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Studies of Confinement and Pasture Management Systems for Swine

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In 1957 and 1958 at the Ft. Reno station 107 sows and litters were used to compare the effects of pasture and confinement managements on pre-weaning and post-weaning performance of pigs. In these earlier trials the same rations were fed on pasture as in confinement. Sows on pasture weaned heavier pigs and heavier litters than those on concrete floors in confinement. These differences were less when adequate anemia preventative treatment was given the confinement pigs, but even when this was done pigs raised on pasture were heavier than those in confinement. There was little difference in litter size. Confinement pigs gained faster and slightly more efficiently than pasture pigs after weaning. They were slightly fatter at market weight, but pasture pigs were sounder on their legs. The best combination system in these earlier trials was pasture for the sows and litters up to weaning and then confinement feeding of the pigs from weaning to market weight. This combination system gave the highest rate of gain and the most efficient feed conversion.

In 1959 and 1960 Hillier and associates conducted a series of tests at Stillwater to improve the creep ration for pigs and the lactation ration for sows in confinement. Confinement raised pigs were somewhat smaller at weaning and had lower hemoglobin levels than pasture raised pigs. The hemoglobin levels of confinement pigs, however, was not critically low. Additional trace mineral supplementation or the addition of soil to the creep ration was not effective in preventing a drop in hemoglobin level of confinement pigs. However, a second iron injection at 21 days (first injection at three days) did prevent a drop in hemoglobin level. Under adverse weather conditions fewer pigs were lost and pigs were heavier in confinement than on pasture. Sows fed trace mineral fortified rations in confinement consumed more feed, lost less weight, and their pigs were 4 lbs. heavier at 42 days than sows that were not supplemented with trace minerals. Additional calcium and phosphorus in the sow ration seemed to have no beneficial effect.

1961 Fall Trial with Gilts and Litters

In the fall of 1961, 28 crossbred gilts and their litters were used to study pre-weaning performance on pasture and in confinement when extra vitamin and mineral supplementation was made in the confinement rations. The sow lactation rations are shown in Table 1 and the pig creep feed rations are shown in Table 2. The 28 Duroc x Beltsville No. 1 gilts were all bred to Hampshire boars. Gilts with equal size

Table 1.—Lactation Rations in 1961 Fall Confinement—Pasture Trial.

Ingredient	Confinement	Pasture
Milo	75.0	78.0
Soybean meal (44%)	11.0	9.5
Alfalfa meal	10.0	10.0
Dikal	1.5	1.5
Ground limestone	0.5	0.5
Trace mineralized salt	0.5	0.5
Vitamin-mineral premix*	1.7	---
Cost per cwt.	$2.23	$2.11

* Premix provides 4 mgs. niacin, 5 mgs. pantothenic acid, 1.2 mgs. riboflavin, 200 mgs. choline, 10 mcgs. B_{12}, 180 I.U. vitamin D, 45 mgs. iron, 2 mgs. copper, 0.88 mgs. cobalt, 18 mgs. manganese, and 50 ppm. zinc.

Table 2.—Creep Rations for Pigs in 1961 Fall Confinement—Pasture Trial.

Ingredient	Confinement	Pasture
Corn	31.0	32.0
Milo	32.0	32.0
Soybean meal (44%)	13.0	13.0
Dried Buttermilk	10.0	10.0
Fish meal	6.0	6.0
Liquid molasses	5.0	5.0
Dikal	0.5	0.5
Ground limestone	0.5	0.5
Trace mineralized salt	0 5	0 5
Hygromix	0.25	0.25
Aurofac 10	0.25	0.25
Vit. A	0.05	0.1
Vit. and min. premix*	0.95	---
Cost per cwt.	$3.83	$3.83

* Premix provides 3 mgs niacin, 5 mgs. pantothenic acid, 1.2 mgs. riboflavin, 200 mgs. choline, 12 mcgs. B_{12}, 168 I.U. Vitamin D, 42 mgs. iron, 2 mgs. copper, 0.88 mgs. cobalt, 18 mgs. manganese, and 50 ppm. zinc.

litters at seven days of age were assigned to pasture and confinement treatments. The gilts were on test from the time each individual litter was seven days of age until weaning at 56 days. Confinement gilts raised their litters in individual pens in the farrowing barn. Each pen was equipped with a float type automatic waterer, a self-feeder for the gilt, and a creep area with feeder for the pigs. The pen area was 10 ft. by 12 ft. in the barn with a 6 ft. by 12 ft. concrete floor outside of the barn where the sow feeder was located.

Table 3.—Pigs Per Litter and Weights of Pigs and Gilts in Confinement —Pasture Trial, 1961 Fall.

	Confinement	Pasture	Diff.
Number of gilts	14	14	
Pigs per litter at 7 days	8.29	8.29	0
Pigs per litter at 21 days	8.00	7.14	0.86
Pigs per litter at 42 days	8.00	7.00	1.00
Pigs per litter at 56 days	8.00	6 93	1.07
% death loss, 7 to 56 days	3	16	—13
Wt. per pig at 21 days, lbs.	11.1	10.4	0.7
Wt. per pig at 42 days, lbs.	24 0	24.3	— 0.3
Wt. per pig at 56 days, lbs.	38.9	39.8	— 0.9
Avg. litter wt. at 21 days, lbs.	89 0	74.3	14.7
Avg. litter wt. at 42 days, lbs.	192.3	170.0	22.3
Avc. litter wt. at 56 days, lbs.	310.9	276.1	34.8
Gilt Weights in lbs.			
109th day of gestation	401	393	8
21 days after farrowing	374	376	— 2
42 days after farrowing	369	377	— 8
56 days after farrowing	355	379*	—24
Weight loss 109th day to 56 days	46	14	32

* One gilt not included that died on 54th day.

Two gilts and their litters were assigned to each of seven one acre lots on pasture. About one-half acre of each lot was in field peas. Each pasture lot had a self-feeder near an automatic waterer for the gilt and a creep pen and feeder in a movable house. All gilts were self-fed. When the pigs were two weeks old feed was placed in the creep feeders but none was consumed until after three weeks of age.

The number of pigs per litter and the weights of pigs and gilts is shown in Table 3. A greater death loss resulted among the pigs on pasture. Pasture averaged 6.93 pigs per litter at 56 days as compared to eight pigs per litter at the same age in confinement. There was little difference in the individual weights of the pigs. Confinement pigs were slightly heavier at 21 days, but at 56 days pasture pigs were slightly heavier. However, due to the lower death losses and larger litters, confinement litters were 35 lbs. heavier at 56 days than pasture litters.

Confinement gilts lost more weight than pasture gilts although the confinement gilts were thrifty and showed no evidence of stiffness or other undesirable leg conditions. All gilts were on pasture and fed the same ration during gestation. They were brought to the farrowing barn and weighed on the 109th day of gestation. From the 109th day of gestation to weaning of their litters at 56 days, the confinement gilts lost 46 lbs. as compared to a 14 lb. loss for the pasture gilts.

The amount of feed consumed and the feed costs for the gilts and litters are given in Table 4. Without allowing for the forage consumed by pasture gilts, the confinement gilts consumed more feed than pasture gilts. Confinement litters also consumed more creep feed (42 lbs.) than pasture litters, but because of the larger litters raised in confinement this difference was only 2 lbs. more per pig. Feed cost of the confinement gilts was $15.80 as compared to $13.67 for the pasture gilts. The cost of creep feed for confinement litters was $7.78 as compared to $6.17 for the pasture litters. Total cost of sow and creep feed per litter in confinement was $23.58 as compared to $19.84 on pasture —a difference of $3.74 in total feed cost without any charge for pasture. On an individual pig basis, however, the feed cost per pig raised in confinement was $2.95 as compared to $2.86 per pig raised on pasture.

Table 4.—Feed Consumption and Costs for Gilts and Litters in 1961 Fall Confinement—Pasture Trial.*

	Lbs. Feed Consumed			Feed Cost, $		
	Confinement	Pasture	Diff.	Confinement	Pasture	Diff.
Sow feed in lbs.						
0 to 7 days	30	30	0	0.63	0.63	0
7 to 21 days	177	156	21	3.95	3.29	0.66
21 to 42 days	322	263	59	7.18	5.55	1.63
42 to 56 days	181	199	—18	4.04	4.20	—0.16
Total	710	648	62	15.80	13.67	2.13
Avg. daily feed	12.7	11.6	1.1	0.28	0.24	0.04
Creep feed in lbs.						
7 to 21 days	0	0	0	0	0	0
21 to 42 days	50	53	—3	1.92	2.03	—.11
42 to 56 days	153	108	45	5.86	4.14	1.72
Total	203	161	42	7.78	6.17	1.61
Total feed per litter						
Sow feed	710	648	62	15 80	13.67	2.13
Creep feed	203	161	42	7 78	6.17	1.61
Total	913	809	104	23 58	19.84	3.74
Feed per pig weaned						
Sow feed	89	94	—5	1.98	1.97	0.01
Creep feed	25	23	2	.97	.89	0.08
Total	114	117	—3	2.95	2.86	0.09
Value of weight lost by sow**				6.44	1.96	4.48
Feed cost per pig plus credit for weight loss by sow				3.75	3.14	0.61
Iron injections per pig				.30	.00	

* Ration costs per cwt.

Confinement sow ration	$2.23
Pasture sow ration	$2.11
Confinement creep ration	$3.83
Pasture crop ration	$3.83

**Calculated at $14 per cwt.

There are two other cost items that should perhaps be charged to the pigs. One of these is the weight loss of the gilt. Charging the feed cost and the weight loss of the dam to each pig made the cost $0.61 more per pig raised in confinement than on pasture. A further charge of $0.30 per pig for iron injections should be made on confinement pigs. These pigs were given a 2 cc. injection of iron dextrin at three days of age and a 1 cc. injection at 21 days of age. Pasture pigs were not given iron dextrin injections. The cost of iron dextrin injections, differences in feed cost, and weight loss of gilt charged to the pigs made a total difference in the cost of raising pigs in confinement $0.91 more per pig than on pasture. This does not include any charge for pasture. If such a charge were made the difference would be considerably less and likely would be unimportant.

None of the differences in this 1961 fall trial were statistically significant. Comparable pigs were raised in confinement to those on pasture by fortification of the lactation sow ration and creep ration. Larger litters were raised in confinement, but confinement gilts consumed more feed and lost more weight than gilts on pasture.

1959-60 Growing-finishing Trials

A total of 240 pigs from three lines of breeding were used in three trials in 1959 and 1960 at Ft. Reno to compare the post-weaning performance of pigs fed a fortified, pelleted ration in confinement with those fed a simple, free-choice ration on pasture. Because of sickness or death, 17 of the 240 pigs failed to finish the test. The ingredients in the rations are given in Tables 5 and 6. Trials 1 and 2 were conducted in the spring and fall of 1959. Each trial had three pasture and three confinement lots of 12 pigs each. Trial 3 was conducted in the spring of 1960 with four pasture and four confinement lots, making a total of 10 lots of 12 pigs each on each treatment. In each trial the pigs were started on test at about 40 lbs. at 8 to 10 weeks of age. All pigs were handled alike on pasture prior to weaning at approximately eight weeks of age. An equal number of barrows and gilts were used from a Duroc line, a Hampshire line, and a Hampshire x Duroc-Beltsville No. 1 cross. Pigs were equalized on treatment by sex, weight, and line of breeding. They were weighed off test individually at weights of 198 lbs. or over on biweekly weigh days. The last pig in a lot was removed regardless of weight when the next to last pig reached 198 lbs. When weighed off test each pig was probed at four sites for backfat thickness. These sites were about 1½ inches on each side of the midline of the back at about the 5th rib and the 4th lumbar vertebra. These four probes on each pig were averaged and adjusted to a 200 lb. barrow equivalent. All barrows were slaughtered for carcass measurements, and, in addition, cut-outs were obtained on the barrows in the first two trials.

Table 5.—Pasture Ration for Growing-Finishing Pigs in 1959-1960 Trials. (Free Choice)

Ingredients	Percent of Mix
Shelled corn	100.0
Protein supplement mix	
Tankage	50.00
Soybean meal	25.00
Alfalfa meal	25.00
Mineral supplement mix	
Salt	33.3
Bone meal	33.3
Ground limestone	33.3

Table 6.—Pelleted Confinement Rations for Growing-Finishing Pigs in 1959-1960 Trials.

Ingredients	1st Month Ration	After 1st Month Ration
Ground Corn	38.00	41.00
Ground Milo	38.00	41.00
Soybean Meal	13.00	10.00
Meat and Bone Scraps	5.00	3.00
Alfalfa Meal	3.50	3.00
Dikal	1.00	1.00
Trace Mineral Salt	.50	.50
Vitamin-Antibiotic pre-mix	.75	.50
Hygromix	.25	--
TOTAL	100.00	100.00

The confinement lots had concrete floors with a 10 by 10 ft. area inside the barn and a 10 by 12 ft. area outside of the barn. Self-feeders and automatic waterers were located inside the barn. A mist type sprinkler under a shade outside of the barn was used during the summer.

Each pasture lot for 12 pigs averaged 1½ acres in size and had an automatic waterer and self-feeder with compartments for shelled corn, protein supplement, and mineral supplement. Movable houses were used for shelter in both summer and winter. In the first trial in the summer of 1959, an old alfalfa field was used for pasture. Although this was a thin stand, there was ample alfalfa pasture for the pigs. In the winter of 1959 excellent wheat pasture was used. In the summer of 1960 about half of each lot was planted in oats, for grazing during April and May, and the other half was planted in sudan for summer grazing. Pasture lots were rotated and no lot was used more than once in these trials.

Table 7.—Confinement Vs. Pasture Systems for Growing—Finishing Pigs, 1959, 1960 Trials.

	Confinement	Pasture	Difference
Number of pigs	113	110	
Avg. initial wt., lbs.	43.0	42.9	0.1
Avg. final wt., lbs.	206.0	201.4	4.6
Avg. daily gain, lbs.	1.62	1.32	0.30
Feed per 100 lbs. gain	320.0	338.0	—18.0
Feed cost per 100 lbs. gain, $	10.61	7.94	2.67
Probed backfat thickness, in.	1.57	1.45	0.12
No. carcasses measured	55	53	
Carcass backfat, in.	1.55	1.47	0.08
Carcass length, in.	29.5	29.8	—0.3
Loin eye area, sq. in.	3.53	3.33	0.20
No. carcasses cut	32	30	
Dressing %	72.0	70.4	1.6
% ham	12.7	12.8	—0.1
% loin	10.4	10.4	0
% shoulder	11.4	11.6	—0.2
% belly	13.0	11.7	1.3
% lean cuts (ham, loin, shoulder)	34.5	34.7	—0.2
% primal cuts	47.4	46.4	1.0

Confinement pigs gained .3 lbs. per day faster than pasture pigs and required 18 lbs. less feed per 100 lbs. of gain (Table 7). The confinement ration, however, cost $0.93 per hundred more than the pasture ration so that the cost of 100 lbs. gain in confinement was $2.67 more than on pasture. The confinement ration was a complete pelleted ration delivered to the station in 50 lb. bags. The average cost of the ration as consumed was $3.28 per hundred lbs. The simple, free-choice ration had no processing charge, as the corn was not ground and the supplements were mixed on the farm. The cost of this pasture ration as consumed was $2.35 per hundred lbs. In comparing the two rations on the basis of the cost of ingredients, the cost per cwt. of the confinement ration was $2.47, which made it only $0.12 higher than the pasture ration. The major difference in the cost of the ration was in the processing and handling charges.

Pasture pigs were slightly leaner than confinement pigs as shown by .12 inch less probed backfat on all pigs and .08 inch less carcass backfat on the barrows. Pasture pigs also had longer carcasses, but confinement pigs had larger loin eyes, a higher dressing percent, and a higher yield of belly. There was no difference in the yield of lean cuts (expressed as a percent of the live weight off test), but confinement pigs produced a one percent greater yield of primal cuts.

An interesting observation provided by these trials was the opportunity to compare response of the three lines of breeding to the two management systems. Although the three lines in these trials were quite different in most traits studied, they responded in a similar manner to the two managements. The non-significance of these line of breeding-management interactions indicated that the best performing line under one set of environmental conditions was also the best under the other set of conditions.

In summary, pigs fed on concrete floors in confinement gained faster, required less feed per lb. of gain, had more backfat, larger loin eye area, heavier bellies, higher dressing percent, and a higher yield of primal cuts than pigs fed a simple, free-choice corn and supplement ration. These differences were statistically significant. The lower cost of the pasture ration made the cost per hundred lbs. gain considerably less on pasture than in confinement in these trials. Pigs fed on pasture were sounder on their legs and produced slightly leaner and longer carcasses than those raised in confinement.

Creep-Feeding Fall Calves

L. R. Kuhlman, A. B. Nelson, and W. D. Campbell

Creep-feeding is a method of increasing the gain and finish of suckling beef calves. One would expect creep-feeding to be of greater importance with fall calves than with spring calves because fall-calving cows nurse their calves during the winter when the dry forage of the native grass pastures is of lowest nutritive value. The milk production of these cows would be expected to be lower than if green grass were available unless the level of supplemental winter feeding was very high. Such high levels of feeding are costly.

Results of a four-year study (Okla. Agr. Exp. Sta. MP-55:72) indicated that creep-feeding fall calves nursing cows fed 1.5 lbs. of cottonseed meal per head daily increased calf gains 87 lbs., whereas providing high levels of supplemental feed for the cows (2.5 lbs. cottonseed meal and 3 lbs. grain per head daily) increased calf gains 52 lbs. These results suggest that increased levels of feed should be given to the calf rather than to the cow. Neither of these systems was as profitable as not creep-feeding and feeding the cows 1.5 lbs. of cottonseed meal per head daily. However, young cows will not perform satisfactorily when fed at such low levels. Creep-feeding only until spring grass becomes available may be a satisfactory practice. A high proportion of the gain resulting from creep-feeding occurred during the winter months while the largest proportion of creep-feed was consumed during the following summer.

Procedure

On December 12, 1960, 102 calves born in October and November were divided into six lots of 17 head. The calves remained with their dams, high quality grade Hereford cows, in native grass pastures. The cows were fed an average of 2.5 lbs. of pelleted cottonseed meal per head daily until April 14.

The calves in Lot 1 were not creep-fed. Those in Lot 2 were creep-fed a mixture consisting of 55 percent steam rolled milo, 30 percent whole oats, 10 percent cottonseed meal, and 5 percent cane molasses until weaning in July. The Lot 3 calves were creep-fed this mixture only until May 12. Calves in Lot 4 were fed the above mixture after grinding and pelleting. The calves in Lot 5 received alfalfa hay and those in Lot 6 received pelleted alfalfa hay. Creep-feeding of Lots 4, 5, and 6 was also discontinued on May 12.

Results

In the period from December 12 until May 12 all creep-fed calves gained more than the Lot 1 calves (see Table 1). The creep-fed calves in Lots 2 and 3 consumed an average of 320 lbs. of creep-feed and gained an average of 188 lbs. which is 50 lbs. more than the non-creep-fed calves.

In the 69-day period from May 12 until weaning (July 20), the calves receiving the creep mixture (Lot 2) gained 178 lbs. and those not previously creep-fed (Lot 1) gained 160 lbs. The total increase in gain (winter and summer) due to creep-feeding was 54 lbs. (Lot 1 vs. 2). In this year, as in the 1960 test, the value of the increased gain due to creep-feeding was not as great as the cost of the creep-feed; therefore, creep-feeding reduced profits. The two-year average increase in total gain due to creep-feeding the mixture was 64 lbs. (see Table 2). Again, the increased selling value of the creep-fed calves has not been as great as the cost of the creep-feed.

In the 1961 test, creep-feeding was discontinued in Lot 3 on May 12. From May 12 until weaning, the calves which had not received creep-feed (Lot 1) gained 18 lbs. more than the calves in Lot 3, which had received the concentrate mixture during the winter (Table 1). Thus, the 63-lb. weight advantage due to creep-feeding until May 12 was reduced to 45 lbs. by weaning. Although the calves in Lots 2 and 3 received identical treatment until May 12, one group gained 174 lbs. and the other 201 lbs. to that date. This difference in winter gain was reflected in the small difference (9 lbs.) in total gain. In the 1960 trial, the difference in total gain was 38 lbs. The two-year average difference in gain was 24 lbs. (Table 2) and the difference in creep-feed consumption was 619 lbs. Thus, stopping creep-feeding in May when green grass was available was the preferred practice.

Table 1.—Creep-Feeding Fall Calves, 1960-61.

Lot number	1	2	3	4	5	6
Creep-feed	None	Mixture[1] until weaning	Mixture[1] until spring	Pelleted mixture until spring	Alfalfa[2] hay until spring	Pelleted alfalfa hay until spring
Number of calves[3]	17	17	17	16	17	16
Avg. wt. per calf, lbs.						
Initial (Dec. 21, 1960)	135	134	135	136	136	137
Spring (May 12, 1961)	273	308	336	281	292	296
Weaning (July 20, 1961)	433	486	478	438	455	460
Gain to spring (142 days)	138	174	201	145	156	159
Gain, May to July (69 days)	160	178	142	157	163	164
Total gain (211 days)	298	352	343	302	319	323
Creep-feed per calf						
Pounds	---	775	311	71	108	259
Cost	---	$19.76	$7.93	$1.90	$1.36	$4.53
Dollar values						
Value of total gain	75.99	89.76	87.46	77.01	81.94	82.36
Value of gain minus creep-feed cost	75.99	70.00	79.53	75.11	80.58	77.83

[1] Creep-fed a mixture of 55 percent steam rolled milo, 30 percent whole oats, 10 percent cottonseed meal, and 5 percent cane molasses.

[2] Baled alfalfa hay fed in an open bunk.

[3] Originally there were 17 calves per lot. Two calves were removed from the experiment due to the death of the cow.

[4] Creep-feed mixture cost $2.55 per 100 lbs. The pelleted mixture cost $2.68 per 100 lbs. Alfalfa hay cost $25.00 per ton. Pelleted alfalfa hay cost $35.00 per ton.

Different creep-feeds were compared in Lots 3, 4, 5, and 6. In these lots creep-feeding was stopped on May 12 (Table 1). In the 142 days until spring, the average increase in gain over the non-creep-fed group was 7, 18, and 21 lbs. for the pelleted mixture (Lot 4), alfalfa hay (Lot 5), and pelleted alfalfa hay (Lot 6), respectively. Consumption of the mixture was decreased by pelleting. In this year an average of only 71 lbs. of pellets was consumed compared to 194 lbs. during the previous test. The two-year average total winter and summer gain of those fed the pelleted mixture was only slightly greater than the total gain of the Lot 1 calves.

Gains of calves creep-fed alfalfa hay and pelleted alfalfa hay were nearly equal in both periods. In the 1961 trial consumption of the pelleted alfalfa hay was greater than the 1960 trial, but consumption of the loose alfalfa hay was 200 lbs. less. This lower consumption was probably due to the poorer quality of the hay. The two-year average

Table 2.—Creep-Feeding Fall Calves (Two-year average).

Lot number	1	2	3	4	5	6
Creep-feed	None	Mixture[1] until weaning	Mixture[1] until spring	Pelleted mixture until spring	Alfalfa[2] hay until spring	Pelleted alfalfa hay until spring
Number of calves	34	35	34	34	34	33
Avg. wt. per calf, lbs.						
Initial	137	141	136	131	133	136
Spring	268	309	322	278	284	294
Weaning	427	495	466	432	442	447
Gain to spring	131	168	186	147	151	158
Gain, spring to weaning	159	186	144	154	158	153
Total gain	290	354	330	301	309	311
Creep-feed per calf						
Pounds	---	894	275	132	208	242
Cost[3]	---	$21.40	$6.96	$3.47	$2.22	$3.94
Dollar values						
Value of total gain[3]	73.25	88.48	83.48	76.13	78.22	78.68
Value of gain minus creep-feed cost	73.25	67.08	76.52	72.66	76.00	74.74

[1] Creep-fed a mixture of 55 percent steam rolled milo, 30 percent whole oats, 10 percent cottonseed meal, and 5 percent cane molasses.
[2] Baled alfalfa hay fed in an open bunk.
[3] Based on prices current when the two tests were conducted.

increase in gain due to creep-feeding an average of 208 lbs. of alfalfa hay was 20 lbs. Feeding alfalfa hay in either form was slightly more profitable than not creep-feeding.

Summary

In a two-year test with fall calves, creep-feeding a concentrate mixture until spring increased gains an average of 46 lbs. (137 vs. 168 and 186 lbs.). The winter gains of calves creep-fed long alfalfa hay and pelleted alfalfa hay were nearly equal and were an average of 18 lbs. greater than the gain of calves not creep-fed. Feed consumption of the pelleted mixture was low and resulted in only an 11 lbs. increase in gain compared to the non-creep-fed calves. During the summer, creep-feeding the mixture increased gains 27 lbs. when compared to Lot 1 calves. When creep-feeding was discontinued in the spring, calves previously creep-fed the concentrate meal mixture gained an average of 15 lbs. less during the summer than the non-creep-fed calves. The value of the calf gain minus the cost of the creep-feed was lowest when the calves were creep-fed until weaning, highest when creep-fed the mixture until spring, second and third highest when fed alfalfa hay in the different forms, and intermediate and nearly equal for not creep-feeding and for creep-feeding the pelleted mixture.

Stilbestrol Implants for Fall Calves

A. B. Nelson and L. R. Kuhlman

Stilbestrol implantation of beef cattle has been used in many management systems. Both feeding and implantation of stilbestrol have been generally accepted as means of increasing live weight gain and feed efficiency. The response to stilbestrol administration is considerably less for cattle fed for little or no gain such as is found under many wintering conditions. Stilbestrol has increased gains of yearling steers grazing native grass during the summer.

Tests at Oklahoma and at least 10 other experiment stations have shown that the weight gain of suckling calves can be increased by the use of stilbestrol implants. In our 13 tests with spring calves, the average increase in gain has been 29 lbs. An implant of 12 mg. has been accepted as standard for suckling calves. At this level certain calves may exhibit side effects such as high tail-heads and elongated teats. Also, noticeable swelling of the external genitalia of heifers has been reported. In current tests the value of stilbestrol implants for fall calves is being studied. A level of 6 mg. of stilbestrol is being tested to determine if it will result in increased gains without producing any noticeable side effects in some of the calves.

Procedure

A total of 272 calves born in October, November, and December has been used in four trials to study the value of ear implants of 6 mg. and 12 mg. of stilbestrol. The cows were high quality grade Herefords which were allowed to graze the native grass pastures yearlong. The cows and calves were also used in different nutrition and management studies at the Lake Blackwell experimental range area. In the first year, one-half of the calves were creep-fed and the cows were fed at a high or low level of supplemental winter feed. During the other three years all cows were fed an average of 2½ lbs. of pelleted cottonseed per head daily during the winter. In the second trial, one-fourth of the calves were creep-fed until weaning and the remaining three-fourths were creep-fed only until spring. In trials three and four one lot of calves was not creep-fed, one lot was creep-fed until weaning, and three lots were creep-fed only until spring. Within each of the feeding treatments within each year, calves of like sex were divided into lots. Those in Lot 1 served as controls. There was no Lot 2 in the first trial. In the remaining trials the calves in Lot 2 were implanted with 6 mg. of stilbestrol. In all four trials the calves in Lot 3 were implanted with 12 mg. of stilbestrol.

The calves were weighed and those in Lots 2 and 3 were implanted in March or April. They were left with their dams in native grass pastures, weighed every month, and weaned in July of each year.

Table 1.—Stilbestrol Implants for Fall Calves.

Lot Number Stilbestrol Implant, mg[1]	1 0	2 6	3 12
		Steers	
Number of calves	62	39	55
Average gain per calf, lbs.			
1958 (98 days)	233	---	260 (27)[2]
1959 (108 days)	224	240 (16)	240 (16)
1960 (128 days)	240	245 (5)	253 (13)
1961 (97 days)	214	230 (16)	231 (17)
4-year average	228		246 (18)
3-year avg. (1959-61)	226	238 (12)	241 (15)
		Heifers	
Number of calves	40	38	38
Average gain per calf, lbs.			
1959 (108 days)	191	208 (17)	222 (31)
1960 (128 days)	224	221 (-3)	240 (16)
1961 (97 days)	207	218 (11)	212 (5)
3-year average	207	216 (9)	225 (18)

[1] Implants furnished by Charles Pfizer and Co., Terre Haute, Indiana.

[2] Figures in parentheses are increased gain of implanted calves compared to those not implanted.

Results

The response to stilbestrol implants has been nearly the same for both sexes (Table 1). The greatest increase in gain occurred in the first trial where only steers were implanted. This 27 lbs. was a 11.6 percent increase. The gains of steers have been increased an average of 18 lbs. or 7.9 percent in the four trials. During the last three trials, level of implant was studied and the increased gain of the steers was nearly equal for both levels. The 6 mg. implant increased gains 12 lbs. (5.3 percent) and the 12 mg. implant increased gains 15 lbs. (6.6 percent).

The average increase in gains of heifers was 9 lbs. (4.3 percent) for the 6 mg. implant and 18 lbs. (8.7 percent) for the 12 mg. implant. These increased gains are considerably less than the 29 lbs. or 12.6 percent increases for spring calves which were recorded in earlier tests.

Observations as to general appearance of the calves were recorded. The implanted calves were given a slightly higher average feeder grade. There were no noticeable side effects in those calves implanted with 6 mg. of stilbestrol. Some of the calves implanted with 12 mg. were identified as having increased teat length, elevated tailheads, or swollen vulva. However, many calves which were not implanted were identified by experienced cattlemen as having noticeable side effects.

As was found with spring calves, the implantation of suckling calves did not have any detrimental effect on subsequent feed-lot gains. The two-year average 128-day feed-lot gains were 267, 262, and 265 lbs. for those not implanted as calves, those implanted with 6 mg. of stilbestrol and those implanted with 12 mg., respectively. All calves were implanted with 24 mg. of stilbestrol at the beginning of the feedlot period.

Summary

Weight gains of fall calves have been increased an average of 10 lbs. by implanting with 6 mg. of stilbestrol and 18 lbs. by implanting with 12 mg. of stilbestrol. There was only a small difference in gain response of steers and heifers. Implanting calves did not have any detrimental effect on subsequent feed-lot gain.

Carcass Composition as Influenced by Animal Age[1]

R. L. Henrickson, Bill Blackmon, and Kenneth Urban

Introduction

The age of the beef animal at slaughter is an important feature influencing carcass composition. At birth, the carcass possesses a high percentage of lean with little fat. However, as age advances, the percent lean decreases and fatty deposition increases. Since lean (muscle) is the principle product of the beef industry, effort should be made to slaughter the animal at a time when muscle development is at its maximum. This would seem to be at an age when the animal slows down in muscle development and fat deposition tends to be more rapid. Generally, lean meat is produced more efficiently than fat. However, the age at which maximum muscling and efficiency of growth occur is not generally known.

Some evidence tends to indicate that all parts of the animal body do not mature at the same rate. Consequently, muscular development of the various wholesale cuts can be reached at different age levels. One may conclude that the most appropriate age to slaughter would be when the majority of the high priced cuts reach a point of maximum development or maximum development which is economically feasible.

This report is devoted to providing information on the absolute and relative differences which exist in carcass composition between young females and their aged counterpart. A comparison of data from animals varying in age should provide information for a sounder approach to more detailed research related to the optimum slaughter age.

[1] Financed in part by a contract from the Agricultural Marketing Service, United States Department of Agriculture.

Procedure

Sixteen (16) Hereford females of four different ages were used. Carcasses included are those which by visual appraisal had or approached a marbling score of "slight amount", as determined by an official meat grader of the United States Department of Agriculture. The 18-month-old cattle averaged slightly greater than the desired marbling score, while those at 6-months were slightly under the desired marbling level. The 18-, 42-, and 90-month age groups received similar nutrition and management. They were pastured on native grasses and supplemented *ad libitum* with cottonseed hulls and milo. The 6-month-old calves were creep-fed a ration consisting predominantly of ground milo, while obtaining milk from nurse cows that were on dry pasture.

Slaughtering and cutting were done following the recommended research procedures. Both sides of the carcasses were divided into wholesale cuts and each cut weighed to the nearest one-tenth pound. Percent high priced cuts were calculated by combining the weights of the round, rump, loin, and rib from both sides of the carcass. All percentage figures are expressed as a percent of the chilled carcass weight.

Physical separation of the 9-10-11th rib sections were made. The composition of this portion of the carcass was then used to estimate the composition of lean, fat, and bone in the carcass. Rib sections from both sides were separated to reduce possible error that may have resulted from splitting the carcass.

Results and Discussion

A review of these data points out the fact that dressing percent will increase with advancing age when all animals are kept at a comparable degree of marbling. The greatest change occurred between six and 42 months of age.

Age at slaughter did not greatly influence the percent of high priced cuts but did have a significant effect upon the percent hindquarter. As shown in Table 1, the percent hindquarter decreased with advancing animal age. A difference in the percent round (rump on) was also found to be significant. Calf carcasses were found to have the highest percent round with a progressive decline with advancing age.

A highly significant difference in percent loin was found. Changes in percent loin favored an increase with advancing age. The difference in percent rib was not great, but some increase was evident as age advanced.

These data pointed out that the percent chuck from the 90-month old cows was slightly greater than in the other three age groups. The percent chuck for the 6-, 18-, and 42-month age groups increased with animal age, but the difference was small.

Table 1.—Percentage Difference in Various Cuts as Influenced by Animal Age.[1]

Age mo.	Hind Quarter	High Priced	Round[2]	Loin	Rib	Chuck
6	50.4	47.1	25.3	13.8	7.9	24.1
18	49.1	46.8	23.4	15.0	8.4	24.5
42	48.5	46.7	23.8	14.4	8.5	24.8
90	47.8	46.4	22.0	15.7	8.7	26.1

[1] Marbling levels similar.
[2] Rump is included with the round.

The percentage of lean meat in the carcass tended to decrease as the age of the animal advanced (Table 2). It is of interest to note that approximately 50 percent of the carcass is actually edible red meat. When expressed in terms of pounds, the total amount of lean does increase, but the quantity is relatively small once the animal reaches 42 months of age. The cost involved in obtaining these extra pounds would determine the desirability of feeding at such advanced age levels. These data further point up the fact that additional work is needed to determine the age at which the beef animal ceases to provide maximum muscular development which is economically feasible. Rate of gain in some cattle indicate that maximum growth may occur prior to one year of age.

The percentage of fat increases quite rapidly with advancing age. This further indicates that the total fatty composition of the carcass is not directly associated with marbling as appraised in the rib eye. This fact would permit rapid progress in selecting against the undesired fat cover.

Meat or muscle development must be bred into cattle. The size of a muscle is influenced to a great degree by the number of fibers in the muscle. Ample research evidence now indicates that the number

Table 2.—Differences in Carcass Composition as Influenced by Animal Age.

Age	Pounds in Carcass[2]			Percent in Carcass[1]			Loin Eye
mo.	Lean	Fat	Bone	Lean	Fat	Bone	Area
6	146.8	91.3	35.7	55.2	32.3	13.0	5.9
18	234.2	172.9	59.2	51.4	35.7	12.9	9.2
42	361.6	250.5	85.0	50.3	37.4	12.5	11.2
90	370.1	319.8	87.5	48.6	39.7	11.8	11.7

[1] Estimated from the 9-10-11th rib separation.
[2] Calculations based on the carcass weight and the estimate obtained from the 9-10-11th rib section.

of muscle fibers is determined when the egg cell is fertilized. Consequently, good feeding or management practices can only exploit the potential muscular development. It is quite evident then, that the cows and bulls used for breeding purpose must have the potential for transmitting these muscle development characteristics.

Aside from visual appraisal, one may use carcass indices for appraising muscle development. Size of the loin eye muscle is one of the practical indications of the degree to which muscle has development. A correlation of .85 between the surface of the eye muscle and the separable lean in the carcass has been reported to exist. Heritability estimates have been reported to account for three-fourths of the variation in the size of the loin eye muscle. Consequently, the surface area of the loin muscle of animals at a given age may serve as a production tool.

The loin eye size is also influenced by animal age. Evidence in Table 2 indicates that the loin eye area increased rather rapidly up to 42 months with little increase between 42 and 90 months. This would indicate that maximum muscular development would likely occur prior to the time the animal reaches 42 months. These and other data indicate that such a point occurs between 12 to 18 months. Breed and animal differences will cause some variation. Further work is now planned to investigate the rate of muscle development as influenced by age.

The Growth and Development of Beef Calves From Weaning to Slaughter Weight with Reference to the Effect of Plane of Nutrition

J. J. Guenther, L. S. Pope,
G. V. Odell, and R. D. Morrison

During the last decade, advances in our living standards, working conditions, human nutrition, and medical science have brought about drastic changes in the eating habits of most Americans. As far as the livestock industry is concerned, the most important of these changes has been the great "purge" of fat from our diets—particularly animal fats. The "modern" consumer is demanding, and getting, retail cuts with an absolute minimum of waste or external fat. The retailer, in turn, is exerting considerable pressure upon meat packers to supply him with trim wholesale cuts and the packer, naturally, is letting this pressure fall squarely on the shoulders of the producer. Consequently, today's cattleman is faced with the task of producing (economically) the kind of cattle that still yield high percentages of high priced, high quality, tender, flavorful, juicy retail cuts; but that have only small amounts of "waste" fat trim.

These circumstances have pointed up the need for more basic information concerning the effects of various breeding and feeding practices. In order to effectively cope with today's production problems, it is imperative that we obtain more fundamental information on the growth, development, and deposition of the major carcass tissues throughout the growing period of the beef calf. First we need to know how and when these tissues (muscle, fat, and bone) are being developed in the beef animal and then we must develop techniques to control them to produce the type of cattle demanded by present day and future markets.

Research is currently under way at the Oklahoma Agricultural Experiment Station to obtain such information. The following data represent a portion of the initial results of this study.

Procedure

Twenty closely related Hereford steer calves were used in the initial test. Calves were sired by two half-brother bulls and were selected on the basis of age and productivity of dam, weaning weight and age, and weaner grade. All calves were individually fed a standard fattening ration throughout the study. The high level calves received as much feed as they would consume, while those on the moderate level were fed to gain about 1.3 lbs. per day. Four calves each were randomly assigned to one of the following treatment lots:

Lot W—These calves were slaughtered at weaning and data obtained were used as a baseline for subsequent growth and development comparisons.

Lot H-1—Fed on a high plane of nutrition to make 200 lbs. post-weaning gain, then removed and slaughtered.

Lot M-1—Fed at a moderate rate. These calves were removed from the test and slaughtered at the same time as those from from Lot H-1.

Lot H-2—Fed on a high plane to make 400 lbs. post-weaning gain.

Lot M-2—Fed at a moderate rate and removed from test with the H-2 calves.

Nutritional data obtained were: feed consumption; average daily gain, and efficiency of feed conversion. Slaughter and carcass data included: weight of dress off items; stomach compartments and internal fats; dressing percent; grade; marbling scores; ribeye area; fat cover; cutout and specific gravity; and chemical chomposition of all wholesale cuts.

Results

The average carcass quality data and feed conversion results are given in Table 1. Calves on the high plane of nutrition (Lots H-1 and H-2) were considerably heavier than the M-1 and M-2 calves when slaughtered. Consequently, their carcasses were, on the average, 50 and 86 lbs. heavier than the M-1 and M-2 chilled carcasses. This is reflected by the differences in average daily gains of the two groups, 1.53 and 2.07 lbs. respectively, for the high level calves. Though these differences were small, small differences here can account for large differences in total carcass weight.

Carcass grade of the high level steers was increased by one full unit at the H-2 period, i.e., from average standard to average good; whereas no grade change was encountered feeding calves at the moderate level.

Another important factor in evaluating carcass quality is the marbling content. In this respect, results indicate that the H-2 calves increased three full units (practically devoid to small), while the M-2 steers showed only one unit of increase. Since under present federal grading standards marbling plays such an important part in final grade determination, it is apparent that beef calves must be full-fed during the early periods of life if maximum marbling (hence grade) is to be attained at an early age.

Ribeye area, which is indicative of muscle development, was greater for the faster gaining steers. These data also point out that the ribeye muscle develops at its maximum rate during the early part of the calf's life—a fact that should be exploited.

Table 1.—Average Carcass Data and Feed Conversion

	Weaning	High-1 W+200	Mod-1	High-2 W+400	Mod-2
No. of Steers/Treatment	4	4	4	4	4
Age at Slaughter (days)	261	403	390	452	447
Weight at Slaughter	491	716	631	880	738
Carcass Weight	265	424	374	527	441
Average Daily Gain	1.88	1.53	1.08	2.07	1.18
Chilled Carc. lbs/day age	1.02	1.06	0.98	1.17	0.98
Carcass Grade	Avg Std	Low Good	Low Std	Avg Good	Avg Std
Marbling Score	Pract. Devoid	Slight	Traces	Small	Traces
Area of Ribeye[1]	6.47	8.19	7.91	9.14	8.81
Average Fat Cover[2]	1.52	1.00	0.62	1.47	0.77
Lbs Feed/lb Gain	---	12.10	11.00	10.10	11.60
TDN/lb Gain	---	7.93	7.16	6.58	7.60

[1] Square Inches-Average Right and Left Side.

[2] Inches-Average Three Measurements on Right and Left Side.

No great differences were noted in efficiency of feed conversion, however, the H-2 calves appeared to require less TDN per pound gain than did the moderates.

The weight of various dress-off items together with the overall skeletal growth and development data are presented in Table 2.

Table 2.—Average Slaughter Data and Carcass Measurements

	Lot W Weaning	Lot H-1 W+200	Lot M-1	Lot H-2 W+400	Lot M-2
Head Weight	18.2	25.2	24.2	28.9	26.9
Hide Weight	41.2	66.5	58.2	75.4	70.4
Shank Weight	10.4	13.9	13.2	16.0	14.8
Total Stomach Weight	61.1	84.4	66.9	99.5	75.7
Internal Fats[1]	14.0	26.8	16.1	41.6	25.4
Length of Body[2]	39.9	43.8	43.1	44.8	44.5
Length of Leg[2]	25.5	28.0	28.0	29.0	28.4
Length of Loin[2]	21.5	23.1	23.2	24.3	23.7
Chest Depth[2]	13.4	15.1	15.0	16.1	15.6
Width of Shoulder[2]	4.6	7.2	6.8	8.1	7.3
Width of Round[2]	5.2	7.8	7.5	8.3	7.7
Length of Cannon Bone[2]	6.67	7.53	7.57	7.58	7.58
Area of Cannon Bone[3]	1.09	1.22	1.17	1.50	1.41
Weight of Cannon Bone	3.07	3.50	3.33	4.05	3.84

[1] Kidney knob, Caul, Ruffle, and Channel fat.
[2] Measured in inches.
[3] Square inches.

On a percentage basis, calves fed at a moderate rate tended to have larger heads and shanks, but less internal fats. Little difference was noted in percent hide or total stomach; however, rumen development appeared to favor the full-fed animals.

Plane of nutrition had little affect on the linear skeletal growth. Results show that skeletal development proceeded at a maximum rate until 200 lbs. post-weaning gain (10-11 months of age), but after this time little increase in size was noted. This does not mean that bone ceases to grow after this particular age period, for such is not the case. An examination of the cannon bone data in Table 2 shows very clearly that while bone stops increasing in length at the 10-11 month period, it certainly continues to develop in thickness and in weight. This may be an important consideration in long term grain-grazing operations.

The data in Table 3 depict the general carcass development from the standpoint of wholesale cut yield. These cuts are grouped into five "Top Line Cuts" and five "Bottom Line Cuts". The high gaining calves showed greater development in all cuts, but particularly so in the rib, loin, rump, flank, plate, and brisket.

Table 3.—Average Yield of Wholesale Cuts and Chemical Composition of Carcass

	Lot W Weaning	Lot H-1 W+200	Lot M-1	Lot H-2 W+400	Lot M-2
"Top Line Cuts"					
Chuck	66.6	105.3	96.3	132.4	118.1
Rib	21.7	36.3	32.1	45.8	35.9
Loin	43.5	69.1	62.8	85.7	69.5
Rump	13.7	22.5	19.3	26.8	22.6
Cushion Round	44.4	62.7	58.8	70.5	65.9
"Bottom Line Cuts"					
Hind Shank	15.2	20.6	19.1	24.4	21.7
Flank	10.4	18.3	14.1	27.7	18.9
Plate	18.4	31.6	25.8	43.2	30.6
Brisket	11.9	22.6	19.7	30.5	21.3
Fore Shank	14.6	19.8	18.8	22.9	21.3
Carcass Composition[1]					
Moisture	132.0	189.9	176.1	224.0	206.8
Ash	1.8	2.6	2.4	2.9	2.5
Fat	29.3	78.7	56.8	122.3	65.6
Protein	35.1	53.5	49.0	63.7	57.8
Bone	49.2	65.5	61.5	74.0	69.8

[1] All data in total pounds.

Table 3 also shows the carcass composition in terms of total pounds of moisture, ash, fat, protein, and bone produced. These data further point out that the maximum rate of lean development occurred during the first 200 lbs. of post-weaning feed lot gain.

Summary

Results indicate that perhaps the most important period in the growth and development of the feeder calf is during the first 200-250 lbs. post-weaning gain. It is during this time that the beef calf attains its greatest potential skeletal size. Maximum rate of lean production also occurs during this period. These results suggest that beef calves must be full-fed during the early periods of life, if maximum marbling and carcass grade are to be realized.

Feedlot Performance and Carcass Composition of Slaughter Cattle as Affected by Winter Feed Level of Their Dams

D. O. Pinney, L. S. Pope,
L. E. Malkus, and Dwight Stephens

While many experiments have been conducted on the effects of low or high planes of nutrition after weaning on the growth and development of the beef calf, limited data are available on the effects of feed level prior to weaning.

The performance of a beef calf after weaning may be critically affected by the plane of nutrition imposed from fetal stage to weaning due to poor feeding and management of the dam.

Thousands of lightweight and undernourished stocker calves from dams which have been poorly fed and managed are purchased each year for winter pasture and fattened out later in Oklahoma. To what extent their development is retarded by poor planes of nutrition prior to weaning has not been established.

In British experiments, beef calves fed poorly to approximately eight months of age failed to recover from this stunting effect until two years of age.[1] In studies at South Dakota, calves from cows on a low plane of nutrition due to heavily grazed pastures were not equal to well-fed calves at 18 months of age.[2] Hence, the effect of stunting a beef calf prior to weaning may be more severe than a low plane of nutrition imposed during the first winter after weaning at eight months of age.

Plan of Experiment

Two pilot studies have been initiated at the Oklahoma Experiment Station to study this problem. In the fall of 1960, 12 weaner heifer calves were selected from the Ft. Reno herd; six from first calf two-year-old heifers wintered at a Low Level the previous year and six from similar heifers wintered at a High level. The calves were selected to be as near alike as possible on the basis of age and sire, although an 18-day difference in age existed in favor of those out of better fed dams. Following a 158-day growing period after weaning, the calves were gradually worked up full-feed on a fattening ration and then placed on self-feeders containing 50 percent ground milo, 8 percent dehydrated alfalfa meal, 8 percent cottonseed meal, and 8 percent molasses. The remaining 26 percent consisted of cottonseed hulls, calcium carbonate, salt, and a vitamin A concentrate. A two parts salt and one part steamed bone meal mineral mix was also available, free choice. The feedlot per-

[1] Brookes and Hodges, J. Agri. Sci. Vol. 53, Part 1, p. 78.

formance of calves out of Low vs. High plane heifers was observed for an additional 160 days on this ration. Cattle in both groups were slaughtered at 17 months of age and a detailed study was made of the carcass. In addition to the many measurements taken on the carcass itself, a complete separation of one side was made into lean, fat, and bone components.

In the fall of 1961, a group of 14 steer calves out of Low or High plane dams were started on test. These calves, which differed an average of 65 lbs. at weaning, were placed on full-feed after a one month post-weaning adjustment period. The fattening ration is similar to the one described for heifers. These calves have now been on feed approximately 115 days and will be slaughtered in early summer on a weight-constant basis.

These two trials are merely exploratory studies and will be followed by more extensive tests in which the effects of pre-weaning planes of nutrition during this sensitive growth period will be investigated.

Results

The results of the first trial with heifer calves are summarized in Table 1. Note that the different planes of nutrition of their dams resulted in a difference of 121 lbs. in average weaning weights. Low level dams lost 266 lbs. or 35 percent of their fall weight to spring, whereas High level dams lost only 15 percent of their fall weight the previous winter. Other data indicates that such excessive winter weight losses of young females, as occurred on the Low level, will reduce the birth weight and subsequent milk flow of the dam, even on good summer pasture.

During a post-weaning growth phase of nearly five months, a further rate of gain advantage was shown for calves out of High level dams. In contrast, during the next phase on fattening rations, calves from Low level dams out-gained those from better wintered females, a tendency expected by most cattlemen. Nevertheless, at slaughter age (17 months of age), the effect of pre-weaning plane of nutrition was still evident among calves from Low plane females which weighed 85 lbs. less than those out of High level dams. Calves of Lot 1 were considerably more efficient during the growing-fattening phase, however, requiring only 83 percent as much feed per pound of gain after weaning.

Marked differences were evident in height, length of body, width, and heart girth at weaning between calves of the two groups. These differences were much reduced by slaughter time as evidenced by the measurements taken on the live animal. Perhaps more accurate were the measurements taken from the carcass which indicate that these differences were slight although the trend in favor of Lot 2 calves was still evident in all measurements. It is probable that if both groups had been continued on feed for a longer time, such differences might have disappeared entirely.

Table 1.—Subsequent Feedlot Performance and Carcass Composition of Beef Heifers As Affected by Pre-Weaning Treatment of Their Dams.

Winter treatment of dams	Lot 1 Low	Lot 2 High	Difference in favor of Highs
No. of heifers	6	6	
Winter wt. loss of dams, lbs.	266	88	—178
Winter wt. loss of dams as % of fall wt.	35	15	
Pre-weaning performance of calves:			
Avg. birth wt., lbs.	51	66	15
Avg. weaning wt., lbs.	287	408	121
Avg. daily gain, birth to weaning, lb.	1.21	1.56	0.35
Feedlot performance of calves:			
Avg. daily gain, lbs.			
Growing period, 158 days	1.26	1.35	0.09
Fattening period, to 17 mo. age	1.61	1.52	—0.09
Total post-weaning period	1.43	1.42	—0.01
Final slaughter wt., lbs.	701	786	85
Feed required per lb. gain, lbs.	8.93	10.71	—1.78
Live animal and carcass measurements (inches):			
Height at withers—at weaning	35.6	38.7	3.1
at slaughter	42.2	43.7	1.5
Length of body—at weaning	35.3	40.3	5.0
at slaughter	46.8	48.2	1.4
Width at hooks—at weaning	10.7	12.7	2.0
at slaughter	17.4	18.3	0.9
Hearth girth—at weaning	43.8	49.8	6.3
at slaughter	64.6	68.0	3.4
Carcass measurements (inches):			
Carcass length[1]	42.8	43.4	0.6
Length of rear leg[2]	26.8	27.4	0.6
Length of loin	22.8	23.5	0.7
Depth of body	14.2	14.5	0.3
Width of round	16.8	17.0	0.2
Carcass grade and composition data:			
Live slaughter grade[3]	7.0	6.1	—.9
Avg. carcass grade[3]	6.75	6.5	—.25
Dressing percent	63.7	65.1	1.4
Marbling score[4]	7.8	7.7	
Cut-out value[5]			
Lean, lbs.	227	255	28
Fat, lbs.	159	185	26
Bone, lbs.	61	72	11
Shear value (longissimus dorsi), lbs.	16.3	18.5	—2.2

[1]Distance from anterior part of first rib to aitch bone.
[2]Distance from aitch bone to furtherest point of metatarsal.
[3]Low choice = 6.0, top good = 7.0.
[4]Scored on basis of 1-12, 1 most abundant.
[5]Determined by complete separation of one side of carcass.

Of most interest in this pilot study was the effect on the carcass. Even though the animals had been treated similarly since weaning and were all slaughtered at 17 months of age, live slaughter grades were approximately one-third grade higher for the heifers out of the High plane cows. Carcass grades also favored the Lot 2 calves. Dressing percent and marbling scores again indicated a greater degree of fatness for Lot 2 calves.

Marked differences were apparent in the actual amount of various tissues obtained, calculated from the physical separation of one side of each carcass. An average of nearly 28 lbs. more lean, 26 lbs. more fat, and 11 lbs. more bone were recovered from Lot 2 calves. Hence, a retardation in growth and development between conception and weaning was still evident in actual yield of body tissues at 17 months of age. However, shear value results indicated that degree of tenderness favored the Lot 1 calves.

In the second trial, now in progress, steer calves from first-calf, two-year-old heifers on Low vs. High levels have been full-fed since weaning for approximately 115 days. A difference of 188 lbs. in winter weight loss of their dams (29 vs. 5 percent of fall weight to spring after calving for Low vs. High dams) resulted in 7 lb. lighter birth weights and 65 lb. lighter weaning weights for the Low plane calves. The average daily gain from birth to weaning was 0.29 lbs. less for the calves from Low as compared to High level dams. Average daily feedlot gains have favored Lot 2 calves, out of better-fed dams, by 0.10 lb., but with 5.6 percent more feed required per cwt. gain. These calves will be slaughtered on an equal-weight basis, starting in June, 1962.

Table 2.—Subsequent Feedlot Performance of Steer Calves From Dams Wintered at Low or High Nutritional Levels

Winter treatment of dams	Lot 1 Low	Lot 2 High	Difference in favor of Highs
No. of steer calves	8	6	
Winter wt. loss of dams, lbs.	227	39	—188
Winter wt. loss of dams as % of fall wt.	28.6	4.8	
Pre-weaning performance of calves:			
Avg. birth wt., lbs.	59.8	67.0	7.2
Avg. weaning wt., lbs.	361	426	65
Avg. daily gain, birth to weaning, lbs.	1.44	1.73	0.29
Feedlot performance of calves: (115 days)			
Avg. daily post-weaning gain, lbs.	2.24	2.32	0.10
Feed required per lb. gain, lbs.	7.55	7.97	—0.42

Summary

In two pilot trials, weaner calves out of two-year-old dams which had been wintered at either Low or High feed levels have been fattened out in drylot to study the effects of pre-weaning nutritional levels on subsequent gains and carcass composition.

Results from the first trial with heifer calves, which differed on the average by 121 lbs. at weaning, show a tendency for Low plane calves to recover in the 10-month post-weaning period. At 17 months of age, however, the yearling heifers still differed by 85 lbs. in body weight. Live animal and carcass measurements showed that total recovery had not been achieved. At this age cattle out of Low plane dams lacked 28 lbs. in lean, 26 lbs. in fat, and 11 lbs. in bone tissues, as compared to those from dams more liberally fed. In the first trial, the rate of gain during the fattening period favored calves out of Low Plane dams. Feed efficiency in both trials to date has been better for the Low reared calves.

To the stockman who purchases calves at weaning, a retarded plane of nutrition may not be detrimental in terms of expected gains and efficiency of feed conversion, although a long period until slaughter may be necessary. But to the producer who winters and then feeds out his own calves, the advantage of a better plane of nutrition prior to weaning in terms of carcass weight produced is obvious. Also, in the development of maximum lean in the carcass of the beef animal, it is apparent that low planes of nutrition during fetal life and prior to weaning may exert an effect far beyond the pre-weaning period.

Fattening Lambs During the Summer

Robert L. Noble, Kenneth Urban, and George Waller, Jr.

Many Oklahoma lambs, born during February and March, fail to reach market weight by the middle of June and are sold as feeder lambs. Due to the heat during the summer months, few of these lambs are fattened. Selling these lambs as feeder lambs or carrying them over until fall for feeding as quite an economic loss to the state. With the ration improvements in recent years, it was considered desirable to test the feasibility of feeding lambs in dry-lot during the summer.

Procedure

Crossbred lambs (Dorset, Hampshire, or Suffolk x Rambouillet) born in January and February were used in this experiment. The lambs were weaned on April 17 and grazed on small grain pasture until the beginning of the fattening trial. These were the slow gainers out of approximately 100 winter-born lambs.

On July 7, 15 lambs were allotted to each of the following dry-lot treatments:

Lot 1. 45 percent ground milo, 5 percent molasses, and 50 percent ground alfalfa hay.

Lot 2. Same ration as fed Lot 1, pelleted.

Lot 3. 60 percent ground milo, 5 percent molasses, and 35 percent ground alfalfa hay.

Lot 4. Same ration as fed Lot 3, pelleted.

Table 1.—Weight Gains, Rations Fed, and Financial Results Obtained With Fattening Lambs Self-fed in Dry-lot.

Treatment:	45% milo 5% molasses 50% alf. hay ground & mixed	Same as 1 Pelleted	60% milo 5% molasses 35% alf. hay ground & mixed	Same as 3 Pelleted
Lot Number:	1	2	3	4
No. of lambs per lot	15	15	15[1]	15
Initial weight	66.3	66.5	66.7	67.5
Avg. no. days on feed	69.0	63.0	64.0	67.0
Average daily gain	.44	.53	.49	.47
Avg. daily feed intake	2.36	3.29	2.94	2.98
Feed per lamb	163.0	207.0	188.0	200.0
Lbs. feed per lb. gain	5.40	6.23	6.12	6.98
Financial results				
Avg. purchase price ¢	13.0	13.0	13.0	13.0
Avg. selling price ¢	16.5	16.5	16.5	16.5
Total value per lamb $	15.96	16.52	16.12	16.34
Initial cost per lamb $	8.62	8.65	8.67	8.71
Feed cost per lamb $	3.39	4.82	3.93	4.66
Misc. cost $[2]	1.00	1.00	1.00	1.00
Profit per lamb $	2.95	2.05	2.52	1.97

[1]One lamb died, cause unknown.
[2]Includes cost of transportation, marketing, and drenching.

Table 2.—The Effect of Shearing Lambs During the Summer on Rate of Gain

Lot Number	1		2		3		4	
	Sheared	Not Sheared	Sheared	Not Sheared	Sheared	Not Sheared	Sheared	Not Sheared
No. of lambs per lot	7	8	8	7	7	8	8	7
Avg. daily gain	.50	.39	.56	.50	.59	.40	.54	.39

All rations contained 2 lbs. of Aurofax 10 and 10 lbs. of salt per ton. Approximately one-half of the lambs of each lot was sheared on the first day of the trial. The lambs were started on feed gradually and turned loose on self-feeders after five days.

During the first week of the trial all the lambs were drenched with phenothiazine and implanted with 3 mg. of stilbestrol.

Individual weights following an overnight period without access to feed and water was taken at the beginning and at the end of the trial. Intermediate weights without shrinking the lambs were taken at approximately 30 day intervals. The lambs were weighed off the experiment and shipped to Oklahoma City market as they reached 100 lbs.

Average weight gains, feed consumed, feed per cwt. gain, market data, and financial results are shown in Table 1. The effect of shearing lambs during the summer on rate of gain is shown in Table 2. Chemical analysis of the ration is found in Table 3.

Table 3.—Chemical Analysis of Feed

Ration	D.M.	Protein	Mineral Matter
1 and 2	90.29	11.00	4.39
3 and 4	90.69	11.88	5.43

Results

The lambs of all lots made excellent gains during the dry-lot feeding period of July, August, and early September. Average daily gains were comparable to lambs fed during the fall and winter. The feed required per pound of gain was less than is normally required. This may be a reflection of the younger age lambs used in this experiment as compared to Southwestern feeder lambs. The lambs were fed in the same barn that is used for winter feeding trials.

The average response of the two rations was essentially the same on rate of gain. The lambs fed the standard ration (45 percent ground milo, 5 percent molasses, and 50 percent ground alfalfa hay) required less feed per pound of gain.

Pelleting the ration increased gains slightly with the standard ration. A slight decrease in gain was noted on the higher energy ration. Less feed per pound of gain was required with the mixed ration than the pelleted ration.

Shearing the lambs increased gains in each lot. The overall response from shearing was a 30 percent increase in rate of gain.

Although the summer of 1961 was not extremely hot, this study would indicate that lambs can be successfully fed in Oklahoma during the summer months. The lambs returned a profit of approximately $2 to $3 per head.

Observations on the Early Weaning of Creep Fed Lambs

Joe V. Whiteman, G. W. Nichols,

D. G. Brothers, and Gene Kennedy

There are many times when it is desirable to wean lambs before the usual four or five months of age. A lamb's rumen is fully developed at 8 to 10 weeks of age and he can efficiently utilize pasture and other feed at that time. If the ewe is not giving much milk, it is a waste of good feed to allow her to eat twice as much good pasture as her lamb and give the lamb little milk. This is especially important if there is a shortage of pasture. Lambs get internal parasites by grazing on the same pastures with adult sheep during warm, wet weather. Consequently, spring born lambs can be kept relatively parasite free by weaning them before the warm, wet weather starts.

During the past four years lambs have been weaned at the Ft. Reno Livestock Research Station at varying weights and ages to measure the influence of such weaning on their subsequent gain and market grade.

Materials and Methods

Lambs used in these studies were part of those produced in the experimental flock at Ft. Reno. The dams of the lambs were Western* or Dorset X Western cross-bred ewes. The sires were purebred Dorset, Hampshire, or Suffolk rams.

Born between October 15 and November 25 each year, the lambs were moved with their dams to wheat pasture when they were about 10 days old. A mixture of one part chopped, leafy alfalfa hay and two parts cracked kafir grain was creep-fed. During the last two years, five per cent molasses was added to the mixture.

The lambs were weighed biweekly starting when they were about a month old. When they reached 90 to 95 lbs. they were sent to market. The conditions of weaning were changed each year and will be discussed with the results in each trial.

The dams of weaned lambs were moved to Bermuda grass or poor native pasture and fed about 2 lbs. of poor quality alfalfa hay for the remainder of the winter.

Results of Trial I (1958-59)

The 121 lambs used in this trial were out of yearling and two-year-old ewes. Those weaned were weaned at the biweekly weigh periods when they weighed 50 or more lbs. The lambs ranged from 47 to 109 days old when weaned. The ewes were removed and the lambs stayed in the same pasture and night lot in the case of single lambs. One lamb of each set of twins was weaned by moving him into an adjoining pasture and night lot with other ewes and lambs.

Results of this trial appear in Table 1. It will be noted that for the entire post-weaning period the non-weaned lambs gained faster (about .03 lbs. per day) than the weaned lambs. Most of the reduced rate of gain occurred during the first two weeks after weaning for the single lambs. Twin lambs that were about 12 days older than the single lambs when weaned were not adversely affected during the first two weeks by weaning. There were small numbers of twin lambs and, consequently, not too much confidence can be placed in the results.

Results of Trial II (1959-60)

The 104 lambs used in this trial were all single lambs out of yearling, two- and three-year-old ewes. The method of weaning was the same as in Trial I except that lambs were weaned on the first biweekly weigh day on which they were 56 days old or older. They ranged in weight from 31 to 60 lbs. at this time and no lambs were as old as 10 weeks (70 days) when weaned.

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*These ewes were of predominantly Rambouillet breeding.

Table 1.—Average Daily Gain of Weaned and Non-Weaned Lambs During First Two Weeks of the Post-Weaning Period, Two Weeks Post-Weaning to Final Weight and for the Entire Period (1958-59). Lambs Were Weaned Within Two Weeks After Reaching 50 Pounds.

Weaning group	Number of lambs	Average weaning age[1]	Average weaning weight[1]	Average daily gain first two weeks	Average daily gain two weeks to final	Average daily gain entire period
Single lambs (yrlg. dams)		days	lbs.	lbs.	lbs.	lbs.
Weaned	23	78	55	0.48	0.51	0.50
Non-weaned	21	74	53	0.63	0.51	0.53
Single lambs (2-year-old dams)						
Weaned	24	69	56	0.46	0.57	0.54
Non-weaned	25	69	55	0.50	0.60	0.57
All single lambs						
Weaned	47	73	55	0.47	0.54	0.52
Non-weaned	46	71	54	0.56	0.56	0.55
Twin pairs						
Weaned	14	86	52	0.57	0.56	0.56
Non-weaned	14	83	54	0.52	0.62	0.60
All lambs						
Weaned	61	76	55	0.49	0.54	0.53
Non-weaned	60	74	54	0.55	0.57	0.56

[1]For the non-weaned lambs, these figures are the ages and weights at the time the weaned lambs were weaned.

The results of this trial appear in Table 2. These lambs averaged about 10 days younger than the single lambs weaned in Trial I. It will be noted that the rate of gain of weaned lambs was considerably reduced (about .12 lbs. per day) for the first two weeks after weaning as compared to the non-weaned lambs. For the entire post weaning period, weaning apparently slowed the rate of gain by about .05 lbs. per day.

Results of Trial III (1960-61)

The 232 lambs used in this trial were out of mature ewes from three to seven years of age and included both singles and twins. The weaned lambs were weaned when they weighed at least 46 lbs. and were at least 66 days old. When weaned, they were moved to a new night lot and into a new pasture. They were obviously thrown off feed by their treatment and spent considerable time walking the fence trying to return to the other sheep.

Table 2.—Average Daily Gain of Weaned and Non-Weaned Lambs During First Two Weeks of the Post-Weaning Period, Two Weeks Post-Weaning to Final Weight and for the Entire Period (1959-60). Lambs Were Weaned Within Two Weeks After Reaching 56 Days of Age.

Face color and weaning group of lamb	Number of lambs	Average weaning age[1]	Average weaning weight[1]	Average daily gain first two weeks	Average daily gain entire period	Average daily gain two weeks to final
		days	lbs.	lbs.	lbs.	lbs.
Black faced						
Weaned	34	62	47	0.36	0.50	0.48
Non-weaned	35	61	49	0.51	0.56	0.54
White faced						
Weaned	18	60	45	0.34	0.47	0.45
Non-weaned	17	61	48	0.38	0.52	0.49
Total						
Weaned	52	61	46	0.35	0.48	0.47
Non-weaned	52	61	48	0.47	0.54	0.52

[1]For the non-weaned lambs, these figures are the ages and weights at the time the weaned lambs were weaned.

Table 3.—Average Daily Gains for Weaned and Non-Weaned Lambs From Weaning Time Until Marketed When Minimum Weaning Weight Was 46 Pounds and Minimum Weaning Age was 66 Days. (1960-61)

Type of rearing and weaning group	Number of lambs	Average weaning age[1]	Average weaning weight[1]	Average daily gain	Average days weaning to market
		days	lbs.	lbs.	days
Singles					
Weaned	53	73	60	.44	82
Non-weaned	53	74	59	.51	71
Twins					
Weaned	62	79	50	.42	101
Non-weaned	64	88	50	.49	90
Total					
Weaned	115	76	54	.43	92
Non-weaned	117	82	54	.50	82

[1]For the non-weaned lambs, these figures are the ages and weights at the time the weaned lambs were weaned.

NOTE: The gains for the first two weeks after weaning were so erratic due to the behavior of the weaned lambs and bad weather which caused poor weighing conditions that they were considered to be of little or no value.

Results of this trial appear in Table 3. It will be noted that the single lambs averaged about 59 lbs. when weaned since their age tended to be the restriction as to when they were weaned. Slower gaining twins were older and lighter in weight since their weight tended to be the restriction as to when they were weaned.

It was expected that the setback due to weaning in this trial would be intermediate in effect between Trials I and II since the weight and age specifications were intermediate to those in the first two trials. Such was not the case. The weaned lambs gained about .07 lb. per day slower than the non-weaned lambs which was greater than in Trial II when the lambs were weaned at younger ages and lighter weights. It is believed that the poor performance of weaned lambs in Trial III was partially due to the treatment of the lambs.

Results of Trial IV (1961-62)

The 307 lambs used in this trial were out of mature ewes ranging in age from two to eight years. The lambs included both singles and twins. The specifications for weaning were at 46 lbs. in weight and 66 days of age as in Trial III. The method of weaning was as in Trials I and II i.e. the ewes were removed and the lambs remained in the familiar environment. Ewes raising twins were removed when the lightest lamb had reached 46 lbs.

Table 4.—The Average Daily Gain of Weaned and Non-Weaned Lambs For Two Weeks After Weaning. The Lambs Were Weaned with 46 Pounds Minimum Weight and 66 Days Minimum Age.

Weaning group	Number of lambs	Average weaning age[1]	Average weaning weight[1]	Average daily gain 1st, two weeks
		days	lbs.	lbs.
Single lambs				
Weaned	99	74	60	.47
Non-weaned	94	74	60	.53
Twin lambs				
Weaned	56	81	52	.45
Non-weaned	58	80	54	.47
Total				
Weaned	155	77	57	.46
Non-weaned	152	76	57	.51

[1]For the non-weaned lambs, these figures are the ages and weights at the time the weaned lambs

Early results of this trial appear in Table 4. These results confirmed suspicions about Trial III. The setback during the first two weeks after weaning was slight (.05 lbs. per day) when the lambs were left in the familiar environment whereas in Trial III moving the lambs to a new environment caused a rather severe setback. These results further suggest that the method of weaning lambs at a minimum weight and a miminum age influences the lambs less than weaning on weight only (Trial I) or on age only (Trial II).

The Influence of Early Weaning on Estimated Slaughter Grade

During the first two trials, each lamb was handled and given an estimated slaughter grade when he reached market weight. Those grading the lambs did not know which had been weaned and which had not. The results of this grading are shown in Table 5. It is clear from these results that little or no difference due to weaning was detectable.

As a result of the failure of the grading to show differences in the market grade of the lambs due to early weaning, the lambs were not graded during the latter two years.

Table 5.—Average Estimated Live Grades of Lambs Weaned and Non-Weaned.

Year and treatment	Number of lambs	Average estimated live market grades[1]
1958-59		
Weaned	61	12.03
Non-weaned	60	12.52
1959-60		
Weaned	52	12.73
Non-weaned	52	12.79

[1]12 = High choice.
13 = Low prime.

The Influence of Early Weaning on the Subsequent Breeding and Lambing of the Ewes

Another consideration relative to the early weaning of lambs involves the subsequent lambing performance of the ewes. The ewes whose lambs were weaned early were roughed through the remainder of the winter on winter dormant Bermuda and other grasses and were given about 2 lbs. of low quality alfalfa hay per day. They generally were thin but strong when annual grasses started in March and were reasonably fat by shearing and rebreeding time in May. Some of the old ewes with short teeth during the last year were still thin at breeding time. The ewes whose lambs were not early weaned were moved to the weaned ewe pasture as their lambs were marketed or when they weaned their lambs. Most of the latter ewes had dried up by March each year.

Table 6 summarizes the rebreeding performance of the ewes whose lambs were in the first three weaning tests. A more intensive study of the records than is possible from Table 6 leads to the conclusion that the time of weaning the lambs had little or no effect on the rebreeding and subsequent lambing performance of the ewes with two exceptions. First, yearling ewes whose lambs were weaned early in Trial I apparently recovered and bred back better than those that were weaned later as evidenced by the production of more twins the following year. Second, old ewes whose lambs were weaned early were maintained so poorly on the Bermuda grass that their recovery was much poorer than that of the old ewes that stayed on wheat pasture with their lambs. The ewes that

Table 6.—The Lambing Performance of Ewes the Year Following the Weaning Test as Influenced by When Lambs Were Weaned.

	Time of weaning		
	Early	Late	Both*
Trial I			
Number of ewes	49	47	14
Ewes not fall lambing	2	6	0
Ewes producing singles	28	28	3
Ewes producing twins	19[1]	13	11
Lamb crop born (%)	135	115	179
			Twins** Previous year
Trial II			
Number of ewes	52	52	42
Ewes not fall lambing	6	7	1
Ewes producing singles	30	33	17
Ewes producing twins	16	12	24
Lamb crop born (%)	119	112	155
Trial III			
Number of ewes	80	81	
Ewes not fall lambing	13	10	
Ewes producing singles	48	39	
Ewes producing twins	19	32[2]	
Lamb crop born (%)	107	127	

*These ewes were rearing twins, one of which was early weaned.
**These ewes were rearing twins, all of which were early weaned.
[1]This difference was due to a few yearling ewes that benefitted from early weaning.
[2]This difference was due to old, late weaned ewes recovered on wheat pasture and were fatter at breeding time than comparable ewes whose lambs were early weaned.

had their lambs weaned early scored thinner at breeding time and produced 41 percent fewer twins the following year than those that stayed on wheat pasture with their lambs throughout the winter.

The majority of all ewes in these trials were from two to six and showed no relationship between time of weaning their lambs and subsequent lambing performance.

Discussion and Summary

The results of these trials indicate what might be expected. Milk production studies show that most ewes are not giving much milk by the time the lambs are 10 weeks old. Therefore, lambs that have good feed (creep-feed plus pasture) available can be successfully weaned near this age. There is a short period after weaning when their rate of gain slows down but they seem to adjust during the first two weeks and gain satisfactorily thereafter.

Although these trials have not included different kinds of creep-feed, our knowledge of feeding young, growing, fattening animals will permit some generalizations. If lambs are to be weaned early, (1) they should be eating readily when weaned; (2) they should have palatable, nutritious feed and (3) the feed after weaning should be the same as or better than that received before weaning.

There was no evidence in the data that weaned lambs were not completely desirable as a market product. However, it should be remembered that the lambs were creep fed until market time.

Generally, there was little difference in subsequent performance of the ewes related to the time of weaning their lambs. There was an indication that young, immature ewes benefited from early weaning. Old ewes that were severely treated (in relation to the condition of their teeth) after their lambs were early weaned recovered too slowly to breed back as well as other ewes whose lambs were not early weaned and thus the ewes were better fed.

High Energy Rations for Fattening Feeder Lambs

Don Ely, R. L. Noble,
Andy Snider, and George Waller, Jr.

Although we have known for many years that sheep can adequately utilize large amounts of roughage, many people still believe that only a small amount should be used in a fattening ration for optimum gains and finish. Opinions vary as to the proportion of concentrates-to-roughage a fattening ration should contain in order to obtain maximum performance in the feedlot.

In determining what concentrate:roughage ratio we should feed to drylot lambs, we should consider rate of gain; feed consumption; feed efficiency; carcass merit; and economic aspects, which might include cost of the various feeds fed, cost of preparing the feed, and death losses.

Farmers and ranchers who feed lambs in drylot usually raise a good part of their feed. Under the circumstances where a feeder raises a lot of grain and very little or no hay, it may be cheaper for him to feed a high grain ration rather than the normal 50 percent concentrate and 50 percent roughage ration.

Procedure

On October 2, 1961, 163 head of Western range feeder lambs were purchased from Southwest Texas. The lambs were grazed at Fort Reno on wheat pasture until November 1, at which time they were divided into five groups of equal weight. The average weight of all lambs on November 1 was 59.51 lbs. A grain adjustment period of 14 days was used in starting the lambs on feed. During this two-week period, the lambs of each lot were fed a standard ration of 45 percent ground milo, 50 percent ground alfalfa hay, and 5 percent molasses with the addition of 10 lbs. of salt and 2 lbs. of Aurofac 10 added per ton of feed. The lambs were started on feed gradually and turned loose on self-feeders after the 5th day.

On November 14, 600 lbs. of each test ration was mixed with 600 lbs. of the control ration. After this mixture was consumed, the test rations were fed alone. The rations studied are shown in Table 1. The control or standard ration (Lot 1) contained approximately 11.7 percent crude protein, 63.8 percent T.D.N., and 15 percent crude fiber. The high energy ration (Lots 2, 3, 4, and 5) were balanced on the basis of crude protein, T.D.N., and crude fiber. These rations contained approximately 11.5 percent crude protein, 72.5 percent T.D.N., and 8 percent crude fiber. All rations contained adequate calcium, phosphorus, and carotene.

Table 1.—Composition of Rations Used in All Trials.

Lot Number	1 Control	2	3	4	5
			(Percent)		
Ingredient					
Ground milo	45.0	69.5			
Steam rolled milo			69.5		
Ground barley				80.0	
Steam rolled barley					80.0
Molasses	5.0	5.0	5.0	5.0	5.0
Soybean oil meal		7.0	7.0	2.0	2.0
Ground alfalfa hay	50.0	12.5	12.5	12.5	12.5
Cottonseed hulls		5.5	5.5		
Salt[1]		.5	.5	.5	.5
Aurofac[2]					
Total	100.0	100.0	100.0	100.0	100.0
Proximate Composition[3]					
Dry matter	89.42	88.22	88.22	88.33	88.33
Crude protein	11.70	11.43	11.43	11.60	11.60
Fiber	15.34	8.07	8.07	8.02	8.02
TDN	63.77	72.11	72.11	72.76	72.76
Calcium	.782	.262	.262	.270	.270
Phosphorus	.250	.276	.276	.367	.367
Carotene (mg./lb. ration)	4.145	1.111	1.111	1.189	1.189

[1] 10 lbs. salt added per ton of feed in Lot. 1.
[2] 2 lbs. Aurofax 10 added per ton of feed in each lot.
[3] Based on chemical analysis and TDN is calculated on chemical analysis plus digestion coefficients given by Morrison in *Feeds and Feeding*, 22nd edition.

At the beginning of the trial, all lambs were drenched with phenothiazine and implanted with 3 mg. of stilbestrol. All lambs were self-fed throughout the test period and had access to fresh water at all times.

Individual weights were taken at the beginning and end of the trial following an overnight period without access to feed and water. Intermediate weights without shrinking the lambs were taken at approximately 30 day intervals. The lambs were weighed off the experiment and shipped to the Oklahoma City market as they reached 100 lbs.

Average weight gains, feed consumed, feed efficiency, market data, and financial results are shown in Table 2.

Results

The average daily gain of the lambs of all lots was essentially the same except for Lot 4. The poor response in Lot 4 was perhaps caused by the unpalatability of the ground barley. The lambs of Lot 4 consumed approximately 1 lb. less feed per head daily.

The overall response from steam rolled milo and steam rolled barley was essentially the same. The rate of gain was slightly higher in the steam rolled milo lot but feed efficiency was in favor of the steam rolled barley.

Table 2.—Weight Gains, Rations Fed, and Financial Results Obtained with Fattening Lambs Self-fed in Drylot.

Treatment:	45% gr. milo 50% ground alf. hay 5% molasses	69.5% gr. milo 12.5% gr. alf. hay 7% SBOM 5.5% CS Hulls 5% molasses .5% salt	Same as Lot 2 except milo was steam rolled	80% gr. barley 12.5% gr. alf. hay 2% SBOM 5% molasses .5% salt	Same as Lot 4 except barley was steam rolled
Lot Number:	1	2	3	4	5
No. lambs per lot	31	33[1]	33[1]	33[1]	33[1]
Avg. wt. when put on 2 week adj. period	60.54	59.64	59.54	58.72	59.12
Avg. wt. when put on test ration	67.83	65.91	66.30	66.63	65.91
Avg. no. days on feed	78	79	78	111	82
Final weight (lbs.)	102.91	100.14	101.73	101.41	101.15
Avg. Daily gain (from initial wt.)	.55	.51	.54	.38	.51
Avg. daily feed intake (lbs.)	3.54	3.81	3.60	2.59	3.24
Total feed/lamb (lbs.)	276	301	281	288	266
Lbs. feed/lb. gain	6.51	7.43	6.66	6.75	6.33
Feed cost/cwt. gain	12.70	17.16	15.38	16.87	15.82
Financial Results:					
Avg. purchase price, del.[2]	14.70	14.70	14.70	14.70	14.70
Avg. selling price	15.25	15.25	15.25	15.25	15.25
Total value/lamb[3]	16.15	15.84	16.07	16.03	15.99
Int. cost/lamb	8.90	8.77	8.75	8.63	8.69
Feed cost/lamb[4]	5.38	6.95	6.49	7.20	6.65
Misc. cost[5]	.85	1.81	1.34	1.34	1.81
Net profit or loss/lamb	+$1.02	—1.69	—0.51	—1.14	—1.16

[1]Death loss. Two lambs died in Lot 2, one in Lot 3, one in Lot 4, and two in Lot 5.

[2]$13 F.O.B. Barnhart, Texas, $14.70 per cwt. delivered, includes cost of transportation, commission, and miscellaneous expenses.

[3]Deducts 4% shrinkage to market and includes wool return $1.18 per lamb.

[4]Cost of ration per ton: For Lot 1, $39; Lot 2, $46; Lot 3, $46; Lot 4, $50; Lot 5, $50. Included is grinding, 15¢ per cwt. and mixing, 15¢ per cwt.

[5]Includes 60¢ per lamb for marketing, 25¢ per head for transportation, and death losses.

Feed Prices: Milo, $2/cwt.; alf. hay $25/ton; barley $2.30/cwt.; SBOM $4/cwt.; cottonseed hulls $20/ton.

Steam rolling the milo as compared to grinding increased average daily gains slightly and increased feed efficiency considerably. Steam rolling the barley vs. the ground barley increased both rate of gain and feed efficiency. It would appear that high energy rations (72 percent T.D.N. and only 8 percent fiber) composed primarily of ground milo, steam rolled milo, or steam rolled barley can be successfully fed to fattening lambs. However, the standard ration containing approximately 50 percent concentrate and 50 percent roughage (63.8 T.D.N. and 15 percent crude fiber) gave better results. The feed cost per cwt. gain was considerably lower for this group of lambs.

Inheritance of Mothering Ability in Beef Cattle

Charles A. Pratt, J. A. Whatley, Jr., and Doyle Chambers

In Oklahoma, the production of feeder calves is one of the major enterprises of the beef cattle industry. Oklahoma farms and ranches are estimated to have 1½ million head of beef cows and heifers that are two years old and older. Studies of cow and calf operations reveal that approximately $1000 in capital is invested or managed for each brood cow maintained in a breeding herd. With the high capital requirement of the beef cow and with the trend to slaughter younger cattle, Oklahoma stockmen are finding that mothering ability is one of the more important traits in their herds.

Commercial cattlemen have recognized the importance of this trait for many years. Breeders have culled open cows and cows that raise "dogie" calves. As a result, cows which spend their lifetime in a herd have raised a calf regularly and none were "dogie". Before these old cows were removed from the herd, their last heifer calves would be retained for replacement purposes.

With the technological changes that research has brought about in beef cattle breeding, many stockmen are now maintaining production records on their herds to add precision to their selection. This increased accuracy in selection is the result of our increased knowledge of the heritability of many important traits.

Many traits in beef cattle are so strongly influenced by environment that a particular trait in a rather uniform environment (or ranch), would appear highly heritable while this same trait in another more variable environment (or ranch), would appear to have a low heritability. Due to this feature, we cannot expect selection to be equally effective for a given trait under all environmental conditions.

Procedure and Results

The purpose of this study was to estimate the heritability of mothering ability in beef cattle, using the adjusted weaning weights and weaning scores of calves produced by groups of paternal half-sisters. The data used in this study were secured during a five year period from five registered and commercial herds located in the northeastern part of the state. Three were Hereford herds and two were Angus herds.

Weaning weights of all calves were adjusted to a standard age of 205 days; the records of heifer and steer calves were adjusted to a bull equivalent; and the weights of calves from cows of all ages were adjusted to a mature dam equivalent of six and seven years. The correction factors used were those of the Oklahoma Extension Division's beef cattle program.

Table 1 shows the extreme variations that were observed between different sire progeny groups of daughters at four of the ranches. These sire differences may be more extreme than found in some herds, but the point is that sire differences do exist. Selections that are based on sound records of performance should prove effective in improving this trait.

Table 1.—Intra-herd Production Differences Between Groups of Daughters by Several Sires.

Ranch	Mgt. of calves	Sire	Number daughters	Total records of daughters	Average Weaning wt., lbs.	Average Weaning score[1]
1	Non-creep fed	M1	13	44	420	85
		M4	11	21	350	82
2	Creep fed	P4	11	29	432	88
		P2	8	18	414	88
3	Non-creep fed	B5	4	8	452	85
		B9	10	20	437	87
		B1	16	24	409	83
4	Creep fed	L11	9	22	504	87
		L17	16	22	451	85
		L10	11	25	448	85

[1]Weaning score code: 91 — up very top herd replacement.
86 - 90 average herd replacement.
81 - 85 Low end of herd replacements.

The records of 680 calves produced by a total of 368 daughters sired by 130 bulls were used to make these heritability and repeatability estimates. These estimates were obtained from intraclass correlations computed from two statistical designs. From the hierarchical design with a single classification, the heritability estimates as measured by the adjusted weaning weights and weaning scores of calves were .19 and .30, respectively. From the cross classification, where records on the sire's daughters' production were available for three consecutive years (1956, 57, and 58), heritability estimates were .22 and .40 for weaning weights and weaning score, respectively.

Table 2 summarizes various heritability and repeatability estimates of mothering ability in beef cows as measured by the weaning weights of their calves. The estimates for repeatability range from .29 to .52. The estimates for heritability range from .19 to .39. However, the high estimate of .39 was obtained by the use of the average of several records on each cow. This use of average production on individuals will naturally increase the heritability of a trait as compared to single record measurements.

Table 2.—Summary of Estimates of Heritability and Repeatability of Mothering Ability in Beef Cattle as Measured by Weaning Weight of the Calf.

Source	Heritability	Repeatability
Botkin and Whatley (1953) J. Animal Sci. 12:552		.43
Chambers *et al.* (1956) Okla. Agri. Exp. Sta. MP-45:30		.30
Chambers *et al.* (1958) Okla. Agri. Exp. Sta. MP-51-69	.28	
Dawson *et al.* (1954) J. Animal Sci. 13:556	.19	
Kieffer (1959) PhD thesis, Okla. State Univ.	.39	
Koch (1951) J. Animal Sci. 10:768		.52
Koger and Knox (1947) J. Animal Sci. 6:461		.49
Present data	.19 .22	.29

In Table 3 the heritability of .2 is used to estimate the progress to be expected in a herd with a given amount of selection in the dams of heifer replacements and in the selection of dams of the sires of replacement heifers. More selection pressure can be applied on the sire's side, but this effect is diluted by the fact that we cannot select the sire directly for this trait and must normally select on his dam's production, at least, until such time as he has daughters whose production can be measured. Then we can apply progeny test selection. This can be illustrated by referring to Table 1. At Ranch 1 the daughters of sire M1 weaned calves averaging 70 lbs. heavier than the daughters of sire M4. This 70 lb. difference in favor of sire M1 is a difference in the transmitted ability of these sires for this trait. Note that the expected progress by selection in Table 3 is not exceptionally large because of the rather low heritability of the trait and the fact the sire selection is on dam's production which is two generations from the response to this selection in her paternal granddaughters.

Progress from selection on the sire's side can be improved by selection of sires from dams with superior lifetime production. If the dams of selected bulls have high average production records on three to five calves, the heritability of the lifetime productivity would be greater than that of single records. If, for example, the dams of the bulls in

Table 3.—Example of Rate of Improvement Expected Per Generation From a Given Amount of Selection for Cow Productivity (Weaning Weight of Calves).

Selection in dams	
Avg. production of dams of selected heifers	460 lbs.
Avg. production of all cows in herd	430 lbs.
Selection differential	30 lbs.
Heritability	.2
Genetic superiority of dams of selected heifers	6.0 lbs.
Fraction of genetic superiority transmitted to daughters	½
Expected increase in daughter's production from selection on dam's production	3.0 lbs.
Selection in Paternal Granddams	
Avg. production of sire's dam	530 lbs.
Avg. production of all cows in herd	430 lbs.
Selection differential	100 lbs.
Heritability	.2
Genetic superiority of sire's dam	20 lbs.
Fraction of genetic superiority transmitted from paternal granddam to granddaughter	¼
Expected increase in daughter's production from selection of sires on their dam's production	5.0 lbs.
Total expected increase in one generation from selection in both parents above	8.0 lbs.

Table 3 were 100 lbs. above herd average and each had records of five calves, the heritability would be about 50 percent higher than the .2 used in the example; and perhaps a 7½ lb. increase in their daughter's production would be expected instead of the 5 lb. increase as shown in Table 3. This would increase the overall expected improvement in production per generation from 8 lbs. to 10½ lbs. This extra selection refinement might well be worth going after. This is especially true when the relative economic value of this trait is considered.

Summary

Mothering ability in beef cows can vary greatly within a herd. Differences can be recognized if a good set of records is kept. This study and others indicate that if genetic improvement in this trait is desired, replacement heifers should be selected from top producing dams. Bulls should also be selected from top producing dams and this offers the greater opportunity because fewer bulls are needed and they leave many more daughters in a herd than is true for individual females.

Self-feeding Lambs on Wheat Pasture

Robert L. Noble, Kenneth Urban, and George Waller, Jr.

During years of adequate rainfall, thousands of lambs are fattened on wheat pasture in Oklahoma and adjoining areas. Lambs grazing wheat pasture make excellent gains at much lower cost per unit of gain than can be obtained in the feed lot.

Previous tests at the Ft. Reno Station have shown that wheat pasture on fertile soil will carry five lambs per acre. In the fall of 1960 (M.P. 64), 10 lambs were carried per acre of wheat by self-feeding the lambs on pasture after they reached 75 lbs. This year's study tests the feasibility of self-feeding high energy rations to lamb grazing wheat.

Procedure

Four hundred feeder lambs were used in this study. Three hundred of these lambs were purchased in Southwest Texas. They were sheared at San Angelo prior to shipment. The remaining 100 lambs were native feeder lambs purchased on the Oklahoma City livestock market. These lambs were not sheared. Just prior to starting the first 300 lambs on pasture, the lambs were divided into three weight groups and each weight group was divided into two lots as follows: Five acres of pasture per lot; 10 lambs per acre)

Light lambs—62 lbs. and below.

Lot 1. Self-fed a ground mixture of 45 percent milo, 5 percent molasses, and 50 percent alfalfa hay. (Control ration).

Lot 2. Self-fed a mixture of 69.5 percent steam rolled barley, 12.5 percent alfalfa hay, 7 percent S.B.O.M., 5 percent cottonseed hulls, 5 percent molasses, and .5 percent salt

Medium weight lambs—63-72 lbs., inclusive.

Lot 3. Self-fed the same ration as the lambs of Lot 1. (Control ration).

Lot 4. Self-fed steam rolled barley.

Heavy weight lambs—73 lbs. and up.

Lot 5. Self-fed the same ration as the lambs of Lots 1 and 3 (Control ration).

Lot 6. Self-fed steam rolled barley.

The lambs of the first six lots were started on wheat pasture on October 25. The lambs grazed the wheat from about 8:00 a.m. to 5:00 p.m. They were penned in a dog-proof lot at night. The lambs were self-fed in the night lot. The heavy lambs were started on the self-feeders immediately, the light and medium weight lambs as the group averaged 75 lbs.

The Lot 5 and 6 lambs were sold on December 20 and January 9, respectively. The pasture used for grazing these lambs was restocked with 50 lambs each. (Lots 7 and 8)

Second group of heavy lambs.

Lot 7. Self-fed the same ration as the lambs of Lots 1, 3, and 5. (Control ration).

Lot 8. Self-fed a mixture of 80 percent steam rolled barley, 12.5 percent ground alfalfa hay, 2 percent S.B.O.M., 5 percent molasses, and .5 percent salt.

The composition of all rations is shown in Table 1.

Table 1.—Composition of Rations.

	Control Lots 1, 3, 5, 7	Lot 2	Lots 4 & 6	Lot 8
		(Percent)		
Ingredients				
Ground milo	45.0			
Steam rolled milo		69.5	100.0	
Steam rolled barley				80.0
Molasses	5.0	5.0		5.0
Soybean oil meal		7.0		2.0
Ground Alfalfa hay	50.0	12.5		12.5
Cottonseed hulls		5.5		
Salt[1]		.5		.5
Aurofax[2]				
Total	100.0	100.0	100.0	100.0
Proximate Composition[3]				
Dry matter	89.42	88.22	90.92	88.3
Crude protein	11.70	11.43	9.59	11.6
Fiber	15.34	8.07	1.71	8.02
T.D.N.	63.77	72.11	76.00	72.76
Calcium	.78	.26	.07	.27
Phosphorus	.25	.27	.29	.37
Carotene (mg./lb. ration)	4.14	1.11	1.10	1.19

[1] 10 lbs. of salt added per ton of feed for Lots 1, 3, 5, 7.
[2] 2 lbs. of Aurofax 10 added per ton in all mixed rations; for Lots 4 and 6, 3 lbs. of Aurofax 10 per 37 lbs. of salt, fed free choice.
[3] Based on chemical analyses and T.D.N. is calculated by chemical analysis times digestion coefficients given by Morrison in *Feeds and Feeding*. 22nd edition.

Individual weights following an overnight period without access to feed and water were taken at the beginning and at the end of the trial. Intermediate weights without shrinking were taken at approximately 30 day intervals.

Average weight gain, feed consumed, market data, and financial results are shown in Table 2.

Table 2.—Weight Gains, Rations Fed, and Financial Results Obtained with Feeder Lambs Self-fed on Wheat Pasture.

Weight group	Light Lambs (62 lbs. and below) Started on self-feeder at 75 lbs.		Medium Wt. Lambs (63-72 lbs.) Started on self-feeder at 75 lbs.		Heavy Lambs (73 lbs. and up) Started on self-feeder immediately		Second Group Heavy lambs Started on self-feeder immediately	
Lot Number	1	2	3	4	5	6	7	8
Acres of pasture	5	5	5	5	5	5	5[1]	5[1]
No. lambs/lot	50[2]	50[2]	50[2]	50[2]	50[2]	50[2]	50[2]	50[2]
Initial weight	56.8	56.4	65.9	65.1	74.9	74.0	74.6	76.3
Wt. when started on self-feeder	75.1	75.1	76.1	75.5	74.9	74.0	74.6	76.3
Days on self-feeder	64	64	74	74	55	74	52	54
Total feed per lamb	163.0	186.0	248.0	169.0	152.0	131.0	142.0	110.0
Avg. daily gain								
Wheat pasture alone	.26	.25	.30	.31	—	—	—	—
During self-feeding period	.34	.39	.40	.37	.43	.29	.49	.54
Financial results								
Date sold	3/12	3/12	2/13	2/13	12/20	1/9	2/13	3/5
Avg. selling price	15.25	15.25	15.00	15.20	15.00	14.50	15.75	15.75
Total value per lamb[3]	16.06	16.63	17.0	16.83	15.97	15.03	15.75	16.57
Initial cost per lamb[4]	8.34	8.29	9.69	9.57	11.01	10.88	10.07	10.30
Feed cost per lamb								
Ration self-fed[5]	3.18	4.28	4.83	3.89	2.96	3.01	2.77	2.75
Alfalfa hay[6]	.60	.60	.60	.60	.60	.60	—	—
Misc. cost[7]	1.78	2.92	3.58	6.23	1.21	1.07	1.49	1.06
Profit or loss	+2.16	+ .54	—1.68	—3.46	+ .19	— .53	+ .92	+2.46

[1] The lambs of Lots 7 ad 8 grazed the same pasture as the lambs of Lots 5 and 6 respectively; after the Lot 5 and 6 lambs were sold.

[2] Death loss. Five lambs died in Lot 1, 10 in Lot 2, 11 in Lot 3, 18 in Lot 4, 2 in Lot 5, 1 in Lot 6, 3 in Lot 7, and 1 in Lot 8. Most of the death loss was due to enterotoxemia. The feed consumed by these lambs was charged to their lot.

[3] Includes wool return $1.18 per lamb for Lots 1 through 6.

[4] $13 F.O.B. Barnhart, Texas for the lambs of Lots 1 through 6, $14.70 per cwt. delivered; delivered price on lambs of Lot 7 and 8 purchased at Oklahoma City, $13.35 per cwt.

[5] Cost of ration per ton: Lots 1, 3, 5, and 7, $39; Lot 2, $46; Lot 4 and 6, $46; Lot 8, $50. Included is cost of grinding, 15¢ per cwt., and mixing, 15¢ per cwt.

[6] Alfalfa hay was fed during inclement weather.

[7] Includes 60¢ per lamb for marketing, 25¢ per head for transportation to market, and the remainder for death loss.

Results

The average daily gains of the lambs of the first six lots were the lowest experienced in self-feeding lambs on wheat at the Ft. Reno Station. The death loss (approximately 12 percent) for these lots was also the highest recorded in fattening lambs at the station. The low rate of gain can be partly attributed to the severe winter. The high death loss was probably due to both the severe cold weather and the high energy rations being tested. The death loss was considerably lower in the lambs fed the control ration.

The average daily gain and feed efficiency of the lambs of Lots 7 and 8 were considerably better than those of the first six groups. Also, the death loss was quite low in both groups. These lambs were started on pasture after the Lot 5 and 6 lambs were sold and the weather was considerably warmer. The performance of the Lot 8 lambs on the high energy ration was quite satisfactory. They required less feed and gained more rapidly than Lot 7 lambs. However, considering the overall death loss of the lambs on the high energy rations, it would appear that they may be unsafe to self-feed to lambs grazing wheat.

Although 400 lambs were carried on 30 acres of wheat, the overall return was quite small due to the high death loss and low margin.

Effect of Winter Plane of Nutrition on the Performance of Three- and Four-Year-Old Beef Cows

Don Pinney, L. S. Pope,

Carlos Van Cotthem, and Kenneth Urban

Due to the low nutrient value of forage during the period from November to the following April, at a time in which the beef cow is developing a fetus or nursing her calf, it is obvious that the wintering period is the most critical time in the nutrition of the beef female. The proper amount of winter supplement to feed is of great economic importance, not only because of its cost, but also in terms of its effect on overall reproductive performance.

In addition to seven other experiments, either completed or now in progress, two additional trials were recently initiated to determine the effects of four widely different wintering regimes upon growth, milk production, and reproductive processes in the beef female. Early results from these trials through the fall of 1960 have been reported.[1] Summarized in this report are the results obtained during the 1960-61 period, constituting the second or third calf crops from three- and four-year-old cows, respectively.

Experimental Procedure

Sixty, weaner, Hereford heifer calves were selected each fall in 1957 and 1958 from the Ft. Reno experimental herd and allotted to four groups of 15 each on the basis of sire, dam's productivity, age, grade, and shrunk weight. The heifers were started on winter feed in early November of each year and fed each winter (approximately 160 days to mid-April) according to the following program:

Lot 1 (Low)—No gain during the first winter as weaner calves, with a loss of at least 20% of fall weight during subsequent winters as bred females.

Lot 2 (Moderate)—Gains of 0.5 lb. per head daily the first winter as weanling calves, with a loss of nearly 10% of fall weight during subsequent winters as bred females.

Lot 3 (High)—Gains of approximately 1 lb. per head daily during the first winter, with no loss in weight during subsequent winters.

Lot 4 (Very High)—Self-fed a 50% concentrate mixture to gain as rapidly as possible, both as weanling calves and in subsequent winters.

During their fourth wintering period, Lot 4 (Very High) females of the first trial were reverted to the Moderate treatment; thus, in one trial, the effects of three successive winters on a Very High feed level followed by a drastic decrease to the Medium level could be observed. Females of Lot 4 in Trial II have been continued on the Very High regime each winter in order to study the long-term effects of overfeeding.

In both years the heifers were started on test between seven and nine months of age at an initial weight of about 460 lbs. The daily amount of winter supplement (cottonseed cake and ground milo) was adjusted frequently within each group during the winter to produce, as nearly as possible, the gains or losses outlined above. In each trial, Low level females were confined to dry lot and fed wheat straw during several weeks at the start of the wintering period to initiate the desired weight loss. The wintering period generally extended from early November to mid-April. All females were given approximately seven acres of native pasture per head, year-long, and have had free access to a mineral mixture of two parts salt and one part steamed bone meal throughout the year.

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[1]See Okla. Agr. Exp. Stat. Misc. Pub. MP-64

All heifers were exposed to bulls as yearlings and bred to calve first at two years of age. Each year they were placed with various purebred bulls to obtain progeny test data according to level of wintering and previous productivity. Most females calved in February, March, and early April. Thus winter weight losses from November to mid-April reported herein, include the loss in weight due to calving. Detailed records have been maintained on body weight changes, skeletal development and reproductive performance.

Results

Since the results of the two trials have been summarized through the fall of 1960 and published in last year's report, this discussion will be confined to the results obtained from the fall of 1960 to October, 1961 which includes the second and third calf crops of the three-year-old cows in Trial I and four-year-olds in Trial III, respectively.

Body measurements for both trials made in the Fall of 1961 are given in Table 1. It can be seen that treatment had a definite effect on the measurements in Trial II, but of lesser magnitude than one would expect. It is interesting that in Trial I, in which the Very High group had been reverted to the Medium treatment, body measurements are in no case as large as those of Lot 3, the High group. In both width of hooks and length measurements, they are smaller than the Medium fed group. This would suggest that the extremely large measurements of Lot 4 in Trial II are largely a reflection of body fat rather than true skeletal growth. Also, it is clearly apparent that the Low regime definitely delays growth and possibly even stunts the beef cattle.

Table 1.—Effects of Four Widely Different Winter Feed Levels on Body Growth Measurement of Three- and Four-Year-Old Beef Cows.

Lot Number Wintering Level	1 Low	2 Medium	3 High	4 Very High
Trial II				
Three and one-half-year-olds (Fall, 1961)				
Height of withers (inches)	46.38	46.29	46.62	47.04
Width of hooks (inches)	20.02	20.88	20.81	21.96
Length of body (inches)	54.27	55.82	56.42	57.62
Trial I				
Four and one-half-year-olds (Fall, 1961)				
Height of withers (inches)	46.37	46.67	47.11	47.00[1]
Width of hooks (inches)	20.97	21.53	21.61	21.36[1]
Length of body (inches)	53.87	54.70	54.79	54.11[1]

[1]Lot 4 of Trial I was reverted to the Medium level the previous winter after three successive winters on the Very High regime.

Affect of Feed Level on Productivity

Summarized in Table 2 are results obtained in Trial II during the period November, 1960, to November, 1961, which represents their second calf crop. Originally 15 cows were started on test in each treatment group. Two cows were removed from Lot 1 (Low level) and one cow from Lot 2 (Moderate). The only two cows culled for failure to raise a calf two years in succession were in Lot 3 (Highs). Two cows died in Lot 4, the full-fed group, as a result of calving difficulty.

Differences in body weight in the fall of 1960 reflected the accumulative effects of the different winter feed levels. Weight gains to calving and winter weight losses were related directly to the amount of supplement fed. As has been confirmed in many previous studies, there was an inverse relationship between winter and summer weight gains with cows wintered on the Low level showing remarkable recuperative ability during the summer when on lush pasture. It is interesting that the

Table 2.—Effects of Four Widely Different Winter Feed Levels on Performance of Three-Year-Old Beef Cows.

Lot Number Wintering Level	1 Low	2 Medium	3 High	4 Very High
Number of cows started on test	15	15	15	15
Number remaining	13	14	13	13
Avg. body wt. changes, lbs.				
Fall wt., 10-26-60	863	931	986	1084
Gain to calving to 2-1-61	—82	—3	34	108
Total winter wt. gain to 4-13-61	—139	—74	—67	98
Summer gain to 10-27-61	254	184	144	15
Fall wt., 10-27-61	978	1041	1063	1197
Net yearly change	115	110	77	113
Supplemental winter feed per/head, lbs.				
Cottonseed cake	32	202	206	
Ground milo		88	815	
50 percent concentrate mixture				4660
Supplemental winter feed cost per cow since 1958, ($)	74.62	107.29	147.87	281.71
Reproductive performance				
Avg. calving date	4/4	3/16	3/1	3/9
Percent calf crop weaned[1]	71.4	85.7	92.9	84.6
Avg. birth wt., lb.[2]	69.5	73.8	75.3	77.0
Avg. weaning wt., lb.[2]	361	455	512	455
Total lbs. calf weaned per lot through two calf crops	7,142	9,504	10,940	8,940

[1]Based on number of females exposed the previous summer.
[2]Sex corrected to steer equivalent by adding 5 lbs. to birth wt. and 24 lbs. to weaning wt. of heifers.

cows wintered at the Very High level gained only 15 lbs. during the summer, following the full-feeding regime the previous winter. At 3.5 years of age (fall, 1961) there were still large differences in body weight between the Very High and other levels. Most probably, this large advantage in body weight is due to fat rather than skeletal size. This is further suggested by the results of body measurements and weights obtained in the second trial in which Very High females were reverted to the Medium level. Net yearly change in body weight favored the Low level group due to extremely rapid summer gains. This illustrates the tremendous ability of the beef cow to resume growth at a rapid rate following restriction. Also these cows, because of the treatment imposed, may have been in an earlier physiological stage of growth where the potential is greater.

Lot 1 females calved over a month later than the High level cows of Lot 3, which is consistent with previous observations. Evidently, the treatment imposed on Low level females results in such poor condition that estrus is inhibited until the cows can recover on lush spring grass. Medium and Very High level cows of Lots 2 and 4 calved at intermediate dates on the average. Birth weights were related directly to previous winter feeding level, although this was not the case with weaning weights. Weaning weights improved with increasing feed levels up to Very High treatment, which showed a marked depression in weaning weight when compared to the High level (Lots 4 vs. 3). Surprisingly, the Very High's weaned calves no larger than the Medium's although they received over two tons more feed per head the previous winter.

This depression is explained by the reduced milk yield from the Very High group as shown in Figure 1. Other research with dairy cattle and laboratory animals has demonstrated the adverse effect of very high planes of nutrition on mammary development and milk yield. Thus, in addition to increased calving difficulty and drastically increased feed costs, excessively high amounts of feed resulted in decreased milk production. On the other hand, it is obviously seen that severe body weight losses during the winter as great as those observed on the Low level (Lot 1) also result in delayed calving, lower birth weights, lower calf crop percent, less milk production (See Figure 1), and, also, greatly decreased weaning weights.

In these trials and other previous tests, percent calf crop weaned has been depressed by this extremely low level of supplementation. When one compares the productivity of the Medium and High groups, less difference is seen. Total pounds of calf produced through two calf crops is seen to favor the High level females as does average weaning weight. These advantages are easily offset, however, by the increased feed costs associated with the High level treatment. In economic terms, the Medium level in this study usually has been most advantageous even though weaning weights may be slightly depressed during the first two or three calf crops as compared to the High level. There has been a tendency for these differences to become smaller as the cow reaches maturity (See Table 2.).

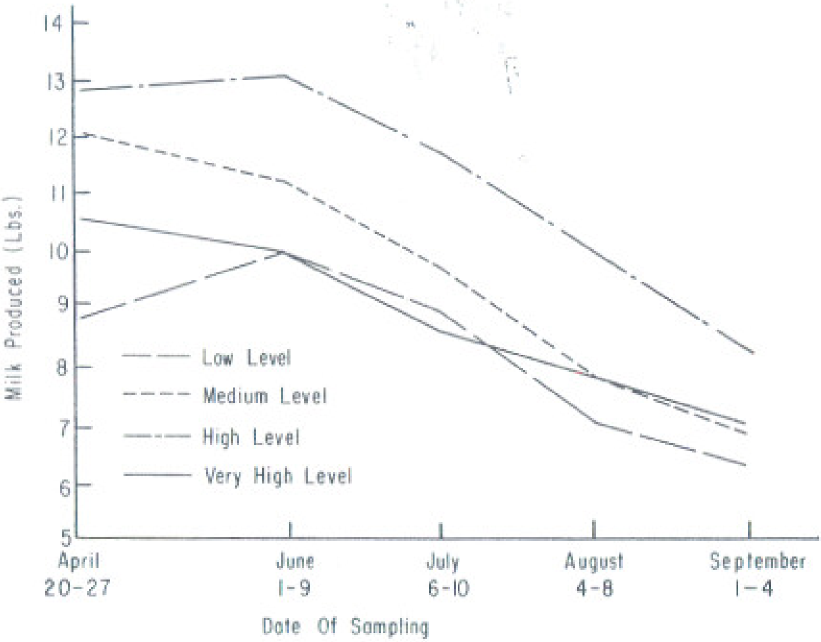

Figure 1. Milk Production (Five Daily Estimates) of Three-Year-Old Cows During the Summer of 1961. (Trial II).

The accumulative effects of similar feed levels in Trial I are presented in Table 3, summarizing the data accumulated from the fall of 1960 to 1961, during which time the cows weaned their third calves. The cattle in this trial were fed and managed as described for Trial II, with the exception of Lot 4. Of primary interest in this trial is Lot 4, which after three successive winters on the Very High regime, was reverted to the Medium level of wintering.

Body weight changes were comparable to the results discussed for Trial II, with the exception of Lot 4, which lost excessively when reverted to the Medium treatment. In fact at 4.5 years of age (fall, 1961), these cows were lighter than those in the Low level. This indicates that the differences in body weight seen between feeding levels may be more of an indication of fatness, rather than true size or skeletal development. It is of interest that the cows in this group presently appear to have aged to a much greater extent than the other groups.

Table 3.—Effects of Four Widely Different Winter Feed Levels on Performance of Four-Year-Old Beef Cows.

Lot Number Wintering Level	1 Low	2 Medium	3 High	4 Very High[1]
Number of cows started on test	15	15	15	15
Number remaining	15	15	14	14
Avg. body wt. and changes, lbs.				
Fall wt., 10-26-60	958	1033	1069	1171
Gain to calving to 2-1-61	—68	4	33	—75
Winter wt. gain to 4-13-61	—159	—88	—85	—246
Summer gain to 10-27-61	282	177	144	154
Fall wt., 10-27-61	1081	1122	1128	1079
Net yearly change	123	89	59	—92
Supplemental winter feed per/head, lbs.				
Cottonseed cake	32	202	258	202
Ground milo		56	623	56
Supplemental winter feed cost per cow since 1957, ($)	100.71	140.06	191.61	314.48
Reproductive performance				
Avg. calving date	3/19	3/9	3/4	3/3
Percent calf crop weaned	80.0	86.7	100.0	100.0
Avg. birth wt., lbs.	75.7	79.1	81.7	79.7
Avg. weaning wt., lbs.	429	470	485	463
Total lbs. calf weaned per lot through three calf crops	14,263	17,107	17,397	16,047

[1]This lot was full-fed a 50 percent concentrate mix during their first three wintering periods and reverted to the Medium level during their fourth winter.

Reproductive performance follows the same trend as indicated in Trial I, but with smaller differences in calving dates, birth weights, and weaning weights. This has been frequently observed in other tests, in that as the cow approaches maturity and no longer needs nutrients for growth, reproductive performance is less affected by winter feeding levels. Small differences in weaning weights between the Medium and High treatments are almost entirely due to younger calves in the Medium level lot. As in the previous trial, little difference exists between High and Medium lots in total pounds of calf produced over the first three calf crops. Under the conditions of this experiment the economic advantage for the Medium level is obvious. Reverting the Very High level cows back to the Medium level seemed to have had no marked effect of their reproductive performance during the subsequent year.

All cows in both trials will be continued on their respective treatments for lifetime performance data. The effects on longevity will be most interesting to follow.

Summary

As a part of a series of studies on the effect of winter feed levels on the growth and productivity of beef females, results of two trials with young cows carried to 3.5 and 4.5 years of age are reported. The results to date clearly point out the danger of underfeeding which results in delayed skeletal growth, body weight, and late calving, with smaller calves at birth and weaning, and depressed milk production. Conversely, overfeeding may result in more calving difficulty, depressed milk production, and a tremendous increase in feed cost. Although feeding regimes similar to the Very High level, as practiced in this study are rarely encountered in the field, the possibility of damaging the young growing beef female by overfeeding, as in fitting show animals, should be guarded against.

A Medium to High level appears to be most desirable in this study in terms of growth of the dam, weaning weight, and number of offspring produced. When considered from the economic standpoint, the Medium level appears most desirable, wherein heifer calves are wintered to gain approximately 0.5 lb. daily throughout the first wintering period, and fed so as to lose less than 10 percent of their fall body weight each winter thereafter to maturity. It should be pointed out that these studies involve only spring-calving cows, and that this loss in body weight during the winter includes the loss due to calving in February and March.

The Inheritance of Two Different Types of Dwarfism in Beef Cattle

E. J. Turman, B. J. Watkins,

Doyle Chambers, and Dwight Stephens

Few, if any, hereditary defects in farm animals have received the attention that was focused on dwarfism. Certainly the present optimism on the part of cattlemen that dwarfism is under control is in sharp contrast to the fear, doubt, and confusion that accompanied the onset and early history of this defect.

To most cattlemen the word "dwarf" and "snorter dwarf" are synonymous. Few are aware that there are several other types of hereditary dwarfism of cattle, because these other types were much less frequently encountered and were never an important problem to the industry. However, in a few individual herds these other dwarfism types were a problem as serious as snorter dwarfism.

One of the other forms of dwarfism in cattle is the longheaded dwarf. It was first described in a scientific publication at approximately the same time as the snorter dwarf. Therefore, it is not a new type of dwarfism, but rather a different type. For both types of dwarfism the mode of inheritance was reported to be due to an autosomal recessive gene. Subsequent research plus the experiences of breeders has confirmed this mode of inheritance for the snorter dwarf. Little research has been concerned with the longheaded dwarf, however, and nothing further has been reported in the literature since the original paper that described it.

The name, longheaded, is descriptive of the principal difference between mature animals of the two types (Figures 1 and 2). The long narrow head of the longheaded dwarf is in sharp contrast to the short, broad, distinctly dished head of the snorter dwarf which is characteristic of all dwarfs in the minds of most breeders. The two are very similar in other characteristics, being definitely dwarf in stature with short thick cannons and heavy middles.

Unfortunately the long narrow head is not evident at birth in the longheaded dwarf calf. It usually begins to be noticeable after the calf is several months of age and appears to continue to grow longer throughout the lifetime of the dwarf. The typical longheaded calf at birth shows many dwarf symptoms. It is lowset and blocky with short thick cannons, but it also appears almost normal in the head. Because longheaded dwarf calves do not have the typical snorter dwarf symptoms in the head they are often overlooked at birth. This oversight is corrected later if the calf survives until weaning time. It is likely that a number of longheaded dwarf calves, which were either born dead or died soon after birth, have not been correctly identified.

Material and Methods

The data reported in this paper were largely obtained from breeding records of the experimental cow herd of Project 873 at Ft. Reno from 1955 through 1961. This cow herd includes a group of Angus and Hereford cows that are known to be carriers of snorter dwarfism. In addition to the carrier cows, a herd of snorter and longheaded dwarfs are also maintained for physiological studies. The bulk of the information on inheritance of the longheaded type came from another experimental herd of Angus cows.

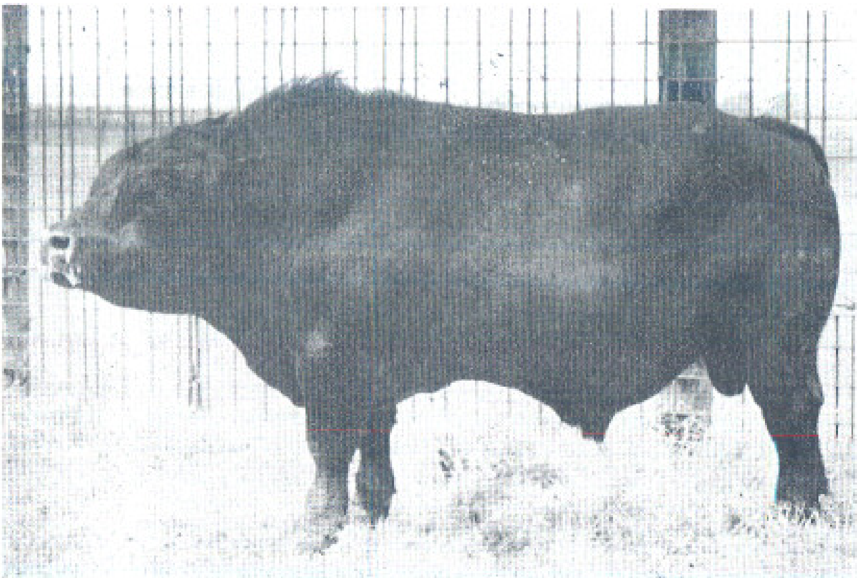

Figure 1. Mature Snorter Dwarf Angus Bull.

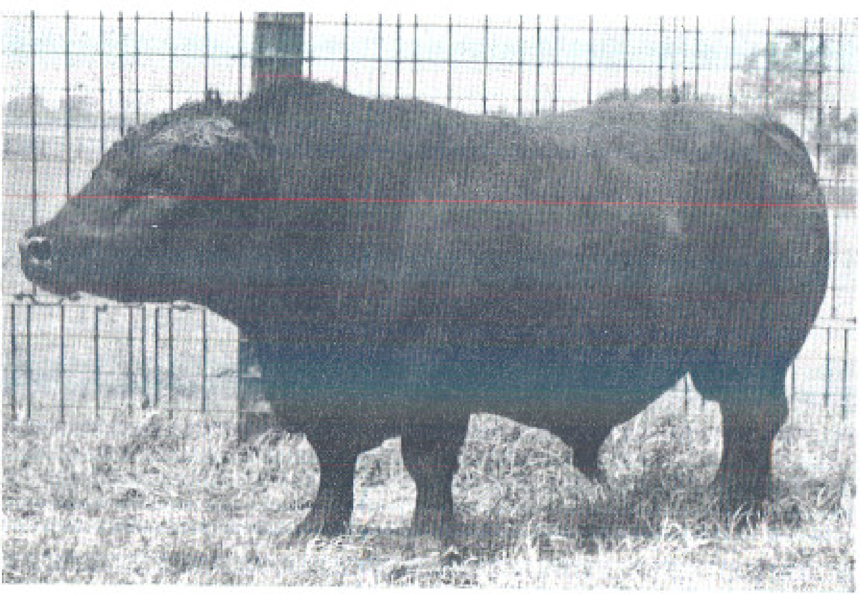

Figure 2. Mature Longheaded Dwarf Angus Bull

The inheritance of snorter dwarfism was studied by considering all matings of a carrier bull to carrier cows. Since all cows were known to be carriers, any calf dropped to the service of a carrier bull could be counted. However, since none of the bulls were known to be carriers at the time they were bred to the cows, it was necessary to use a post probant analysis. The first dwarf sired by a bull was used to prove him a carrier, and that dwarf and all earlier calves that had been born were discarded. Thus, the only calves credited to a sire in this analysis were those dropped after the dwarf calf that proved him to be a carrier.

Additional information on the inheritance of snorter dwarfism was obtained from a limited number of matings of snorter dwarf bulls to snorter dwarf heifers. This mating was made to produce a number of dwarf calves for a hematological study. Such matings are difficult to make because only a small percentage of dwarf calves live to reach breeding age and are fertile and will conceive. It was also necessary to deliver all calves from dwarf heifers by caesearan.

The inheritance of longheaded dwarfism was studied by considering all matings of sons of known carriers to daughters of known carriers of the longheaded gene. This approach was necessary because only a limited number of cows were known to be carriers.

The genetic relationship of the two forms of dwarfism was also studied. A number of matings of longheaded carrier bulls to snorter carrier cows were made. The critical matings, however, were six snorter dwarf heifers bred to a longheaded dwarf bull.

Results and Discussion

The results of this study are presented in Table 1. For each mating the observed numbers of each type of offspring are presented. An expected ratio has also been calculated on the assumption that the two forms of dwarfism are inherited as an autosomal recessive as has been reported in earlier reports by other research workers. The inheritance of snorter dwarfism was described in a previous Feeders Day report (Okla. Agr. Exp. Sta. MP-34). It was further assumed that the two types of dwarfism are inherited independently.

The data reported in this study strongly supports the assumption that snorter dwarfism is inherited as a simple autosomal recessive. The observed and expected ratios obtained from carrier matings are almost identical. The most critical mating was that of snorter dwarf x snorter dwarf, and, as was expected, only snorter dwarf calves resulted.

In the case of the longheaded form, the data are not as clear cut although there is no reason to believe that it is not also inherited as a simple autosomal recessive. The deviations between observed and expected approach statistical significance $(P<.10)$. However, it should be pointed out that the calculated expected number of six dwarfs is a minimum estimate. It was assumed that all test animals were offspring of only one dwarf carrier parent and the other parent was free of dwarfism. It is probable that a number of the animals included in this study were offspring of two carrier parents. In such cases the probability of dwarfs resulting is greater than one chance in eight which was the fraction used in calculating the expected. It should also be pointed out that, while there was essentially no selection of heifers that went back into the line, selection was practiced on the bulls to be used. There is, therefore, the possibility that selection favored the carrier bulls over the clean bulls, and more than one half of the sons of the carrier were actually themselves carriers. Had the true frequency of the longheaded gene in this herd been known, it is likely that the calculated expected number of dwarfs would have been nearer to the number actually observed than is reported in Table 1.

The results obtained in this study proves that the longheaded and snorter genes are non-allelic. The critical test was the fact that only normal calves resulted from six matings of a longheaded dwarf bull to

Table 1. Results of Matings of Animals Whose Genotype for Snorter and Longheaded Types of Dwarfism Either Was Known or Could be Predicted.

Matings		Total Number Calves	Numbers of Each Type of Calf: Normal-Non-Dwarf	Snorter Dwarf	Longheaded Dwarf
Snorter dwarf carriers X Snorter dwarf carriers:					
	Observed	43	33	10	0
	Expected[1]	43	32	11	0
Snorter dwarf X Snorter dwarf:					
	Observed	7	0	7	0
	Expected[1]	7	0	7	0
Longheaded dwarf X Snorter dwarf:					
	Observed	6	6	0	0
	Expected[2]	6	6	0	0
Longheaded dwarf carriers X Snorter dwarf carriers:					
	Observed	27	27	0	0
	Expected[2]	27	27	0	0
Sons of Longheaded dwarf carriers X Daughters of Longheaded dwarf carriers:					
	Observed	96	86	0	10
	Expected[1]	96	90	0	6

[1] Expected ratios calculated on the assumption that the dwarf gene is a simple autosomal recessive.
[2] Expected ratios calculated on the assumption that the two dwarf genes are not alleles.

snorter dwarf heifers. Additional proof was obtained by considering all matings of known longheaded carriers with known snorter carriers. There were 27 such matings, representing two sires, and all calves were normal.

The calves that resulted from the mating of the two types of dwarfs were completely normal in appearance. Despite the fact that they were carriers of both types of dwarfism, they were grossly indistinguishable from calves that were believed to be free of dwarfism. These results mean that a bull must be progeny tested on cows that are known to be carriers of the specific type of dwarfism in which he is interested. A progeny test for one type tells a breeder nothing about the genotype of the animal for the other type of dwarfism.

Some additional observations were made that are not reported in Table 1. The longheaded dwarf has occurred only in Angus cattle in our study. It has not been observed in any Hereford lines. While there are one or two reports in the literature of longheaded dwarfs of other breeds, it has largely been reported in the Angus breed. It is also relatively rare in occurrence. However, as mentioned previously, it can be a serious problem in individual herds. There is also the possibility that many longheaded dwarf calves may have been produced and not recognized.

This study confirmed earlier reported observations that the snorter dwarf gene in the Hereford breed is identical to the snorter dwarf gene in the Angus breed. A total of 16 Hereford x Angus crossbred snorter dwarfs have been produced. Therefore, in progeny testing bulls for snorter dwarfism, it is valid to test bulls of one breed on carrier cows of the other breed.

The characteristic abnormalities seen in the lumbar vertebrae of most snorter dwarf calves* were present in all longheaded dwarfs studied. Radiographs of the lumbar spine appear to be an accurate method for identifying either type of dwarf since no non-dwarf has ever shown these typical vertebral abnormalities. It is recommended that dead calves whose dwarfism status is questionable be x-rayed. The results of the dwarfism research to date indicates that any calf that has the typical dwarf vertebrae may safely be considered to be a dwarf. Whether it is a snorter or longheaded dwarf must be determined from the other symptoms.

Summary

The inheritance of two different types of dwarfism in beef cattle, the snorter and longheaded types, were studied from the 1955-1961 breeding records of the Project 873 cow herd at Fort Reno. The data indicate that each is inherited as a simple autosomal recessive gene. The same gene produces the snorter dwarf in both the Hereford and Angus

*Described in Okla. Agri. Exp. Sta. MP-57.

breeds. The longheaded dwarf gene is a different gene from the snorter dwarf gene. Bulls may be progeny tested for snorter dwarfism on snorter carrier cows of either the Hereford or Angus breeds. However, bulls may be tested for snorter dwarfism only on snorter carrier cows, and for longheaded dwarfism only on longheaded carrier cows. Longheaded dwarf calves may be identified at birth on the basis of characteristic abnormalities of the lumbar vertebrae. Since these abnormalities are similar to those that have been observed in snorter dwarfs, and have never been seen in non-dwarfs, they offer an accurate method for identifying dwarf calves of either type.

Lifetime Performance of Beef Cows Wintered Each Year on Three Different Levels

D. O. Pinney, L. S. Pope,

Dwight Stephens, and L. M. Henderson

Few studies with beef cows have been continued over an interval of time necessary to show the accumulative effects of different feed levels on lifetime production. This is an important issue since (1) most producers have a tendency to be either "good" or "poor" feeders, i.e., following high or low feeding regimes year after year; (2) beef cattle have remarkable ability to recover from one or, perhaps, several years of poor winter feeding by compensatory gains on lush summer grass; and (3) some of the effects of good or bad feeding practices may be accumulative, affecting the life span and productivity of the beef cow, which one year's data may not reveal.

Surprisingly, our knowledge of the exact requirements of the beef cow is still fragmentary. It is important to the Oklahoma cattle industry, however, as nearly 60 percent of our total beef cattle population is classified as breeding females over two years of age. To study the effects of continuous low, medium, or high levels of supplemental feed on the performance of the range beef cow during her life span in the herd, a project was initiated in the fall of 1948 with a group of weaner, heifer calves. The results of individual years have been reported in this series of publications.[1] This report summarizes the results from this experiment to the fall of 1961, at which time most of the cows have passed out of production and only a remnant of the original herd remain on test.

As background for this study, let us first consider the yearly picture for native range grass since this is the basic foundation for a profitable herd and for our methods of feeding beef cows in the Southwest. Results

[1]See Okla. Agr. Expt. Sta. MP-22,27,31,34,43,45,48,51,55 and 57.

of numerous chemical analyses of samples of native grass (bluestems and associated "tall" grasses) consistently show that much of the forage produced on our 21 million acres of native range is deficient at least six months out of the year in several nutrients needed by beef cattle. A sharp drop in digestible protein and phosphorus, two of the most critical items needed by beef cows, occurs from the time the grass matures in July to mid-winter. By December, most of native tall grasses have lost 80 percent or more of the protein and phosphorus they contained during early growth. Hence, the need to supplement this dry, weathered range forage has long been recognized by successful stockmen, but the question remains: How much should I feed?

Feeding less supplement than a beef cow needs to prevent excessive weight loss, resulting in thin, weak females at the end of the winter, delayed calf crops, poor milk production, and unprofitable weaning weights is "pennywise and pound foolish." On the other hand, to feed more than a beef cow requires to come through the winter in strong, thrifty shape may seriously reduce the net returns with surprisingly little increase in production.

Plan of Experiment

In the fall of 1948, 120 weaner, Hereford, heifer calves were selected from a large commercial herd in the Hereford Heaven area and the Lake Blackwell experimental herd. They were started on test in late October. Three rates of supplemental winter feed were offered on native grass. One-half of the heifers in each winter treatment were bred to calve first as two-year-olds, while the remainder calved first as three's. Calving for all heifers was in late February or March. Each winter, after grazing together during the summer, the females were returned to their respective winter feed levels. This practice has been continued throughout their productive lives in the herd (i.e. 14 years of age). Cows that failed to calve by three years of age or which failed to calve and raise a calf for two successive years were removed from the test, together with animals removed for death loss, disease, or unsoundness rendering them unfit for future production.

The three feeding regimes imposed on native grass pastures (principally bluestems) from early November to mid-April each year were:

Low level (Lots 1 and 2)—1 lb. cottonseed meal pellets per head daily.

Medium level (Lots 3 and 4)—2.5 lbs. cottonseed meal per head daily.

High level (Lots 5 and 6)—2.5 lbs. cottonseed meal and 3 lbs. oats per head daily.

All cows have had access to a mineral mix of two parts salt and one part steamed bone meal, year-long. The above supplements were fed every other day, twice the daily allowance. The pasture allowance has been about six to eight acres per head, year-long. During the breeding season, all females were exposed to bulls under pasture conditions from May 1 to August 15 each year. Two additional lots were wintered at a Medium level and used in a summer feeding study during the first five years; whereupon they were continued on test with the Medium level group with no summer feeding. These females have been used only in comparing two- vs. three-year-old calving.

Detailed records on weight changes of the cows, calf production, and reasons for removal from test have been maintained. At present, the cows are 14 years of age (March 1, 1962) and have weaned 12 or 11 calf crops, for those that calved first as two's or three's, respectively.

Results

Survival and Weight Changes of Beef Cows

The effects of continous winter feed levels on the survival of range beef cows and their productivity to 14 years of age are shown in Table 1. In these data, results from two- and three-year-old calving groups within each treatment have been pooled. Some startling differences are apparent from the results. Of 30 females that started on test in the fall of 1948 on the three different feed levels, 16, 11, and 5 remain in the herd for the Low, Medium, and High levels, respectively. Reasons for removal of the cows from test indicate that 50 percent more females have been removed from the High vs. the Low level for failure to calve, and that the disease loss was nearly twice as great for High level. Note also the increase in cancer eye incidence. The greater survival of females wintered consecutively on Low as compared to High feed levels appears to be due to greater fertility and lower disease loss—corresponding to results from more basic studies with identical twin cattle in Scandanavia and with laboratory animals. Medium level females were intermediate in these respects.

Starting with an average weight of 475 lbs. as weaner heifers, Low level females have gained less, or lost more, during each winter than the other groups, with the exception that at maturity there was little difference between Low and Medium treatments for several years. Weight losses among the Lows were most severe the first three winters as young heifers, or as older cows (1960-61), which is to be expected. Low level females were observed to be better rustlers and more active in grazing habits—hence, they may have overcome some of the disadvantage of lower levels of supplement.

Using fall weights in 1956 as a mature weight, at which time the cows were 8.5 years of age and most cows had raised a calf, the accumulative differences due to winter feed level were small (only 52 lbs. difference between Low vs. High level treatments). If the data is broken down into two- vs. three-year-old calving groups within each feed level, it is apparent that the Lows calving at two's were lighter and High's calving as three's heavier than the other lots. Other groups tended to weigh about the same. Hence, little difference was apparent between levels of winter feed in terms of body weight at maturity, as was also indicated by various measurements of skeletal size.

Low level cows have calved somewhat later on the average than the Medium or High groups. This was most pronounced during the early crops and not during mature production. The percent calf crop weaned has been approximately 6.5 percent greater for the Lows, based on 11 or 12 opportunities to calve within each group. Surprisingly,

Table 1.—Long-Term Effects of Three Winter Feeding Regimes on the Performance of Range Beef Cows.

Winter Feed Level	Low 1 lb. CSM	Medium 2.5 lbs. CSM	High 2.5 lbs. CSM 3.0 lbs. oats
Number females started on test (Fall, 1948)	30	30	30
Number remaining, March, 1962	16	11	5
Reasons for removal from test:			
Open or failing to calve in two successive years	6	9	9
Cancer eye	1	4	5
Spoiled udder	2	1	4
Crippled	1	2	1
Disease	0	1	2
Hardware disease	1	0	2
Accidental	1	0	0
Unknown	2	2	1
Avg. weight change, lbs.			
Initial wt., Fall, 1948	476	476	476
First winter gain	22	58	88
Avg. 4-9th winter, mature cows	—104	—128	— 79
Winter loss, 1960-61	—235	—166	—128
Mature weight, Fall, 1956	1142	1147	1194
Reproductive performance:			
Avg. calving date	3/15	3/10	3/9
% calf crop weaned[1]	90.3	83.9	83.8
%calf crop born	94.7	90.8	92.1
%calves lost—birth to weaning	3.9	7.2	8.6
Avg. birth weight, lbs.[2]	77.6	77.6	78.8
Avg. weaning weight, lbs.			
1961 calf crop[2]	451	478	471
All calves[2]	479	482	483

[1] Based on number females exposed and calves weaned the following year.
[2] Corrected for sex by adding 5 lbs. to birth weight and 24 lbs. to weaning weight.

this advantage has been largely due to more calves saved from birth to weaning, rather than a greater percent calf crop born. As shown in Table I, Low level cows lost only 3.9 percent of their calves from birth to weaning, whereas the Highs lost 8.6 percent. This may be a reflection of a more vigorous and active female due to the lighter body weights and better rustling tendencies.

Calf Production Data—Financial Results

The planes of nutrition imposed by the three different feed levels were not severe enough to significantly affect birth weights. During most years, weaning weights differed only slightly. Note, however, that as the cows advanced in age the Low level group appeared to wean lighter calves, as indicated by the results of their most recent (1961) calf crop.

In Table 2, the results in terms of lifetime performance are summarized. A marked difference exists in total "cow years" accumulated for each treatment. The increase in favor of Low level cows was nearly 21 percent over the Highs with the Moderate intermediate. Hence, the calving opportunities were greater for the Low cows and this, together

Table 2.—Summary of Total Production of Beef Cows Wintered at Three Different Levels.

Winter Feed Level	Low 1 lb. CSM	Medium 2.5 lbs. CSM	High 2.5 lbs. CSM 3.0 lbs. oats
Number females started on test (Fall, 1948)	30	30	30
Number cows years/lot to 1962	364	331	306
Total number calves weaned	290	245	223
Total lbs. calves weaned/lot	138,186	117,237	107,296
as % of Low lot	--	84.8	77.6
Financial results, ($)			
Value cows salvaged and those remaining[1]	4,644	4,574	4,702
Value calves weaned[2]	35,543	29,531	27,064
Total supplemental feed, pasture, and mineral cost/cow[3]	374.48	486.01	646.24
Total net returns (value cows & calves minus feed costs)	29,585	21,623	16,450
Net return/cow year[4]	81.25	65.41	53.83
Cow cost/cwt. calf weaned	7.62	10.89	14.39

[1] Based on average value of 14/cwt. for cows sold and those remaining on test.
[2] Based on yearly Kansas City prices for Choice feeder steer calves.
[3] Based on current yearly prices of feed, pasture, and mineral.
[4] Net return divided by total number of years spent by all cows in each treatment group.

with a larger percentage calf crop and better survival of calves to weaning, resulted in nearly two extra calves per female starting on test for the Low as compared to the High level. Again, as in nearly all measures of performance, the Moderates were intermediate. It is also striking that the total pounds of calf produced per lot throughout the entire trial has been only 84.8 and 77.6 percent as great for Moderates and Highs, respectively, as for the Lows.

Complete records have been maintained on the costs of maintaining the cows and of producing a calf under each system of management. The average value of the calves at current yearly prices, together with the value of cows salvaged and those remaining, have been summarized in Table 2. Note that the total cost of feed, pasture, and mineral for the Low level treatment was only 77 percent as much as for the Mediums and only 58 percent as much as for the Highs.

When the entire financial results of each lot in this experiment are summarized, Low level cows returned $7,962 more than the Mediums and $13,135 more than the Highs. Expressed as "net returns per cow per year—over all feed, pasture, and mineral costs," this amounts to 24 percent more return for the Low vs. the Mediums, and 43 percent for the Lows over the Highs. This is further illustrated by the "cow cost per cwt. calf weaned" which was $7.62, $10.89, and $14.39 for the Lows, Medium, and High levels, respectively.

It must be borne in mind that the females in this experiment represent only one sample or test group. Due to the possibility of unkown bias in selection of the females, there is necessity of repeating the test. Also, native range pastures have always been adequate even during the exceptionally dry years of 1954 and 1956. The cows have never suffered for lack of grass in either the summer or winter, a factor which is highly important and may cause results to differ in areas where sparse range and overgrazed pastures are common. There is no question that too low feed levels can adversely affect the performance of a beef female to the point where such a practice is both unwise and unprofitable. Moreover, the "Low level" as practiced in this experiment actually proved too "moderate" or satisfactory in terms of cow performance. This factor has been considered in later studies and has resulted in a more severe feeding regime at the low level.

Nevertheless, the results clearly indicate that once a beef cow meets her nutritional needs, higher feed levels are both unprofitable and may actually prove detrimental in terms of life span and percent calf crop weaned. In well-managed, commercial herds where feed is abundant, or in purebred herds where beef females are maintained in 'show conditions" as an advertisement, producers should carefully guard against the adverse effects of too high planes of nutrition.

Two- vs. Three-year-old calving on lifetime performance.

This project has permitted the best estimate thus far of the effects of early calving on lifetime usefulness of the beef female. Average results to 14 years of age are shown in Table 3. The survival of beef cows has not been adversely affected by early calving as a two-year-old. Little difference between two- and three-year-old calves is apparent in reasons for removal of females from the test including those removed as open cows, or for cailing to calve two successive years, disease, or unsoundness. Therefore, if the beef heifer is sufficiently well-developed to calve first as a two-year-old, subsequent reproductive processes and her life span in the herd are not adversely affected.

Note that nearly 50 percent of the two-year-old heifers had to be assisted at first calving, whereas only one heifer required help in the three-year-old group. The slight effect on average body weight at maturity is due chiefly to Lows that calved first as two-year-olds being slightly lighter, and the three-year-olds that were wintered at the High level slightly heavier, than the average of the other groups.

Table 3.—Two- vs. Three-Year-Old Calving and Lifetime Performance.

Age at first calving	Two-Year-Old	Three-Year-Old
Number females started on test, Fall, 1948	60	60
Number remaining, March, 1962	23	22
Reasons for removal from test		
Open or failing to calve in two successive years.	16	16
Cancer eye	9	6
Spoiled udder	4	5
Crippled	2	2
Disease	1	2
Hardware disease	2	1
Accidental	0	2
Unknown	2	3
Heifers assisted at first calving	28	1
Avg. mature body wt., Fall, 1956 (lbs.)	1148	1178
Total number calves weaned	533	482
Number calves weaned per cow year	.80	.71
Total percent calf crop weaned	86.7	85.2
Average weaning wt., all calves (lbs.)[1]	476	485
Average weaning wt., minus two-yr.-old calf	482	485
Cow cost per cwt. calf weaned, $	10.33	11.34

[1] Sex corrected (See footnote table 1).

An extra 51 calves have been obtained from the two-year-old calving program. This is about .85 more calve per female started on test than the three-year-old-group. This has amounted to nearly .1 more calf per cow year in the herd, or an advantage of nearly 330 lbs. calf for the two-year-old group.

Weaning weights between the two groups have differed only slightly, and the small difference seen is almost entirely due to the lighter weights of the first calves from two-year-old heifers (nearly 68 lbs. lighter than the average of their mature production). Cow cost per cwt. calf weaned, therefore, has been reduced by $1.01 for the two-year-old calving regime.

Summary

Lifetime studies with beef cows, subjected each year to Low, Medium, or High feeding regimes on native bluestem pastures, show that females receiving 1 lb. of cottonseed meal pellets per head daily survived longer in the herd, produced a 6.5 percent greater calf crop, and returned 43 percent more net return than those fed 2.5 lbs. cottonseed meal plus 3 lbs. oats per head daily. Cows carried at the Medium levels (2.5 lbs. cottonseed meal) were intermediate in performance. Cows on the Low level appeared to be more active grazers and saved more of their calves from birth to weaning.

The results show that there is no necessity to feed the spring-calving beef cow more than needed to maintain her in a thin, but strong, thrifty condition. In fact, more liberal feed levels may actually prove detrimental.

Beef females which calved first as two-year-olds produced nearly .8 more calf per cow over their entire productive life at 10 percent less cost than those calving first as three-year-olds. The results show little or no affect on mature size or longevity. Thus, where practical, early calving appears desirable.

Level of Wintering Fall-Calving Beef Cows

A. B. Nelson, R. D. Furr, and G. R. Waller

The effect of feeding different levels of supplemental winter feed to fall-calving cows grazing dry grass has been under study for several years. The original study with mature cows, which had previously produced at least one calf, was conducted at the Lake Blackwell range area where adequate native grass was available. Four-year average results indicated that the low level of wintering (1.5 lbs. of cottonseed meal per cow daily) was more profitable than the high level (2.5 lbs. of CSM plus 3 lbs. of grain). It should be emphasized that these cows had completed much of their growth when placed in the test. They had first calved in the spring as two-year-olds and their second calf was born in the fall when they were three and one-half-years old. Therefore, they had several additional months of growth between calvings without the added burden of reproduction.

In later studies with young cows fed at different levels, production usually has not been satisfactory with losses of from 20 to 30 percent of their body weight resulting during the winter when grazing dry grass. The level of nutrient intake has been increased in current studies by feeding prairie hay in a small trap instead of allowing the cattle to graze the dry native grass during the winter.

This report presents the results of (1) feeding three-year-old cows prairie hay and two levels of supplemental winter feed and (2) feeding two-year-old cows prairie hay in a small trap vs. grazing dry range grass and two levels of supplemental winter feed within each of these groups.

Part 1. Results with Three-Year-Old Cows, 1960-61

Procedure

The heifers had previously been subjected to different levels of supplemental winter feed as yearlings (1958-59) and as two-year-olds (1959-60). As two-year-olds the two lots of cows were retained in adjacent traps (approximately three acres per trap) during the winter feeding period when prairie hay was fed ad libitum. The feed intake in Lot 1 was 25.5 lbs. of prairie hay and 1.43 lb. of pelleted cottonseed meal per head daily. In Lot 2, the intake was 17.8 lbs. of prairie hay, 1.56 lb. cottonseed meal, and 4.69 lbs. ground milo. The winter weight losses of the cows were 140 and 111 lbs., respectively. The calf weaning weights were nearly equal (370 vs. 374 lbs.).

In the current test these cows were three and one-half years old in October and were again fed prairie hay during the winter. They were weighed on October 7 but supplemental feeding was not started until

October 27. The low level of supplemental feed was 1.43 lbs. of cottonseed meal. The high level group was self-fed a mixture which contained an average of 59 percent ground milo, 20 percent cottonseed meal, and 21 percent salt. The daily consumption was 1.80 lb. cottonseed meal, 5.32 lbs. ground milo, and 1.84 percent salt. During the summer all cattle grazed the native grass pasture. A mineral mixture of 2 lbs. salt and 1 lb. steamed bone meal was available at all times.

Results

A summary of the results may be found in Table 1. There was only a small difference in the winter weight losses of the two groups of cows (—158 and —144 lbs.), although there was a considerable difference in intake of supplemental feed. The consumption of hay was inversely related to the level of supplement fed. The group that was fed the low level consumed 24.4 lbs. of hay per head daily and those fed the higher quantity of supplement consumed 16.9 lbs. of hay.

The difference in gain from spring to weaning of 63 lbs. (—40 vs. 23) was reduced to 10 lbs. (21 vs. 31) by August 31. The average spring weights of the calves were 214 and 264 lbs. for the low and high levels, respectively. This difference is considerably larger than that recorded in any previous test. The level of winter feeding also had a marked effect on weaning weight of the calves. The difference of 91 lbs. (382 vs. 473 lbs.) was considerably greater than differences obtained in other tests. The average weight of 473 lbs. was considered satisfactory, although a high level of winter feeding was necessary to produce such calves.

The calves were weaned on July 17 and sold at the Oklahoma City stockyards. The steers in Lot 1 sold for $29.50 per 100 lbs., and the heifers in this lot sold for $26. The heavier calves in Lot 2 sold at $28 and $25 per 100 lbs. for the steers and heifers, respectively.

The total feed costs, including pasture, were relatively high ($57.73 and $68.38) because both groups were fed prairie hay ad lib. instead of being allowed to graze the dry range grass. Even though the heavier calves sold at a lower price per 100 lbs., their selling value per head was higher and the selling value minus feed cost was also higher.

Part 2. Results with Two-Year-Old Cows, 1960-61

Procedure

Seventy-one two and one-half-year-old heifers were divided into four lots on October 13, 1960. During the two previous winters they had been fed at different levels. As calves (1958-59) all were fed prairie hay as the roughage and one-half was provided with supplemental feed adequate to maintain body weight. The other group was fed to gain about 1 lb. per head daily. During the second winter feeding season

(1959-60), the heifers were continued on their respective levels of supplemental feed; however, one-half of the heifers on each feeding level was fed prairie hay in a small trap and one-half was allowed to graze the native grass. Within each roughage group, the heifers were fed a low and a high level of supplemental winter feed. The heifers were bred during this winter so that they would calve in October, November, and December when they were about two and one-half-years-old.

Table 1. Levels of Supplemental Winter Feeding of Three-Year-Old Beef Cows, 1960-61.

Lot Number Level of Feeding		1 Low[1]	2 High[2]
Number of cows raising calves[3]		11	8
Average weight per cow, lbs.			
Initial	10-7-60	1025	1036
Spring	4-28-61	867	892
Weaning	7-17-61	985	1059
Late summer	8-31-61	1046	1067
Winter gain		—158	—144
Gain to weaning		—40	23
Total gain		21	31
Average weight per calf, lbs.			
Birth[4]		71	72
Spring[5]		214	264
Weaning[6]		382	473
Average birth date of calves, Nov.		3	6
Winter feed per cow, lbs.[7]			
Prairie hay		4474	3096
Cottonseed meal		262	329
Ground milo		---	974
Financial, dollars			
Feed cost per cow[8]		57.73	68.38
Selling value			
Per 100 lbs.			
Steers		29.50	28.00
Heifers		26.00	25.00
Per head[9]		100.42	121.22
Selling value minus feed cost		42.69	52.84

[1] Fed 1.43 lb. of pelleted cottonseed meal per head daily in addition to prairie hay starting October 27.
[2] Self-fed a cottonseed meal-milo-salt mixture as supplement to prairie hay during winter. The average daily consumption was 1.80 lb. cottonseed meal, 5.32 lbs. ground milo and 1.84 lb. salt.
[3] Originally there were 14 cows in Lot 1 and 10 cows in Lot 2. In Lot 1, one calf drowned, one calf was born deformed, an done cow failed to calve. In Lot 2, one calf was born dead and one cow died for causes apparently unrelated to nutritional treatment.
[4] Corrected for sex by the addition of 3 lbs. to the birth weight of each heifer.
[5] Corrected for sex by the addition of 18 lbs. to the weight of each heifer after a 170-day age correction.
[6] Corrected for sex by the addition of 43 lbs. to the weight of each heifer after a 260-day age correction.
[7] Not including salt and steamed bone meal.
[8] Using prices of feeds and pasture at the time tests were conducted.
[9] Based on an equal number of steers and heifers in each lot using the age- and sex-corrected weaning weights as the steer selling weight and this weight minus 43 lbs. (sex-correction factor) as the average weight of the heifers.

In the fall of 1960, the same heifers were continued in the test. Prairie hay was fed ad lib. The low level of supplemental feed for heifers on the range was 2.78 lbs. of cottonseed meal pellets per head daily, and the high level of supplemental feed was 7.35 lbs. of a pellet containing 35 percent cottonseed meal and 65 percent ground milo. The supplemental feed for the cows fed hay in the traps was 1.39 lb. of pelleted cottonseed meal for the low level and a milo-cottonseed meal-salt mixture self-fed for the high level. The average daily consumption was 4.85 lbs. of milo, 1.76 lb. of cottonseed meal, and 1.78 lb. of salt. Supplemental feeding was started on October 17, 1960 and discontinued on April 19, 1961.

All cattle grazed the native grass pastures during the summer. A mineral mixture of 2 lbs. salt and 1 lb. steamed bone meal was available at all times.

Estimates of milk production of the cows were obtained on December 2, December 31, February 11, March 11, April 20, May 30, June 23, and July 18. The technique used in estimating milk production was weighing the calf immediately before and after nursing and any increase in weight was recorded as the quantity of milk produced by the cow. The 24-hour estimates are the average of three 8-hour estimates on December 8 when the calves were young, and the average of two 12-hour estimates on subsequent dates.

Results

A summary of the level of wintering data is given in Table 2.

The cows fed the low level of supplement in the traps (Lot 1) consumed more hay than those fed the high level (Lot 2). The average daily consumption was 19.9 and 15.0 lbs., respectively. Estimated total digestible nutrient intakes were 9.68 and 11.65 lbs. This difference of 1.97 lb. of TDN per head daily was reflected in the winter weight losses of 140 and 17 lbs. for the cattle in Lots 1 and 2, respectively.

When dry range grass was the forage available, the cows on the low level lost 179 lbs. and those on the high level lost 190 lbs. It is probable that the TDN intakes of these two groups were nearly equal. Apparently the cows fed the lower quantity of supplemental feed consumed more dry range grass, although no estimates of consumption are available.

Differences in spring calf weights favored the higher levels of supplemental feed. The difference was 17 lbs. for the groups fed prairie hay and 6 lbs. for those on the range. Average weaning weights were 357 and 371 lbs. for the low and high levels of feeding in the traps, and 337 and 343 for the low and high levels on the range, respectively. Therefore, the high level of feeding increased weaning weights only 14 lbs. in the traps and 6 lbs. on the range.

Both the steers and heifers were weaned in July and sold as good-choice feeder calves at the Oklahoma City Stockyards. The steers sold

Table 2. Levels of Supplemental Winter Feeding of Two-Year-Old Beef Cows.

Location	Trap		Range	
Lot Number	1	2	3	4
Level of Supplemental Feed	Low[1]	High[2]	Low[3]	High[4]
Number of cows raising calves[5]	15	11	13	11
Average weight per cow, lbs.				
Initial 10-13-60	948	965	909	972
Spring 4-19-61	808	948	730	782
Weaning 7-18-61	927	1016	857	911
Winter gain	—140	—17	—179	—190
Gain to weaning	—21	51	—52	—61
Average weight per calf, lbs.				
Birth[6]	73	72	69	72
Spring[7]	193	210	165	171
Weaning[8]	357	371	337	343
Average birth date of calves, Nov.	18	17	18	12
Average winter feed per cow, lbs.[9]				
Cottonseed meal	253	336	512	477
Ground milo	---	893	---	789
Prairie hay[10]	3670	2766	---	---
Range	---	---	ad lib.	ad lib.
Total feed cost per cow ($)	51.79	69.45	42.41	54.09
Selling value ($)				
Per 100 lbs.				
Steers	29.50	29.50	29.50	29.50
Heifers	26.00	26.00	26.00	26.00
Per head[12]	93.48	97.36	87.93	89.59
Selling value minus feed cost ($)	41.69	27.91	45.52	35.50

[1]Fed 1.39 lbs. of cottonseed meal per head daily in addition to prairie hay.

[2]Cows fed same as those in Lot 1 until October 27, at which time the cows started receiving a milo-salt-cottonseed meal mixture from a self-feeder. Over the entire wintering period, the average consumption was 4.85 lbs. of milo, 1.76 lb. of cottonseed meal, and 1.78 lb. of salt.

[3]Fed 2.78 lbs. of cottonseed meal pellets per head daily.

[4]Cows fed same as those in Lot 3 until November 5, at which time the daily feed was increased to 7.35 lbs. of pellets consisting of 35 percent cottonseed meal and 65 percent ground milo.

[5]There were 18, 18, 18, and 17 heifers in Lots 1, 2, 3, and 4, respectively, in the experiment in 1959-60. In Lot 1, two cows failed to calve and one calf was born dead. In Lot 2, two cows failed to calve three calves were born dead, and two calves died. In Lot 3, four cows failed to calve and one calf died. In Lot 4, three cows aborted, two cows failed to calve, and one calf died.

[6]Corrected for sex by the addition of 3 lbs. to the weight of each heifer.

[7]Corrected for sex by the addition of 18 lbs. to the weight of each heifer after a 150-day age correction.

[8]Corrected for sex by the addition of 43 lbs. to the weight of each heifer after a 240-day age correction.

[9]184 days of feeding which started 10-17-60.

[10]Total pounds of prairie hay consumed per cow. Average daily consumption was 19.9 lbs. per head daily in Lot 1 and 15 lbs. in Lot 2.

[11]Using prices of feeds and pasture at the time tests were conducted.

[12]Based on an equal number of steers and heifers in each lot using the age- and sex-corrected weaning weights as the steer selling weight and this weight minus 43 lbs. (sex-correction factor) as the average weight of heifers.

for an average of $29.50 per 100 lbs. and the heifers for $26 with no differences among the lots. When 1960-61 feed costs were used, the total feed cost (including pasture) per cow was $51.79, $69.45, $42.41, and $54.09 for Lots 1, 2, 3, and 4, respectively. Since weaning weights were increased only slightly by the high level of wintering but feed costs were increased considerably, the higher level of feeding was not economical.

A summary of the milk production data is presented in Table 3. Only those cows which had calved prior to December 2 (date of the first milk production estimate) were included in the data, although milk yields were obtained for all lactating cows within each of the four lots.

Table 3. Average Daily Gains of Calves and Milk Yields of Cows, and Their Correlations, 1960-61.

Location	Trap		Range	
Lot Number Level of Supplemental Feed	1 Low	2 High	3 Low	4 High
Average daily gain, lbs.	1.16	1.27	1.06	1.18
Average milk yield, lbs.	6.82	6.88	5.33	6.54
Correlation coefficient	.75	.91	.80	.80

The average yields were nearly equal in Lots 1 and 2 but there was more than a 1 lb. difference in average yield of the cows in Lots 3 and 4. The correlation coefficients between average daily gain of the calves and average milk yield of the cows were relatively high (.75 to .91). These indicate that the fastest gaining calves were those which obtained the most milk from their mother.

The yields were highest on December 2. Both groups of cows fed hay in the traps produced a greater quantity of milk during the entire wintering period than those on the range. Milk production gradually declined until April 20 (when supplemental feeding was stopped) for all lots except the high level in the trap. The milk production of the three lots increased when green grass was available and then declined until weaning in July. The production of the lot fed on the high level in trap stayed higher than that of the other lots during the winter, was relatively high in April, and then gradually declined to July without the increase in May as was noted in the other lots.

Summary

Fall-calving cows were fed at different levels of supplemental winter feed in two experiments. In the experiment with three and one-half-year-old cows, prairie hay was the roughage during the winter feeding season. Feeding a high level of supplement decreased winter weight losses of the cows and markedly increased weaning weights of the calves compared to feeding a low level of supplement. With first-calf two and one-half-year-old heifers fed prairie hay in a trap and those grazing the dry range, the level of winter feeding had little effect on weaning weights of the calves. Weight losses of the cows were less and weaning weights of the calves were heavier for cows fed prairie hay than for those grazing dry grass. Estimated milk production of the cows was relatively low but was highly correlated with average daily gain of the calves.

Effect of Alternate Low-High or High-Low Winter Feed Levels on Growth and Reproduction of Replacement Heifers

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A serious obstacle in maintaining a cow-calf herd is the long interval between birth and the time the young heifer gets into production. In well-managed herds, heifers usually calve at two or three years of age. This results in considerable expense in rearing the replacement heifer, much of which is related to the cost of supplemental feed during the first and second winter periods. Any method of reducing this cost without affecting reproduction or future usefulness, therefore, would improve the net return.

As a part of an extensive study on the effect of different planes of nutrition to which the beef female is exposed during the winter, one phase was directed toward the problem of how seriously poor feed levels may effect body development and reproductive processes during the first winter as a weaner calf, or the second winter as a bred yearling.

Plan of Experiment

In the fall of 1960, 75 weaner, Hereford, heifer calves were selected from the Ft. Reno Experimental herd for similarity in age, weight, sire, and productivity of dam. Five uniform groups were started on winter feeding tests in early November at aproximately eight months of age.

All heifers were pasture exposed to bulls the following summer as yearlings, whereupon they returned to their original winter feeding level, or in the case of the reversal treatments (i.e. Low-High or High-Low) to the opposite level. The treatments imposed during the first winter as calves or the second winter as bred yearlings were as follows:

Lot Number	First Winter (Calves)	Second Winter (Bred yearlings)
1	Low	Low
2	Low	High
3	Moderate	Moderate
4	High	High
5	High	Low

All heifers grazed native grass pastures (principally bluestem) year-long. In the Low treatment, the supplemental feed allowance was adjusted at two week intervals to permit no gain in weight as weaners, and a loss of 20 percent or more of fall body weight the following winter as bred yearlings. Moderately fed heifers gained about .5 lb. per head daily during the first winter and lost less than 10 percent fall weight the second winter. In the High level treatment, 1 lb. or more daily gain the first winter as calves was desired, with essentially no loss the second winter. Actually, to induce early winter weight loss, Low level heifers were confined to drylot and fed wheat straw with no supplement for three to four weeks before returning to range pasture. All heifers had free access to a mineral mix of two parts salt and one part steamed bone meal, year-long.

The wintering period each year extended from about November 1 to mid-April (approximately 165 days). Gains or losses in body weight were controlled by frequent weighings and subsequent adjustment of supplemental feed. In addition to detailed records on body weight changes, feed intake, and skeletal size at six-month intervals, reproductive performance and weaning weights were obtained. The results discussed below were obtained from the first group of heifers from weaning to 2.5 years of age, or after they had weaned their first calves.

Results

The average results obtained during the two wintering periods are summarized in Table 1. Due to an oversight, the heifers were not vaccinated for Leptospirosis, an infectious reproductive disease, known to be prevalent on the Ft. Reno station. As a consequence, 10 heifers aborted within a month's period during the late fall of 1961 and were removed from the data shown in Table 1. A prompt vaccination program was instituted among the heifers that had not aborted, and the difficulty was checked. A yearly vaccination program (early May) has been routinely followed at Ft. Reno with all females since 1956, and losses from Leptospirosis among vaccinated females has been very light. Older females in the experimental herd were less affected during this outbreak. This incident clearly shows the need for a consistent vaccination program where the threat of Lepto is prevalent.

Upon completion of this study, all heifers in the trial were culled. A new repetition is now in progress. While the numbers involved in this trial are small, it is believed that they represent a trend which may be borne out in future studies.

Table 1.—Effect of Alternate Winter Treatments (Low-High and High-Low) on Growth and Reproductive Performance of Two-Year-Old Heifers.

Lot No. 1st Winter Treatment 2nd Winter Treatment	1 Low Low	2 Low High	3 Mod. Mod.	4 High High	5 High Low
Number heifers[1]	13	14	12	15	11
Avg. weight change, lbs.					
8 to 18 months of age					
Winter gain	—40	—39	91	162	167
Summer gain	337	327	282	232	236
Net yearly change	297	288	373	394	403
18 to 30 months of age					
Winter gain	—170	+17	—113	—18	—254
Summer gain	281	186	249	187	315
Net yearly change	111	203	136	169	61
Fall wt. at 30 months of age[2], lbs.	**855**	**956**	**928**	**1009**	**911**
Winter supplement per/head (lbs.)					
1st winter					
C.S. Meal	97	97	259	334	334
Grd. Milo	133	133	450	1040	1040
2nd winter					
C.S. Meal	90	266	185	266	90
Grd. Milo	24	817	126	817	24
Avg. winter supplemental feed cost per/head, ($)	8.87	27.54	24.32	50.11	31.44
Calf production data:					
Avg. calving date	3/27	3/24	3/13	3/7	3/2
% calf crop[1]	77	64	58	67	82
Avg. birth weight, lbs.[3]	60.5	69.4	64.8	67.2	62.5
Avg. weaning wt., lbs.[2]	357	383	392	428	373
Avg. Daily Gain of Calves	1.56	1.62	1.60	1.69	1.44
Avg. daily milk production, lbs., (five estimates)	8.34	8.70	8.73	8.10	7.30

[1]Excludes heifers that aborted due to Leptospirosis in the late fall of 1960.
[2]Includes only heifers calving and raising a calf.
[3]Corrected for sex by adding 5 lbs. to birth wts. and 24 lbs. to weaning wts. on heifer calves.

Note the typical winter-summer gain pattenrs of heifers fed at different levels during the winter. The winter performance each year directly reflected the level of supplemental feed, as was planned. After weaning their first calves (2.5 years of age), heifers of Lots 1, 3, and 4 averaged 855, 928, and 1009 lbs., respectively. These weights were related to the continuous Low, Moderate, and High treatments imposed each of two successive winters. In other words, a difference of about 150 lbs. between Low vs. High, and 75 lbs. between Low vs. Moderate, remained at 2.5 years of age.

Where the alternate winter feeding programs were followed, heifers wintered at High levels the first winter as weaner calves (Lot 5) lost excessively the second winter when switched to the Low treatment. Doubtless, this was due to their fleshy condition at the start of the second winter. Conversely, poorly-fed heifers the first winter, but well fed the second (Lot 2), gained 17 lbs. during the second winter while bearing calves. This was better than any other treatment imposed.

The fall body weights, when compared to continuous Low, Moderate, or High treatments, show a weight advantage of about 100 lbs. for the Low-High group over Lot 1 wintered each year at the Low level, and about 50 lbs. for Lot 5 on the High-Low regime. Hence, there was some advantage in body weight, as borne out in skeletal size from photographic measurements, for the switchover to the High level, but this was most advantageous for the Low-High regime. Both Low-High and High-Low groups tended to about equal the Moderates (Lot 3) in body weight and were 50 to 100 lbs. lighter than those wintered High level both years (Lot 4).

In terms of calf production data, it can be seen that Low feed levels the first winter as weaner calves delays conception the following summer on pasture with an average difference of about 20 days between Low and High levels. Due to the small numbers involved, data on percent calf crop are not too meaningful. Birth weights reflected the previous winter's treatment of the dam, with an average difference of about seven lbs. between Lows (Lots 1 and 5) and Highs (Lots 2 and 4).

Weaning weights of calves from Lots 1, 3, and 4 (continuous Low, Moderate, or High levels) were directly related to the winter feed treatment of the dam. Where alternate levels were followed (Lots 2 vs. 5) little difference was observed (10 lb. average). This may be best explained by an examination of average daily gain of calves from birth to weaning in light of average birth dates. Low-High calves were dropped later than those of Lot 4 (High level), but the heifers did about as good a job of raising them according to average daily gains and milk production data. On the reverse treatment (High-Low), while the calves were dropped early, the previous winter's feed level was so poor that the daily gains of the calves and milk yield were both reduced.

Milk production data shown in Table 1 appear somewhat erratic and with the exception of the low milk production of Lot 5, females, showed little difference among the treatments. Much more difference due to feed level has been reported elsewhere for older cows.

Summary

Winter feed levels that permit a weaner heifer calf to make little or no gain from fall to spring markedly retards the appearance of heat and delays the subsequent calf crop. Poor winter feeding during the second winter as a bred yearling seriously reduces milk flow the following summer and affects weaning weights. Both treatments, however, appear superior to a Low level both years, but of no advantage over the Moderate level. Maximum body size and weaning weight have been obtained when heifers are fed to gain at least 1 lb. per head daily as weaners, and lose little or no weight as bred yearlings from fall to spring after calving. Feed costs from this regime, however, were excessively high in this experiment, therefore the Moderate regime proved more profitable.

Mineral-Vitamin Interrelationship in Ruminant Nutrition

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It has been estimated that fully 60 percent of the veterinary practice in the United States involves noninfectious diseases, most of which are of nutritional origin. In most cases, severe individual nutrient deficiencies can be identified and rectified by adding the missing nutrient, but the greatest loss in livestock production results from borderline deficiencies. In animals with borderline deficiencies, there are no definite clinical symptoms. Metabolic functions simply slow down to comply with the level of the limiting nutrient resulting in slower growth and less efficiency. To prevent these borderline or subclinical conditions, the nutrient requirements of animals must be met. This is sometimes much more difficult than is apparent to the layman. Recent changes in production methods in plants and animals, with emphasis upon faster and greater growth by the use of fertilizers and other adjuncts, have tended to increase the incidence of borderline deficiencies. Several mineral-vitamin interrelationships in ruminant nutrition are discussed in this article. They include nitrate and vitamin A, calcium and zinc, cobalt and vitamin B_{12}, vitamin E and selenium, and copper and molybdenum.

Nitrate and Vitamin A

Research and field reports have indicated that vitamin A deficiency symptoms occur in fattening beef cattle on rations formerly considered adequate in the carotenes. It has been suggested that either nitrates or some other factor (s) in ruminant rations are inhibiting the conversion of the carotenes to vitamin A by the intestinal walls.

It has been known for some years that the efficiency of carotene utilization decreases with increasing animal requirements. The National Research Council (NRC, 1955) Bulletin, "recommended nutrient allowances of beef cattle" established a ratio of 2.5:1 in favor of vitamin A over carotene at the minimum level of growth, 3.3:1 for reproduction, and 8.3:1 for a high level of lactation indicating that energy level of diet could be involved in the poor conversion of the carotenes to vitamin A.

Phosphorus Deficiency

Work at the Oklahoma Station (1)[1] indicated that a phosphorus deficiency in cattle rations decreased the efficiency of conversion of carotene to vitamin A. As there is widespread usage of phosphorus supplements in ruminant ration it is doubtful if this is a factor in the modern fattening rations.

Nitrates

Heavy nitrogen fertilization increases the nitrate content of some forages (2,3). In feeding tests with rats (4) it was shown that the addition of .3 percent KNO_3 to the diet resulted in a rapid destruction of vitamin E with subsequent rapid decrease in liver stores of vitamin A. High nitrate corn silage was found to exert an adverse effect upon the vitamin A status of rats (5). Similar results were obtained with sheep (6). Results with cattle are not conclusive but trends are in the same direction (7,8,9). The preliminary results indicate that liver storage is affected more than plasma levels (5,6,8,9). It appears that concentration of energy (8) in the diet may have more effect (negative) upon the conversion of carotenes than the nitrate content. A cattle fattening diet containing 71 percent TDN caused much more depletion of liver stores of vitamin A than a diet containing 54 percent TDN.

The conversion of carotene to vitamin A is lower in the vitamin A deficient animal (10) and in animals with hypothyroidism (11,12). It has also been shown that nitrates (13) interfere with the retention of iodine by the thyroid gland. Thus the mechanism of action of nitrates in reducing the conversion of the carotenes to vitamin A appears to be through their actions on the thyroid gland.

[1]Number in parenthes's refers to reference to original research data. These references are found at the end of each report covered in this article.

Vitamin A Requirements

High producing dairy cows weighing 1400 lbs. require a minimum of 34,000 I.U. (14) per day of vitamins (86 mg. carotene). These can be added in the dry form (vitamin A acetate or palmitate) at a cost of only $1.25 per year. Research at Purdue University (15) has shown that steers require additional vitamin A when fed rations containing 1 mg. of carotene per lb. The best results were obtained when 32,000 I.U. of supplemental vitamin A was provided daily. Steers receiving the high levels of vitamin A were observed to have sleeker coats and appeared to be more vigorous. Hale *et al.* (16) reported that the feeding 10,000 I.U. per day of vitamin A to steers failed to maintain liver stores of vitamin A when a fattening ration was fed. When the level of vitamin A was increased to 40,000 I.U. per day, the steers were just able to maintain the liver levels found when they were first placed on the fattening diets while levels above 40,000 I.U. per day promoted rapid storage of vitamin A in the livers of the steers. Beeson (17) recommends that fattening steers receive 30,000 I.U. of vitamin A daily. If the dry form of vitamin A (vitamin A acetate of palmitate) were used for a six months feeding period, the costs would be less than about 60¢ per steer.

Summary

It appears that ruminant animals are poor converters of carotene to vitamin A. Efficiency of conversion of the carotenes appears to be lowered by nitrates or by a greater concentration of energy. Hypothyroidism reduces the efficiency of conversion of the carotenes to vitamin A and it appears that nitrates reduce thyroid function. Some researchers recommend that fattening steers receive a daily allowance of 30,000 I.U. of vitamin A daily.

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Calcium and Zinc

A condition called parakeratosis in swine was observed for many years before Tucker and Salmon (1) showed that zinc supplementation prevented this condition. Results with swine and chicks (2,3,4,5) indicate that the severity of the parakeratoti symptoms increased as the calcium level in the diet increased.

Recently Miller and Miller (6) were able to produce a zinc deficiency in calves. When fed a low-zinc purified diet, the calves developed the following symptoms in about eight weeks: slightly red and inflamed nose and mouth, soft swelling above the rear feet in front of the fetlock, small areas of alopecia on the rear legs, breaks in the skin around the hoofs, rough and sealy skin on the rear legs, and a dull, listless appearance. Later symptoms, obtained 11 weeks after the animals were placed on the purified diets, were similar to those reported for hyperkeratosis. The zinc content and carboic anhydrase activity of the blood from the calves were much lower than those of the controls. Evidence that symptoms of zinc deficiency does occur in beef cattle kept under natural conditions is presented by Legg and Sears (7). They observed that cattle grazing on the Berbice savannahs had lesions resembling those described for rats receiving a zinc deficient diet. In the most severe conditions, parakeratosis spreads rapidly over about 40 percent of the body. Symptoms occur between March and June. Zinc supplementation administered either orally (2 gm. per week) or by injection (1 gm. per week) to affected cows caused new hair growth within one week and the animals were normal within three weeks. The unsupplemented control animals continually deteriorated. Later the control animals were also given zinc and responded rapidly. It was found that plants growing in the affected area also responded to supplement zinc.

In my travels through Finland in 1959, I saw many dairy cows suffering from an itch that covered much of their bodies. They had a scurfy skin and there was loss of hair. This condition caused lowered production (11.4 percent) and reproduction (delayed an irregular estrus). There were increased incidences of uterine inflammation, retention of afterbirth, abortus, milk fever, and ketosis. Feeding 300 to 500 mg. of zinc for 1000 lbs. of body weight daily clears up the condition (8) and new hair growth starts within two weeks.

The high calcium requirement of the dairy cow undoubtedly increases the zinc requirement. No one has studied this, however, in systematic experiments.

Summary

Zinc deficiencies can be produced experimentally and occur in cattle under natural feeding conditions. Cattle deficiency symptoms are similar to those noted in swine, rats, and chicks. Deficiency symptoms in cattle can be alleviated by either feeding supplemental zinc or by subcutaneous injections. Feeding 300 to 500 mg. daily per 1000 lbs. body weight has been effective while injection levels have been about 150 mg. daily for each 1000 lbs. body weight.

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Cobalt and Vitamin B_{12}

It has been 27 years since Underwood and Filmer (1) first reported that cobalt was required in ruminant diets and since that time much progress has been made in locating areas of acute deficiency. Cobalt deficiency in ruminants and its relation to vitamin B_{12} has been the subject of several excellent review papers (2,3,4,5). The experimental evidence supports the idea that rumen microorganism use cobalt to synthesize vitamin B_{12} and that the absorbed vitamin B_{12} is required by ruminant tissues in much the same way that non-ruminant tissues require this vitamin. Thus a cobalt deficiency in the ruminant is essentially a vitamin B_{12} deficiency which can be alleviated by either an oral or intravenous administration of vitamin B_{12} (5); however, the practical control is through feeding supplemental cobalt. Australian workers have described a new procedure (6) for supplying cobalt to ruminants. The procedure makes use of the anatomy of the reticulum, which retains heavy foreign bodies. Cobalt oxide is pelleted and placed in the esophagus of the animal, who swallows it. It is subsequently trapped in the reticulum and there the cobalt is released at a slow rate to the rumen fluid. Our best proof of a cobalt deficiency in animals is the rapid recovery when cobalt is fed, thus many new cobalt-deficient areas have been found in this country by using this new procedure of cobalt administration. The requirement for cobalt is about .1 mg. per 100 lbs. body weight daily.

It has always been a mystery regarding why the vitamin B_{12} requirement in ruminants is so high and the answer had come only recently (7,8,9,10). Experimental evidence supports the idea that the coenzyme form of vitamin B_{12} is required for the metabolism of methylmalonate to succinic acid; methylmalonate is an intermediate in the pathway of propionic acid metabolism. Thus, cobalt, through vitamin B_{12}, is required for energy reactions typical of the ruminant animal only.

Summary

Ruminant animals have a high requirement for vitamin B_{12} because it is used in the metabolism of propionic acid. Dietary cobalt is used by rumen microflora in synthesizing vitamin B_{12}, thus ruminant requirements for vitamin B_{12} can be met by supplying .1 ppm of cobalt in the ration. This amounts to only .1 mg. per 100 lbs. body weight and can be supplied in pellets or in salt.

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Vitamin E and Selenium

Losses from White Muscle Disease (WMD) in certain areas of the western states have reached serious proportions (1). This disease has been recognized for many years (1,2) but there has not been an understanding of it. The disease has been described as Muscular Dystrophy, Nutritional Myopathy, Vitamin E Deficiency, or Stiff-lamb Disease. It causes varying degrees of stiffness when skeletal muscles are involved and sudden death when the heart muscles are involved.

For many years WMD was considered to be caused by a vitamin E deficiency (3); early work also indicating that the milk from cows or ewes consuming such diets were low in vitamin E (4). Also there was, in general, an improvement when vitamin E was administered to affected animals (5); however, evidence became available (6) that vitamin E was not the primary or sole cause of WMD. Experimental diets containing much lower levels of vitamin E than those found to produce WMD in the field produced normal animals (5,6,7). Authorities at this time were confused by these inconsistencies and attention was drawn to the brilliant researches of Schwarz and colleagues (8,9,10,11,12,13) in which they showed that selenium was an essential nutrient and that it was 500 times more active than vitamin E in preventing degeneration in rats and chicks. At this time it was also demonstrated that exudative diathesis was prevented in the fowl by selenium or vitamin E.

Interest in the possible beneficial effects of selenium in ruminant nutrition was aroused by the results of Muth *et al.* (2) and Proctor *et al.* (14) who, almost simultaneously, found that dietary selenium reduced the incidence of WMD in lambs. The Oregon results (2) showed that the feeding of .1 ppm of selenium as Na_2SeO_3, from 90 to 100 days prior to lambing showed a preventive effect against WMD, while vitamin E given orally or parentally to similar ewes was ineffective. When the New York workers fed ewes 1 ppm supplemental selenium 30 days prepartum, confirmatory results (14) were obtained. Later the Nevada workers (1) found that either oral or injectable selenium given to the ewe prior to lambing was effective in preventing WMD. These workers added .1 ppm (sodium selenite) to the diet during the last three months of pregnancy. They also injected some ewes with barium selenate ($BaSeO_4$). The selenium was suspended in a mixture of 98 percent peanut oil and 2 percent beeswax and enough selenium to supply .2 gm. $BaSeO_4$ per ml. and the ewes received .1 gm. barium selenate per 100 lbs. body weight. In order to determine the effectiveness of the treatments serum samples from their lambs were taken 10, 24, and 38 days of age and tested for its transaminase (serum glutamic-oxalacetic transaminase, SGOT) activity. The enzyme, transaminase, is liberated into the blood as a result of muscle damage or destruction.

The Nevada workers (1) also have shown that WMD can be prevented in susceptible lambs by feeding vitamin E in the creep feed. They provided each lamb with approximately 200 international units of vitamin E daily and it was found that this method of feeding was effective in preventing WMD.

Much interest was aroused by the report (15) that WMD in lambs from susceptible areas was prevented by a subcutaneous injection of 1 mg. sodium selenate at birth and each 10 days thereafter until the lambs were weaned. Gains of the injected lambs were greater than their controls even in areas where no WMD has been observed. Results with calves in Scotland (16) are confirmatory.

It is interesting to note that, even though a direct comparison is impossible, protection from selenium in 1960 was similar to that afforded by vitamin E from 1953 to 1959. The single injection consisted of 15 mg. of selenium, while 5 mg. of selenium was either injected subcutaneously or given orally for three consecutive weeks beginning shortly after the calves were born. Evidence that selenium injected subcutaneously has both prophylactic and therapeutic effect in lambs was presented by Lagase (17).

Evidence is accumulating which indicates that the major if not only biochemical role of vitamin E is its inhibition of tissues lipid peroxide formation with the consequent effect of the free radicals. The association between vitamin E and selenium involves the antioxidant or antioxygenic properties of tissues but the exact relationship is not clear. Recent work (18) indicates that the antioxidant, 1,2-dihydro-6-ethoxy-2,2,4-trimethylquinoloine (Santoquin) prevents WMD in lambs and exudative diathesis in chicks. This opens up a new area in which several groups are actively investigating at this time.

Summary

Selenium fed to ewes in selenium-deficient areas at a level of .1 ppm for 3 to 4 months prepartum will prevent WMD in lambs; 1 ppm appears to be effective when given 30 days prepartum. Either vitamin E or selenium will prevent WMD if given to the lambs in selenium-deficient areas. Vitamin E is required at a level of 200 I.U. per lamb daily while selenium injected subcutaneously is required at a level of 1 mg. sodium selenate every 7 to 10 days. Either vitamin E (fed) or selenium was effective in preventing WMD in calves. Selenium was as effective when fed as when injected subcutaneously.

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Copper, Molybdenum, and Sulfur

Ferguson *et al.* (1) reported that some pastures in certain areas of England caused severe scours in cattle and that the pasture grasses from these areas contained from 20 to 100 ppm of molybdenum. Later these workers (2) reported that the feeding or the drenching of cattle with copper sulfate prevented the excessive scouring and it was also found that increased levels of molybdenum (3) caused reduced levels of copper in the liver. The mechanism of the copper-molybdenum interaction is still not clear (4,5) even though it has been demonstrated that molybdenum toxicity symptoms are, in effect copper deficiency symptoms.

Inorganic sulfate is also involved (6,7) in the molybdenum-copper interaction. Molybdenum exerts its effect on copper only if inorganic sulfates are present at a sufficient level. The effectiveness of each of the elements is increased as the level of the other is increased, thus chronic copper poisoning can be obtained when copper intake is moderate but sulfur and molybdenum contents are low (8). It is also quite apparent that copper deficiency symptoms appear very quickly if the ration contains high levels of sulfur and molybdenum. The mechanism of action appears to have been elucidated by the researches of Mills *et al.* (9) and Halverson *et al.* (10). They observed that high levels of molybdenum in the presence of the sulfates caused a great reduction in the liver sulfide oxidase level, indicating that there is a great loss of copper through the formation of highly insoluble cupric sulfides in the liver.

In areas in which the pasture grasses contain 20 to 100 ppm of molybdenum, copper sulfate fed at levels of 2 gm. per day in adult and 1 gm. per day in young cattle overcomes the detrimental effects of the excessive molybdenum. Daily drenching with 2 gm. of copper sulfate for four days also brings the condition under control.

Molybdenum is a part of an enzyme system (11), xanthine oxidase, thus is an essential mineral. Deficiency symptoms have been produced in chicks and rats but special treatment of the animals are necessary (12,13). Missouri workers (14) produced molybdenum deficiency symptoms in sheep, but these results were not confirmed by the Oklahoma workers (15).

Copper levels of 5 ppm meet the requirements of most animals in diets containing normal levels of molybdenum and sulfur. Molybdenum requirements of most animals are probably less than 1 ppm if normal copper and sulfur levels are used.

Summary

Molybdenum toxicity symptoms in ruminants appear to be copper deficiency symptoms. If adequate sulfur is present the excess molybdenum apparently causes precipitation of insoluble copper sulfide in the liver. Copper toxicity levels are much lower if inadequate levels of molybdenum or sulfur are present. Molybdenum toxicity symptoms can be alleviated by the feeding of copper sulfate.

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The Influence of Two Levels of Feed Intake During Gestation on the Reproductive Performance of Gilts

J. C. Hillier, Marvin Heeney, and Ray Washam

The nutrition of the bred gilt during gestation has been shown to have a marked influence on her reproductive performance. Specific nutrient deficiencies have been demonstrated. This test was designed to study the influence of level of energy intake with protein, mineral, and vitamin requirements at recommended daily levels.

The compositions of the gestation rations tested are shown in Table 1. Ration one was a 14 percent protein ration that has been used in gestation studies with gilts for the past several years. Ration two was calculated to supply the same daily protein, mineral, and vitamin amounts when fed at the rate of 70 percent of the amount of ration one. Only the daily energy allowance was limited in group two below

Table 1. — Gestation Rations.

Ration Number:	One	Two
Level of daily feed intake (lbs.)		
1960	7.0	4.9
1961	6.3	4.5
Percentage composition of ration		
Milo, Western Yellow, ground	82.08	63.91
Soybean meal, 44%	2.80	9.70
Tankage, 60%	2.80	9.70
Dehy. alfalfa meal, 17%	10.00	14.30
Dicalcium phosphate	1.10	1.30
Calcium carbonate	0.50	0.00
Salt (trace mineral)	0.50	0.72
Zinc sulfate	0.02	0.03
B_{12} supplement[1]	0.10	0.14
B complex vitamins[2]	0.10	0.20
Total	100.00	100.00
Calculated chemical composition		
Protein	14.01	20.02
Calcium	0.82	1.17
Phosphorus	0.59	0.83
T.D.N.	75.00	73.00
Cost per cwt. of ration, ($)	2.10	2.40

[1]Contains 6 mg. of B_{12} activity per pound.
[2]Contains 2,000 mg. of riboflavin, 4,000 mg. of pantothenic acid, 9,000 mg. of niacin, and 90,000 mg. of choline per pound.

Table 2. — Calculated Average Daily Nutrient Intake During Gestation.

Ration:	One		Two	
	1960	1961	1960	1961
Avg. amount fed (lbs.)	7.00	6.30	4.90	4.50
T.D.N. (lbs.)	5.15	4.64	3.58	3.29
Protein (lbs.)	0.98	0.88	0.98	0.90
Calcium (lbs.)	0.06	0.05	0.06	0.05
Phosphorus (lbs.)	0.04	0.04	0.04	0.04
Alfalfa meal (lbs.)	0.70	0.63	0.70	0.64
Riboflavin (mg.)	21.20	19.08	22.80	20.93
Pantothenic acid (mg.)	67.8	61.04	60.2	55.30

that fed group one. In the first trial (1960), ration one was fed at the rate of 7 lbs. per day and ration two at the rate of 4.9 lbs. per day. In the second trial, the levels were 6.3 and 4.5 lbs. daily, fed in two equal feedings. These levels of feed intake remained constant throughout gestation.

The gilts used were Yorkshire and Hampshire gilts that had been well grown up to breeding age. For the most part they had been used on growing-finishing tests in confinement up to a weight of 200 lbs. — 165 days of age. They were then hand fed on pasture for approximately 75 days before breeding. During the last two weeks prior to the breeding season, the daily feed allowance was increased. As the gilts were bred they were moved to the test lots and started on the trial. Gilts that re-occurred in heat were re-bred and allowed to remain in their test group. Each group of gilts was restricted to a dry lot, thus their entire nutrient intake during the gestation period came from the ration fed. As each gilt reached 110 days of gestation she was taken to the farrowing barn and prepared for farrowing. During the period from 110 days of gestation to 14 days post farrowing, these gilts were fed on an individual basis in relation to their appetite. Their average consumption during this period was 7 lbs. per day. From 14 to 42 days post farrowing these gilts had access to the lactation ration in a self-feeder and to water. Each litter ran with their mother in a concrete floored pen. The sows were moved out on the 42nd day post farrowing and the pigs continued on the creep ration until they were 56 days of age.

The results of the 1960 trial are shown in Table 3. Gilts receiving 7 lbs. per day gained 136.5 lbs. during gestation; those receiving 4.9 lbs. of feed gained 85.3 lbs. or 51.2 lbs. less during this period. Litters from the high level gilts weighed 1.7 lbs. more and contained .80 more pigs at farrowing. Pig losses from farrowing to weaning were greater among litters nursing gilts which had been on restricted feed intake during gestation. However, it is doubtful if these losses can be attributed to the gestation treatment of the gilts. When placed on self-feeders during lactation, the low level gilts consumed about one pound more feed per

Table 3. — The Influence of Two Levels of Feed Intake During Gestation on the Reproduction Performance of Gilts. May - November 1960.

Sow Treatment (Ration Number)	One	Two	Difference (One-Two)
Avg. daily feed intake (lbs.)	7.0	4.9	+2.1
Avg. daily T.D.N. intake (lbs.)	5.2	3.6	+1.6
Avg. litter weight at farrowing (lbs.)	28.4	26.7	+1.7
Avg. birth weight per pig (lbs.)	2.5	2.5	00.0
Avg. no. pigs farrowed per litter	11.5	10.7	+0.8
Avg. no. stillborn pigs per litter	1.4	1.4	0.0
Avg. no. pigs weaned per litter	9.0	7.1	+1.9
Avg. litter weight — 42 days (lbs.)	166.5	148.6	+17.9
Avg. litter weight — 56 days (lbs.)	231.6	207.2	+24.4
Avg. pig weight — 56 days (lbs.)	25.7	29.1	—3.4
Weights on Gilts (lbs.)			
Avg. initial weight of gilts at breeding	315.5	319.0	—3.5
Avg. weight of gilts at farrowing	452.0	404.3	+47.7
Avg. weight gained during gestation	136.5	85.3	+51.2
Avg. gilt weight 7 days post farrowing	409.6	361.5	+48.1
Avg. gilt weight at weaning	336.4	336.4	0.0
Avg. weight loss of gilts farrowing to weaning	115.6	67.9	+47.7
Avg. daily weight loss	2.8	1.6	+1.2
Avg. weight increase — breeding to weaning	20.9	17.4	+3.5
Feed Weights			
Avg. feed per gilt — 114 days gestation	798.0	558.6	+239.4
Avg. feed per gilt during lactation (0-42 days)	356.0	398.0	—42.0
Avg. total feed per gilt farrowing	1154.0	95.6	+197.4
Avg. creep feed consumed per litter	168.2	173.3	—5.1
Avg. creep feed consumed per pig weaned	18.7	24.4	—5.7
Avg. total feed per litter (sow and creep)	1322.2	1129.9	+192.3
Avg. total feed per pig weaned	146.9	159.1	—12.2

day than those that had received more feed during lactation, thus, they lost 51.20 lbs. less weight during lactation (136.5 vs. 85.30). Both groups had about the same starting and ending weight. However, those on ration one had each consumed 197.4 lbs. more during the combined gestation and lactation period than those on ration two.

In terms of the combined gestation and lactation feed to the sow and the creep ration to the pigs, 146.9 lbs. was required in group one and 159.1 lbs. in group two for each pig weaned. This difference is due largely to the smaller number of pigs weaned in group two. The pigs in both groups were unusually light at weaning. The exact cause of this is not known.

It seemed that the high level gilts in the first test were receiving a little more feed than was necessary so the intake was reduced to 6.3 and 4.5 lbs. for the second trial. The results of this trial are given in Table 4. Here the pattern was much the same as for the first trial. The high

Table 4. — The Influence of Two Levels of Feed Intake During Gestation on the Reproductive Performance of Gilts. May - December 1961.

Sow Treatment (Ration Number)	One	Two	Difference (One-Two)
Avg. daily feed intake — gestation (lbs.)	6.3	4.5	+1.8
No. gilts bred	12.0	12.0	0.0
No. gilts farrowing	9.0	11.0	—2.0
Avg. No. services per litter farrowed	1.0	1.6	—0.6
Avg. length of gestation (days)	112.9	113.6	—0.7
Avg. litter weight at farrowing (lbs.)	27.7	26.9	+0.8
Avg. birth weight per pig (lbs.)	2.6	2.5	+0.1
Avg. no. pigs farrowed per litter	11.0	10.8	+0.2
Avg. no. stillborn pigs per litter	.4	.3	+0.1
Avg. no. pigs lost per litter (0-14 days)	1.6	1.7	—0.1
Avg. no. pigs lost per litter (14-56 days)	.3	.2	+0.1
Avg. no. pigs weaned per litter	8.9	8.6	+0.3
Avg. litter weight — 42 days (lbs.)	173.2	176.4	—3.2
Avg. litter wight — 56 days (lbs.)	245.0	251.7	—6.7
Avg. pig weight — 56 days (lbs.)	28.4	29.8	—1.4
Weights on Gilts			
Avg. initial wt. of gilts at breeding (lbs.)	358.6	347.1	+11.5
Avg. gilt weight at farrowing	498.8	452.8	+37.0
Avg. gilt weight 14 days post farrowing	417.4	384.7	+32.7
Avg. gilt weight at weaning	364.0	354.4	+9.6
Avg. weight loss on gilts — farrowing to weaning	126.6	98.5	+28.1
Avg. daily wt. loss — farrowing to weaning (lbs.)	3.0	2.3	+0.7
Avg. weight change — breeding to weaning (lbs.)	+5.4	+7.3	—1.9
Feed Weights			
Avg. feed per gilt — 114 days gestation	718.0	490.0	+228.0
Avg. feed per gilt during lactation (0-42 days)	412.9	498.5	—85.6
Avg. total feed per gilt farrowing	1130.9	979.6	+151.3
Avg. creep feed consumed per litter	190.4	196.0	—5.6
Avg. creep feed consumed per pig (weaned)	22.0	21.0	—1.0
Avg. creep feed per litter (sow and creep)	1321.4	1175.6	+145.8
Avg. total feed per pig weaned	148.6	136.1	+12.5

level gilts consumed 228 lbs. more feed each during gestation and gained an average of 37 lbs. more during this period. However, the low level gilts consumed an average of 85.6 lbs. more during lactation when they were self-fed. Considering the greater consumption during lactation, the low level gilts average 151.3 lbs. less feed from breeding to weaning. They averaged only 9.6 lbs. lighter in weight at weaning.

The performance in terms of litter size, livability, weaning weights, and feed consumption of the pigs was essentially the same in both groups. In this trial pigs raised by gilts on the low level of feed intake during gestation were charged with 136.1 lbs. of feed as compared to 148.6 lbs. for pigs farrowed and raised by gilts fed the higher level. This is the reverse from the situation in the first trial and is probably due to the fact that the average litter size at weaning was about the same for each group in Trial Two whereas there were fewer pigs weaned per litter in the low level group in Trial One.

In considering the results of these trials it should be pointed out that the daily intake of such essential nutrients as protein, minerals, and vitamins was essentially the same for both groups of gilts during gestation. These intakes were at, or near, the National Research Council recommended levels. Only the total digestible nutrient level for group 2 was held below N.R.C. recommended allowances. Gilts in group 2 appeared to be quite hungry and thin, particularly as they approached farrowing. When placed on self-feeders during lactation, these gilts consumed more feed and lost less weight; thus, at weaning the two groups of gilts were essentially alike in appearance.

Bermuda Grass Hay for Wintering Beef Cattle

A. B. Nelson, W. C. Elder,

G. R. Waller, and W. D. Campbell

Pasture improvement programs have resulted in the increased use of improved strains of bermuda grass, which in turn have made large quantities of bermuda grass hay available for feeding. The protein content of the forage may vary considerably with fertilizer treatments. Little is known of the nutritive value of such hays for beef cattle. Preliminary studies have indicated that gains of cattle fed bermuda hay containing 13.1 percent protein were increased when supplemental cottonseed meal was fed. Thus, supplemental feeding (protein or energy) is important with bermuda hay even though chemical composition of the hay does not so indicate. The great potential production of bermuda hay could serve as the basis of an expanded beef cattle program when proper nutrient supplementation of the hay when fed to cattle has been determined.

Procedure

Thirty grade Hereford weanling calves were divided into three lots (five steers and five heifers per lot) on December 21, 1961. Each lot was placed in one-acre traps and fed hay ad libitum. Those in Lot 1 were fed prairie hay and 1.25 lb. of pelleted cottonseed meal per head daily. The supplement was fed at the rate of twice the daily allowance every other day. The hay, which had been harvested at the Lake Blackwell experimental range area, was mainly little bluestem with appreciable quantities of big bluestem and Indian grass.

The calves in Lots 2 and 3 were fed bermuda grass hay produced at Stillwater under direction of the Agronomy department. The hay was from Midland bermuda grass grown under conditions of adequate moisture, fertilized with 200 lbs. of nitrogen per acre for the season, and cut periodically during the summer. Calves in Lot 2 were not given any supplemental feed. Those in Lot 3 were fed 1.25 lb. of ground corn per head daily. Corn was fed as a source of energy because it is lower in protein than milo, barley, or oats.

A mineral mixture of 2 lbs. of salt and 1 lb. of defluorinated rock phosphate was available in all lots.

Results

The chemical composition of the supplements is given in Table 1. The protein content of the prairie hay was slightly higher than is usually found in hay produced on the experimental area. The protein content of the bermuda hay was lower than was expected.

Table 1.—Chemical Composition of Feeds.

	Percent Composition							
Feed	Dry Matter	Ash	Protein	Fat	Fiber	NFE	Ca	P
Prairie hay	93.5	7.4	5.2	2.6	30.0	48.3	.39	.12
Bermuda hay (First 55 days)	93.4	8.0	11.0	2.5	28.5	43.9	.46	.38
Bermuda hay (Last 38 days)	93.2	7.6	9.8	1.8	28.3	45.7	.44	.68
Cottonseed meal	92.6	6.3	39.6	3.3	8.4	35.0	.22	1.40
Ground corn	89.9	1.6	8.8	3.8	1.5	74.2	.06	.39

The average daily intake of prairie hay by the calves in Lot 1 was 11.4 lbs. The calves in Lots 2 and 3 consumed an average of 10 lbs. of bermuda hay per head daily. At this rate of hay intake, the daily total protein intake was 1.09, 1.10, and 1.21 lbs. for Lots 1, 2, and 3, respectively, for the first 55 days. Bermuda hay from a different plot was fed for the last 38 days, and because its protein content was slightly lower, the total protein intake for Lots 1, 2, and 3 was 1.09, .98, and 1.09 lb. per head daily, respectively, during this period.

Table 2.—Weight Gains of Cattle Fed Prairie and Bermuda Hay.

Lot number Hay Supplement	1 Prairie 1.25 lb. CSM	2 Bermuda None	3 Bermuda 1.25 lb. corn
Number of head per lot	10	10	10
Average weight per head, lbs.			
Fall 12-21-61	488	488	490
Spring 3-24-62	554	511	557
Gain 93 days	66	23	67

Average weight gains of the cattle are given in Table 2. The cattle in Lot 1 gained .71 lb. per head daily when fed prairie hay and cottonseed meal. The average daily gain was .25 lb. for those fed bermuda hay only. When the high-energy supplement, corn, was added to the bermuda hay (Lot 3), the gains were increased considerably. The data indicated the feeding value of bermuda hay plus corn is equal to that of prairie hay plus cottonseed meal.

In a previous test, prairie hay and cottonseed meal were compared to bermuda hay alone when fed to weanling calves. The two rations were equal in protein content, but the 87-day gains were 51 lbs. less for the bermuda hay. In a subsequent 56-day period, both hays were supplemental with cottonseed meal and the gains were equal.

Summary

Bermuda hay is a satisfactory roughage for wintering cattle when proper supplemental nutrients are provided. Studies have indicated that the high nitrogen content of certain bermuda hays is not efficiently utilized. Also, corn was a satisfactory supplemental feed for cattle fed bermuda hay.

Interval of Feeding Supplemental Protein to Range Beef Cows

A. B. Nelson and W. D. Campbell

Cattlemen recognize the need for providing supplemental protein during the winter months for cattle grazing dry native grass. A generally accepted practice is to feed twice the daily allowance every other day in order to reduce the labor necessary. Early tests at Oklahoma and Kansas have indicated that such a practice is satisfactory. Another practice which will result in a saving of labor is the self-feeding of mixtures of salt and protein supplement or other feeds with the salt serving as the regulator of consumption.

Weekly feeding of the total ration for sheep in certain sections of Australia during a drouth has satisfactorily furnished a subsistence ration for sheep. Currently, there is considerable interest concerning whether or not range beef cattle can be given supplemental feed at intervals as long as one week without adversely affecting production.

Nebraska workers have shown that heifer calves, weighing about 400 lbs. at the start of the test, gained satisfactorily during a 141-day winter feeding season when fed an average of 4 lbs. of alfalfa hay per head daily as a supplement to dry range grass whether the feeding interval was daily, twice weekly, or weekly. At the Texas station, heifer calves were fed ground hegari stover and cottonseed hulls as the roughage free-choice and hand-fed an average of 14 lbs. of cottonseed cake per head at three feeding intervals. The 111-day gains for calves fed 2 lbs. daily, a total of 14 lbs. in three equal feedings, and 7 lbs. twice weekly were 165, 152, and 170 lbs., respectively.

In 1960-61 at the Oklahoma station, yearling heifers were fed an average of 2 lbs. of pelleted cottonseed meal per head daily at intervals of two, four, and six days. The 137-day winter losses were 2, 8, and 26 lbs. for those fed 4 lbs. every two days, 8 lbs. every four days, and 12 lbs. every six days, respectively.

Preliminary results using spring-calving cows are presented here.

Procedure

Sixty two-year-old grade Hereford cows were divided into three lots of 20 on November 13, 1961 and allowed to graze the dry native grass at the Lake Blackwell experimental range area. They were fed an average of 2½ lbs. of pelleted cottonseed meal per head per day. Those in Lot 1 were fed an average of 5 lbs. per head every other day, those in Lot 2 were fed 10 lbs. every fourth day, and those in Lot 3 were fed 15 lbs. every sixth day. A mineral mixture of 2 lbs. salt and 1 lb. steamed bonemeal was available in all pastures.

Results

A summary of the weight gains is given in Table 1. In the 81-day period between November 13 and February 3, which was the date of the last weighing before the first calves were born, the cows fed an average of 5 lbs. of pelleted cottonseed meal every other day lost 100 lbs. per head. When the feeding interval was increased to four days (Lot 2) the cows lost only 59 lbs. When fed every six days (Lot 3) the loss was 95 lbs. Although there was considerable variation among the cows, the losses were greatest for those fed every two days and those fed every six days. The least loss was for those fed every four days. Weight losses of the cows during the remainder of the winter, weight gains during the summer, and weaning weights of calves will be available for use as measures of the value of the feeding system in October, 1962. Recommendations should not be made on the basis of the preliminary data available at this time.

Table 1.—Weight Gains of Cows Fed Pelleted Cottonseed Meal at Two, Four, and Six-Day Intervals (Preliminary Results 1961-62).

Lot Number Interval Between Feedings Pounds Cottonseed Meal per Head per Feeding	1 Two Days 4	2 Four Days 8	3 Six Days 12
Number of cows per lot	20	20	20
Average weight per cow, lbs.			
Initial 11-17-61	961	971	991
Winter 2-3-62	861	912	896
Gain (81 days)	—100	—59	—95

Fattening Cattle on "All Barley" Rations in Oklahoma

L. S. Pope, O. F. Harper,

Dwight Stephens, and George Waller

Drylot fattening of steers and heifers has increased sharply in Oklahoma to the point where we now feed about 160,000 head yearly. Two types of feeding operations are most important to Oklahoma; the large commercial feedlot, with a capacity of over 1000 head, and the small farmer-feeder. The large feeder specializes in cattle feeding and usually purchases all grain and roughage. The small feeder makes use of his home-grown feeds, but may work through a "grain bank" where his feed can be stored and processed. Some feeders have a complete mixed ration from a local feed mill delivered to the self-feeder.

Whether large or small, cattle feeders often find that roughage is relatively costly to obtain, store, and process. Thus, highly concentrated rations have become popular, not because the cattle do better than where conventional rations (65 percent or so concentrate) are fed, but because less feed is required per pound of gain by eliminating most of the roughage from the ration.

Since fattening cattle in drylot is the most costly phase of beef production, involving more risk and investment than nearly any other system, costs of gain must be watched carefully. In the usual fattening ration fed in the Southwest, about 8 to 10 lbs. of feed are required for each pound of gain. Of this, about 20 to 25 percent is roughage, which is thought to be necessary to provide bulk or "ballast" to the ration. If this expenditure for roughage can be reduced by steam rolling grains to increase the bulkiness of the mix, for example, part of the feed cost can be reduced. Experiments at other stations have shown that steam-rolled barley, plus a proper supplement, can be fed as the sole ration to fattening steers.

Feed Grains Available in Oklahoma

Since cattle feeding is highly competitive and the operator works on a very narrow margin, the choice of grain to feed is often an important item. This is especially true if all feed is to be purchased off the farm. In most fattening rations used in the Southwest, grain makes up 60 percent or more of the ration and contributes over 70 percent of the total feed cost. Obviously, the choice of grain to feed can greatly affect profits. This is even more important if a wide difference in feeding value exists between grains.

A look at the feed grains available to the Oklahoma feeder provides some interesting comparisons. The 1961 estimates of feed grains produced in Oklahoma are shown in Table 1. The past year, 1961, was an exceptionally good crop year, and nearly all yields of grain were at, or approached, record highs. This was certainly true of corn, which in most parts of the state is a risky crop during an average season.

Of most interest is a comparison of grain sorghum and barley, two of our most important feed grains. It should be pointed out that in 1961, the acreage of grain sorghum was cut back nearly 30 percent from the previous year due to the government's feed grain program. Thus, 1961 production of grain sorghum represents the smallest output in the past four years, and grain sorghum and barley were closer in total yield than normally occurs.

Note that oats ranked third as a feed grain, a trend which is continuing to be more unfavorable for oats each year. Not only is the total acreage much lower for oats than for barley or grain sorghum, but the yield in lbs. per acre is only about 80 percent and 55 percent, respectively, of these grains. Add to this the lower energy value of oats (about 85 per-

Table 1.—Total Production and Per Acre Yields of Oklahoma Feed Grains in 1961[1].

Grain	Acres Harvested	Total Production		Avg. Yield per Acre	
		Bushels	Tons	Bushels	Pounds[2]
Barley	770,000	19,250,000	444,000	25.0	1200
Grain Sorghum	553,000	16,866,000	472,248	30.5	1708
Oats	469,000	13,836,000	221,376	29.5	944
Corn	154,000	5,390,000	150,920	35.0	1960

[1]Oklahoma Crop Reporting Service estimates for 1961.
[2]Calculated from bushel basis using 48, 56, 32, and 56 lbs. per bushel for barley, grain sorghum, oats, and corn, respectively.

cent of the energy of milo for example) and its relative importance is further reduced.

Barley and grain sorghums are produced in different areas of Oklahoma, with nearly all of our production of grain sorghums in the western one-third of the state and most of the barley in the middle belt counties. Consequently, the two grains are not really competitive in most areas of the state, and each has its place in cattle feeding. Bear in mind, however, that with present means of transporting feed grains, the area in which the grain is produced has less bearing on where it will be used to fatten cattle than in the past.

In many areas, barley has a bright outlook as a feed grain because:

1. New winter-hardy varieties with high yields have been developed by the Oklahoma Experiment Station representing a real "break-through" in potential barley production for both grain and winter pasture.

2. Costs of production are somewhat lower for barley than for grain sorghum and harvesting and storage problems are often less with this grain.

3. New varieties of barley provide good winter pasture, greatly increasing the returns per acre above the grain alone.

4. A new concept of cattle feeding, based on the use of steam-rolled or crimped grains to supply the necessary bulk in the ration, fits barley ideally.

When due credit is given to both the fiber and energy contents of barley (i.e., when it substitutes for both roughage and grain in a fattening ration) it may have much higher feeding value relative to other grains than we have given it in the past. With these considerations in mind, a series of experiments have been undertaken at the Ft. Reno station to study some of the problems involved in feeding "all-barley" rations. Chiefly, these have centered around the nutritional deficiencies of an "all-barley" ration and the best supplement to use.

Supplementing Barley Rations

Even though the roughage used in the typical fattening ration makes up less than 25 percent of the total feed, it contributes significant amounts of protein, minerals, and carotene, providing it is of good quality. A look at the nutrient intake of a 700 lb. yearling steer from a conventional ration, with dehydrated alfalfa meal and cottonseed hulls, and an all-barley ration is illustrated in Table 2.

Table 2.—All Concentrate Vs. a Conventional Fattening Ration for a 700 Lb. Yearling Steer*.

	All Concentrate	Conventional Ration
Avg. Daily Ration, lbs.		
Steam Rolled barley	18	16
Cottonseed meal	1.5	1.5
Dehydrated alfalfa meal		1
Cottonseed hulls		3
Percent of Daily Requirements		
Digestible protein	148	143
TDN	103	106
Crude Fiber	? (1.3 lb.)	? (2.7 lbs.)
Calcium	33	75
Carotene	---	105
Phosphorus	210	204

*Feed composition and requirements from Morrison, Feeds and Feeding, 22nd edition.

Note that in both types of rations, digestible protein, and TDN (energy) are ample. In this respect, we can expect equal performance. Also, both rations are more than ample in phosphorus because of the high levels of grain and protein supplement they contain.

When it comes to fiber, minerals, and provitamin A (carotene), the two rations differ significantly. The "all-barley" ration contains a lower fiber level, although the actual amount supplied may not be as important as the "bulkiness" of the ration itself. In terms of calcium and total minerals, the "all-barley" mixture is decidedly low. Furthermore, there is no source of provitamin A in this ration, thus cattle on feed for more than 75 to 100 days should have a source of carotene (35 to 50 mg. per head daily) or dry, stabilized vitamin A (3,000 I. U. per 100 lbs. body weight.)

Not indicated in this comparison are the trace minerals supplied by each type of ration. Normally, if we feed even a small amount of good roughage such as alfalfa hay or dehydrated alfalfa meal, or add molasses to the mix, much of the trace mineral needs of fattening cattle may be taken care of. With a simple barley-oil meal mixture, such may not be the case.

The effect of minerals on feedlot performance is illustrated by the results of a feeding trial conducted during the winter of 1961-62 at Ft. Reno. Five lots of six yearling steers each (three replicates of two steers in each treatment) were fed steam-rolled barley plus the following supplements:

Lot 1—(Basal)—1.5 lb. pelleted soybean meal plus .15 lb. ground limestone (Ca) and 20,000 I.U. vitamin A per head daily.

Lot 2—Basal plus .75 lb. dehydrated alfalfa meal.

Lot 3—Basal plus .5 lb. molasses mixed with the barley supplement.

Lot 4—Basal + 3 grams of trace minerals and B vitamins, or the approximate amounts supplied by 4 lbs. alfalfa.

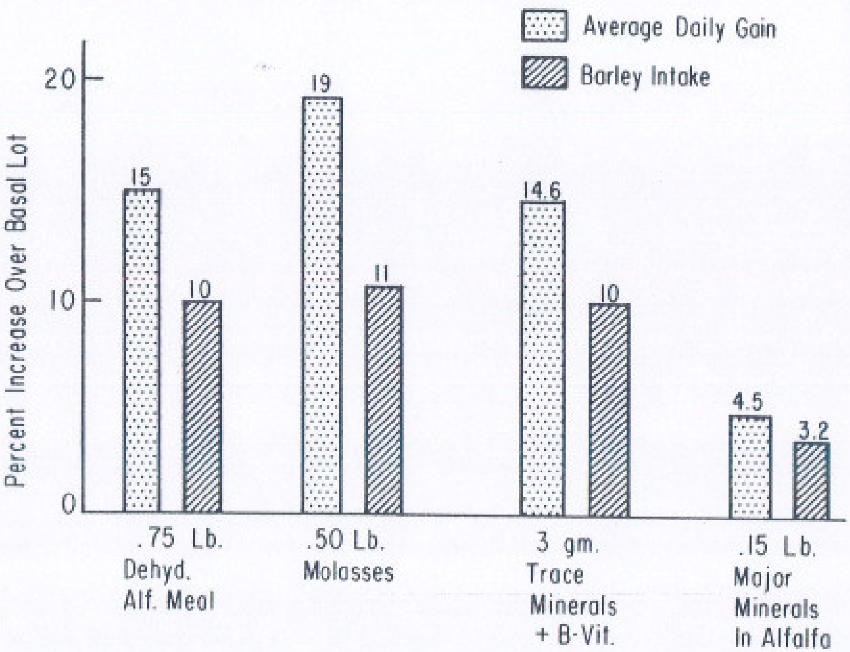

Figure 1. Increase in Average Daily Gain and Grain Intake Over the Basal Lot for 186 Days on Test.

Lot 5—Basal + the major minerals in alfalfa to "buffer" the acids produced from rumen fermentation of the feed.

The results in terms of the increase in average daily gain and grain intake over the basal lot for 186 days on test are illustrated in Figure 1. All supplements increased rate of gain and barley intake over the basal ration, but those containing trace minerals, or those feeds known to be good sources of trace minerals such as dehydrated alfalfa meal and molasses, were most effective. It is of interest that the inclusion of the major minerals contained in alfalfa in the Lot 5 ration had less effect on performance.

Is there a difference in oil meals used to supplement an "all-barley" ration? A comparison of the feedlot performance of yearling steers fed a 46 percent protein soybean meal supplement (plus added calcium and vitamin A) with a similar group fed 41 percent protein cottonseed meal. Both oil meals were solvent-processed, and the results were as follows:

	Soybean meal + Ca + Vitamin A	Cottonseed meal + Ca + Vitamin A
Avg. daily gain, lbs.	2.47	2.44
Avg. feed intake per day, lbs.		
Barley	15.9	16.0
Supplement	1.65	2.16
Feed per cwt. gain, lbs.		
Barley	642	657
Supplement	67	88
Feed cost per cwt. gain, $	17.53	18.76
Carcass yield and grade	62.5% (Gd +)	62.8% (Gd +)

Note that average steer performance was essentially the same between the two groups and thus both supplements were equally effective in this type of feeding program. However, nearly 30 percent more cottonseed meal was needed to provide the same protein level as the soybean meal supplement. It then becomes a matter of cost per pound of protein in choosing the oil meal supplement.

Factors To Consider In Feeding "All-Barley" Rations

From the results of several feeding trials, the following observations on feeding "all-barley" rations might be made at this time.

1. The initial "warming up" period is highly important in getting the cattle started off properly without founder or digestive upsets. If the cattle can be supplemented on pasture with 5 lbs. or more of steam rolled barley per head daily this will help them adjust to the high-

concentrate program. Often, a mixture of barley, molasses, and cottonseed hulls can be fed while on grass, so that the cattle will become accustomed to the mixture to be fed in drylot.

2. Once in drylot, a mixture containing at least 50 percent cottonseed hulls or other roughage should be used in the starter mix. Adding 3 to 5 percent molasses improves the palatability of the mixture. Roughage should be removed in stepwise fashion over a three-week period, until only steam rolled barley and supplement remain. The supplement can be pelleted in a "chicken size" cube (3/16 inch) and mixed with the crimped barley. Again 3 percent molasses added to the mix improves palatability.

3. It is important to keep the cattle on a self-feeder at all times. Some scouring and "looseness" of the droppings can be expected, but this usually clears up if the roughage is gradually removed and the ration is properly supplemented.

4. The barley should be properly steam rolled. A barley with 48 lb. test weight should be reduced to at least 33 lb. per bushel after crimping. This takes a careful "crimping" job. Research at other stations on whether or not steam heating improves the feeding value of barley have been variable.

5. Adding a small amount of roughage to the mix may help in safely feeding the barley ration, but adds little to the performance of the cattle, and increases the feed required per cwt. gain. For example, in a recent test, adding 2 lbs. of cottonseed hulls to the "all barley" ration had little effect on rate of gain, but increased the feed required per cwt. gain.

6. A "balanced" supplement is essential. A mixture containing the following ingredients has given good results at Ft. Reno:

65 percent soybean meal,
25 percent dehydrated alfalfa meal,
10 percent molasses,
2 percent ground limestone,
with 3 gm. trace minerals and 20,000 I.U. vitamin A per head daily.

The above supplement can be mixed as a meal with the steam rolled barley or pelleted (with slightly less molasses if pelleted).

Many good commercial protein supplements contain the above ingredients and can be used if reasonable in cost. Cottonseed meal can be substituted for soybean meal in the above formula, but more total supplement will be required because of its lower protein content.

7. The barley intake of cattle on full feed should exceed 2 lbs. per 100 lbs. body weight daily. About 7 to 7.5 lbs. total feed per pound gain with stilbestrol (10 mg. per day if fed or 24 implanted), will be required.

Efficiency of Gains by Beef Calves as Influenced by Weight and Rate of Gain

Doyle Chambers, Dale Burnett,

J. A. Whatley, and D. F. Stephens

The feeding of beef cattle for slaughter is a major enterprise in the American beef industry. Some factors which affect the efficiency of feed utilization by cattle during growth and fattening have been identified and appraised; other factors have received little attention.

The recent abundance of feed grains at relatively low costs and the increased demand for quality beef from younger cattle of lighter weights have caused some rather marked changes affecting both producers of feeder calves and feeders. To produce a 900 to 1000 pound steer of choice grade at 12 to 16 months of age requires the full feeding of such cattle from the time they are weaned.

In recent years the price of choice feeder calves at weaning time has been from four to six cents per pound higher than the price of fat cattle of the same quality. With pressure by the retail chain stores for carcasses weighing from 500 to 700 pounds, feeders have been looking for calves of lighter weights. This pressure has sometimes been so great that calves weighing 400 pounds have brought almost as much per head as those of similar quality weighing 500 pounds. Feeder calf producers know that it costs just about as much to produce a 400 pound calf as to produce one weighing 500 pounds. They have been striving to produce this heavier calf through selection of better breeding stock and through better management. These conflicts of interest have been brought into rather sharp focus during recent years.

Experimental Procedure

During the past five years at the Ft. Reno station, some 285 steer calves and 44 heifer calves of Angus breeding have been full fed from weaning at approximately seven months of age to a slaughter age of about 13 months. These calves have provided data on some factors which have a bearing on the efficiency of feed lot gain.

The Angus calves were produced in a herd belonging to the Federal Reformatory at El Reno. During the breeding season 250 mature cows were randomly allotted to 10 breeding groups of 25 cows each. Ten selected Angus bulls were randomly assigned, one to each breeding group, and the breeding season lasted for about three months beginning in early May each year. The calves were weighed, tagged, and tattooed at birth. All bull calves were castrated. All calves were creep-fed, and they were weighed and graded at weaning time in early October. In 1957 and 1958 seven sire progeny groups were purchased for post-weaning feed lot tests and carcass appraisals. Calves of both sexes were fed for three sires in 1957 and for six sires in 1958. They were self-fed, by sexes in sire progeny groups of four to six head, a complete mixed ration. Feed consumption records and weight gains were kept so that feed efficiency for each pen could be computed.

During 1959, 1960, and 1961 only steer calves were purchased for the post-weaning tests. Sixty calves by 10 different sires were obtained each year. They were the calves nearest the average birth date. Each sire group was divided into a heavy and a light weight group for the feed lot test. The heavy half of the calves by each sire was fed as a group in one pen, while the light weight half of the calves by each sire was fed as a group in an adjoining pen. All calves were self-fed the same complete mixed ration. Feed consumption records and weight gains were kept for each pen. Feed efficiency data were obtained for both groups of calves which were sired by the same bulls. They differed slightly in ages but rather markedly in weights at weaning.

Beginning and final weights were obtained following a shrink of some 18 hours off water and some six hours off feed. Average daily gains, feed efficiency, and dressing percentages were based upon these shrunk live weights and the chilled carcass weights in the latter case. The calves were weighed each 14 days and feed consumption records were kept separately for each period.

The ration fed was made up of the following ingredients:

35 percent ground whole ear corn
20 percent cottonseed hulls
10 percent ground alfalfa hay
10 percent whole oats
10 percent wheat bran
10 percent cottonseed oil meal
5 percent molasses

This mixture contained approximately 9 percent digestible protein and 63 percent total digestible nutrients. A mineral mixture of equal parts of salt and calcium carbonate was fed in a separate container. Water was available in each pen; sufficient shed space was available; and sand was used as the bedding material. No growth stimulants or antibiotics were implanted or fed.

At the completion of the feed lot tests the cattle were slaughtered in Oklahoma City where carcass weights were obtained following a 48 to 72 hour chill. Each carcass was graded by Federal graders to the nearest third of a grade.

Results and Discussion

To determine the amount of feed required per 100 lbs. of gain by these calves during different periods of growth and fattening, the data

Table 1.—Amount of Feed Required Per 100 Lbs. of Gain for Steer Calves During Different Periods of Growth.

Approx. Wt. Gps.	No. Yrs.	No. Calves	Lbs. Feed per 100 Lbs. Gain
425 - 500	3	107	419
501 - 600	5	253	682
601 - 700	5	271	916
701 - 800	5	284	1038
801 - 900	5	233	1235

for all steers were examined. Table 1 presents the results of this study. The increased feed requirement per unit of gain with increasing body weights was quite marked and this was expected. Undoubtedly the estimate for the first weight group (425 to 500 lbs.) is too low; and for the last weight group (800 to 900 lbs.) it may be too high, as the initial and final weights were obtained following the rather severe shrink described earlier. The intervening 14-day weights were obtained after a 12 hour period off water, but feed was not withdrawn for these weights. Differences in fill would have made the initial period appear to have been more efficient and the final period appear to have been less efficient than they should have been. The average steer weighed about 475 lbs. at the beginning of the test and about 900 lbs. at the end of the feeding period. The data shown for the weight groups from 500 to 800 lbs. were based upon more animals and would not be biased to the same extent by differences in fill. It is obvious that as calves became heavier and fatter, it takes more feed for each unit of additional gain.

The differences in feed requirement for calves of different weights during a feeding test of six months are shown in Table 2. The 104 calves in the heavy groups were sired by the same bulls as the 107 calves in the light weight groups. The heavy calves were heavier than their light weight half brothers by 71 lbs. at the beginning of the test, and they were 12 days older at that time. For the three year period the two groups gained at about the same rate. The two groups did not differ appreciably in dressing percentage or in carcass grades, indicating that the composition of gain for the two groups was similar. The heavier groups required 980 lbs. of feed per 100 lbs. of gain to reach a final slaughter weight of 942 lbs., while the lighter groups required 934 lbs. of the same ration per 100 lbs. of gain to reach a final weight of 866 lbs. The heavier calves required 46 lbs. more feed per 100 lbs. of gain to maintain the additional 71 to 76 lbs. of body weight during the period of this test. At a feed cost of two cents per pound this would have meant a difference in the feed cost per 100 lbs. of gain of about 92 cents. In this case, where the heavier calves gained 427 lbs., the added feed cost for the heavier calves was about four dollars per head above that of their half brothers which weighed 71 lbs. less at the start of the test.

Table 2.—Performance of Steer Calves Fed in Groups Which Differ in Initial Weight.

Year	Grp.	No. Steers	Initial Age	Initial Wt.	Final Age	Final Wt.	ADG	Dr. %	Carc Gr.[1]	Lbs. Feed 100 lbs.Gain
1959	H	28	217	520	388	942	2.47	63.1	10.7	991
	L	31	200	434	371	843	2.39	61.4	11.2	946
1960	H	39	214	497	413	953	2.29	63.7	10.4	988
	L	39	209	431	408	889	2.30	63.2	10.6	924
1961	H	37	225	528	393	931	2.40	62.5	11.1	960
	L	37	213	467	381	867	2.38	62.6	10.9	933
Avg.	H	104	219	515	398	942	2.39	63.1	10.7	980
	L	107	207	444	386	866	2.36	62.4	10.9	934
Diff. H-L		=	12	71	12	76	.03	0.7	—0.2	46

[1]Carcass Grades: Low Choice, 10; Avg. Choice, 11; High Choice, 12.

Differences in feed efficiency found here would have justified a price spread of a little less than one cent per pound for feeder calves of these weights when they were of comparable breeding and quality.

It was interesting that the calves which were heavier at weaning gained as fast as did their lighter weight half-sibs. No evidence of compensatory gain by the smaller calves was noted in this three year test. The similarity of the two groups in dressing percentage and carcass grades was also very interesting in view of the youth of the cattle at slaughter. Perhaps the fact that all calves had been creep-fed prior to weaning is significant in this connection.

Breeders and producers of feeder calves have claimed that calves having the genetic capacity for more rapid gains, which may be expressed in heavier weaning weights, also make more rapid and efficient gains in the post weaning period. Numerous studies have shown that rapid feed lot gains are the more efficient gains. Through weight constant tests this association has been found to be very high. At the same time the genetic correlation between rate of gain in the preweaning and post-weaning periods has been quite high if the calves have been exposed to nutrient levels conducive to rapid gains in both periods. For the feeder to get and feed fast gaining, efficient calves he will usually have to buy calves which are heavier at a given age. If he requires them to be light in weight, he would have to buy them at younger ages.

There are some contradictory relationships among rate of gain, feed efficiency, and weight. Fast gains are associated with efficient feed conversion, but fast gains automatically lead to heavier weights which reduce feed efficiency. The data obtained in 1957 and 1958, when the

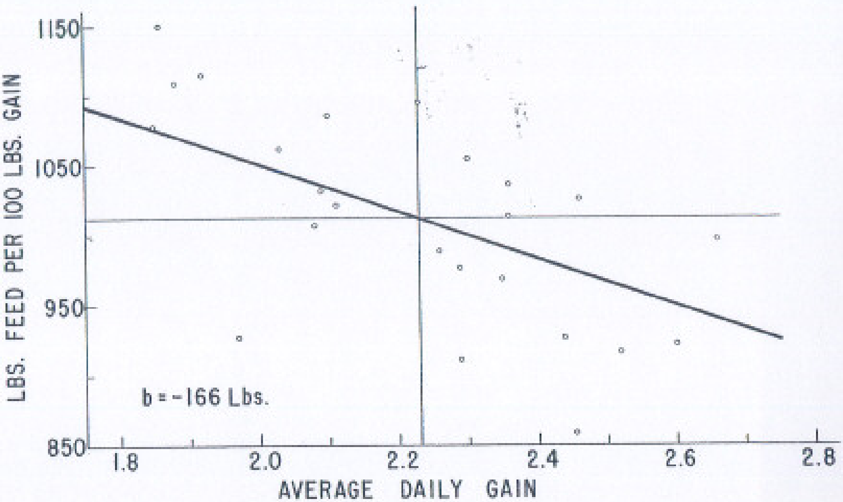

Figure 1. Intra-Season, Intra-Sex Regression of Pounds Feed Per 100 Lbs. Gain on Average Daily Gain of Sire Groups.

sire progeny groups were fed in separate pens, show that the calves which are the fast gaining progeny were more efficient in feed use, in spite of their heavier weights at the beginning and at the end of the tests. This information is given in Table 3 and in Figure 1. The intra-season, intra-sex regression coefficient was —166 lbs. This means that for an increased rate of gain of .1 of a pound per day, the feed required per 100 lbs. of gain was reduced nearly 17 lbs., in spite of the fact the faster gaining calves were heavier.

The data presented in Table 3 for the different pens and sires reveal one of the reasons why rate and efficiency of gain were not more closely related. In 1957 two pens of calves by sire 264 were fed. They differed by nearly 100 lbs. in body weight during the test. The 638 lb. calves gained 2.66 lbs. per day for the entire test while their 546 lb. half-sibs gained 2.60 lbs. per day on the same test. The heavier calves in this sire group required about 75 lbs. more feed per 100 lbs. of gain than was required for their 546 lb. half brothers. In the same year, however, the calves by sire 15, which weighed 515 lbs. and gained only 2.03 lbs. per day, required 1062 lbs. of feed per 100 lbs. of gain. This was 100 lbs. more than that required by the 10 much heavier calves by bull 264. If one were to assume a selling price of 25 cents per pound for the slaughter steers, and a feed cost of 2 cents per pound, he could show that 546 lb. feeder calves could be worth, to the feeder, about 1½ cents per pound more than the 638 lb. group by the same sire. They

Table 3.—Performance of Steers and Heifers Fed by Sire Progeny Groups.

Year	Sex	Sire	No. Calves	Initial Age	Initial Wt.	Final Age	Final Wt.	ADG	Lbs. Feed 100 Lbs. Gain
1957	M	264	5	230	638	389	1051	2.66	998
	M	264	5	224	546	383	949	2.60	923
	M	114	3	242	607	401	985	2.44	926
	M	114	4	235	541	394	905	2.35	969
	M	2	6	231	532	390	898	2.36	1014
	M	5	4	214	528	373	926	2.57	917
	M	17	6	197	517	356	898	2.46	1026
	M	15	6	234	515	393	830	2.03	1062
	M	7	6	193	472	352	854	2.46	859
1958	M	115	5	224	561	392	948	2.08	1007
	M	155	5	236	539	404	890	2.09	1032
	M	7	5	224	510	392	890	2.26	989
	M	6	5	231	505	399	891	2.30	1054
	M	175	5	219	482	387	836	2.11	1022
	M	185	4	195	454	363	838	2.29	912
1957	F	264	4	230	564	389	930	2.36	1037
	F	114	5	239	498	398	823	2.10	1086
	F	5	6	210	448	369	803	2.29	977
1958	F	115	5	226	533	394	846	1.86	1150
	F	185	4	233	508	401	839	1.97	927
	F	175	5	229	489	397	804	1.88	1108
	F	155	5	213	472	381	794	1.92	1114
	F	5	5	199	450	367	760	1.85	1078
	F	6	5	215	450	383	824	2.23	1095

would have been worth 2½ cents per pound more than the 515 lb. calves by sire 15. This points out the need for information on reasons for weight differences among calves. If calves are heavy because they are older or have been on a higher plane of nutrition, they may be less efficient in their gains. If they are heavy because they have greater genetic capacity for growth, they may be more efficient in their gains in spite of their heavier weights. This means that the producer of feeder calves needs to know the genetic capacity of his cattle and that feeders need to purchase cattle with the greater probability for efficient gains. Initial weight alone is not a good indication of the future performance of calves.

In Table 4 is given the average growth data for each of the 30 sire groups of steers fed during 1959, 1960, and 1961. The tremendous differences which occur between sire progeny groups in growth rate emphasize the opportunity which exists for the improvement of this trait in beef cattle by selection. Average differences of from .4 to .6 of a pound per day were found each year. In cases where some sires were repeated in different years, there was remarkable consistancy in progeny performance from year to year. Sires 264 and 6 sired calves which gained about .4 of a pound per day more than those of sire 21 in 1959. Those sired by the same two sires gained nearly .6 of a pound per day more than those by bull 21 in 1960.

Calves by sire 21 in 1961 weighed 838 lbs. at slaughter age of 395 days, while those by sire 158 weighed 988 lbs. at 389 days of age. The dressing percentage and carcass grades for these two sire groups did not differ. Under these circumstances one can see that the calves by 158 would be much more profitable than those by sire 21 to both the producer of feeder calves and the feeder, even if they changed hands at the same price per pound. They were actually worth about 2 cents per

Table 4.—Performance of Steers by Thirty Sires Fed in Groups During 1959, 1960, and 1961.

Year	Sire	No. Calves	Initial		Final		ADG	Dr. %	Carc. Gr.[1]
			Age	Wt.	Age	Wt.			
1959	264	7	199	483	370	949	2.62	62.4	11.1
	21	7	211	451	382	848	2.23	63.3	11.9
	6	5	219	501	390	963	2.60	61.7	10.4
	426	8	202	474	373	941	2.62	62.3	10.6
	436	6	202	499	373	950	2.53	61.7	10.2
	096	6	211	478	382	928	2.53	61.7	10.8
	196	7	204	493	375	941	2.52	63.9	10.4
	066	3	212	437	383	865	2.40	62.0	12.3
	406	4	220	459	391	859	2.25	61.9	11.0
	046	6	212	454	383	854	2.25	61.1	11.8
1960	264	5	207	487	406	986	2.51	64.0	11.0
	21	4	214	455	413	839	1.93	64.2	10.8
	6	5	215	503	414	995	2.52	62.8	9.0
	157	7	204	470	403	980	2.56	63.3	10.7
	047	6	207	437	406	936	2.51	63.2	10.3
	22	4	217	445	416	919	2.38	63.7	11.0
	327	8	213	496	412	967	2.37	64.2	10.9
	187	8	210	443	409	894	2.27	63.3	10.2
	337	8	212	446	411	891	2.24	63.7	10.8
	24	5	210	448	409	890	2.22	64.2	10.4
1961	158	6	221	543	389	988	2.65	63.3	11.0
	328	6	228	522	396	931	2.43	62.5	11.3
	23	6	222	522	390	930	2.43	63.0	11.7
	258	6	222	517	390	898	2.27	63.3	10.8
	24	6	220	516	388	924	2.43	63.0	10.8
	468	6	218	510	386	917	2.42	61.6	11.8
	048	6	212	496	380	904	2.43	62.7	11.5
	038	6	214	475	382	882	2.42	61.5	10.3
	21	6	227	468	395	838	2.20	62.6	11.5
	22	6	214	457	382	817	2.14	63.5	11.2

[1]Carcass Grades: High Good, 9; Low Choice, 10; Avg. Choice, 11; High Choice, 12.

pound more because they were more efficient in their gains. In recent years the prices paid per pound would likely have been the reverse of the above values because the genetic superiority or inferiority of sires was unknown to producers and feeders. The feeder who paid a premium price for the calves by sire 21 would have been at an economic disadvantage, while the producer of the calves by sire 158 would not be getting proper remuneration for his calves. However, the 543 lb. calves by 158 would bring the producer as many dollars at 28 cents per pound as would the 457 lb. calves by sire 21 at 33 cents per pound.

If strong pressure against heavy calves is encountered by a producer who has unusually rapid gaining calves, he could sell at younger ages to take advantage of the higher prices being offered for the lighter weight calves or he might wish to feed them for slaughter, himself. Because feeder demand for calves of different weights changes, varying with the price of feed and the price of fat cattle in relation to the price of feeder calves, the breeder and producer of feeder calves will do well to keep a long range objective in mind. Changes in genetic capacity are made only by considerable selection over a period of years. He can better meet temporary shifts in demand by altering management practices than by changing goals in selection. If heavy calves are in demand, he can creep-feed his calves and wean them at an older age. If light weight calves are more profitable to him, he can wean them at a younger age without creep. The breeder who produces cattle with superior genetic capacity for gains and grades is better able to make adjustments to changing demands. The breeder who knows the genetic capacity of his cattle is also better able to negotiate intelligently with his customer in arriving at a price which is fair to both.

Methods of Processing Milo for Fattening Steer Calves

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Grain sorghum is the chief concentrate for fattening cattle in most areas of the Southwest. During the past few years, several changes of importance relative to this feed grain have taken place. For one thing, new varieties of hybrid grain sorghum, heavy fertilization, and irrigation have greatly increased the yields per acre, and also may have affected the chemical composition of the grain, especially its protein content. Another change has taken place in the feeding of the grain. No longer is most of our grain processed on the farm. Today, new methods of processing (dry or steam rolling, pelleting, etc.) are available to either the large feeder or the small operator who buys a complete fattening ration from a well-equipped feed mill.

Table 1.—Cost Breakdown of a Typical Steer Fattening Ration.

Ingredient	Daily Intake (lbs.)	Cost per ton ($)	Cost per day	% of total feed cost
Ground or rolled milo	12.0	48.00	0.29	64.4
Cottonseed meal	1.5	70.00	0.05	11.1
Dehydrated alfalfa meal	1.0	55.00	0.03	6.6
Molasses	1.0	35.00	0.02	4.4
Cottonseed hulls	4.5	22.50	0.05	11.1
Mineral + Vitamin A	.2	--	0.01	2.2
Total	20.2		0.45	

This has emphasized the importance of finding the best way to process grains such as milo. Its relative importance in the fattening ration is apparent if we consider the costs of the various ingredients that make up a typical ration for a fattening steer in drylot, as illustrated in Table 1. From these calculated values, we can see that with milo at $48 per ton, about 64 percent of the total cost of the entire ration is accounted for by this grain alone. Obviously, the other ingredients in the ration, such as the protein oil meal and dehydrated alfalfa meal, are essential for rapid and efficient gains. Milo is by far the most costly item considering the ration as a whole, in fact nearly twice as costly as all other ingredients combined.

The milo kernel differs from other grains, being more dense and compact. Nearly 65 percent of the milo kernel is starch. Our laboratory tests show that the starch of milo is less available to enzymatic breakdown than the starch of a grain such as barley. It is important to remember that while the starch of different grains are similar in many properties, they may also differ considerably in others. One possibility is that they may respond differently to various methods of processing, such as steam heating.

All cattle feeders recognize the need to reduce the hard and flinty milo kernel to smaller size by grinding or rolling in order to improve its utilization by cattle. The appearance of large amounts of apparently undigested grain in the droppings, however, raises a question as to how fine a grain such as milo should be ground or rolled. Recently, new methods of processing grains such as steam rolling have become popular, and claims are made that this method of preparation will result in greater gains and feed efficiency. Since most new methods of processing the grain also increase its cost to the feeder, they must pay off in greater gains and feed efficiency to be profitable.

Results of Previous Tests

Since 1956, a series of tests have been underway at this station to explore the various methods of processing milo for fattening steer calves. A promising early lead from these studies was the effect of fine grinding and pelleting milo grain (⅜ inch cubes). A summary of the average results of four trials are shown in Table 2.

Table 2.—Dry Rolled vs. Finely Ground and Pelleted Milo for Fattening Beef Calves. (Avg. of Four Trials, 168 Days on Feed)

	Dry Rolled	Finely Ground and Pelleted (⅜ in.)	Advantage for Pelleting, %
Total calves/treatment	38	39	
Avg. daily gain, lb.	2.29	2.38	+ 3.9
Avg. daily milo intake, lb.	11.9	11.1	— 6.7
Milo required/cwt. gain, lb.	521	467	—10.4
Dressing percentage	64.5	63.4	
Carcass grade score[1]	6.8	7.0	

[1] Low Choice = 6.0; High Good = 7.0.

When compared to dry rolled milo (medium to course in texture), the finely ground and pelleted milo had little effect on rate of gain, but decreased the milo required per 100 lbs. gain by nearly 10 percent. However, in all tests, carcass grade and dressing percentage were slightly lower for the pelleted milo group. Nevertheless, the advantage in feed efficiency was consistent from trial to trial either on a live or carcass weight basis.

Several variables were present in these early trials. One was the difference in particle size between the two products. Another was the possible effect of steam heat and pressure during the pelleting process in altering the structure of the starch granule, and in some way improving feed efficiency.

Accordingly, a test was conducted in 1959-60 in which finely ground milo in the meal form was compared with the same product in pelleted form, or with reground pellets. Both forms of milo were also compared to the steam rolled product. Where steers were hand-fed rations containing either ground or ground and pelleted milo, the results showed a depression in grain intake and lowered rate of gain with the pelleted grain, with only a slight effect on feed efficiency.[1] Likewise, where the

[1] Okla. Agr. Exp. Station MP-61:134.

pellets were reground and fed in meal form, results were nearly equal to the unpelleted grain. Hence, the pelleting process itself appeared to have no beneficial effect on the same particle size product. Steam rolled milo in this initial test proved to be the form least efficiently utilized.

Interest was then centered on the effect of particle size to which the milo kernel is reduced during processing. Two tests have been initiated to study this effect and this report summarizes the results of Trial I (1960-61), which has been reported in preliminary form.[2] A subsequent study, Trial II, is now in progress. In both trials, fine vs. coarsely ground or steam rolled milos are compared in complete mixed rations, self-fed to weaner steer calves. In Trial II, the effect of steam heating either a finely ground or dry rolled milo is being studied. By steam heating, it is hoped that an alteration of the starch might occur which would lead to more efficient utilization.

Procedure

Trial I

Sixty, uniform, Hereford steer calves were selected from the Experiment Station herd and a commercial herd in the southern part of the state. They were allotted to six groups of 10 calves each on the basis of shrunk weight, source, and feeder grade. After an initial period to recover from the effects of weaning, the calves were started on experimental rations (see Tables 3 and 4). The calves were self-fed a complete mixed ration containing milo, cottonseed meal, molasses, dehydrated alfalfa meal, cottonseed hulls and additional calcium, salt, and

Table 3.—Composition of Self-Fed Mixtures for Fattening Steer Calves. (Percent)

Ingredients	Trial I (1960-61)	Trial II (1961-62)
Processed milo	50	60
Cottonseed meal (solvent)	9	9
Dehydrated alfalfa meal	8	9
Molasses	8	6
Cottonseed hulls	24	15
Calcium carbonate	.5	.5
Salt	.5	.5
Vitamin A premix[1]	.05	.05

[1]Supplied approximately 21,000 I.U. per steer daily.

[2]Okla. Agr. Exp. Sta. MP-64:82.

Table 4.—Percent Composition of Mixtures Fed in Trial I.

Lot No. and Mix	Dry Matter	Ash	Crude Protein	Ether Extract	Crude Fiber	N-Free Extract
Lot 1—Meal	88.12	4.14	11.31	2.47	13.36	56.84
Lot 2—Pellet	88.77	4.83	12.63	2.15	10.63	58.53
Lot 3—Meal	88.12	5.17	11.56	2.55	10.02	58.82
Lot 4—Pellet	89.80	5.15	13.50	3.32	11.12	56.71
Lot 5—Meal	88.56	4.30	11.06	2.17	13.03	58.00
Lot 6—Pellet	89.59	5.30	12.88	3.39	10.54	57.48

vitamin A. The mixture contained 50 percent milo processed in one of three different ways: Lots 1 and 2, finely ground through a high-speed hammer mill (3500 rpm) with an ⅛-inch screen; Lots 3 and 4, coarsely ground milo processed through the same hammer mill without a screen, and Lots 5 and 6, steam rolled by introducing live steam for approximately two minutes before passing through the rollers. In addition to the above treatments, the mixtures fed Lots 2, 4, and 6 were pelleted in 5/16-inch cubes. One half of the calves in each lot were implanted with 24 mg. stilbestrol, the remainder with 12 mg. All calves had access to a mineral mixture containing two parts salt and one part dicalcium phosphate, free choice. At the completion of the trial, the calves were slaughtered at Oklahoma City and detailed carcass data were obtained.

Trial II

Fifty, uniform, Hereford steer calves were selected from the Dunkin ranch herds near Hominy and Fairfax. After a six-week preliminary period to permit the calves to recover from the effects of weaning and become adjusted to the feeds to be used during the trial, they were divided into five groups of 10 head each on the basis of shrunk weight (16 hours off feed and water) and grade. During the preliminary period, the calves received 350 mg. Aureomycin in the daily ration. The calves were started on a mixture containing 50 percent milo, plus cottonseed meal, dehydrated alfalfa, molasses, cottonseed hulls, calcium, salt, and vitamin A (see Table 3). After 40 days, they were advanced to a mixture containing 60 percent milo, and after 125 days to 62.5 percent milo, with a corresponding reduction in cottonseed hulls in each case. One-half the steers in each lot received 24 mg. stilbestrol implants at the start of the trial with the remainder receiving two 12 mg. implants 90 days apart.

All mixtures were self-fed. The finely ground milo fed Lots 1 and 2 was prepared as in Trial I. The dry rolled milo fed Lots 3 and 4, and steam rolled milo fed Lot 5 were processed through the same mill, with and without steam. For Lots 2 and 3, the processed milo was passed through the steam chamber of a commercial pelleting mill and subjected to a maximum quantity of steam heat in order to study the effect of steam heat with milo of two different particle sizes. Temperature readings upon emergence from the heating chamber exceeded 185°F., with a temperature of 170°F. persisting for over two minutes in the heated mass. With the steam rolled product, temperatures above 175°F. were recorded as the milo emerged from the rollers. Figure 1 shows the particle size distribution of the various products.

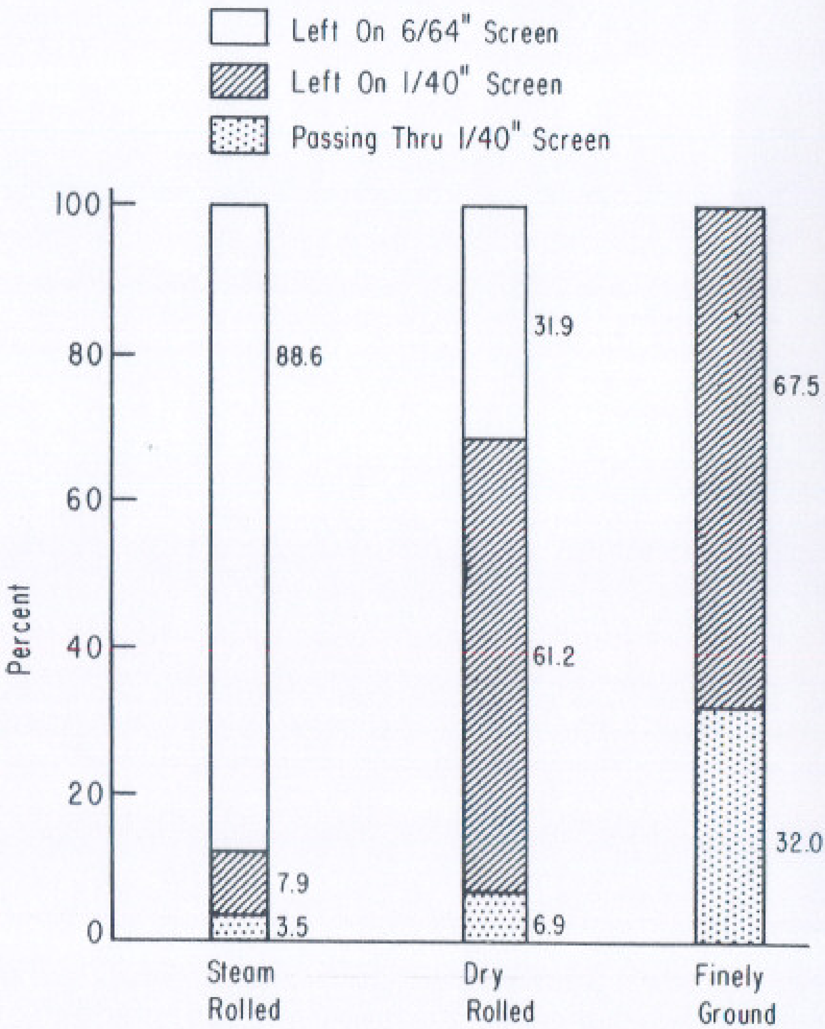

Figure 1. Particle Size Distribution of Milo Processed In Three Ways.

The calves were full-fed for days. Upon slaughter at Oklahoma City, detailed carcass data was obtained. A digestion trial, using additional calves, is now in progress. Basic laboratory tests on the enzymatic breakdown of milo starch in differently processed forms are also underway.

Results

A summary of the average results obtained in Trial I are shown in Table 5. While no significant difference in average daily gains from different processing of milo was obtained, the calves fed the finely ground milo in meal rations (Lot 1) gained slightly better than those fed coarse or steam rolled milos. This was also reflected in improved feed efficiency with nearly 60 and 30 lbs. less total ration required for the finely ground ration vs. the coarse or steam rolled mixtures (Lots 1 vs. 3 and 5).

Table 5.—Trial I: Feedlot Performance and Carcass Data from Calves Fed Differently Processed Milo in Meal Vs. Pelleted Rations.[1] (193 Days on Test)

Milo preparation	Finely Grd. Milo		Coarsely Grd. Milo		Steam Rolled Milo	
Lot no.	1	2	3	4	5	6
Ration form	Meal	Pellet	Meal	Pellet	Meal	Pellet
No. calves[2]	8	10	9	9	10	10
Avg. initial wt., lbs.	479	460	463	463	460	460
Avg. daily gain, lbs.	2.31	2.24	2.16	2.21	2.20	2.35
Avg. daily feed intake, lbs.	19.8	18.2	19.8	18.4	19.5	19.4
Feed required per cwt. gain, lbs.	857	813	917	833	886	826
Feed cost per cwt. gain,[5] $	18.43	18.29	19.72	18.74	19.49	19.00
Dressing %[3]	60.8	59.1	60.4	59.2	59.7	58.9
USDA Carcass grade score[4]	6.6	7.6	7.0	7.8	7.3	7.3

[1]One-half of the steers in each lot implanted with 12 mg. stilbestrol, the remainder with 24 mg.

[2]Two calves in Lot 1 and one from Lot 3 removed for urinary calculi; one calf removed from Lot 4 with sickness of unknown origin. Data on these calves not included.

[3]Based on Stillwater weights and warm carcass weights shrunk 2.5 percent.

[4]Carcass grade score: Good = 7; Top Good = 6.

[5]Feed costs were: Lots 1 and 3, $2.15 per cwt; Lots 2 and 4, $2.25; Lot 5, $2.20 and Lot 6, $2.30 per cwt.

However, when the rations were fed in pelleted form, little difference was apparent between finely ground and coarsely ground milo rations and both produced slightly less gain than the same rations in meal form (Lots 2 and 4 vs. 1 and 3). Pelleting the steam rolled milo ration (Lot 6) appeared to give a slight boost in gains, and in this form the pelleted ration was superior to the ground milo mixtures. Hence, pelleting the more bulky ration fed Lot 6 may result in a slight increase in gain, although feed intake was not improved. With the increase in gain, Lot 6 calves required 60 lbs. less per cwt. gain than Lot 5.

Overall, pelleting the three types of rations caused a 5 percent decrease in feed intake with slight effect on daily gain, but resulted in 7 percent less feed per 100 lbs. gain. However, this advantage largely disappears when the lower dressing percentages of pellet-fed calves are considered.

This trend is consistent with research at a number of stations which shows that pelleting a fattening type ration containing over 65 percent concentrates will depress feed intake and rate of gain. It can be calculated that at the prices prevailing during this test, the savings in feed cost per cwt. gain for pelleting of $1.37 was nearly offset by the increased pelleting cost of $1.03. Hence, there was little economic advantage from pelleting. No adverse effects in terms of looseness of droppings or founder were observed from any of the mixtures fed, possibly because a relatively low level of milo was used.

Trial II

Results for the 177-day trial show that with mixtures containing 60 percent or more of the differently processed milos, averaged daily gains favored Lots 3 and 4 (dry rolled product). These calves gained about 7 percent faster than those of Lots 1 and 2 fed the finely ground milo rations, and slightly faster than the steam rolled milo group (Lot 5). However, it can be seen that the differences in gain are small in each case. Calves of Lot 1 have been most efficient, consuming about 1.5 lbs. less of the daily ration, and requiring nearly 65 lbs. less feed per cwt. gain than calves of Lot 3. Feed efficiency with steam rolled milo, (Lot 5) has been intermediate. The only advantage to finely ground milo appears to be the greater feed efficiency of Lot 1. Carcass grades and yield were essentially the same.

Calves fed the finely ground milo rations exhibited more difficulty from bloat and scouring than those fed the dry or steam rolled products. Hence, the contention of cattle feeders that coarsely processed grain is safer to feed seems justified.

Steam heating, whether applied before or after rolling or grinding, appeared to have little, if any, beneficial effect. Laboratory tests have indicated, however, that when a starch-slitting enzyme was applied to each of the differently processed milos, those treated with steam were more readily attacked. However, in the overall economy of the ruminant, a more readily available starch may not be desirable since it may also adversely affect the efficiency of rumen fermentation of pH.

Refering to the earlier results from pelleting milo, the steam heat associated with the pelleting process does not appear to be the reason for the increased efficiency of milo utilization. This is supported by earlier work in which reground, pelleted milo gave no improvement over untreated milo in fattening rations. The reason for the observed greater feed efficiency from pelleting milo, therefore, may be due to the slightly lower grain intake when pellets are fed, resulting in better feed economy, rather than to the pelleting process itself. The slightly lower dressing percentage shown in Table 2 tends to bear this out.

Table 6.—Trial II: Effect of Different Methods of Processing Milo in Fattening Rations for Steer Calves (177 days on test)

Milo preparation	Fine Ground		Coarsely Ground		Steam
	Unheated	Steam Heat	Unheated	Steam	Rolled
Lot Number	1	2	3	4	5
No calves per lot	9[1]	9[1]	10	10	9[1]
Avg. weights, lb.					
Initial, Nov. 8, 1961	478	471	477	480	484
Final, May 5, 1962[2]	904	879	919	930	917
Total gain	426	408	442	450	433
Avg. daily gain	2.41	2.31	2.50	2.54	2.45
Avg. daily feed intake, lb.	21.2	22.4	23.8	24.0	21.8
Feed required per cwt. gain, lb.	880	970	952	945	890
Feed cost per cwt. gain, lb.[3]	23.32	27.16	25.23	26.46	24.48
USDA Carcass grades:					
Avg. Choice		2	1		
Low Choice	1	1		2	2
High Good	2		1	1	2
Avg. Good	3	1	6	3	3
Low Good	3	2	1	3	
High Standard		3	1	1	2
Dressing percentage[4]	62.6	61.7	62.7	62.0	62.4
Avg. on-fat value per cwt., based on yield and carcass grade	24.45	23.96	24.45	24.15	24.34

[1]One calf removed from each of Lots 1 and 2 for urinary calculi; one calf removed from Lot 5 for founder. Data on these calves not included.
[2]Based on initial and final shrunk weights.
[3]Cost per cwt. = Lots 1 & 3, $2.65; Lots 2 & 4, $2.80; Lot 5, $2.75.
[4]Hot carcass weights shrunk 2%; values based on Stillwater shrunk weights.

Summary

Earlier trials have shown that fine grinding and pelleting milo vs. dry rolling for fattening steers would decrease the milo required per 100 lbs. gain by about 10 percent. Subsequent trials have failed to show that this is due either to (1) the particle size of the milo, since no consistent advantage has been observed with different preparations of milo for fattening steer calves, or (2) to the effect of steam heating as might occur during the pelleting process. The milo kernel may differ from corn or other grains in that its dense, compact nature and characteristic starch are more impervious to the effects of steam heat. In

the trials to date, no consistent advantage has been obtained for fine vs. coarse grinding or rolling of milo for fattening steer calves.

Steam rolled milo has not proven superior to the best ground or rolled product in any of the trials thus far. Hence, the additional cost and effort of steam rolling cannot be justified by feedlot performance. However, one possible advantage to the bulky, steam rolled grain is that a higher grain ration can be safely fed, thus lowering the feed required to produce 100 lbs. gain.