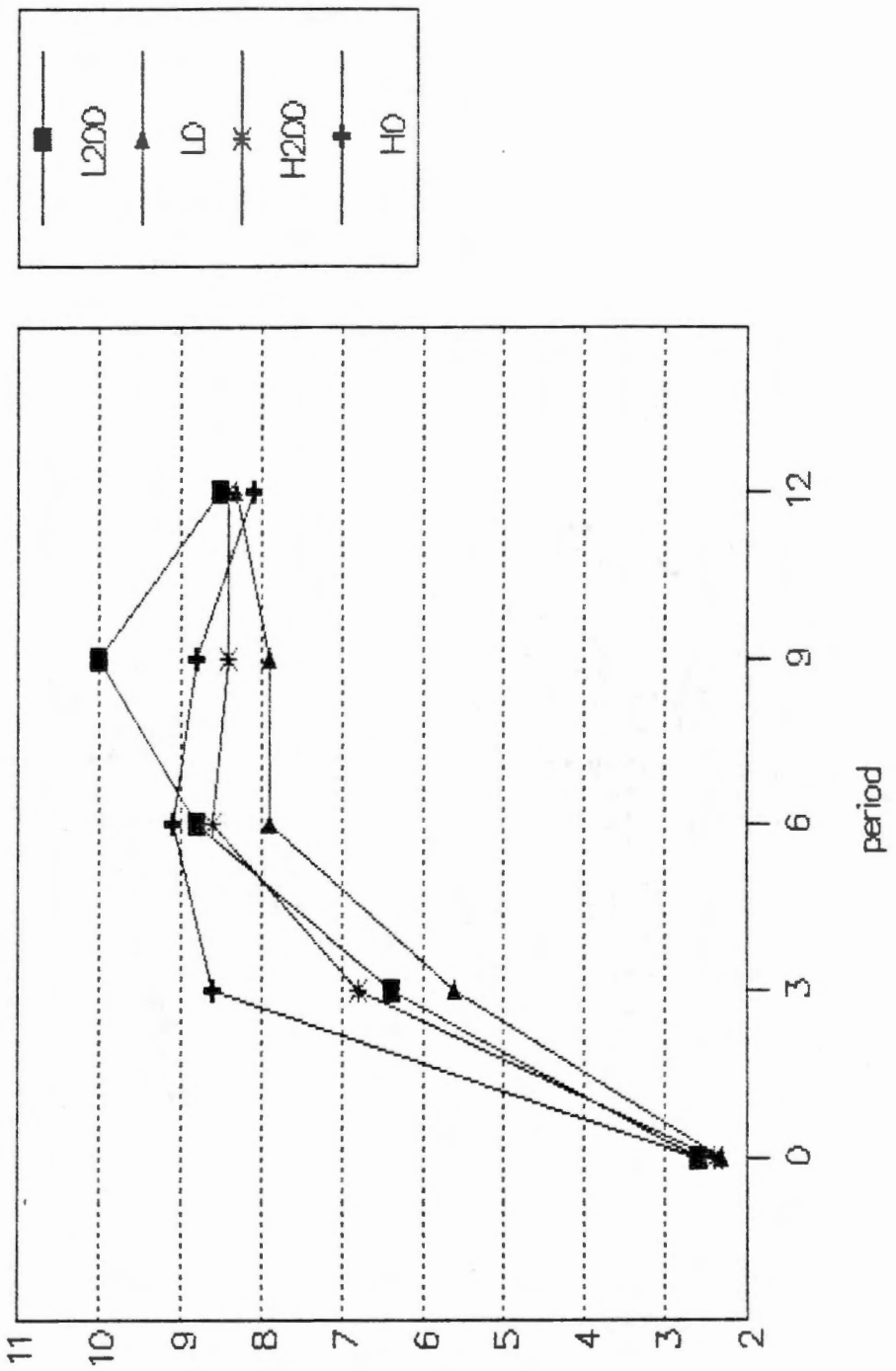


Figure 3. 13th Rib Protein (Experiment 1)

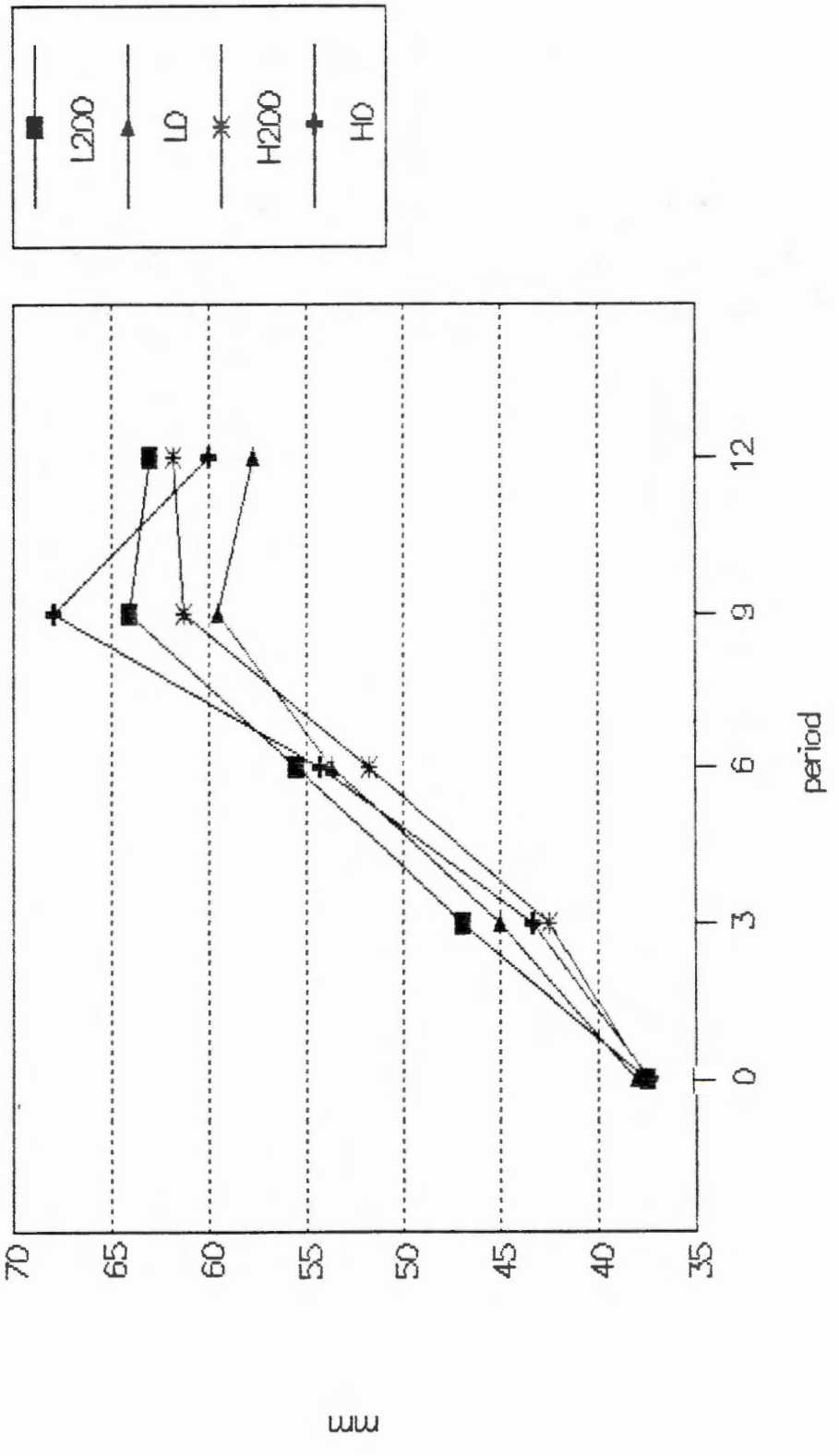
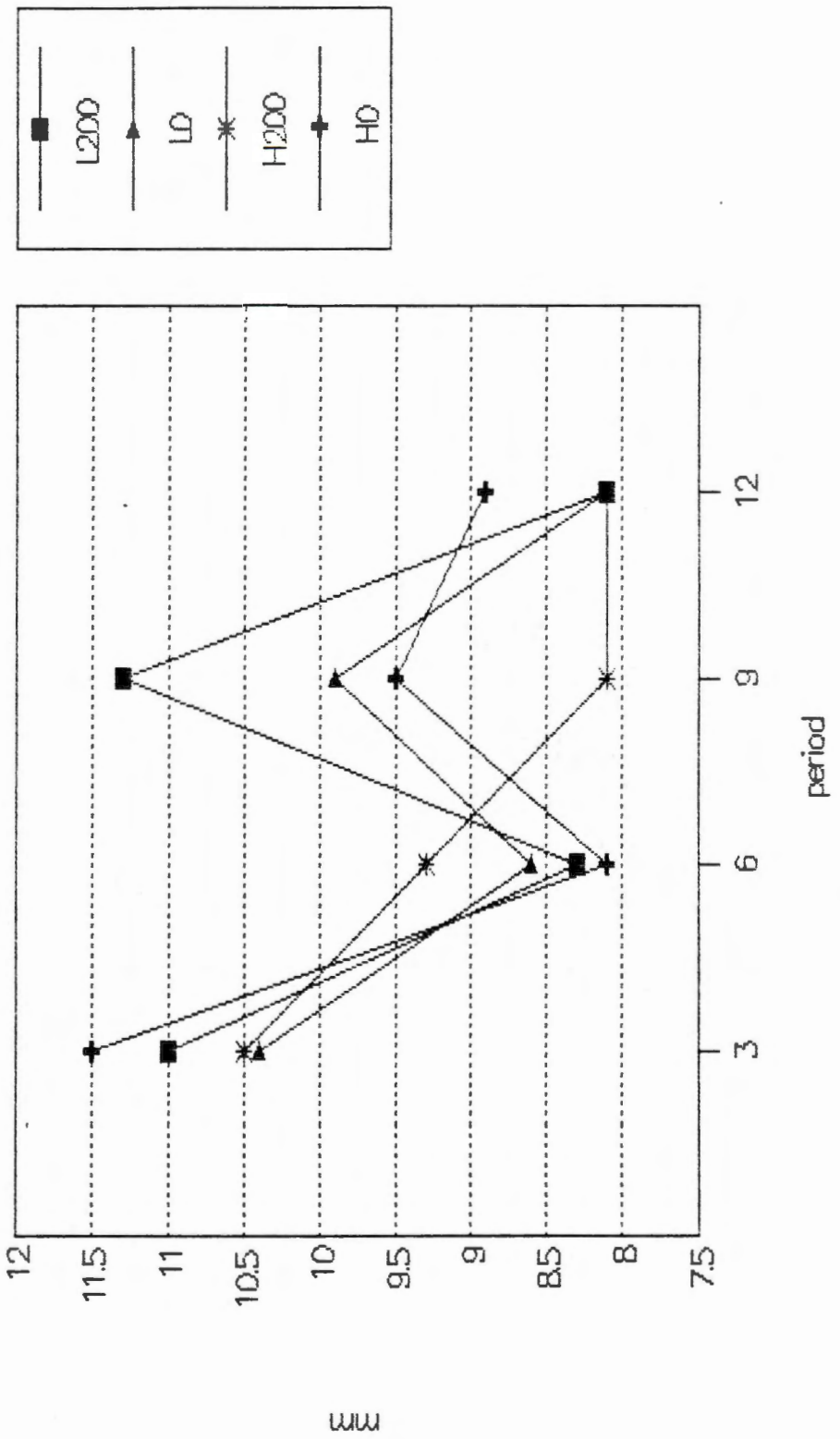


Figure 4. Flank Fat (Experiment 1)



(Bartley, 1979). Bryant (1970) suggested that rumen microflora prefer nitrogen from ammonia than amino acids. Rumen ammonia concentrations have been decreased by adding monensin (Dinius, 1976) by decreasing protein deamination or inhibiting hydrolysis of urea to ammonia. When protein quality or quantity is low, ruminal fermentation is necessary (Church, 1988). With the application of the ionophore, in addition to higher undegradability of the protein supplement, ruminal microbial protein synthesis may have been impaired due to insufficient microbial nitrogen.

Although microbial protein synthesis and protein degradability were not directly measured in this experiment, estimates were calculated using formulas taken from NRC requirements of dairy cattle (1988). Formulas include:

Total protein = BCP[4] + UIP,

$$BCP = 6.25(-31.86 + 26.12 \times TDN).$$

These calculations utilized NRC tabular values of chemical composition of feeds and intakes recorded throughout the experiment. Requirements were interpolated for each treatment from NRC requirements of dairy cattle (1988) for large-breed growing females gaining 600 g/d and averaged into one for comparisons. Estimates (Figure 5) show that protein probably was within acceptable levels through period

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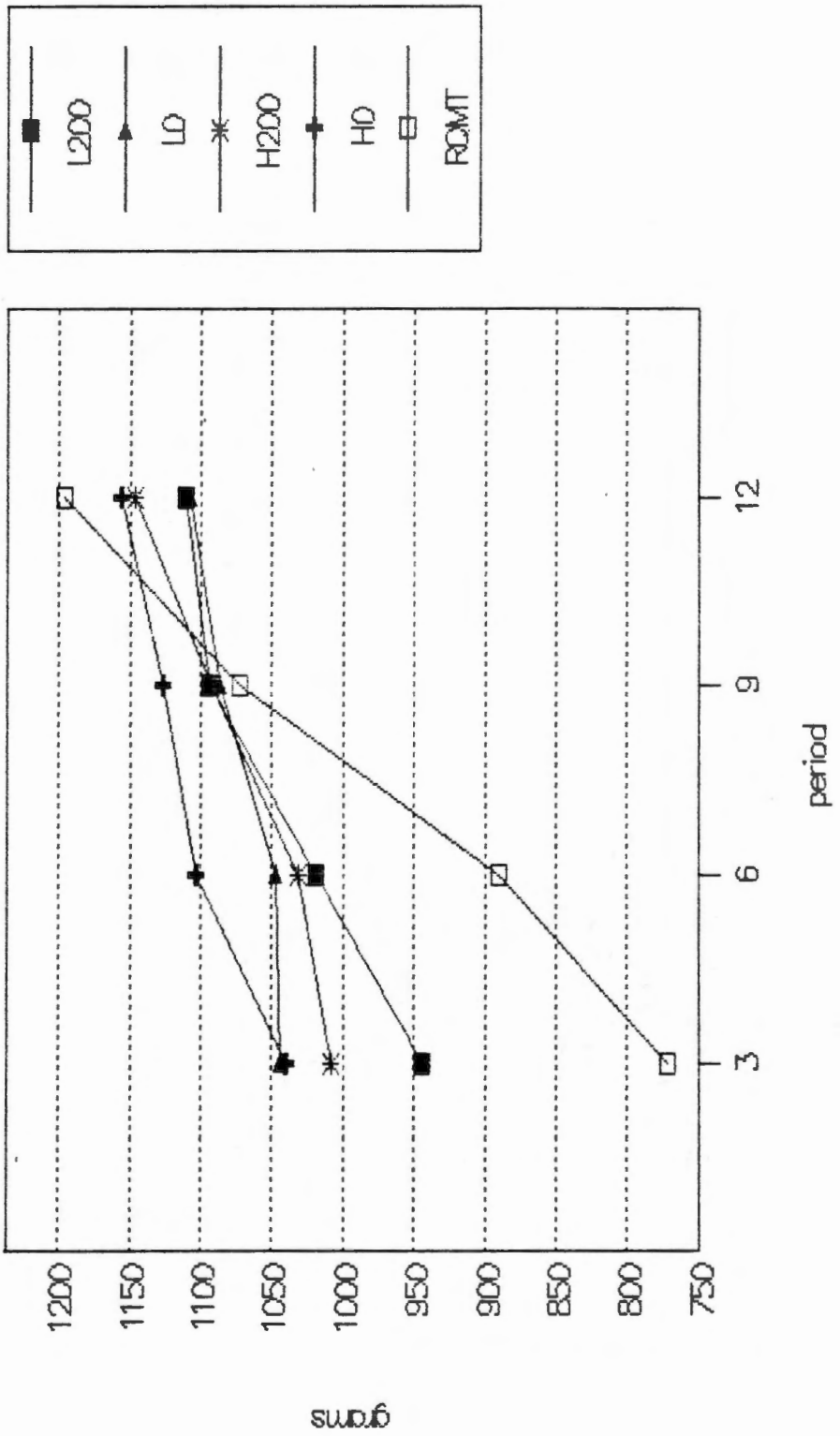
[4]Bacterial crude protein

Figure 5. Estimated Crude Protein Levels Passed to the Small Intestine



10. Protein potentially was deficient for all animals during periods 11 and 12 possibly due to low digestibility of hay. However, microbial protein, particularly for animals fed H200, may have been depressed and, thus, had decreased total protein available for absorption in intestinal tract. This would possibly explain the lack of muscle depth at the 13th rib seen with ultrasonic measurements and urea space body protein percentage. Also, the potential decrease in microbial proliferation could possibly decrease intake and potentially account for the lack of significant feed efficiency and possibly explain the non-significant weight gain and growth differences.

2. EXPERIMENT 2

Chemical composition of commercially formulated experimental supplements, grain and supplemental forage are shown in Tables 8 and 9. Average CP was higher in control supplement (37.4 vs 32.5%) possibly due to variations in least cost formulations. Neutral detergent fiber was slightly higher in lasalocid supplement (41.0 vs 38.7%) and in hay (72.3%) potentially due to the 1989 drought experienced in the Southeast. Total intake data was not measured in this experiment as animals were managed on pasture.

TABLE 8. CHEMICAL COMPOSITION OF SUPPLEMENTS[1]

Item	Supplement 1	Supplement 2
DM	87.1	88.8
CP*	37.4	32.5
ADF*	26.8	26.7
NDF*	38.7	41.0
Ca**	34.8	36.2
P**	9.8	7.3

[1]Mean of 8 observations.

* % of DM.

** mg/g DM.

TABLE 9. CHEMICAL COMPOSITION OF CORN[1], PASTURE[2], CORN SILAGE[3] AND HAY[4]

Item	Grain	Pasture[5]	Pasture[6]	Corn Silage	Hay
DM	86.5	32.6	39.0	36.7	89.8
CP*	9.6	14.5	14.2	7.9	9.3
ADF*	4.4	36.1	36.5	29.4	45.6
NDF*	21.4	68.8	68.4	54.2	72.3
Ca**	0.6	5.6	5.0	2.9	6.2
P**	3.2	6.9	6.2	2.8	3.4

[1]Mean of 8 observations.

[2]Mean of 6 observations.

[3]one observation.

[4]Mean of 4 observations.

[5]Pasture grazed by control animals.

[6]Pasture grazed by animals receiving lasalocid.

* % of DM.

** mg/g DM.

At the beginning of the experiment, heifers averaged 6 months of age. Body weights and heights measured initially (period = 0) are listed in Table 10. Although not significant, control heifers were 5.9 kg heavier and 1.3 cm shorter than heifers fed lasalocid. These data suggest that heifers were relatively uniform in weight and stature and representative of animals of this age according to NRC (1988) suggestions.

Initial fat thickness over the 13th rib for control heifers recorded by ultrasound (Table 10.) was 0.5 mm less than lasalocid heifers, however, this was not significant. Further, although not significant, control heifers had 12.1% decrease in urea space% (body water), a 1.6 % decrease in urea space body fat % and 25 oocyst/g decrease incoccidia numbers over heifers fed lasalocid. Other variables were similar between treatments.

Upon completion of the experiment (period = 12), no differences existed between heifers, however, control heifers had 3.6 mm more protein at the 13th rib ($P< .12$) than heifers fed lasalocid. Heifers finished the study slightly underweight, according to NRC (1988) suggestions, and, subsequently, were bred approximately 2 months later than expected due to lighter weights and normal management practices. At the end of the study, control heifers finished the study with a 10.8 oocyst/g increase over

TABLE 10. LEAST SQUARES MEANS OF INITIAL BODY, ULTRASONIC, UREA DILUTION MEASUREMENTS AND COCCIDIA

Item	Treatments[1]		SE	P[2]
	Control	Lasalocid		
BW	192.5	186.6	4.0	NS
BH	102.6	103.9	0.7	NS
13F	2.0	2.5	0.2	NS
13P	34.3	36.3	1.1	NS
HF	7.2	9.9	0.7	NS
BF	11.9	12.4	0.6	NS
FF	11.2	10.6	0.4	NS
US	47.0	59.1	4.8	NS
USF	6.4	8.0	0.6	NS
USP	17.2	17.4	0.2	NS
Coc	70.0	95.0	18.5	NS

[1]BW=body weight, kg; BH=body height, cm; 13F=fat over 13th rib, mm; 13P=protein depostition at 13th rib, mm; HF=fat between hooks and pins, mm; BF=brisket fat, mm; FF=flank fat, mm; US=urea space, %; USF=body fat, %; USP=body protein, %; Coc= coccidia, oocyst/g.

[2] NS=P >.05.

lasalocid heifers, although this was not significant (P= .14) (Table 11). Least squares means of body measurements for all time periods are listed in Table 12. Period affected body measurements, and, numerically, BW tended to be increased for control vs. lasalocid heifers, however, this difference was not significant. Paterson (1983) reported similar results when feeding supplemental protein containing lasalocid to pastured beef steers, although additional protein increased performance over cattle receiving no supplement. Treatment did not significantly influence body height, body circumference, hook width, body length or forearm length.

Similar to experiment 1, control animals had increased (P< .05) muscle depth at the 13th rib. Treatment means were 52.5 and 49.0 mm, respectively. Heifers fed lasalocid tended to have increased urea space percent and decreased urea space body fat percent, although not significant. The large variation associated with urea space body fat percent, as can be seen by the increased SE is potentially due to heifers being young and relatively light weight during early phases of the experiment.

Results suggest that protein quantity may have been insufficient to maintain increased rates of growth. Increased protein deposition, particularly muscle depth at the 13th rib possibly was caused by increased CP associated

TABLE 11. LEAST SQUARES MEANS OF FINAL BODY, ULTRASONIC, UREA DILUTION MEASUREMENTS AND COCCIDIA

Item	Treatments[1]		SE	P[2]
	Control	Lasalocid		
BW	433.8	423.8	4.8	NS
BH	128.1	127.3	0.7	NS
CM	174.6	174.0	0.6	NS
LN	145.0	144.8	1.0	NS
FL	36.6	36.4	0.3	NS
13F	8.8	8.8	0.2	NS
13P	55.7	52.0	1.1	NS
HF	9.8	9.1	0.6	NS
BF	14.5	14.7	0.4	NS
FF	10.4	11.6	0.4	NS
US	45.3	48.8	2.9	NS
USF	13.4	13.8	0.5	NS
USP	18.4	18.3	0.03	NS
Coc	46.9	36.1	3.3	NS

[1]BW=body weight, kg; BH=body height, cm; 13F=fat over 13th rib, mm; 13P=protein depostition at 13th rib, mm; HF=fat between hooks and pins, mm; BF=brisket fat, mm; FF=flank fat, mm; US=urea space, %; USF=body fat, %; USP=body protein, %; Coc=coccidia, oocyst/g.

[2]NS=P >.05.

TABLE 12. LEAST SQUARES MEANS OF BODY, ULTRASONIC, UREA DILUTION MEASUREMENTS AND COCCIDIA

Item	Treatments[1]		SE	P[2]
	Control	Lasalocid		
BW	311.4	306.2	5.8	NS
BH	121.0	121.4	0.9	NS
CM	159.0	158.2	2.5	NS
HW	39.8	40.1	0.4	NS
LN	134.7	133.5	0.9	NS
FL	35.1	35.0	0.3	NS
13F	8.3	8.6	0.2	NS
13P	52.5	49.0	1.0	*
HF	8.9	9.0	0.3	NS
BF	11.9	12.2	0.3	NS
FF	10.8	11.0	0.3	NS
US	53.0	64.0	8.1	NS
USF	33.5	15.4	14.5	NS
USP	17.8	17.7	0.1	NS
Coc	60.8	36.6	5.2	*

[1]BW=body weight, kg; BH=body height, cm; 13F=fat over 13th rib, mm; 13P=protein depostition at 13th rib, mm; HF=fat between hooks and pins, mm; BF=brisket fat, mm; FF=flank fat, mm; US=urea space, %; USF=body fat, %; USP=body protein, %; Coc=coccidia, oocyst/g.

[2]NS=P >.05; *=P< .05.

with the control supplement. In addition, because intake data was not collected, estimation of total protein could not be achieved. However, results are similar to experiment 1 and, although microbial protein synthesis and protein degradability were not measured, suggests that heifers fed lasalocid may have lacked sufficient total protein. This would further support Church (1988) in that ruminal fermentation is critical when protein quantity and quality is deficient.

Animals fed lasalocid had significantly lower coccidia oocyst counts (table 11). Treatment means were 36.6 and 60.8 oocyst/g, respectively. Although coccidial counts were low, these data support Bartley (1979) and further suggests that lasalocid is an effective coccidiostat.

CHAPTER V

CONCLUSIONS

Protein source (experiment 1) and lasalocid (experiments 1 and 2) did not affect rates of gain in heifers. In experiment 1, heifers tended to have increased performance when fed H0. Body composition and fat deposition throughout the growing phase, seen by lack of significant increases in ultrasonic fat thickness and urea space body fat percent, does not appear to be adversely affected by lasalocid. Coccidial infections were not a problem during the experiments, however, lasalocid did effectively reduce coccidial oocyst numbers in experiment 2. Data suggest that addition of lasalocid to supplements may have impaired microbial protein production, thus, decreasing potential total protein flow to the lower tract, which, in turn, may have caused decreased protein deposition and muscle depth. Alternatively, feed efficiency and increased gain : feed ratio was not supported in experiment 1.

Further work is necessary to evaluate and determine the association of DIP, UIP, ionophores and ruminal microbial protein synthesis and its effects on growth and protein deposition in heifers.

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