ANIMAL SCIENCE RESEARCH

With Sheep, Swine and Beef Cattle

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OKLAHOMA AGRICULTURAL EXPERIMENT STATION

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Summary Reports on Other Projects

Observations on Preconditioned and Preweaned Calves

Robert Totusek and Norris Whitfield

Story in Brief

Calves were immunized against several diseases before weaning, and taught to eat concentrates during a 12 day post-weaning period before shipment to market or a feedlot. These practices: (1) Did not result in any appreciable gain during the 12 day post-weaning period, (2) Did not prevent a typical 5 percent shrink during marketing, and (3) Did not prevent the large shrink often observed after arrival of calves in the feedlot.

Introduction

There has been much interest in the cattle industry about various aspects of preconditioning calves due to the high death loss and large shrink of feeder cattle after entering the feedlot. Various management and/or disease prevention techniques are being explored in an effort to decrease losses and improve early feedlot performance. Therefore, the data in this report are being presented even though only a limited number of cattle is represented.

Procedure

A total of 110 Angus and Hereford calves, both steers and heifers, were included in the trial. They were out of 2, 3, and 4-year-old cows, and were dropped in March, April and May.

All calves were weighed monthly to yield data for another experiment. At the time they were in the corral for monthly weighing they were treated against grubs by spraying with the systematic insecticide CoRal on August 1 and September 1, and immunized against bovine viral diarrhea (BVD) on September 1, infectious bovine rhinotracheitis (IBR) on September 1, Leptospira pomona on October 1 and Clostridium feseri septicum (blackleg) on October 1. In addition, a mixed culture of inactivated parainfluenza-3 virus and Pasteurella bactrin, multocida and hemolytica, (Bar-3)[1] was administered on August 1 and October 1.

The assistance of Herb Sneed in caring for the cattle is gratefully acknowledged.

[1] Elanco Products Company, Division of Eli Lilly Company, Indianapolis, Indiana, generously provided the Bar-3 vaccine used in this trial.

Calves were weaned and weighed (unshrunk) October 26 and placed in three traps, each approximately 1 acre in size. Weights (unshrunk) were obtained again on November 7, and 36 of the calves were hauled to Stillwater (15 miles) to the experimental feedlot. The remaining 74 calves were continued on feed and water until the morning of November 9 at which time they were hauled to Oklahoma City (approximately 75 miles) and sold through the auction market.

Water and hay (prairie and alfalfa) were available at all times. In addition, a concentrate mixture of the following composition was fed (percent): milo, 50; dehydrated alfalfa pellets, 20; cottonseed hulls, 17.5; cottonseed meal, 11.5; salt, .5; and dicalcium phosphate, .5.

Results and Discussion

Weight changes during the 12 day postweaning period are shown in Table 1. The average gain was only 3 lb. per head, with little apparent difference between steers and heifers. Average daily feed intake was 10.5 lb. hay (5.75 lb. prairie hay and 4.75 lb. alfalfa hay) and 2.33 lb. concentrate mix.

A greater weight gain than observed in this trial is necessary in order to make preweaning attractive to the feeder calf producer. This might have been accomplished with a longer period between weaning and marketing, or by a greater intake of energy. Weaned calves grazing native or improved pastures in the fall occasionally make greater gains than observed in this trial with calves in drylot. It is possible that

Table 1. Weight Changes of Preconditioned Calves

Classification	No. Calves	Weight, Per Head: Weaning 10-26-67	Weight, Per Head: 11-7-67	Weight Change, Per Head
		lb.	lb.	lb.
Sex				
Steers	47	425	427	+2
Heifers	63	389	393	+4
Total	110	405	408	+3
Breed and sex				
Angus				
Steers	31	452	454	+2
Heifers	29	407	421	+14
Total	60	431	438	+7
Hereford				
Steers	16	390	388	—2
Heifers	34	373	374	+1
Total	50	378	378	0

greater gains could have been stimulated with an increased intake of a more palatable concentrate mix, perhaps further facilitated by limiting the intake of hay. Producers in the field have reported a high intake of concentrates and good gains during a short postweaning period, particularly with calves which had received at least small quantities of grain previously. The calves in this trial had received no grain prior to weaning. The health of the calves was good throughout the 12 day postweaning period.

Feeders have frequently observed that Angus calves start eating more rapidly than Hereford calves. Although differences are not large, comparative postweaning gains in Table 1 indicate that their observations may be correct.

Marketing shrink is shown in Table 2. A weight loss of 19 lbs. per head was observed from the prehauling weight to sale weight. This 5 percent shrink is as large as normally observed with newly weaned calves shipped directly to market from our experimental range. It has not been possible to obtain follow-up information on the subsequent performance of the marketed calves to determine the value of the preweaning immunizations and postweaning treatment which they received.

The performance of the 36 calves taken to the feedlot 12 days after weaning is indicated in Table 3. Note the very large shrink of 56 lb. per

Table 2. Marketing Shrink of Preconditioned and Preweaned Calves

No. Calves	Weight, Per Head			Shrink, Per Head
	Weaning 10-26-67	11-7-67[1]	Sale 11-9-67	
	lb.	lb.	lb.	lb.
74	373	376	357	19

[1] Hauled 75 miles to market on 11-9-67.

Table 3. Early Feedlot Gain of Preconditioned and Preweaned Calves

No. Calves	Weight, Per Head			
	Weaning 10-26-67[1]	11-7-67[1]	Feedlot 11-16-67[2]	12-14-67[3]
	lb.	lb.	lb.	lb.
36	468	470	414	468

[1] Unshrunk weights.
[2] Weight obtained after 16 hour shrink without feed and water.
[3] Weight obtained after 16 hour shrink without water.

head (12 percent) during the first 9 days in the feedlot after a haul of only 15 miles. Only a part of the weight loss can be explained by a difference in weighing conditions (unshrunk to shrunk weight). During the subsequent 28 days sufficient gain was made to only return the calves to their weaning weight. During the first 9 days in the feedlot, the calves were gradually shifted from the concentrate mix which they had received after weaning to a high concentrate ration containing 83 percent milo. Although this was a rather abrupt shift, the health and appearance of the calves remained good; only a few minor respiratory infections occurred during the first 6 weeks of the feeding period.

Summary

The value of the immunizations could not be properly assessed in this trial because the calves were not challenged by disease situations during the period of observation. It should be recognized that immunizations are not likely to be of any value in the absence of disease, and should not be used haphazardly and routinely with the expectation of benefit in weight gains. It has also been suggested that certain immunizations might be of greater benefit after weaning than before weaning.

The calves in this trial were young (mostly 6-7 mo. old) and light in weight (about 400 lb. average), and the results which were obtained are probably most typical for this kind of calf. It is obvious that simply "preconditioning" and "preweaning" calves will not automatically insure desirable weight changes during shipment and the early feedlot phase. If undesirable weight changes can be prevented in young, light weight calves, conditions different from those used in this trial must be provided.

One Versus Two Stilbestrol Implants for Suckling Calves

Robert Totusek

Story in Brief

Angus steer calves which received one stilbestrol implant or two implants approximately 90 days apart weighed 15 and 53 lb. more at weaning time than nonimplanted calves. In the case of Hereford steer calves, either one implant or two implants 90 days apart resulted in a 38 lb. advantage in weaning weight. A breed difference in response to stilbestrol is suggested by the results. Two consecutive stilbestrol implants produced no undesirable results and may be of greater benefit than a single implant.

Introduction

Much previous research at Oklahoma State University has shown an increased rate of gain from the implantation of suckling calves with stilbestrol. The average increase in weaning weight was 25 lb., with both steer and heifer calves showing a response to the treatment. Considerable variation among trials was observed; improvement in weaning weight varied from 0 to 45 lb. per head.

Feeder calf producers have been reluctant to implant calves with stilbestrol because of possible buyer discrimination against the practice. There is little basis for discrimination against implanted calves. Research at this station has demonstrated that calves which have been implanted while suckling respond to stilbestrol in the feedlot as well as calves without previous implantation. Research at the Texas Station has shown that a response to stilbestrol could be obtained in two out of three production periods (suckling, stocker, finishing). In previous experiments at this station calves have been implanted at approximately 90 days of age. One 12 mg. implant was most desirable, providing greater weight gain than one 6 mg. implant but without undesirable side effects observed at higher levels of implantation. The objective of this trial was to compare (1) no stilbestrol, (2) one 12 mg. stilbestrol implant at an early age, and (3) one early 12 mg. implant plus a second 12 mg. implant 90 days later.

The assistance of Herb Sneed in caring for cattle is gratefully acknowledged.

Procedure

Eighteen Angus steer calves and 27 Hereford steer calves were available for this trial. Within each breed the calves were divided into three groups on the basis of birth date. One group received no stilbestrol. The second group received one 12 mg. stilbestrol implant at an average age of 46 and 42 days for the Angus and Herefords, respectively. The third group received one implant at the same average age as the second group, plus a second 12 mg. stilbestrol implant at an average age of 131 days. Approximately 90 days elapsed between first and second implantations, and also between the second implantation and weaning. Stilbestrol pellets were implanted in the ear.

All calves were spring-dropped and out of 7-year-old cows. They grazed native pasture at the Lake Carl Blackwell Range, without creep feed, and were weaned in October. Table 1 shows a summary of dates and ages.

Results and Discussion

A summary of gains and weaning weights is presented in Table 2. Two Hereford calves scheduled to receive two implants disappeared early in the trial. The rate of gain from birth to time of the first implant was similar for all three groups within each breed, indicating that the groups were comparable in terms of genetic potential for growth. Differences in rate of gain among the three treatments between the time of first and second implantation were small, although those calves which had received an implant tended to gain faster. All implanted calves gained considerably faster than nonimplanted calves from the time of second implantation to weaning. This was true for the calves which had received only a single earlier implant as well as those which received a second implant.

It appears that potential to respond to stilbestrol is limited in the calf at a young age, but that this potential increases with age, and

Table 1. Dates and Ages of Calves at Implantation and Weaning

Breed	Date of			
	Birth	1st Implant	2nd Implant	Weaning
Angus	2-20	4-7	7-1	10-4
Hereford	3-3	4-14	7-12	10-22

	Age in Days at		
	1st Implant	2nd Implant	Weaning
Angus	46	131	226
Hereford	42	131	233

Table 2. Influence of 0, 1, and 2 Stilbestrol Implants[1] on Rate of Gain and Weaning Weight of Steer Calves

Treatment	No. Calves	Daily Gain, lb. To 1st Implant	Daily Gain, lb. 1st to 2nd Implant	Daily Gain, lb. 2nd Implant to weaning	Daily Gain, lb. 1st Implant to weaning	Weaning Weight, lb.	Weaning Wt. Advantage Over 0 Implant, lb
Angus							
0 Implant	6	1.46	2.15	2.17	2.16	524	
1 Implant	6	1.36	2.14	2.33	2.24	539	15
2 Implants	6	1.40	2.24	2.64	2.45	577	53
Hereford							
0 Implant	9	1.31	1.86	2.08	1.98	507	
1 Implant	9	1.30	2.01	2.34	2.19	545	38
2 Implants	7	1.27	1.99	2.39	2.20	545	38
Both Breeds							
0 Implant	15	1.37	1.98	2.11	2.05	513	
1 Implant	15	1.32	2.06	2.34	2.21	542	29
2 Implants	13	1.33	2.10	2.50	2.32	559	46

[1] 12 mg. per implant.

further, that a pellet implanted when the calf is very young continues to release stilbestrol for a considerable period of time.

A second implant, compared to a single early implant, was of considerable value in the Angus calves, resulting in 38 lb. additional weaning weight, but was without benefit in the Hereford calves. Numbers were too limited in this trial to permit definite conclusions. The results do suggest a breed difference in response to stilbestrol, with Angus calves requiring a higher level for growth stimulation and benefiting more from a second implant.

The results of this trial suggest that one 12 mg. stilbestrol implant at a young age (40-50 days) followed by a second 12 mg. implant about 90 days later has no detrimental effect and may stimulate considerable additional gain, compared to a single implant. No side effects were observed in any of the calves in this trial.

A Comparison of Cottonseed Meal and Urea in Low Protein Winter Range Supplements for Cattle

D. L. Williams, J. V. Whiteman, R. S. Pittman and A. D. Tillman

Story in Brief

One hundred and ninety grade Angus cows, bred for spring calving, were used to compare urea and cottonseed meal in low protein supplements, when these were fed to beef cows grazing native range forage during the winter season.

Animals fed the cottonseed meal supplement lost less weight and were in better condition at the end of the supplemental feeding period. Differences in weights and condition changes from November 1 to September 26 were small, but tended to favor cows receiving the cottonseed meal. Treatments did not affect birth weights of calves. Dams which had received the cottonseed meal during the winter season weaned calves which averaged twelve pounds heavier than those receiving urea.

Treatments did not affect blood levels of calcium, magnesium, copper, zinc or urea, but animals receiving the urea supplement had higher levels of phosphorus and ammonia. The supplements were also fed to steers, which were equipped with permanent rumen fistulae, and which permitted sampling of rumen fluid at various times after the rations were fed. Higher ruminal fluid ammonia levels were found in those fed the urea-containing supplement.

These results indicate that the level of urea was too high for this type of urea-containing ration.

Introduction

For many years ranchers have fed cottonseed and soybean meals to supply protein to cattle kept on low-protein forages during the winter season. However, the rapid increase in world population has increased the demand for oil meals in human nutrition and thereby has decreased the supply of these products for ruminant nutrition. Therefore, the need for protein substitutes in ruminant nutrition is becoming acute.

Urea can be made from the products of air, and economics would indicate a wider usage of it in ruminant rations. Research results indicate that urea has high value as a protein substitute in ruminant fattening-type rations; however, urea-containing supplements have not been well-utilized when fed to cattle consuming high levels of low-quality roughage.

The purpose of this study was to compare a urea-containing supplement to an isonitrogenous one containing cottonseed meal when both were fed to beef cows grazing native range forages during the winter season.

Experimental Procedure

Trial 1.

One hundred and ninety grade Angus cows, bred for spring calving, were divided into two equal groups on the basis of initial weight, age, and sire-test group. Each of these groups was then further subdivided into two groups and four groups were fed their assigned rations from November 5, 1966, until April 25, 1967. Two locations on the north side of the Lake Carl Blackwell Range area were utilized with both rations being fed at each location. Animals on the different treatments within a location were rotated among the pastures in an attempt to minimize the effect of pasture upon animal performance.

Each cow received three lb. per day of its assigned ration from November 5 until parturition, at which time her ration was increased to four pounds per day, the level fed until April 25. All animals were fed the supplements (Table 1) daily during the feeding period. In addition, a poor quality grass hay was fed when snow covered the forage.

Each cow was weighed at the beginning of the experiment, when supplemental feeding was discontinued, and when their calves were weaned. The calves were weighed within 24 hours after birth, when supplemental feeding was discontinued, and again when weaned. Condition scores were assigned to each cow at the initiation of the experiment, when the supplemental feeding period ended, and again when the calves were weaned. A score of one was assigned, arbitarily, to animals in the poorest condition of flesh, while those animals in better condition were assigned higher scores, up to a score of nine for those showing the highest condition in the groups.

Five animals were randomly selected from each subgroup on March 1, 1967, and blood samples were taken from each of these animals 2 hours after feeding. The plasma of each sample was analyzed for its content of calcium, phosphorus, magnesium, copper, zinc, ammonia and urea.

Table 1. Percentage Composition of Rations[1]

Treatments	Ration 1	Ration 2
Ingredients		
Ground milo	48.0	74.5
Alfalfa meal	5.0	5.0
Molasses	5.0	5.0
Wheat bran	5.0	5.0
Cottonseed meal	32.0	----
Trace minerals—salt[2]	3.0	3.0
Diammonium phosphate	1.0	1.0
Dicalcium phosphate	1.0	1.5
Vitamin A[3]	---	----
Urea	---	4.0
Sodium phosphate	---	1.0
TOTAL	100.0	100.0
Chemical Analysis		
Crude protein	20.8	21.0
Calcium	0.42	0.45
Phosphorus	1.00	1.00

[1] Feeds ground and pelleted into three-quarter inch diameter pellets.
[2] To each 100 pounds of diet was added the following mineral salts in grams: NaCl, 1296.2; $CoSO_4.7H_2O$, 0.4; $CuSO_4.H_2O$, 3.7; $FeSO_4.7H_2O$, 41.3; $MnSO_4.H_2O$, 5.6; K. I. 0.02; and $ZnSO_4.H_2O$, 13.6.
[3] Each pound of supplement contains 10,000 I.U. of vitamin A palmitate.

All cows were allowed to graze the indigenous green forage in two different locations during the subsequent spring and summer, allotment to the locations being made on the basis of winter treatment and sire group. The cows were rebred starting on May 1 and ending Aug. 1. In order to determine the possible effect of previous winter rations upon reproductive performance, the subsequent date of calving as well as the weight of the calf were obtained on all cows.

Trial 2.

Steers, equipped with permanent rumen fistulae, were used to determine the effect of the two rations, which were used in the first trial (Table 1), upon ruminal fluid ammonia levels. The trial consisted of two parts: In the first part, six steers, three per treatment, were given their assigned rations for 10 days in order that they might adjust to the supplements. Food was removed for 36 hours and they were then fed four lb. of the assigned supplement and eight lb. of poor-quality grass hay. Rumen fluid samples were taken zero, 30, 60, 90, 120, 180, 240, 300, 360, 480, 600 and 720 min. after feeding and analyzed for their ammonia contents.

In the second part, four fistulated steers, two per treatment, were used. Feeding, management, and sampling of the animals were the same as described in the first part of the trial except no fasting period preceded the feeding and sampling of the rumen fluid.

Results and Discussion

The performances of the cows in trial 1 are shown in Table 2. Animals receiving the cottonseed meal supplement lost less ($P<.005$) weight during the winter feeding period and were in better ($P<.005$) condition of flesh when the season ended.

Weight changes and condition scores during the total period from November 1, 1966, to September 1, 1967, were small; however, both measurements apparently favored the cows which received the cottonseed meal. The cows did not consume the urea-containing supplement readily and on some days they did not consume all of the supplement for several hours after feeding. In contrast those receiving ration 1 consumed the feed within a very short time after feeding.

Neither birth weight nor weaning weight of the calves was affected significantly by winter feed; however, there appeared to be a trend in favor of the calves from mothers receiving the cottonseed meal-containing supplement. Winter treatments did not affect the subsequent calving dates or birth weights.

Blood values on samples taken from five cows in each subgroup are shown in Table 3. As location had no effect ($P>.05$) on any mineral, each value in Table 3 represents the average values from 10 cows. Rations did not affect ($P>.05$) serum levels of calcium, magnesium, copper, zinc or urea. However, the animals receiving the urea-containing supplement contained higher levels ($P<.005$) of both ammonia and phosphorus. The higher phosphorus level in cows receiving the urea-containing supplement has two plausible explanations: (1) The forage in one pasture contained a higher level of phosphorus than the

Table 2. The Effect of Protein Supplements on Performance of the Cows

Item	Diet		SE[1]
	Ration 1 CSM	Ration 2 urea	
Weight change, winter[2]	—80.4	—124.3	7.1
Condition change, winter[2]	— 1.5	— 2.1	0.13
Weight change, total[3]	9.6	— 14.1	12.7
Condition change, total[3]	— 0.52	— 0.83	0.17
Birth weight of calves[4]	63.9	62.9	1.4
Weaning weight of calves[5]	469.4	457.9	7.1

[1] Standard error of treatment means.
[2] The winter feeding period was from November 5 to April 25.
[3] The total period was from November 1, 1966, to September 26, 1967.
[4] Corrected for sex by multiplying the heifer weight by 1.048.
[5] Corrected for 205 day weaning weight by formula (ADG $\times$ 205 + birth weight), and corrected for sex by multiplying the heifer weight by 1.059.

Table 3. Effect of Protein Supplements upon Blood Serum Constituents of the Cows

Item	Diet		SE[1]
	Ration 1 CSM	Ration 2 urea	
Constituents			
Number of cows	10	10	
Calcium (mg/100 ml.)	11.10	10.75	.185
Phosphorus (mg./100 ml.)	6.79	8.18	.230
Magnesium (mg./100 ml.)	2.61	2.59	.044
Copper (ppm)	0.80	0.77	.034
Zinc (ppm)	0.80	0.79	.061
Ammonia (mg./100 ml.)	1.56	2.05	.095
Urea (mg./100 ml.)	5.14	7.16	1.09

[1] Standard error of treatment means.

other three pastures and one group of cows from those fed the urea-containing diet were in this pasture when blood samples were obtained. (2) The urea-containing diet contained a higher proportion of inorganic phosphorus than the other diet.

The higher blood ammonia values in cattle fed urea were expected: Urea is readily hydrolyzed by microbial urease present in ruminal

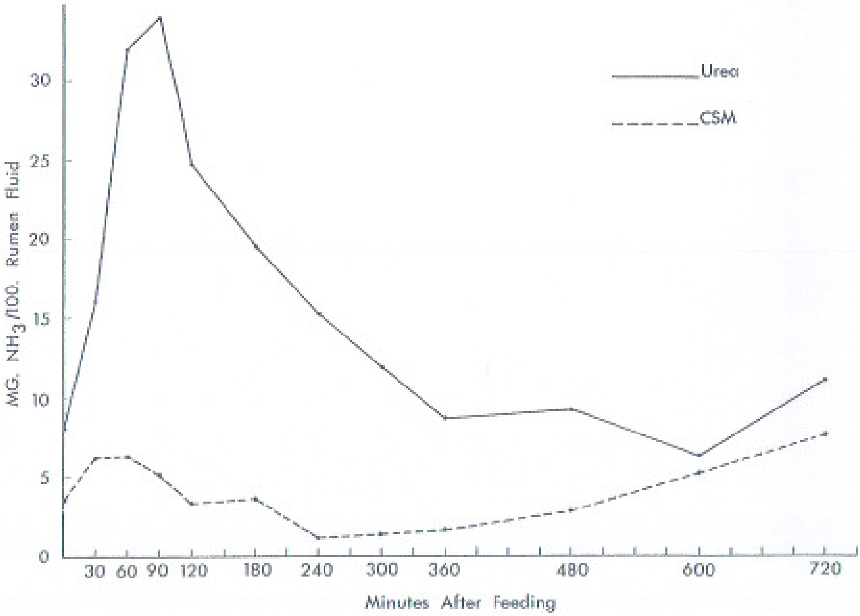

Figure 1. The effect of protein supplement on ammonia concentration in rumen fluid of steers.

fluid to ammonia and carbon dioxide. If there are sufficient carbon fragments (alpha keto acids) from carbohydrate origin present, the ammonia is incorporated into microbial protein. However, if there is not a sufficiency of the carbon fragments present, the ammonia crosses the rumen wall and goes into the blood. These results indicate combination of weathered range grass and the supplement did not provide enough carbon fragments and that much of the urea nitrogen provided in ration 2 was wasted.

Ruminal fluid ammonia values of trial 2 are shown in Table 4 and these values were greater ($P < .005$) in animals which had received the urea-containing ration. These values along with the blood ammonia values of Trial 1 indicate that protein synthesis in animals consuming the urea-containing supplement was low. For this reason greater weight loss and a poorer condition was found in these animals as compared to those fed the cottonseed meal-containing supplement.

These results support the idea that the level of urea in ration 2 was too high. Missouri workers have shown by use of artificial rumen

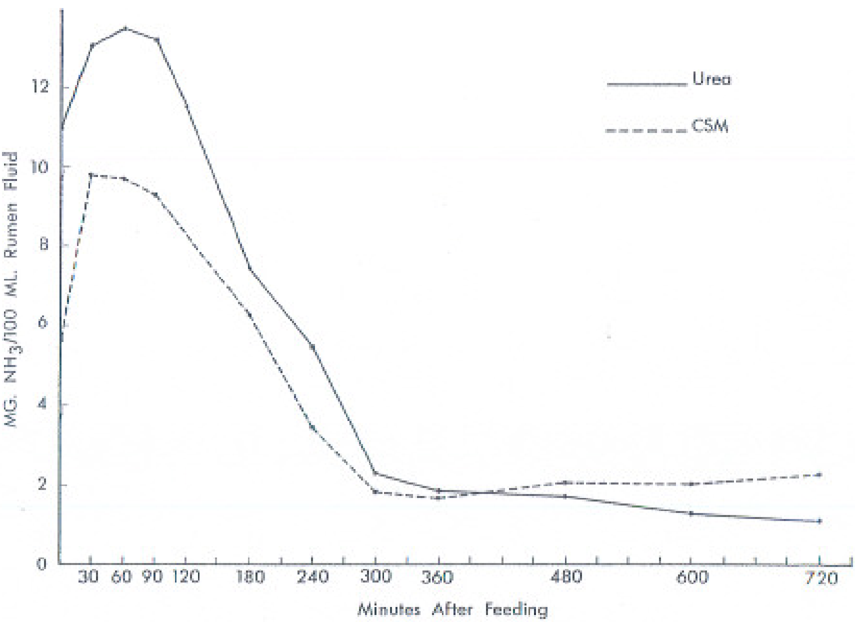

Figure 2. The effect of protein supplements on ammonia concentration in rumen fluid of steers fasted 36 hours prior to feeding and sampling.

Table 4. The Effect of Protein Supplements on Ammonia Concentrations in Rumen Fluid

	Diet		
	Ration 1	Ration 2	SE[1]
36 hour fasting (mg./100 ml.)	5.2	7.0	0.30
Non fasting (mg./100 ml.)	4.0	16.0	1.8

[1] Standard error of treatment means.

studies that a ratio of 55 parts of carbohydrate is needed for optimum protein synthesis when urea is the sole source of dietary nitrogen. As feed grade urea contains about 45 percent nitrogen, these results would indicate that a ratio of about 25 parts of NFE to one part of urea is needed for optimum urea utilization. More importantly, the NFE of weathered range forage is slowly hydrolyzed, thus it is doubtful if the NFE contained in these feeds is of much value for furnishing the carbon fragments needed for protein synthesis in the rumen. If this is true, all of the required NFE for protein synthesis must be included in the urea-containing supplement. This, of course, would place the upper level of urea in most range supplements to around two percent.

These results of the present experiments offer a possible explanation as to why Nelson and coworkers of this station never obtained good urea utilization when urea-containing supplements were fed to range cows.

The Association Between Sex and Certain Lamb Carcass Characteristics

Lowell E. Walters, J. V. Whiteman and Melton Ezell

Story in Brief

Differences in economically important live animal and carcass characteristics were observed between sexes in lambs. Ram lambs grew faster, reached slaughter weight at an earlier age, had higher daily gains throughout life and produced more muscle and bone in a shorter period of time than wether and ewe lambs. Ewe lambs grew slower, thus re-

quiring more time to reach market weight, and produced carcasses that were fattest of the sexes—with wethers intermediate with respect to these characteristics. Carcass quality grade scores were highest for ewe carcasses as were palatability scores for tenderness, flavor and meat juice. Differences in growth and carcass composition were observed to be greater among sexes than were the differences in quality and palatability of prepared cuts of the carcasses.

Introduction

Consumer preference for lamb with high ratios of lean to fat and of lean to bone has been well established. During recent years, researchers have dealt with the problem of producing heavier muscled lamb carcasses through selection and management techniques. Earlier studies with cattle have demonstrated that the uncastrated male has a greater potential for muscle production with minimal fat than the castrated male or the female.

This study was undertaken to investigate the differences among sexes in lambs for (1) growth, (2) carcass composition (lean, fat and bone) and (3) carcass quality and palatability.

Materials and Methods

Equal numbers of ram, wether and ewe lambs out of Dorset X Rambouillet or Western ewes and sired by mutton breed rams, were slaughtered in each of two years. The lambs were fall born and reared on wheat pasture. Lambs were weaned at approximately 70 days of age at which time the ewes were removed, and the lambs remained on wheat pasture with access to creep feed. From this point in time, the lambs were weighed regularly until they reached a slaughter "full" weight of one-hundred pounds. Slaughter occurred after 18-hour shrink at which time carcass component measurements and appraisals were made following accepted procedures.

Results and Discussion

Growth

Data presented in Table 1 summarize the influence of sex on certain estimates of growth and carcass measurements.

Ram lambs were observed to grow faster by all measures of growth. This difference has been observed in other species also. They were heavier at 70 days and had higher average daily gains to slaughter weight

Table 1. Mean Comparisons for Growth and Slaughter Measurements

Measurement	Mean		
	Ram	Wether	Ewe
70-day weight (lbs.)	56.4	52.7	52.1
ADG to 70-days (lbs.)	0.7	0.6	0.6
ADG 70-days to slaughter (lbs.)	0.7	0.6	0.6
Age at slaughter (days)	137.3	154.9	160 0
Slaughter weight (lbs.)	92.3	91.7	90.3
Chilled carcass weight (lbs.)	48.7	50.8	50.7
Carcass weight per day of age (lbs.)	0.4	0.3	0.3
Dressing percent	53.5	56.2	56.9
Carcass quality grade	Ave. Ch.	Hi. Ch.	Low Pr.

than wethers and ewes. There were only small differences in growth rate between wethers and ewes. The somewhat lower dressing percentage of the ram lambs is believed to be due to smaller deposits of fat than was the case with wether and ewe lamb carcasses. Also, some of the ram lambs had heavy horns. Carcass quality differences were observed as shown in Table 1. The fatter ewe carcasses had more feathering, fat streaking in primary and secondary flank and firmer flanks than wethers and rams. Rams had lower quality scores because they exhibited less feathering and fat streaking and were softer.

Carcass Lean

The rate and efficiency with which meat animals produce muscle is becoming more important since the consumer is placing more emphasis on the matter of proportion of lean in retail cuts at the self-service counter. Lamb carcass lean differences by sex are presented in Table 2.

Table 2. Mean Comparisons of Lean Measurements

Measurement	Mean		
	Ram	Wether	Ewe
Total lean weight (lbs.)[1]	26.8	25.7	25.3
Percent carcass lean[2]	55.1	50.7	49.8
Percent lean of slaughter wt.[3]	29.0	28.0	27.9
Percent trimmed major wholesale cuts[2]	35.6	35.9	35.9
Loin eye area (sq. in.)	2.3	2.2	2.2
Left trimmed leg weight (lbs.)	5.6	5.5	5.4
Percent left trimmed leg weight[2]	11.5	10.7	10.6

[1] Lbs. of lean per lamb.
[2] Calculated as a percentage of carcass weight.
[3] Calculated as a percentage of slaughter weight.

Rams weighed slightly more at slaughter than wethers and ewes, and the total lean in the ram carcasses was found to be higher than for wether and ewe carcasses. When lean was expressed as a percent of slaughter weight, the rams yielded one percent more lean than the wethers and ewes. When lean was expressed as percent of carcass weight, rams were found to have 55.1 percent lean as compared to 50.7 and 49.8 percent respectively for wether and ewe carcasses. This apparent advantage however, is somewhat unrealistic because it does not take into consideration the lower dressing percentage for rams. The presence of larger amounts of intermuscular fat, plainly visible in the wholesale cuts of ewe and wether carcasses is thought to be responsible for the higher dressing percentages in these sexes as well as for the higher percent of trimmed major wholesale cuts in ewe and wether carcasses.

Carcass Fat

While fat is essential to lamb carcass quality and to certain of the palatability characteristics, the search for animals with superior muscling must consider the carcass component variable known from earlier work to have the greatest magnitude—namely FAT. Mean measurements for carcass fat by sexes are presented in Table 3.

In terms of fat trim from the 4 major cuts and total carcass fat as determined by ether extract procedures, ram carcasses had significantly less fat than wethers and wethers significantly less fat than ewes. Similar rank order is observed in such carcass fat estimates as percent kidney knob, average fat thickness at the 12th rib, thickest fat at 12th rib, percent fat trim from the loin and loin fat trim expressed as percent of carcass weight.

Table 3. Mean Comparisons of Fat Measurements

	Mean		
Measurement	Ram	Wether	Ewe
Fat trim from four major cuts (lbs.)	5.4	6.8	7.3
Total carcass fat weight (lbs.)	13.1	16.9	17.8
Percent carcass fat	26.9	33.3	35.2
Percent kidney knob	2.9	4.0	4.7
Ave. fat 12th rib (in.)	0.2	0.2	0.3
Thickest fat 12th rib (in.)	0.5	0.7	0.8
Percent left loin fat trim (of carcass)	1.7	2.1	2.3
Percent left loin fat trim (of left loin)	21.2	25.1	26.4

Carcass Bone

Bone represents the remaining major carcass constituent. Because of the association of growth characteristics with size and proportionate development of the parts of the animal, certain estimates and measures of bone content in the carcass were observed. Mean comparisons of certain of these are presented in Table 4.

Percent carcass bone was found to be significantly different for each of the three sexes. Bone in the leg, expressed as weight or percent of carcass weight was also found to be significantly different for each of the sexes. It should be noted that rams have more bone by all measurements. It should be further noted that excessive bone is just as objectionable in the carcass as excessive fat.

Palatability

Tenderness, flavor and meat juiciness scores were obtained from a taste panel for one-inch thick cooked rib chops from each carcass. For season II of the study, differences in the 3 mentioned palatability characteristics between sexes were small and non-significant. Rank order for mean values of the panel scores for tenderness was ewe, wether and ram; for flavor—ram, ewe and wether and for meat juice, the differences were small and inconclusive. Warner-Bratzler shear force values for tenderness were determined. From these results, it appears that ewe carcasses were more tender than wethers and wether carcasses more tender than rams (taste panel results are in agreement).

Table 4. Mean Comparisons for Bone Measurements

Measurement	Mean		
	Ram	Wether	Ewe
Total bone weight (lbs.)	8.77	8.14	7.62
Percent carcass bone	18.03	16.03	15.10
Left leg bone weight (lbs.)	1.14	1.02	0.95
Percent left leg bone weight (carcass basis)	2.34	2.01	1.87

Observations Relative to Raising Spring Born Lambs

W. A. Zollinger, A. A. Ovejera, S. V. Tennery, J. V. Whiteman

Story in Brief

In the spring of 1967, 354 lambs were born. They had an average birth date of April 2, 1967 and an average weight of 9.6 pounds. They were weaned in an average of 72.2 days and weighed 59.0 pounds. Of these, 343 were marketed at an average of 157.5 days of age and 95.4 pounds.

Efficiency figures were 1.34 and 7.0 pounds of feed per pound of gain, preweaning and postweaning respectively. Combining these figures we have 3.74 pounds of feed per one pound of body weight produced. Average daily gain from weaning to market was 0.47 pounds.

Introduction

A large percentage of the lambs in Oklahoma are born in the fall. The existing opinion of sheepmen is that lambs born in the spring cannot make a profit because of the high incidence of internal parasites, the lower efficiency due to higher temperature and other adverse conditions. The question that arises is, can proper management overcome these conditions and make spring lambing profitable?

The purpose of this paper is to present observations from one spring born lamb crop at the Fort Reno Livestock Research Station.

Materials and Methods

The observations reported were obtained from the spring 1967 lamb crop of ewes lambing on a twice-yearly program at the Fort Reno Livestock Research Station. The ewe flock consisted of 275 Dorset, Rambouillet and Dorset X Rambouillet ewes. It should be kept in mind that some of these ewes lambed the previous fall.

The procedures followed for the project were:

1. The ewes were bred over a period of sixty days beginning October 20, 1966. During the winter the ewes were on pasture and were not supplemented with grain until February 13, approximately one month before lambing. The grain supplement consisted of one pound of milo per ewe per day. This supplement was continued until the lambs were weaned.

2. The breeding period was such that lambing occurred from March 15 to May 15, 1967. As the ewes lambed, they were placed in individual stalls for a period of 2-5 days depending upon the strength of the lamb. The animals were then removed from these pens and put in larger ones with up to 10 other ewes and their lambs.

   In these pens the lambs were docked within 24 hours. After a three day retention the ewes and lambs were released into the main corral area.
3. The ewes were separated from the lambs once in the morning and once in the afternoon for intervals of 1½ hours and allowed to graze on bermudagrass-alfalfa pasture. The lambs were retained in the pen in an effort to reduce internal parasite infestation. As the lambs grew older, the periods lengthened to 3 hours.
4. From the time the lambs were turned into the main pen, they had access to a creep. The ration here was: 57 pounds ground milo: 10 pounds soybean oil meal: 5 pounds molasses: 28 pounds ground alfalfa hay.
5. The lambs were first weighed when the oldest reached 45 days and at 14 day intervals thereafter. They were weaned when they attained a minimum age of 66 days and weight of 50 pounds. When the number of lambs not meeting these requirements decreased to 22, all were weaned regardless of age and weight.
6. The weaned lambs were moved to a feedlot. All ewes and lambs received phenothiazene mixed with salt until the lambs were weaned, then the lambs received only salt. Also, two weeks after the last lambs were weaned, the soybean oil meal in the ration was replaced by an equal amount of alfalfa hay.
7. Observations on earlier spring lamb crops showed a decline in gains as the temperature increased. In order to avoid this as much as possible, the lambs were shorn when they showed heat stress. Since this was a cool summer, only 55 lambs were shorn on August 15, 1967.
8. The lambs were marketed as they reached a minimum of 93 pounds. Also, as in weaning procedures when the number of lambs under 93 lbs. decreased to 28, the remaining were sold regardless of weight.

Results and Discussion

This report presents observations pertaining to birth, weaning, market weights and efficiency of gain of lambs born in the spring. Table 1 contains the average weights and ages of this lamb crop.

Table 1. Average weight and age of lambs at various life stages

Stage	Number of lambs	Average Weight	Average Age in days
Birth	378	9.6	----
Weaning	354	59.0	72.2
Market	343	95.4	157.5

Birth

Of the 276 ewes in the flock, 236 lambed. Lambing began on March 15 and ended on May 15, 1967. During this period 378 lambs were born with an average birth date of April 2, 1967.

Lamb weights ranged from 4.0 to 14.7 pounds with an average of 9.6 pounds. The lambs were healthy and active on the whole and developed normally.

Weaning

As the lambs reached a minimum age of 66 days and 50 pounds of weight, they were taken from the lambing barn to the feedlot. The last group weaned took all lambs regardless of age because of the small number (22) remaining under 66 days of age.

Of the 378 lambs born, 354 lived and were weaned. Tetanus and starvation caused the majority of deaths and no sign of internal parasites was noted. Overall weaning averages were 59.0 pounds of body weight at 72.2 days of age. The average weight adjusted to a standard at 70 days was 57.0 pounds.

Market

Of the 354 lambs weaned, 343 were marketed. Internal parasites were not the cause of any deaths, rather 10 of the 11 lambs were destroyed because they had hemorrhoids.

The lambs were weighed at two week intervals and marketed as they reached 93 pounds. The first group was sold on July 17 and the last on November 15, 1967 which contained all remaining lambs regardless of weight. The average market date was September 9 and the average market age was 157.5 days. The average weight was 95.5 pounds.

Efficiency

Perhaps the most significant data that can be given on any production program are feed efficiency figures. Table 2 contains average daily gains and feed efficiency figures.

These lambs gained 0.65 lb. per day or an average of 47.3 pounds of body weight from birth to weaning. This weight, 16,752 pounds, was gained on 22,500 pounds of creep feed plus mother's milk. Remembering that part of the gain was due to mother's milk before weaning, the lambs gained one pound of body weight for every 1.34 pounds of feed consumed.

More important, after weaning the lambs gained 0.47 pounds per day. They were fed 86,025 pounds of feed and gained 12,242 pounds, thus for every 7.0 pounds of feed consumed, the lambs gained one pound.

The overall daily gain was 0.53 pounds and with a gain of 28,994 pounds on 108,525 pounds of feed; therefore, for every 3.74 pounds of feed consumed, one pound was gained.

One factor should be explained. The temperature in the summer of 1967 was lower than normal. This undoubtedly affected the performance of the lambs and the number that had to be sheared to obtain satisfactory performance.

Table 2. Rate of gain and feed efficiency at various periods

Period	Daily Gain	lb. Feed/one lb. gain
Birth-weaning	0.65	1.34
Weaning-market	0.47	7.03
Birth-market	0.53	3.74

The Age and Weight at Puberty of Some Angus and Angus-Hereford Crossbred Heifers

E. J. Turman, R. H. Edwards, R. L. Willham and R. E. Renbarger

Story in Brief

Seventy-four Angus heifers were started on self-feeders containing a 60 percent concentrate ration one week after weaning. After 140 days on feed, 69 (93.2 percent) had attained sexual maturity (puberty) at an average age and weight of 267 days and 514 lbs. Average daily gain during this period was 2.02 lbs. per day. In comparison, a comparable group of Angus heifers being developed as replacement heifers gained 0.19 lbs. per day during the same period and 4 (15.5 percent) reached puberty. Twenty-seven Angus-Hereford crossbred replacement heifers gained 0.53 lb. per day during this period and only 2 (7.4 percent) attained puberty.

The Angus and crossbred replacement heifers were maintained on native grass pastures and fed the necessary supplemental feed (cottonseed meal and ground milo) for the moderate level of winter gain (approximately 0.5 lb. per day). Estrus observations were discontinued on April 16, at which time the average ages of the heifers were just under 14 months. Twelve (46.1 percent) of the Angus and 7 (25.9 percent) of the crossbred heifers had attained puberty. The average ages and weights were: Angus 375 days and 474 lbs.; and crossbred, 383 days and 459 lbs. This response of the Angus and crossbred heifers is very similar to that reported previously for Hereford replacement heifers on the moderate level of winter feeding.

The data obtained in this study emphasized, again, the effect of higher levels of nutrition in stimulating early sexual maturity in heifers. It suggests that Angus and crossbred heifers must be fed during the winter to gain faster than 0.5 lb. per day if all are to reach sexual maturity by 15 months of age.

Introduction

The age at which beef heifers start production is usually dictated by the system of management. The most common management system practiced by Oklahoma cow-calf operators is calving only during a single limited season. This forces the cattleman to make the decision as to whether heifers should be bred to calve first at 2-years of age or wait until they are 3-year-olds.

The results of studies at the Ft. Reno Research Station have indicated that if beef heifers are sufficiently well developed they may safely be calved at two-years of age. The results, as summarized in the 1963 Feeders' Day report (Okla. Agr. Exp. Sta. MP-70, page 15), showed there was no adverse effect of two-year old calving on later reproductive performance, mature size, or life span.

If heifers are to be bred to calve at two-years of age they must have reached sexual maturity (puberty), as evidenced by the establishment of a regular estrual cycle, by 15 months of age. Several factors are known to influence age of puberty, the most important of which is the level of nutrition following weaning. It has also been reported that there are definite differences between breeds in age of puberty, although most of these studies have been concerned with heifers of the dairy breeds.

A previous Feeders' Day report (Okla. Agr. Exp. Sta. MP-70, page 28) reported the average age of puberty for replacement Hereford heifers being carried at three levels of winter feeding at the Ft. Reno Station. The average ages and weights for heifers on the various levels were: high level, 353 days and 540 lb.; moderate level, 373 days and 522 lb.; and low level, 386 days and 475 lb. The average daily gain of the heifers on each of these levels during the winter were: high, 1.05 lbs/day; moderate, 0.53 lb./day; and low no gain.

Comparable observations have not been obtained for Angus heifers at the Ft. Reno Station. This report is concerned with data collected on the attainment of puberty of a limited number of Angus and Angus-Hereford crossbred heifers that were being carried on two levels of post-weaning nutrition.

Materials and Methods

The data used in this report were obtained from: 100 Angus heifers produced in an Experiment Station cow herd at the Lake Carl Blackwell range, Stillwater in 1965, and moved to the Ft. Reno Experiment Station at time of weaning; and 27 Angus-Hereford crossbred heifers produced in a Ft. Reno Experiment Station cow herd in 1965. Seventy-four of the Angus heifers were immediately placed on full-feed for 168 days at the Ft. Reno Station. They are part of the 279 Angus described in a previous Feeders' Day report (Okla. Agr. Exp. Sta. MP-79, page 31). They were self-fed a 60 percent concentrate ration starting one week after weaning. The remaining 26 Angus heifers, plus the 27 crossbred heifers, were developed as replacement heifers to be used in estrus synchronization studies in the following spring. They were maintained on a moderate level of winter feeding on native grass pastures receiving 1½ lb. cottonseed meal per head per day starting November 15, plus ground milo as needed to obtain approximately 0.5 lb. per day gain.

The occurrence of estrus was determined by use of vasectomized bulls running with the heifers. Estrus observations were terminated in the feedlot heifers on February 10, 1966. The observations were continued in the replacement heifers until April 16, 1966 at which time hormone feeding was started.

Results and Discussion

The data reported in Table 1 compares the rate of reproductive maturity of full fed and limited fed beef heifers. The Angus heifers used in this study responded to full feeding following weaning by reaching sexual maturity at an average age of slightly less than 9 months. After 140 days in the feedlot, 93.2 percent had reached puberty and began to cycle. This compares to only 15 percent of a comparable group of Angus heifers fed to gain only 0.19 lb./day during the same period, and 7.4 percent of the crossbred heifers gaining 0.53 lb. per day. Certainly, this data does not suggest that any heterosis is associated with attainment of sexual maturity of crossbred heifers being fed only a limited amount of supplemental feed during the winter.

The data summarized in Table 2 suggests that there are differences between sires in the rate at which their daughters reach sexual maturity. The difference of nearly a month in the ages at which heifers of the various sire groups reached puberty (range 253.1 days to 277.1 days) was

Table 1. Some measures of reproductive development of Angus and Angus-Hereford crossbred heifers maintained under two different levels of nutrition from weaning on September 28, 1965 until February 10, 1966—number attaining puberty and age and weight at first estrus.

Description of Heifer	No.	Avg. Wt./Heifer 9-28-65	Avg. Wt./Heifer 2-10-66	Avg. Daily Gain	Attaining Puberty No.	Attaining Puberty %	First Estrus Avg. Age	First Estrus Avg. Weight
		(lb.)	(lb.)	(lb./day)	No.	%	(days)	(lb.)
Feedlot Heifers								
Angus	74	401.2	683.8	2.02	69	93.2	267.4	514.4
Replacement Heifers								
Angus	26	422.9	448.8	0.19	4	15.4	329.8	490.0
Crossbred	27	392.2	462.8	0.53	2	7.4	328.5	420.0

Table 2. Some measures of reproductive development of sire progeny groups of Angus heifers on full feed—number attaining puberty during a 140 day feedlot period and average age and weight at first estrus.

Sire	No. Heifers	Avg. Wt./Heifer 9-28-65 (lb.)	Avg. Wt./Heifer 2-10-66 (lb.)	Avg. Daily Gain (lb /day)	First Estrus Age (days)	First Estrus Wt. (lb.)	Attaining Puberty No.	Attaining Puberty %
02303	7	396.4	686.0	2.15	253.1	510.3	7	100.0
02305	8	411.3	705.5	2.18	255.5	524.9	8	100.0
02205	7	438.6	715.4	2.06	260.5	502.3	7	100.0
02222	9	377.8	617.0	1.79	263.3	458.8	7	77.8
02211	8	407.5	675.9	1.99	269.7	520.0	6	75.0
02227	8	388.1	642.8	1.89	269.8	502.8	6	75.0
02301	8	427.5	704.6	2.04	275.3	564.7	7	87.5
02302	9	392.8	677.8	2.12	277.1	530.3	8	88.9

not statistically significant, but the differences in the groups in weight at first estrus (range 458.8 lb. to 564.7 lb.) was significant ($P<.05$). This suggests that the differences between sire groups in attainment of sexual maturity are largely a function of differences in average rate of gain of their daughters. The importance of rate of gain is further indicated by the observation that the three groups in which all heifers had reached puberty by February 10 were also the three groups with the youngest average age at first estrus and included the top two groups and the fourth ranked group in average daily gain.

Table 3 presents data on the reproductive development of Angus and Angus-Hereford crossbred replacement heifers wintered at a moderate level (0.5 lb./day gain). Because of the necessity to start hormone treatments on April 16, data on age and weight at first estrus was not obtained on all heifers in the experiment. At the time the observations were terminated on April 16, the average ages of the heifers in each breed group were; Angus heifers 13.7 months, and crossbred heifers, 13.9 months. Twelve (46.1 percent) of the Angus heifers had attained sexual maturity at an average age of 375 days and a weight of 474 lbs. Seven (25.9 percent) crossbreds had reached puberty at an average age and weight of 383 days and 459 lbs., respectively. These limited data obtained on the Angus and crossbreds compare very closely to the average age at first estrus of 373 days observed in Hereford heifers wintered on the moderate level at Ft. Reno and referred to previously (Okla. Agr. Exp. Sta. MP-70, page 28). The average weight reported for the Hereford heifers (522 lbs.) was approximately 50 lbs. heavier. However, it should be pointed out that these averages were obtained on only one-half of the Angus and one-fourth of the crossbred heifers. Had observations been continued until all heifers had reached puberty it is

Table 3. Some measures of reproductive development of Angus and Angus-Hereford crossbred replacement heifers maintained at a moderate level of winter feeding—number of heifers attaining puberty by April 16, and average age and weight at first estrus.

Breed	No.	Av. Wt./Heifer 11-15-65 (lb.)	Av. Wt./Heifer 4-13-66 (lb.)	Avg. Daily Gain (lb./day)	Attaining Puberty No.	Attaining Puberty %	At First Estrus Avg. Age (days)	At First Estrus Avg. Wt. Wt.
Angus	26	431.5	491.9	0.41	12	46.1	375.1	474.2
Crossbred	27	437.6	513.7	0.51	7	25.9	383 3	458.9

likely that the average age would have been older and average weight heavier.

These observations confirm other reports of the importance of level of nutrition on rate of sexual development. While complete data was not available on the Angus replacement heifers, it would appear that their performance is very similar to that observed in Hereford heifers in previous years. When age of sexual maturity was checked in Hereford heifers wintered at high (1.0 lb. per day gain), moderate (0.5 lb. per day gain), and low (no winter gain) levels of feeding, it was found that the group on the high level was the only one in which all of the heifers had reached puberty by 15 months of age. In comparison, in the moderate and low level groups respectively, 90 and 70 percent were cycling by 15 months and, thus, could have been bred to calve at 24 months. Since only 46 percent of the Angus heifers maintained at the moderate level had reached puberty by 13½ months of age, it would appear that if data had been available for 15 months the number reaching puberty would have been very similar to that reported for Herefords.

The results reported in this study emphasize, again, the stimulatory effect of high levels of nutrition (and, conversely, the suppressing effects of low levels) on sexual maturity of heifers. Of course there are so many undesirable effects associated with full feeding of heifers that it cannot be recommended regardless of its effect on attainment of puberty. It appears, therefore, that the optimum level for developing replacement heifers is somewhere between the full-feeding and the moderate levels reported in this paper. Therefore, even though the high level used in previous Ft. Reno research (1.0 lb. per day gain) was not studied in this trial, the results obtained does not give any reason to alter the recommendation that a level of winter feeding to give a gain of approximately 1.0 lb. per day is the level that will result in the optimum development of replacement heifers.

The Use of an Oral Progestogen, Melengestrol Acetate (MGA), in Controlling the Estrous Cycle of Beef Heifers

E. J. Turman, R. H. Edwards and R. E. Renbarger

Story in Brief

Melengestrol acetate (MGA) is a potent oral progestogen, that is highly effective in suppressing estrus in heifers during the time it is included as part of the ration. This is a report of a study of the effectiveness of MGA in synchronizing estrus. Twenty six Angus and 27 Angus X Hereford crossbred heifers were wintered at a moderate level (0.5 lb. per day gain) on native grass pastures at Ft. Reno. They were divided into two comparable groups: one group (26 heifers) served as untreated controls; the other group (27 heifers) were individually fed 0.5 mg. MGA per head per day for 18 days, April 16, 1966 to May 3, 1966.

Estrus was effectively suppressed during the 18 days of MGA feeding, only 1 MGA fed heifer was observed in estrus compared to 7 control heifers during the same period. Estrus was synchronized: 81.5 percent of the treated heifers were in estrus within 7 days, and 74.1 percent were in estrus within 5 days after the last feeding of MGA. In the same 5 day period, 34.6 percent of the controls were in heat. Conception rate at the first post-MGA estrus was only fair, 59.1 percent, but no other undesirable effects were noted on fertility: only 1 MGA treated, as well as 1 control, heifer were open at the end of a 90 day breeding season; 80 percent of the MGA treated and 53 percent of the control heifers calved in the first 30 days of the 1967 calving season; and the average date of calving of the MGA group was 8 days earlier than the controls. No detrimental side effects of any sort were noted.

The results obtained in this study indicate that MGA is a safe and effective means of synchronizing estrus in non-lactating beef heifers.

Introduction

Precise control of the estrous cycle of beef heifers would offer many possibilities for improvement of efficiency in cattle production. A very important possibility associated with estrus control in beef cow herds would be facilitating the use of artificial insemination. One of the big factors limiting the use of AI in beef herds, particularly commercial

Melengestrol acetate was provided by Dr. R. G. Zimbelman, the Upjohn Company, Kalamazoo, Mich.

herds, is the labor involved in heat detection. If the estrus cycle is synchronized a high percentage of a group of heifers come into heat within two or three predictable days and heat detection becomes less of a problem.

Practical techniques for estrus synchronization became possible following the development of the oral progestogens—compounds with the same physiological activity as naturally occurring progesterone but, unlike progesterone, effective when fed. Today several pharmaceutical houses either now have, or soon will have, on the market, oral progestogens for use in synchronizing estrus in beef cows.

The 1967 Feeders' Day report (Okla. Agr. Exp. Sta. Misc. Publ. MP-79, page 37) summarized estrus synchronization studies conducted over a three year period at the Ft. Reno Research Station. These studies utilized an oral progestogen, medroxyprogesterone acetate (MAP)[1], fed for 18 days at a level of 180 mg. per head per day. The response obtained in post-partum lactating cows was variable and unpredictable. However, excellent synchronization was obtained in non-lactating cycling heifers, with estrus occurring within 6 days after the last feeding of MAP in 90 percent of the heifers.

There are a number of other compounds that are similar to MAP in their effect but are much more potent, and their characteristic effect can be obtained with a much lower dose than 180 mg. per day. One of these compounds is melengestrol acetate (MGA)[2], which is reported to be 300 to 900 times more potent than MAP in estrus suppression. It is effective when fed and has also been extensively studied as a feed additive which will suppress estrus in feedlot heifers as well as stimulate rate of gain and feed utilization.

The purpose of this study was to determine the effectiveness of melengestrol acetate in synchronizing estrus in non-lactating cycling heifers.

Materials and Methods

The data used in this report were obtained from 26 Angus and 27 Angus X Hereford crossbred yearling heifers. The heifers were maintained at the Ft. Reno Research Station during the 1965-66 wintering season at a moderate level of feeding on native grass pasture. They were

[1] Repromix is the trademark for a premix containing medroxyprogesterone acetate, the Upjohn Company, Kalamazoo, Michigan.

[2] MGA is the trademark for melengestrol acetate, The Upjohn Company, Kalamazoo, Michigan.

fed 1½ lb. cottonseed meal per head per day starting November 15, plus ground milo as needed to obtain approximately 0.5 lb. per day gain.

The heifers were divided into two groups as equally as possible on the basis of age, weight, breeding and whether or not they had attained puberty. One group served as an untreated control and the other group was fed 0.5 mg. MGA per head per day for 18 days with the first feeding on April 16 and the last feeding on May 3. The MGA was thoroughly mixed with cottonseed meal so that 1½ lb. of cottonseed meal contained the daily dose of 0.5 mg. MGA, and the heifers were individually fed to insure that each heifer received the allotted dosage. The control heifers were group fed the same amount of cottonseed meal but minus the MGA. Vasectomized bulls ran with the heifers at all times to detect the occurrence of estrus.

Following the last feeding of MGA on May 3, the heifers were held in drylot for 10 days to facilitate heat detection and hand mating. When detected in heat the heifers were removed from the drylot and hand mated to fertile Angus bulls. All heifers were hand mated at the first estrus only if it occurred during the 10 day detection period, after which all heifers ran in pastures with fertile Angus bulls until August 1. Pastures were checked twice daily in an effort to record all mating. The heifers were checked for pregnancy on October 11. The crossbred heifers remained at the Ft. Reno Station to calve in 1967. Five of the Angus heifers, although pregnant, were culled and the remainder were moved to the Lake Carl Blackwell range area near Stillwater to calve in the Spring of 1967.

Results and Discussion

The response of the Angus and crossbred heifers to MGA is presented in Table 1. Average daily gains during the wintering period (November 15, 1965 to April 15, 1966) were: Angus heifers, 0.41 lb. per day; and crossbred heifers, 0.51 lb. per day.

While not one of the items under study, it is apparent that MGA was effective in suppressing estrus during the period of feeding. Only 1 MGA treated heifer was observed in estrus during feeding, compared to 7 control heifers during the same period of time.

Estrus was synchronized in the heifers used in this trial. Twenty two of 27 MGA fed heifers (81.5 percent) were observed in estrus within 7 days after the last feeding of MGA, with 20 (74.1 percent) in estrus within a 5 day period from day-1 to day-5 post-MGA. In comparison,

Table 1. Reproductive Performance of Angus and Angus X Hereford Crossbred Yearling Heifers Fed 0.5 mg. MGA per Head per Day for 18 Days (April 16-May 3, 1966), and Bred by Natural Service at the First Post-Treatment Estrus.

Item	Treatment Group	
	MGA	Control
Number of heifers.	27	26
Avg. age on 4-16-66 (days).	419	407
Avg. weight on 4-16-66 (lb.)	510	512
Number observed in estrus:		
Prior to start of MGA feeding.	9	8
During period of MGA feeding.	1	7
Number in estrus, days 1-7 post-MGA:		
Number on day-1.	4	5
Number on day-2.	6	0
Number on day-3.	5	2
Number on day-4.	3	2
Number on day-5.	1	0
Number on day-6.	1	0
Number on day-7.	1	0
Number settling at first post-MGA estrus.	13	–
Number open after 3 months breeding season.	1	1
Number retained to calve in 1967.	26	20
1967 calving data:		
Total number of heifers calving.	25	19
Number calving in first 30 days.	20	10
Avg. calving date.	2-25	3-5

during the same 5 and 7 day periods there were 9 control heifers (34.6 percent) in estrus.

The conception rate at the first post-MGA estrus was only fair, 13 of 22 (59.1 percent) conceived to service at this estrus. Unfortunately, complete conception data was not obtained on the controls in this study for a comparison. However, one would expect to obtain a conception rate of at least 65 percent with natural service. The conception rate obtained is not greatly depressed below this level, and is better than has been obtained with Hereford heifers fed MAP at Ft. Reno in previous years.

Other than the possibility that the conception rate was slightly depressed, there was no other detrimental effect on fertility associated with MGA feeding. Only 1 MGA treated, as well as 1 control, heifer failed to conceive during the 90 day breeding esason. Eighty percent of the MGA treated heifers, compared to 53 percent of the control heifers, calved in the first 30 days of the calving season. However, the remainder of the controls were not far behind since there was only 1 week difference, in favor of the MGA treated group, in average date of calving in 1967.

Only 33 percent of the heifers had reached puberty by the time MGA feeding was started. However, 81.5 percent responded with a synchronized estrus. This suggests that if heifers are at an age and weight at which puberty should occur, its onset can be stimulated by the oral progestogen, MGA. Similar observations have been made in Hereford heifers fed medroxyprogesterone acetate (MAP).

No undesirable side effects of any sort were noted to be associated with the feeding of MGA. Therefore, the results obtained in this study indicates that melengestrol acetate is a safe and effective means of synchronizing estrus.

The Association Between Beef Carcass Conformation and Carcass Composition

Lowell E. Walters, Everett L. Martin and Robert Renbarger

Story in Brief

Muscle development in slaughter cattle has become increasingly more important during recent years as the result of increased emphasis on high ratios of lean to fat and of lean to bone in retail cuts of beef by the consumer. These studies suggest that superior carcass conformation, as generally interpreted, is not closely related to percentage yields of the thick, high value muscle in the carcass. With one exception, lower conformation carcasses were found to be comparable to the higher conformation carcasses in the percentage yield of high value muscle.

The most striking differences between the carcass conformation grades were found to be in fat and bone percentages. Standard and Low Good conformation carcasses were observed to have more bone and less fat than Choice conformation carcasses. Since differences in muscle content (on a carcass basis) were quite small, the sum of percentage fat and percentage bone was observed to make up a rather constant percentage of the carcass weight among conformation groups.

From Oklahoma Agricultural Experiment Station Project Contributing to Southern Regional Research Project, SM-19.

Introduction

Beef carcass conformation appraisals have traditionally been associated with carcass value. The inclusion of carcass conformation in the U.S.D.A. Beef Carcass Grading Standards has been based on the belief that so-called superior carcass conformation (width and fullness in relation to length, etc.) is related to yield of the preferred cuts of beef.

Several studies have pointed out that fat tends to be a confounding factor when visual appraisals for beef carcass onformation are made. These studies further revealed the lack of positive and significant association between conformation and retail yield. On the other hand, some researchers have observed a positive association between percent carcass bone and retail yield. Since superior conformation has been assumed to reflect a high ratio of lean to bone, there appears to be a contradiction between what is commonly accepted as superior carcass conformation and measures of value based on muscle yields. The need to consider more fully the associations between carcass conformation and carcass composition (thick muscle, thin muscle, total muscle, fat and bone) formed the basis for this study.

Procedure

This research was conducted in two phases over a two-year period, 1966-1967. Phase I (1966) involved feeding two different types of feeder steers (Choice and Common). Forty feeder calves were utilized,—twenty of each type. Half of each type was fed a fattening type ration for 100 days, and the remaining steers were full fed for 140 days before slaughter. The ration fed was a conventional fattening ration consisting of approximately 65 percent concentrates and 35 percent roughage.

Phase II (1967) involved dry-lot feeding 15 Growthy Choice crossbred steers (Charolais X Angus), 15 Conventional Choice steers (Angus) and 13 Common feeder steers (Ayrshire) to a live weight, based on anticipated dressing percentage, that would result in 600 pound carcasses.

At the end of each respective feeding period (1966) or at the time proper live weight was reached (1967) the animals were weighed (after an overnight shrink) and trucked from the Ft. Reno Experiment Station to Oklahoma City for slaughter. Routine carcass information was collected in the cooler, and the right side of each carcass was shipped to the O.S.U. Meat Laboratory for further study and processing. The cutting method involved the determination of the yield of closely trimmed, boneless "thick" and "thin" muscles, fat and bone and expressed as a percentage of the cold carcass weight. Briefly, thick muscles consisted of muscles and/or muscles systems from the carcass considered to be suitable for steak and roast (high value cuts). Thick muscles and/or muscle systems were as follows: strip loin, tenderloin, top-butt, knuckle, top round, bottom round, eye round, chuck roast and rib roast. Thin muscle included all of the lower value muscle from the underline cuts, bone trimmings, etc. This method differs from conventional retail cutting tests in that a more critical differentiation is made between high value thick muscle and lower value thin muscle.

Results: Phase I

Table 1 presents averages of certain of the production and carcass characteristics. The Common feeder steers were considerably lighter in weight when they were placed on feed, and they produced lighter weight carcasses than the Choice steers. While there were differences in initial weight on feed between the two groups, their ages were quite comparable. The thicker-fleshed choice steers were heavier for their age.

Choice steers had significantly higher dressing percentages, and the carcasses graded higher than those of the Common steers. The Choice carcasses graded, on the average, one and one-half U.S.D.A. conformation grades higher than the Common carcasses (high Choice versus low Good). On the average, Common carcasses had less fat thickness at the 12th rib. This may, in part, be a function of lighter average carcass weight. It is not known if this difference in fat thickness would have prevailed had the Common steers been fed to comparable Choice steer weights. Differences between the two types with respect to predicted U.S.D.A. cutability were small, however, the lighter weight Common car-

Table 1. Comparison of Some Average Production and Carcass Characteristics (1966)

	Feeder Grade			
	Common Days on Feed		Choice Days on Feed	
Characteristic	100	140	100	140
Number of steers	10	8	8	10
Initial weight, lbs.	430.5	423.8	565.0	555.5
Cold carcass weight, lbs.	406.4	456.1	520.6	575.7
Dressing percent	58.3	59.2	64.1	62.9
Marbling score	Slight	Small	Small	Modest
Conformation score	Good —	Good —	Choice +	Choice +
Final U.S.D.A. grade	Good —	Good +	Choice —	Choice
Average fat thickness 12th rib, inches	0.27	0.42	0.52	0.67
Rib eye area, sq. inches	8.84	9.06	10.55	10.86
Cutability, U.S.D.A. prediction	51.43	49.72	49.87	48.25

casses were slightly favored, primarily because of their lower fat measurements.

Major carcass component yields and ratios are summarized in Table 2. Thick muscle, thin muscle and total muscle yields were very similar between the two types—Common and Choice. Total muscle yields were slightly higher for the two groups of Common carcasses when expressed as percent of cold carcass weight. While little association was observed between differences in carcass conformation and muscle component yields, differences in fat and bone yields, on the other hand, were found to be associated with differences in conformation.

Lower conformation Common carcasses were observed to have less fat and more bone than the corresponding Choice groups. Increased bone percentages in carcasses from Common steers were offset by a lower percentage fat while lower bone percentage within the Choice carcasses were associated with higher percentages of fat. Thus, fat and bone combined were found to make up a relatively constant percentage of the carcass weight among conformation groups or "types".

Muscle-bone ratios were investigated and are presented in Table 2. The Choice feeder steers produced carcasses with much higher ratios of both thick and total muscle to bone than the lower conformation carcasses produced from the Common feeder steers. However, it should be pointed out that the ratios were higher within the higher conformation carcasses because of a smaller percentage of bone and not because of more muscle.

Table 2. Average Percentage Yields[1] of Carcass Components and Ratios (1966)

	Feeder Grade			
	Common Days on Feed		Choice Days on Feed	
Component	100	140	100	140
Thick muscle	30.99	29.92	30.30	28.41
Thin muscle	27.20	27.78	27.16	26.76
Total muscle[2]	58.19	57.70	57.46	55.17
Fat[3]	20.20	22.29	23.94	26.34
Bone	17.30	14.97	13.60	12.58
Fat + Bone	37.50	37.26	37.54	38.91
Ratio thick muscle/bone	1.80:1	2.00:1	2.23:1	2.26:1
Ratio total muscle/bone	3.38:1	3.87:1	4.23:1	4.40:1

[1] As percent of cold carcass weight
[2] Sum of thick and thin muscle yields
[3] Fat does not include *kidney, pelvic* and *heart fats*

Individual thick muscle and muscle system yield comparisons were made between the two carcass classifications, a summary of which is presented in Table 3. Again, results from the two types were strikingly similar. Within both types, the yields decreased with an increase in length of feeding period, which was expected since increased amounts of fat lower the muscle yields. Total thick muscle yields from the hind and fore quarters further suggested that muscle weight distribution was effected very little by carcass conformation.

Results: Phase II

Phase II differed from Phase I in that steers were fed until they reached a live weight that would produce 600 pound carcasses, rather than on a time constant basis, as in Phase I. This procedure was followed in order to reduce, as much as possible, carcass weight variation among the test groups. Table 4 presents certain of the average production and carcass characteristics. Average conformation grades ranged from high Standard (Common carcasses) to average Choice (Conventional Choice and Growthy Choice carcasses). Conventional Choice carcasses averaged 0.73 inches of fat at the 12th rib as compared to 0.50 and 0.42 for the Growthy Choice and Common carcasses respectively. Average predicted U.S.D.A. cutability percentages (weight of boneless, closely trimmed round, loin, rib and chuck expressed as a percent of the cold carcass weight) were similar for the Common and Conventional Choice carcasses (48.2 versus 48.9 respectively) while the Growthy Choice carcasses averaged 50.8 percent—approximately two percent higher.

Table 3. Mean Percentage Yields[1] of Individual Muscles and Muscle Systems (1966)

	Feeder Grade			
	Common Days on Feed		Choice Days on Feed	
Muscle	100	140	100	140
Hind Quarter				
Strip	2.47	2.33	2.36	2.22
Tender	1.19	1.11	1.16	1.17
Top butt	2.47	2.31	2.40	2.23
Knuckle	3.09	2.90	2.90	2.67
Top round	3.94	3.71	3.88	3.60
Bottom round	3.71	3.59	3.59	3.40
Eye round	1.32	1.25	1.37	1.31
Thick muscle, hind	18.19	17.20	17.66	16.60
Fore Quarter				
Rib roast	3.53	3.47	3.46	3.08
Chuck roast	9.25	9.24	9.17	8.73
Thick muscle, fore	12.78	12.71	12.63	11.81

[1] As percent of cold carcass weight

Table 4. Comparison of Some Average Production and Carcass Characteristics (1967)

Characteristic	Feeder Grade		
	Common	Conventional Choice	Growthy Choice
Number	13	15	15
Initial weight, lbs.	472	562	555
Cold carcass weight, lbs.	564	600	597
Dressing percent	57.5	61.9	61.1
Marbling score	Modest —	Modest +	Small +
Conformation score	Standard +	Choice	Choice
Final U.S.D.A. grade	Good	Choice	Choice —
Average fat thickness 12th rib, inches	0.42	0.73	0.50
Rib eye area, square inches	10.0	11.9	12.6
Cutability, U.S.D.A. prediction	48.2	48.9	50.8

Major carcass components and ratios are summarized in Table 5. The Growthy Choice carcasses excelled in all three categories of muscling,—thick, thin and total muscle yields. They averaged 61.0 percent total muscle as compared to 55.4 and 55.3 for the Common and Conventional Choice carcasses respectively. Further study revealed that the Growthy Choice carcasses excelled in muscling as compared to the Common and Conventional Choice carcasses because of less fat. Both the Common and Conventional Choice carcasses were fatter at approximately 600 pounds carcass weights; therefore muscle yields were lower.

Muscle bone ratios are also presented in Table 5. Thick muscle and total muscle to bone ratios were similar and not significantly different for the Conventional Choice and Growthy Choice carcass. However, since the Growthy Choice carcasses had a higher average bone percentage

Table 5. Average Percentage Yields[1] of Carcass Components and Ratios (1967)

Component	Feeder Grade		
	Common	Conventional Choice	Growthy Choice
Thick muscle	28.9	29.2	32.5
Thin muscle	26.5	26.1	28.2
Total muscle[2]	55.4	55.3	61.0
Fat[3]	23.2	27.7	21.5
Bone	14.7	11.6	12.9
Fat + Bone	37.9	39.3	34.4
Ratio thick muscle/bone	1.98:1	2.54:1	2.53:1
Ratio total muscle/bone	3.79:1	4.81:1	4.72:1

[1] As percent of cold carcass weight
[2] Sum of thick and thin muscle yields
[3] Fat does not include *kidney, pelvic* and *heart fats*

Table 6. Mean Percentage Yields[1] of Individual Muscles and Muscle Systems(1967)

Muscle	Feeder Grade		
	Common	Conventional Choice	Growthy Choice
Hind Quarter			
Strip	2.11	2.34	2.52
Tender	1.13	1.09	1.24
Top Butt	2.23	2.27	2.58
Knuckle	2.94	2.70	3.11
Top round	3.41	3.64	4.05
Bottom round	3.15	3.41	3.75
Eye round	1.08	1.29	1.45
Thick muscle hind	16.05	16.74	18.70
Fore Quarter			
Rib roast	3.45	3.43	3.62
Chuck roast	9.34	9.19	10.17
Thick muscle-fore	12.79	12.62	13.79

[1] As percent of cold carcass weight

than the Conventional Choice carcasses, they had a higher average percentage muscle yield.

It is of further interest to note that the Common and Conventional Choice carcasses were similar with respect to thick muscle and total muscle yields but had significantly different muscle bone ratios resulting from a higher average bone percentage within the lower conformation Common carcasses. Therefore, these data would suggest that carcass conformation is associated with muscle-bone ratios,—the higher the conformation grade the higher the muscle to bone ratio. Furthermore, this data suggests that muscle bone ratios do not adequately evaluate carcasses and that percentage yield knowledge of one of the components is necessary before ratios of muscle to bone are meaningful—an example being the Conventional Choice and Growthy Choice carcasses.

Individual thick muscle and muscle systems yield comparisons were made among the three types—a summary of which is presented in Table 6. Without exception the Growthy Choice carcasses excelled when these muscles were expressed as a percent of cold carcass weight. On the other hand, the Common and Conventional Choice carcasses produced very similar muscle yields even though there was a difference of one and one-half of U.S.D.A. conformation grades between the two types.

The Growthy Choice carcasses studied in Phase II were found to be superior in muscling (i.e. thick and thin as well as total muscle) to other conformation groups (types). It is theorized that, with such cattle as have heavier mature weights, these animals were still growing muscle at the time of slaughter, whereas, cattle from the smaller, earlier maturing groups had perhaps gone past the period of maximum muscle growth and, hence, were laying down more fat. If this be true, the question of the most desirable mature size and growth characteristics in feedlot cattle becomes an important consideration (insofar as muscling is concerned).

Analysis of a Breed Herd Classification Program[1]

James E. Tanner, Joe V. Whiteman, Richard L. Willham and Dwight F. Stephens

Story in Brief

Official breed classifiers scored the same cows during the spring and fall for two years. There was a general trend for increased agreement between different classifiers from the first to fourth classification. Classifiers agreed more closely with each other on scores for older cows than for scores on cows which were 2 years old when first classified.

Individual classifiers were able to repeat scores at different times on older cows with more accuracy than on younger cows. Correlations between scores at different times on younger cows were generally low. Differences in the correlations between scores at different times indicated differences in individual classifiers' abilities to repeat scores on the same animals. Interactions between cows, seasons and classifiers were more important in younger cows.

Correlations of spring scores near the time the cows were calving with calf weaning weights and grades were near zero for 2 and 3 year old cows but were positive for older cows. Correlations of fall scores after weaning with calf weaning weights and grades were essentially zero for 3 and 4 year old cows but were negative for 2 year old cows. Correlations between scores of slaughter cattle and hot carcass weight, fat

[1] This study was supported by a grant from the American Angus Association, headquarters, St. Joseph, Missouri.

thickness per cwt., percent retail cuts and percent trimmed round indicated classifiers scored heavier, fatter slaughter animals higher.

Introduction

Visual scores have been used extensively in classifying or evaluating and comparing animals for many years. This study was conducted to determine how well different classifiers agreed with each other on scores given the same animals at the same time and to measure the agreement between the same classifiers scores on the same animals at different times. Also the association between scores and certain measures of production were investigated.

Materials and Methods

Five official Angus classifiers scored cattle at the Ft. Reno Livestock Research Station during 1964 and 1965. Cattle were scored during the spring and fall of each year, making a total of four classifications over an eighteen month period. The majority of this report involves 76 cows which were classified each time by the same four classifiers. These cows consisted of three age groups, 2, 3, and 4 years and older based on their age at the first classification in the spring of 1964. The older cows will be referred to as 4 year olds in the remainder of this report. The cows either had calved or were about to calve in the spring and all had weaned a calf before being classified in the fall.

The score card was based on the following nine items with their respective maximum points in parenthesis; conformation (20), size (10), head and breed character (8), feet and legs (12), shoulder and foreribs (8), rib and back (10), loin (10), rump (10), and round (12). The first four were grouped as general appearance (50) and the last five as beef character (50). A slightly different score card was used during the first three classifications with conformation being divided into type and quality scores but with a total score of 100 points possible in each case.

The majority of this study involves correlations between scores. Correlations can be used to measure the degree of association between variables. Correlations range in magnitude from —1.0 to +1.0, with a correlation of —1.0 indicating a perfect negative association between the variables and +1.0 a perfect positive association. A correlation of zero would indicate no association between the variables. Many of the correlations reported in this study are average (pooled) correlations obtained by using a Z transformation. Before there is good agreement between scores, the correlation should probably be at least +0.8 or higher.

Results and Discussion

Correlations Between Scores at the Same Time and at Different Times

If classification scores are to be meaningful, a classifier must be able to repeat scores given the same animal with a reasonable degree of accuracy. Ideally there should also be close agreement between classifiers if different classifiers score animals and any comparison is made on the basis of such scores.

Table 1 contains pooled correlations between total scores given by each classifier and scores given by the other classifiers at the same time. This was done separately for each of the three age of cow groups and only scores of the four classifiers participating in all four classifications were used. The correlations in this table are a measure of the agreement between classifiers for total score. In general, the correlations became higher from the first classification in the spring of 1964 to the last classification in the fall of 1965. This indicates that classifiers were scoring more alike during the latter periods. There were distinct differences between cow groups during the first classification but little difference in the fall of 1965. This trend toward closer agreement during the latter classifications was generally true for all items making up total score.

Correlations between a classifier's score each season with his score every other season are presented in Table 2. Six between season correlations were obtained, three between scores at six month intervals, two at twelve month intervals and one with an eighteen month interval. There was no general tendency for the totals at six month intervals to be more

Table 1. Within Season Correlations for Total Score Between Each Classifier and the Other Three Classifiers[1]

Age of Cow	Season	Classifiers 1	2	3	4
2	Spring '64	0.49	0.55	0.44	0.53
	Fall '64	0.63	0.62	0.73	0.68
	Spring '65	0.80	0.80	0.83	0.83
	Fall '65	0.91	0.86	0.91	0.90
3	Spring '64	0.59	0.54	0.56	0.62
	Fall '64	0.64	0.74	0.80	0.77
	Spring '65	0.70	0.66	0.77	0.76
	Fall '65	0.72	0.51	0.68	0.69
4	Spring '64	0.71	0.66	0.70	0.75
	Fall '64	0.76	0.67	0.76	0.77
	Spring '65	0.84	0.81	0.84	0.81
	Fall '65	0.72	0.83	0.85	0.85

All correlations were significant ($P < .01$)

Table 2. Pooled Correlations Between Scores Given by Each Classifier and His Scores at Following Classifications[1]

Variable	Age of Cow	Classifier 1	Classifier 2	Classifier 3	Classifier 4
Total Score	2	0.42	0.62	0.38	0.41
	3	0.53	0.71	0.57	0.47
	4	0.73	0.83	0.75	0.72

[1] All correlations were significant ($P < .01$)

highly correlated than those at twelve and eighteen months and correlations were therefore pooled for each classifier. The correlations between a classifier's total score at different times were in general low, particularly between scores even at six month intervals in the younger cows. While actual changes in the cows during these periods, particularly in the younger cows, can account for some of the lack of agreement it is probably due in part to the inability of even experienced classifiers to repeat subjective scores.

The correlations tend to be higher between scores for the older cows for each classifier. This may be partly the result of a smaller, more select group of cows but to some extent probably reflects more extensive changes in the younger cows. Younger cows are likely to be more drastically affected by stage of lactation and other environmental influences. The higher correlations for classifier 2 indicate that he scored cows more nearly the same from time to time than did the other classifiers.

Table 3 contains pooled correlations between a classifier's score with the other three classifiers within each season (W) and the pooled correlations of an individual classifier's scores between each season (B). These correlations reveal that the agreement is higher among different classifiers at the same time (W) than between the same classifier at different times (B). This difference is much more pronounced in the younger cows and probably indicates actual changes in younger cows.

Table 3. Pooled Correlations for Classifiers with Themselves Between Seasons and with Other Classifiers Within Seasons[1]

Age of Cow	2		3		4	
Variable	W[2]	B[3]	W	B	W	B
Total—Beef Character	0.72	0.44	0.56	0.53	0.70	0.71
Total Score	0.76	0.47	0.68	0.58	0.79	0.77

[1] All correlations were significant ($P < .01$)
[2] Classifiers with others within seasons
[3] Classifiers with themselves between seasons

While there is little difference in the respective correlations for beef character and total score, the correlations between totals tended to be consistently higher than for individual items. This would be expected since differences in the separate variables have a chance to be cancelled out in the totals and would indicate that comparisons between animals would probably be more meaningful based on totals rather than individual items.

Scores of Variation in Scores of Cows Classified Four Times

In another part of this study scores given cows classified all four times were analyzed to determine the importance of cows, seasons, and classifiers and the interactions of these factors as sources of variation. Seasons in this case correspond to the four times of classification. It would be desirable if cow differences accounted for most of the variation in scores. If scores are to be consistent from one time to another, the interactions must make up only a relatively small part of the variation.

The interactions were significant for most of the items and totals analyzed. The percentage of total variation in total score accounted for by each of the factors and interactions are listed in Table 4. Cow and season differences were important sources of variation in total score for all age groups. However classifiers contributed only a small portion of the total variation. Interactions generally accounted for a larger portion of the variation in scores of younger cows, indicating scores were least consistent for younger cows.

Correlations Between Classification Scores and Measures of Production

It would be desirable if classification scores, particularly total score, were positively related to such performance traits as weaning weight and grade. If not positively related, they should not be antagonistic to per-

Table 4. Components of Variance as a Percent of Total Variance of Total Score

Source of Variation	Age Group		
	2	3	4
Cows	23.1	32.1	41.6
Seasons	27.0	35.3	32.3
Classifiers	0.4	0.1	0.4
Cows x Seasons	15.6	14.0	6.7
Cows x Classifiers	6.9	5.0	6.0
Seasons x Classifiers	13.7	6.2	5.7
Cows x Seas. x Class.	13.3	7.3	7.3

formance. Each score given a cow was correlated with the average weaning weight and grade (feeder grade) of her calf. There were no large differences among correlations obtained for different classifiers during the spring and fall classifications. These correlations were pooled within seasons and age of cow groups.

Table 5 contains correlations between average weaning weight and grade with total score. The correlations between spring scores were essentially zero for 2 and 3 year old cows, but were positive and significantly greater than zero for 4 year old cows. This pattern was generally the same for most of the items making up total score. The larger correlations for the smaller number of older cows may have been due in part to a few high scoring cows that had heavy calves or low scoring cows with light calves and probably are not truly this high.

Correlations between fall scores and weaning weight and grade present a different picture. Correlations between fall scores and average weaning weight and grade were close to zero for 3 and 4 year old cows. Significant negative correlations were obtained for 2 year old cows, the correlation of —0.3 between total score and average weaning weight would suggest that the beter producing younger cows were being penalized. This was probably a result of the better milking cows being thinner in the fall and consequently receiving a lower score. It would therefore seem advisable to score younger cows during the spring rather than following weaning.

Yearling slaughter cattle consisting of 36 bulls, 35 steers, and 44 heifers were scored in the spring of 1965. Classification scores were correlated with hot carcass weight, rib eye area per cwt., fat thickness per cwt., percent retail cuts and percent trimmed round. The correlations did not differ appreciably between the sexes and were therefore combined. Table 6 contains correlations of beef character and total score with carcass measures. While many of the correlations are significantly dif-

Table 5. Correlations Between Total Scores of Cows of Different Ages and Average Weaning Weights and Grades of Their Calves

	Spring			Fall		
Age of Cow	2	3	4	2	3	4
Weaning Weight	—.06	—.06	.59	—.30	—.10	.07
Weaning Grade	.05	.14	.39	—.19	.14	—.13

Correlations equal to, less than or greater than ±0.13, ±0.18, and ±0.25 for two, three, and four year old cows, respectively, were significant ($P < .01$).

Table 6. Pooled Correlations Between Classification Scores of Yearling Bulls, Steers, and Heifers and Carcass Measurements

	Beef Character	Total Score
Hot Carcass Weight	.24	.28
Rib Eye Area Per Cwt.	—.26	—.04
Fat Thickness Per Cwt.	.20	.20
% Retail Cuts	—.26	—.29
% Trimmed Round	—.12	—.12

Correlations equal to or greater than 0.12 or equal to or less than −0.12 are significant ($P < .01$).

ferent from zero they were generally small. All significant correlations between hot carcass weight and fat thickness per cwt. were positive indicating that heavier, fatter animals were scored higher. All significant correlations between percent retail cuts and percent trimmed round were negative. This is probably a further reflection of the tendency to give fatter animals higher scores.

Methods of Processing Milo for Fattening Cattle*

James R. Newsom, Robert Totusek, Robert Renbarger, E. C. Nelson, Larry Franks, Vincent Neuhaus, and Willie Basler

Story in Brief

Six methods of processing milo—coarse grinding, fine grinding, dry rolling, reconstituting-rolling, reconstituting-grinding, and steam-process-flaking—were compared in a high concentrate ration. All processing methods significantly improved feed efficiency compared to coarse grinding, with greatest improvements noted for reconstituting-rolling and steam-process-flaking. Steam-process-flaking resulted in the fastest rate of gain; gains on the other processed grains were similar. Feed intake was significantly lower on reconstituted-rolled milo, reflecting more efficient utilization since rate of gain was not depressed. Carcass merit and dressing percentage were not affected by processing method.

* Appreciation is extended to Farmland Industries, Kansas City, Missouri, for partial financial support of this research.

The cooperation of Wilson and Company, Oklahoma City, Oklahoma, in obtaining slaughter and carcass data is gratefully acknowledged.

Thanks are also extended to personnel at Ft. Reno for valuable assistance in the conduct of the experiment and collection of data.

Introduction

Milo (sorghum grain) has been the most readily available and cheapest grain for fattening cattle in Oklahoma and throughout the Southwest. The trend toward increased cattle feeding in this area indicates that milo will be even more widely used as a feed grain in the future.

Previous research has shown that the feeding value of milo is lower than its chemical composition indicates, possibly due to a lower protein digestibility and a lower starch availability compared to corn or barley. The availability of starch is especially important, since starch comprises 70-75 percent of milo grain, and milo is included in rations primarily as a source of energy. Since many fattening rations today contain as much as 80-90 percent or more milo, any improvement in the feeding value of milo would be of great benefit to the cattle feeding industry.

The most promising method of improving starch availability and the utilization of the energy of milo, and thereby feed efficiency, is in the area of grain processing. The milo kernel must be ruptured before feeding to cattle. Whole milo grain, because of the hard, waxy seed coat, passes through the animal undigested in large quantity. In the past, milo has most commonly been coarsely ground, dry rolled or steam rolled ("conventional" steam rolling, with 3-5 min. exposure to steam). Considerable research at this station and elsewhere has indicated very little difference in feeding value of milo processed by these three methods.

Previous work at this station showed that pelleting milo improved its utilization 5-9 percent, but lowered carcass grade and dressing percent were rather consistently observed. The high cost of pelleting is a further and major deterrent to its use. A 5 percent improvement in feed efficiency from fine grinding of milo, compared to coarse grinding, has also been indicated. However, finely ground milo may present a problem with dust and "fines," especially in rations which contain no molasses, fat or silage.

High moisture (25-35 percent) harvesting of milo has been reported by the Kansas and Texas stations to improve dry matter utilization an average of 10 percent. Reconstituting of milo (adding water to air-dry milo to raise the moisture level to about 30 percent and subsequent fermentation with exclusion of air) has shown a similar improvement in feed efficiency.

Work at the Arizona station has indicated a 4 percent or greater improvement in feed efficiency, along with increased feed intake and rate of gain, from the partial cooking of milo by live steam followed by "flaking" through a roller mill. Research at the California station has indicated an occasional but inconsistent response from pressure cooking of milo followed by rolling.

The objective of this experiment was to compare six methods of processing milo—coarse grinding, fine grinding, dry rolling, reconstituting-rolling, reconstituting-grinding and steam-process-flaking—in a 90 percent concentrate ration.

Procedure

Seventy-two Hereford steer calves with an average weight of 535 lb. and an average age of 10 mo. were started on trial December 28, 1966. They were selected from 154 calves, which were produced in Oklahoma State University experimental herds. The calves were started on feed four weeks before the trial was initiated. The starter ration consisted of 48.5 percent coarsely ground milo, 10.0 percent cottonseed meal, 10.0 percent chopped alfalfa hay, 30.0 percent cottonseed hulls, 1.0 percent salt and 0.5 percent bonemeal.

The steers were divided into four blocks on the basis of shrunk weight and condition score, and randomly assigned to the six treatments within each block. Four pens of three steers each were assigned to each treatment. The six types of processed milo were fed in a high concentrate ration, as shown in Table 1. All ingredients other than milo were combined into a premix, which was mixed with the milo in the ratio of 83.4 percent milo to 16.6 percent premix. Proximate analyses of the premix and the processed milo grains are shown in Table 2.

Table 1. Ration Composition

Ingredient	Percent
Milo	83.4
Alfalfa hay, chopped	6.0
Cottonseed hulls	4.0
Cottonseed meal (41% crude protein)	4.0
Urea (42% nitrogen)	1.0
Salt	1.0
Bonemeal	1.6
	100.0
Added, Per lb. of Ration	
Vitamin A	1500 I. U.
Aureomycin	
1st 40 days	10 mg.
Remainder of trial	5 mg.

Table 2. Proximate Analyses

	Dry[1] Matter	Ash[2]	Crude[3] Protein	Ether[3] Extract	Crude[3] Fiber	N.F.E.[4]
	Percent					
Coarsely ground	87.0	1.92	10.03	2.54	1.70	83.81
Finely ground	87.3	1.85	10.00	3.42	1.58	83.15
Dry rolled	87.3	2.03	10.11	2.79	1.76	83.31
Recon. rolled	79.9	1.98	10.54	2.03	1.72	83.73
Recon. ground	80.9	2.01	10.70	1.55	1.67	84.07
Steam-Proc.-Flaked	83.2	2.11	10.77	2.18	1.38	83.56
Premix	90.4	7.48	36.99	4.08	16.33	35.12

[1] Average of 7 determinations.
[2] One determination.
[3] Average of 3 determinations.
[4] 100—(sum of figures reported for ash, crude protein, ether extract, and crude fiber).

Processing Methods

Coarsely and finely ground milo was produced with a hammer mill, using 3/16 and 1/8 in. screens, respectively. Reconstituted milo was produced in a 14 x 27 ft. glass-lined, air-tight Harvestore silo. Water was added to the air-dry grain (14 percent moisture) as it was augured into the silo, raising the moisture level to approximately 24 percent. Before feeding, it was either rolled with approximately .003 in. tolerance between the rollers, or ground through a 1/8 in. screen. Dry rolled milo was produced by rolling air-dry milo with a roller tolerance in excess of .003 in.

Steam-process-flaking was accomplished by using the procedure reported by Hale and co-workers at the Arizona station. Milo was subjected to steam in an unpressurized steam chamber for 20 min. at 205° F., then rolled immediately with no tolerance between the rollers. The steaming chamber was 1 x 2 x 5 ft., with a capacity of 500 lb.

All milo used in this trial was produced on the Fort Reno station and was of the variety Northrup King 222. Air-dry whole milo was stored in a 14 x 27 ft. Harvestore silo. All rolling was done through a heavy duty Ross 18 x 24 in. roller mill.

Feeding

The three "wet" grains, reconstituted-rolled, reconstituted-ground and steam-process-flaked, were processed daily, with the exception that enough was processed on Friday to feed through the weekend. The coarsely ground and finely ground grains were processed, combined with premix and stored in quantities of one ton. The three rolled products were combined with the premix by hand in the feed trough to preserve the character of the grain as produced by the processing methods. The cattle were fed once daily in suffiicent quantity to assure availability of feed until the next feeding. Feed was weighed to the nearest .5 lb. and unconsumed feed was weighed and removed frequently. The steers had access to open-sided sheds and outside lots, with water (warmed in winter) available at all times.

Data Obtained

Feed samples were taken at the end of each 21 day period for proximate analysis and dry matter determination. Dry matter percentages were used to adjust all rations to an equal dry matter content (90 percent). The grains were sieved and test weights were taken to determine particle size and density, respectively, as shown in Table 3.

Initial and final weights were taken after a 16-hr. shrink with no feed and water. Intermediate weights were taken at 21 day intervals, after a 16-hr. overnight shrink from water (feed was available). Performance data were summarized after 149 days on feed (May 26, 1967) because the steers were subjected to ultrasonic determinations and rumen sampling following this period. Ration treatments were continued until time of slaughter, which was on June 5, 6 and 7. Standard carcass data were collected after a 24-hr. cooler chill. Bladders were collected at slaughter and the amount of calculi in each bladder was determined.

Table 3. Particle Size[1] and Density[2] of Processed Milo

	Screen Size, in.									
	18/64	16/64	12/64	8/64	1/12	1/18	1/25	40 Mesh	40 Mesh	Wt. per Bu.
	% Retained on Screen								% Passed	lb.
Recon. ground	0	0	0	.24	1.94	16.30	20.04	26.79	34.69	40.7
Finely ground	0	0	0	.25	1 94	13.78	20.13	34.14	29.76	47.4
Coarsely ground	0	0	0	2.93	9.34	23.69	18.19	23.71	22.14	49.7
Dry rolled	.02	.30	.34	3.11	18.14	27.89	16.38	21.13	12.69	38.8
Recon. rolled	.44	1.09	5.49	24.69	26.89	14.39	6.24	11.60	9.17	28.4
Steam-Proc.-Flaked	13.65	19.08	40.25	17.55	4.35	2.15	.90	1.28	.79	23.3
Steam-Proc.-Flaked (after mixing in mechanical mixer)										35.7
Whole dry										59.1
Whole reconstituted										50.2

[1] Particle size: Five 100-gm. samples were sieved for each grain and averages are reported.
[2] Test weights reported are averages of several determinations throughout the trial. Considerably lower values were obtained at times for steam-proc.-flaked and recon. rolled (lowest values—steam-proc.-flaked-16.6, recon. rolled-26.6 lb./bu.). Values are on a 90% dry matter basis.

Results

Note the effect of processing method on dry matter (100 percent minus the percent moisture), shown in Table 2, and test weight per bushel (density) and particle size, shown in Table 3. The air dry milo, which was either rolled or ground, averaged approximately 13 percent moisture, while the steam-process-flaking, reconstituting-grinding and reconstituting-rolling procedures increased moisture levels to averages of 16.8, 19.1 and 20.1 percent, respectively.

All of the processing methods decreased the density of milo as compared to the whole milo. Steam-process-flaking and reconstituting-rolling resulted in the greatest decreases in density (58.4 and 47.2 percent less than whole milo, respectively). These two processing methods also produced the greatest change in particle size. However, steam-process-flaking, compared to reconstituting-rolling, produced more large particles (flakes) and much less fine material. The fine particles in both of the reconstituted products (rolled and ground) were very fluffy in nature. This characteristic resulted in a test weight per bu. for the reconstituted-ground milo that was less than that for the finely ground air-dry milo (45.3 and 48.9 lb. per bu., respectively), even though the reconstituted-ground milo contained slightly more fine material than the finely ground dry milo (34.69 and 29.76 percent through the 40 mesh screen, respectively).

Feedlot performance is shown in Table 4. Table 5 presents a further summary showing the relationship of other processing methods to coarse grinding in terms of rate of gain, feed intake and feed efficiency.

Although rate of gain did not differ statistically among the six treatments, it is interesting to note that gains for coarsely ground, dry rolled, reconstituted-rolled and reconstituted-ground milo were almost identical, while the steers on finely ground milo gained 3.2 percent faster and those on steam-process-flaked milo 11.9 percent faster than those fed coarsely ground milo.

Table 4. Feedlot Performance (149 days)

	Method of Processing Milo					
	Coarsely Ground	Finely Ground	Dry Rolled	Recon.-Rolled	Recon - Ground	Steam-Process-Flaked
No. Steers	12	12	11	11	10	11
Av. initial wt., lb.	533	533	533	526	533	547
Av. final wt., lb.	909	920	906	901	908	967
Av. daily gain, lb.	2.52	2.60	2.51	2.52	2.52	2.82
Av. daily feed, lb.[1]	16.98^{a}	16.81^{a}	16.27^{a}	14.58^{b}	16.16^{a}	16.42^{a}
Feed/lb. gain, lb.[1]	6.77^{a}	6.47^{c}	6.43^{c}	5.82^{b}	6.44^{c}	5.90^{b}

[1] Any 2 averages without a common letter differ significantly ($P < .05$).

Table 5. Summary of Effect of Milo Processing Method on Feedlot Performance

	Coarsely Ground	% Change Compared to Coarsely Ground Milo				
		Finely Ground	Dry Rolled	Recon.-Rolled	Recon.-Ground	Steam-Process-Flaked
	lb.					
Av. daily gain	2.52	3.2	— .8	— .1	— .3	11.9
Av. daily feed	16.98	—1.0	—4.2	—14.1[1]	—4.8	— 3.3
Feed/lb. gain	6.77	—4.4	—5.0	—14.0[1]	—4.9	—12.9[1]

[1] Significantly different ($P < .05$) than value for coarsely ground milo.

Significant differences in feed intake and feed efficiency were observed. The cattle fed steam-process-flaked milo required significantly less feed per lb. of gain (12.9 percent) than those fed coarsely ground milo. Average daily intake of reconstituted-rolled milo was significantly less than the other five treatments (14.1 percent less than coarsely ground milo) resulting in an increase in feed efficiency of 14.0 percent over coarsely ground milo. This difference was also statistically significant.

The six types of processed milo produced carcasses that were not significantly different for any of the criteria shown in Table 6. Quantities of calculi in the bladder were extremely small in all steers and apparently unrelated to the processing method.

Discussion

The results of this trial, comparing processing methods of milo fed in a high concentrate ration, were very similar to results of a previous trial[1] at this station in which processed milo was fed in a conventional ration containing approximately 26 percent roughage and 54 percent milo. A summary of the feedlot performance as influenced by processing method in the two trials is shown in Table 7, for those methods which were included in both trials. Coarsely ground milo was used as the standard of comparison. Note the average results. Fine grinding resulted in a slight increase in gain on a lower feed intake, and a consequent average improvement in efficiency of 6.0 percent. Reconstituting-rolling affected gain very little, but lowered feed intake markedly and improved feed efficiency 9.7 percent. On the other hand, steam-process-flaking increased gain considerably with very little additional feed, resulting in an improvement in feed efficiency of 8.8 percent.

[1] See Oklahoma Agr. Exp. Sta. Misc. Pub. MP-79, p. 79.

Table 6. Slaughter and Carcass Information

	Method of Processing Milo					
	Coarsely Ground	Finely Ground	Dry Rolled	Recon.-Rolled	Recon.-Ground	Steam-Process-Flaked
Dressing %[1]	62.2	61.9	61.9	61.8	61.8	61.7
Carcass grade[2]	9.7	9.0	9.4	9.0	9.5	9.7
Ribeye area, sq. in.[3]	10.5	10.8	10.4	10.8	10.9	11.0
Fat thickness, in.[4]	0.65	0.67	0.63	0.60	0.52	0.72
Marbling[5]	12.9	12.8	13.8	11.9	12.9	14.8
Cutability, %[6]	49.2	49.2	49.1	49.8	50.0	48.7

[1] Calculated on basis of Ft. Reno live shrunk weight and chilled carcass weight.
[2] U.S.D.A. carcass grade converted to following numerical designations: high prime-15, average prime-14, low prime-13, high choice-12, av. choice-11, low choice-10, high good-9, av. good-8, low good-7.
[3] Determined from tracings at the 12th rib.
[4] Average of three measurements on ribeye tracing.
[5] Marbling scores: 1 to 30, 11=slight, 12=slight plus, 13=small minus, 14=small, 15=small plus.
[6] Percent of boneless trimmed retail cuts on carcass basis=51.34 (fat thickness)-.462 (% kidney fat) + .740 (ribeye area)-.0093 (chilled carcass wt.).

Table 7. Summary of Effect of Milo Processing On Feedlot Performance in Two Trials

	% Change Compared to Coarsely Ground Milo								
	Daily Gain			Daily Intake			Feed/lb. Gain		
	Trial 1[1]	Trial 2[2]	Av.	Trial 1	Trial 2	Av.	Trial 1	Trial 2	Av.
Finely Ground	3.3	3.2	3.2	—4.7	— 1.0	— 2.9	—7.6	— 4.4	—6.0
Recon.-Rolled	.4	—.1	.2	—5.0	—14.1	— 9.6	—5.4	—14.0	—9.7
Steam-Process-Flaked	8.2	11.9	10.0	4.3	— 3.3	1.0	—3.5	—12.9	—8.8

[1] Trial 1—54% milo ration
[2] Trial 2—83.4% milo ration

Both steam-process-flaking and reconstituting-rolling produced greater improvements in feed efficiency in this trial than in the previous trial (3.5 and 5.4 percent in the first trial and 12.9 and 14.0 percent in this trial, for steam-process-flaking and reconstituting-rolling, respectively). The greater improvements in efficiency in this trial may have been due to the higher concentrate ration which was fed, and the higher level of milo in the ration (83.4 vs. approximately 54 percent).

Dry rolled and reconstituted-ground milo produced very similar results in all respects. It should also be noted that results from fine grinding and dry rolling were very similar. Fine grinding has a definite advantage over coarse grinding, but little apparent advantage over rolling. This is consistent with results obtained at the Kansas Station.

It is interesting to note that the percent increases in feed efficiency paralleled the percent decreases in intake for the dry rolled, reconstituted-rolled and reconstituted-ground grains, while for finely ground and steam-process-flaked milo the increases in feed efficiency were of greater magnitude than the decreases in intake. For the first three, energy intake seemed to be the governing factor; that is, if utilization of a grain is increased, less is required to provide the same amount of energy. However, for the other two grains, particularly the steam-process-flaked, the improvement in feed efficiency seemed to be the result of faster gain without a significant decrease in intake, with the feed required for maintenance thus spread over a greater gain. Even if this is true, however, it is obvious that advantages in rate of gain and apparent feed efficiency are important economically. Furthermore, the faster gaining steers on the steam-process-flaked milo could be marketed earlier, resulting in a real improvement in feed efficiency not demonstrated in this experiment in which steers were fed a constant time rather than to a constant weight.

Results of this research indicate that the mechanical process of rolling improved the efficiency of utilization of milo grain. Dry rolling was superior to coarse grinding and reconstituted-rolled milo outperformed reconstituted-ground milo. Work at the Arizona station has shown that the success of the steam-process-flaking procedure depends on a flat flake produced by slow rolling with much roller pressure. The results of these two trials indicate that significant improvements in utilization can be obtained by combining proper rolling with either the reconstitution process or partial cooking with steam.

It should be pointed out that the "coarsely ground" milo used in this trial, ground through a 3/16 in. screen, was considerably finer than that used in many feedlots which is undoubtedly utilized much less efficiently than the "coarsely ground" milo used in this trial.

Energy Requirements of Mature Beef Cows as Influenced by Weight and Level of Milk Production

S. A. Ewing, Larry Smithson, Craig Ludwig and Dwight Stephens

Story in Brief

Twenty mature Hereford cows were fed individually in drylot to determine energy requirements during maintenance or gestation and lactation. The cows were selected to provide a range of from 800 to 1300 pounds in body weight. Digestible energy requirements were determined for each cow during a yearly cycle involving gestation and lactation.

For dry, mature and pregnant cows the daily digestible energy requirement can be expressed by the formula DE (Mcal.) $= 5.669 + 0.00831 \times$ weight TDN requirements appear to increase about 0.4 to 0.5 pound per 100 pounds increase in cow weight. Estimates of energy requirements of beef cows as affected by body weight and milk production are presented. Such data will be useful in determining the energetic efficiency of beef cows varying in body size.

Introduction

Previous research at the Oklahoma Station concerning level of winter feeding has contributed to the establishment of recommended seasonal weight change patterns for brood cows. Such weight change patterns appear to be consistent with both reproductive efficiency and winter feeding economy. No previous work has been reported which would establish the energy requirements to support these suggested weight changes for the beef cow. In addition, much interest has been expressed by the industry relative to the influence of cow size on energy requirements and the corresponding feed input.

The work reported herein was done with both of the above factors in mind to establish the energy requirements to foster desirable weight change patterns during typical lactation and dry periods for the mature beef cows representing a reasonably wide range of weights.

Procedure

The experiment was conducted at the Ft. Reno Station during the period from February 1965 to March 1966. Twenty mature Hereford

Acknowledgement is extended to the American Hereford Association, Kansas City, Missouri, for financial assistance for this study and to Codding Cattle Research, Foraker, Oklahoma, for permitting purchase of experimental cows from their performance-tested commercial herd.

cows from 6 to 7 years of age were selected as experimental animals. Weights of the cows ranged from 800 to 1400 pounds when measured at a point immediately prior to calving.

Four cows were not permitted to raise their calves and remained open. These cows served to establish the energy requirements for maintenance.

The remaining producing cows were utilized to establish energy requirements for the producing cow during a lactating period of 215 days post partum at which time the calf was weaned. This period was followed by a non-lactating period from 215 days post partum to a point immediately prior to the following parturition. During the non-lactating period the energy requirements for wintering dry, pregnant cows were observed.

All cows were maintained in a large dry lot and were fed individually. The mixed ration fed during the lactation and dry periods contained 59 and 49 percent TDN, respectively. Digestible energy values for the respective rations were 1.216 and 1.067 Mcal/pound. Energy values were determined by digestion trials conducted during each period using the chromic oxide reference technique.

Weights were taken routinely at weekly intervals for the purpose of adjusting feed allowance. All weights were obtained after a 12-hour shrink period without feed and water. The weight change pattern for each cow was established as follows:

Period	Time	Cow Weight Change
I_a (lactation)	From immediately prior to calving to 56 days post partum.	Lose approximately 15 percent of pre-calving weight.
I_b (lactation)	From 56 days post partum to 215 days post partum.	Gain approximately 8.5 percent of pre-calving weight.
II (non-lactation)	From 215 days post partum to immediately prior to the following parturition.	Gain approximately 6.5 percent of pre-calving weight and as a result return to the weight observed at the time the cow was placed on experiment prior to calving.

The calves were permitted to run with the cows except during feeding periods each day. All calves were offered feed individually to supplement that consumed in the form of milk.

Milk production was estimated at 14 day intervals for each cow by the calf weight difference technique involving weights before and after nursing. Milk samples were taken periodically for fat analysis to permit the expression of milk yield on a fat-corrected basis. Energy requirements determined during the lactation phase for individual cows were corrected for milk yield in order to express requirements exclusive of that for milk production.

The weights of cows, expressed as the initial weight observed prior to calving, and the numbers involved in each phase of the study are shown in Table 1.

Results

The results of the study concerning Digestible Energy (DE) and Total Digestible Nutrient, (TDN) requirements during the non-lactation period are summarized in Table 2. It should be noted that the requirements stated are average requirements for the entire non-lactation period of approximately 150 days or the last 5 months of pregnancy. No attempt has been made at this writing to determine requirements for advancing pregnancy during this period. Maintenance requirements for dry, open cows are shown in Table 3.

Results from the lactation phase are shown in Table 4. The energy values are based on observed requirements for the pregnant cow correct-

Table 1. Initial Weights of Individual Cows Comprising the Experimental Group

Maintenance[1]	Lactation Period	Non-Lactation Period
1320	1370	1370
1250	1315	1315
930	----	1315[2]
780	1285	1285
	1285	1285
	1280	1280
	----	1260[2]
	----	1140[3]
	----	1130[3]
	1040[4]	----
	1005	1005
	1005	1005
	990	990
	980	980
	975[4]	----
	970	970
	935	935

[1] Dry, open cows utilized for determining maintenance requirement.
[2] Cows lost calves during lactation period, but were re-bred and utilized during non-lactation period.
[3] Cows that were selected from Ft. Reno range herd and conditioned for the non-lactation period.
[4] Cows removed from test at end of the lactation period.

Table 2. Energy Requirements for Wintering Mature, Pregnant Cows During the Dry Period.

	Daily Energy Requirement	
Cow Weight (lb.)	Digestible[1] Energy (Mcal.)	Total Digestible[2] Nutrients (lb.)
800	12.31	5.80
900	13.14	6.28
1000	13.97	6.56
1100	14.80	6.94
1200	15.64	7.32
1300	16.47	7.70

[1] Daily DE (Mcal.) = 5.669 + 0.00831 W
[2] Daily TDN (lb.) = 2.771 + 0.00379 W

Table 3. Energy Requirements for Maintenance (Dry-Open Cows)

	Daily Energy Requirement	
Cow Weight (lb.)	Digestible[1] Energy (Mcal.)	Total Digestible[2] Nutrients (lb.)
800	11.71	5.35
900	12.31	5.63
1000	12.92	5.91
1100	13.53	6.19
1200	14.13	6.46
1300	14.74	6.74

[1] Daily DE (Mcal.) = 6.861 + 0.00606 W
[2] Daily TDN (lb.) = 3.138 + 0.00277 W

ed for estimated yield of 4 percent fat-corrected milk, plus the energy probably required in addition for a given yield of milk containing 4 percent butter fat.

It should be noted that degree of activity and climate influence energy requirements. Therefore, these data should be interpreted with regard to the location in which the work was accomplished, which was central Oklahoma. Further, the degree of activity experienced in dry lot may be considerably less than under range conditions. It is generally accepted that the energy requirement for walking is approximately one percent above maintenance per 100 pounds of weight per mile.

Table 4. Estimated Energy Requirement of Beef Cows Representing Different Weights and Levels of Milk Production.

Cow Weight (lb.)	Daily Milk Production (lb.)	Daily Energy Requirement: Digestible[1] Energy (Mcal.)	Daily Energy Requirement: Total Digestible[2] Nutrients (lb.)
	8	19.90	9.41
	10	21.23	10.07
	12	22.55	10.73
800	14	23.87	11.39
	16	25.20	12.05
	18	26.52	12.71
	20	27.85	13.37
	8	20.88	9.94
	10	22.21	10.60
	12	23.53	11.26
900	14	24.85	11.92
	16	26.18	12.58
	18	27.50	13.24
	20	28.81	13.89
	8	21.86	10.47
	10	23.19	11.13
	12	24.51	11.79
1000	14	25.83	12.45
	16	27.16	13.11
	18	28.48	13.77
	20	29.81	14.43
	8	22.84	11.00
	10	24.17	11.66
	12	25.49	12.32
1100	14	26.81	12.98
	16	28.14	13.64
	18	29.46	14.30
	20	30.79	14.96
	8	23.82	11.53
	10	25.15	12.19
	12	26.47	12.85
1200	14	27.79	12.51
	16	29.12	14.17
	18	30.44	14.83
	20	31.77	15.49
	8	24.80	12.06
	10	26.13	12.72
	12	27.45	13.38
1300	14	28.77	14.04
	16	30.10	14.70
	18	31.42	15.36
	20	32.75	16.02

[1] Daily DE (Mcal.) = 6.764 + 0.0098 W + (Daily lb. 4% FCM × 0.662)
[2] Daily TDN (lb.) = 2.529 + 0.0053 W + (Daily lb. 4% FCM × 0.330)

Effect of Supplemental Feed and Stilbestrol Implants on the Performance of Heifer Calves Grazing Winter Wheat Pasture

Robert Renbarger, S. A. Ewing and Dwight Stephens

Story in Brief

Heifer calves grazing winter wheat pasture consumed over 10 lb. per head daily of a concentrate mixture, but gained only 0.61 lb. more per head daily than calves without supplement. Implanting with 12 mg. stilbestrol increased gains of calves on wheat pasture without supplement by 0.22 lb. per head daily. No response from the implant was obtained when supplemental feed was available. The most profitable results were obtained by implanting with 12 mg. stilbestrol without additional concentrate.

Introduction

Numerous opinions are available on the best way to utilize winter wheat pasture in Oklahoma. Procedures vary from straight pasture utilization to a rotating program with various levels of supplemental feeds being used by different producers. It is apparent that some reserve of supplemental feed (roughage or concentrate) should be available to maintain carrying capacity in those years which adverse climatic conditions are encountered.

Procedure

The test involved forty head of weaner Hereford heifer calves weighing approximately 480 lbs. These animals were randomly allotted to four lots of 10 heifers each. Lots 1 and 3 served as the control groups and were maintained on wheat pasture only from November 21, 1967, to March 14, 1968. Lots 2 and 4 were placed on wheat pasture with access at all times to a high concentrate ration during this same period of grazing. The groups were rotated on the four pasture areas to eliminate field differences. The concentrate feed consisted of:

Ground Milo	**77.00 %**
Molasses	**8.00 %**
Chopped Alfalfa Hay	**15.00 %**

Within each lot, one-half of the calves were selected at random to receive a 12 milligram stilbestrol implant at the beginning of the

Table 1. Treatment Design for Wheat Pasture Study

	Wheat Pasture Only		Wheat pasture + Energy Feed	
	Lot 1	Lot 3	Lot 2	Lot 4
12 mg. Stilbestrol	5	5	5	5
No Stilbestrol	5	5	5	5

test. Initial and final weights were taken after a 12 hour shrink without feed and water. Wheat pasture was in good supply during the entire grazing period; however, snow covered the pastures for a total of 11 days during the grazing period. Lots 1 and 3 received 21 bales each, while Lots 2 and 4 received 14 bales each of alfalfa hay during this time. Mid-term weights were taken at 58 days on test.

Results

The average response of calves to supplemental energy feed on wheat pasture are summarized in Table 2. Calves having access to a high-concentrate ration while on wheat gained .61 lbs. daily more than the heifers in the control lots. These higher gaining heifers consumed 10.7 lbs. of feed daily in addition to the wheat pasture. It is reasonable to believe that these calves consumed a limited amount of wheat pasture since they were nearing their maximum energy intake by the quantity of concentrate feed consumed. Differences in plant growth of the four lots could not be detected since stocking was at a rate to insure adequate pasture.

Feed conversion based on total concentrate feed consumed against total gains of these calves was a respectful 5.4 to 1. The realistic feed conversion, however, for that additional gain which was apparently obtained as a result of the concentrate feeding was a dismal 17.5 to 1.

Table 2. Response of Heifer Calves to High Energy Feed on Wheat Pasture

	Wheat Pasture Only	Wheat Pasture + High Energy Feed
No. of Heifers	20	20
Initial Wt. (11/21/67), lbs.	481	482
Final Wt. (3/14/68), lb.	637	708
Total Gain (114 da), lb.	156	226
Average Daily Gain, lb.	1.37	1.98
Feed Consumed per head		
Hay (during snow cover) lb.	135	90
Concentrate Feed, lb.		1216

Results associated with the stilbestrol implants gave very similar results to that work which was done in the preceding year. A marked advantage in average daily gains of .22 lb. per day was made by those calves on wheat pasture only when implanted with 12 milligrams of stilbestrol (Table 3). This advantage was closely related to the .24 lbs. per day advantage that was obtained in the preceding year. Results were likewise repeated in this trial whereby no response was obtained from stilbestrol implants on those calves that had access to a high concentrate feed.

The 12 milligrams may not be adequate for the higher energy intake of these calves.

Summary

Four lots of 10 weaner Hereford heifers each were utilized to measure response to high energy feeding on wheat pasture and to evaluate the response to stilbestrol implants. Access to high energy feed while grazing wheat pasture resulted in an increase of .61 lb. of gain daily over those calves on wheat pasture only; however, the added gain was much too low to offset the cost of high energy feed consumed. Stilbestrol implants of 12 mg. showed an increase daily gain of .22 lb. on calves consuming wheat pasture only; however, no response was made on the calves which had access to the high energy feed.

Table 3. Response of Heifer Calves to Stilbestrol Implants

	Wheat Pasture Only		Wheat Pasture + High Energy Feed	
	Control	*Implant*	*Control*	*Implant*
No. of Heifers	10	10	10	10
Initial Wt. (11/21/67) lb.	481	480	478	486
Final Wt. (3/14/68) lb.	625	649	705	711
Total Gain (114 da) lb.	144	169	227	225
Average Daily Gain, lb.	1.26	1.48	1.99	1.97
Daily Gain Advantage over Controls, lb.		+ .22		— .02

Milo vs. Wheat for Fattening Cattle*

Robert Totusek, Larry Franks, James R. Newsom and E. C. Nelson

Story in Brief

Wheat, milo, and a mixture of equal parts of wheat and milo were compared in a feeding trial. Net energy and ruminal volatile fatty acid values were also obtained. Differences in rate of gain, feed intake, and feed efficiency were small and not statistically significant. The type of grain had little apparent effect on carcass merit, but the feeding of milo resulted in more calculi in the bladder than did wheat. Differences in production of volatile fatty acids and net energy were small and non-significant. Correlations between the production of volatile fatty acids and feedlot performance are presented. The results of this trial indicate that the wheat and milo which were used were similar in energy value.

Introduction

The price of wheat has usually been too high to allow it to be used extensively as a livestock feed. However, there have been occasional periods in recent years when wheat has been available at a price to make it competitive with feed grains, and there are likely to be such periods in the future. Quantities of wheat unfit for human fod are also occasionally available for livestock feed. In these instances it is desirable to know the relative feeding value of wheat. Current information concerning the feeding value of wheat for finishing cattle is limited. Some reports have indicated best results when wheat does not comprise more than one-half to two-thirds of the ration. It is also generally recognized that milo is lower in feeding value than other feed grains, and many cattle feeders feel that milo is utilized more efficiently when mixed with one or more additional grains. The objective of this experiment was to compare (1) milo, (2) wheat, and (3) a mixture of equal parts of milo and wheat, for finishing steers.

Procedure

Twenty-seven steer calves with an average weight of approximately 500 lb. and an average age of 9 mo. were obtained from the Experiment Station herds. They were randomly allotted into 3 groups of 9 calves each. All of the calves received a basal ration composed of (percent): dehydrated alfalfa pellets, 35; cottonseed hulls, 23.0; cottonseed meal,

* The cooperation of Harris Packing Company, Oklahoma City, Oklahoma, in obtaining slaughter, carcass and specific gravity data is gratefully acknowledged.
Appreciation is extended to Farmland Industries, Kansas City, Missouri, for partial financial support of this research.

40.0; salt, 1.0; and dicalcium phosphate, 1.0. Vitamin A was added at a level of 2,000 I.U./lb. of basal, and chlortetracycline was added in necessary quantity to effect an intake of 75-100 mg. per steer daily. This basal ration was fed in sufficient quantity to meet the maintenance requirements of the calves, with daily allowances adjusted at 3 week intervals. Grains were fed to appetite, in addition to the basal. The grains were steam rolled.

The steers were individually fed twice daily in metal stalls approximatel 3 x 7 ft. in size. They were allowed to remain in the stalls about 90 min. at each feeding. The remainder of the time the steers were allowed to run together in 4 pens and had access to an open sided shed and an outside paved pen. Water was available in the outside pen but not in the individual stalls.

Samples of rumen fluid (25 ml.) were obtained by stomach tube and analyzed for volatile fatty acid content by gas chromotography.

Initial and final weights were taken after a 16-hr. shrink without feed and water. The feeding period was 180 da. long. At the conclusion of the feeding trial the steers were slaughtered at the Harris Packing Company, Oklahoma City, and carcass information was obtained after a 48-hr. chill. Specific gravities of the carcasses were obtained and used to estimate caloric content. Net energy values were calculated by comparing feed intake to energy gained and used for maintenance, by the method devised by Garrett and Lofgreen at the California Station.

Results and Discussion

Feedlot performance of the steers is shown inTable I. The rates of gain were smaller than those attained with group-fed cattle, but very acceptable for cattle fed individually in stalls. Steers fed milo gained slightly faster than those fed either wheat or a combination of milo and wheat, with little difference between the latter two rations. However, differences were not statistically significant. Steers receiving milo consumed the most feed, those receiving the milo-wheat combination consumed the least, with consumption of wheat intermediate between the two. Milo produced the most efficient gains, with wheat second, and milo-wheat third. Since differences in intake and feed conversion were very small and not statistically significant, little importance can be attached to them.

Slaughter and carcass data are presented in Table 2. All differences in dressing percent and carcass merit were small and non-significant and the results indicate that cattle fed wheat as all or part of the grain produced carcasses equal to those produced by cattle fed milo. The type

Table 1. Feedlot performance (180 days, 9 steers per treatment, individually fed)

	Ration		
	Milo	Wheat	½ Milo ½ Wheat
Initial wt., lb.	506	509	510
Final wt., lb.	914	889	882
Daily gain, lb.	2.25	2.07	2.05
Daily feed, lb.			
Milo	6.80		3.07
Wheat		6.46	3.08
Basal	8.11	7.91	7.81
Total	14.91	14.37	13.96
Feed/lb. gain, lb.			
Grain	3.02	3.05	3.00
Basal	3.63	3.91	4.08
Total	6.65	6.96	7.08

Table 2. Slaughter and carcass data

	Ration		
	Milo	Wheat	½ Milo ½ Wheat
Dressing %[1]	58.8	57.5	57.9
Fat thickness, in.[2]	.34	.29	.26
Ribeye area, sq. in.[3]	11.27	11.01	11.57
Cutability, %			
Carcass basis[4]	51.4	51.8	52.4
Live basis[5]	30.3	29.8	30.3
Carcass grade[6]	8.9	8.2	8.6
Urinary calculi[7]			
No. without calculi	3	8	4
No. with calculi	6	1	5
Av. wt. of calculi, gm.[8]	2.43[9]	.16[9]	.75

[1] Calculated on basis of shrunk Ft. Reno live weight and chilled carcass weight.
[2] Average of three measurements determined on tracings at the 12th rib.
[3] Determined by measurement of tracings of ribeye.
[4] Calculated as follows: percent of carcass as boneless trimmed retail cuts from the four major wholesale cuts = 51.34 (fat thickness) − .462 (percent kidney fat) + .740 (ribeye area) − .0093 (carcass weight).
[5] Trimmed retail cut yield as determined in footnote 4 multiplied by dressing percent.
[6] USDA carcass grade converted to following numerical designations: high prime — 15, average prime — 14, low prime — 13, high choice — 12, average choice — 11, low choice — 10, high good — 9, average good — 8, low good — 7.
[7] Based on contents of bladder at time of slaughter.
[8] Average of those which had measureable calculi.
[9] The milo ration produced significantly more calculi ($P < .05$) than the wheat ration.

of grain did influence the incidence of urinary calculi, with a higher incidence observed in the steers fed milo than in those fed wheat or a combination of the two grains. Many cattlemen believe that milo produces more calculi than other grains.

The results of this experiment, considered alone, would indicate that milo and wheat, or an equal mixture of the two, are similar in feeding value for fattening cattle. The tendency toward a lower rate of gain which was observed when wheat was included in the ration was also noted in experiments conducted at the Ft. Hays, Kansas Station (Bul. 487, Kansas Agricultural Experiment Station) when wheat replaced milo. However, in the Ft. Hays tests feed intake decreased more than rate of gain so that efficiency of conversion of grain to cattle gain was 15 percent better for wheat than milo. Furthermore, wheat had an especially high feeding value (24 percent greater than milo) when fed in combination with milo in the Ft. Hays trials.

An advantage of wheat over milo was demonstrated by the Ft. Hays trials in which the protein supplement was reduced when wheat replaced milo, with no decrease in cattle performance. Since the digestible protein of milo and wheat averages 7.0 and 10.7 percent respectively, each 1 lb. replacement of wheat for milo results in a net gain of .037 lb digestible protein. Supplemental protein can be reduced accordingly. The approximate digestible protein content of several protein feeds, and the amount each could be reduced in the daily ration is indicated below.

	Cottonseed meal	44% Soybean meal	50% Soybean meal	32% Supplement	20% Supplement	Alfalfa hay
% Digestible Protein	33	42	46	26	16	10
Reduction, lb. daily	.11	.09	.08	.14	.22	.37

For example, if 7 lb. milo in the daily ration were replaced by 7 lb. wheat, cottonseed meal could be reduced .77 lb. daily ($.11 \times 7 = .77$). The possible saving in supplemental protein cost in this way is obvious.

No significant differences were obtained in volatile fatty acids, as shown in Table 3. This is to be expected, since the grains did not differ significantly in feed efficiency. Correlations of volatile fatty acids with feed intake and feed efficiency are shown in Table 4. Significant negative correlations were obtained for feed intake and acetic-propionic ratio and for feed/lb. gain and total volatile fatty acid concentration. A significant positive correlation between feed intake and percent propionic acid was also obtained. A possible explanation is that as percent propionic acid increased and the acetic-propionic ratio therefore decreased, feed intake increased and feed required per lb. of gain decreased. Also, as total VFA concentration increased, feed/lb. of gain decreased. It should be pointed out that these correlations indicate only a relationship between two variables; they do not indicate cause and effect.

Table 3. Production of rumen volatile fatty acids[1-2]

	Ration		
	Milo	Wheat	½ Milo ½ Wheat
Acetic acid, %	52.9	51.9	54.3
Propionic acid, %	33.9	34.7	34.2
Butyric acid, %	13.2	13.4	11.4
Acetic-propionic ratio	1.57	1.53	1.80
Total volatile fatty acid conc., μm/liter[3]	85.0	79.7	90.7

[1] None of the differences due to treatment were significant ($P < .05$).
[2] Rumen samples from steers, obtained by tubing, were analyzed by gas chromotography.
[3] Micro moles per liter.

Table 4. Correlations of volatile fatty acids with feedlot performance[1]

	Propionic acid, %	Acetic-propionic ratio	Total VFA conc, μ/m l
Av. daily feed intake, lb.	0.54[2]	—.62[2]	0.10
Feed/lb. gain, lb.	— .34	0.41	— .56[2]

[1] All correlations were adjusted for treatment effects.
[2] Significantly different from zero ($P < .05$).

Net energy values of the total ration for maintenance and production, and of the grain for maintenance, production and maintenance plus production are shown in Table 5. The NEp of the milo-wheat combination was slightly lower than either the milo or the wheat. However, the differences were not statistically significant, and probably were the result of animal variation and not due to real differences in net energy of the grains.

Table 5. Net energy values of milo and wheat[1-2]

	Ration		
	Milo	Wheat	½ Milo ½ Wheat
		Megcal./100 lb.	
NEm+p of total ration[3]	57.6	58.2	57.4
NEm+p of grain[4]	64.5	67.0	65.7
NEm of grain[5]	69.3	67.8	63.4
NEp of grain[6]	46.2	45.2	42.0

[1] Net energy values were determined by the comparative slaughter technique developed at the California Station.
[2] None of the differences due to treatment were significant ($P < .05$).
[3] Net energy of total ration for maintenance and production.
[4] Net energy of grain for maintenance and production.
[5] Net energy of grain for maintenance, determied by multiplying NEp value by 1.5.
[6] Net energy of grain for production.

Results of this trial and other research indicate that results with wheat may be variable, but that acceptable feedlot performance and carcass merit can be obtained with wheat in the finishing ration. For consistently best results, wheat should not replace over one-half of the milo. The higher protein content of wheat should be recognized and the supplemental protein reduced accordingly.

The Value of Vitamin E Injections for Feedlot Calves*

Robert Totusek, James E. Tanner, Robert Renbarger Larry G. Franks and Norris B. Whitfield

Story in Brief

Vitamin E injections were given to one-half of a group of steers, heifers and bulls during a 168-day feeding trial. A total of 1500 I.U. was administered on the 28th day and again on the 84th day. The vitamin E was without apparent affect on rate of gain and carcass traits. It was concluded on this basis that the ration fed was adequate in Vitamin E.

Introduction

Several research reports from other states have indicated a possible deficiency of vitamin E in some cattle finishing rations, and occasional reports from the field have suggested a benefit from the administration of supplemental vitamin E to feedlot cattle. The objective of this experiment was to determine the value of vitamin E injected into calves being finished in drylot.

Procedure

A total of 138 Angus calves, including 44 steers, 48 heifers, and 46 bulls, was available for this experiment. The calves were dropped primarily in February and March and placed in the feedlot immediately

*The cooperation of Hoffman-Roche, Inc., Roche Chemical Division, Nutley, New Jersey, in providing the vitamin E used in this study is gratefully acknowledged.

Thanks are also extended to Dr. J. V Whiteman for the use of the experimental cattle, and to personnel at the Ft. Reno Experiment Station for caring for the cattle.

The cooperation of the Maurer-Nauer Packing Company, Arkansas City, Kansas, is obtaining slaughter and carcass data was very much appreciated.

after weaning at an average age of seven months. The calves were sired by eight bulls, and all eight sires were represented within each sex group. The progeny of each sire within each sex group was randomly allotted to one of two treatments, vitamin E or no vitamin E, so that equal numbers of each treatment were represented within each sire-sex group. The calves were fed together by sex group; that is, all steers were fed together, all heifers were fed together, and all bulls were fed together. Consequently, it was not possible to obtain data on feed efficiency.

The feeding period was 168 days long. At 28 days, those calves designated to receive vitamin E were injected as they passed through the chute to be weighed. A second injection was given 56 days later, 84 days after the beginning of the feeding period. The vitamin E product used contained 100 I.U. of dl-alpha-tocopheryl per c.c. A total of 15 c.c., containing a total of 1500 I.U. of vitamin E, was administered at each injection.

Injections were intramuscular and in each case were made at two different sites in the rump. The ration consisted of (percent): ground shelled corn, 27.0; chopped alfalfa hay, 12.5; cottonseed hulls, 25.0; whole oats, 10.0; wheat bran, 10.0; cottonseed meal, 10.0; molasses, 5.0; and salt 0.5 Chlortetracycline was fed at a level of 5 mg. per lb. of ration. Feed was available at all times in self feeders. The cattle were housed in open sheds, with free access to outside pens paved with concrete. Water was available at all times.

Results and Discussion

The rate of gain of the three sex groups, with and without injected vitamin E, by accumulative period following each of the two injections, is presented in Table 1. A summary of all sex groups, and for the total 140-day period following the first injection, is also given in Table 1.

A trend in rate of gain due to treatment is not apparent. Differences in rate of gain following either the first or second injection were not consistent among sex groups. Differences in gain within sex groups, and for the average of all sex groups, for the entire 140 day period, seemed to be largely a reflection of genetic potential for rate of gain as indicated by gains made during the 28 day preinjection period.

Average values obtained for various slaughter and carcass traits are shown in Table 2. All differences between treatments were very small, indicating that injected vitamin E did not affect carcass merit.

The results of this trial indicate that the ration which was fed was adequate in vitamin E, because there was no obvious benefit from in-

Table 1. Rate of Gain of Feedlot Calves as Affected by Vitamin E Injections

Sex	Vit. E	No. Calves	Initial Wt., lb.	Average Daily Gain, lb.: Pretest 28 Days	After 1st Injection[1]: 28 Days	After 1st Injection[1]: 56 Days	After 2nd Injection[2]: 28 Days	After 2nd Injection[2]: 56 Days	After 2nd Injection[2]: 84 Days	140 Days
Steers	No	22	480	2.91	3.67	2.76	2.55	2.62	2.30	2.56
	Yes	20[3]	476	2.64	3.75	2.62	2.62	2.56	2.25	2.44
Heifers	No	24	456	2.20	2.63	2.37	2.32	2.22	2.05	2.22
	Yes	24	469	1.98	2.77	2.38	2.07	2.06	1.94	2.09
Bulls	No	23	494	2.88	3.48	3.74	1.94	2.16	2.35	2.90
	Yes	23	488	2.88	3.38	3.58	2.36	2.27	2.44	2.89
Total	No	69	477	2.66	3.26	2.96	2.27	2.33	2.23	2.56
	Yes	67	478	2.50	3.30	2.86	2.35	2.30	2.21	2.47

[1] The first injection consisted of 1500 I.U. of dl-alpha-tocopheryl given 28 days after the beginning of the feeding trial.
[2] The second injection consisted of 1500 I.U. of dl-alpha-tocopheryl given 84 days after the beginning of the feeding trial.
[3] Two calves were removed from test early in the trial and were not included in the data.

Table 2. Carcass Traits as Affected by Vitamin E Injections

	Vit. E	Dress.[1] Percent	REA Sq. in.	Percent[3] Round	Fat[4] .in	Kid. Fat[5] Percent	Marb.[6] Score	Grade[7]	Mat.[8] Score	Cutability[9]
Steers	No	64.1	11.0	20.5	.80	2.7	5.4	10.3	16.7	49.2
	Yes	64.0	10.9	20.1	.82	2.8	5.6	10.3	16.6	49.2
Heifers	No	63.9	10.5	19.8	.79	3.3	6.2	10.9	17.2	48.6
	Yes	63.8	10.6	19.6	.74	3.1	6.2	11.0	17.2	49.3
Bulls	No	62.8	12.4	21.1	.63	1.5	3.7	8.6	17.8	52.0
	Yes	61.4	12.1	21.1	.64	1.7	4.3	9.0	17.8	51.6
Total	No	63.6	11.3	20.4	.74	2.5	5.1	9.9	17.2	49.9
	Yes	63.1	11.2	20.3	.73	2.5	5.4	10.4	17.2	50.0

[1] Based on shrunk Ft. Reno live weight and chilled carcass weight.
[2] Ribeye area measured on tracings of the ribeye.
[3] Based on trimmed round and chilled carcass weight.
[4] Average of three measurements on tracings at the twelfth rib.
[5] Estimated by visual observation.
[6] Based on 2=practically devoid, 3=trace, 4=slight, 5=small, 6=modest, 7=moderate, 8=slightly abundant, 9=moderately abundant.
[7] U.S.D.A. grade with high prime=15, high choice=12, high good=9.
[8] Based on A=17, B=14, C=11.
[9] Estimated percent of carcass as boneless trimmed retail cuts.

jecting cattle with vitamin E at two times during the feeding trial. It is possible that vitamin E could exert a beneficial influence on feed efficiency, which could not be measured in this trial. It is also possible that in other situations with different feedstuffs, supplemental vitamin E might be of some value if the ration is deficient in vitamin E. Deficiencies of vitamin E in feedlot cattle do not appear to be widespread, however.

Early Weaning vs. Normal Weaning vs. Creep Feeding of Heifer Calves

Robert Totusek

Story in Brief

Angus and Hereford heifer calves were subjected to (1) low, (2) medium, and (3) high planes of nutrition previous to weaning by (1) weaning at 140 days, (2) weaning at 240 days, and (3) creep feeding and weaning at 240 days, resulting in over 100 lb. spread in weight at 240 days of age. Compared to normal weaning, early weaning has resulted in a slight decrease in weight to 4 years of age, no permanent affect on appearance and skeletal size, and an increase in productivity based on the weaning weight of calves produced, while creep feeding has resulted in no permanent advantage in body size and no advantage in productivity.

Introduction

Since feeder calves represent an important source of agricultural income in Oklahoma, the development of the beef female for maximum productivity (milk production) and reproductive performance is of obvious importance. Milk production and reproductive performance can be markedly influenced by both undernutrition and overnutrition during the postweaning period of development. The harmful effects of severe undernutrition during the growth period on milk production of the beef female have been recognized for many years. More recently the possible detrimental influence of a high plane of nutrition during the postwean-

The assistance of Norris Whitefield in collecting and summarizing data, and of Jim Newsem, Larry Franks, Vincent Neuhaus, George Hall and Curtis Absher in collecting data, and Herb Sneed in caring for the cattle is gratefully acknowledged.

ing developmental period on the ultimate milk producing ability of both beef and dairy cows has been reported. Similarly, it has been shown that a low plane of nutrition results in inferior reproductive performance, and that a high plane of nutrition may also result in suboptimum reproduction. Much of the research with beef cattle has been conducted at this station and reported in Feeder's Day Reports during the past 18 years.

Observations at this station have indicated a tendency for heifers with the lowest preweaning gains to develop into the best milk producers, and for heavy milking cows to produce heifer calves with lowered milk producing ability. These limited observations suggested that preweaning plane of nutrition does influence the subsequent performance of beef females. Since no controlled research on this problem had been reported, an experiment was initiated to determine the influence of preweaning plane of nutrition of heifer calves on (1) body development, (2) milk production, and (3) reproductive performance.

Procedure

The experiment is being conducted under range conditions at the Lake Carl Blackwell Range near Stillwater, and includes both Angus and Herefords. Within each breed, three preweaning planes of nutrition were imposed on heifer calves. A low plane was accomplished by weaning heifers at 140 days of age, then maintaining a gain of approximately .75 lb. per day to an age of 240 days with a ration of either alfalfa hay or prairie hay plus a protein supplement. A medium plane was obtained by weaning the heifers at 240 days. A high plane was induced by creep feeding during the suckling period and weaning at 240 days of age.

All heifers within each breed produced in the same year were kept together after the age of 240 days. They were wintered in a trap, on alfalfa hay or prairie hay and protein supplement, at a moderate level of nutrition. After reaching 1 year of age, the heifers were allowed to graze native pasture, supplemented with protein concentrate or alfalfa hay during the winter. All heifers of the same breed born the same year were bred to the same bull, and were bred to calve first at 2 years of age.

Results and Discussion

Although numbers are still limited, and insuffiicent to allow definite conclusions relative to many questions, some trends have become apparent and the preliminary data are being reported.

Figure 1 illustrates weight changes to 4 years of age as influenced by preweaning plane of nutrition. At 240 days of age normal weaned and

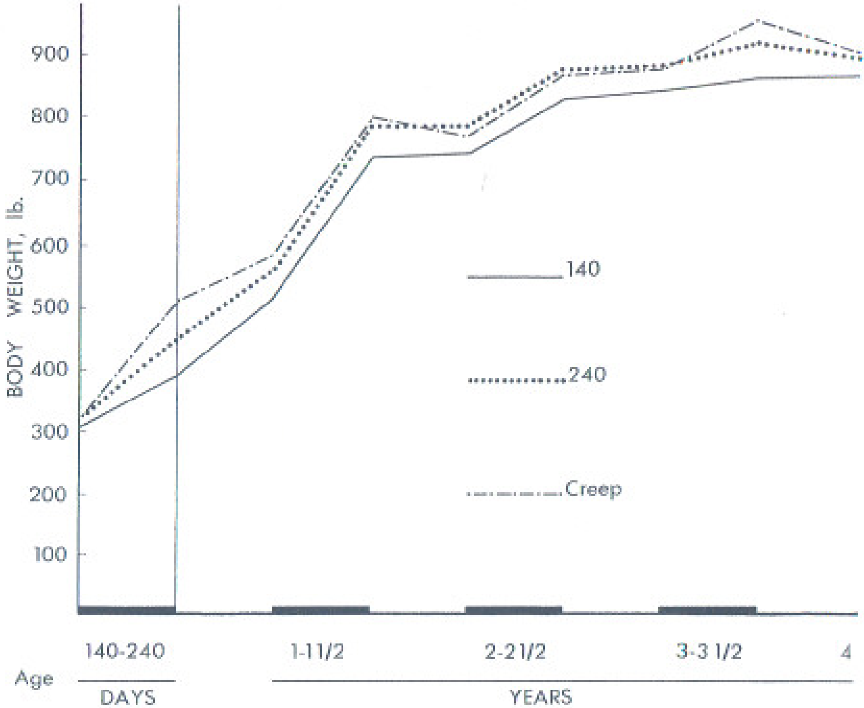

Figure 1. Body weight is influenced by three pre-weaning planes of nutrition.

creep fed heifers weighed 51 and 117 lb. more than early weaned heifers. The early weaned heifers have remained slightly lighter in weight (about 40 lb.) to 4 years of age than the other heifers. Perhaps this difference in size as measured by weight will be permanent. However, creep fed heifers have not maintained their advantage in weight over the normal weaned heifers, indicating that their weight advantage at 240 days was largely fat rather than skeletal and muscle tissue.

The actual appearance of the heifers is rather accurately reflected by condition score, shown in Figure 2. There was a great difference in appearance at 240 days of age. The early weaned heifers were thin and appeared rather frail. The creep fed heifers were big and thick and bloomy, and suggested potential for developing into large productive cows. The normal weaned heifers were intermediate in appearance. Differences in appearance were less apparent at 1 and 1½ years of age, and after the age of 2 years it has been difficult to identify the heifers ac-

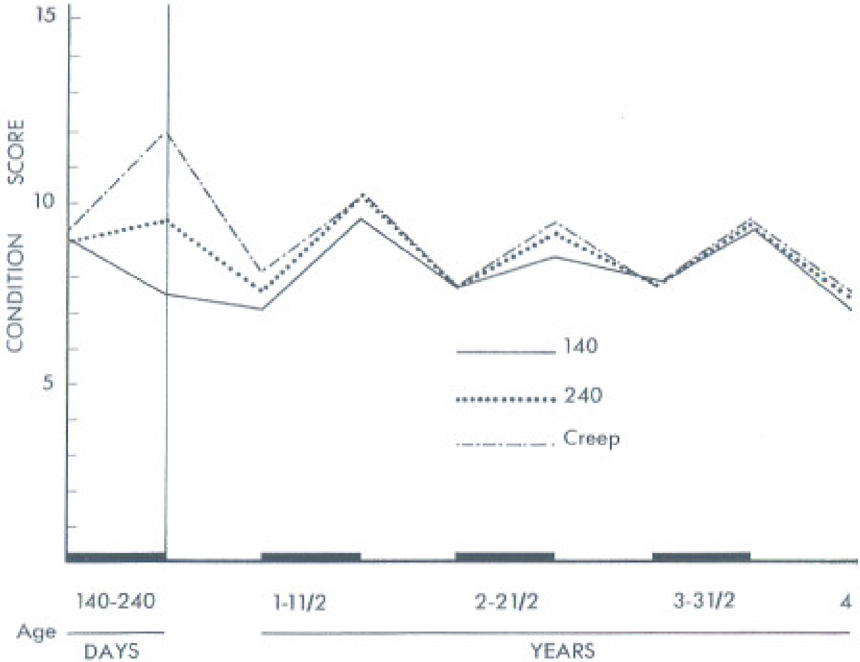

Figure 2. Body condition score as influenced by three pre-weaning planes of nutrition.

cording to preweaning treatment, even when they are sorted into their treatment groups.

Changes in skeletal size as indicated by height at withers are illustrated in Figure 3. Skeletal size was affected less by preweaning plane of nutrition than was weight. Differences in wither height between early weaned and creep fed heifers did approach 2 in. at 240 days of age, but these differences disappeared by 2 years of age.

Cow productivity as affected by preweaning plane of nutrition is summarized in Table 1. About one-half of the data is for first-calf cows, one-third for second-calf cows, and only one-sixth for third-calf cows.

There was little difference in calving date, indicating that conception date was not greatly affected by preweaning plane of nutrition. There was also very little difference in birth weight of calves due to preweaning treatment of the cows. Conception rate, as indicated by per-

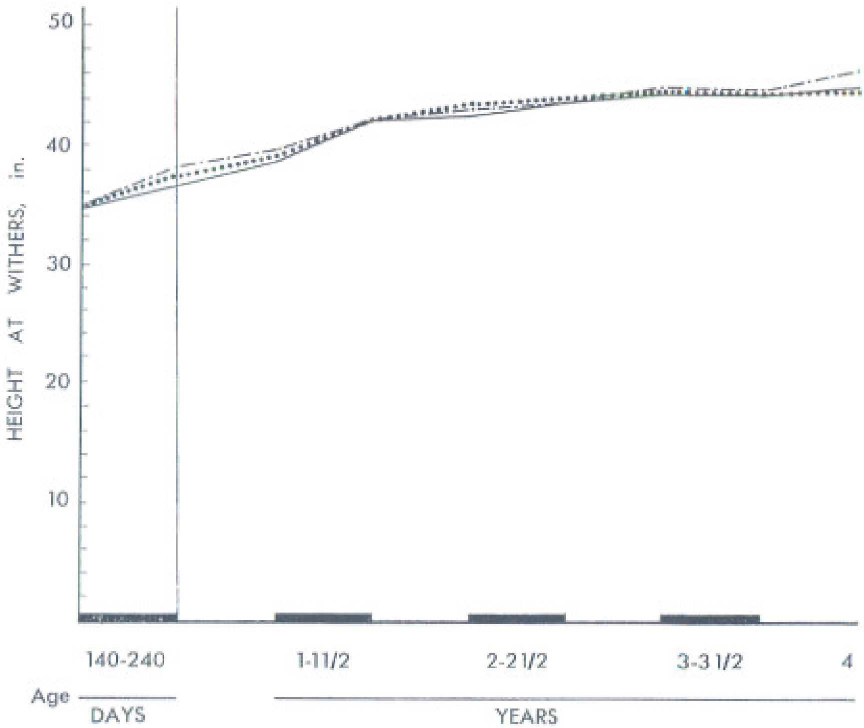

Figure 3. Height at withers is influenced by three pre-weaning planes of nutrition.

centage of cow calving, has tended to be higher for the cows which were creep fed as heifers, although this advantage has decreased by weaning time due to slightly greater losses at and following calving. More data is definitely needed to justify conclusive statements in this regard.

Early weaned heifers have produced heavier calves than either of the other two groups. Creep fed heifers have produced calves only very slightly lighter than normal weaned heifers. The advantage in weaning weight of calves produced by the early weaned heifers has averaged 15 to 20 lb. over the normal weaned heifers, and 19 to 24 lb. over the creep fed heifers.

The preliminary data presented here suggest that a high plane of nutrition of heifers previous to weaning has little permanent advantage in terms of body size and productivity, while a low plane of nutrition has a slight depressing affect on body size but improves productivity in terms of weaning weight of calves produced.

Table 1. Effect of Preweaning Plane of Nutrition on Cow Productivity

	Preweaning Treatment of Cows		
	Weaned at 140 days	Weaned at 240 days	Creep fed, weaned at 240 days
1965 and 1966 Calves			
No. cows bred	48	49	45
Calving date	4-4	3-31	4-8
Birth wt., lb.	65	65	63
% calved	77	79	84
% weaned	71	72	75
210-day wt., lb.	402	387	383
1967 Calves			
No. cows bred	49	46	50
Calving date	3-31	3-28	3-30
Birth wt., lb.	68	69	70
% Calved	90	85	90
% Weaned	78	74	76
210-day wt., lb.	430	410	406

Performance of Beef Calves During a Three Week Pre-weaned Period

S. A. Ewing, Kern Hendrix, and Bob Renbarger

Story in Brief

Two hundred weaner beef calves were used to observe weight change patterns during a three-week period after weaning. Steer and heifer calves consuming limited amounts of supplemental feed while being weaned on pasture averaged 30 and 13 pounds of gain, respectively, during 21 days after weaning. The possibility of important sex differences in gain immediately after weaning is suggested.

Introduction

Much interest in pre-weaning of feeder calves before they are shipped to the feedlot has occurred during the past two years. It appeared desirable to establish the weight change pattern of calves after weaning when maintained on the farm or ranch for periods up to 3 weeks prior to shipment. This test was conducted in the fall of 1967 at the Ft. Reno Research Station.

Procedure

Two hundred, spring-dropped, commercial beef calves were selected as experimental animals for this test. The group consisted of 115 steer calves and 85 heifer calves from research herds maintained at the Ft. Reno Station. The calves were weaned at an average age of approximately 7 months.

Steers and heifers were maintained in separate Bluestem grass pastures after weaning on October 3, 1967. All calves were weighed individually at weaning and at 7-day intervals thereafter to measure weight changes occurring during a typical 3 week weaning period. All weights were non-shrunk weights following a one-quarter mile drive. The calves had been previously vaccinated (at about 3 months of age) for blackleg and no immunizations were given as a pre-weaning or pre-conditioning treatment since the test was designed to observe typical weight changes during a post-weaning period of the duration mentioned.

Supplemental feed was provided as follows: Free choice access to alfalfa hay for 6 days. From this point hay was eliminated and the calves were started on 1 pound of a 50:50 mixture of ground milo and crimped coats and remained near this level of grain intake for the balance of the period.

Results and Discussion

The results concerning calf performance, conformation grade and condition scores are summarized in Table 1.

The average increases in weight during the 21 day period were 30 and 13 pounds respectively for steers and heifers. Since the steers and heifers were maintained in different pastures, the difference in weight gain between the two groups should not be considered entirely due to sex differences. The question is raised, however, as to the relative aggressiveness of calves of different sex following weaning.

The small difference observed in grade and condition scores suggest that these characteristics remained basically unchanged during the period.

Hay consumption during the first week averaged about five pounds daily. Grain consumption during the last two weeks averaged about one pound daily. The low rate of supplemental feed consumption suggests the calves were on good pasture, which was the case. It is likely that the calves would have approached the gains observed without supplemental feed.

Table 1. Changes in Weight, Grade and Condition of Beef Calves During A Three Week Period Following Weaning

No. of Calves[1]	Steers 115	Heifers 85	Avg.
Calf Performance, lbs.:			
Weaning weight (10-3-67)[2]	469	459	464
Weight 21 days post-weaning[2]	499	472	485
Total Gain (21 days)	30	13	21
Daily Gain (21 days)	1.43	.62	1.00
Conformation Grade:[3]			
At weaning	14.5	14.2	14.3
21 days post weaning	14.7	14.2	14.4
Condition Scores:[4]			
At weaning	10.9	11.4	11.2
21 days post weaning	11.6	11.3	11.4
Feed Consumption per calf (21 days) lbs.:			
Ground Milo	8.9	8.9	8.5
Crimped Oats	7.4	7.5	7.4
Alfalfa Hay	35.8	33.3	34.5

[1] All calves were dropped in late winter and early spring of 1967.
[2] All weights are non-shrunk weights after approximately one-quarter mile drive.
[3] Scores based on following scale: Average prime=16, average choice=13, average good=10
[4] Scores based on visual appraisal with 11 representing calves that would grade average choice and 10 low choice as slaughter calves.

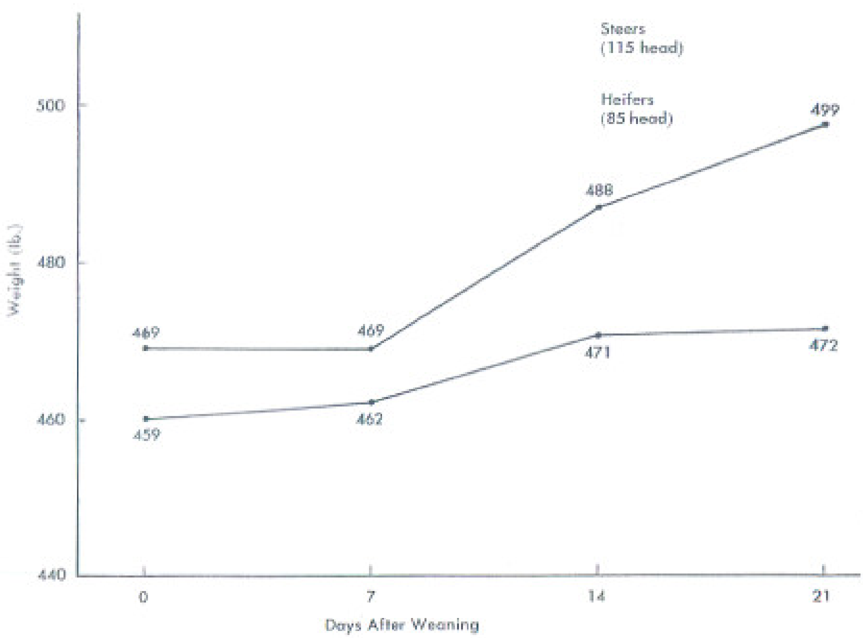

Figure 1. Weight change pattern of beef calves during a 3 week pre-weaning period.

The weight changes of steer and heifer calves are shown graphically in Figue 1. It is apparent that essentially no gain was made the first week. Both sexes exhibited the greatest weight gain the second week. During the third week the heifers made essentially no gain while steers exhibited a rate of gain of about 50 percent of that observed during the previous week. These data suggest that one week may not be sufficient to recover or exceed weaning weight. Therefore, at the end of two or three weeks weights could be comparable to those at weaning.

There are numerous factors that should be studied in conjunction with pre-weaning and pre-conditioning of beef calves (i.e. vaccinations & parasite control). Therefore, a total program must be designed to properly pre-condition calves.

Seasonal Variation in the Composition and Digestibility of Midland Bermudagrass

J. E. McCroskey, N. E. Brackett and Robert Renbarger

Story in Brief

The seasonal variation in *in vitro* dry matter digestibility and certain chemical constituents are presented for samples of Midland bermudagrass taken at the Fort Reno Experiment Station during the years 1966 and 1967. Chemical analyses determined were crude protein, neutral detergent solubles, neutral detergent fiber, acid detergent fiber and acid detergent lignin. Also, samples were analyzed for percent calcium, phosphorus, magnesium and potassium.

The data indicate a positive relationship between neutral detergent solubles (cell contents), crude protein and *in vitro* dry matter digestibility. There is a negative relationship between dry matter digestibility and all three fiber fractions. It appears that Midland bermudagrass is a high quality forage for only about the first sixty days of the growing season.

Introduction

Bermudagrass continues to play an ever increasing role as a forage for beef cattle in Oklahoma. Its rapid and widepread acceptance across the state has resulted from its ability to produce a large amount of forage and withstand heavy grazing pressures. Much is known about the fertilization requirements and expected dry matter yield but the data are rather limited on its composition and nutritive qualities.

This report presents an average of two years' data on the composition and *in vitro* dry matter digestibility of Midland bermudagrass samples collected monthly at the Ft. Reno Experiment Station during the years 1966 and 1967 as a part of Project S1220. In 1966, two-hundred pounds of nitrogen was applied per acre in three equal applications during the spring and summer months. In 1967, one-hundred fifty pounds of nitrogen and 50 pounds each of phosphorus and potassium were applied per acre. The phosphorus and potassium were applied in one aplication in the spring whereas nitrogen was divided into three equal applications.

Procedure

Shown in Table 1 are some chemical constituents of the forage and values for *in vitro* digestibility of dry matter by months. The values for neutral detergent solubles (NDS), neutral detergent fiber (NDF), acid detergent fiber (ADF) and lignin were determined according to the procedures developed by Van Soest (1963 and 1967) for evaluating forages. Using these techniques the forage is divided first into cell contents (NDS) and cell-wall constituents (NDF). The NDS fraction represents

Table 1. Seasonal Variation in Chemical Composition and in Vitro Dry Matter Digestibility of Midland Bermudagrass (2 Yr. Average)

Month	Crude Protein	N.D.S. (cell contents)	N.D.F. (cell walls)	A.D.F.	Lignin	In Vitro D.M. Digest.
	% of Dry Matter					
January	5.6	21.4	78.6	45.5	6.1	37.5
February	6.6	23.7	76.3	44.1	6.1	39.6
April	24.2	50.3	49.7	23.1	2.8	70.2
May	20.6	33.6	66.4	31.0	3.8	67.3
June	16.9	30.0	70.0	34.2	4.3	59.9
July	13.2	27.7	72.3	34.4	5.1	58.1
August	13.4	22.6	77.4	37.1	5.0	54.8
September	13.8	25.4	74.6	35.2	4.8	57.8
October	12.1	23.3	76.7	35.0	5.2	52.7
November	8.2	25.8	74.2	37.4	5.3	45.1
December	7.1	22.2	77.8	40.9	6.0	44.1

the easily digested and more soluble parts of the forage (starch, sugars, protein, fat etc.), whereas NDF contains the less digestible, high fiber, cell-wall constituents (cellulose, hemicellulose, lignin etc.). The ADF fraction includes primarily cellulose and lignin. From the ADF fraction lignin is determined by treating with sulfuric acid. Dry matter digestibility was determined in the artificial rumen according to the method of Tilley and Terry (1963). Samples were digested for 48 hours in the artificial rumen then subjected to pepsin digestion for an additional 48 hours.

Results and Discussion

Most forage researchers consider these chemical determinations and this *in vitro* technique to be among the best laboratory techniques available for evaluating forages. Animal gain data are not available for these forage samples but most forage researchers agree that *in vitro* digestibility values are rather closely correlated with animal response. Therefore, some of the analyses values are compared with *in vitro* dry matter digestibility values in Figures 1 through 4.

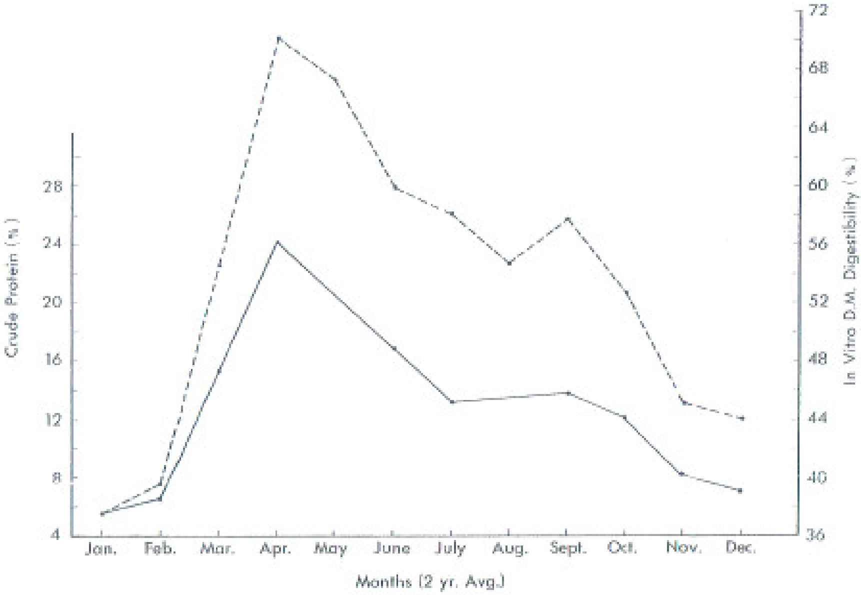

Figure 1. In vitro D.M. digestibility vs. crude protein.

Figures 1 and 2 show a positive relationship of crude protein and cell contents (NDS) to dry matter digestibility. Note the high values for all three in the early growing months of April, May and June. Dry matter digestibility, NDS and crude protein all decline rapidly from April to July. A rather high positive relationship between cell contents and dry matter digestibility should be expected since cell contents consist of materials which are almost completely digested. Cell-wall constituents, on the other hand, are rather low in digestibility.

Figures 3 and 4 show a negative relationship between dry matter digestibility and ADF and lignin. This is reasonable since fiber material is relatively low in digestibility and lignin is considered completely undigestible. Although the range in lignin content throughout the year is not great in terms of percent of dry matter, its effect upon digestibility is quite marked (Figure 4).

Table 2 and Figure 5 show the percentages of some of the minerals in bermudagrass. It is interesting to note that the curve for potassium (Figure 5) is similar in shape to that of *in vitro* dry matter digestibility (Figure 1). If we compare mineral content of the grass with requirements of different classes of cattle we find that it is adequate in the minerals shown for all classes of cattle during the

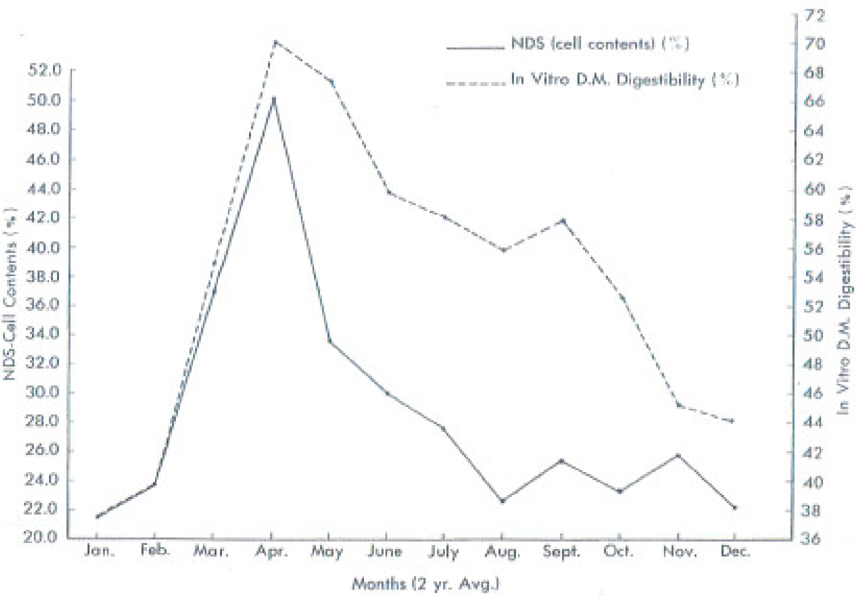

Figure 2. In vitro D.M. digestibility vs. NDS (cell contents).

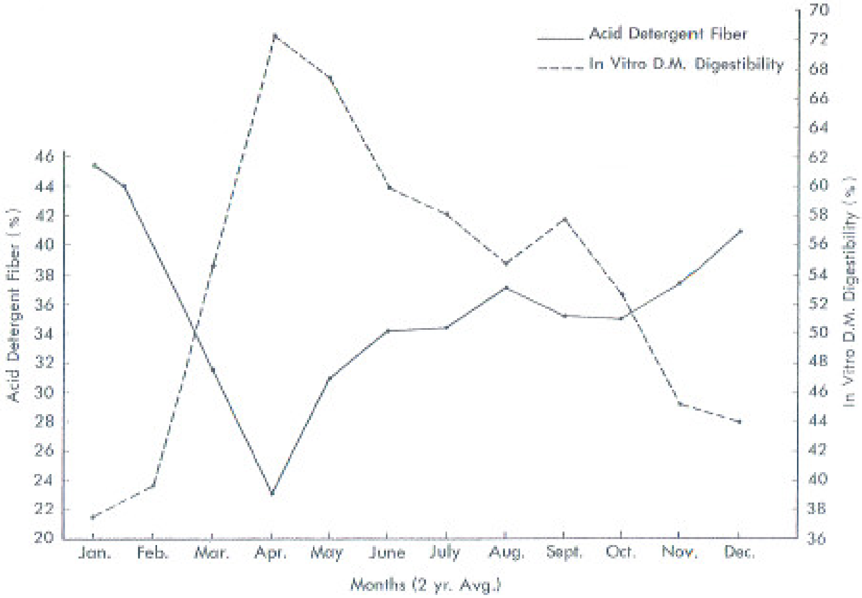

Figure 3. In vitro D.M. digestibility vs. acid detergent fiber.

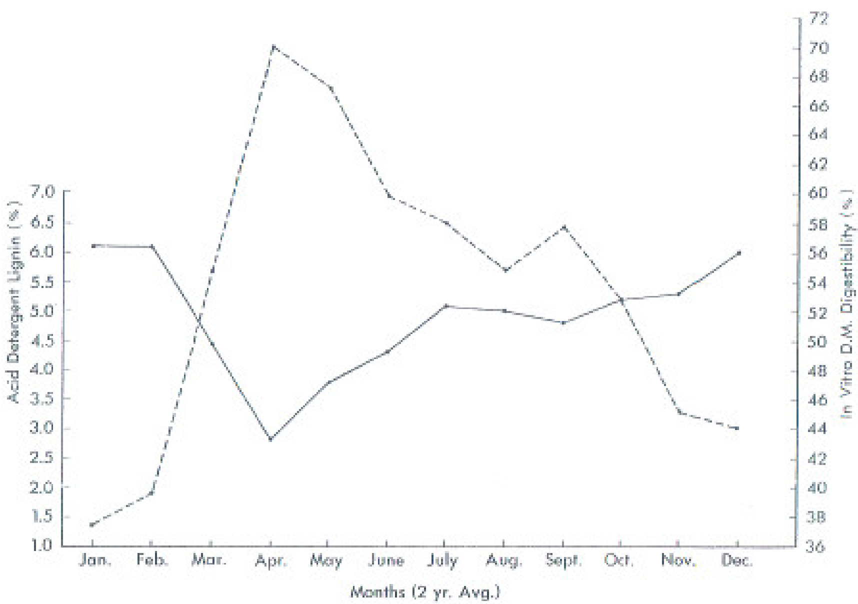

Figure 4. In vitro D.M. digestibility vs. acid detergent lignin.

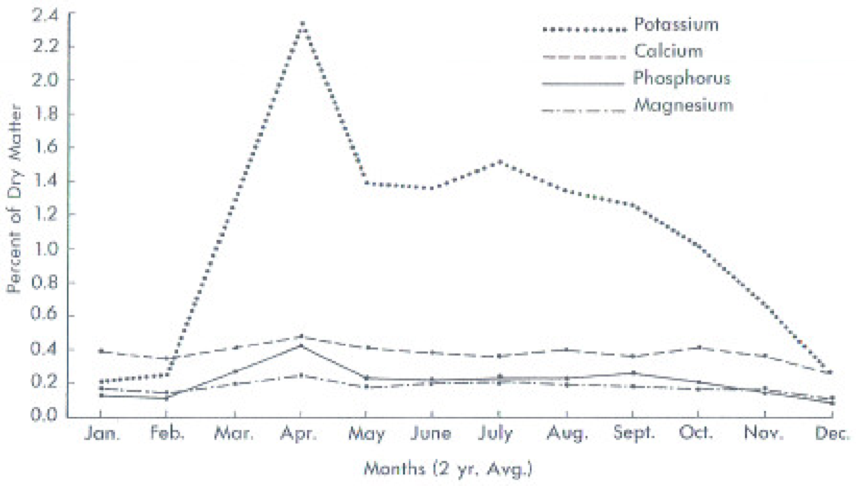

Figure 5. Seasonal variation in content of certain minerals.

Table 2. Seasonal Variation in Mineral Content of Midland Bermudagrass (2 Yr. Average)

Month	Calcium	Phosphorus	Magnesium	Potassium
	% of Dry Matter			
January	.39	.12	.17	.20
February	.35	.11	.14	.25
April	.48	.42	.25	2.34
May	.41	.23	.18	1.39
June	.38	.22	.20	1.36
July	.36	.23	.21	1.52
August	.40	.23	.19	1.35
September	.36	.26	.18	1.26
October	.41	.21	.17	1.02
November	.36	.14	.15	.69
December	.27	.09	.11	.25

growing season (April to October). During the winter months bermudagrass is definitely deficient in phosphorus and possibly some trace elements not shown.

When we consider the chemical composition and *in vitro* dry matter digestibility of Midland bermudagrass throughout the year we see that it is high in digestibility and low in fiber only during the spring and early summer months. Some forage specialists state that in order for a forage to be classed as "high quality forage" it must have a dry matter digestibility of 65 percent or more. Thus, if this be true, bermudagrass is high in quality for only about 60 days of the year. This may explain the reason why young, growing cattle gain well during April, May and June but gain poorly during the remainder of the growing season. Furthermore, research has shown that forage intake increases as digestibility increases up to about 60 percent dry matter digestibility. Since digestibility of bermudagrass is below 60 percent except for April, May and June it is likely that cattle do not consume enough forage at other times to promote rapid gains.

Factors Influencing Muscle Fiber Variation

R. L. Henrickson and W. A. Gillis

Story in Brief

Skeletal muscle fibers vary greatly in size with respect to class of animal, muscle, and within muscle. These variations have been shown to be affected by specie, size, breed, sex, age, and level of nutrition. Postmortem influences on muscle fiber size, sarcomere length, percent kinky fibers and shear force have been shown to be influenced by rigor mortis, temperature, and muscle tension.

This investigation was designed to study the effect of four levels of muscle tension on the shear force of the semitendinosus and semimembranosus muscles. Levels of tension used were 0, 1000, 2500, 5000 gm.

Fiber size varied inversely with sarcomere length. No significant relationships were noted for fiber size and the percentage of kinky fibers.

Introduction

Skeletal muscle makes up approximately 40 percent of the live body weight of which approximately 75 percent is muscle fibers. Any variation as to quality and quantity of the muscle components can ultimately affect tenderness. The structure of muscle is a function of the relative amounts and kinds of the various component tissues. Therefore a thorough appreciation of the important tissues comprising muscle must be realized before any consideration of fiber variation can be made.

With the advent of technological advancements in electron and light microscopy and new methods of tissue preparation the structure of the skeletal muscle fiber has drawn considerable interest. A brief review of the literature relative to striated muscle fiber will be given before considering variations.

Walls (1960) described the muscle fiber as a cylindrical, elongated, multinucleated syncytium that generally does not branch, however Bardeen (1903) has shown that variations of this description do exist. The muscle fiber is surrounded by a connective tissue sheath that is very similar to the plasma membrane and internal membranes of other cells and is referred to as the sarcolemma. The sarcolemma is not a perfectly smooth cylindrical membrane, but is marked by several small vesicles and carveolae (Porter and Palade, 1957). Beneath the sarcolemma there exists a fluid matrix referred to as the sarcoplasm, which is made of various soluble proteins such as myogen and myoglobin (color pigment). The sarcoplasm serves a function similar to that of typical cellular cytoplasm and contains the various cellular inclusions and organelles. An organelle, the myofibril, has received considerable attention due to its contractile properties. The myofibril is an elongated striated structure comprised of two different types of filaments. The coarse filament is approximately 100 angstroms in diameter and 1.5 microns in length. The fine filament is approximately 50 angstroms in diameter and 2 microns in length (Huxley and Hanson, 1957). The thick filament, comprised of the protein myosin, is called the A band. The thin filament is comprised of the protein actin and makes up what is referred to as the I band. Between adjoining I bands there is another band referred to as the Z disc. The distance from one Z disc to another comprises the contractile unit of the myofibril, the sarcomere.

Inherent Variation

Walls (1960) reported that there is considerable variation in fiber diameter, with a range of 10 to 100 microns commonly being accepted. Fiber size differs in the major animal classes with fish having the largest fibers and birds the smallest (Mayeda, 1890). The fibers of one muscle may be generally larger than those of another muscle in the same animal (Hommond and Appleton, 1932). In addition, the fiber diameters vary considerably within the same muscle. Other factors such as specie, size, age, breed, sex, and level of nutrition also have been found to influence this variation.

Joubert (1956a) reported that muscle diameter had no clear relationship to size of species, however, an increase in fiber diameter was closely associated with relative increase in body weight.

Using cattle, Joubert (1956a) studied the effect of breed on fiber diameter. He found that one breed of cattle, British Friesian, whether crossbred or purebred had significantly larger fiber diameters than another breed, Dairy Shorthorn. This breed significance was not shown to be independent of body weight. Other workers, Adametz (1888), Hammond and Appleton (1932), Strateciuc (1933), Mehner (1938) and Glebina (1952), have supported the findings that interbreed differences do exist, however, in most cases the difference is proportional to differences in body size.

A review of early reports caused Joubert (1956a) to conclude that males generally have thicker fibers than females. However, taking size into consideration he found that there was a slight tendency for females to have thicker fibers than males. Adametz (1888) reported that muscle fibers of bulls were appreciably larger than of cows, but that only slight differences existed between bulls and steers. Other workers, Hammond and Appleton (1932) using sheep, Mehner (1938) with fowl, and Ishihara *et al.* (953) in Japanese Black cattle, confirmed these results.

Contradictory evidence has been presented by Brady (1937), and Satorius and Child (1938) that cows had significantly thicker muscle fibers than steers. The true relationship, if any, that does indeed exist is still a matter of conjecture.

The effect of age on fiber diameter has been studied extensively by many workers: McMeekan (1940-41), Thompson (1942), Meara (1947), Hiner *et al.* (1953), Joubert (1956a), Tuma *et al.* (1962), Carpenter *et al.* (1962) and Henrickson *et al.* (1963), and all are in agreement that fiber diameter increases from birth to maturity and that it increases in size rapidly while the animal is quite young and tends to level off as the animal approaches maturity.

Yeates (1964) studied starvation changes and subsequent recovery of adult beef muscle. The experiment revealed that with starvation of the adult animal the shrinkage in cross sectional areas of the muscles, after allowing for the loss of some intramuscular fat, was associated with the reduction in diameter of the individual fibers; thus, with repair of live weight, recovery both of whole muscle dimensions and muscle fiber diameter appeared to be complete.

Large fibers within a muscle are often closely associated with "growthy" or meat type animals. Unusually large muscles possess many fibers which are intermediate to grey-white in color. This condition is first noted on the surface muscles of the thick portions of the carcass and are most extensive on the periphery of the muscle bund'es. These white fibers are characterized by being low in myoglobin, but high in potassium and phosphorus. The K-40 content of total muscle may be influenced greatly by the predominance of white muscle fibers. Connective tissue surrounding the fibers are filled with fluid and the muscle is described as being soft, watery, and pale. Fibers such as these have the ability to contract at a rapid pace. Thus, leading to death of the animal often as a result of excitement. In less severe cases the animals are slaughtered and the condition is detected as light colored muscle.

The chemical composition of white muscle in the red meat animal is such that it leads to meat with undesirable quality. It would seem now that such a condition in meat should be well guarded against as we strive for improvement in the meat type animal.

Post-Mortem Variations

Another cause of structure variation of the muscle fiber is the conditions to which it is subjected after the animal is slaughtered.

Muscle contraction referred to as rigor mortis has received much attention by investigators. Rigor mortis is defined as the physical and chemical changes that take place after death of the animal. This discussion will be limited to the physical effects of rigor on the muscle fiber. The main observed physical change is from a highly extensive elastic condition of muscle or freshly killed animals to the inextensible and rigid condition of the muscle fiber in full rigor. This is a result of the actin filaments becoming bound to the myosin filaments thus greatly decreasing fiber extensibility. This actomyosin complex remains locked in a contracted state until rigor resolves (Marsh, 1954). Along with this change in extensibility, there is a gradual shortening of the sarcomere as rigor approaches, which leaves the muscle in a semi-contracted state (Locker, 1960).

Similar results with an increase in fiber diameter and a decrease in sarcomere length were obtained at the Oklahoma Station. Another well known physical effect of rigor on the muscle fiber is the presence of rigor kinks found in localized areas along some fibers. In an attempt to objectively determine the amount of kinkiness in different muscles and as a result of different treatment Gillis and Henrickson (1967) have devised a method of expressing the amount of kinkiness on a percentage basis. This method consisted of subjectively assigning a value to the condition of the muscle fiber, similar to the subjective appraisal of carcass grade, and then relating this measurement with other known estimates of contraction.

The effect of temperature on the condition of the muscle fiber has been shown to have considerable influence. Locker and Hagyard (1963) showed that shortening of the muscle fiber occurs when exposed to very cold temperatures. This phenomenon is referred to as cold shortening. It is currently thought that cold shortening occurs simultaneously with the formation of cross-linkages in rigor; a degree of internal strain or actual disorganization occurs, and actually increases the resistance of the muscle to cleavage. Herring *et al.* (1965a) reported that slightly more shortening appeared, as indicated by sarcomere length, to take place in stretch-restrained muscle samples at 1° C. than at 5° C. It was postulated in this experiment that some cold shortening may have occurred at this temperature as well.

Cook and Wright (1966) using samples of unfrozen and pre-rigor frozen ovine semitendinosus muscle, incubated for 24 hours at six temperature levels between 0° and 40°C., found that variations in temperature caused muscle fibers to be in various states of contraction. The variations in sarcomere length of unfrozen and pre-rigor frozen muscle did not follow any specific course in relation to temperature, but a difference did exist.

Harrison *et al.* (1949) noted that the differences between sections of raw and cooked muscle were slight, however, the cooked sections tended to have straighter fibers than the raw muscle sections.

Paul *et al.* (1944) noted that the histological appearance of the muscle fibers varied with biological aging. Harrison *et al.* (1949) noted that freshly killed beef muscle showed poorly differential straight to slightly wavy fibers. After 1 day of storage at 1.7°C. the fibers and cross striations were more distinct, and the longitudinal striations less distinct. Contracture nodes, kinks, and waves increased in the fibers with long aging, however, they did tend to disappear after 4 to 9 days of storage. Disappearance of cross striae in small, infrequent areas of the fibers was noted on the second day of storage, and this disintegration tended to increase in frequency and extent as the storage time increased.

Younger and Baigent (1965) studied the effect of precooking on freeze-dried lamb and noted that uncooked freeze-dried meat appeared to suffer much more fiber damage, in terms of fiber distortion and shrinkage, than the cooked freeze-dried samples. When rehydrated, the samples revealed a similar pattern, the uncooked freeze-dried material revealed considerable distortion of the fibers and many were smaller in diameter than normal. The cooked, freeze-dried samples very closely resembled fresh meat. The fibers were restored almost completely in size and shape, with no abnormal spaces between them.

Carcass position has a definite effect on sarcomere length and fiber diameter, (Herring *et al.* 1965b). When the carcass is suspended vertically certain muscles are in a stretched state, as indicated by sarcomere length, while some are in a shortened state. In general, the differences in sarcomere lengths were associated with differences in diameter. When the muscles shortened, there was a corresponding decrease in sarcomere length and an increase in fiber diameter.

Recent work at the Oklahoma Station, using the semitendinosus and semimembranosus muscles from five choice grade steers of similar age, weight, and genetic background, indicated that a positive relationship existed between muscle tension and sarcomere length, fiber diameter, and percent kinkiness. Both muscle types were removed from the carcass post slaughter (45 min.), divided into four samples (6x6x21cm.) and subjected to four degrees of tension (0, 1000, 2500, and 5000 gm. pull). The samples were held in this state for 48 hr. post-mortem at 34°C. Histological amd shear samples were then taken.

An analysis of variance showed that a highly significant difference ($P<.01$) existed for sarcomere length for the different degrees of tension. Further analysis, using Duncan's new Multiple Range test, clearly indicated that with succeeding increases in tension, a corresponding increase in sarcomere length occurred. All ranges were highly significant at the ($P<.01$) level except the range 2500-5000 which was significant at the ($P<.05$) level.

These findings are in general agreement with those of Herring *el al.* (1965) who noted that sarcomere length of the semitendinosus muscle shortened as a result of pre-rigor excision, but that the pre-rigor excised stretch-restrained semitendinosus muscles generally exhibited longer sarcomeres than the control samples.

A highly significant difference ($P<.01$) in fiber diameter was found for the different degrees of tension. There was also a highly significant difference ($P<.01$) between muscles, indicating that, with an increase in the amount of tension there was a corresponding decrease in fiber diameter, to a point.

Variation in percent kinkiness was found to be highly significant ($P<.01$) for the different degrees of tension, significant differences at the ($P<.05$) level were noted between muscles and for a muscle by tension interaction. The semimembranosus muscle and an average of both muscles were found to have highly significant ($P<.01$) differences in percent kinkiness for ranges of 0-1000, 0-2500 and 0-5000 gm. pull.

Work at the Oklahoma Station by Reddy and Henrickson (1967) on the effect of pre-rigor excision of three bovine muscles on fiber diameter and percent kinkiness showed interesting relationships. Percent kinkiness was greater ($P<.10$) for the pre-rigor excised longissimus dorsi muscle than the post-rigor excised muscle. However, the opposite was true for the gluteus medius muscle thus supporting the postulation of Locker (1960) that different internal strains among muscles exist in the vertically suspended carcass. This also is in agreement with the findings of Gillis and Henrickson (1967) that the percent kinkiness is to a certain degree, a function of muscle tension.

We also found that fiber diameter of pre-rigor, exercised, semitendinosus muscle was greater than those in post-rigor, exercised muscles, apparently because of muscle shortening.

In a study to determine the relationship of fiber diameter to tenderness Hiner *et al.* (1953) showed that a curvilinear relationship exists between fiber diameter and tenderness. He found that, up to a point, an increase in fiber diameter results in an increase in shear force. Tenderness in this report is considered to be the resistance to shear. A position correlation does exist between the taste panel score for tenderness and a mechanical shear force. Tuma *et al.* (1962) also reported that with an increase in fiber diameter there was a corresponding increase in shear force among different age groups of cattle. However, when the effect of age was removed little relationship existed. Carpenter *et al* (1962) on the other hand found that with an increase in maximum fiber diameter there was a decrease in shear force of raw longissimus dorsi muscle. Opposite results were found for cooked longissimus dorsi muscles. They postulated that for a given size core there may be more small than large fibers per unit area, therefore more of the the sarcolemma and endomysial connective tissue was present, resulting in a less tender product.

Herring *et al.* (1965b) noted that as fiber diameter increased tenderness decreased whereas the opposite was true when fiber diameter decreased. It was also shown that a change in fiber diameter was related to a change in sarcomere length. In a previous experiment Herring *et al.* (1965a) found that stretching a muscle rather than not stretching it increased tenderness and resulted in smaller fiber diameters. It was assumed that a greater number of fibers per unit area, were being severed in the stretched sample. This assumption is in agreement with that of Carpenter *et al.* (1962) in that the greater number of smaller fibers should theoretically make the muscle less tender. However, the stretched muscle was more tender, indicating that the thickness of the sarcolemma and endomysial connective tissue was reduced in thickness when the fibers were stretched (Cassella, 1950).

This fact is applicable to our work with muscles subjected to four degrees of tension. An analysis of variance indicated a significant difference ($P<.05$) in shear force. Further analysis indicated that shear force decreased up to 1000 and 2500 gm. pull for the semimembranosus and semitendinosus muscles, respectively.

Fiber diameter and shear force decreased as tension increased indicating that the stretched samples with the smallest average diameters were the most tender.

The relation of fiber size, amount of fat, and amount of connective tissue per unit area undoubtedly all effect tenderness.

The degree of muscular contraction as it effects tenderness has received considerable interest in recent years. Locker (1960) first postulated that different muscles in the carcass go into different states of contraction in rigor as a result of different internal strains imposed on the muscles of the vertically suspended carcass. In an experimental study of the effects of pre-rigor excision of several muscles he concluded that muscles in a relaxed state, as indicated by fibrillar pattern, are more tender than those partly contracted. To this effect Marsh and Leet (1966) studied the effects of cold shortening on tenderness. They noted that with a decrease in length of up to about 20 percent caused little or no toughening, but with 20 to 40 percent shortening the toughness increased several fold. Beyond 40 percent shortening the meat became increasingly more tender, and at 60 percent shortening it was cleaved almost as easily as meat in which almost no shortening had occurred. They postulated that the 40-60 percent range may be a zone of progressive rupturing thus causing a rapid decrease in internal strain in this phase, with consequent realignment of previously distorted cleavage planes.

Our work agrees with that of Herring *et al.* 1965 and indicates that, with increasing amounts of strain on a muscle, sarcomere length increases to a point of physical limitation, and there is a subsequent increase in tenderness.

The percent kinkiness decreased with the application of tension to the muscle samples. The semimembranosus muscle tended to increase in percent kinkiness greater than the 100 gm. pull treatment. A gradual increase in shear force was also noted, after the 2500 gm. pull treatment for this muscle, indicating that some fiber breakage may have occurred when the amount of tension overcame the physical limits of the fiber. This may have resulted in partial contraction of some of the broken fibers which would account for the increase in shear. Theoretically this also would allow these broken fibers to be distorted to a greater degree. A similar response was noted by Herring *et al.* (1965) when they tried to stretch the psoas major muscle; tearing and failure of the muscle to regain its initial length resulted.

In summary, the condition in which the muscle fiber is found is highly variable. Inherent differences of diameter and sarcomere length as a result of species, breed, sex, age and level of nutrition exist. Differences occur after the slaughter of the animal as a result of contraction and distortion in rigor, due to temperature change, and as a result of different amounts of tension on the muscle.

These structural variations affect the ultimate tenderness of the muscle. It stands to reason then that some of the commonly associated differences in tenderness with age, sex etc. may be due to the structural condition of the muscle fiber.

Further work appears necessary to clarify the relationship of sex to muscle fiber size and fiber size to muscle degeneration.

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Reproductive Performance of Gilts Following Exposure to Heat Stress Prior to Breeding and in Early Gestation[1]

Ronnie Edwards, I. T. Omtvedt, E. J. Turman, D. R. Rule, D. F. Stephens and G. W. A. Mahoney

Story in Brief

Two trials were conducted to study the influence of high ambient temperatures prior to breeding and in early pregnancy on the reproductive performance of gilts. Two environmental control chambers were used with one maintained at 74°F. continuously and the other elevated to 100°F. for 17 hours daily and lowered to 90°F. for the remaining 7 hours.

When gilts were exposed to high ambient temperatures the cycle before breeding, the onset of estrus was delayed by over 2 days, but no significant changes were noted in the number of gilts conceiving, the ovulation rates, or the number or size of embryos at 30 days postbreeding.

Heat stress applied 1-15 days postbreeding was more detrimental to productivity than heat stress 15-30 days postbreeding. Gilts maintained in the hot chamber the first 15 days after breeding had fewer viable embryos and lower survival rates than either those maintained in the cool chamber or in the outside pasture lots.

Based on these results, heat stress during estrus and in early gestation is more critical than heat stress prior to breeding. Gilts are more susceptible to high ambient temperatures the first few days after breeding than after implantation has occurred. Since August and September farrowed litters are smaller and pigs weigh less at weaning than those born in January and February, investigations to determine the influence of heat stress during mid and late pregnancy are presently being pursued.

Introduction

Multiple farrowing of swine has become increasingly popular in recent years. One disadvantage to this system of production is the lowered reproductive performance from sows and gilts during the hot summer

[1] Department of Animal Science in cooperation with USDA, ARS, AHRD, and Department of Agricultural Engineering.

months. Previous observations made at this station indicate that sows farrowing in August and September farrow and wean fewer pigs per litter, and the fall pigs are lighter at weaning. This is readily apparent when comparing the fall and spring litter production of control line (no selection line) gilts for the past four years at Ft. Reno (Table 1).

This study was undertaken to investigate the effect of high ambient temperatures prior to breeding and in early gestation on the estrual cycle, conception rate and subsequent embryo survival of crossbred gilts.

Materials and Methods

Two trials were conducted utilizing two environmental chambers in each trial. These chambers were constructed inside a closed building at the Ft. Reno Livestock Research Station. One chamber served as a control and was maintained at an ambient temperature of 74°F. continuously.

The temperature in the other chamber was elevated to 100°F. for 17 hours daily (4 p.m. to 9 a.m.) and lowered to 90°F. for the remaining 7 hours (9 a.m. to 4 p.m.). No atempt was made to regulate humidity, but it averaged approximately 35 percent in the heat chamber and 65 percent in the cool chamber. Each chamber was equipped with an artificial light source, but length of the photoperiod within the chambers was not strictly controlled. The dimensions and general layout of the chambers are presented in Figures 1 and 2.

Each gilt was fed 2½ pounds of feed morning and evening and water was supplied *ad libitum*. Yearling Hampshire boars were used to breed the gilts in both trials.

Table 1. Comparison of Fall and Spring Farrowed Litters Of Control Line Population Gilts at Fort Reno Station[1]

Year	Season	Number of Litters	Farrowing		42-Days	
			No. Pigs Per Liter	Avg. Pig Wt., lbs.	No. Pigs Per Litter	Avg. Pig Wt., lbs.
1964	Spring	10	11.0	2.7	8.0	49.3
	Fall	16	6.7	2.5	4.7	44.7
1965	Spring	14	10.5	2.6	7.5	43.1
	Fall	14	9.1	2.6	7.3	39.2
1966	Spring	21	11.8	2.6	8.8	37.5
	Fall	17	10.6	2.8	9.1	36.0
1967	Spring	20	10.6	2.8	9.3	43.5
	Fall	12	9.4	2.8	7.6	40.2
Overall	Spring	65	11.0	2.7	8.4	45.8
	Fall	59	9.0	2.7	7.2	40.0

[1] Spring refers to January and February farrowed litters and fall refers to August and September farrowed litters.

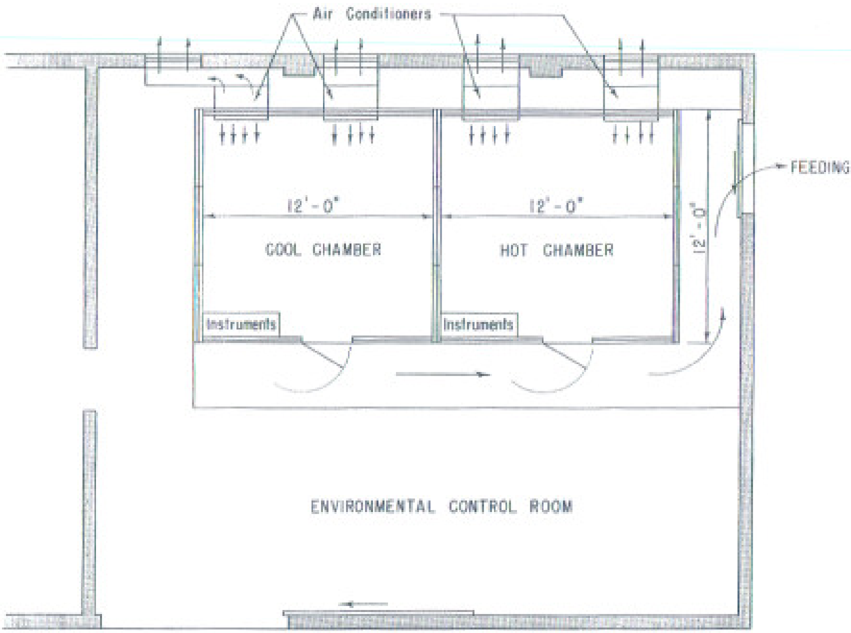
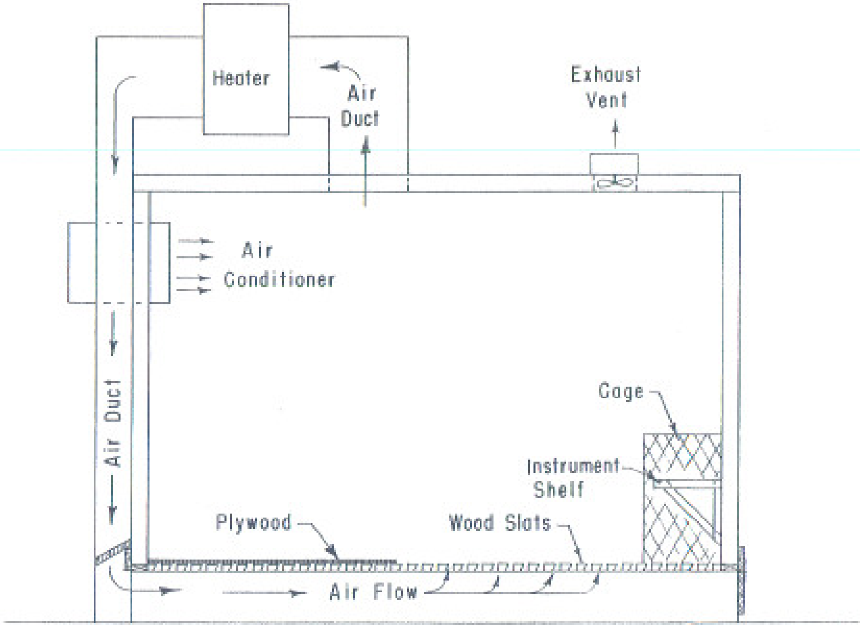


Figure 1. Environmental control room showing location of environmental control chambers, work area, and access walk for moving gilts in and out of the chamber.

Rectal temperatures were obtained twice daily from each gilt in each chamber. One reading was obtained at 4 p.m. before the heat was increased and the other at 11 p.m. These times were selected in an effort to obtain the maximum and minimum body temperatures. All gilts were slaughtered between the 30th and 35th day of gestation and intact reproductive tracts were recovered. The uterine horns were dissected and the embryos removed and examined. Crown-rump measurements were made with embryos still enclosed in the amnionic sac. Hemorrhagic and partially decomposed embryos were noted, but such embryos were not measured. Ovaries were removed and corpora lutea counted and verified by dissection.

Trial 1, conducted from February through April of 1967, was designed to study the influence of heat stress prior to breeding. Seventeen gilts were assigned to the cool chamber and 22 were assigned to the heat chamber for one estrous cycle prior to breeding. After breeding, the gilts were maintained in outside lots until time of slaughter.



HOT CHAMBER

Figure 2. Cross section of high temperature environment control chamber, showing location of air conditioners, heating facilities, instrument cage and exhaust fan.

Trial 2 consisted of two replications. One was conducted during March and April and the other during November and December of 1967. Sixty crossbred gilts were randomly assigned to four treatments at time of breeding on first day of estrus. In treatment 1 the gilts were maintained in the hot chamber for the first 15 days after breeding and then were maintained in the regular Ft. Reno sow facilities until slaughter at about 30 days postbreeding.

In treatment 2, gilts were kept in the regular outside sow facilities for the first 15 days after breeding and then placed in the hot room from 15-30 days postbreeding. Treatment 3 gilts were confined to the control chamber from breeding until slaughter at about 30 days postbreeding. Treatment 4 gilts were maintained in the outside lots from breeding until slaughter.

Results and Discussion

Trial 1:

Average rectal temperatures for the gilts in trial 1 are presented graphically in Figure 3. The gilts showed definite response to the high temperatures for the first 6-8 days of exposure and then apparently became somewhat adjusted to the stress conditions. However, rectal temperatures for the gilts exposed to the heat chamber remained well above what is considered normal (102.5°F.) for the entire time of exposure. In contrast, rectal temperatures for gilts maintained in the cool chamber were slightly below normal.

Five gilts exposed to the heat chamber in trial 1 died during the heat stress period and one failed to conceive. The reproductive performance of the remaining 33 gilts is summarized in Table 2. Among gilts alloted to the control chamber, no significant differences were found between the estrous cycle lengths during confinement and the average of the two cycles prior to confinement. However, the cycle lengths were increased ($P<.05$) during confinement for the gilts alloted to the heat chamber. Other differences observed in reproductive performance were not significant. The gilts exposed to the heat stress suffered a severe loss of appetite and, as a result, lost significantly more weight during confinement than those confined to the cool chamber.

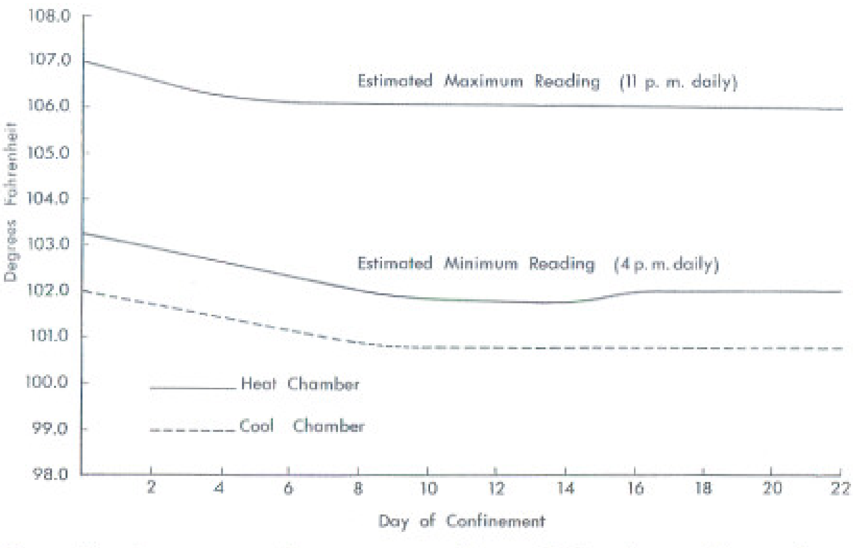


Figure 3. Average rectal temperatures for cool chamber and heat chamber gilts during chamber confinement.

Table 2. Influence of High Ambient Temperatures On Estrous Cycle Prior to Breeding

Item	Treatment Cycle Before Breeding	
	Hot Room	Cool Room
No. gilts allotted	17	17
No. pregnant at 30 days	16	17
Length of estrous cycle, days:		
Prior to confinement	20.0^{1}	21.4
During confinement	22.4^{2}	21.5
No. corpora lutea per gilt	15.5	15.9
No. viable embryos per gilt	11.5	12.4
Percent viable of ovulated	74.2	78.0
Adjusted embryo length, mm.	28.3	29.0

[1,2] Values with different superscripts significantly different ($P < .05$).

Trial 2:

Rectal temperatures of heat stressed gilts in trial 2 followed the same pattern as those in trial 1. Readings obtained from animals in the heat chamber were significantly higher than those in the cool chamber.

Of the 15 gilts assigned to treatment 1, four failed to conceive and one died during the stress period. Two gilts in treatment 2 and one from treatment 4 also failed to conceive. The reproductive performance of the remaining 52 gilts is summarized in Table 3. Conception rates were lowest among the gilts exposed to heat stress 1-15 days post-breeding. No significant differences were found in number of corpora lutea among the four treatments. However, gilts stressed 1-15 days post-breeding had significantly ($P<.01$) fewer viable embryos and significant-

Table 3. Influence of High Ambient Temperatures During Early Pregnancy

Item	Postbreeding Treatment[1]			
	Hot Room (1-15)	Hot Room (15-30)	Cool Room (1-30)	Pasture (1-30)
No. gilts allotted	15^{2}	15	15	15
No. pregnant at 30 days	10	13	15	14
No. corpora lutea/gilt	14.6	15.4	15.2	13.8
Viable embryos/gilt	9.4^{3}	12.8^{4}	12.6^{4}	11.5^{4}
Percent viable of ovulated	64.2^{3}	83.4^{4}	82.8^{4}	83.4^{4}
Adjusted embryo length, mm.	30.09	31.08	31.38	31.76

[1] Figures in parenthesis refer to the days of postbreeding phase that gilts exposed to treatment.
[2] Includes one gilt that died during stress period.
[3,4] Values with different superscripts significantly different ($P < .01$).

ly ($P<.01$) lower survival rates. Embryos at 30 days postbreeding tended to be smaller but these differences were not significant.

The results of this study indicate that heat stress during early gestation is more of a factor in embryonic mortality than heat stress prior to breeding. It also appears that the embryo is more susceptible to heat stress during the first 15 days postbreeding than in the period 15-30 days postbreeding.

Summary Reports on Other Projects

Mineral Interrelationship Studies With Ruminants

Allen D. Tillman, T. E. Nelson and L. J. Bush

Procedures and Results

In work done on this project during the past year, it was found that both adult sheep and laboratory rats responded to a calcium-free diet in a similar manner: There was a linear decrease in blood plasma calcium level for three weeks, but by the end of the fourth week the levels had returned to a normal level and remained in the normal range for the five-week period the rats were on test and for 25 weeks in the case of sheep. Plasma phosphorus levels rose at the time the calcium levels returned to normal, thus the calcium x phosphorus product in blood plasma rose to high level. The data show that a calcium x phosphorus product of 70 or above indicates that the animal is receiving an insufficient amount of dietary calcium thus is drawing this element from the bones.

Sheep, which had been on the calcium-free diet for six weeks or more excreted injected phosphorus more rapidly than those maintained on an adequate dietary level of calcium. These results indicate that the parathyroid hormone activity was higher in calcium-deficient sheep. As the kidney arterial-venous blood differences were greater in calcium-deficient sheep than the controls, these results lend further support to the idea that the activity of the parathyroid was higher in the calcium-deficient sheep.

That a calcium-deficient diet, when fed to rats, affects the metabolism and balance of other minerals was found in another series of studies.

These results indicate that a measure of parathyroid hormone activity in animals would be valuable in determining the calcium status of cattle, sheep, swine and horses. Research is underway to develop an adequate radioimmunological assay for this important hormone.

In another experiment, the interrelationship of calcium, magnesium and phosphorus was studied using the laboratory rat. High levels of magnesium affected phosphorus metabolism when dietary phosphorus levels were low. If dietary magnesium and phosphorus levels were low, high levels of calcium affected the utilization of both magnesium and phospohrus.

Publications

The following articles have been published from this project during the past year:

Nelson, T. E. and A. D. Tillman. 1967. Calcium status on adult sheep. J. Animal Sci. 26:977. (Abstr.).

Nelson, T E. 1967. Mineral metabolism on a calcium deficient diet. Thesis for M.S. Degree. Oklahoma State University, Stillwater.

Nelson, T. E. 1967. Calcium status studies on adult sheep. J. Nutrition 93:475.

Frontera, A. R. and A. D. Tillman. 1968. Estudio Sobre Las Interrelaciones De Calcio, Fosforo, y Magnessio. La Re vista de Investigaciones Agropecuarias del INTA. (In press).

Future Work

Work continues on the developing of a method to determine ptH activity. Also, the effect of varying calcium: phosphorus ratios on the utilization of calcium, phosphorus, sodium, potassium, copper, cobalt, iron, manganese, zinc and other cations is being determined in young sheep.

Role of Vitamin E and Selenium in Sheep Reproduction

Allen D. Tillman, E. C. Nelson, B. I. Osburn and J. E. Smith

Procedures and Results

An experiment was conducted to determine if the Oklahoma State purified diet, which contains urea as the sole nitrogen source would support reproduction in ewes. The diet contained selenium but no additional vitamin E except the small amount in corn oil, which was fed at a level of 1% of the diet. All lambs died at birth or shortly afterwards and the ewes had symptoms of muscular dystrophy, indicating a vitamin E deficient diet.

An experiment was then designed to determine the value of selenium and vitamin E in the reproduction of the ewe. Four treatments are used as follows: (1) negative control, having no added vitamin E or selenium, (2) selenium added, (3) vitamin E added, and (4) both selenium and vitamin E were added. Corn oil, from which the vitamin E had been removed, replaced regular corn oil in the diets. Ewes which were about four months of age were placed on the trial in the summer of 1967 and have been fed their assigned diets up to the present time. Breeding was initiated in October and extended over a 60-day period.

The experiment is still underway and the observations are too incomplete for further report at this time.

Publications

One article has been reported on this project.

Erlinger, L. E. 1967. Effect of a purified diet upon reproduction in ewes. Thesis for M.S. Degree. Oklahoma State University, Stillwater.

Future Work

The experiment will be continued as outlined.

Non-Protein Nitrogen Studies With Ruminants

Allen D. Tillman, J. E. McCroskey, R. J. Panciera and E. I. Williams

Procedures and Results

As protein is the most limiting nutrient in the nutrition of man, work is underway to determine means of feeding more urea to ruminant animals. This has been and continues to be an active project. During the past year, it was discovered that purified jackbean urease, when injected subcutaneously in cattle and sheep, increased gains of these animals if urea was fed as the major nitrogen source in the diet. Antibodies to urease are developed in the bodies of the animals and these antibodies inhibit the rate of hydrolysis of urea to ammonia and carbon dioxide. Ruminal and blood plasma ammonia levels are decreased in the immunized animals as was the hydrolysis of urea decreased in the ileum, cecum and colon. Many physiological studies are underway on these animals and the results should provide more insight on the mechanism of urea utilization. Results of such studies will provide the knowledge necessary for the practical use of urea in cattle and sheep rations.

Urea can be utilized in diets containing high levels of cane molasses if the phosphorus and zinc levels are adjusted upward. The higher calcium level of cane molasses is the cause for these needs. These results have practical value in areas where cane molasses is an economical energy source.

Liquid hemicellulose, obtained by steaming and applying pressure to wood in making pressboard, was found to be a good source of carbohydrate in diets where urea was the major nitrogen source. A 1:1 mixture of liquid hemicellulose and cane molasses gave excellent gains in sheep. These results indicate that wood carbohydrates may be valuable in the feeding of ruminants and that technology should be developed so that these carbohydrate sources available for ruminant feeding at an economical price.

Chemical urease inhibitors have not been found to be of value in urea utilization. Most of these inhibit other enzymes and reduce overall feed utilization.

A study is underway having as its goal to determine the effect of "*near*" urea toxicity upon the subsequent reproductive performance of pregnant cows. All animals were given enough urea via drench to cause toxicity, but when severe symptoms of urea toxicity were evident, they were given acetic acid (5% v/v) to neutralive the ammonia and death was prevented. High levels of ruminal fluid and blood ammonia were obtained on all treated cows. The project is designed to determine the effects of the high blood ammonia levels upon the developing fetus and upon the subsequent ability of the cow to conceive and produce another calf. The experiment is underway and the results are incomplete at this time.

Publications

The following publications appeared last year:

Tillman, A. D. 1967. Urea utilization by ruminant animals. Southern Veterinarian 3:8.

McCartor, M. M. and A. D. Tillman. 1967. The performance of beef steers fed isonitrogenous, isomineral all-concentrate rations. Okla. Agr. Exp. Sta. M.P. 79:97.

Clifford, A. J., R. D. Goodrich and A. D Tillman 1967. Effects of supplementing ruminant all-concentrate and purified diets with vitamins of the B complex. J. Animal Sci. 26:400.

Merina, Hector Z. 1967. Effect of molasses on feed utilization by sleep. Thesis for M.S. Degree. Oklahoma State University, Stillwatr.

Clifford, A. J. 1967. Urea utilization studies with ruminants. Thesis for Ph.D. Degree. Oklahoma State University, Stillwater.

Five additional papers have been prepared from results obtined during the past year and four of these have been accepted by the Journal of Animal Science.

Future Work

Additional practical tests to determine how to use urea under typical Oklahoma winter range conditions are underway as are basic studies on the mechanism of urea toxicity.

Development of Methods for Relating Forage Properties to Intake and Digstibility

J. E. McCroskey

Rumen fistulated steers are being used to sample grazed bermudagrass and to compare different indicators for estimating forage intake. Undigestible cellulose (determined by nylon bag technique) and lignin are the natural grass constituents being compared as indicators of forage digestibility. Chromic-oxide and polyethylene glycol are external indicators being compared in estimating fecal output. By the use of these internal and external indicators intake of grazed forage is being calculated. Chemical composition of bermudagrass at various times during the year is being related to voluntary forage intake.

The Effects of Season and Exogenous Hormones on the Reproductive Performance of Swine

J. C. Hillier and E. J. Turman

This project has involved several separate studies with gilts and boars. One study comparing lot-mating and hand-mating of gilts was published in an earlier Feeder's Day report (Okla. Agr. Exp. Sta. Misc. Publ. MP-78, p. 25). No results are ready to be released from the present study involving gilts in which various compounds are being studied for their effectiveness in synchronizing estrus.

A study has just been completed on the effects of season and three types of shelters on semen quality of boars. Twelve Yorkshire boars were divided into three groups and maintained in lots with access the year round to an open shade only, an open fronted house and an insulated, air conditioned house. Semen was collected three times weekly and evaluated once weekly. There was a marked decline in semen quality associated with hot summer weather, and providing air conditioning did not prevent this decline. In general the semen quality of the boars in the open fronted house remained as good as that of boars in the insulated house. The data is now being analyzed and the results will be published at a later date.

Swine Breeding Research Program

I. T. Omtvedt

The swine breeding projects consist of a 90 sow herd at Ft. Reno and a 50 sow herd at Stillwater yielding approximately 280 litters yearly. These herds are primarily involved in a basic selection study to determine if performance can be improved by selection for crossing ability in traits that reveal heterosis in crossing but have low heritabilities and normally show very little response to direct selection. Two lines of breeding are being selected on the basis of their crossbred half-sisters' productivity (litter size and weight at 3 weeks). A zero-selection control line is also maintained along with these two lines for the purpose of measuring the changes that take place in the selected lines. Only four generations of selection have been completed and it is too early to draw any conclusions at this time.

Investigations are also being conducted on the inheritance of pork quality traits such as color, firmness, marbling and tenderness. The increased concern over the incidence of pale, soft, watery pork prompted the initiation of this project in 1965. The two primary objectives were to determine the genetic relationships between various measurements of quality, and to estimate the extent to which these conditions are inherited. The data are presently being analyzed and the results will be available for the 1969 Progress Report.

In addition to the environmental physiology research partially reported in this bulletin, studies regarding swine management and performance testing are also being conducted. Three studies underway at the present time are: (1) an analysis of sow weight and sow condition scores to determine their influence on reproductive performance; (2) a study to develop selection indices involving various combinations of economically important traits; and (3) an analysis of the performance records of littermate boars, barrows and gilts to investigate the influence of sex and sire-sex interactions in growth rate, probed backfat thickness and carcass traits.

The Desirability of Pork Products Processed Prior to Chilling

R. L. Henrickson, I. T. Omtvedt, Gopal Reddy, Allen Parr, Earl Cagle and F. Arganosa

High temperature curing of porcine muscle appears to have practical value for the meat industry. Data are available which support the view that muscle processed prior to chilling has a greater water-holding capacity than muscle processed post-chill. Total moisture, press fluid, and free fluids in the can all cause one to review rapid processing of meat with renewed vision. Pre-chilled processed muscle tended to take up the cure more rapidly and provided a more stable cured tissue as evident by nitrosopigment content.

Shear force values indicated that pre-chilled canned muscle is not as tender as post-chilled muscle. This may be a practical advantage since canned ham is often over heated resulting in poor texture. It is difficult at this time to predict the significance of tenderness in canned ham since it has not been possible to establish the desired tenderness level for this product. Studies concerned with the size and condition of the muscle fiber did not reveal great differences due to the processing treatment. However, there was some fiber variation between muscles.

The Eating Quality of Beef as Influenced by Age and Muscle Difference

R. L. Henrickson, S. G. Reddy, W. A. Gillis and W. L. Lee

The beef carcass is composed of over 200 individual muscles. Some muscles are tender and are used for steak. However, numerous other muscles particularly in the frontquarter, may have utility as steak. A more efficient utilization of the beef carcass would be wise particularly now as beef must meet competition from other protein sources.

Restricted funds has limited progress to the evaluation of techniques for quality measurement. Methods have been employed for the excision of individual muscles. Fiber size and variation in the degree of rigor have been investigated. Other factors evaluated were myofibril size, sarcomere length, collagen, elastin, and mucoproteins. These investigations provided the following:

1. Muscles and/or muscle systems can be more easily extracted from the warm carcass than from one chilled.
2. Muscles within a carcass are under varied levels of tension depending upon its location within the carcass and the chilling position.
3. Fiber diameter of muscles under 1000 gram tension were smaller than those with no tension.
4. No significant change was noted in muscles with additional levels of tension.
5. Both muscles studied exhibited less rigor fibers when the muscle was under 1000 gram tension than with no tension.
6. Muscles and muscle fibers varied in the response to rigor mortis.

Factors Affecting the Energy Value of Feeds and Energetic Efficiency of Ruminants

J. E. McCroskey

Two open-circuit respiration chambers for cattle have been installed and will be used in the determination of energy values of various feeds and rations and the influence of certain feed additives upon energy utilization by cattle of different ages.

Selection Procedures for Beef Cattle Improvement

Richard R. Frahm and Joe V. Whiteman

The beef cattle selection experiment being conducted at the Fort Reno Livestock Research Station was designed to: (1) measure direct genetic response to selection for increased body weight at 7 and 12 months of age, (2) measure correlated genetic response of increased weight at 7 months as a result of selection based on weight at 12 months of age, (3) measure correlated genetic response of increased weight at 12 months resulting from selection based on weight at 7 months, and (4) compare genetic response between lines selected on the basis of individual performance with lines selected on a combination of individual and progeny test performance. Table 1 outlines the design of this experiment.

Table 1. Design of Beef Cattle Selection Experiment

	Line Number					
	5	6	7	8	9	10
Breed: H = Hereford, A = Angus	H	H	A	A	A	A
Number of Cows per Line	50	50	50	50	50	50
Selection Procedure:						
Traits: Month of weight and grade	7	12	7	12	12	7
Criteria: I=Individual, P=Progeny	I	I	I	I	I/P	I/P
Number males selected per year	2	2	2	2	5/2	5/2
Number years selected males used	2	2	2	2	2	2
Number females selected per year	10	10	10	10	10	10
Generation Interval (Years)	4.5	4.5	4	4	5	5
Year Line Closed	65	65	67	67	68	68

Weight at a given age is the primary criteria for making selections of both bulls and replacement heifers in each of the selection lines; however, conformation grade is also considered. In the progeny test lines, 9 and 10, the top five bulls will be selected in each line on the basis of their individual performance to be progeny tested. Based upon the progeny test information, the top two bulls in each line will be selected for use in their respective selection lines.

The process of establishing this project is now complete. The Hereford lines were closed in 1965. Angus lines 7 and 8 were closed in 1967, and the progeny test information was available this spring to evaluate the first sires to be selected for lines 9 and 10. This is a long term experiment and it will be several years before enough data have been obtained to make even a preliminary analysis with respect to measuring the genetic progress obtained from selection.

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