309

EFFECT OF MONENSIN ON COW PERFORMANCE WHEN SUPPLEMENTING WINTER RANGE WITH TWO LEVELS OF ENERGY

by

MARTHA P. KATZ

B.S., University of Massachusetts, 1978

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

Approved by:

Robert R. Schalles

Major Professor

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I would like to take this opportunity to thank Dr. Robert Schalles, my major professor for his guidance in the completion of my research and in the preparation of this thesis. Appreciation is extended to Dr. Arthur Dayton and Dr. E. E. Bartley for their assistance as members of my supervisory committee.

I would like to extend a special thanks to Mr. Jim Whitney for his cheerful attitude, sense of humor and invaluable assistance in the collection of data during a long, cold winter.

This thesis is dedicated to my mother and father for the opportunities, encouragement and support they have provided and for the motivation they have instilled that enabled me to complete this thesis.

REVIEW OF LITERATURE

Effect of Energy on Beef Cow Performance

Reproductive performance and total calf production are the important factors affecting the efficiency of a beef cow-calf operation. The level of winter nutrition of the cow will greatly effect these factors. Often, the beef cow is expected to utilize dormant range as the primary source of nutrition during the winter months. Supplemental feeding may be provided to improve the nutritional plane of the beef cow. Therefore, not only is it important to consider the effects of providing an additional source of energy on the productive and reproductive performance of the cow but also to consider how energy supplementation affects consumption of winter forage.

Davis et al. (1977) reported that energy is more important than protein for beef cow production. They observed earlier conception for cows fed higher energy levels rather than for higher protein supplements, indicating energy's importance for reproduction. Sorghum grain (1.4 kg/day) was a superior supplement to soybean meal (.7 kg/day) in improving reproductive performance when fed with 1.4 kg alfalfa hay per day.

Warnick et al. (1967), while studying the factors influencing pregnancy rates in beef cows, showed weight change of cows during the breeding season influenced pregnancy rate, with cows losing the most weight having the lowest rate. Lamond (1969 and 1970) associated a high level of fertility in lactating heifers and cows with a high condition score. Cows in the herd with better condition had a final conception rate of 88.2% while cows in the herd with less condition had a final conception rate of 65.5%. Hight (1966) in New Zealand, altered the plane of nutrition of beef cows from mid pregnancy to calving by altering the stocking rate and providing hay supplement. Only 75% of the cows on the low level of nutrition reared calves to weaning while 93% of the cows on a high plane of nutrition reared calves to weaning. All cows were offered a high plane of nutrition after calving.

Smithson et al. (1966) found after feeding cows at four planes of nutrition (low, moderate, high, very high) over six calf crops, that the low plane was sub-optimum during the first four winters of a cow's life, but beyond this point of maturity, the low plane produced levels of productivity (expressed as pounds of calf weaned per cow) comparable to the moderate and high planes. Cows on the high and very high planes exhibited lower survival rates over the six year period.

Flushing cows shortly before and during the breeding season has not been shown to have an effect on reproductive performance. Bellows et al. (1968) reported no improvement in reproductive performance when a grain supplement was fed to cows during the periods when the cows were with bulls. Loyacano et al. (1973 and 1974) observed no effect on calving percentage, calf birth weights and weaning weights of calves when Hereford cows were flushed for 30 days beginning 15 days prior to a 60-day breeding season. However, Davis et al. (1977) reported that cows could be fed a low energy level if they were flushed for approximately 100 days prior to breeding.

It is important in a cow-calf operation for a cow to calve early in the calving season and for her to maintain a 12 month calving interval. The earlier in the season a cow calves, the heavier her calf will weigh at weaning. Accordingly, the length of the interval from calving to first postpartum estrus is a major factor in maintaining a 12 month calving interval.

Zimmerman et al. (1961) reported that the restriction of energy intake for 32 Hereford heifers during the winter months significantly increased the interval from calving to first heat, with the low protein-low energy treatment and the high protein-low energy treatment resulting in a 142 and 148 day postpartum interval, respectively, compared to intervals of 54 and 51 days for the low protein-high energy and high protein-high energy treatments, respectively. Zimmerman also observed a delay in the amount of time necessary for uterine involution when both protein and energy were restricted to the low levels; 74 days for the low protein-low energy treatment vs. 54, 56 and 52 days for the low protein-high energy, high protein-low energy and high protein-high energy treatments, respectively.

Wiltbank et al. (1962) suggested that the main value of supplemental feeding is in decreasing the length of the interval from calving to first estrus. He used 88 pregnant Hereford cows which were divided into four treatment groups; high precalving-high postcalving, high precalving-low postcalving, low precalving-high postcalving, and low precalving-low postcalving energy intake. TDN intake of the high groups approximates NRC requirements and low levels were equal to 1/2 of the high levels. The length of the postpartum interval was significantly influenced by the nutritive level. Even though both pre- and post-calving energy levels appeared to have an effect on the onset of estrus, the precalving energy level appeared to be relatively more important. A high proportion of the cows receiving the high energy ration prior to calving had cycled by 90 days postcalving. The response of cows to the level of energy postcalving was conditioned by the precalving energy level. The postcalving energy level had little effect on cows that had received a high level of energy prior to calving but had a marked effect on the cows fed a low level of energy prior to calving. The majority of cows that received the low level of nutrition, both during precalving and postcalving, failed to show estrus, while 85% of the low precalving-high postcalving plane had cycled by 90 days postpartum. Wiltbank concludes that maintaining the NRC recommended level of energy before calving and reducing it to 1/2 the recommended after calving does not greatly influence the interval from calving to first estrus but does reduce the proportion of cows showing estrus and the conception rate. The low energy level before calving, followed by the recommended level of energy postcalving, increased the interval from calving to first estrus but did not effect conception rate. Half of the recommended level of energy both prior to and after calving results in a high percentage of the cows failing to cycle and in a much lower conception rate.

In a following report, Wiltbank et al. (1964) considered the influence of postpartum energy levels on reproduction where cows were restricted in energy intake prior to calving. The cows were fed at a level of 50% TDN recommended by the NRC for 140 days prior to calving. At calving cows were allotted to 5 treatment groups; (1) 75%, (2) 100%,

(3) 150% of the TDN recommended by the NRC, (4) 50% for 4-5 weeks post-calving and 100% TDN thereafter and (5) 50% for 4-5 weeks postcalving and 150% of the TDN recommended by the NRC thereafter. The interval from calving to first estrus was significantly shorter for the group fed the recommended level (49 days for group 2 compared to 73 days for group 1, 72 days for group 3, 78 days for group 4 and 82 days for group 5). Although feeding a higher than necessary level of TDN after calving did not decrease the interval from calving to first estrus, it did appear to exert a favorable influence on conception. Of group 3 cows, 83% settled on first service while 54%, 31% and 46% settled for groups 1, 2 and 4, respectively. All cows on 150% TDN had settled by the third service. The overall fertility of cows that received more than the recommended level of TDN was higher although the difference was not significant. However, cows that had received the recommended level of TDN had a shorter interval from calving to conception, resulting from a shorter interval from calving to first estrus.

Dunn et al. (1969) reported the precalving energy level exerted the greatest influence in the early postpartum period. Before 40 days after calving 25% of the cows fed a high precalving energy level had shown estrus compared to 6% of those fed the low precalving energy levels. At 60 days, 69% of the cows fed the high level before calving had cycled compared to 44% of those fed the low precalving level. After 100 days postcalving, precalving energy level was no longer an important factor which affected the occurrence of estrus. The pregnancy rate 120 days after calving was directly related to the postcalving energy level. Eighty-seven % of the cows fed the high energy level were pregnant compared to 72% of those fed the moderate level and 64% of those fed the low postcalving energy level. Precalving energy affected pregnancy rates only during the first 100 days after calving. Forty-one % of the cows on the low level before calving were pregnant at 80 days compared to 47% of the cows on a high precalving energy level.

Turman _et al_. (1964) concluded that the level of energy fed before calving is more important than the level fed after calving when considering rebreeding performance of heifers. All heifers in the high precalving-low postcalving energy group and 93% of the high pre and post-calving energy group conceived compared to only 53% of the heifers fed a low level continuously and 75% of those heifers fed low to calving and then raised to high. The high level heifers prior to calving also had an earlier breeding date which can be explained by the shorter interval from calving to first estrus. Comparing extremes, heifers fed high continuously returned to heat on an average of 56 days, while those fed the low energy level required 93 days to cycle.

Both Zimmerman _et al_. (1959) and Pinney _et al_. (1972) reported lower winter feeding levels delayed calving date consistently each year. Zimmerman fed three levels of winter supplement to cows grazing native Oklahoma pasture over a period of 10 years. His data showed an average calving date for the low energy cows of 7 to 11 days later than for those cows being fed the medium or high energy level. Pinney observed over a 5 year period a one week to 12 day delay in calving date for low level groups as compared to the high level groups.

Age of the female is an important factor when considering the effects of energy on reproductive performance. Smithson _et al_. (1966)

reported that for the first four calf crops each higher energy level resulted in an earlier calving date by about one week. He observed that the level of winter feed appeared to have no consistent effect upon calving date after the fourth calf crop. This is in agreement with results of Hughes _et al_. (1978). In the first 4 calf crops of range cows the higher levels of supplemental energy resulted in earlier calving dates. There was no significant difference in calving date of the low, medium, high and very high energy groups in the fifth calf crop. The low and medium levels of supplementation during the first winter were sufficient to support adequate conception in the first breeding season, shown by a similar calving percentage for all treatments in the first calf crop. Low and medium level cows exhibited a continual decline in conception rate through the third calf crop. The lower levels of feed coupled with pregnancy and lactation were inadequate to support normal estrus. Once the low level cows reached maturity, the level of winter supplementation had little effect on calving percentage. Hughes concludes that once the nutrient demands for body growth and development have been met, the lower level dam was apparently able to prepare herself for pregnancy more rapidly.

Davis _et al_. (1977) observed earlier conception for cows fed higher energy levels, with most of the response to the energy level occurring in two and three year old cows. However, supplementing cows with 1.4 kg of alfalfa hay per day was inadequate even for mature cows indicated by delayed conception dates. Davis reported that delaying a part of winter feed until after calving delayed conception for two and three year olds but not for older cows.

The nutrition level of the dam effects calf viability and growth. Wiltbank _et al_. (1962) and Laster (1974) reported that the level of nutrition fed to the dam prior to calving had no effect on the number of cows requiring assistance at parturition. Laster reported that any increase in calf birth weights due to an increased level of nutrition of the dam is an increase in soft tissue, not skeletal size; therefore, you see no increase in calving difficulty. Bond and Wiltbank (1970) observed a high rate of calf mortality in fat heifers, or those heifers on the high energy supplementation. No calf abnormalities were found at necropsy and findings indicated deaths were caused by slow or difficult deliveries.

The literature is not conclusive on whether the nutritional level of the dam prior to calving affects the birth weight of the calf. It appears that if an effect does exist, it is much more apparent in the first 2 or 3 calf crops of a cow. Stanley (1938), Wiltbank _et al_. (1962), Turman _et al_. (1964) and Bond _et al_. (1964) reported a significant difference in the birth weight of calves from cows being fed a higher level of energy supplementation. Hughes _et al_. (1978) showed that increasing supplement from a low level to a high level resulted in larger birth weights in the first 3 calf crops, with no effect indicated in following calf crops. Zimmerman _et al_. (1959), Smithson _et al_. (1966), Jordan _et al_. (1967), Hironaka and Peters (1969), Rust _et al_. (1970), Pinney _et al_. (1972) and Holloway _et al_. (1973) reported that the level of wintering of the cow had little or no effect on the birth weight of the calf.

Weaning weight is also not consistently altered by the nutritional level of the dam. Pinney *et al*. (1972) and Holloway *et al*. (1973) reported no significant difference in the weaning weights of calves from cows that were at different levels of supplementation. Zimmerman *et al*. (1959) reported higher weaning weights over a 10 year period for calves from cows wintered on a low level of nutrition. Smithson *et al*. (1966) reported a marked difference in weaning weights of the first 2 calf crops with the weights increasing progressively from the low to the high level of supplementation. However, Smithson observed that beyond the second calf crop the difference narrowed considerably. Speth *et al*. (1962), Davis *et al*. (1977), Hironaka and Peters (1969), Rust *et al*. (1970) and Neville *et al*. (1960) reported lighter weaning weights of calves from cows wintered on the low levels of nutrition. Turman *et al*. (1964) observed that the level of feeding both pre- and post calving has an important effect on the weaning weights of calves. This is evident when one compares the 358 lb weaning weight of the calves from the low level pre- and post calving group, the 376 lb weaning weight from the low pre- calving-high post calving group, the 408 lb weaning weight from high pre--low post calving group and the 432 lb weaning weight of the continuously high level group. Turman stated that the level of feeding prior to calving has an important effect on the subsequent mothering ability of the cow. They compared the calves of the high-low group that weaned at an average of 32 lbs heavier than the calves of the low-high group and only 14 lbs of this difference could be explained by heavier birth weights. Turman observed an improved mothering ability expressed as an increase in milk production.

Bond *et al*. (1964), Bond and Wiltbank (1970), Holloway *et al*. (1973) and Neville *et al*. (1960) reported that the level of milk production of the cow increased as her level of nutrition increased. Bond *et al*. (1964) observed that heifers on a low energy supplement produced 3.4 lbs/12 hrs compared to 6.7 lbs/12 hrs for the medium level of energy supplement and 6.6 lbs/12 hrs for the high level. In a later report Bond (1970) observed that the milk production of heifers on a low energy supplement declined as lactation progressed, while milk yield for the medium energy heifers peaked at 60 days then declined, and milk yield for the high energy heifers peaked at approximately 90 to 120 days. Fleck (1976) reported precalving energy had no significant effect on seasonal milk production in heifers. Milk production was similar for heifers fed 100% of NRC requirements for energy from 120 days prior to the first scheduled calf to calving and heifers fed 70% of NRC requirements up to 50 days prior to the first scheduled calf and 100% of the NRC requirements up until calving. A slight but nonsignificant lower seasonal milk production was obtained from heifers fed a continuous restricted energy level (70% of NRC requirements) up until calving.

The kilograms of calf weaned represents the overall effects of conception rate, calf liveability, calf gainability and milk production of the dam. Pinney *et al*. (1972) reported that the total kilograms of calf weaned per cow during her lifetime was significantly affected by winter supplemental feed level with the cows on the low winter supplement level (60% recommended digestible protein) weaning 340 more kg than the cows on the medium level (120% recommended digestible protein) and 478 more kg than the cows on the high supplement (200% of recommended digestible protein). This is a result of a higher percentage of calf crops born and weaned for the lower feed level females and greater longevity of these females. Zimmerman et al. (1959) also reported the percentage of calf crop weaned favored the low and medium supplemental levels. Hughes et al. (1978) observed the opposite result as Pinney and Zimmerman; the high level of supplement weaned more kg of calf/cow over a 10 year period.

Most cow-calf producers depend on a dormant winter range as it is the most abundant, economical source of forage for their cows. However, for better reproductive performance, they may find it necessary to supplement with an additional source of energy. The consumption of the energy supplement will have an effect on the intake and utilization of the forage. Cook and Harris (1968) reported that supplements such as corn or barley resulted in a decrease in dry matter intake and digestibility of desert-range forage consumed during the winter. Rittenhouse et al. (1970) reported very little influence of supplemental crude protein on forage dry matter digestibility and intake. They did observe that supplemental energy levels above 0.041 Mcal per kg $BW^{0.75}$ significantly decreased forage intake but had no influence on dry matter digestibility of the forage. Total dietary intake and digestibility were increased with successive increments of increased energy supplementation. Rittenhouse concluded that any advantage from feeding supplements on forage intake or digestibility is variable under winter conditions. Feeding high levels of energy can be expected to decrease forage intake. Even though the study reported total digestible energy intake was highest at the highest level of energy supplementation, Rittenhouse stated in some years depression of forage intake is sufficient enough that there is no greater total digestible energy available from high levels of supplemental energy than from low levels of supplemental energy.

In one study Lusby et al. (1973) reported a high level of supplementation resulted in a decrease in forage intake. Again, Lusby et al. (1976a), while studying the influence of winter supplementation on the forage intake of cows grazing native tallgrass range in Oklahoma, reported that cows fed the moderate level of supplement consumed more forage dry matter and cellulose than cows fed the high level. The moderate level was calculated to allow good rebreeding performance in mature Hereford females. Lusby compared DE intake to the theoretical requirements and showed that cows fed the high level were only 0.1 to 2.5 Mcal/day closer to meeting their DE requirements than cows fed the moderate level even though the high level females received at least 4.6 Mcal/day more from the supplement than the moderate females. During the summer, cows previously wintered on the moderate level tended to consume more forage dry matter and cellulose than cows wintered on the high level.

This relationship between forage intake and level of winter supplement does not agree with roughage intake data by Holloway et al. (1975) and Lusby et al. (1974) for dry lot cows fed winter supplement along with cottonseed hulls ad libitum. Both reported the cows fed the high level of supplement consumed more cottonseed hulls. Lusby then replaced the cottonseed hulls with baled winter range grass and high supplement females consumed only slightly more forage than the moderate females.

He concluded that roughage palatability is a factor, where with a readily consumed roughage (such as cottonseed hulls), intake increases with higher levels of supplementation while with a less palatable roughage such as range forage, consumption decreases with increasing levels of supplementation. Lusby *et al*. (1976b) reported similar results to his earlier study where drylot cows fed the high level of supplementation showed an increase in forage intake over the moderate level fed cows.

LITERATURE CITED

Bellows, R. A., R. B. Gibson, O. O. Thomas and O. F. Pahnish. 1968. Grain supplement-forage production relationships in range cow reproduction. Proc. Amer. Soc. Anim. Sci. West. Sect. 19:313.

Bond, James and J. N. Wiltbank. 1970. Effect of energy and protein on estrus, conception rate, growth and milk production of beef females. J. Anim. Sci. 30:438.

Bond, J., J. N. Wiltbank, E. J. Warwick, R. P. Lehman and T. B. Kinney. 1964. Feed intake and milk production of beef cows. J. Anim. Sci. 23:901 (Abstr.).

Cook, C. W. and L. E. Harris. 1968. Effect of supplementation on intake and digestibility of range forage. Utah Agr. Exp. Bull. 475.

Davis, Duane, R. R. Schalles, G. H. Kiracofe and D. L. Good. 1977. Influence of winter nutrition on beef cow reproduction. J. Anim. Sci. 46:430.

Dunn, T. G., J. E. Ingalls, D. R. Zimmerman and J. N. Wiltbank. 1969. Reproductive performance of 2-year-old Hereford and Angus heifers as influenced by pre- and post-calving energy intake. J. Anim. Sci. 29:719.

Fleck, Arnold T. 1978. Effect of varying energy levels, fed during gestation, on the performance of beef heifers. Master's Thesis. Kansas State University, Manhattan, KS.

Hight, G. K. 1966. The effect of undernutrition in late pregnancy on beef cattle production. New Zealand J. Agr. Res. 9:479.

Hironaka, R. and H. F. Peters. 1969. Energy requirements for wintering mature pregnant beef cows. Can. J. Anim. Sci. 49:323.

Holloway, J. W., D. F. Stephens, J. V. Whiteman and Robert Totusek. 1975. Performance of three-year-old Hereford, Hereford x Holstein and Holstein cows on range and in drylot. J. Anim. Sci. 40:114.

Holloway, J. W., D. F. Stephens, Leon Knori, Keith Lusby, Art Dean, J. V. Whiteman and Robert Totusek. 1973. Performance of three-year-old Hereford, Hereford x Holstein and Holstein females as influenced by level of winter supplement under range conditions. Oklahoma Agr. Exp. Sta. Res. Rep. MP-90.

Hughes, J. H., D. F. Stephens, K. S. Lusby, L. S. Pope, J. V. Whiteman L. J. Smithson and Robert Totusek. 1978. Long-term effects of winter supplement on the productivity of range cows. J. Anim. Sci. 47:816.

Jordan, W. A., E. E. Lister and G. J. Rowlands. 1967. Effect of varying planes of winter nutrition of beef cows on calf performance to weaning. Can. J. Anim. Sci. 48:155.

Lamond, D. R. 1969. Sources of variation in reproductive performance in selected herds of beef cattle in northeastern Australia. Australian Vet. J. 45:50.

Lamond, D. R. 1970. The influence of undernutrition on reproduction in the cow. Anim. Breed. Abstr. 38:359.

Laster, Danny B. 1974. Factors affecting pelvic size and dystocia in beef cattle. J. Anim. Sci. 38:496.

Loyacano, A. F., J. E. Pontif, W. A. Nipper and C. K. Vincent. 1973. Season and energy effects on reproduction in beef cattle. J. Anim. Sci. 36:215 (Abstr.).

Loyacano, A. F., W. A. Nipper and C. K. Vincent. 1974. Effect of supplemental energy and season of breeding on the reproductive performance of beef cattle. J. Anim. Sci. 39:281.

Lusby, K. S. 1974. Level of milk production in range cows: Effects on winter feed requirements, forage intake and digestibility in cows and preweaning forage intake, digestibility and postweaning feedlot performance of their calves. Ph.D. Thesis. Oklahoma State University, Stillwater, OK.

Lusby, K. S., D. F. Stephens and Robert Totusek. 1976a. Influence of breed and level of winter supplement on forage intake of range cows. J. Anim. Sci. 43:543.

Lusby, K. S., D. F. Stephens and Robert Totusek. 1976b. Influence of breed and level of winter supplement on roughage intake and digestibility of drylot cows. J. Anim. Sci. 43:1293.

Lusby, K. S., R. A. Dean, J. W. Holloway, D. F. Stephens and Robert Totusek. 1973. Breed and supplement level effect on intake and digestibility. J. Anim. Sci. 37:349 (Abstr.).

Neville, W. E., Jr., D. M. Baird and O. E. Sell. 1960. Influence of sire, dams milk production, three levels of nutrition and other factors on 120- and 240-day weight of Hereford calves. J. Anim. Sci. 19:1223 (Abstr.).

Pinney, Don O., D. F. Stephens and L. S. Pope. 1972. Lifetime effects of winter supplemental feed level and age at first parturition on range beef cows. J. Anim. Sci. 34:1067.

Rittenhouse, L. R., D. C. Clanton and C. L. Streeter. 1970. Intake and digestibility of winter-range forage by cattle with and without supplements. J. Anim. Sci. 31:1215.

Rust, J. W., J. C. Meiske and R. D. Goodrich. 1970. Winter energy requirements for beef cows. North Central Exp. Sta. Grand Rapids Res. Rep. B-150.

Smithson, Larry, S. A. Ewing, L. S. Pope and D. F. Stephens. 1966. The cumulative influence of level of wintering on the lifetime performance of beef females through six calf crops. Oklahoma Agr. Exp. Sta. MP-78.

Speth, C. F., V. R. Bohman, H. Mclendy and M. A. Wade. 1962. Effect of dietary supplements on cows on a semi-desert range. J. Anim. Sci. 21:444.

Stanley, E. B. 1938. Nutritional studies with cattle on a grassland-type range in Arizona. Arizona Agr. Exp. Sta. Tech. Bull. 79.

Turman, A. J., L. Smithson, L. S. Pope, R. E. Renbarger and D. F. Stephens. 1964. Effect of feed level before and after calving on the performance of two-year-old heifers. Oklahoma Agr. Exp. Sta. MP-74.

Warnick, A. C., R. C. Kirst, W. C. Burns and M. Koger. 1967. Factors influencing pregnancy in beef cows. J. Anim. Sci. 26:231 (Abstr.).

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls and D. R. Zimmerman. 1964. Influence of post-partum energy level on reproductive performance of Hereford cows restricted in energy intake prior to calving. J. Anim. Sci. 23:1049.

Wiltbank, J. N., W. W. Rowden, J. E. Ingalls, K. E. Gregory and R. M. Koch. 1962. Effect of energy level on reproductive phenomena of mature Hereford cows. J. Anim. Sci. 21:219.

Zimmerman, D. R., D. C. Clanton and J. K. Matsushima. 1961. Post-partum reproductive performance in beef heifers as affected by protein and energy intake during gestation. J. Anim. Sci. 20:957 (Abstr.).

Zimmerman, E., L. S. Pope, A. B. Nelson and D. F. Stephens. 1959. Effect of different levels of wintering on the performance of spring-calving beef cows. Oklahoma Agr. Exp. Sta. Rep. 55.

Monensin

Monensin is a fermentation product, produced by a strain of *Streptomyces cinnamonensis*. Haney and Hoehn (1967) discovered and isolated monensin while working at the Lilly research laboratories. Monensin was shown by Haney and Hoehn to have microbial growth-inhibitory activity when tested *in vitro* against a broad spectrum of bacteria and fungi. Haney and Hoehn also demonstrated the anti-coccidial activity of monensin in chickens. They observed that when monensin was fed to 7-day-old chicks infected with *Eimeria tenella*, it was effective in reducing mortality. The average weight gain of the infected, treated chicks was 98g, while the average weight gain of the infected, untreated controls was 57g. Shummard and Callender (1967) tested the effectiveness of monensin against a number of species of coccidia, both singly and mixed. Regardless of the combination of species used, mortality was drastically reduced or prevented, and weight gains of the chicks treated with monensin were at least 83% of those observed in the uninfected control groups.

Monensin has been shown also to be effective against coccidiosis in rabbits and calves. Fitzgerald and Mansfield (1973) showed that monensin is effective in the control of coccidiosis in Holstein calves. Calves that were innoculated with a strain of coccidia, *Eimeria bovis*, developed severe infections. A few calves in the group which had received monensin developed light infections but none had clinical signs of coccidiosis.

The effects of monensin in the ruminant have been widely researched, but the mechanisms by which monensin alters rumen fermentation are still uncertain. Monensin alters the proportions of volatile fatty acids in the rumen contents toward higher propionate and decreased acetate and butyrate (Potter et al., 1974; Richardson et al., 1974). Prange et al. (1978) from Illinois reported that supplementing a ration of hay and concentrate with monensin at a level of 33 ppm significantly increased the molar proportion of rumen propionate from 19.1% in the control steers to 24.7% in the treated steers. Monensin supplementation increased propionate production from 7.74 moles per day to 11.18 moles per day. Therefore, the change in the molar proportions of the volatile fatty acids can be explained on the basis of an increase in propionate production in the rumen.

Thorten et al. (1976) demonstrated reduced ruminal methane following the feeding of monensin. Van Nevel and De Meyer (1977) of Belgium determined the inhibition of methane production is not due to a direct toxic effect on methanogenic microorganisms but is due to the inhibition of organisms decomposing formate to CO_2 and H_2, these gases being the most important substrates for methane bacteria. They stated that the increase in propionate production accompanying this inhibition of methanogenesis reflects a shift in the flow of electrons from formate and methane to succinate or propionate. Van Nevel and De Meyer also report an inhibitory effect of monensin on microbial growth yield. As growth inhibition was not accompanied by a decrease in fermentation activity in terms of fermentation products formed, part of the energy generated during fermentation normally used for maintenance and growth of the microbes must be used for other purposes when monensin is added. They suggest that monensin uncouples growth from fermentation and that the mechanism of this action is related to an altered cell permeability, since monensin is known to be an ionophore.

Chen and Wolin (1979) suggest that monensin acts by selecting for a rumen microbial community that produces proportionally more propionic acid than the microbial community of untreated ruminants. They observed that *Ruminococcus albus*, *Butyrivibrio fibrisolvens* and *Ruminococcus flavefaciens*, all acetate producers, were completely inhibited by 2.5 μg of monensin per ml. A delayed growth response, suggesting the selection for antibiotic resistant populations, was shown by *Bacteroides succinogens* and *Bacteroides ruminicola* which are both important succinate producers. *Selenomonas ruminantium* which was insensitive to monensin is a major organism involved in the decarboxylation of succinate, produced by other organisms, to propionate and CO_2. Chen and Wolin hypothesized that monensin increases propionate production because of the selection for the succinate producing bacteroides and the propionate producing *S. ruminantium*.

Beede and Farlin (1977) and Bartley *et al*. (1979) reported that an effect of monensin on rumen fermentation was to increase lactate production. Dinius *et al*. (1976) reported no differences in *in vivo* digestion of dry matter, crude protein, hemicellulose and cellulose of a forage diet with different levels of monensin treatments. Lemenager *et al*. (1978a) reported that the addition of monensin to *in vitro* fermentation of range grass depressed dry matter disappearance but *in vivo* cellulose disappearance was not significantly altered by monensin. Poos *et al*. (1979) also observed a reduction in dry matter digestibility with addition of monensin in two lamb trials.

The effect of monensin on cattle consuming a high energy ration has been improved feed efficiency with monensin maintaining weight gains accompanied by a decrease in feed consumption. Perry et al. (1976) reported that growing-finishing beef steers fed 33 ppm of monensin for 232 days gained at the same rate as the control but required 10% less dry matter per kilogram of gain. Gill et al. (1976) fed 300 mg of monensin per day to steers consuming rations containing 14, 30 or 75% of their dry matter from corn silage. Monensin improved feed efficiency 6% across all roughage levels but had no effect on gain or carcass parameters. Feed intake was 5 to 14% lower for the monensin fed cattle than for the non-monensin fed cattle. Raun et al. (1976) fed cattle doses of 0, 2.7, 5.5, 11, 22, 33, 44 and 88 ppm to determine the effect on daily gain, feed consumption and feed efficiency. All monensin dosages except 88 ppm produced daily gains that were equal to or greater than the non-treated controls, with the biggest improvement being 5.2% at 11 ppm. Feed consumption declined progressively with increasing dosages of monensin. All monensin treatments improved feed efficiency. At 11 and 33 ppm feed efficiency was improved 10 and 17%. Utley et al. (1977), Steen et al. (1978), Heineman et al. (1978) all observed similar results. The effect of monensin on ruminal volatile fatty acids with high concentrate diets has been very consistent. In all cases the molar proportion of propionate increases while the molar proportion of acetate and butyrate declines.

Monensin, when fed to growing steers primarily on a roughage ration, will increase gains compared to the control steers. In all reports, as was the case with high energy rations, the molar percentage of propionic acid has increased. Potter et al. (1976) showed no effect upon dry matter consumption with a monensin dosage of 200 mg per head per day. Potter conducted an experiment feeding five levels of monensin contained in a supplement along with greenchop fed ad libitum. The results of this experiment showed an 18% increase in daily gain (.585 kg/day vs. .495 kg/day) and a 14% increase in feed efficiency (11.91 feed/gain vs. 13.92 feed/gain) when the steers received 200 mg per day of monensin compared to the controls.

In grazing experiments conducted by Potter et al. (1976), three separate trials were conducted during the spring and summer using Brahman, Angus and Charolais crossed cattle in the first trial, Angus steers in the second trial and Hereford and black-white faced steers in the third trial. In all three of the trials, each treatment group was randomly assigned to one of four pastures which contained orchardgrass, alfalfa, brome and ladino clover. The cattle were rotated between pastures so that each group of cattle spent an equal number of days in each pasture. The optimal dose of monensin in these experiments was 200 mg per head per day. Daily gain was increased approximately 17% by 200 mg of monensin. Steers treated at that level gained .51, .72, .78 kg per day compared to a gain of control steers of .37, .56, .68 kg per day for trials 1, 2 and 3, respectively. Monensin dosages of 200 mg/day and below had no effect upon dry matter consumption. Potter suggests that monensin increased the gain of pasture cattle by providing the animal with more net energy per unit of feed consumed.

In other grazing experiments, W. M. Oliver (1975) evaluated the effect of four levels of monensin on weight gains of 120 steers grazing coastal bermudagrass from May 1 through mid-September. Monensin at all levels produced larger average gains than the controls with the largest 140 day gain of 240.8 pounds per head produced by the 100 mg/day level. This treatment produced 66.4 lb more gain than the control level.

Boling _et al_. (1977) conducted an experiment grazing 72 Angus steers starting May 4 on pasture containing a Kentucky bluegrass clover mixture. There were four treatment groups - control, 25, 50 and 100 mg/head daily. Steers fed 50 mg or 100 mg monensin per head daily had significantly higher average daily gains than the control group or those fed 25 mg monensin per head daily.

Muller _et al_. (1979) reported results from 11 trials including 853 animals and 75 pastures in nine states to assess the value of energy supplementation and energy supplementation plus monensin for cattle grazing growing, green pasture. The average trial lasted 117 days. Average daily gains of the supplemented cattle ranged from 0.19 kg to 0.95 kg. The addition of supplement alone increased gains by 0.082 kg daily and the addition of monensin further increased gains by another 0.091 kg daily. The efficiency with which supplement was converted to extra gain was doubled by monensin.

Vijchulata _et al_. (1980) fed 40 steers in four treatment groups of 0 and 200 mg monensin per head daily and two levels of energy supplementation along with cottonseed hulls _ad libitum_. Average total daily feed consumption for monensin fed steers averaged .74 kg less than that for the controls (11.75 vs. 12.49 kg). There were no differences among treatments in gain. Steers receiving the low and high energy levels gained at rates of .81 and .85 kg per day, respectively. Within each respective supplemental treatment, the average daily gain of steers was increased 6.41 and 9.88% by monensin. The reduced intake along with a higher rate of gain for steers fed supplement containing monensin provided an average of 13.01% improvement in feed efficiency over control steers (13.71 vs. 15.76 kg feed per unit gain). The results of this study, where monensin improves feed efficiency by decreasing consumption while maintaining gains, disagrees with the reports of Potter et al. (1976) and Turner et al. (1977) which indicate that monensin improves feed efficiency in cattle fed roughages by increasing weight gains without affecting feed intake. The results of this study are similar to results of studies where the animals are on high energy rations. Vijchulata suggests that perhaps cottonseed hulls do not function as typical low quality roughages.

Males et al. (1979) studied the effect of monensin on the gain of steers on winter pasture. Forty yearling Angus steers were wintered on tall fescue pasture and hay. There were two treatments - zero and 200 mg monensin per head per day - fed in a grain supplement. Cattle receiving the monensin supplement gained .64 kg/day compared to 0.57 kg/day for the control steers.

If similar results with monensin are obtained with brood cows on a maintenance ration the net result would be a savings in forage. An increase in the efficiency of forage utilization would have the effect of increasing stocking rate or improving the performance of grazing cows.

Lemenager et al. (1978b) conducted a trial where 69 Hereford cows grazed native tallgrass range during the winter months. The treatments were 0, 50 and 200 mg of monensin per cow daily added to a 30% crude protein soybean meal based supplement. Forage intake of cows was estimated using 20g of chromium sesquioxide daily as an external marker. Weight losses of cows fed 0 and 200 mg were similar; however, cows fed 50 mg of monensin lost more weight than either the control or 200 mg group. Forage intake was reduced 13.6% (9.61 kg vs. 8.50 kg) when 50 mg of monensin was fed and 19.6% (9.61 kg vs. 7.73 kg) when 200 mg of monensin was fed. In a second trial, Lemenager et al. (1978b) carried out an experiment with 72 Hereford cows grazing winter range. The two treatments were 30% natural crude protein supplement with 0 or 200 mg of monensin added per cow per day. Weight changes of the cows were similar during the dry grass portion of the trial but cows fed monensin gained weight faster during the last 45 days of the trial when the grass began to grow. The number of cows exhibiting estrus, postpartum interval and conception rates of cows were not significantly different. When averaged over the three grazing observations, monensin fed cows grazed 14.6% less than the control cows. This reduction in grazing time is similar to the 20% reduction in forage intake observed in the first trial. Monensin did not effect milk production, milk solids, percentage milk fat or solids-not-fat. Total calf gain was greater for calves weaned by monensin fed cows (.63 kg/day vs. .59 kg/day). Calves were observed to be consuming supplement; therefore, the 6.8% increase in calf gain may be attributed to increased efficiency in utilizing milk and/or forage.

Results from two more Oklahoma trials (Lemenager et al., 1978c) showed that cow weight change was not significantly affected by the addition of monensin to a 30% crude protein soybean meal based supplement, and 30% crude protein extruded urea-grain supplement, or a 15% crude protein soybean meal based supplement.

Stauffer and Ward (1977) at Nebraska conducted three trials, one with gestating yearling heifers, and two with gestating spring calving 3 and 4 year old cows. In the first trial, the heifers winter grazed cool season grass pastures and were fed an average of 7.9 kg of bromegrass hay per head daily for 84 days. There were two treatments; control and 200 mg per head per day. Weight change was .52 kg for control and .58 kg for the monensin supplemented heifers. Monensin supplementation increased weight change by 11.5% which approached significance. In the other two trials the cows were allotted into fields that had been in corn and grain sorghum. One cornstalk group and one grain sorghum stubble group received 200 mg monensin per head per day. Weight change in the first trial was .85 for control vs. .97 kg for monensin fed cows. There was no difference in the weight gain in the second trial.

Turner et al. (1977) conducted two winter trials in Oregon with 48 pregnant Hereford cows receiving meadow hay free choice plus 0.45 kg of barley per day which contained zero or 200 mg monensin. Cows receiving monensin gained .43 kg as compared to .23 kg/day for the control and consumed less hay, 11.0 to 11.4 kg per day. In trial 2, daily gains were 0.47 and 0.28 kg and hay intake was 12.7 and 13.5 kg respectively for monensin supplemented cows and controls. Results from these two trials indicate that monensin improved feed efficiency for gestating cows wintered on low quality roughage. Cows from the monensin group in trial 1 were in first estrus postpartum an average of 12 days earlier than controls. In the second trial the interval from calving to first estrus postpartum was the same for both control and treated cows.

Turner et al. (1980) conducted another trial, with 96 pregnant cows allotted to three replications of four treatments; 0, 50, 200 and 300 mg of monensin per head per day. The monensin was supplied by supplementing hay with .45 kg of barley per head per day. Hay intake was measured on a lot basis by weighing hay daily. The hay was adjusted to maintain equal weight gain or loss among treatments. Prepartum ADG was not different among treatments (.34, .38, .38, .37 kg for 0, 50, 200, 300 mg treatments). Hay intake was 93%, 90% and 92% of the control intake for the 50, 200 and 300 mg treatments. The 200 mg treatment proved to be the most efficient with a similar gain on 10% less hay than the controls. During the period just prior to calving through 30 days of lactation, the 200 mg level cows lost approximately the same weight as controls on 13% less hay (-.78 kg vs. -.75 kg/day) and the 50 mg level group on 10% less hay (-.79 kg vs. .75 kg/day). For the entire confinement period both the 50 mg and 200 mg group lost less weight than the controls (-.05, -.10 vs. -.12 kg/day) and received 8% less hay on the 50 mg level (11.2 kg vs. 12.2 kg) and 11% less hay on the 200 mg treatment (10.8 kg vs. 12.2 kg).

Cow weight gains from termination of the monensin treatment to the weaning of calves were similar, with cows from the 50 and 200 mg treatments gaining slightly better than those from the 300 mg and control treatments. Birth weights and ADG to weaning of calves for all treatments were similar.

The reproductive performance of the treatment groups is similar. Days to first estrus was essentially the same for all treatments. The monensin fed groups had a tendency to breed back at a higher rate than the controls. The calving intervals for the control, 50 and 200 mg groups were not different, while the 300 mg group had a larger interval than the controls. In this study monensin did improve feed efficiency without affecting the reproductive performance of the cows.

LITERATURE CITED

Bartley, E. E., E. L. Herod, R. M. Bechtle, D. A. Sapienza and B. E. Brent. 1979. Effect of monensin or lasalocid with and without niacin or amicloral, on rumen fermentation and feed efficiency. J. Anim. Sci. 49:1066.

Beede, David K. and Stanley D. Farlin. 1977. Effect of antibiotics on apparent lactate and volatile fatty acid production: in vitro rumen fermentation studies. J. Anim. Sci. 45:385.

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

Chen, Min and M. J. Wolin. 1979. Effect of monensin and lasalocid-sodium on the growth of methanogenic and rumen saccharolytic bacteria. Applied and Environmental Microbiology 38:72.

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

Fitzgerald, Paul R. and M. E. Mansfield. 1973. Efficacy of monensin against bovine coccidiosis in young Holstein-Friesian calves. J. of Protozoology 20:121.

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

Haney, Michael E., Jr. and Marvin M. Hoehn. 1967. Monensin, a new biologically active compound. I. Discovery and isolation. Antimicrobial Agents and Chemotherapy-1967:349.

Heineman, W. W., E. M. Hanks and D. C. Young. 1978. Monensin and tylosin in a high energy diet for finishing steers. J. Anim. Sci. 47:34.

Lemenager, R. P., F. N. Owens, B. J. Shockey, K. S. Lusby and Robert Totusek. 1978a. Monensin effects on rumen turnover rate, twenty-four hour VFA pattern, nitrogen components and cellulose disappearance. J. Anim. Sci. 47:255.

Lemenager, R. P., F. N. Owens, K. S. Lusby and Robert Totusek. 1978b. Monensin, forage intake and lactation of range beef cows. J. Anim. Sci. 47:247.

Lemenager, R. P., F. N. Owens and Robert Totusek. 1978c. Monensin and extruded urea-grain for range beef cows. J. Anim. Sci. 47:262.

Males, J. R., C. W. Hunt and D. D. Lee, Jr. 1979. Monensin supplemented winter pasture for growing feeder calves. J. Anim. Sci. 48:1295.

Muller, R. D., E. L. Potter, H. Brown, L. H. Carroll and R. M. Meyer. 1979. Value of energy supplementation and monensin for cattle growing on pasture. Amer. Soc. Anim. Sci. Proc. 71st Annual Meeting p. 391 (Abstr.).

Oliver, W. M. 1975. Effect of monensin on gains of steers grazed on coastal bermudagrass. J. Anim. Sci. 41:999.

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

Poos, M. I., T. L. Hanson and T. J. Klopfenstein. 1979. Monensin effects on diet digestibility, ruminal protein bypass and microbial protein synthesis. J. Anim. Sci. 48:1516.

Potter, E. L., C. O. Cooley, A. P. Raun, L. F. Richardson and R. P. Rathmacher. 1974. Effect of monensin on daily gain of cattle on pasture. Amer. Soc. Anim. Sci. West. Sect. Proc. 25:343.

Potter, E. L., C. O. Cooley, L. F. Richardson, A. P. Raun and R. P. Rathmacher. 1976. Effect of monensin on performance of cattle fed forage. J. Anim. Sci. 43:665.

Prange, R. W., C. L. Davis and J. H. Clark. 1978. Propionate production in the rumen of Holstein steers fed either a control or monensin supplemented diet. J. Anim. Sci. 46:1120.

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, E. L. Potter, C. O. Cooley and R. P. Rathmacher. 1974. Effect of monensin on ruminal fermentation _in vitro_ and _in vivo_. J. Anim. Sci. 39:250 (Abstr.).

Shummard, R. F. and M. E. Callender. 1967. Monensin, a new biologically active compound. VI: Anticoccidial activity. Antimicrobial Agents and Chemotherapy-1967:369.

Stauffer, M. A. and J. K. Ward. 1977. Effect of monensin on the performance of gestating cows and heifers. Amer. Soc. Anim. Sci. Proc. 69th Annual Meeting p. 259 (Abstr.).

Steen, W. Wade, N. Gay, J. A. Boling, N. W. Bradley, J. W. McCormick and L. C. Pendlum. 1978. Effects of monensin on performance and plasma metabolites in growing-finishing steers. J. Anim. Sci. 46:350.

Thorton, J. H., F. N. Owens, R. P. Lemenager and Robert Totusek. 1976. Monensin and ruminal methane production. J. Anim. Sci. 43:336 (Abstr.).

Turner, H. A., D. C. Young, R. J. Raleigh and Dale ZoBell. 1980. Effect of various levels of monensin on efficiency and production of beef cows. J. Anim. Sci. 50:385.

Turner, H. A., R. J. Raleigh and D. C. Young. 1977. Effect of monensin on feed efficiency for maintaining gestating mature cows wintered on meadow hay. J. Anim. Sci. 44:338.

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.

Van Nevel, C. J. and D. I. De Meyer. 1977. Effect of monensin on rumen metabolism in vitro. Applied and Environmental Microbiology 34:251.

Vijchulata, Pravee, P. R. Henry, C. B. Ammerman, S. G. Potter and Nolto Becker. 1980. Effect of monensin with cottonseed hulls and energy supplements for growing steers. J. Anim. Sci. 50:41.

INTRODUCTION

Monensin, a polyether antibiotic, has become extremely important in the cattle industry during the past five years. Monensin has consistently improved feed efficiency in cattle fed high concentrate diets (Raun _et al_., 1976; Utley _et al_., 1976; Perry _et al_., 1976). Cattle fed monensin consuming good quality pasture have made significantly greater gains than control cattle (Oliver, 1975; Potter _et al_., 1976). Since low quality forages (either hay or pasture) make up the primary source of winter nutrition for a cow herd, an increase in the efficiency of forage utilization may provide a means to increase the size of an individual cow herd and/or improve the performance of grazing cows.

The purpose of providing supplemental energy to a cow herd grazing winter range is to obtain the greatest reproductive performance for the cow that is economical. The addition of monensin to an energy supplement fed to cows consuming dormant range may provide an additional increase in the utilization of both forage and supplement. The purpose of this study is to consider the effect of monensin added to two levels of energy supplement, on cow performance when grazing dormant winter range.

EXPERIMENTAL PROCEDURE

Seventy-five pregnant Polled Hereford cows ranging in age from 3 to 10 years were used from November 1978 through October 1979 to study two levels of monensin and two levels of energy. Cows grazed native Kansas tallgrass prairie year around which consists of big bluestem (*Andropogon gerardi*) and little bluestem (*Andropogon scoparius*) as the dominant warm season grasses with indiangrass (*Sorghastrum rutans*) and sideoats grama (*Bouteloua curtipendula*) as secondary species. The cows were divided into four pastures with an average stocking rate of 6.5 ha/cow from November to May and 3.0 ha/cow-calf pair from May to the first of November. Cows were stratified by age, weight, condition, sire of fetus and were randomly allotted to four treatments. Treatments included two levels of monensin (0 mg and 200 mg per head per day) and two levels of supplemental energy (a low energy level which provided approximately 30% of the TDN requirement recommended by the NRC and a high energy level which provided approximately 58% of the TDN requirement recommended by the NRC). Each pasture contained one combination of treatments, with the monensin carried in the supplemental feed. Cows in the low energy (LE)-monensin and low energy (LE)-no monensin groups were fed 1.19 kg of a sorghum based range cube along with 0.54 kg of alfalfa hay per head per day from November 1 through February 14 (rations presented in Table 1). Cows in the high energy (HE)-monensin and high energy (HE)-no monensin groups were fed 2.27 kg of range cubes along with

TABLE 1. WINTER RATIONS AND COMPOSITION OF SUPPLEMENT.

Item	AH-190 LE-No Monensin	AH-189R LE-Monensin	AH-192 HE-No Monensin	AH-191R HE-Monensin	AH-194 No Monensin	AH-193R Monensin
	November 1 - February 14				February 15 - April 20	
Supplement, kg/day[a]	1.19	1.19	2.27	2.27	3.63	3.63
% crude protein[b]	15.28	16.67	10.46	9.85	9.12	9.00
Alfalfa hay, kg/day[a]	0.54	0.54	0.54	0.54	2.27	2.27
% crude protein[b]	18.53	18.53	18.53	18.53	15.96	15.96
Supplement composition, %[a]						
Soybean meal	26.5	26.5	4.3	4.3	0.6	0.6
Grain sorghum	67.5	66.5	89.7	88.7	93.4	92.4
Molasses	6.0	6.0	6.0	6.0	6.0	6.0
Monensin[c]	--	1.0	--	1.0	--	1.0

[a]As-fed basis.

[b]Dry matter basis.

[c]Contained monensin to provide 200 mg/hd/day.

0.54 kg of alfalfa hay for that same period. From February 15 through April 20 all four treatment groups were supplemented with approximately 80% of the TDN requirement recommended by the NRC. All groups received 3.63 kg of range cubes and 2.27 kg of alfalfa hay for this period. Cows were group fed by treatment. During the months of January and February there were extended periods of snow cover; therefore, additional alfalfa hay was fed to all groups.

Forage intake of 10 cows was measured monthly in each treatment group (November through April) using chromic oxide as an external indicator (Hopper _et al_., 1978; Bloom _et al_., 1957; Smith and Reid, 1955; Putnam _et al_., 1958; Lambourne, 1957). Starting the second week of each month, cows were brought in each morning for an 8 day period. Twenty-five grams of chromic oxide was administered in a gelatin capsule between 0730 and 1000 for the first 7 days of the 8 day period with rectal grab samples collected once a day at the same time the last 4 days of the 8 day collection period. The initial 4 day period was necessary for the chromic oxide to be uniformly distributed through the digestive tract. Fecal samples from each cow were weighed and dried at 55°C in a forced air oven until a constant weight was maintained. Samples were ground in a Wiley mill (1 mm screen) and equal amounts were composited for the four day collection period for each cow. Gross energy, crude protein, crude fiber, ether extract, ash (AOAC, 1975) and chromium (ppm) were determined for each sample. Fecal samples were wet-ashed after a nitric acid:perchloric acid digestion (Toth _et al_., 1948). One milliliter (48%) hydroflouric acid was added to the wet-ash solution to dissolve the silica and release bound chromium. Chromium was determined by spectrophotometry and concentrations adjusted to 100% dry matter.

From November through April, monthly range forage samples were obtained by grazing eight esophageally fistulated steers. Collections were done either during the fecal collection period or immediately following. Two steers were maintained with each group of cows to promote similar grazing patterns. The collection period lasted for four days with two pastures being collected on alternate days. The steers were caught in the pasture and the esophageal plugs were removed and the collection bags secured around their necks. The steers were allowed to graze until sufficient sample was collected (usually 1 hr). The esophageally collected samples were then dried to a constant weight in a forced air oven at 55°C, ground through a Wiley mill (1 mm screen) and composited for each animal over the two collections. In vitro dry matter disappearance (IVDMD; Tilley and Terry, 1963; Monson et al., 1969) was determined on each forage and feed sample. A rumen fistulated steer was maintained in both the low energy-no monensin and low energy-monensin pastures to provide innocula for the in vitro procedure. Rumen fluid from the steer maintained in the monensin treated pasture was used for samples collected from monensin treated pastures and rumen fluid from the no-monensin pasture was used for samples collected from the no-monensin treated pastures. Crude fiber, crude protein, ether extract, ash (AOAC, 1975) and gross energy were determined.

Range forage consumption was determined as follows:

1) $$\text{kg fecal dry matter/day} = \frac{\text{chromium fed, g}}{\text{chromium excreted, ppm} \times \text{C.F.*}} \times 1000;$$

2) % total forage indigestibility = 100 - % IVDMD;

3) $$\text{kg total forage dry matter intake/day} = \frac{\text{kg fecal dry matter excreted}}{\text{\% total forage indigestibility}};$$

4) kg range forage dry matter intake/day = total forage dry matter intake/day - [supplement dry matter intake/day + hay dry matter intake/day];

---

*Factor used to correct for incomplete recovery of chromium (Pruitt, 1980).

Cows were weighed at monthly intervals and in November and May shoulder heights were recorded. Calves were born between February 28 and April 29 and weaned on October 4 at an average age of 192 days. Calf weights were recorded at birth and at monthly intervals through weaning. Calf shoulder heights were recorded at weaning.

In May, cows were divided into four breeding groups, and beginning May 21 two pastures were exposed to bulls for a 60 day breeding season. The other two pastures were artificially inseminated for a 42 day period with clean up bulls then turned in for the remainder of the 60 day breeding season.

Cows that lost their calf were removed from the study at that time. Data were analyzed using a least squares analysis of variance using SAS General Linear Model procedure (Barr et al., 1976).

RESULTS AND DISCUSSION

Monthly cow weight change data for the prepartum and calving period (November through April) are presented in Table 2. Over the first 4 month period high energy-monensin gained weight, while the three remaining treatment groups lost weight. The low energy-no monensin group lost less weight than either the low energy-monensin or high energy-no monensin which had similar weight losses. Monensin was effective in reducing weight loss at the high energy level but not at the lower energy level.

Range forage dry matter intake data for this same period are presented in Table 3. Monensin reduced forage intake at both the high and low energy levels. Over the four month prepartum period cows supplemented with the low energy-no monensin ration consumed approximately 26.33% more range forage than the cows supplemented with the low energy-monensin ration. Similar results were observed at the higher level of supplementation. Range forage intake of the cows consuming the high energy-no monensin ration averaged 29.77% higher during the prepartum period. Therefore, at the high energy level monensin increased the efficiency of feed utilization, increasing gains with less forage consumption. At the low energy level monensin was not effective. Loss of heat production associated with a decrease in forage consumption may have greatly affected the performance of the cows. During the cold stress conditions which existed during this extremely harsh January

TABLE 2. MONTHLY COW WEIGHT CHANGE
NOVEMBER 1978 - APRIL 1979.

	Low Energy		High Energy	
	No Monensin	Monensin	No Monensin	Monensin
No. of animals	19	19	19	18
Initial wt, kg	434.5	444.6	457.2	443.1
November wt change, kg	1.89 ± 3.23^{a}	-8.11 ± 3.15^{b}	-17.67 ± 3.15^{c}	-2.27 ± 3.23^{ab}
December wt change, kg	0.25 ± 3.23^{ac}	-8.59 ± 3.15^{b}	-7.16 ± 3.15^{ab}	7.31 ± 3.23^{c}
January wt change, kg	-16.63 ± 3.23^{a}	-12.29 ± 3.15^{ab}	-4.65 ± 3.15^{b}	-7.43 ± 3.23^{b}
February wt change, kg	-0.56 ± 3.80^{a}	3.52 ± 3.52^{ab}	1.79 ± 3.15^{a}	12.59 ± 3.36^{b}
March wt change, kg				
March calving cows	-28.06 ± 10.09^{a}	-26.70 ± 7.81^{a}	-27.78 ± 7.30^{a}	-52.00 ± 9.43^{b}
April calving cows	32.81 ± 12.22^{a}	13.04 ± 12.65^{a}	20.41 ± 9.56^{a}	13.61 ± 7.30^{a}
April wt change, kg				
March calving cows	-11.34 ± 7.63^{a}	-9.88 ± 6.76^{a}	-4.73 ± 7.30^{a}	-10.33 ± 8.43^{a}
April calving cows	-66.53 ± 10.33^{a}	-55.00 ± 12.65^{a}	-60.91 ± 9.56^{a}	-70.95 ± 7.30^{a}
ADG, kg (Nov-February)	-0.12	-0.20	-0.22	+0.08

[a,b,c] Means in a row with different superscripts differ ($P < .05$).

TABLE 3. INTAKE OF DRY MATTER, RANGE FORAGE, CRUDE PROTEIN AND *IN VITRO* DRY MATTER DIGESTIBILITY NOVEMBER 1978 - APRIL 1979.

	Low Energy		High Energy	
	No Monensin	Monensin	No Monensin	Monensin
November:				
Total dry matter intake, kg/day[d]	10.01	7.40	8.32	6.21
Range forage intake, kg/day[d]	8.32 ± 0.53^{a}	5.71 ± 0.50^{b}	5.62 ± 0.50^{b}	3.46 ± 0.53^{c}
% IVDMD	28.2515	21.3780	26.7611	21.0446
% Crude protein[d]	8.21	7.61	6.70	5.33
Total crude protein intake, kg/day[d]	$0.95 \pm .026^{a}$	$0.72 \pm .025^{b}$	$0.71 \pm .025^{b}$	$0.51 \pm .026^{c}$
December:				
Total dry matter intake, kg/day[d]	11.28	9.48	9.85	8.93
Range forage intake, kg/day[d]	9.48 ± 0.53^{a}	7.68 ± 0.50^{b}	7.03 ± 0.50^{bc}	6.06 ± 0.53^{c}
% IVDMD	32.2445	20.9282	19.3002	18.9427
% Crude protein[d]	4.36	6.39	4.02	4.08
Total crude protein intake, kg/day[d]	$0.70 \pm .026^{a}$	$0.80 \pm .025^{b}$	$0.63 \pm .025^{c}$	$0.59 \pm .026^{c}$
January:				
Total dry matter intake, kg/day[d]	8.20	8.32	8.12	7.90
Range forage intake, kg/day[d]	4.03 ± 0.53^{ab}	4.15 ± 0.50^{a}	2.94 ± 0.53^{ab}	2.67 ± 0.57^{b}
% IVDMD	25.0495	24.0981	22.4859	18.1792
% Crude protein[d]	4.09	3.84	3.70	3.63
Total crude protein intake, kg/day[d]	$0.83 \pm .026^{a}$	$0.84 \pm .025^{a}$	$0.83 \pm .026^{a}$	$0.82 \pm .028^{a}$

TABLE 3 (continued)

	Low Energy		High Energy	
	No Monensin	Monensin	No Monensin	Monensin
February:				
Total dry matter intake, kg/day[d]	13.22	8.34	10.67	8.36
Range forage intake, kg/day[d]	6.88 ± 0.53[a]	2.90 ± 0.50[bc]	4.04 ± 0.50[b]	1.71 ± 0.53[c]
% IVDMD	24.8334	24.0015	23.8552	21.7173
% Crude protein	5.07	4.96	4.37	3.85
Total crude protein intake, kg/day[d]	1.12 ± .026[a]	0.96 ± .025[b]	1.07 ± .024[a]	0.97 ± .026[b]
March:				
Total dry matter intake, kg/day[d]				
March calving cows	12.65	12.42	15.22	12.58
April calving cows	12.38	11.84	13.71	13.26
Range forage intake, kg/day[d]				
March calving cows	6.84 ± 3.81[a]	6.64 ± 2.38[a]	9.41 ± 3.37[a]	6.80 ± 2.25[a]
April calving cows	6.57 ± 2.75[a]	6.06 ± 2.75[a]	7.90 ± 1.74[a]	7.48 ± 3.18[a]
% IVDMD	23.7262	23.8083	25.2244	25.2553
% Crude protein[d]	6.06	6.08	5.04	4.07
Total crude protein intake, kg/day[d]	1.10 ± .231[a]	1.04 ± .181[a]	1.10 ± .180[a]	0.99 ± .191[a]
April:				
Total dry matter intake, kg/day[d]				
March calving cows	15.39	13.40	14.46	11.84
April calving cows	10.67	11.70	15.34	9.16
Range forage intake, kg/day[d]				
March calving cows	9.58 ± 2.42[a]	7.62 ± 1.38[a]	8.65 ± 1.95[a]	6.00 ± 1.59[a]
April calving cows	4.86 ± 2.75[a]	5.92 ± 2.75[a]	9.53 ± 1.74[a]	3.38 ± 2.53[a]
% IVDMD	51.0618	45.4680	40.3481	48.2827
% Crude protein[d]	9.98	8.28	7.43	6.28
Total crude protein intake, kg/day[d]	1.39 ± .182[a]	1.24 ± .145[a]	1.36 ± .130[a]	0.97 ± .135[b]

[a,b,c]Means in a row with different superscripts differ ($P < .05$).

[d]Dry matter basis.

and February, cattle must increase their heat production to maintain normal body temperature. Any loss or decrease in heat production, such as a loss of heat increment, would force these animals to increase heat production by other means such as increasing muscular activity. This would reduce the efficiency of production. At the high energy level the cows are not as dependent on heat increment to maintain body temperature so the decrease in forage consumption would not have so great an effect. The reduction in forage consumption with the addition of monensin to the ration is in agreement with the results reported by Lemenager _et al_. (1978b). They observed a reduction of 19.6% in relative forage intake when 200 mg/day was administered to cows grazing native Oklahoma winter range. However, Lemenager reported no difference in the weight change of the cows.

During the calving period cows on all treatments lost weight with no difference among the low energy-no monensin, low energy-monensin and high energy-no monensin. High energy-monensin treated cows lost significantly more weight during this period. This was due to a large weight loss for cows calving in March. Forage consumption for this period was not significantly different among all treatment groups, although the no monensin groups tended to consume slightly more forage than the monensin fed groups (all cows received the same level of energy supplement after February 15).

Monensin tended to depress _in vitro_ dry matter disappearance particularly during November through February. Lemenager _et al_. (1978a) similarly reported that monensin adapted rumen fluid produced significantly lower IVDMD than the control fluid without monensin addition.

However, Lemenager *et al*. (1978a) and Dinius *et al*. (1976) found no effect of monensin on cellulose digestion *in vivo*.

Over the prepartum and calving period there was no difference in crude protein intake among the four treatments. The low energy treatments tended to consume slightly more crude protein.

Cow weight change from the termination of the supplemental feeding through the weaning of calves is presented in Table 4. Average daily gain of the four groups was not significantly different. The high energy groups tended to gain more weight in May and lose more in September. There was no effect due to monensin.

Calf data are included in Table 5. There was no difference in the calf birth weights for all treatments. Percentage of calves weaned of calves born and the average daily gain of the calves to weaning was not different among treatments.

Reproductive performance of the cows for the 1979 breeding season is presented in Table 6. Pregnancy rates at day 21, 42 and 63 (final) were similar for all treatments. The high energy groups tended to have higher final pregnancy rates than the low energy groups.

Similar conception rates for monensin and no monensin fed cows were also reported by Turner *et al*. (1980) and Lemenager *et al*. (1978). However, this is in contrast to the results reported by Schalles and Fleck (1979), where first service conception and final conception of the monensin fed group (40% and 84%) were higher than for the no monensin group (21% and 71%) for cows grazing native Kansas range.

Monensin was not effective in improving the overall performance of the cows in this study. During the prepartum winter months there was

TABLE 4. MONTHLY COW WEIGHT CHANGE
MAY - SEPTEMBER 1979.

Wt. change, kg	Low Energy		High Energy	
	No Monensin	Monensin	No Monensin	Monensin
May	43.54 ± 4.16^{a}	44.65 ± 4.03^{a}	63.20 ± 4.16^{b}	63.20 ± 4.16^{b}
June	28.58 ± 4.16^{a}	37.28 ± 4.05^{a}	29.48 ± 4.16^{a}	27.81 ± 4.16^{a}
July	16.78 ± 4.16^{a}	17.29 ± 4.03^{a}	14.36 ± 4.16^{a}	11.19 ± 4.16^{a}
August	15.08 ± 4.16^{a}	16.87 ± 4.03^{a}	19.96 ± 4.16^{a}	16.18 ± 4.16^{a}
September	2.12 ± 4.16^{a}	4.11 ± 4.03^{a}	-6.05 ± 4.16^{ab}	-10.13 ± 4.16^{b}
ADG, kg	0.69	0.78	0.79	0.70

[a,b]Means in a row with different superscripts differ ($P < .05$).

TABLE 5. CALF PERFORMANCE FROM BIRTH TO WEANING.

	Low Energy		High Energy	
	No Monensin	Monensin	No Monensin	Monensin
Birth wt., kg	32.85 ± 1.41^{a}	32.89 ± 1.31^{a}	33.18 ± 1.17^{a}	32.26 ± 1.47^{a}
May wt. change, kg	25.32 ± 3.40^{a}	23.38 ± 3.18^{a}	22.01 ± 2.85^{a}	23.98 ± 3.42^{a}
June wt. change, kg	19.25 ± 2.65^{a}	24.82 ± 2.48^{ab}	25.84 ± 2.22^{b}	25.94 ± 2.67^{b}
July wt. change, kg	28.21 ± 2.81^{a}	26.27 ± 2.59^{a}	29.83 ± 2.43^{a}	29.65 ± 2.88^{a}
August wt. change, kg	28.85 ± 2.64^{a}	25.88 ± 2.42^{ab}	25.11 ± 2.28^{ab}	22.96 ± 2.70^{b}
September wt. change, kg	17.98 ± 2.88^{a}	17.00 ± 2.65^{a}	15.17 ± 2.49^{a}	19.52 ± 2.95^{a}
Weaning wt., kg	169.37 ± 8.37^{a}	166.10 ± 7.70^{a}	167.42 ± 7.23^{a}	169.87 ± 8.58^{a}
ADG (May - weaning), kg	0.76	0.75	0.75	0.78
% Calves weaned[d]	83.34^{c}	88.89^{c}	78.95^{c}	83.34^{c}

[a,b]Least squares means tested by analysis of variance.
Means in a row with different superscripts differ ($P < .05$).

[c]Means tested by chi-square goodness of fit.
Means in a row with different superscripts differ ($P < .05$).

[d]Percentage based on the number of calves born.

TABLE 6. REPRODUCTION DATA, 1979 BREEDING SEASON.

	Low Energy		High Energy	
% Pregnant	No Monensin	Monensin	No Monensin	Monensin
21 Day breeding season	66.67[a]	56.25[a]	43.75[a]	66.67[a]
42 Day breeding season	80.00[a]	62.50[a]	81.25[a]	100.00[a]
63 Day breeding season	86.67[a]	81.25[a]	93.75[a]	100.00[a]
Conception date[d]	149 ± 6.12[b]	169 ± 5.40[c]	160 ± 4.54[bc]	155 ± 5.61[b]

[a]Means tested by chi-square goodness of fit.
Means in a row with different superscripts differ ($P < .05$).

[b,c]Least squares means tested by analysis of variance.
Means in a row with different superscripts differ ($P < .05$).

[d]Julian calendar.

an improvement in the performance of the cows on the high energy-monensin ration; however, by the following summer no difference existed. There was no difference in calf performance or in the reproductive performance of the cows. Forage intake during November through February was significantly depressed due to monensin. For the cow-calf producer wintering his cows on hay, this would mean a reduction in the amount of hay necessary to maintain his cows. In the case of range cows, a decrease in forage intake due to monensin will only mean a savings in forage and an advantage to the producer if the pastures are more heavily stocked during the winter months. However, since it is important and necessary for the producer to maintain the quality of his rangeland, in the spring the stocking rate must be reduced again. Therefore, a cow-calf producer will benefit from monensin only if at this point he has alternative forage on which to adequately maintain his cows through the summer.

LITERATURE CITED

AOAC. 1975. Official Methods of Analysis (12th Ed.) Association of Official Analytical Chemists, Washington, D.C.

Barr, A. J., G. H. Goodnight, J. P. Sall and T. Helwig. 1976. A User's Guide to SAS 76. SAS Institute Inc., Raleigh, North Carolina.

Bloom, S., N. L. Jacobson, R. S. Allen, L. D. McGilliard and P. G. Homeyer. 1957. Effects of various hay:concentrate ratios on nutrient utilization and production responses of dairy cows. II. Observations on ration digestibility and on the excretion pattern of chromic oxide. J. Dairy Sci. 16:240.

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

Hopper, J. T., J. W. Holloway and W. T. Butts, Jr. 1978. Animal variation in chromium sesquioxide excretion patterns of grazing cows. J. Anim. Sci. 46:1096.

Lambourne, L. J. 1957. Measurement of feed intake of grazing sheep. II. The estimation of feces output using markers. J. Agr. Sci. 48:415.

Lemenager, R. P., F. N. Owens, B. J. Shockey, K. S. Lusby and Robert Totusek. 1978a. Monensin effects on rumen turnover rate, twenty-four hour VFA pattern, nitrogen components and cellulose disappearance. J. Anim. Sci. 47:255.

Lemenager, R. P., F. N. Owens, K. S. Lusby and Robert Totusek. 1978b. Monensin, forage intake and lactation of range beef cows. J. Anim. Sci. 47:247.

Monson, W. G., R. S. Lowery and I. Forbes, Jr. 1969. In vivo bag vs. two-stage in vitro digestion: comparison of two techniques for estimating dry matter digestibility of forages. Agron. J. 61:587.

Oliver, W. M. 1975. Effects of monensin on gains of steers grazed on coastal bermudagrass. J. Anim. Sci. 41:999.

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

Potter, E. L., C. O. Cooley, L. F. Richardson, A. P. Raun and R. P. Rathmacher. 1976. Effect of monensin on performance of cattle fed forage. J. Anim. Sci. 43:665.

Pruitt, R. J. 1980. Forage intake and performance of range cows as affected by delayed winter supplemental feeding and mineral supplementation. Master's Thesis. Kansas State University, Manhattan, KS.

Putnam, P. A., J. K. Loosli and R. G. Warner. 1958. Excretion of chromic oxide by dairy cows. J. Dairy Sci. 41:1723.

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.

Schalles, R. R. and A. T. Fleck. 1979. Rumensin fed during winter on native range. Proc. Amer. Soc. Anim. Sci. 71st Annual Meeting. p. 200 (Abstr.).

Smith, A. M. and J. T. Reid. 1955. Use of chromic oxide as an indicator of fecal output for the purpose of determining the intake of pasture herbage by grazing cows. J. Dairy Sci. 38:515.

Tilley, J. M. A. and R. A. Terry. 1963. A two-stage technique for in vitro digestion of forage crops. J. Brit. Grassland Soc. 18:104.

Toth, S. J., A. L. Prince, A. Wallace and D. S. Mikkelson. 1948. Rapid quantitative determination of eight mineral elements in plant tissue by a systematic procedure involving use of a flame photometer. Soil Sci. 66:459.

Turner, H. A., D. C. Young, R. J. Raleigh and Dale ZoBell. 1980. Effect of various levels of monensin on efficiency and production of beef cows. J. Anim. Sci. 50:385.

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

EFFECT OF MONENSIN ON COW PERFORMANCE WHEN SUPPLEMENTING WINTER RANGE WITH TWO LEVELS OF ENERGY

by

MARTHA P. KATZ

B.S., University of Massachusetts, 1978

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Animal Science and Industry

KANSAS STATE UNIVERSITY

Manhattan, Kansas

1980

Seventy-five spring calving Polled Hereford cows were used to study two levels of monensin and two levels of energy. Cows grazed native Kansas prairie year around. Treatments from November 1 through February 14 included 0 mg and 200 mg/ea/day of monensin and energy supplements providing 30% and 58% of the TDN recommended by NRC. Each of four pastures contained one combination of treatments. February 15 through April 20 monensin and no-monensin groups were supplemented with 80% of the TDN recommended by NRC.

Ten cows in each treatment group were used monthly, November through April, to measure forage dry matter intake. Chromic oxide was the external marker used to determine fecal dry matter output. Gross energy, crude protein, crude fiber, ether extract and ash content were determined on all fecal samples. From November through April monthly range forage samples were obtained by grazing esophageally fistulated steers. Percentage IVDMD, gross energy, crude protein, crude fiber, ether extract and ash were determined on all forage and feed samples.

During the prepartum period (November through April) cows fed high energy-monensin gained weight, low energy-no monensin lost less weight than both the low energy-monensin or high energy-no monensin groups which had similar weight losses. Monensin reduced range forage intake 26.33% for the low energy group and 29.77% for the high energy group. Monensin increased efficiency at the high energy level but was not effective at the low energy level. Forage intake for March and April and cow weight change from May through September was similar for all