PROTEIN LEVELS WITH AND WITHOUT MONENSIN FOR FINISHING STEERS

by

WILLIAM R. THOMPSON

B.S., Kansas State University, 1977

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1979

Approved by:

Major Professor

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGMENTS

Sincere appreciation is expressed to Dr. Jack Riley, major professor, for his advice, counseling and encouragement throughout the author's graduate study. The interest and concern which Dr. Riley has shown the author as both a student and as an individual has made the graduate program enjoyable.

The author also wishes to thank Dr. Keith Bolsen and Dr. Ben Brent for serving on the graduate committee. The author is especially thankful for being able to work with Dr. Bolsen not only with the research included in this thesis but in several other research projects.

A thank you is extended to Steve Plegge and Harvey Ilg for their unselfish assistance and friendship during my two years of graduate study.

This thesis is dedicated to the author's parents, Mr. and Mrs. Ralph C. Thompson, without whose support and encouragement this thesis and many other accomplishments would not have been possible. The author is extremely thankful to have parents who have shown concern, encouragement and support throughout all of his endeavors.

LITERATURE REVIEW

Protein Levels for Finishing Cattle

Protein Levels for Calves

Thonney et al. (1972) reported similar performance for 256 kg Hereford and Charolais x Hereford steers fed ration crude protein levels of 10.6, 12.0, 13.5 and 15.0% for 163 days. Daily gain and efficiency of gain were 1.34, 5.8; 1.37, 5.7; 1.41, 5.6; and 1.42, 5.6 kg, respectively. In contrast, Peterson et al. (1970) reported faster ($P<.05$) and more efficient gains for steers (average initial wt., 240 kg) fed 13% crude protein rations compared to steers fed 9, 11, 15 and 17% rations or those fed rations decreasing in crude protein content from 17 to 9% at five week intervals. Rations were fed to Angus and Angus x Hereford steers for 175 days. This agrees with Fontenot and Kelly (1967) who reported gains of weanling calves to be higher ($P<.05$) when ration crude protein was 12.9% compared to 9.2 or 17%. Calves fed the 9.2% rations gained the slowest and were the least efficient. An earlier report by Fontenot and Kelly (1963) stated that daily gain and efficiency of gain increased as ration crude protein fed to weanling calves increased from 9.9 to 14.7%. According to Haskins et al. (1967), daily gain increased ($P<.05$) for Hereford steer calves (average initial wt., 242 kg) fed ration crude protein levels of 14 vs. 11% for 190 days. Daily gains were 1.13 and

1.06 kg, respectively. Hereford steers initially weighing 227 kg were fed 12.5 and 14.2% crude protein rations for 138 days (Wilson et al., 1972). Daily gains were higher (P<.05) for calves fed the 14.2% rations (1.37 vs 1.30 kg). Preston and Cahill (1973) observed that as ration crude protein increased from 8.2 to 12.5%, daily rate of gain was increased by .154 kg and efficiency improved by .318 kg. Steers initially weighed 281 kg and were fed for 154 days.

In a study by Williams et al. (1969), bulls were fed 11 and 13% crude protein rations from 233.6 to 362.9 kg and 10 and 12% from 362.9 to 435.4 kg for the low and high protein levels, respectively. The higher protein level supported slightly faster and more efficient gains. The following four ration crude protein treatments were fed to Holstein steers (average initial wt., 114 kg): 15% continuously, 11% continuously, decreasing levels of 14, 12 and 10%, and decreasing levels of 18, 15 and 12% (Kliewer et al., 1969). Steers fed the 11% crude protein ration gained the slowest and were the least efficient. Rolled corn diets containing various crude protein levels were fed to Holstein bulls for 245 days by Williams et al. (1971). Ration crude protein levels were: 14, 12 and 10% for the first 112 days; 11, 10 and 9% for the next 84 days; and 10, 9 and 8% for the final 48 days. During the first 112 days, daily gain and efficiency of gain were similar for cattle fed the 14 and 12% rations, while the 10% ration was the poorest. During the final 48 days, after 196 days on feed, the 9% ration produced the fastest rate of gain. Daily gain and efficiency of gain for the entire feeding period were 1.39, 6.00; 1.41, 6.08; and 1.33, 6.42 kg for the high, medium and low protein treatments, respectively. According to Peterson et al. (1973), a significant linear increase in average daily gain occurred with 214 kg Angus-Hereford steers as ration crude protein increased from 9 to 11% and to 13 or 15% during the initial 55 days on trial. In steers fed all concentrate rations, no significant differences in gains were observed between 13 and 15% rations after 172 days on feed. Braman et al. (1973) fed Brangus x Hereford-Shorthorn steers a high moisture corn ration containing 10.8, 13.8, 15.7 and 18.4% crude protein, with soybean meal and urea being the supplemental nitrogen sources. Steers initially weighed 253 kg and were fed for 140 days. Averaged across protein source, daily gain and efficiency of gain increased ($P<.05$) linearly with increasing protein level during the first 56 days. Averaged across protein source, protein level had little effect on steer performance at 140 days.

In recent years research has evolved around reduction or total removal of supplemental protein in the later phases of the finishing period. Preston and Cahill (1972) removed supplemental protein, reducing ration crude protein to 8.6%, after 56 and 112 days on feed. No effect on rate or efficiency of gain was observed. Steers weighed 256.3 kg initially and were fed corn-corn silage rations. Orwig and Clark (1974) obtained similar performance for steer calves fed ration crude protein levels of 12%, 10% reduced to 8% at 84 days, or reductions from 12 to 10 to 8% at 56 day intervals. Daily gain and efficiency of gain were 1.08, 8.7; 1.13, 9.1; 1.10, 8.79; and 1.05, 8.89 kg, respectively. Two trials involving removal of supplemental protein at various times during the feeding period were conducted by

Thomas *et al*. (1976). Hereford steers initially weighed about 270 kg and were fed corn-corn silage rations with urea as the supplemental nitrogen source. In the first trial ration crude proteins were 10.82 and 7.48% for the supplemented and non-supplemented rations, respectively. Removing supplemental nitrogen at 70 or 140 days decreased daily gains for the next 84 or 100 days, respectively. Overall, non-supplemented steers gained less (P<.01) than a comparable group receiving supplemental nitrogen. In trial II, rations without supplemental nitrogen contained 8.66% crude protein while rations with supplemental nitrogen contained 12.82% crude protein. Daily gain and efficiency of gain for cattle fed supplemental nitrogen for 0, 56, 112 and 172 days were .75, 8.78; .88, 7.73; .92, 7.53; and .95, 7.26 kg, respectively. Steers receiving no supplemental nitrogen for the entire feeding period gained the least and were the least efficient (P<.05).

Protein Levels for Yearling Cattle

Goodrich *et al*. (1961) found no significant differences in rate or efficiency of gain for 254 kg Hereford steers fed an 80% rolled corn ration containing 9.5, 10.6, 12 and 12.7% crude protein for 200 days. Daily gain and efficiency of gain were 1.10, 9.25; 1.16, 8.78; 1.12, 8.85; and 1.08, 9.03 kg, respectively. Borger *et al*. (1973) observed no differences (P<.05) in performance of steers initially weighing 269 kg when fed 9.5, 11 and 12.5% crude protein rations for 169 days. Daily gain and efficiency of gain were 1.12, 12.1; 1.22, 12.8; and 1.22, 12.5 kg, respectively. In general agreement, Hale *et al*. (1973) reported similar performance in two trials where 295 kg steers were fed 90% concentrate rations containing 10, 11.5 and 13% crude protein. Daily gain and efficiency of gain were: Trial I: 1.28, 7.18; 1.32, 7.36; and 1.32, 7.32; Trial II: 1.26, 7.64; 1.30, 7.78; and 1.32, 7.67 kg, respectively. Dressing percent increased as crude protein level fed increased, but it was suggested that this may be due to the higher final weights of steers fed the higher crude protein levels. No significant differences were reported in performance of 300 kg steers fed corn-corn silage rations supplemented with 0.0, 0.45 and 1.13 kg soybean meal per head per day (Preston et al., 1973). However, steers fed the 1.13 kg soybean meal tended to gain faster and more efficiently. Daily gain and efficiency of gain were 1.54, 6.2; 1.52, 6.02; and 1.61, 5.60 kg, respectively. Carcass traits did not differ significantly. Heifers (average initial wt., 284 kg) fed an 11.2 or 14.3% crude protein ration had similar rates and efficiencies of gain (Smith et al., 1968b). Daily gain and efficiency of gain were 1.18, 8.0 and 1.20, 7.4 kg, respectively. This agrees with Preston and Parret (1972) who found no significant differences in performance of 286 kg steers fed 11.8 or 14.9% crude protein rations. Basal rations of corn and corn silage were fed for 110 days. Weichenthal et al. (1963) found that increasing the ration crude protein content from 12 to 13.4% had no affect on performance of steers (average initial wt., 352 kg) fed a ration of 80% shelled corn for 160 days. In a later trial, Weichenthal et al. (1972) reported that 390 kg Hereford steers fed a 10% crude protein shelled corn ration for 142 days gained slower and less efficiently than steers fed 11.9% crude protein. Daily gain and efficiency of gain were

.86, 9.51 and 1.00, 8.78 kg, respectively. Smith et al. (1967) fed 336 kg yearling steers sorghum grain rations containing 9.6 or 11% crude protein for 109 days. Performance was similar for steers fed both protein levels. Daily gain and efficiency of gain were 1.33, 7.6 and 1.34, 7.2 kg, respectively. In agreement, Martin et al. (1976) reported no significant differences in performance of 347 kg steers fed high moisture corn diets of 11 and 12.4% crude protein for 117 days. In a trial conducted by Canter et al. (1972), Holstein steers gained faster and more efficiently when ration crude protein was 11 or 13% compared to 9 or 15%. Young et al. (1973) fed 332 kg steers a ground ear corn ration containing 7 or 11% crude protein. Steers fed the 11% crude protein ration gained faster and more efficiently ($P<.05$). Carcass traits did not differ significantly.

Other research has evolved around decreasing protein concentration, as a percentage of the ration, as time on feed and cattle weight increase. Preston and Parrett (1972) reported a reduction in performance of 286 kg yearling steers fed a corn-corn silage ration when crude protein was reduced from 14.9 or 11.8 to 9.8% after 49 days on feed. Daily gain and efficiency of gain were 1.53, 5.56; 1.51, 5.62; and 1.42, 5.84 kg, respectively. Preston et al. (1973) found that removing supplemental protein at 28 or 56 days on feed reduced daily gains when compared to cattle fed supplemental protein for the entire feeding period (107 days); however, this reduction in performance was not statistically significant. Daily gain and efficiency of gain were 1.49, 5.78; 1.46, 6.16; and 1.61, 5.64 kg, respectively. Three trials were conducted by Harrison (1974) involving varying levels of crude protein for yearling cattle. In Trial I reducing the crude protein from 11.1 to 8.9% during the last 28 days on feed resulted in increased gains ($P<.05$) and improved efficiency of gain. In Trials II and III, gain of cattle was not affected by reducing crude protein levels from 11.3 to 9.8 or from 11.1 to 9.9% during the last 28 days. In general agreement, Putnam *et al*. (1969) report that all concentrate rations of 8 to 9% crude protein will adequately meet the protein requirements of yearling cattle from 360 kg to finish if they had been fed a 13% crude protein ration for the previous 63 days.

Monensin for Feedlot Cattle

Monensin, a biologically active compound produced by a strain of *Streptomyces cinnamonesis*, has been shown to be effective in preventing coccidiosis in poultry. Recently, much work has shown that monensin will increase the efficiency of energy utilization in feedlot cattle. In seven field trials involving 1157 feedlot cattle, Brown *et al*. (1974) observed that monensin consistently improved feed efficiency and decreased feed intake, but had no appreciable effect on daily gain or carcass characteristics. Average feed efficiency and feed intake for cattle fed 0, 5.5, 11, 22, 33 and 44 ppm monensin were 9.07, 9.64; 8.54, 9.30; 8.71, 9.24; 8.57, 9.08; 8.18, 8.66; and 8.56, 8.61 kg, respectively. Raun *et al*. (1974) also reported trials involving monensin being fed to feedlot cattle. In one trial monensin was fed at levels of 0, 13 and 71 grams per ton of feed. Efficiency of gain was superior ($P<.05$) for cattle fed monensin. Efficiencies were 8.97, 7.48 and 7.54 kg feed per kg gain, respectively. In a second trial, efficiency of gain was improved ($P<.05$) for cattle fed 10, 20, 30 and 40 grams monensin per ton of feed when compared to cattle not fed monensin and cattle fed monensin at a level of 5 grams per ton of feed. Embry and Swan (1974) fed Hereford steers a 90% concentrate ration containing 0, 10, 20 and 30 grams monensin per ton of complete feed. Compared to steers not fed monensin, monensin improved feed efficiencies by 1.7, 7.4 and 6.8% for the 10, 20 and 30 gram levels, respectively. Carcasses were similar for all treatments. This agrees with Perry et al. (1976) who reported efficiency of gain to be 7.8 and 7.0 for finishing cattle fed monensin at levels of 0 and 30 grams per ton of feed, respectively. Work by Farlin et al. (1975) generally agrees with the 10% improvement in feed efficiency quoted for monensin fed cattle. According to Raun et al. (1976) cattle fed 100 and 500 mg monensin per head per day had improved performance when compared to cattle not fed monensin and cattle fed monensin at a level of 700 mg. In another trial, they fed monensin levels of 0, 2.7, 5.5, 11, 23, 33, 44 and 88 ppm. All dosages except the 88 ppm produced gains equal to or greater than the 0 treatment. Feed intake progressively decreased as monensin level increased, with monensin cattle being more efficient than the controls. Wilson et al. (1975) fed monensin to steer calves at levels of 0, 5, 10, 20, 30 and 40 grams per ton of an 80% shelled corn ration. Daily gain increased at the 5, 10 and 20 gram levels, but decreased at 30 and 40 grams when compared to control cattle. Monensin improved efficiency of gain by 7, 4, 9, 6 and 6% for the 5, 10, 20, 30 and 40 gram levels, respectively. Quality grade was slightly lower and cutability higher with cattle fed the highest level of monensin; however, it was suggested that this may have been due to lower gains for that group. Other carcass traits did not differ. According to Hale et al. (1975), as monensin levels fed to finishing steers increased from 0 to 40 grams per ton of feed, so did daily gain. Efficiency of gain was also reported to improve with increasing monensin levels, while feed intake and carcass characteristics were similar for all treatments. In a 120 day finishing trial, Davis and Erhart (1976) fed the following monensin levels (grams per ton of feed): no monensin; 10 for the first 7 days and 30 thereafter; 10 for the first 21 days and 30 thereafter; and 30 for the entire feeding period. Daily gain and efficiency of gain improved when monensin was fed at the 10 gram level for the first 7 or 21 days. Daily gain was less ($P<.05$) for cattle fed 30 grams monensin the entire feeding period than for cattle fed 10 grams per ton for 21 days, then 30 grams per ton. Monensin improved ($P<.05$) feed efficiency an average of 15.6% over cattle not fed monensin.

Effect of Monensin on Protein Nutrition

Since cattle fed monensin generally consume less feed, but grow at equal rates, it is possible that protein requirements should be higher, as a percentage of the ration, for monensin fed cattle unless monensin has some effect on protein metabolism. Whole shelled corn rations containing 9.5, 10.3, 11.2 and 12.3% crude protein with and without monensin were fed to yearling steers by Gill et al. (1977). An interaction of monensin and protein level was reported, with monensin improving performance the most at the lower protein level. Daily gain for monensin fed cattle was 1.40, 1.44, 1.51 and 1.59 kg, respectively. Daily gain for cattle not fed monensin was 1.48, 1.56, 1.46 and 1.49 kg, respectively. Furthermore, these workers suggest that monensin may have a protein sparing effect. Davis (1977), in summarizing three trials he conducted and one conducted by Gill at Oklahoma, also states that monensin may have a protein sparing effect of about 10%. Rations fed in the four trials were 9.50 or 9.65% crude protein without urea and 11.50 or 11.65% crude protein with urea. All rations were fed with and without monensin. Averaged over the four trials, monensin improved rate and efficiency of gain for cattle receiving no urea and improved feed efficiency but not rate of gain for cattle fed urea. Ratios of gain to protein intake were greater for cattle fed monensin. Dartt et al. (1978) fed the following four treatments to steers in a 168 day trial: control diet consisting of corn, corn silage and soybean meal; control diet with soybean meal removed on day 84; control diet plus 200 mg monensin per steer per day; and control diet plus monensin with soybean meal removed on day 84. Daily gain and TDN per kg of gain were .98, 7.00; .78, 8.28; 1.07, 5.83; and .92, 6.14 kg, respectively. These workers suggested that monensin had an apparent protein sparing effect. In contrast to the aforementioned work, Walker et al. (1977) reported that monensin had no significant effect on protein utilization of finishing steers. Steers were fed a control ration, with or without monensin, and a control ration with supplemental protein removed on day 56 also with or without monensin. Gill et al. (1978) observed that monensin benefits with high moisture corn diets may be minimal if protein intake is marginal, thus disclaiming the possible protein sparing effect of monensin.

Digestibility

Effect of Protein Level

Many researchers (Kay et al., 1969; Greathouse et al., 1974; Poos et al., 1977; Thornton et al., 1978) have found that increasing crude protein concentration in the ration resulted in an increase in dry matter digestibility. Other workers (Stobo and Roy, 1973; Jahn and Chandler, 1976) found protein level to have no effect on dry matter digestibility.

Preston et al. (1965), Kay et al. (1969) and Orskov and Frasier (1969) have shown increasing crude protein concentration of the ration generally increases protein digestibility. However, Gardner (1968) found no effect of elevated protein level on nitrogen digestibility.

Orskov and Frasier (1969) reported increased dietary protein to have no effect on starch digestibility while Thornton et al. (1978) reported an increase in starch digestibility with increased dietary protein.

Effect of Monensin

Dinius et al. (1976) reported that monensin had no effect on dry matter, crude protein, hemicellulose or cellulose digestion in steers fed a forage diet ad libitum. Linn et al. (1975) also observed no significant effect of monensin on dry matter or crude protein digestibilities of steers fed corn silage rations. In contrast, Tolbert and Lichtenwalner (1978) reported that on an ad libitum feeding regimen, monensin increased dry matter, crude protein, ether extract and nitrogen free extract digestibilities, but decreased crude fiber digestibility. Utley et al. (1977) found monensin addition to dry rolled corn or acid preserved high moisture corn had no significant effect on crude fiber or ether extract digestibilities. Monensin addition tended to increase dry matter and crude protein digestibility. Elanco (1975) summarized six feeding trials and concluded that monensin increased nitrogen digestibility when fed at levels up to 300 mg per head per day and increased cellulose and dry matter digestibility only at a level of 100 mg per head per day.

Blood or Plasma Urea Nitrogen

Lewis (1957) reported that ruminant blood urea is dependent on the content of the diet and that changes in blood urea are not necessarily reflections of total nitrogen intake, but a reflection of the extent to which ammonia is formed in the rumen. This agrees with work by Dining et al. (1948) and Repp et al. (1955) who found that administration of non-protein nitrogenous compounds to the ruminant results in an increase in blood urea concentrations. However, Preston et al. (1965) and Torrell et al. (1974) state that blood urea nitrogen (BUN) in sheep is directly related to nitrogen intake. They reported correlation coefficients to be .98 and .99, respectively. It has been suggested that BUN levels over 10 mg per 100 ml indicates adequate nitrogen intake and that plasma urea nitrogen (PUN) levels of 7 to 9 mg per 100 ml or more indicates sufficient nitrogen intake in finishing steers (Preston et al., 1973).

Cross et al. (1974) reported higher (P<.01) PUN values for 272 kg steers fed 15.9% crude protein rations than for steers fed 11.5% crude protein rations. In general agreement, Young et al. (1973) found higher PUN levels in 332 kg steers fed 11% crude protein rations, supplemented with either soybean meal or urea, than those fed 7% crude protein rations. PUN levels were 10.77, 8.87 and 4.98 mg per 100 ml, respectively. According to Boling et al. (1974), 214 kg steers fed corn silage plus 0.0, .45, .68 and .91 kg soybean meal per head per day, had average PUN levels of 1.48, 3.35, 5.33 and 7.43 mg per 100 ml, respectively. Tolstedt and Farlin (1974) reported BUN values taken at 28 day intervals for cattle fed supplemental soybean meal for 45, 90 and 140 days in addition to a base ration. BUN levels for the five bleeding periods and for each of the three protein treatments, respectively, were 11.58, 19.17, 23.22, 24.43, 19.09; 12.37, 18.00, 25.02, 21.61, 20.80; and 12.18, 22.89, 22.97, 24.97, 28.18. Buckland et al. (1974) fed white-tailed deer fawns a high energy 18.2% crude protein ration, a low energy 18.2% crude protein ration, a high energy 9.2% crude protein ration, and a low energy 9.2% crude protein ration. BUN values were 22.0, 25.2, 9.3 and 12.8 mg per 100 ml, respectively. This agrees with work by Preston and Pfander (1963) and Haaland et al. (1977) which indicates that BUN is directly proportional to protein intake and inversely proportional to energy intake.

Monensin also appears to increase PUN values (Raun et al., 1976). Steers fed monensin levels of 0.0, 2.7, 5.5, 11, 22, 33, 44 and 88 ppm in the feed, had PUN levels of 15.2, 17.2, 17.8, 17.2, 16.8, 18.0, 16.9 and 15.6 mg per 100 ml, respectively. All cattle except those fed the 88 ppm dosage had higher ($P<.05$) PUN levels than cattle not fed monensin. This agrees with Hanson and Klopfenstein (1977a) who report higher BUN levels in lambs fed monensin than those not fed monensin. In one split plot design trial, BUN levels for lambs fed monensin at levels of 0, 25, and 30 grams per ton of feed and for two sampling periods, respectively, were 10.24, 13.21, 13.79 and 10.12, 12.47, 14.50 mg per 100 ml. Glenn et al. (1977) obtained conflicting PUN levels for lambs fed monensin. Lambs fed an 11% crude protein ration had higher PUN levels as monensin level increased, while lambs fed a 13% crude protein ration had lower PUN levels as monensin level increased. Steen et al. (1977) reported that monensin had no appreciable affect on PUN levels of yearling steers.

Rumen Constituents

Effect of Protein Level

Davis et al. (1956) fed three protein levels, minimum digestible protein requirements as recommended by Morrison (1948), twice this amount and four times this amount, to nine lactating dairy cows in order to study volatile fatty acid production as affected by protein level fed. There was a trend toward more total acetic acid production with the higher protein level. The total level of propionic acid increased ($P<.01$) as protein level fed increased, while total levels of butyric acid were higher ($P<.01$) when medium and high levels of protein were fed compared to the low level. As a percent of total acids, acetic decreased as ration protein level increased (62.3, 61.3, 58.1; $P<.01$), propionic remained relatively constant, and butyric was higher ($P<.01$) for medium and high levels compared to the low protein level (14.7 and 15.3 vs 14). Overall, there was an increase in total volatile fatty acid production ($P<.05$) as protein level fed increased (105.0, 113.9, 115.4 mM/l). Haskins et al. (1967) reported acetic acid to decrease and butyric acid to increase, as a percentage of total acids, as ration crude protein fed to steers increased from 11 to 14%. However, these differences were not statistically significant. In agreement, Cross et al. (1974) found that molar percent propionic acid increased and molar percent acetic acid tended to decrease as protein intake on soybean meal supplemented rations increased.

Roffler et al. (1977) observed that rumen ammonia concentrations in sheep are positively related to ration crude protein when natural protein nitrogen sources are fed. Many workers (Lewis, 1957; Little et al., 1963; Schmidt et al., 1973) have shown that rumen ammonia concentrations are dependent on the extent to which a given protein is degraded in the rumen.

Effect of Monensin

In summarizing 19 feedlot trials, Richardson et al. (1975) found that cattle fed monensin had consistently lower molar percentages of ruminal acetic and butyric acid, and increased percentages of propionic acid when compared to non-monensin fed cattle. Monensin did not affect total ruminal volatile fatty acid production. Richardson et al. (1974) fed fistulated cattle 25 to 500 mg monensin per head per day for a three week period with sustained increases in molar proportion of propionic acid produced over this period. Ruminal propionic acid molar percentage increased 52% when monensin was fed at a level of 200 mg per animal per day. Corn silage rations with and without monensin were fed to growing heifers in two trials conducted by Riley et al. (1976). Molar percentages of acetic, propionic and butyric acids for monensin and non-monensin fed heifers, respectively, were: Trial I, 60.7, 27.4, 11.8; 66.0, 23.0, 10.9; Trial II, 59.3, 33.0, 7.7; 66.8, 22.1, 11.1. Utley et al. (1976) fed 36 heifers rations with and without monensin in an 84 day growing and then an 84 day finishing trial. In the growing trial, monensin fed cattle had 12% less acetic, 60% more propionic and 25% less butyric acid, on a molar percentage basis, than cattle not fed monensin. Cattle fed monensin in the finishing trial had 11% less acetic, 47% more propionic and 54% less butyric acid, on a molar percentage basis, than control cattle. According to Davis and Erhart (1976), rumen fluid from monensin fed cattle contained more ($P<.05$) propionate and less ($P<.05$) butyrate, on a molar percentage basis, than steers not fed monensin. Two finishing trials reported by Riley and Fink (1976) found average molar percentage acetic acid concentration to be decreased by 9.3% and average molar percentage propionic acid concentration to be increased by 8.3% when monensin fed cattle were compared to the controls. This agrees with Martin et al. (1976) who reported lower ($P<.05$) ruminal acetic acid and higher ruminal propionic acid, on a molar percentage basis for cattle fed monensin. Perry et al. (1976) fed 0 and 33 ppm monensin and 11 ppm monensin for the first 21 days and 33 ppm thereafter in a steer finishing trial. Overall volatile fatty acid patterns for monensin fed cattle showed a 16%

decrease in acetic acid, a 46% decrease in butyric acid, and a 75% increase in propionic acid.

In vitro studies by Short et al. (1978) showed that monensin decreased ($P<.005$) ammonia nitrogen concentration and increased ($P<.0005$) non-ammonia non-microbial nitrogen concentration. Responses were dose dependent. This agrees with Tolbert et al. (1977) who reported that in vitro ammonia concentration was decreased by 5.5 and 13.5% for both soybean meal and urea when monensin was added to the flask. Martin et al. (1976) observed a 6.6% decrease (2.71 vs. 2.89 mg per 100 ml) in rumen ammonia concentration for cattle fed monensin compared to controls. Hanson and Klopfenstein (1977a) found lower rumen ammonia concentrations in monensin fed lambs. In one split plot design trial, rumen ammonia levels for lambs fed monensin levels of 0, 25 and 30 grams per ton of feed and two sampling periods, respectively, were 20.34, 5.39, 7.33; 21.0, 5.15, 7.36 mg per 100 ml. Hanson and Klopfenstein (1977b) also reported decreased rumen ammonia concentrations for cattle fed monensin.

LITERATURE CITED

Boling, J. A., N. W. Bradley and L. C. Pendlum. 1974. Response of steer calves fed different levels of soybean meal. J. Anim. Sci. 39:231 (Abstr.).

Borger, M. L., L. L. Wilson, J. D. Sink, J. H. Zeigler and S. L. Davis. 1973. Zeranol and Dietary protein level effects on live performance, carcass merit, certain endocrine factors and blood metabolite levels of steers. J. Anim. Sci. 36:706.

Braman, W. L., E. E. Hatfield, F. N. Owens and J. M. Lewis. 1973. Protein concentration and sources for finishing ruminants fed high-concentrate diets. J. Anim. Sci. 36:782.

Brown, H., L. H. Carroll, N. G. Elliston, H. P. Greuter, J. W. McAskill, R. D. Olson and R. P. Rathmacher. 1974. Field evaluation of monensin for improving feed efficiency in feedlot cattle. Proc. Western Sec. Amer. Soc. Anim. Sci. Vol. 25:30.

Buckland, D. E., W. A. Alber, R. L. Kirkpatrick, J. B. Whelan and P. F. Scanlon. 1974. Blood urea nitrogen levels in fawns as effected by protein and energy intake. J. Anim. Sci. 39:233 (Abstr.).

Canter, E. W., E. E. Hatfield and D. L. Hixon. 1972. Source and level of protein for yearling steers. Ill. Agr. Exp. Sta. Beef Day Rep. AS-662b:5.

Cross, D. L., R. L. Ludwick, J. A. Boling and N. W. Bradley. 1974. Plasma and rumen fluid components of steers fed two sources and levels of nitrogen. J. Anim. Sci. 38:404.

Dartt, R. M., J. A. Bolins and N. W. Bradley. 1978. Supplemental protein withdrawal and monensin in corn silage diets of finishing steers. J. Anim. Sci. 46:345.

Davis, G. V. 1977. Does Rumensin alter protein needs of feedlot cattle? Kansas Focus on Feedlots. July.

Davis, G. V. and E. B. Erhart. 1976. Effects of monensin and urea in finishing steer rations. J. Anim. Sci. 43:1.

Davis, R. F., N. S. Woodhouse, M. Keeney and G. H. Beck. 1956. The effect of various levels of dietary protein upon the volatile fatty acids in the rumen of the dairy cow. J. Dairy Sci. 40:75.

Dinius, D. A., M. E. Simpson and P. B. March. 1976. Effect of monensin fed with forage on digestion and the ruminal ecosystems of steers. J. Anim. Sci. 42:229.

Dining, J. S., H. M. Briggs, W. D. Gallup, H. W. Orr and R. Butler. 1948. Effect of orally administered urea on the ammonia and urea concentration in the blood of cattle and sheep, with observation on blood ammonia levels associated with symptoms of alkalosis. Amer. J. Physiol. 153:41.

Elanco Products Company. 1975. The effect of monensin on ration digestibility. Rumensin Technical Manual. Eli Lilly Company. Greenfield, Ind.

Embry, L. B. and W. S. Swan. 1974. Effects of monensin on feedlot performance of growing and finishing steers. South Dakota State Univ. Anim. Sci. Series 74-5, 19.

Farlin, S. D., D. C. Clanton and J. D. Heldt. 1975. A new feed additive for beef cattle. Univ. Nebraska 1975 Cattle Report: 8.

Fontenot, J. P. and R. F. Kelly. 1963. Effects of protein levels of steer fattening rations. I. Feedlot performance, nitrogen metabolism and certain blood constituents. J. Anim. Sci. 22: 248 (Abstr.).

Fontenot, J. P. and R. F. Kelly. 1967. Protein and energy levels in steer fattening rations. J. Anim. Sci. 26:918 (Abstr.).

Gardner, R. W. 1968. Digestible protein requirements of calves fed high energy rations ad libitum. J. Dairy Sci. 51:888.

Gill, D. R., F. N. Owens, J. Martin and J. H. Thornton. 1977. Protein levels and monensin for feedlot cattle. J. Anim. Sci. 45 (Suppl. 1) 235 (Abstr.).

Gill, D. R., F. N. Owens, J. J. Martin, J. H. Thornton and D. E. Williams. 1978. Monensin levels for steers fed high moisture corn. J. Anim. Sci. 47 (Suppl. 1) 419 (Abstr.).

Glenn, B. P., D. G. Ely and W. P. Deweese. 1977. Feedlot performance of lambs fed monensin. J. Anim. Sci. 45 (Suppl. 1) 235 (Abstr.).

Goodrich, R. D., L. B. Embry, G. F. Gastler and F. W. Whetzal. 1961. Protein requirements of fattening cattle and the effects of various feed additives. J. Anim. Sci. 20:932 (Abstr.).

Greathouse, G. A., R. R. Schalles, B. E. Brent, A. D. Dayton and E. E. Smith. 1974. Effects of levels and courses of protein on performance and carcass characteristics of steers fed all concentrate rations. J. Anim. Sci. 39:102.

Haaland, G. L., J. K. Matsushima, G. F. Nockels and D. E. Johnson. 1977. Bovine hair as an indicator of colorie protein status. J. Anim. Sci. 45:826.

Hale, W. H., B. Theurer, J. A. Marchello, B. Taylor and J. Kuhn. 1975. The effect of monensin on growing and finishing cattle. Ariz. Cattle Feeders Day. Ariz. Agr. Exp. Sta. Feeders Day Rep. Series P-36:4-1.

Hale, W. H., B. Theurer, B. Taylor, J. Marchello and M. Belew. 1973. The effect of three protein levels on performance of fattening steers. Ariz. Agr. Exp. Sta. Feeders Day Rep. Series P-31:4-1.

Hanson, T. L. and T. J. Klopfenstein. 1977a. Adaptation of lambs fed monensin. J. Anim. Sci. 45 (Suppl. 1) 238 (Abstr.).

Hanson, T. L. and T. J. Klopfenstein. 1977b. Monensin, protein source and protein levels for growing steers. J. Anim. Sci. (Suppl. 1) 238 (Abstr.).

Harrison, K. 1974. Variable levels of crude protein for feedlot cattle. Ph.D. Thesis, Kansas State University, Manhattan, KS.

Haskins, D. R., M. B. Wise, H. B. Craig and E. R. Barrick. 1967. Effects of levels of protein, sources of protein and an antibiotic on performance, carcass characteristics, rumen environment and liver abscesses of steers fed all concentrate rations. J. Anim. Sci. 26:430.

Jahn, E. and P. T. Chandler. 1976. Performance and nutrient requirements of calves fed varying percentages of protein and fiber. J. Anim. Sci. 42:724.

Kay, M. N., A. McLeod and A. MacDearmid. 1969. Protein content of the diet and food intake in steers. Nutr. Soc. Proc. 28:55 (Abstr.).

Kliewer, R. H., W. H. Kennick and D. C. Church. 1969. Influence of varying protein and diethylstibestrol on live performance and carcass characteristics of Holstein steers. J. Dairy Sci. 53:1776.

Lewis, D. 1957. Blood urea concentration in relation to protein utilization in the ruminant. J. Agr. Sci. 48:438.

Linn, J. G., J. C. Meiske and R. D. Goodrich. 1975. Influence of monensin on growing and finishing steers. Minn. Agr. Exp. Sta. Res. Report B-205: 3.

Little, C. O., W. Burroughs and W. Woods. 1963. Nutritional significance of soluble nitrogen in dietary protein for ruminants. J. Anim. Sci. 22:358.

Martin, J., F. N. Owens and D. Gill. 1976. RUMENSIN, protein levels and urea for feedlot cattle. Oklahoma State Univ. and USDA Res. Rep. MP-96, April, p. 87.

Orskov, E. R. and W. C. Fraser. 1969. The influence of protein concentration in concentrate feeds on the apparent disappearance of dry matter, protein, starch, ether extract, and ash in various segments of the digestive tract in sheep. Nut. Soc. Proc. 28: 55 (Abstr.).

Orwig, T. L. and J. L. Clark. 1974. Crude protein levels in cattle finishing rations. J. Anim. Sci. 39:248 (Abstr.).

Perry, T. W., W. M. Beeson and M. T. Mohler. 1976. Effect of monensin on beef cattle performance. J. Anim. Sci. 42:761.

Peterson, L. A., E. E. Hatfield, A. P. Peter, D. L. Hixon and U. S. Garrigus. 1970. Performance of steers fed varying protein levels with all-concentrate high moisture corn diets. Ill. Agr. Exp. Sta. Beef Day Rep. AS-657b:9.

Peterson, L. A., E. E. Hatfield and U. S. Garrigus. 1973. Influence of dietary energy on protein needs of growing finishing cattle. J. Anim. Sci. 36:772.

Poos, M. I., L. S. Bull and R. W. Hemken. 1977. Effectiveness of the urea fermentation potential system in feeding NPN to lactating dairy cows. J. Anim. Sci. 45 (Suppl. 1) 251 (Abstr.).

Preston, R. L. and V. R. Cahill. 1972. Source of supplemental protein and time of supplementation for growing-finishing steers calves. Ohio Agr. Exp. Sta. Res. Summary 63:37.

Preston, R. L. and V. R. Cahill. 1973. Withdrawing supplemental soybean meal from steer calves at varying times during the finishing period and the value of supplemental amino acids, with observations on DES implant levels. Ohio Agr. Exp. Sta. Res. Summary 68:1.

Preston, R. L., S. W. Koch and V. R. Cahill. 1973. Supplemental protein needs and utilization of dry and crimped corn in yearling steers. Ohio Agr. Exp. Sta. Res. Summary 68:9.

Preston, R. L. and N. A. Parrett. 1972. Form of corn grain and protein levels for yearling steers. Ohio Agr. Exp. Sta. Res. Summary 63:75.

Preston, R. L. and W. H. Pfander. 1963. Technique for evaluating protein adequacy in lambs. J. Anim. Sci. 22:844.

Preston, R. L., D. D. Schanakenberg and W. H. Pfander. 1965. Protein utilization in ruminants. I. Blood urea nitrogen as effected by protein intake. J. Nutr. 86:281.

Raun, A. P., C. O. Cooley, E. L. Potter, L. F. Richardson, R. P. Rathmacher and R. W. Kennedy. 1974. Effect of monensin on feed efficiency of cattle. J. Anim. Sci. 39:250.

Raun, A. P., C. O. Cooley, E. L. Potter, R. P. Rathmacher and L. F. Richardson. 1976. Monensin on feed efficiency of feedlot cattle. J. Anim. Sci. 43:670.

Repp, W. W., W. H. Hale, E. W. Cheng and W. Burroughs. 1955. The influence of oral administration of non-protein nitrogen feeding compounds upon blood ammonia and urea levels in lambs. J. Anim. Sci. 14:118.

Richardson, L. F., A. P. Raun, E. L. Potter, C. O. Cooley and R. P. Rathmacher. 1974. Effects of monensin on ruminal fermentation in vitro and in vivo. J. Anim. Sci. 39:250 (Abstr.).

Richardson, L. F., A. P. Raun and E. L. Potter. 1975. The effect of rumensin on ruminal parameters of beef cattle and sheep. Conference on Rumen Function Report, Chicago, Illinois: 11.

Riley, J., K. Bolsen, L. Corah and G. Fink. 1976. Effect of Rumensin on performance of growing heifers. Kansas St. Univ. Cattlemens Day. Report of Progress 262.

Riley, J. and G. Fink. 1976. Effect of Rumensin on performance of finishing steers. Kansas State Univ. Cattlemens Day. Report of Progress 262.

Roffler, R. E., L. D. Satter and A. R. Hardie. 1977. Influence of ration composition on sheep ruminal ammonia concentration. J. Anim. Sci. 45 (Suppl. 1) 254 (Abstr.).

Schmidt, S. P., N. A. Jorgensen, N. J. Benevenga and V. H. Baumgardt. 1973. Comparison of soybean meal, formaldehyde treated soybean meal, urea and starea for steers. J. Anim. Sci. 37:1233.

Short, D. E., M. P. Bryant, F. C. Hinds and G. C. Fahey. 1978. Effect of monensin upon fermentation endproducts and cell yield of anaerobic microorganisms. Amer. Soc. Anim. Sci. Midwestern Section. 11th Ann. Meeting. Southern Ill. Univ.:44.

Smith, E. F., D. Richardson, C. L. Drake and B. E. Brent. 1967. Sorghum grain as the only protein source in an all concentrate steer finishing ration; value of oyster shell in an all concentrate ration. Kansas Agr. Exp. Sta. Bull. 507:39.

Smith, E. F., D. Richardson, C. L. Drake and B. E. Brent. 1968. Sorghum grain as the only protein source in all concentrate heifer finishing rations: two levels of urea in all concentrate rations. Kansas Agr. Exp. Sta. Bull. 518:29.

Steen, W. W., N. Gay, J. A. Boling, N. W. Bradley, J. W. McCormick and L. C. Pendlum. 1977. Influence of different levels of monensin on performance, carcass traits and blood metabolites in growing-finishing steers. J. Anim. Sci. 45 (Suppl. 1) 259 (Abstr.).

Stobo, I. J. F. and J. H. B. Roy. 1973. The protein requirement of the ruminant calf. Brit. J. Nut. 30:113.

Thomas, V. M., W. M. Beeson, T. W. Perry and M. T. Mohler. 1976. Effect of protein withdrawal on the performance of steer calves. J. Anim. Sci. 43:850.

Thonney, M. L., R. D. Goodrich and J. C. Meiske. 1972. Performance of Hereford and Hereford x Charolais steers fed four levels of crude protein. Minn. Agr. Exp. Sta. Res. Rep. B-175:47.

Thornton, J. H., F. N. Owens, R. W. Fent and K. Poling. 1978. Rumensin and digestibility of feedlot rations. Anim. Sci. Res. Rep. MP-103. Okla. Agr. Exp. Sta. and USDA:70.

Tolbert, T. L., R. E. Lichtenwalner and G. A. Broderick. 1977. Effect of monensin on protein degradation. J. Anim. Sci. 45 (Suppl. 1) 263 (Abstr.).

Tolbert, T. L. and R. E. Lichtenwalner. 1978. Effect of monensin on apparent digestibility and nitrogen utilization of sorghum based rations. J. Anim. Sci. 47 (Suppl. 1) 276 (Abstr.).

Tolstedt, S. and S. Farlin. 1974. Urinary creatinine/nitrogen and blood urea nitrogen as nutritional indicators. J. Anim. Sci. 39:255 (Abstr.).

Torell, D. T., I. D. Hume and W. C. Weir. 1974. Factors affecting blood urea nitrogen and its use as an index of the nutritional status of sheep. J. Anim. Sci. 39:435.

Utley, P. R., G. L. Newton, R. J. Ritter III and W. C. McCormick. 1976. Effects of feeding monensin in combination with zeranol and testosterone estradiol implants for growing and finishing heifers. J. Anim. Sci. 42:754.

Utley, P. R., G. L. Newton, D. M. Wilson and W. C. McCormick. 1977. Dry and propionic acid treated high moisture corn fed with and without monensin to feedlot heifers. J. Anim. Sci. 45:154.

Walker, R. D., D. M. Hughes, W. D. Graham and R. A. Jungk. 1977. Monensin and protein withdrawal for finishing steers. J. Anim. Sci. 45 (Suppl. 1) 267 (Abstr.).

Weichenthal, B. A., L. B. Embry, R. J. Emerick and F. W. Whetzal. 1963. Influence of sodium nitrate, vitamin A, and protein level on feedlot performance and vitamin A status of fattening cattle. J. Anim. Sci. 22:979.

Weichenthal, B. A., G. F. Cmarik and A. L. Neuman. 1972. Whole corn, protein level and implants for yearling steers. Ill. Agr. Exp. Sta. Beef Day Rep. AS-662e: 12.

Williams, D., D. Topel, N. Gay and R. L. Vetter. 1969. Early weaning of beef calves at 3½ months versus the standard age of 7 months. Iowa Agr. Exp. Sta. A.S. Leaflet R121.

Williams, D., R. L. Vetter and W. Burroughs. 1971. Evaluation of beef production from young dairy bulls-effects of diethylstilbestrol and protein level on feedlot performance and carcass characteristics. Iowa Agr. Exp. Sta. A.S. Leaflet R155.

Wilson, L. L., E. E. Hatfield and D. L. Hixon. 1975. The effectiveness of different levels of monensin on the feedlot performance of finishing steers. Ill. Agr. Exp. Sta. Beef Day Rep. AS-669a:1.

Wilson, W. M. D., E. E. Hatfield and D. L. Hixon. 1972. Effect of organic-acid treated high-moisture corn and two dietary crude protein levels on performance of feedlot steers. Ill. Agr. Exp. Sta. Beef Day Rep. AS-662d:9.

Young, A. W., J. A. Boling and N. W. Bradley. 1973. Performance and plasma amino acids of steers fed soybean meal, urea or no supplemental nitrogen in finishing rations. J. Anim. Sci. 20:958 (Abstr.).

SUMMARY

Six yearling Hereford steers were individually fed each of the following ration crude protein treatments: 9%, 11% or 15% continuously; 12% for 63 days, then 10.5%; and 13% for 42 days, 11% for 42 days, and then 9% until slaughter. Within each protein treatment, three steers were fed 200 mg monensin daily and three received none. Soybean meal was used as the supplemental protein source in all except the 9% ration which contained no supplemental protein. Steers continuously fed the 9% crude protein ration gained the least ($P<.05$) and were the least efficient ($P<.05$). Daily gain and efficiency of gain were similar for the other four protein treatments. Protein treatment did not significantly affect feed intake. Averaged across all crude protein treatments, monensin did not affect steer performance. However, within steers fed the 11%, 12-10.5% and 15% protein treatments, monensin improved feed efficiency an average of 7.4%.

Dry matter and crude protein digestibility was lowest ($P<.05$) for steers continuously fed the 9% ration. Crude fiber digestibility was lowest for the 9% and 13-11-9% treatments. Monensin increased crude fiber digestibility (36.9 vs. 42.3%) but had no effect on the other digestibility coefficients. The percent starch in the feces was not affected by protein treatment or monensin. Fecal pH tended to be higher for steers fed the 15% protein treatment and lower for steers

fed the 9% protein treatment. Correlation coefficients between fecal pH and fecal starch and between fecal starch and starch digestibility were -.23 and -.91, respectively.

Monensin lowered the acetate:propionate ratio for all steers except for those fed the 15% ration. Rumen NH_3 and plasma urea nitrogen (PUN) were positively correlated with protein intake (.603 and .743, respectively). PUN ranged from 7.0 mg/100 ml for steers consuming the 9% ration to 19.1 mg/100 ml for steers fed the 15% ration. Steers fed monensin had lower rumen NH_3 (2.74 vs. 3.18 mg/100 ml) and higher PUN (12.66 vs. 12.21 mg/100 ml) levels.

INTRODUCTION

Increased cost of protein supplement has stimulated additional research to determine optimal protein levels for finishing cattle. Much of the recent research has involved decreasing the ration protein level as cattle weight and time on feed increase. Researchers have found that supplemental nitrogen may not be necessary during the last part of the finishing period (Preston and Cahill, 1972, 1973; Putnam, 1969; Riley and Harrison, 1975). Monensin has been shown to improve efficiency of gain in finishing beef cattle (Boling et al., 1977; Perry et al., 1976; Raun et al., 1976); however, the effects of monensin on protein requirements of finishing beef cattle are not well documented. Results of several feeding trials (Boling, 1977; Gates and Embry, 1977; Gill et al., 1977; Harvey, 1977) have suggested that monensin may have a protein sparing effect.

The objectives of this study were to evaluate various protein levels for finishing cattle, the effects of monensin on cattle performance, and the effects of monensin on protein requirements for finishing beef cattle.

EXPERIMENTAL PROCEDURE

Thirty yearling Hereford steers with an average initial weight of 280 kg were fed twice daily. Steers were housed in individual pens (1.2 m X 6.1 m) and were given free access to water. Six steers were assigned to each of the following five crude protein treatments: 9%, 11% or 15% continuously; 12% for 63 days (370 kg avg. wt.), and then reduced to 10.5%; and 13% for 42 days (350 kg avg. wt.), 11% for 42 days (399 kg avg. wt.), and then reduced to 9% until slaughter.

Composition of rations and the supplement are shown in Table 1. Soybean meal was used as the supplemental protein source and the 9% crude protein rations did not contain any supplemental protein. Three steers in each protein treatment were fed 200 mg of monensin daily and three steers received none. Ground corn was used as the carrier for monensin and the monensin mix was included in the ration at the expense of rolled corn.

Blood samples, via jugular puncture and rumen samples, via stomach tube were taken 4.5 hours postfeeding on days 21, 42, 63, 84, 126, 147 and 168 of the trial. Plasma urea nitrogen (PUN) was determined by the procedure of Brown (1959). Rumen fluid pH was immediately determined and the fluid was then preserved with hydrochloric acid for ammonia determination by the microdiffusion technique of Conway (1965). Also, rumen fluid was preserved with mercuric chloride and volatile fatty

TABLE 1. COMPOSITION OF RATIONS

Ingredient[1]	Internat'l ref. no.	Protein level 9%	10.5%	11%	12%	13%	15%
Prairie hay	1-07-957	15.0	15.0	15.0	15.0	15.0	15.0
Soybean	5-04-604	0.0	4.0	5.5	8.2	10.9	16.3
Rolled corn	4-02-931	81.0	77.0	75.5	72.8	20.1	64.7
Supplement[2]		4.0	4.0	4.0	4.0	4.0	4.0

[1]The amount of the ingredient in the ration is given as a percent of ration dry matter.

[2]1000 kg of supplement contained: 608 kg ground corn, 227.5 kg limestone, 80 kg potassium supplement (50% K), 62.5 kg NaCl, 5 kg trace mineral salt, 15 kg fat, and 2 kg Vitamin A premix (30,000 I.U. per g).

acid concentration determined by gas chromatography (Erwin et al., 1961).

A digestion trial, using the chromic oxide indicator method, was conducted from day 112 to 126 of the trial. Five g of chromic oxide, mixed with 25 g ground corn and 10 g dry molasses, was fed twice daily with the individual rations. After a chromic oxide prefeeding period of 7 days, fecal samples were collected by rectal palpation at 6 hour intervals beginning at 6:00 a.m. and continuing for 7 days. Fecal pH was determined on the sample obtained at 6:00 p.m. Equal amounts of each fecal collection were combined into one composite sample per steer and dried at 60°C. Diets and feces were analyzed for crude protein, crude fiber, ether extract and ash according to A.O.A.C. (1970). Gross energy was determined using an oxygen bomb calorimeter. Starch was determined on the ration and feces as total alpha-linked glucose polymers by the enzymatic procedure of Macrae and Armstrong (1968). Chromium was determined by atomic absorption following perchloric acid digestion.

One steer on the 13-11-9% crude protein treatment with monensin was removed from the trial due to poor health.

Individual beginning and ending weights were taken after steers were fed 4.5 kg (dry matter basis) of their respective rations for four days and withdrawn from water for twelve hours. Steers were slaughtered when their live weights reached approximately 454 kg, except that those on the 9% crude protein treatment performed so poorly that they were slaughtered at an average of 404 kg. Individual carcass data were obtained.

Steer performance data, digestibility coefficients and carcass characteristics were analyzed statistically as a 2 by 5 factorial design. All ruminal and blood data were analyzed statistically as a split plot design. The analysis included protein level with 4 degrees of freedom (df), monensin treatment with 1 df, the interaction of protein level by monensin treatment with 4 df and Error A with 19 df. The subplot included time with 6 df, the interaction of time by protein level, time by monensin treatment and time by protein level by monensin treatment with 24, 6 and 22 df, respectively. All data were tested for statistical difference by the analysis of variance (Steel and Torrie, 1960) and Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

Steer Performance

Effect of protein level on steer performance is shown in Table 2. For the entire feeding period, steers consuming the 9% crude protein treatment gained the least and were the least efficient ($P<.05$). Daily gain and efficiency were similar for steers consuming the other four protein treatments. Protein level did not significantly affect feed intake.

Performance, at each period, for steers withdrawn from supplemental protein (13-11-9% treatment) at day 84 was similar to performance of steers fed supplemental protein for the entire trial. Other researchers (Preston and Cahill, 1972, 1973; Putnam, 1969; and Riley and Harrison, 1975) have also reported that protein levels in the ration of finishing steers can be reduced during the feeding period without affecting feedlot performance. Feeding protein at levels greater than 11% did not result in improved steer performance at any time during the trial. Preston and Parrett (1972) and Weichenthal et al. (1963) have reported similar results. However, Bramen et al. (1973), Kliewer et al. (1969), and Peterson et al. (1973) suggest that protein levels greater than 11% may be necessary for optimum performance at least during the initial phases of the finishing period.

The data reported here does indicate that steers weighing 280 kg need supplemental protein for maximum performance. Boling et al. (1972),

TABLE 2. EFFECT OF PROTEIN LEVEL ON STEER PERFORMANCE

	Protein level					
	9%	11%	12-10.5%	13-11-9%	15%	SE
No. of steers	6	6	6	5	6	
Initial weight, kg	283	284	278	278	277	.315
1 - 42 days[1]						
Avg. daily gain, kg	1.04[c]	1.85[a]	1.84[a]	1.72[ab]	1.33[bc]	.158
Daily feed intake, kg	8.16[b]	9.30[a]	9.61[a]	9.75[a]	8.98[ab]	.307
Kg feed per kg gain	8.02[a]	5.41[b]	5.37[b]	5.77[b]	7.00[ab]	.240
Daily protein intake, kg	.77	.98	1.15	1.25	1.35	
1 - 84 days[1]						
Avg. daily gain, kg	.85[a]	1.44[b]	1.32[b]	1.39[b]	1.20[b]	.086
Daily feed intake, kg	7.60	7.90	8.08	7.79	8.01	.260
Kg feed per kg gain	9.38[a]	5.68[b]	6.19[b]	5.64[b]	6.81[b]	.259
Daily protein intake, kg[2]	.70	1.01	1.00	1.05	1.34	

[1]42 and 84 day weights are non-shrunk weights.

[2]Daily protein intake is for days 42 through 84.

[abc]Means in the same row with different superscripts differ significantly ($P<.05$).

TABLE 2. Continued

	Protein level					
	9%	11%	12-10.5%	13-11-9%	15%	SE
84 days to slaughter[1,3]						
Avg. daily gain, kg	.63[a]	1.05[b]	.99[b]	.93[b]	1.09[b]	.051
Daily feed intake, kg	8.41	9.40	8.09	7.93	7.83	.641
Kg feed per kg gain	13.75[a]	7.92[b]	8.25[b]	8.57[b]	7.26[b]	.228
Daily protein intake, kg	.75	1.02	.86	.72	1.18	
Entire Trial						
Avg. daily gain, kg	.67[a]	1.12[b]	1.04[b]	1.05[b]	1.03[b]	.041
Daily feed intake, kg	8.05	8.10	8.09	7.87	7.96	.209
Kg feed per kg gain	12.19[a]	7.27[b]	7.77[b]	7.51[b]	7.82[b]	.189
Daily protein intake, kg	.71	.90	.86	.83	1.19	

[1]42 and 84 day weights are non-shrunk weights.

[2]Daily protein intake is for days 42 through 84.

[3]Steers fed the 13-11-9% protein treatment were fed the protein withdrawal ration (9% crude protein) from day 84 to slaughter. Average weight for the steers was 399 kg at 84 days.

[abc]Means in the same row with different superscripts differ significantly ($P<.05$).

Burris et al. (1974), and Thomas et al. (1976) report similar decreases in cattle performance when supplemental protein was withdrawn from that weight of beef cattle.

Individual treatment effects are shown in Table 3. The effect of protein treatment and monensin on steer performance was consistent throughout the trial; therefore, only performance for the entire trial is shown. Averaged across all protein treatments, monensin did not significantly affect steer performance. This is in disagreement with Boling et al. (1977), Gill et al. (1976), Perry et al. (1976), and Raun et al. (1976) who have reported monensin to improve feed efficiency. However, these researchers did not use a wide range of protein levels such as were evaluated in this trial. Though the interaction between protein level and monensin was not significant, monensin improved feed efficiency (avg. of 7.4%) for steers fed the 11%, 12-10.5%, and 13-11-9% protein treatments. Feed efficiency of steers fed the 9% and 15% crude protein treatments was not improved by feeding monensin. This data suggest that the improved efficiency usually seen with monensin feeding may not occur with protein deficient cattle or with cattle fed protein levels greatly exceeding their requirements. This is in partial agreement with Gill et al. (1978) who reported that monensin benefits with high moisture corn may be minimal if protein intake is marginal.

Digestibility

There were no protein by monensin interactions with ration digestibility coefficients. Effects of protein level and monensin treatment are shown in Table 4. Apparent dry matter digestibility was lowest for

TABLE 3. EFFECT OF PROTEIN LEVEL AND MONENSIN ON STEER PERFORMANCE

	9%		11%		12-10.5%		13-11-9%		15%		
	C	M	C	M	C	M	C	M	C	M	SE
Avg. daily gain, kg	0.67	0.68	1.05	1.20	1.03	1.06	1.04	1.06	1.03	1.02	.041
Daily feed intake, kg	8.02	8.08	7.96	8.23	8.25	7.93	8.00	7.67	7.94	7.97	.209
Feed/gain	12.14	12.24	7.57	6.96	8.03	7.50	7.70	7.24	7.70	7.94	.189

TABLE 4. EFFECTS OF PROTEIN LEVEL AND MONENSIN ON APPARENT DIGESTIBILITY, FECAL STARCH AND FECAL pH

	9%	11%	12-10.5%	13-11-9%	15%	Control	Monensin	SE
Daily dry matter intake, kg	6.08	6.80	7.17	6.35	6.85	6.71	6.58	
Digestibility coefficient								
Dry matter	86.34^{a}	89.06^{b}	89.34^{b}	89.37^{b}	88.93^{b}	88.37	88.81	.294
Energy	60.52	63.81	62.09	64.63	60.32	60.74	63.75	.779
Starch	86.84	86.70	88.22	89.90	89.16	88.61	87.56	.830
Crude protein	31.05^{a}	42.00^{b}	38.67^{bc}	35.52^{c}	53.30^{d}	40.86	39.65	.525
Crude fiber	34.51^{a}	43.89^{b}	44.72^{b}	33.64^{a}	40.04^{b}	36.97^{d}	42.33^{e}	.720
Ether extract	64.03	60.18	53.78	66.11	61.35	61.07	60.75	1.369
Starch in feces, %	20.12	25.00	21.79	17.12	20.19	19.75	22.28	1.190
Fecal pH	5.83^{a}	6.19^{bc}	5.91^{ab}	5.97^{ab}	6.36^{c}	6.00	6.12	.055

[abc]Means in the same row with different superscripts differ significantly ($P<.05$) due to protein treatment.

[de]Means in the same row with different superscripts differ significantly ($P<.05$) due to monensin treatment.

steers continuously fed the 9% ration. Steers fed 9% rations after previously being fed 13 and 11% rations had apparent dry matter digestibilities similar to steers fed the other three protein levels. Other workers (Greathouse et al., 1974; Kay et al., 1968; and Poos et al., 1977) have reported increases in dry matter digestibility as protein concentration in the ration increased. In contrast, Jahn and Chandler (1976) and Stobo and Roy (1973) found various protein levels to have no effect on dry matter digestibility. Apparent energy, starch and ether extract digestibilities were not affected by protein level and were highly variable between steers within the same treatment. Apparent crude protein digestibility was lowest for steers continuously fed the 9% ration and highest for steers fed the 15% ration. Kay et al. (1968) and Orskov and Fraser (1969) have also reported increased crude protein digestibilities with increased protein intake. Apparent crude fiber digestibility was lowest for steers fed the continuous 9% ration and those fed 13-11-9% rations. Differences between digestibility coefficients of steers fed continuous 9% rations and those fed 9% rations after previously being fed 13% and 11% rations indicates that previous dietary protein regimen does affect dry matter and crude protein digestibilities but not crude fiber digestibility.

Dry matter, energy, starch, crude protein and ether extract digestibilities were similar for steers fed monensin and those not fed monensin. Crude fiber digestibility was higher for steers fed monensin. This is in disagreement with Tolbert and Lichtenwalner (1978) who found that cattle fed on an ad libitum feeding regimen with monensin had increased apparent digestibilities of dry matter, crude protein, and ether extract and decreased crude fiber digestibility. Elanco (1975) summarized six feeding trials and concluded that monensin increased nitrogen digestibility when fed at levels up to 300 mg/hd/day and increased cellulose and dry matter digestibilities at a level of 100 mg/hd/day.

Fecal Starch and pH

Effects of protein treatment and monensin on the percent starch in the feces and fecal pH are shown in Table 4. Fecal starch was not significantly affected by protein treatment or monensin. Rust (1978) found no significant differences in fecal starch due to ration protein level or monensin; however, fecal starch tended to decrease with increasing protein concentration in the diet and with monensin feeding.

Fecal pH tended to be higher for steers fed the 15% protein treatment and lowest for steers fed the 9% protein treatment. Monensin had no affect on fecal pH. In contrast, Rust (1978) found ration protein level to have no affect on fecal pH and monensin to increase fecal pH.

Correlation coefficients between fecal pH and fecal starch and between fecal starch and starch digestibility were -.23 and -.91, respectively. The low correlation between fecal pH and fecal starch would suggest that fecal pH may not be as indicative of fecal starch as Wheeler and Noller (1977) have suggested. Thornton *et al*. (1978) also found a low correlation (-.24) between fecal starch and fecal pH. The high negative correlation between fecal starch and starch digestibility would indicate that the percent starch in the feces is a good indicator of the extent of starch digestion.

Rumen and Blood Constituents

Protein level by sample day interactions and monensin significantly affected plasma urea nitrogen (PUN) and rumen NH_3. The effects of protein level and sampling day on PUN are shown in Table 5 and in Graph 1. PUN was lower for steers fed the 9% protein treatment at each sampling period except 168 days when PUN levels for cattle fed the 9% treatment and the 13-11-9% treatment were similar. PUN was highest at each sampling period except 21 days for steers fed the 15% treatment. All PUN values within each protein treatment were affected by sampling day; however, only PUN values for steers fed the 13-11-9% protein treatment followed any trends with PUN decreasing as the percent protein in the ration decreased.

It appears that PUN levels of 8-9 mg/100 ml may indicate adequate protein intake for maximum performance during the last part of the finishing period. However, PUN levels of 7-8 mg/100 ml during the beginning phases of the finishing period appear to indicate inadequate protein intake for finishing steers initially weighing 283 kg. This is in partial agreement with Preston et al. (1973) who suggested that PUN levels of 7-9 mg/100 ml would indicate sufficient protein intake in finishing steers.

Steers fed monensin had higher PUN levels than steers not fed monensin (12.66 vs. 12.21 mg/100 ml). Hanson and Klopfenstein (1977a) and Raun et al. (1976) also reported monensin to increase PUN.

Effects of protein level and sample day on rumen NH_3 are shown in Table 6 and Graph 2. Steers fed the 15% treatment had higher rumen NH_3

TABLE 5. EFFECTS OF PROTEIN LEVEL AND SAMPLE DAY ON PLASMA UREA NITROGEN

Sample Day	Plasma Urea Nitrogen (mg/100 ml)					SE
	9%	11%	12-10.5%	13-11-9%	15%	
21	$7.77^{d,g}$	$12.04^{c,gh}$	$14.32^{b,g}$	$16.03^{a,g}$	$15.97^{a,h}$	.590
42	$8.75^{e,g}$	$11.66^{d,h}$	$12.99^{c,gh}$	$16.34^{b,g}$	$18.85^{a,g}$	.680
63	$7.73^{d,gi}$	$11.47^{c,h}$	$12.06^{bc,hi}$	$13.21^{b,h}$	$18.85^{a,g}$	.704
84	$7.82^{c,gi}$	$13.12^{b,g}$	$12.34^{b,hi}$	$12.04^{b,h}$	$18.98^{a,g}$	.785
126	$7.01^{d,hi}$	$11.17^{b,h}$	$12.01^{b,hi}$	$8.82^{c,i}$	$19.06^{a,g}$	.788
147	$7.09^{d,hi}$	$11.64^{b,h}$	$11.09^{b,i}$	$8.93^{c,i}$	$19.01^{a,g}$	.931
168	$7.57^{c,gi}$	$10.93^{b,h}$	$12.07^{b,hi}$	$8.79^{c,i}$	$18.71^{a,g}$	.892

[abcde]Means in the same row with different superscripts differ significantly ($P<.05$).

[ghi]Means in the same column with different superscripts differ significantly ($P<.05$).

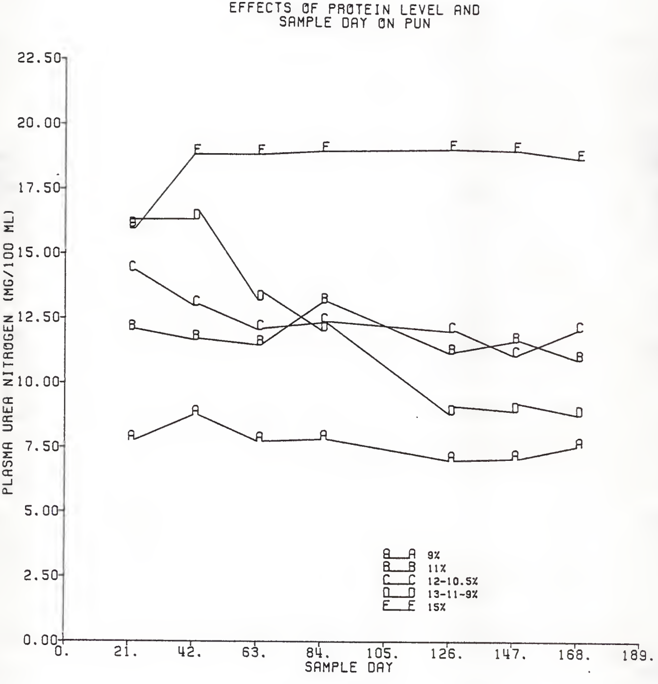
EFFECTS OF PROTEIN LEVEL AND
SAMPLE DAY ON PUN
PLASMA UREA NITROGEN (MG/100 ML)
22.50
20.00
17.50
15.00
12.50
10.00
7.50
5.00
2.50
0.00
0.
21.
42.
63.
84.
105.
126.
147.
168.
189.
SAMPLE DAY
A A 9%
B B 11%
C C 12-10.5%
D D 13-11-9%
E E 15%

FIGURE 1

TABLE 6. EFFECTS OF PROTEIN LEVEL AND SAMPLE DAY ON RUMEN NH_3

Sample Day	Rumen NH_3 (mg/100 ml)					SE
	9%	11%	12-10.5%	13-11-9%	15%	
21	1.90^{a}	2.48^{a}	2.86^{a}	$4.28^{b,i}$	$5.93^{b,g}$	.451
42	1.27^{a}	1.95^{ab}	2.93^{b}	$3.04^{b,g}$	$7.53^{c,h}$	.443
63	1.80^{a}	2.01^{a}	2.12^{a}	$2.69^{a,g}$	$4.73^{b,g}$	.245
84	1.71^{a}	2.17^{a}	2.24^{a}	$2.36^{a,gh}$	$4.85^{b,g}$	.245
126	1.67^{a}	2.28^{a}	2.36^{a}	$1.72^{a,h}$	$4.67^{b,g}$	.222
147	1.64^{a}	2.22^{a}	2.27^{a}	$1.87^{a,gh}$	$5.04^{b,g}$	.298
168	1.72^{a}	2.23^{a}	2.26^{a}	$1.85^{a,gh}$	$5.17^{b,g}$	.303

[abcde]Means in the same row with different superscripts differ significantly ($P<.05$).

[ghi]Means in the same column with different superscripts differ significantly ($P<.05$).

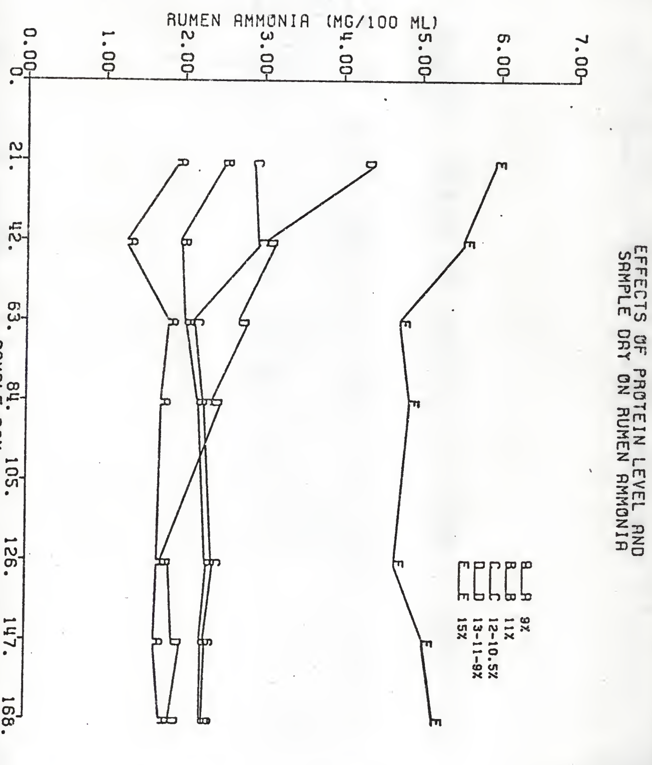
EFFECTS OF PROTEIN LEVEL AND SAMPLE DAY ON RUMEN AMMONIA
RUMEN AMMONIA (MG/100 ML)
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
0.
21.
42.
63.
84.
105.
126.
147.
168.
SAMPLE DAY
A 9%
B 11%
C 12-10.5%
D 13-11-9%
E 15%

FIGURE 2

levels at each sample day. Rumen NH_3 levels tended to decrease as protein level fed to steers consuming the 13-11-9% treatment decreased.

Steers fed monensin had lower rumen NH_3 concentration (2.74 vs. 3.18 mg/100 ml) than steers not fed monensin. This agrees with the findings of Hanson and Klopfenstein in sheep (1977a) and in cattle (1977b).

Correlation coefficients between PUN and rumen NH_3, PUN and daily protein intake for the period prior to bleeding, and between rumen NH_3 and daily protein intake for the period prior to rumen sampling were .703, .743 and .603, respectively. The positive correlation between PUN and rumen NH_3 agrees with the findings of Lewis (1957) that changes in blood urea concentration are a direct result of NH_3 production in the rumen. The correlations between PUN and protein intake is lower than the correlation of .986 reported by Preston _et al_. (1965) and .99 reported by Torrell _et al_. (1974) for correlation coefficients between blood urea nitrogen and nitrogen intake in sheep. The correlation between protein intake and rumen NH_3 agrees with Roffler _et al_. (1977) who found rumen NH_3 concentrations to be positively related to ration crude protein level fed to sheep when natural protein nitrogen sources are fed.

Effects of protein level and monensin on volatile fatty acids and rumen pH are shown in Table 7. Rumen pH was similar for all treatments. The monensin by protein interaction was significant for acetic and propionic acids and the acetate:propionate ratio. Butyric acid and total volatile fatty acids were not affected by protein level or monensin treatment.

TABLE 7. EFFECTS OF PROTEIN LEVEL AND MONENSIN ON RUMEN CONSTITUENTS

Item		Protein level					
		9%	11%	12-10.5%	13-11-9%	15%	SE
pH	control	6.60	6.53	6.74	6.65	6.31	.0046
	monensin	6.51	6.47	6.50	6.58	6.44	.0042
Acetic acid moles/100g	control	$61.11^{a,c}$	$59.81^{a,c}$	$60.23^{a,c}$	$59.37^{a,c}$	$54.97^{a,d}$	.709
	monensin	$56.48^{b,cd}$	$53.46^{b,c}$	$56.33^{b,cd}$	$55.28^{b,cd}$	$57.74^{a,d}$	.560
Propionic acid moles/100g	control	$29.69^{a,c}$	$32.25^{a,c}$	$30.95^{a,c}$	$31.44^{a,c}$	$36.34^{a,d}$	.737
	monensin	$34.60^{b,cd}$	$37.31^{b,d}$	$35.19^{b,cd}$	$36.84^{b,d}$	$32.77^{b,c}$	.602
Butyric acid moles/100g	control	9.20	7.94	8.81	9.19	8.69	.245
	monensin	8.92	9.24	8.48	7.88	9.48	.298
Total VFA	control	62.08	60.78	55.76	67.00	69.88	1.944
mmol/ml	monensin	63.27	74.05	70.67	65.36	67.95	1.713
Acetate: Propionate ratio	control	$2.25^{a,c}$	$2.01^{a,c}$	$2.06^{a,c}$	$2.07^{a,c}$	$1.59^{a,d}$	.070
	monensin	$1.72^{b,c}$	$1.51^{b,c}$	$1.65^{b,c}$	$1.55^{b,c}$	$1.79^{a,c}$	.044

^{ab}Means in the same column with different superscripts differ significantly ($P<.05$) within an item.
^{cd}Means in the same row with different superscripts differ significantly ($P<.05$) within an item.

Monensin lowered acetic acid and increased propionic acid on a molar percent basis and lowered the acetate:propionate ratio with all except the 15% crude protein treatment. Within steers not fed monensin, those fed 15% crude protein had lower acetic and higher propionic acid on a molar percent basis and a lower acetate:propionate ratio than steers fed the other four protein treatments. Within steers fed monensin, acetic acid tended to be the highest and propionic acid the lowest on a molar percent basis for steers fed the 15% crude protein treatment. The decrease in molar percent of acetic acid and increase in molar percent of propionic acid with steers fed 9%, 11%, 12-10.5%, and 13-11-9% protein treatments with monensin is in agreement with findings of Martin *et al.* (1976), Richardson *et al.* (1975), and Utley *et al.* (1976). The fact that monensin did not alter volatile fatty acid production in the 15% protein treatment would partially explain why efficiency of gain was not improved. It would also appear that lowering the acetate:propionate ratio may not always improve efficiency of gain if protein is deficient as was observed in steers fed the 9% crude protein treatment.

Carcass Data

Effects of protein level and monensin on carcass characteristics are shown in Table 8. There were no monensin by protein level interactions. Neither protein level nor monensin had any significant affect on carcass characteristics. Quality grade was not analyzed statistically due to differences in time on feed.

TABLE 8. EFFECTS OF PROTEIN LEVEL AND MONENSIN ON CARCASS CHARACTERISTICS

	9%	11%	12-10.5%	13-11-9%	15%	Control	Monensin	SE
No. of steers	6	6	6	6	6	15	14	
Backfat, in.	.36	.53	.48	.58	.62	.44	.59	.040
Loin eye area, sq. in.	11.33	11.12	11.62	11.04	11.32	11.34	11.25	.193
USDA grade								
No. Choice	2	2	3	4	6	9	8	
No. Good	4	4	3	1	0	6	6	
Yield grade	2.33	2.83	2.83	2.60	3.17	2.67	2.86	
Dressing percent	60.86	60.28	60.43	59.93	61.80	60.56	60.82	

LITERATURE CITED

A.O.A.C. 1970. Official methods of analysis (11th ed.) Association of Official Analytical Chemists. Washington, D.C.

Boling, J. A. 1977. The effects of monensin and protein withdrawal on performance of growing finishing steers. Rumensin Protein Seminar Proc., Greenfield, Ind.

Boling, J. A., N. W. Bradley and L. D. Campbell. 1977. Monensin levels for growing and finishing steers. J. Anim. Sci. 44:867.

Boling, J. A., A. W. Young and N. W. Bradley. 1972. Growth and blood plasma amino acids patterns in the bovine fed different sources of supplemental nitrogen. J. Nutr. 102:1247.

Braman, W. L., E. E. Hatfield, F. N. Owens and J. M. Lewis. 1973. Protein concentration and sources for finishing ruminants fed high-concentrate diets. J. Anim. Sci. 36:782.

Brown, Harold H. 1959. Determination of blood urea with p-dimethyl-aminobenzaldehyde. Anal. Chem. 31:1844.

Burris, W. R., J. A. Boling, N. W. Bradley and R. L. Ludwick. 1974. Preformed protein sources in steer finishing rations. J. Anim. Sci. 39:818.

Conway, E. J. 1963. Microdiffusion analysis and volumetric error. Chem. Pub. Co., New York, N.Y.

Duncan, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1.

Elanco Products Company. 1975. The effect of Rumensin on ration digestibility. Rumensin Technical Manual. Eli Lilly Company, Greenfield, Ind.

Erwin, E. S., G. J. Marco and E. Emery. 1961. Volatile fatty acid analysis of blood and rumen fluid by gas chromatography. J. Dairy Sci. 44:1768.

Gates, R. N. and L. B. Embry. 1977. Effects of monensin on dietary protein needs and non-protein nitrogen utilization by growing feedlot cattle. Rumensin Protein Seminar Proc., Greenfield, Ind.

Gill, D. R., J. R. Martin and R. Lake. 1976. High, medium and low corn silage diets with and without monensin for feedlot steers. J. Anim. Sci. 43:363.

Gill, D. R., F. N. Owens, J. R. Martin, D. E. Williams and J. H. Thornton. 1977. Protein levels and Rumensin for feedlot cattle. Anim. Sci. Res. Report MP 101, Okla. Agr. Exp. Sta. and USDA. 42.

Gill, D. R., F. N. Owens, J. R. Martin, J. H. Thornton and D. E. Williams. 1978. Monensin levels for steers fed high moisture corn. J. Anim. Sci. 47 (Suppl. 1): 419 (Abstr.).

Greathouse, G. A., R. R. Schalles, B. E. Brent, A. D. Dayton and E. F. Smith. 1974. Effects of levels and sources of protein on performance and carcass characteristics of steers fed all concentrate rations. J. Anim. Sci. 39:102.

Hanson, T. L. and T. J. Klopfenstein. 1977a. Adaptation of lambs fed monensin. J. Anim. Sci. 45 (Suppl 1):238 (Abstr.).

Hanson, T. L. and T. J. Klopfenstein. 1977b. Monensin, protein source and protein levels for growing steers. J. Anim. Sci. 45 (Suppl 1): 238 (Abstr.).

Harvey, R. W. 1977. Effects of monensin on performance of young stocker cattle fed corn silage with and without urea supplementation. Rumensin Protein Seminar Proc., Greenfield, Ind.

Jahn, E. and P. T. Chandler. 1976. Performance and nutrient requirements of calves fed varying percentages of protein and fiber. J. Anim. Sci. 42:724.

Kay, M., N. A. McLeod and A. MacDearmid. 1969. Protein content of the diet and food intake in steers. Nutr. Soc. Proc. 28:55 (Abstr.).

Kliewer, R. H., W. H. Kennick and D. C. Church. 1969. Influence of varying protein and diethylstilbestrol on live performance and carcass characteristics of Holstein steers. J. Dairy Sci. 53:1766.

Lewis, D. 1957. Blood urea concentration in relation to protein utilization in the ruminant. J. Agr. Sci. 48:438.

Macrae, J. C. and D. E. Armstrong. 1968. Enzyme method for determination of alpha linked glucose polymers in biological materials. J. Sci. Fd. Agric. 19:578.

Martin, J., F. N. Owens and D. Gill. 1976. Rumensin, protein levels and urea for feedlot cattle. Okla. St. Univ. and USDA Res. Rpt. MP-96, 87.

Orskov, E. R. and W. C. Fraser. 1969. The influence of protein concentration in concentrate feeds on the apparent disappearance of dry matter, protein, starch, ether extract, and ash in various segments of the digestive tract in sheep. Nutr. Soc. Proc. 28:55 (Abstr.).

Perry, T. W., W. M. Beeson and M. T. Mohler. 1976. Effect of monensin on beef cattle performance. J. Anim. Sci. 43:670.

Peterson, L. A., E. E. Hatfield, and U. S. Garrigus. 1973. Influence of concentration of dietary energy on protein needs of growing finishing cattle. J. Anim. Sci. 36:772.

Poos, M. I., L. S. Bull and R. W. Hemken. 1977. Effectiveness of the urea fermentation potential system in feeding NPN to lactating dairy cows. J. Anim. Sci. 45 (Suppl. 1):251 (Abstr.).

Preston, R. L. and V. R. Cahill. 1972. Source of supplemental protein and time of supplementation for growing finishing steer calves. Ohio Agr. Exp. Sta. Res. Summary 63:37.

Preston, R. L. and V. R. Cahill. 1973. Withdrawing supplemental soybean meal from steer calves at varying times during the finishing period and the value of supplemental amino acids, with observations on DES implants. Ohio Agr. Exp. Sta. Res. Summary 68:1.

Preston, R. L., S. W. Koch and V. R. Cahill. 1973. Supplemental protein needs and utilization of dry and crimped corn in yearling steers. Ohio Agr. Exp. Sta. Res. Summary 68:9.

Preston, R. L. and N. A. Parrett. 1972. Form of corn grain and protein level for yearling steers. Ohio Agr. Exp. Sta. Res. Summary 63:75.

Preston, R. L., D. D. Schanakenberg and W. H. Pfander. 1965. Protein utilization in ruminants. I. Blood urea nitrogen as affected by protein intake. J. Nutr. 86:281.

Putnam, P. A., R. R. Oltjen and J. Bond. 1969. Effect of soybean oil, urea, roughage and a progestigin on the utilization of corn based finishing rations by beef cattle. J. Anim. Sci. 28:256.

Raun, A. P., C. O. Cooley, E. L. Potter, R. P. Rathmacher and L. F. Richardson. 1976. Effect of monensin on feed efficiency of feedlot cattle. J. Anim. Sci. 43:670.

Richardson, L. F., A. P. Raun and E. L. Potter. 1975. The effect of rumensin on ruminal parameters of beef cattle and sheep. Conference on Rumen Function Report. Chicago, Ill.

Riley, J. G. and K. F. Harrison. 1975. Varying levels of crude protein for growing and finishing steers. J. Anim. Sci. 41:115 (Abstr.).

Roffler, R. E., L. D. Satter and A. R. Hardie. 1977. Influence of ration composition on sheep ruminal ammonia concentration. J. Anim. Sci. 45 (Suppl. 1):254 (Abstr.).

Rust, S. R. 1978. Influence of corn moisture, protein concentration and monensin on digestion by feedlot steers. M.S. Thesis, Oklahoma State University.

Steel, R. G. D. and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw Hill Book Co., Inc., New York.

Stobo, I. J. F. and J. H. B. Roy. 1973. The protein requirement of the ruminant calf. Brit. J. Nutr. 30:113.

Thomas, V. M., W. M. Beeson, T. W. Perry and M. T. Mohler. 1976. Effect of protein withdrawal on the performance of steer calves. J. Anim. Sci. 43:850.

Thornton, J. H., F. N. Owens and R. W. Fent. 1978. Butters and digestion of high moisture corn by steers. J. Anim. Sci. 47 (Suppl. 1):444 (Abstr.).

Tolbert, T. L. and R. E. Lichtenwalner. 1978. Effect of monensin on apparent digestibility and nitrogen utilization of sorghum based rations. J. Anim. Sci. 47 (Suppl. 1):276 (Abstr.).

Torell, D. T., I. D. Hume and W. C. Weir. 1974. Factors affecting blood urea nitrogen and its use as an index of the nutritional status of sheep. J. Anim. Sci. 39:435.

Utley, P. R., G. L. Newton, R. J. Ritter III and W. C. McCormick. 1976. Effects of feeding monensin in combination with zeranol and testosterone-estradiol implants for growing and finishing heifers. J. Anim. Sci. 42:754.

Weichenthal, B. A., L. B. Embry, R. J. Emerick and F. W. Whetzal. 1963. Influence of sodium nitrate, vitamin A, and protein level on feedlot performance and vitamin A status of fattening cattle. J. Anim. Sci. 22:979.

Wheeler, W. E. and C. H. Noller. 1977. Gastrointestinal tract pH and starch in feces of ruminants. J. Anim. Sci. 44:131.

PROTEIN LEVELS WITH AND WITHOUT MONENSIN FOR FINISHING STEERS

by

WILLIAM R. THOMPSON

B.S., Kansas State University, 1977

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree of

MASTER OF SCIENCE

Department of Animal Sciences and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1979

Six yearling Hereford steers (avg. init. wt. 280 kg) were fed each of the following ration crude protein levels: 9%, 11% or 15% continuously; 12% for 63 days (370 kg avg. wt.) then 10.5%; and 13% for 42 days (350 kg avg. wt.), 11% for 42 days (399 kg avg. wt.), then 9%. Within each protein treatment three steers received 200 mg monensin daily and three received none. Soybean meal was used as the supplemental nitrogen source and the 9% ration contained no soybean meal. Steers were slaughtered when their live weights reached approximately 454 kg, except those fed the continuous 9% ration performed so poorly that they were slaughtered at an average of 404 kg. Average daily gain, daily feed intake (kg), and feed efficiency, averaged across monensin treatment, for steers fed 9%, 11%, 12-10.5%, 13-11-9% and 15% rations, respectively, were: .67, 8.05, 12.19; 1.12, 8.10, 7.27; 1.04, 8.09, 7.77; 1.05, 7.87, 7.51; and 1.03, 7.96, 7.82. Steers fed the continuous 9% ration gained the least (P<.05) and were the least efficient (P<.05). Daily gain and efficiency were similar for cattle fed the other four protein levels. Protein treatment did not affect feed intake. Averaged across protein levels monensin did not affect steer performance. Though the protein level by monensin interaction was nonsignificant, monensin tended to improve feed efficiency (avg. of 7.4%) for steers fed 11%, 12-10.5% and 13-11-9% rations. Monensin did not improve feed efficiency with steers fed 9% or 15% protein rations. Carcass traits were not affected (P<.05) by protein level or monensin.

A digestion trial was conducted from day 112 to 126 of the trial and rumen and blood samples were taken every 21 days, except at 105 day. Dry matter (DM), starch (S), crude protein (CP), and crude fiber

(CF) digestibilities for cattle fed 9%, 11%, 15%, 12-10.5% and 13-11-9% rations, respectively, were: 86.3, 86.8, 31.1, 34.5%; 89.1, 86.7, 42.0, 43.9%; 89.3, 88.2, 38.7, 44.7%; 89.4, 89.9, 35.5, 33.6%; 88.9, 89.2, 53.3, 40.0%. DM digestibility was lowest ($P<.05$) for steers fed the 9% ration. CP digestibility was lowest ($P<.05$) for steers fed the 9% ration and highest ($P<.05$) for steers fed the 15% ration. CF digestibility was lowest ($P<.05$) for steers fed 9% and 13-11-9% rations. Averaged across protein levels, monensin increased CF digestibility (37.0 vs. 42.3%) but did not affect DM, S or CP digestibility. The percent starch in the feces was not affected by protein treatment or monensin. Fecal pH tended to be higher for steers fed the 15% protein treatment and lower for steers fed the 9% protein treatment. Correlation coefficients between fecal pH and fecal starch and between fecal starch and starch digestibility were -.23 and -.91, respectively.

Monensin lowered the acetate:propionate ratio for all steers except those fed the 15% ration. Rumen NH_3 and plasma urea nitrogen (PUN) levels were positively correlated with protein intake (.603 and .743, respectively). PUN ranged from 7.0 mg/100 ml for steers fed 9% rations to 19.1 mg/100 ml for steers fed 15% rations. Steers fed monensin had lower ($P<.05$) rumen NH_3 (2.74 vs. 3.18 mg/100 ml) and higher ($P<.05$) PUN (12.66 vs. 12.21 mg/100 ml) levels.