Nebraska Beef Cattle Reports | Department of Animal Science

1967

1967 Beef Cattle Progress Report of Research Activities

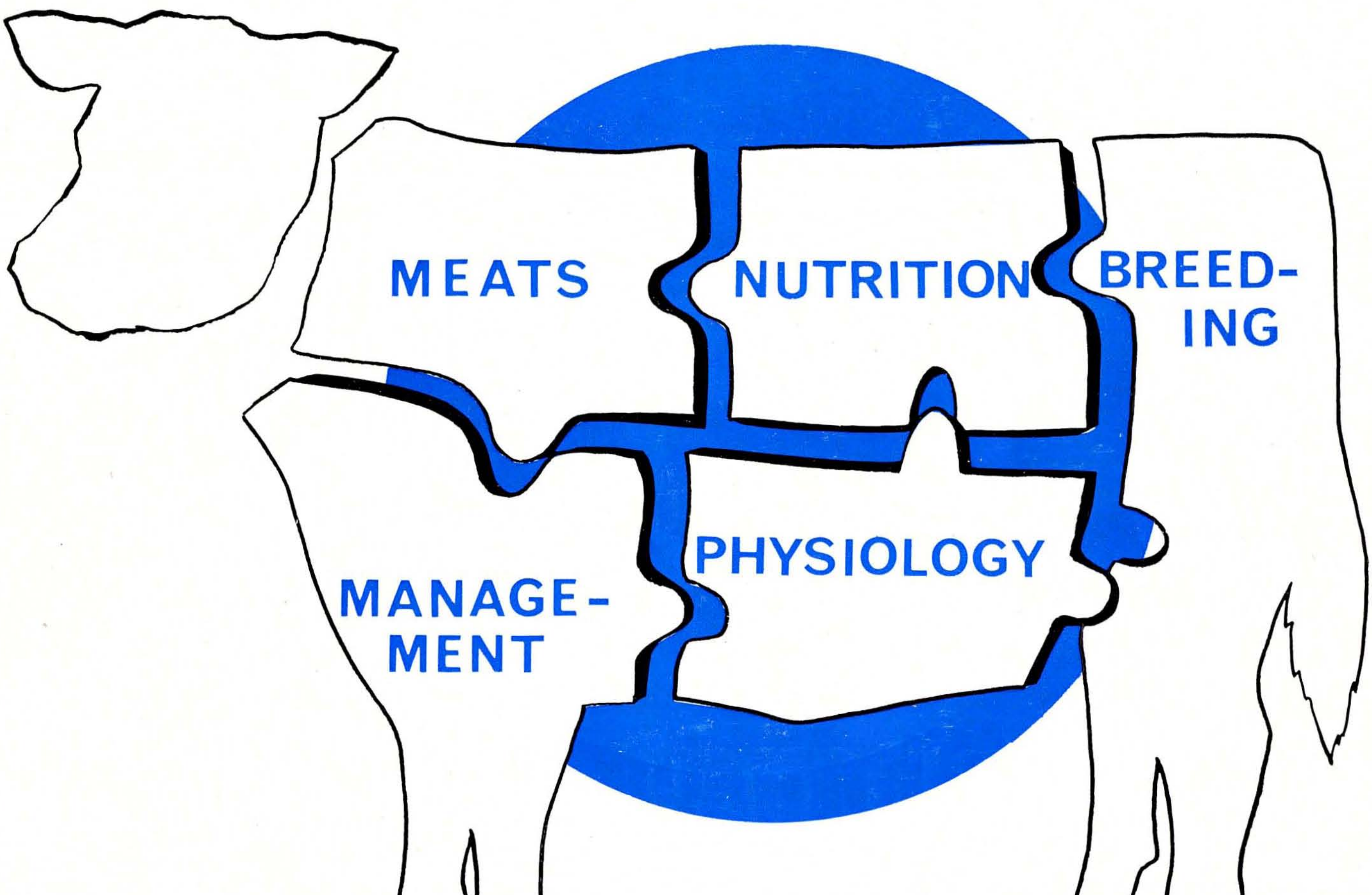
E. F. Frolik

H. W. Ottoson

J. L. Adams

1967 BEEF CATTLE...

PROGRESS REPORT of RESEARCH ACTIVITIES



* Progress in BEEF CATTLE PRODUCTION

PUBLISHED BY ANIMAL SCIENCE DEPARTMENT
UNIVERSITY OF NEBRASKA COLLEGE OF AGRICULTURE AND HOME ECONOMICS
THE AGRICULTURAL EXPERIMENT STATION AND EXTENSION SERVICE
E. F. FROLIK, DEAN H. W. OTTOSON, DIRECTOR. J. L. ADAMS, DIRECTOR

ACKNOWLEDGMENTS

All research reported from the Fort Robinson Beef Cattle Research Station is cooperative between the Beef Cattle Research Branch, Animal Husbandry Research Division, ARS, USDA, and the Nebraska Agricultural Experiment Station.

Appreciation is expressed to the following firms for their support in the beef cattle program.

1. Agri-Tech, Inc., Kansas City, Missouri.
2. Allied Chemical Corporation, New York, New York.
3. Hoffman-La Roche, Inc., Nutley, New Jersey.
4. Calcium Carbonate Company, Quincy, Illinois.
5. Chas. Pfizer and Company, Terre Haute, Indiana.
6. Eli Lily and Company, Indianapolis, Indiana.
7. Merck and Company, Inc. Rahway, New Jersey.
8. Nopco Chemical Company, Harrison, New Jersey.
9. Nebraska Artificial Breeders, Fremont, Nebraska.
10. Pacific Vegetable Oil Corporation, Richwood, California.
11. Consumers Cooperative Association, Kansas City, Missouri.
12. Birdwood Products Company, North Platte, Nebraska.
13. Monsanto Company, St. Louis, Missouri.
14. Neuswangers, Alliance, Nebraska.
15. American Cyanamid, Kansas City, Missouri.
16. Nixon and Company, Omaha, Nebraska.
17. Biochemical Corporation of America, Salem, Virginia.
18. Oyster Shell Products Company, Mobile, Alabama.
19. Upjohn Company, Kalamazoo, Michigan.
20. Commercial Solvents Corporation, San Jose, California.
21. Cargill, Inc., Omaha, Nebraska.

TABLE OF CONTENTS

Issued March 1967, 10,000

Animals on trial.

Stilbestrol, Synovex

Influence on Cattle

By Walter Woods[1] and Walter Tolman[2]

Oral feeding of stilbestrol or implanting with stilbestrol or Synovex has resulted in increased weight gain and efficiency of gain for cattle fed finishing rations.

Combining oral feeding or stilbestrol with implanting did not give increased performance above that obtained from oral stilbestrol alone in two tests. Implanting cattle fed oral stilbestrol at the start of the feeding program with either stilbestrol or Synovex gave a similar pattern of performance to that obtained from oral stilbestrol alone.

The first trial was conducted to determine if the implanting of stilbestrol would influence the performance of cattle fed oral stilbestrol. A control treatment without stilbestrol was compared to treatments in which cattle received oral stilbestrol (10 mg./day) and oral stilbestrol plus a 24 mg. implant of stilbestrol at the start of the experiment or after 56 days.

Two lots of approximately 42 steers each received each treatment. The cattle were fed a full feed of milo with 4.9 lb. alfalfa hay and .5 lb. of supplement per day during the 146-day feeding period.

[1] Department of Animal Science, University of Nebraska.

[2] Department of Animal Science, Northeast Station.

Full Feed of Corn

In the second trial, conducted at the Northeast Station, a control treatment without stilbestrol was compared to treatments in which cattle received oral stilbestrol (10 mg./day) or oral stilbestrol plus implants of 12 or 24 mg. of stilbestrol or Synovex S at the start of the feeding period.

There were 2 lots of 10 head on each treatment. The steers were given a full feed of corn, 3.2 lbs. of alfalfa hay, and 0.5 lbs. of supplement per day during the 168-day trial. The supplement for both trials contained adequate levels of minerals, and vitamins.

Results of the first trial are shown in Table 1. The addition of stilbestrol in the first trial increased gains by 9.5% and decreased feed required by 7.1% per 100 pounds of gain.

Implanting of cattle with 24 mg. of stilbestrol at the start of the experiment did not change the performance as compared to the cattle receiving oral stilbestrol.

Waiting until 56 days after the cattle were started on feed tended

(continued on next page)

Table 1. Influence of stilbestrol implants in addition to oral stilbestrol.

	Oral Stilbestrol +			
	Control	O	24 mg. imp. at start	24 mg. imp. 56 days
No. steers	85	83	84	82
Initial weight, lb.	743	747	747	745
Daily gain, lb.	2.20	2.41	2.45	2.52
Daily feed, lb.				
Milo	19.7	20.2	20.2	20.1
Alfalfa hay	4.9	4.9	4.9	4.9
Supplement	.5	.5	.5	.5
Total	25.1	25.6	25.6	25.5
Feed/cwt. gain, lb.	1142	1061	1048	1012
Fat thickness, inch	.69	.70	.69	.66
Rib eye area, sq. inch	11.7	11.8	11.9	11.9
Carcass grade score[a]	17.1	17.1	16.9	16.8
Dressing %[b]	58.3	58.2	57.9	58.0
Marbling score	10.0	10.1	9.9	9.9

[a] Carcass grade score assigned; 17 = low choice; 16 = high good.
[b] Dressing % based on full weights at end of experiment and hot carcass weights shrunk 2½%.

Table 2. Influence of stilbestrol and Synovex implants on cattle fed oral stilbestol.

	Oral Stilbestrol (10 mg./day) +				
	Control	O	12 mg. implant DES	24 mg. implant DES	Synovex
Length of trial, days	168	168	168	168	168
No. head	20	20	20	20	20
Initial weight, lb.	711	705	710	697	701
Daily gain, lb.	2.42	2.90	3.00	2.79	2.88
Daily feed consumption, lb.					
Corn	16.3	17.6	17.7	17.5	17.7
Alfalfa hay	3.2	3.2	3.2	3.2	3.2
Supplement	0.5	0.5	0.5	0.5	0.5
Total	20.0	21.3	21.4	21.2	21.4
Feed/cwt. gain, lb.	828	734	718	760	744
Carcass grade[a]	20.2	20.0	19.5	19.4	19.2
Dressing %[b]	59.4	59.1	58.8	59.6	59.6

[a] Carcass grade score assigned; 17 = low choice; 18 = average choice.
[b] Dressing % based on full weights at end of experiment and hot carcass weight shrunk 2½%.

Stilbestrol, Synovex

(continued from page 3)

to give a slight benefit in gain and added reduction in feed required per unit gain. The measurements taken on carcass characteristics did not vary significantly among treatments.

Results from Trial 2 are shown in Table 2. Feeding oral stilbestrol resulted in a 19.9% stimulation in weight gain and a 11.4% decrease in feed required per unit gain as compared to the non-treated controls. Implanting steers at the beginning of the feeding period with 12 or 24 mg. stilbestrol or with Synovex did not produce consistent benefits above that received from oral feeding.

During the first part of the trial there seemed to be a slight benefit in weight gains because of the combination of oral stilbestrol and an implant. The carcass characteristics of cattle from the various treatments were evaluated and it would appear there was a tendency for a slight reduction in grade as the level of stilbestrol increased through the combination of the implanting and feeding orally.

Results Show Benefits

Results of the study suggest that considerable benefit is obtained from feeding stilbestrol in rate of gain and efficiency of feed conversion. These results have been consistently shown in previous trials.

Although the effect of implant alone was not part of this study, research has shown implanting to be effective in giving a similar response in gain and efficiency as compared to oral stilbestrol.

The practice of implanting cattle in addition to oral feeding is questioned by the results obtained in this study. No consistent benefits were found except a possible benefit by delaying until after the cattle had been on feed 56 days. The level of stilbestrol or stilbestrol as compared to Synovex implants did not change the results.

Effects of Hybrid Vigor

By K. E. Gregory,[1] R. M. Koch,[2] J. E. Ingalls,[1] J. A. Rothlisberger[3] and C. W. Kasson[3]

Comprehensive analyses have been made of data from an extensive crossbreeding experiment conducted at the Fort Robinson Beef Cattle Research Station. The experiment involves the Hereford, Angus and Shorthorn breeds.

In the first phase of this experiment the three straightbreds and all reciprocal crosses among them were produced. Heterosis or hybrid vigor was evaluated by comparing the crossbreds with the average of the straightbreds.

Crossbreds and straightbreds were sired by the same bulls and were out of comparable cows.

Effects of Hybrid Vigor

These studies involved an eval-

Table 1. Experimental designs showing the total number of sires, dams and calves weaned (both sexes) for the four years.

Dams		Sires and Number of Offspring			
Breed	No.[a]	Hereford[b] (16)	Angus (17)	Shorthorn (16)	Total
Hereford	80	HH[c] - 118	AH - 60	SH - 72	250
Angus	80	HA[c] - 66	AA - 115	SA - 65	246
Shorthorn	80	HS[c] - 68	AS - 62	SS - 125	255
Total	240	252	237	262	751

[a] Experiment was initiated with 80 females of each breed and open females were removed each fall.
[b] General plan to rotate four sires of each breed per year. Sixteen Hereford, 17 Angus and 16 Shorthorn sires were used during the four years.
[c] Breed of sire is listed first. H = Hereford, A = Angus and S = Shorthorn.

Table 2. Heterosis effects on preweaning traits—sexes combined.

	No.	Birth Wt. Lbs.	Wn. Wt. 200-days Lbs.	Wn. Sc.[a] 200-days
Crossbreds	393	74.2	437.4	10.87
Straightbreds	358	71.5	418.0	10.70
Difference		+2.7	+19.4	+.17
H x A & reciprocal	126	73.8	440.8	10.94
Average of H & A	233	71.3	419.0	10.70
Difference		+2.5	+21.8	+.24
H x S & reciprocal	140	79.6	441.1	10.72
Average of H & S	243	74.9	417.3	10.62
Difference		+4.7	+23.8	+.10
A x S & reciprocal	127	69.5	430.4	10.95
Average of A & S	240	68.4	417.6	10.75
Difference		+1.1	+12.8	+.20

[a] Scores of 10, 11 and 12 = Low, average and high choice, respectively.

Table 3. Heterosis effects on postweaning traits of steers—growth and feed efficiency.

	No.[a]	Wn. Wt. 200-days lbs.	425-day Weight lbs.	TDN req. per lb. gain lbs.	Sl. Grade[b] 452 days
Crossbreds	191/143	447	912	5.76	10.6
Straightbreds	183/143	431	883	5.77	10.5
Difference		+16	+29	−.01	+.1
H x A & recip.	64/44	449	919	5.55	10.7
Average of H & A	117/92	431	880	5.73	10.4
Difference		+18	+39	−.18	+.3
H x S & recip.	67/52	452	938	5.64	10.4
Average of H & S	129/98	430	898	5.58	10.3
Difference		+22	+40	+.06	+.1
A x S & recip.	60/47	439	877	6.09	10.7
Average of A & S	120/96	433	871	6.00	10.8
Difference		+6	+6	+.09	−.1

[a] Number on left is the number of steers for measures of growth rate. Number on right is the number of steers for measures of feed efficiency.
[b] Grades of 10, 11 and 12 = Low, average and high choice, respectively.

in Beef Cattle Significant

Table 4. Heterosis effects on carcass traits and returns per steer.

	No.[a]	Carc. Wt. 452 days lbs.	Carc. grade[b] 452 da.	Fat[c] th. in.	Ribeye area sq. in.	Cuta-bility[d] %	Retail product[e] %	Retail[f] product at 452 days lbs.	Retail product at 452 da. Wt. adj. lbs.	Fat trim 452 da. Wt. adj. lbs.	Retail prod. / lb. TDN lbs.	Net Merit $
Crossbreds	191/143	564	10.2	.51	10.8	52.2	63.4	331	332	118	.1345	220.33
Straightbreds	183/143	541	9.9	.45	10.5	52.5	63.9	320	332	118	.1338	211.52
Difference		+23	+.3	+.06	+.3	−.3	−.5	+11	0	0	+.0007	+8.81
H x A & reciprocal	64/44	563	10.0	.51	11.0	53.7	65.2	339	340	109	.1391	226.80
Average of H & A	117/92	534	9.7	.43	10.7	54.1	65.9	325	341	107	.1381	215.89
Difference		+29	+.3	+.08	+.3	−.4	−.7	+14	−1	+2	+.0010	+10.91
H x S & reciprocal	67/52	578	10.0	.48	10.7	51.7	62.6	337	329	119	.1333	224.29
Average of H & S	129/98	548	9.6	.44	10.3	52.4	63.6	322	330	118	.1325	211.45
Difference		+30	+.4	+.04	+.4	−.7	−1.0	+15	−1	+1	+.0008	+12.84
A x S & reciprocal	60/47	551	10.5	.54	10.6	51.1	62.5	316	326	125	.1313	209.91
Average of A & S	120/96	543	10.3	.49	10.5	51.1	62.4	313	324	127	.1309	207.21
Difference		+8	+.2	+.05	+.1	0	+.1	+3	+2	−2	+.0004	+2.70

[a] Number on left is number of steers for routine carcass traits. Number on right is the number of steers for detailed carcass cut-out data and feed efficiency.
[b] Grade of 10, 11 and 12 = low, average and high choice, respectively.
[c] Single measure at 12th rib.
[d] Actual yield of closely trimmed boneless retail cuts from round, loin, rib and chuck.
[e] Actual yield of closely trimmed boneless retail cuts from entire carcass.
[f] Pounds of closely trimmed, boneless cuts from entire carcass.
[g] Net merit is the value of the retail product (dollars) minus feed costs from weaning to slaughter.

uation of the effects of hybrid vigor on:

1. Embryo survival.
2. Postnatal mortality.
3. Birth weight.
4. Preweaning growth rate.
5. Weaning weight.
6. Weaning conformation score.
7. Postweaning growth rate and yearling weight of heifers developed under two management programs.
8. Age and weight at first heat of heifers developed under two management programs.
9. Postweaning growth rate and yearling weight of steers on a growing-fattening ration.
10. Postweaning feed efficiency of steers on a growing-fattening ration.
11. Slaughter grade of steers.
12. Detailed information on carcass characteristics of steers involving complete cut-out data on one side of each carcass.

[1] Animal Husbandry Research Division, ARS, USDA.
[2] Department of Animal Science, University of Nebraska.
[3] Nebraska Agricultural Experiment Station, Fort Robinson Beef Cattle Research Station, Crawford, Nebraska.

Cooperative between the Beef Cattle Research Branch, Animal Husbandry Research Division, ARS, USDA and the Nebraska Agricultural Experiment Station.

Four Calf Crops

These studies included 751 calves from four calf crops sired by 16 Hereford, 17 Angus and 16 Shorthorn bulls. Summaries of the results from this experiment are presented in Tables 1 through 10.

The effects of hybrid vigor were significant for most of the economic traits evaluated.

A three percent greater calf crop was weaned in the crossbred than in the straightbred calves because of differences in early postnatal mortality.

The heterosis effect on 200-day

(continued on next page)

Table 5. Heterosis effects on growth rate of heifers.

	1960 and 1961 calf crops[a]					1962 and 1963 calf crops[a]				
	No.	Wn. wt. 200 da. lbs.	396-day wt. lbs.	550-day wt. lbs.	550-day score[b]	No.	Wn. wt. 200 da. lbs.	396-day wt. lbs.	550-day wt. lbs.	550-day score[b]
Crossbreds	97	415	511	764	10.7	96	440	653	853	10.3
Straightbreds	86	388	463	712	10.2	77	418	611	805	10.0
Difference		+27	+48	+52	+.5		+22	+42	+48	+.3
H x A & reciprocal	33	419	514	783	10.8	29	445	657	869	10.6
Average of H & A	56	389	468	719	10.3	52	423	615	814	10.1
Difference		+30	+46	+64	+.5		+22	+42	+55	+.5
H x S & reciprocal	30	416	512	772	10.6	36	443	667	864	10.3
Average of H & S	56	388	456	715	10.1	52	419	619	817	10.1
Difference		+28	+56	+57	+.5		+24	+48	+47	+.2
A x S & reciprocal	34	409	506	737	10.6	31	433	636	826	10.0
Average of A & S	60	388	465	701	10.2	50	412	600	784	10.0
Difference		+21	+41	+36	+.4		+21	+36	+42	0

[a] Heifers from 1960 and 1961 calf crops were developed for calving as threes, while heifers from 1962 and 1963 calf crops were developed for two-year-old calving.
[b] Scores of 10, 11 and 12 = low, average and high choice, respectively.

Hybrid Vigor

(continued from page 5)

Table 6. Experimental design for Phase 2 of the experiment.

Dams	Sires[a]		
	Hereford	Angus	Shorthorn
Hereford		A x H	S x H
Angus	H[b] x A		S x A
Shorthorn	H x S	A x S	
H x A & reciprocal			S x (H x A)
H x S & reciprocal		A x (H x S)	
A x S & reciprocal	H x (A x S)		

[a] Object is to compare crossbred cows with their straightbred half-sisters when both produce crossbred calves by the same sires.
[b] Breed of sire is listed first. Comparisons will be between crossbred and straightbred cows for each column and the average of all crossbred cows with the average of all straightbred cows.

weight was 24 lbs. in heifers and 16 lbs. in steers.

The heterosis effect on postweaning growth rate of heifers on a low level of feeding was greater than in steers on a growing-fattening ration.

The magnitude of the heterosis effect on growth rate was related to level of feeding and age. That is, heterosis or hybrid vigor tended to decrease with increasing age after about one year and was greatest on a restricted feed intake when comparing heifers with steers.

The heterosis effect was 50 lbs. on 550-day weight of heifers and 29 lbs. on 452-day weight of steers. The heterosos effect on carcass weight at 452 days was 23 lbs. for steers.

Heterosis effects on age at first heat of heifers were 41 and 35 days for low and moderate levels of feeding, respectively.

Table 7. Weaning weight of calves, weaning scores of calves and estimated milk production of dams in phase 2 of the experiment—1963, 1964, 1965 and 1966 (preliminary report of results).

Dams	No.	Wn. Wt.[a] 200-days lbs.	Wn. score[b] 200-days	Est. Milk Production 12-hour period[c] lbs.
		1963 calf crop		
Crossbreds	27	472	10.3	9.44
Straightbreds	24	455	9.6	8.97
Difference		+17	+.7	+.47
		1964 calf crop		
Crossbreds	97	474	11.0	7.87
Straightbreds	73	443	10.2	7.03
Difference		+31	+.8	+.84
		1965 calf crop		
Crossbreds	105	457	10.6	7.37
Straightbreds	74	437	10.2	6.70
Difference		+20	+.4	+.67
		1966 calf crop		
Crossbreds	106	470	10.8	
Straightbreds	89	448	10.3	
Difference		+22	+.5	

[a] Adjusted to a mature equivalent dam basis—average of steers and heifers.
[b] Scores of 10, 11 and 12 = low, average and high choice, respectively.
[c] Calves averaged 2 - 3 months of age and dams were on summer range when estimates were made.

Table 8. Heterosis effects on survival (Phase 1 of experiment).

	No. matings	Calves born %	Calves born alive %	Calves alive at 2 weeks %	Calves weaned %
Crossbreds	470	89	87	86	84
Straightbreds	447	89	84	82	81
Difference		0	+3	+4	+3
H x A & reciprocal	154	87	86	84	83
Average of H & A	290	89	85	82	82
Difference		−2	+1	+2	+1
H x S & reciprocal	160	94	91	90	88
Average of H & S	307	88	84	82	80
Difference		+6	+7	+8	+8
A x S & reciprocal	156	87	85	84	83
Average of A & S	297	88	84	83	82
Difference		−1	+1	+1	+1

After adjusting age at puberty for the effects of average preweaning and postweaning daily gains, about half to three-fourths of the heterosis effect on age at puberty (days) remained. Thus, there was a heterosis effect on age at puberty independent of its effects through average daily gains.

(continued on next page)

Table 9. Heterosis effects on age and weight at first heat.

	1960 and 1961 calf crops[a]					1962 and 1963 calf crops[a]			
	No.	Age at 1st heat days	Wt. at 1st heat lbs.	Age at 1st heat adj. for A.D.G. birth to weaning days	Age at 1st heat adj. for A.D.G. birth to 396 days days	No.	Age at 1st heat days	Wt. at 1st heat lbs.	Age at 1st heat adj. for A.D.G. birth to weaning days
Crossbreds	97	382	528	386	392	95	321	580	324
Straightbreds	85	422	534	417	412	76	356	587	351
Difference		—40	−6	−31	−20		−35	−7	−27
H x A & reciprocal	33	398	554	404	408	28	361	630	364
Average of H & A	55	427	552	422	421	51	375	613	372
Difference		−29	+2	−18	−13		−14	17	−8
H x S & reciprocal	31	382	526	384	392	36	300	559	303
Average of H & S	56	436	544	428	419	51	366	604	359
Difference		−54	−18	−44	−27		−66	−45	−56
A x S & reciprocal	34	366	504	369	376	31	303	551	305
Average of A & S	59	405	504	400	397	50	328	544	322
Difference		−39	0	−31	−21		−25	7	−17

[a] Heifers from 1960 and 1961 calf crop were developed for calving as threes, while heifers from 1962 and 1963 were developed for two-year-old calving.

Table 10. Heterosis effects on fertility (preliminary).

	No. matings	Calving to first heat days	Settled on first service %	Pregnant %	Calves born %	Calves weaned %
1962—to calve as 3 year olds.						
Crossbreds	30		64	94	92	89
Straightbreds	30		56	89	78	72
Difference			+8	+5	+14	+17
1963—to calve as 2, 3 and 4 year olds.						
Crossbreds	131	56	59	84	79	75
Straightbreds	109	59	44	81	73	69
Difference		—3	+15	+3	+6	+6
1964—to calve as 2, 3, 4 and 5 year olds.						
Crossbreds	139	68.9	72	97	90	76
Straightbreds	116	69.4	63	90	80	66
Difference		—.5	+9	+7	+10	+10
1965—to calve as 3, 4, 5, and 6 year olds.						
Crossbreds	133	55.6	60.2	86.5	85	80
Straightbreds	108	59.6	51.9	92.6	87	83
Difference		—4.0	+8.3	—6.1	—2	—3
1966—to calve as 4, 5, 6 and 7 year olds.						
Crossbreds	130	47.6	55.4	93.1		
Straightbreds	106	52.9	54.7	86.8		
Difference		—5.3	+.7	+6.3		

The advantage of the crossbred steers in feed efficiency was small. The crossbred steers produced slightly fatter carcasses when killed at the same age.

However, when adjustments were made for the effects of weight there was no difference in carcass composition. Thus, if they had been slaughtered at the same weight, the composition of the carcasses would have been the same.

In net merit (value of the boneless, closely trimmed retail meat, adjusted for quality grade, minus feed costs from weaning to slaughter) the advantage of the crossbred steers over the straightbred steers was $8.81 per carcass. This net merit difference is among the steers that lived to slaughter. The three percent advantage for the crossbreds in calf crop weaned was not involved in computing this difference.

For growth, feed efficiency and carcass traits the heterosis effect was greater in the Hereford-Angus and Hereford-Shorthorn combinations than for the Angus-Shorthorn combination, while for age and weight at puberty the heterosis effect was greatest for the Hereford x Shorthorn and reciprocal cross. In evaluating all traits for the effects of heterosis, it can be concluded that heterosis results in an increased rate of maturity.

Second Phase

The second phase of this experiment is now in progress.

This involves the evaluation of the effects of hybrid vigor on fertility and mothering ability. Straightbred cows of the three breeds are being compared with their crossbred calf sisters when both are bred to the same bulls.

For the four years (1963, 1964, 1965 and 1966) on which data have been collected, the advantage of the crossbred cows has been 17, 6, 10 and -3 percent, respectively, for calf crop weaned and 17, 31, 20 and 22 lbs. respectively, in average weaning weight of calves at 200 days.

Table 10 provides a summary of results of heterosis effects on fertility traits through the 1966 breeding season and Table 7 provides information on the preweaning performance of calves out of both crossbred and straightbred cows through the 1966 calf crop. The results of heterosis effects on cow performance traits (fertility and mothering ability) should be regarded as preliminary because data are still being collected from this phase of the experiment.

Experimental animals.

Urea and Corn Silage

By Walter Tolman[1] and Walter Woods[2]

Urea is an effective source of protein in cattle fattening rations when carefully mixed into rations adequate in energy, minerals and vitamins. The level of energy in the ration is important in urea utilization.

The use of urea to supply all the supplemental protein for a corn silage ration fed to calves did not support the performance obtained from soybean meal or combinations of soybean meal and urea. The optimum level of urea for a high corn silage ration was indicated to be about ⅓ of the supplemental protein needed in the ration.

The value of urea as part, or all, of the supplemental protein to a corn silage ration was studied in two trials with calves. Soybean meal was compared to urea. All rations were supplemented equally with vitamin A and minerals. Finely ground corn was used as a carrier for the urea supplements to equalize energy levels with the soybean meal supplement. The supplements were sprinkled over the silage and hand mixed into it. These rations were full fed once daily.

Extra Comparison Made

Two lots of 10 or 11 Hereford steer calves were fed each ration in each trial; the trials were re-

[1] Department of Animal Science, Northeast Station.

[2] Department of Animal Science, University of Nebraska.

(continued on next page)

Urea, Silage

(continued from page 7)

peated in two years. The lengths of the tests were 89 days and 154 days. In the first test there was an additional ration with a supplement of three protein sources: soybean meal, urea and corn gluten meal.

In the second test an extra comparison was made by adding elemental sulfur to another ration supplemented with urea to see if this could be limiting performance on the high level of urea.

It was planned that soybean meal would furnish all the protein in the basic supplement; soybean meal ⅔ and urea ⅓ in the second; soybean meal ⅓ and urea ⅔ in another; and all the supplemental nitrogen (protein) in the other.

In the extra treatment of the first year three protein sources (soybean meal, corn gluten and urea) furnished about equal amounts of supplemental protein. The extra supplement the second year was the all-urea supplement plus sulfur. The composition of each supplement is shown in Table 1.

The results of the first and second trials are given in Table 2 and 3 respectively.

Table 4 gives a summary of performance as compared to the performance on the soybean meal basal ration. In general, there was a trend for rate of gain to decline slightly and feed required per unit gain to increase slightly as the level of urea in the supplement increased.

Not as Primary Source

It appears that urea should not be used as the primary source of nitrogen for supplementing corn silage. Based on these results up to ⅓, possibly ⅔, of the supplemental protein could be used.

If the cost of a supplement that supplied from ⅓ to ⅔ of the supplemental protein from urea was sufficiently decreased so that it more than offset the approximately 6% increase in the amount of silage required then it could be economically used to an advantage. The rest of the protein in the supplement should come from other natural protein sources.

Management factors influence urea usage and it is possible the results would have been altered if the concentration of urea in the supplement was changed, if there was more adequate mixing of the supplement in the ration or if the supplement or ration was fed twice daily.

Since it is a common practice to add some corn to a silage ration this practice would probably modify the results.

Further work is planned to find the optimum levels of urea in various feeding and management programs.

Table 1. Composition of supplements.

	Supplemental protein supplied by					
	SBM [a] 3/3 %	SBM 2/3 Urea 1/3 %	SBM 1/3 Urea 2/3 %	Urea 3/3 %	SBM1/3 Urea 1/3 CGM 1/3 %	Urea 3/3 plus Sulfur %
Soybean meal	94.60	62.80	28.20		31.45	
Ground corn		26.50	55.50	78.05	34.60	77.65
Urea (feed grade)		4.75	9.50	14.40	4.20	14.40
Prime gluten meal					23.55	
Dicalcium phosphate	4.00	4.55	4.95	5.00	4.65	5.00
Monosodium phosphate			0.45	1.15	0.15	1.15
Trace mineral premix	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin A (30,000 IU/gm)	0.15	0.15	0.15	0.15	0.15	0.15
Salt	1.00	1.00	1.00	1.00	1.00	1.00
Elemental sulfur						0.40

[a] SBM refers to soybean meal and CGM refers to corn gluten meal.

Table 2. Urea supplementation of corn silage for calves.

	Supplemental protein supplied by				
	SBM 3/3	SBM 2/3 Urea 1/3	SBM 1/3 Urea 2/3	Urea 3/3	SBM 1/3 Urea 1/3 CBM 1/3
No. head	20	20	20	20	20
Initial wt. lb.	518	512	521	521	526
Daily gain, lb.	1.58	1.50	1.52	1.44	1.62
Daily consumption feed, lb.					
Silage	43.10	43.40	43.10	42.80	43.40
Supplement	1.25	1.25	1.25	1.25	1.25
Feed per cwt. gain, lb.					
Silage	2734	2894	2850	2894	2683
Supplement	80	84	82	87	78

Table 3. Urea supplementation of corn silage for calves.

	Supplemental protein supplied by				
	SBM 3/3	SBM 2/3 Urea 1/3	SBM 1/3 Urea 2/3	Urea 3/3	Urea 3/3 plus Sulfur
No. head	22	22	22	22	22
Av. Initial wt., lb.	436	444	438	442	440
Av. Daily gain, lb.	1.78	1.68	1.60	1.59	1.56
Daily feed consumption, lb.					
Silage	31.60	31.60	31.00	31.20	31.20
Supplement	1.25	1.25	1.25	1.25	1.25
Feed/cwt. gain, lb.					
Silage	1773	1884	1938	1954	2011
Supplement	68	73	76	77	79

Table 4. Percentage change in performance of cattle fed corn silage supplemented with various levels of urea.

	Percentage of change from all soybean meal supplemented rations.		
	2/3 SBM 1/3 Urea	1/3 SBM 2/3 Urea	O SBM 3/3 Urea
Daily rate of gain	− 5.4	− 7.1	−10.1
Silage required/100 lb. gain	+ 6.0	+ 6.3	+ 9.6

Functions in Beef Cattle Feeding

By Walter Woods,[1] Harry La-Toush,[1] Roger Voss[1] and Walter Tolman[2]

The interests in feeding higher grain rations or seeking substitutes for roughage should not be surprising when one considers the happenings taking place in the beef cattle feeding industry. Some of the changes are:

1. Increased mechanization is occurring in feedlots and the ability to handle roughage economically may not be compatible in the program.
2. Roughage does not have the movement through trade channels that grain enjoys. Thus, the concentration of cattle in larger feeding programs has created problems in procurement of roughage.
3. Grain may decrease the cost of energy for finishing cattle as compared to roughage. Certainly, in any feeding situation the relative cost of obtaining energy from roughage or grain must be a prime factor in buying either of the two.

Reduce Roughage Level

Research work has suggested more economical gains may result when the roughage level in high concentrate rations is reduced to a minimum but not below the level to cause increased difficulty with management of the cattle. The substitution of oyster shell for all or part of the roughage in the ration has indicated more efficient gain but in some cases gains have been reduced. The supplemental program for a ration containing oyster shell appears critical. However, phosphorus levels higher than .3% did not show consistant benefits.

Roughage furnishes protein, calcium, phosphorus, trace minerals and vitamins to high grain rations. Thus, one of the reasons we add roughage to the finishing ration is to take advantage of the nutrients that the roughage contains. Roughages vary in their composition and this aspect is well understood. In beef cattle feeding, you should take advantage of the nutrients supplied by the roughage in the ration.

Energy was not indicated as one of the primary factors for adding roughage to high grain rations. Under conditions of high amounts of readily fermentable carbohydrates, the digestiblity of the cellulose contained in roughage is depressed. Efficiency of feed conversion data on high concentrate rations suggest that roughages are not efficiently utilized as energy sources under these conditions. Data from the Northeast Station are shown in Table 1.

The feeding of 3 pounds of roughage (hay) per day to steers presented a more efficient ration than 5 pounds of hay. It took about 40 days to produce 100 pounds of grain in the study. Those steers fed the extra 2 pounds of hay would have consumed 80 more pounds of hay during this period. The amount of hay required per 100 pounds of gain was 77 pounds more for the higher hay fed group as compared to lower fed group.

Other data on addition of alfalfa hay to ground ear corn ration suggest a similar picture. These data are shown in Table 2.

Adding 2 pounds of alfalfa hay to the ration resulted in an increased feed requirement per 100 pounds of gain. In this particular study no attempt was made to take advantage of nutrients contained in the alfalfa hay to permit modification of the supplement. This indicates that the energy obtained from roughage is reduced when fed in combination with high amounts of grain as compared to high roughage rations. The comparison is not between high roughage and high grain rations but what is the relative efficiency of utilization of the roughage in a high grain ration.

Roughage supplies feed and livestock management factors to high grain rations. There is less trouble with digestive upsets, founder, bloat, etc., with adequate roughage levels in the ration as compared to rations with little or no roughage.

(continued on next page)

Table 1. Effect of roughage level in a fattening ration for beef cattle.

	Amount of hay fed	
	3 pounds	5 pounds
No. steers	71	72
Initial weight, lb.	516	523
Daily gain, lb.	2.49	2.53
Daily ration, lb.		
Ground shelled corn	15.3	15.3
Hay	3.0	5.0
Supplement	0.25	0.25
Feed/cwt. gain, lb.		
Concentrate	624	615
Hay	120	197
Total	744	812
Dressing percent[a]	57.7	57.9
Carcass grade[b]	15.6	15.7
Condemned livers	14	3

[a] Dressing percent as based on weight off experiment and hot carcass weight shrunk 2½%.
[b] Federal carcass grade score: 15 = high good, 16 = low choice.

[1] Department of Animal Science, University of Nebraska.
[2] Department of Animal Science, Northeast Station.

Roughages

(continued from page 9)

Research data to document this statement may be difficult to find, yet, research and practical feeding observations have found this to be true. Research at Beltsville, North Carolina, and Texas Tech, to mention a few stations, has indicated that all concentrate rations can be fed. Without reviewing each trial in detail several of these studies have experienced little difficulty in managing cattle on these types of rations. However, others have reported some of the items mentioned earlier.

Important Problems

In feeding all concentrate or minimum roughage rations the following appear to be important problems.

1. Difficulty may be encountered in starting cattle on feed or at the time the roughage is removed from the ration.
2. Abscessed livers and rumen disorders may be increased with the feeding of higher levels of concentrates.
3. Protein, mineral, and vitamin supplementation may become critical since roughage supplies considerable quantities in certain rations.
4. Increased managerial ability may be required.

It appears that roughage needs to be included in the average feeding situation to avoid many of the problems in livestock management. The primary effects of the lack of roughage appears to be those observed effects on digestive disturbances. The following points appear worthy of mentioning:

1. The way roughage is processed influences its value as a roughage source.
2. When hay is offered separate from grain a higher level of roughage is required to manage cattle compared to feeding mixed rations.
3. The size of the enterprise or number of head in a lot becomes a factor. It appears to be easier to manage cattle on a minimum roughage situation in small groups than in larger groups and where larger numbers of groups are fed.

Sources of Roughage

Many sources of roughage have been shown to be effective in supplying the physical needs to the ration.

Table 2. Influence of alfalfa additions to a corn-corn cob ration.

	Corn—corn cobs and supplement		
	O	+ 2 lb. hay	+ Hay free choice
Daily gain, lb.	3.33	3.44	3.43
Daily ration, lb.			
Corn	18.1	19.1	18.8
Ground cobs	3.9	3.9	3.9
Alfalfa hay	0.1	2.0	2.6
Supplement	2.0	2.0	2.0
Total	24.1	27.0	27.3
Feed required per 100 pounds of gain, lb.			
Corn	543	558	545
Ground cobs	117	113	114
Supplement	59	57	58
Alfalfa hay	4	57	78

Table 3. Performance of cattle fed oyster shell.[a]

	Control 20% roughage	Oyster Shell 2½%
No. head	19	19
Initial weight, lb.	824	822
Daily gain, lb.	2.88	2.51
Adjusted daily gain, lb.[b]	2.78	2.62
Daily feed consumed, lb. [c]		
Concentrate	19.5	18.2
Oyster shell	....	0.5
Corn cobs	4.8	....
Alfalfa hay[c]	0.3	0.3
Total	24.6	19.0
Feed required/cwt. adjusted grain, lb.		
Concentrate	700	698
Corn cobs	175	......
Oyster shell	......	18
Alfalfa hay	10	10
Total	886	726
Carcass grade score[d]	16.4	15.9
Dressing percent[e]	58.7	59.9
Cold carcass weight, lb.	652	640
No. livers condemned	5	8

[a] Trial length was 99 days.
[b] Gains adjusted to equal dressing percent.
[d] Carcass grade score: 15 = average good, 16 = high good.
[c] Alfalfa hay fed first 8 days in starting cattle on feed.
[e] Dressing percent based on weight off experiment and hot carcass weight shrunk 2½%.

Oyster shell has been evaluated as a roughage substitute in high grain rations to see if a material such as this could supply "roughage" to the ration.

Initial results are shown in Table 3. A reduced rate of gain as compared to a conventional feeding program was found, however, adjusting to an equal yield basis made the gains appear more favorable. The amount of feed required per 100 pounds of grain was improved on the oyster shell ration and this action appeared to be through the reduction in the amount of roughage required.

The performance of steers fed different levels of roughage (½ alfalfa and ½ cobs), oyster shell and a combination of roughage and oyster shell for 154 days is given in Table 4. The daily gain was superior for steers fed the 15% roughage ration as compared to those fed oyster shell. Adding 2½ or 3½% hen size oyster shell to the ration did not alter the performance. Rations containing 5% roughage or 5% roughage plus 2½% oyster shell gained slightly less than those fed 15% roughage.

Difficulty was encountered in getting as much concentrate into the cattle fed the lower level of roughage as on the higher level of roughage. However, in each case total feed required per 100 pounds of gain was in favor of the lower levels of roughage or oyster shell as compared to the 15% roughage rations. The ration containing 5% roughage was most efficient. However, it supported the highest evidence of liver condemnation.

The possibility that phosphorus could be limiting in oyster shell ration was investigated in a 168 day individual feeding trial. The results (Table 5) from feeding rations containing .28, .38, or .48% of phosphorus did not vary significantly. Slightly reduced rates of gain were experienced in this study but more efficient feed conversion was encountered for the cattle fed oyster shell rations as compared to the control ration.

Additional data are needed to answer questions concerning the use of oyster shell in beef cattle rations. Oyster shell has been considered in our research program as a possible substitute in high grain rations. The possible practice of adding oyster shell to rations already containing adequate levels of roughage does not appear to have merit at the present time.

The research to determine if oyster shells could serve as a roughage substitute and supply in part the livestock and feed management factors was initiated because of the difficulty in handling roughage and the expense associated with it in certain feeding programs.

Table 5. Influence of phosphorus level in oyster shell rations.[a]

	Control 20% Roughage	Oyster Shell		
		.28% P	.38% P	.48% P
No. steers	6	6	6	5
Initial weight, lb.	655	656	650	654
Daily gain, lb.	2.57	2.44	2.32	2.50
Adjusted daily gain, lb.[b]	2.65	2.40	2.27	2.48
Feed intake, lb.	21.6	16.7	16.4	17.4
Total feed/100 lb. gain, lb.	869	691	715	706
Concentrate	695	673	697	689
Roughage	174	......	......	......
Shell	......	17	18	18
Carcass grade[c]	6.7	5.7	6	6.2
Dressing percent[d]	60.3	59.2	59.0	59.2

[a] Length of trial 168 days.
[b] Cattle adjusted to an equal dressing and gains calculated on adjusted final weight.
[c] Federal carcass grade assigned: 5 = average good, 6 = high good and 7 = low choice.
[d] Based on weight off experiment and hot carcass weight shrunk 2½%.

Oyster shell can be fed; however, the specific value has not been worked out at the present time. Since oyster shells are being used at the present time by feeders, the following are suggestions concerning its use. As more information becomes available, these suggestions will no doubt require modification and changes. These suggestions are made as a guide if oyster shell is fed to cattle but it is emphasized there is a need for more information to answer the many questions about its use.

Oyster Shell Guide

1. Utilize 1 pound hay or hay equivalent in high grain fattening rations where oyster shell is being fed.

2. The oyster shell should probably be fed at the rate of ½ pound per animal per day.

3. High grain rations may require considerable added calcium to balance them. It has been a practice to include the calcium in the ration through a protein supplement, a mineral supplement, or both. Some data have indicated that possibly calcium levels could become excessive if both a high level of shell and other sources of supplemental calcium are used. The calcium contained in the ½ pound oyster shell appears to be sufficient to meet the needs of the animal. Studies measuring the digestibility of calcium in oyster shell suggest it is in excess of 50%.

4. Particular attention should be given to trace mineral and vitamin supplementation. This would be true in high grain rations regardless of whether shell is fed. Roughage in high grain rations supply most of the mineral and vitamins with the exception of phosphorus.

5. The level of phosphorus in the complete ration is suggested at approximately .3%. Preliminary results suggest that a higher level of phosphorus is not beneficial to animal performance in oyster shell rations.

6. Protein supplement must be adequate to balance the ration. Where programs were previously based on alfalfa hay, attention should be given to including sufficient supplemental protein.

It would appear that additional work is needed to determine the role oyster shell will play in the feeding of beef cattle. However, the previous suggestions are made to aid in the use of oyster shell where it is being fed.

Table 4. Performance of steers fed oyster shell.

	15% Roughage	5% Roughage	5% Roughage + 2½% O.S.	2½% O.S.	3½% O.S.	2½% O.S. + 5% Dehy
No. of animals	12	12	12	12	12	12
Initial wt., lb.	595	609	615	590	594	584
Daily gain, lb.	3.23	3.10	2.93	2.65	2.68	2.84
Adjusted daily gain, No.	3.21	3.12	2.97	2.69	2.65	2.82
Feed consumption, lb.						
Ration	23.88	20.96	20.82	18.09	18.51	19.85
Hay[b]	.13	.13	.13	.13	.13	.13
Total	24.01	21.09	20.95	18.22	18.64	19.98
Feed/cwt. gain	744	677	715	689	698	704
Dressing percent[c]	58.49	58.82	58.93	58.96	58.28	58.38
Carcass grade[d]	6.2	6.5	5.6	5.7	5.5	5.9
No. livers condemned	4	5	0	3	3	1

[a] Adjusted to an equal yield basis.
[b] Alfalfa hay was fed in starting the cattle on feed.
[c] Based on weights off and of experiment and hot carcass weight shrunk 2½%.
[d] Carcass grade score 6 = high good, 5 = average good.

Nutritive Value of Native Range Forage

By C. L. Streeter,[1] O. E. Hoehne[1]
and D. C. Clanton[2]

During the summer of 1964 and 1965 eleven digestion trials were conducted with grazing esophageal fistulated cattle at the Scotts Bluff Station. Nutritive value was estimated from measurements of digestibility and total forage consumption.

A pasture rotation scheme was used in which the animals were moved to a previously ungrazed area every three days. In such a scheme the animals could consume only plants which were increasing in maturity rather than consuming regrowth material. However, advance in season was confounded with trial location as there was no trial replication.

During each six-day digestion trial dietary samples were collected via esophageal fistulae and chemically analyzed to determine the nutrient content of the diet. They were also used to determine the botanical composition of the diet.

Digestibility

The digestible energy content of the forage consumed in 1964 decreased during June and thereafter gradually increased until the end of the study in early September (Figure 1).

In early June the steers consumed primarily needleandthread grass (*Stipa comata*) but changed to prairie sandreed grass (*Calamovilfa longifolia*) in late June (Figure 2). Thereafter, prairie sandreed was the major species in the diet until late July when it was replaced by blue grama grass (*Bouteloua gracilis*).

The drop in energy digestibility in early June was attributed to the decrease in the digestibility of the needleandthread grass consumed during this time.

The continual replacement of a species of lower digestibility with a species of higher digestibility resulted in a slight increase in energy digestibility from late June to early September.

The protein content of the forage consumed in 1964 decreased until early August when it increased slightly (Figure 3). The decrease in the protein content of the diet during June and July was attributed to the decrease in the protein content of all species of forage consumed during that period. The slight increase in the protein content of the diet in August was attributed to the consumption of relatively large quantities of blue grama grass which contained more protein than needleandthread and prairie sandreed grass which had been the main constituents in the diet during June and July.

In 1965, energy digestibility was depressed more by plant maturation than in 1964, especially in the month of July (Figure 1). The large quantity of precipitation that fell in 1965 following the relatively small amount falling in 1964 resulted in a more vigorous growth of vegetation during the latter year (Figure 4).

The available herbage contained a greater quantity of forbes in 1965 than in 1964. The rapid drop in energy digestibility in July can be associated with the consumption of the forb, lambsquarters (*Chenapodium pratericola*), (Figure 5).

The lambsquarters began to set seed in early July and by the last of the month most plants of this species bore large quantities of seed

[1] Former graduate students in Department of Animal Science, University of Nebraska.

[2] Professor of Animal Science, North Platte Station.

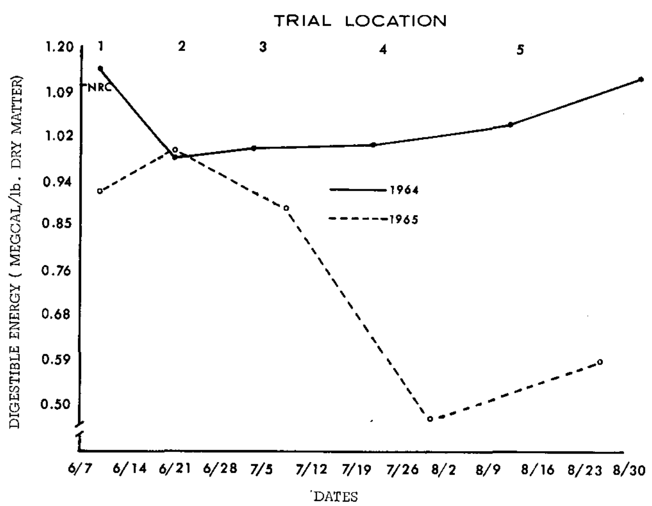


Figure 1. Influence of advance in season and trial location on digestible energy. (NRC is National Research Council's recommended nutrient allowance for the "normal" growth of 600 lb. yearling cattle to gain an average of 1.4 lb. per day).

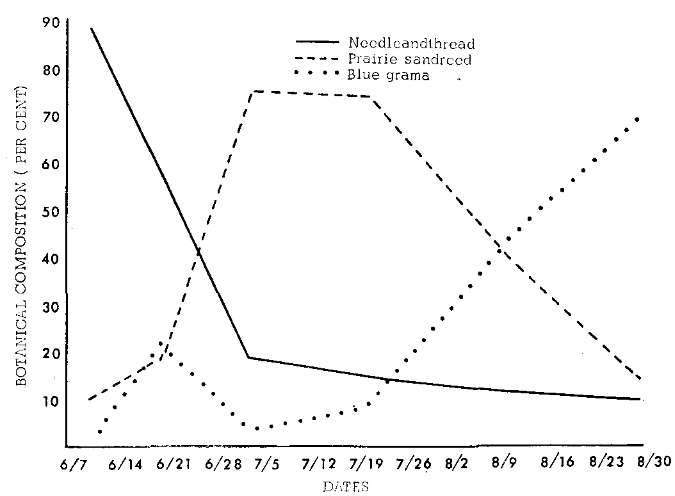


Figure 2. Influence of advance in season and trial location on botanical composition of forage consumed in 1964.

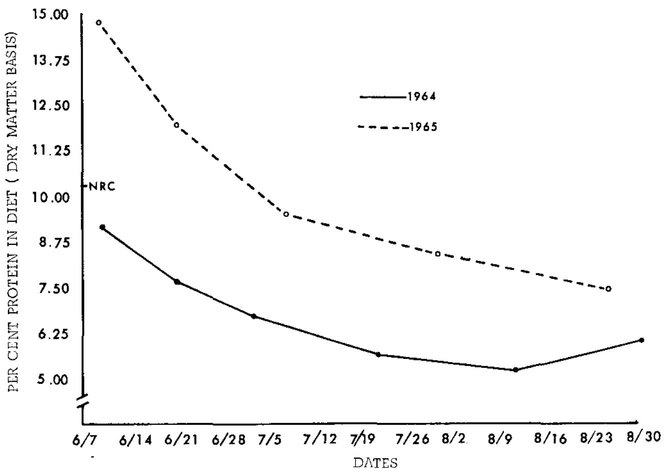


Figure 3. Influence of advance in season and trial location on protein content of diet. (NRC is National Research Council's recommended nutrient allowances for the "normal" growth of 600 lb. yearling cattle to gain an average of 1.4 lb. per day).

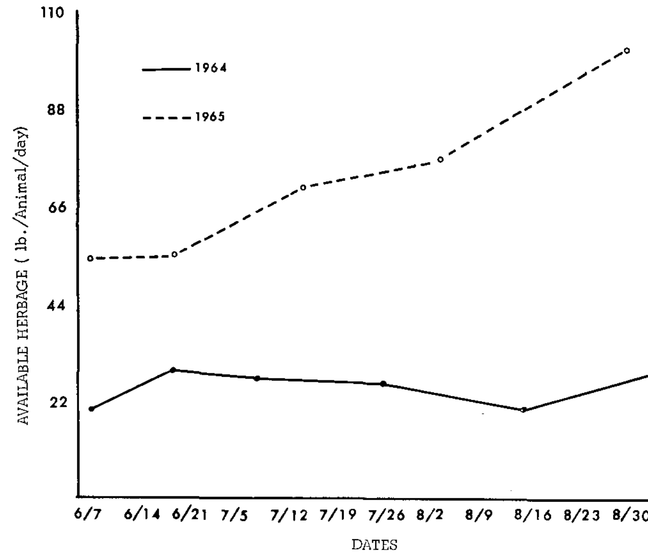


Figure 4. Influence of advance in season and trial location of herbage available per animal per day.

which apparently possessed a highly lignified seed coat. Many of the seeds were observed in the dietary samples collected during this period. This resulted in an increased lignin content of the diet and a decreased energy digestibility.

The digestible energy content of the forage consumed in 1965 increased slightly in the month of August. During this time more prairie sandreed grass was consumed than lambsquarters.

The protein content of the diet decreased more rapidly in 1965 than in 1964 (Figure 3). This was attributed to a more rapid decrease in the protein content of the individual forage species which were consumed in 1965 as compared to 1964.

Unlike energy digestibility, the protein content was higher in 1965 than in 1964. This indicates that the protein and energy content of range forage are not influenced similarly by changes in environmental conditions.

Total Forage Consumption

In 1964 no large change in the total forage consumption of the grazing animals was found during the month of June. However, a steady increase was noted from early July to early September (Figure 6).

Information concerning the mechanism controlling total forage consumption in limiting both dry matter content and dry matter digestibility have been shown to be positively correlated with total forage consumption. The increased forage consumption from July through August was attributed to the increased dry matter content of the forage during that period (Figure 7).

Little change occurred in the total forage consumption of the grazing animals in 1965. The dry matter content of the diet and dry matter digestibility remained relatively unchanged up to early July (Figure 7). After this time the effect of the increase in the dry matter content of the diet on forage consumption was canceled by a decrease in dry matter digestibility.

The fact that total forage consumption was lower throughout the

(continued on next page)

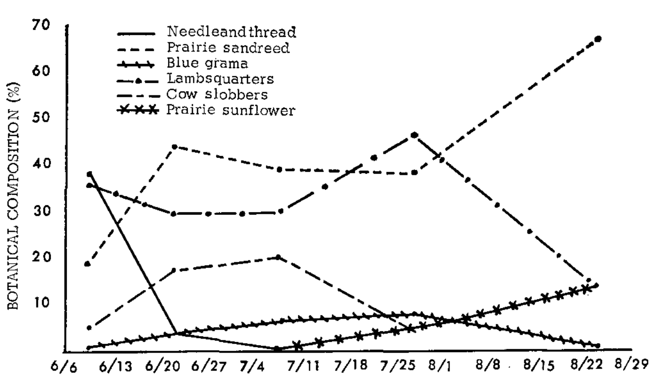


Figure 5. Influence of advance in season and trial location on botanical composition of forage consumed in 1965.

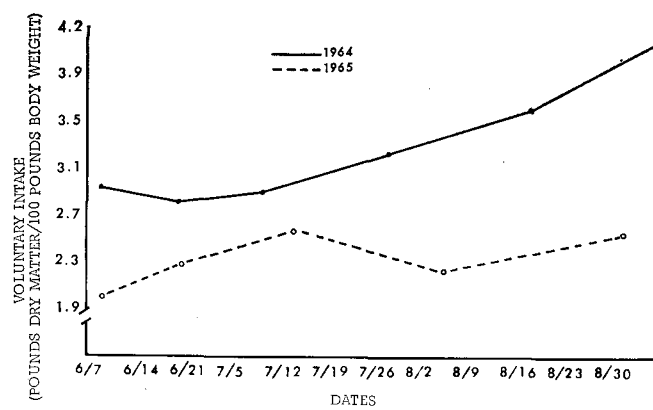


Figure 6. Influence of advance in season and trial location on voluntary intake (excretion to indigestibility method).

Forage Value

(continued from page 13)

1965 grazing season than in 1964 was attributed to the lower dry matter content and dry matter digestibility of the forage that was consumed in 1965.

Summary

Energy digestibility was higher with less seasonal variation in 1964 (the year in which there was less precipitation) than in 1965. A sharp decrease in energy digestibility was noted in the latter part of the season in which there was more rainfall and an abundance of forbes in the diet.

The protein content of the diet was higher in the year in which there was more precipitation and an abundance of forbes. A decrease in dietary protein occurred with the advance in season during both years. Total forage consumption increased somewhat with the advance in season and was greater during the year in which precipitation was less and grass constituted nearly all of the diet.

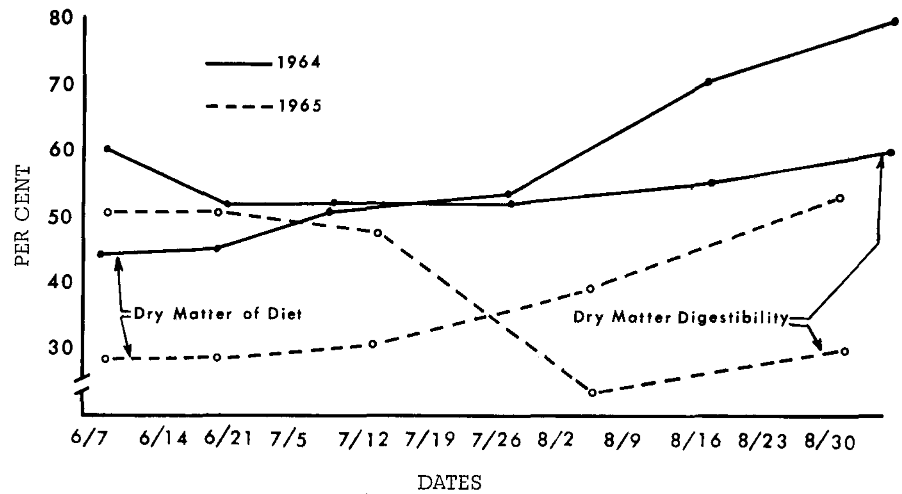


Figure 7. Influence of advance in season and trial location on per cent dry matter of diet and dry matter digestibility.

Protein and Energy Supplementation For Young Cows

By C. W. Kasson,[1] D. R. Zimmerman,[2] J. A. Rothlisberger,[1] D. C. Clanton,[3] J. E. Ingalls,[4] L. D. Baumann[1] and D. L. Hall[1]

United States Department of Agriculture and University of Nebraska[5]

This report represents the findings of a study conducted at the Fort Robinson Beef Cattle Research Station on the effect of type of supplement provided on native range or in dry lot before and after calving on the performance of two-year-old first-calf heifers. The design of the experiment is shown in Figure 1.

One hundred pregnant two-year-old Hereford heifers were divided into four groups of 23 head each and placed on native range (December 1, 1965). Two groups were supplemented with 1 lb. of 40% protein (soybean oil meal pellet) per head daily and two groups received 4 lb. of a 10% protein (sorghum grain pellet) supplement daily in addition to native winter range.

Figure 1. Experimental design.

Pre-Calving Suppl.	Post-Calving Suppl.
1 lb. 40% protein[a]	1 lb. 40% protein 4 lb. 10% protein
4 lb. 10% protein[a]	4 lb. 10% protein 1 lb. 40% protein

[a] One-half of the cows on each pre-calving supplement were switched to the other supplement after calving.

Total protein provided by these supplements was the same, but the energy or TDN (total digestible nutrients) supplied was different. The remaining eight heifers were put in dry lot and supplemented with 1 lb. of 40% protein daily in addition to sufficient grass hay to match the weight gains of the heifers receiving a like supplement and native range.

The heifers were weighed at 2-week intervals during the pre-calving period. The daily hay allotment for the heifers in dry lot was adjusted at two- or four-week

[1] Dept. of Animal Science, University of Nebr., Fort Robinson Beef Cattle Research Station, Crawford, Nebraska.

[2] Dept. of Animal Science, University of Nebr., Lincoln, Nebr.

[3] Dept. of Animal Science, University of Nebr., North Platte Station.

[4] Animal Husbandry Research Division, Agricultural Research Service. U.S. Meat Animal Research Station, Clay Center, Nebr.

[5] The authors wish to acknowledge and express their appreciation for the assistance of Robert DeGunia, Ronald Butler and Gene White in making the daily observations and supplementations in this experiment.

Table 1. Effect of pre-calving supplements.

Pre-calving supplement	1 lb. 40% protein	4 lb. 10% protein
No. of heifers	45	40
Initial weight (lb.)	690	682
Av. daily hay intake (lb.)[a]	13.5	13.2
Av. daily gain (lb.)	0.29	0.39
Interval calving to first heat (days)	91	86
Interval calving to conception (days)	96	94
Not cycling during breeding season (%)	35	49
Pregnancy rate (%)	53	65
Not cycling during breeding season (%)	24	13
Calving difficulty (%)	31	27[b]

[a] Heifers were fed hay for 39 days during the time that snow cover prevented their grazing.
[b] Includes two calves with backward presentations.

intervals. Grass hay was fed to the range heifers for a 39-day period when snow cover prevented grazing. The heifers were on native winter range a total of 112 days (12/1/65 - 3/23/66) before being taken to the calving area.

In the calving area, the heifers received grass hay plus their respective supplements. The heifers in dry lot were fed with the range heifers receiving 1 lb. of 40% protein supplement during this time. Each cow consumed about 12 lb. of grass hay daily in addition to her supplement during this period.

At calving the cows were switched to their post-calving supplement (no change was required for half of the cows). The cows and calves were removed from the calving area within a week of calving (normally 2 or 3 days) and were fed grass hay at about 16 lb. per head per day.

However, enough green grass became available in mid April in the river trap areas where they were confined that the cows would not eat their supplement. As a consequence, they were put in dry lot April 26 and were fed twice daily as much grass hay as they would eat without waste.

Each cow remained in the dry lot and received her post-calving supplement until 50 days after calving. Cows that were 50 days post-calving were taken out of the dry lots and moved to small pasture areas along the river. Cows were maintained on pasture without supplement after being taken out of the dry lot. Cows that lost calves were taken off the experiment.

Heat checks were made daily with sterilized bulls equipped with marking harnesses. Four proven fertile bulls equipped with marking harnesses were placed with the cows on pasture June 15 and the breeding dates were recorded daily. Pregnancy was determined by rectal palpation at 2-week intervals beginning 40 days after the start of the breeding season. The length of the breeding season was 70 days.

Results

The group of heifers in dry lot outgained the group of similarly supplemented heifers on native range. Over the entire pre-calving period they gained an average of 0.2 lb. more per head daily than the similarly supplemented range heifers. Efforts to adjust hay intake were apparently offset by variations in the quantity and/or quality of available forage on range.

Average daily hay consumption for the dry lot heifers was 14.0 lb. This amount of average quality grass hay apparently provided considerably more energy than the range heifers were able to obtain from the range grasses. Range condition was judged good to excellent in the winter pastures used and the heifers did not appear to suffer from lack of feed at any time.

During the pre-calving supplemental period on native range the heifers receiving 4 lb. of 10% protein supplement gained 0.1 lb. more per head per day than the heifers on 1 lb. of 40% protein (Table 1). They did this while apparently eating less forage. During the 39-day period when snow cover required that hay be fed, the group of heifers receiving 4 lb. of 10% protein consumed an average of 0.3 lb. less hay daily than the heifers fed 1 lb. of 40% protein supplement.

The effects of the different pre-calving supplements on heifer weight gains and post-calving performance are shown in Table 1. It is worth noting that the heifers receiving the energy supplement (4 lb. of 10% protein) showed estrus 5 days sooner, had a higher conception rate at first service (14%), a higher rate of pregnancy (12%), and fewer cows that failed to cycle during the breeding season (13%).

The effects of the different post-calving supplements on cow weight gains and reproductive performance are shown in Table 2. Cows receiving the energy supplement again out performed those receiving the protein-type supplement even though half of their number came from the lower performing pre-calving supplemental group.

The cows receiving the energy supplement gained more rapidly (.42 lb. per day), showed estrus sooner (5 days), became pregnant

(continued on next page)

Table 2. Effect of post-calving supplements.

Post-calving supplement	1 lb. 40% protein	4 lb. 10% protein
No. of cows	41	44
Av. daily hay intake (lb.)[a]	16.2	15.6
Av. daily gain (lb.)[b]	0.19	0.61
Interval calving to first heat (days)	91	86
Interval calving to conception (days)	101	91
Conception at first service (%)	38	45
Pregnant (%)	44	73
Not cycling during breeding season (%)	29	9

[a] During the 50-day dry lot period after calving.
[b] A.D.G. from calving to the first week of the breeding season.

Protein Energy

(continued from page 15)

sooner (10 days) and had a higher conception rate at first service (7%), a higher pregnancy rate (29%) and fewer cows that failed to cycle during the breeding season (20%).

Fertility data and calf performance from cows in each of the four treatments are shown in Table 3. No differences in calf performance are traceable to supplements fed. The differences in cow weight gains were apparently not associated with a like increase in milk production.

The most dramatic effect of supplementation was shown in cow weight gains and fertility increases from post-calving energy supplementation. The difference in weight gains is traceable to the 50-day dry lot period in which the cows receiving the energy supplement gained an average of 42 lb. compared to 2 lb. for the group receiving the protein-type supplement.

This resulted even though an attempt was made to provide hay at a rate determined by appetite. The cows receiving the protein-type supplement consumed more hay during the dry lot interval (Table 2); however, this additional intake did not compensate for the three pounds additional supplement received by the other cows.

One factor which causes some concern in evaluating these data is that the breeding pastures were poor because of an extended drought period experienced in late spring and summer. This explains the overall low fertility of these cows and may be the cause of the long intervals from calving to first heat. The relationship of this factor to the specific treatment effects observed is not known but this problem should be recognized when comparing the results.

Conclusions

Results of this study emphasize the need of the young cow for an adequate supply of energy, especially after calving, if she is to reproduce successfully.

Native winter range plus 1 lb. of 40% protein supplement did not provide sufficient energy for young pregnant heifers.

The full feeding of grass hay and 1 lb. of 40% protein supplement the first 50 days post-calving and access to drought retarded summer range after 50 days post-calving did not provide sufficient energy to support good reproductive performance.

Post-calving reproductive performance was improved by providing additional energy to young pregnant heifers before and after calving. The level of performance, however, was not considered optimal in any of the experimental groups compared. This is probably a reflection of the poor condition of the summer range during the breeding season.

Table 3. Fertility data and calf performance.

Pre-calving supplement	1 lb. 40% protein	1 lb. 40% protein	4 lb. 10% protein	4 lb. 10% protein
Post-calving supplement	1 lb. 40% protein	4 lb. 10% protein	1 lb. 40% protein	4 lb. 10% protein
Fertility data:				
No. of cows and calves	22	23	19	21
Initial weight (lb.)	684	696	688	676
Interval calving to first heat (days)	97	86	85	87
Interval calving to conception (days)	103	91	99	91
Conception at first service (%)	36	35	40	55
Pregnant (%)	41	65	47	81
Not cycling during breeding season (%)	36	13	21	5
Calf performance:				
Date of birth (day of year)	103	103	105	104
Calf weight at birth (lb.)	60.5	59.8	63.8	61.5
Calf weight at 4 1/3 mo.—Aug. 23 (lb.)	178	183	184	179
Calf weight at weaning—Nov. 1 (lb.)	265	263	272	262

Influence of Pre

By R. K. Christenson,[1] D. R. Zimmerman,[1] D. C. Clanton,[2] R. L. Tribble,[3] L. E. Jones[3] and R. A. Sotomayor[3]

This report gives the first year's findings of a study on the influence of pre-calving energy intake on the post-calving reproductive performance of two-year-old first-calf heifers.

The work was done at the University of Nebraska in Lincoln.

A second year's work has begun. It is a replicate of the first year's work except identical twin beef heifers obtained from Nebraska and surrounding states are being used. This research project is supported by a grant from the Agriculture Research Service of the U.S.D.A. and Nebraska Agricultural Experiment Station funds.

The main objective of the research is to determine the cause of the delayed interval from calving to first heat in heifers fed a low level of energy before calving and to determine the pre-calving en-

[1] Department of Animal Science, University of Nebraska.

[2] Department of Animal Science, North Platte Station.

[3] Graduate Student, Department of Animal Science, University of Nebraska.

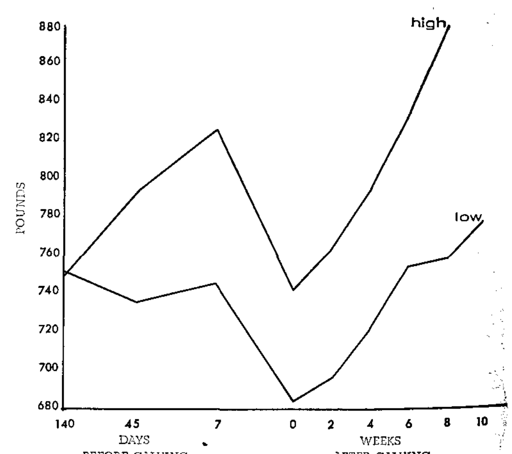


Figure 1. Pre-and post-calving weight changes.

Calving Energy Levels on Bred Heifer Reproduction

ergy requirement of the two-year-old bred heifer.

Energy Levels Vary

Seventy-four Hereford heifers were used in the experiment. Two pre-calving rations (Table 1) containing different levels of energy (high vs. low) were individually fed at a constant level during the 140-day pre-calving period. The level was based on the initial metabolic size of each heifer.

Heifers fed the high level of energy received 2.1 megacalories/100 lb. body weight/day (6.58 lb. of corn plus 4.27 lb. brome hay for a 676-700 lb. heifer). Heifers fed the low level of energy received 1.36 megacalories/100 lb. body weight/day (0.64 lb. soybean meal plus 9.32 lb. of brome hay for a 676-700 lb. heifer). The intake of protein and other nutrients was similar for two groups. All heifers were individually fed 3 lb. of corn and a full feed of alfalfa hay following calving.

Slaughter at Random

Six heifers were slaughtered at the beginning of the experimental period to establish pre-treatment body composition. Equal numbers of heifers from each ration treatment were then randomly selected for slaughter at six different slaughter times (45 days pre-calving, calving, 15, 30, 45 days post-calving and on day 10 of the second estrous cycle following calving).

Heifers fed the low energy ration maintained their weight during the last half of gestation while those fed the high energy ration gained about the weight of the calf they produced (low, -5 lb. vs. high, 78 lb., Figure 1).

Heifers fed the high energy ration produced heavier calves at birth (66.0 vs. 58.6 lb.) but experienced more calving difficulty than heifers fed the low energy ration (17.2 vs. 3.4% had difficult births). However, calving difficulty was not a severe problem with these heifers; 100% of the calves were born alive.

Calves Have Advantage

The weight advantage of the calves from the heifers fed the high energy ration increased with time after calving (Figure 2). This appears to be due to the greater milk production of their dams (Figure 3). Milk production tended to parallel the gains of the calves.

Heifers on both rations gained rapidly after calving, regaining their pre-calving weight in about 5½ weeks (Figure 1). However, heifers fed the high energy ration gained at a considerably faster rate after calving.

Alfalfa consumption increased sharply until about six weeks after calving when it leveled off. There was little difference in the average alfalfa consumption between the two groups (Figure 4).

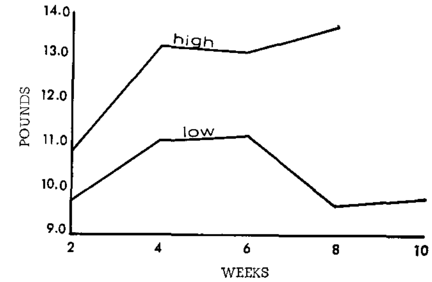


Figure 3. Post-calving milk production.

"Heat" Shown Sooner

As observed in previous studies, heifers fed the high energy ration exhibited estrus sooner after calving than did the low energy heifers (37.3 vs. 59.8 days).

The cause of the delay in the interval from calving to first heat and the changes in energy retention of the body produced by the feeding of different levels of energy before calving are being investigated. These studies are in progress and the results are not yet complete enough to include in this report.

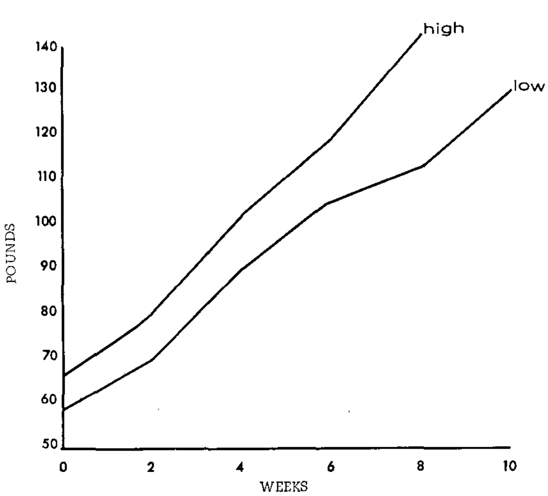


Figure 2. Two-week weight changes of calves.

Table 1. Daily ration allowance for 676-700 pound heifer.

Daily allowance Lb.	High	Low
Bromegrass hay	4.27	9.32
Corn	6.58	....
Soybean meal, 44%	.06	.64
Monosodium phosphate	.02	.04
Limestone	.07	....
Total Feed	11.0	10.0

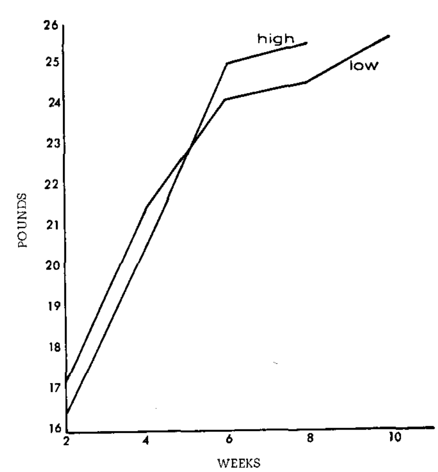


Figure 4. Post-calving alfalfa consumption.

Nutrient Preservation and Animal Performance

By Walter Woods,[1] Virgil McClatchey[2] and Lionel Harris[3]

Under study is the addition of additives to alfalfa or corn silage, using both miniature and concrete stave silos. Results of adding Bacillus subtilis and Aspergillus oryzae cultures singularly and in combinations indicated slight but non-significant increases in dry matter and protein preservation.

In feeding tests adding these fermentation cultures did not significantly influence rate of gain, feed consumption, or efficiency of gain. However, there was a trend toward increased efficiency.

The amount of silage required per 100 pounds of gain by the steers fed the treated silage was reduced by 9.5% as compared to steers fed the untreated silage. The addition of limestone to corn silage indicated non-significant effects upon dry matter and protein preservation.

Miniature Silos Used

Miniature silos holding about 30 pounds of silage were used at first to investigate the influence of additives on dry matter and protein preservation. Alfalfa or corn was cut, ground and thoroughly mixed.

Samples were taken for original analysis of material going into the silo. An equal quantity of material was added to each silo. The additives were mixed thoroughly into the silage. Then the silage was packed and each silo sealed with plastic and sand. A 50-pound weight was placed on top of each for continued pressure on the silage. The silage was removed for analysis after a 28-day fermentation period. The treatments were replicated.

Materials added to the silo were a culture of Aspergillus oryzae, a culture of Bacillus subtilis, limestone (finely pulverized) or various combinations of these.

The cultures were added at a rate equivalent to that commonly used in silage additives of this type and also at twice this rate. Limestone was added at a rate equivalent to 20 pounds per ton of chopped material.

Concrete Stave Silo

The study conducted at the Scottsbluff Station was with silage stored in concrete stave silos. First cutting alfalfa was about 1/10 bloom when harvested. Because only one blower was available, loads were not alternated between silos which probably accounts for the differences in composition at filling time.

The additive was applied at a rate of 10 pounds per ton of direct cut alfalfa. It was sprinkled on each load and then blown with the load into the silo. The direct cut without preservative was blown directly into the silo.

The wilted alfalfa was on the ground several days because of weather conditions before it was low enough in moisture to put in-

Table 1. Nutrient preservation of alfalfa in miniature silos.

	Dry matter[a]		Protein[a]	
	%	% Preserved[b]	% of dry matter	% Preserved[b]
Control	24.1	88.7	14.8	85.8
Control + 2.2 gm. A. oryzae	24.7	90.5	15.4	89.3
Control + 200 mg. B. subtilis	25.3	93.7	16.0	97.6
Control + 4.4 gm. A. oryzae	24.5	90.5	15.7	91.1
Control + 400 mg. B. subtilis	24.7	91.8	15.7	92.8
Control + 2.2 gm. A. oryzae + 200 mg. B. subtilis	25.1	93.7	15.1	92.7
Control + 4.4 gm. A. oryzae + 400 mg. B. subtilis	25.1	94.1	15.7	95.2

[a] Alfalfa analyzed 25.7% dry matter and 17.1% protein when placed into silos.
[b] Percent preserved based on weight of dry matter and protein removed from silo as percentage of weight of each added to silo.

Table 2. Nutrient preservation of corn silage in miniature silos.

	Dry matter[a]		Protein[a]	
	%	% Preserved[b]	% of dry matter	% Preserved[b]
Trial 50				
Control	27.1	84.9	9.2	97.2
Control + 2.2 gm. A. oryzae	26.3	84.3	9.7	100.0
Control + 200 mg. B. subtilis	26.5	83.9	9.5	99.6
Control + 2.2 gm. A. oryzae + 200 mg. B. subtilis	26.7	85.2	9.3	100.0
Trial 52				
Control	31.5	86.3	10.5	91.1
Control + 2.2 gm. A. oryzae	34.5	94.0	10.0	94.4
Trial 52 A				
Control	33.0	89.7	9.6	86.8
Control + 2.2 gm. A. oryzae	32.8	90.1	9.2	83.7

[a] Composition of materials going into silo

	Dry matter	*Protein, % of dry matter*
Trial 50	30.1	8.2
Trial 52	35.7	9.8
Trial 52 A	35.7	9.8

[b] Percent preserved based on weight of dry matter and protein removed from silo as percentage of weight of each added to silo.

[1] Department of Animal Science, University of Nebraska.
[2] Department of Animal Science, University of Nebraska.
[3] Department of Animal Science, Scotts Bluff Station.

Table 3. Influence of limestone on nutrient preservation and nitrate reduction.

	Dry matter[a]		Protein[a]		Potassium Nitrate[a]	
	%	% Preserved	% of dry matter	% Preserved	% of dry matter	% Preserved
Trial 50						
Control	27.2	85.0	8.6	90.2	.05	23.3
Control + Limestone[b]	28.0	86.9	8.6	92.6	.02	8.5
Trial 52						
Control	31.5	86.2	10.5	91.1	.07	20.1
Control + Limestone[b]	33.0	89.7	9.6	86.8	.07	18.5
Control + KNO_3[c]	32.3	88.1	11.2	87.5	1.49	68.4
Control + Limestone + KNO_3	32.8	89.8	10.7	84.5	1.43	67.7

[a] Composition of material going into silo.

	Dry matter %	*Dry matter basis* Protein %	Potassium nitrate %
Trial 50	30.1	8.2	.20
Trial 52	35.7	9.8	.32

[b] Limestone added at rate equivalent of 20 lb. per ton of silage.
[c] Potassium nitrate added to raise level 2 percentage units.

to the silo. Three lots of steers were fed each kind of silage. The steers were fed eight pounds of corn per head per day and all the silage they would consume.

Results from the miniature silo test are shown in Tables 1 and 2 with the addition of fermentation cultures to either alfalfa or corn silage. The differences were not statistically significant but there was a tendency for slight increases in both dry matter and protein preservation.

Effect Not Apparent

The addition of limestone to corn silage did not significantly change the dry matter preservation for corn silage, Table 3). There was a tendency for protein preservation to be lowered in one of the studies.

Previous research has suggested that limestone may decrease the amount of nitrates in corn silage. In the study in which potassium nitrates were added the effect of limestone was not apparent. The effects of moisture levels and other factors appear to be important considerations in this area.

Nutrient preservation and animal performance data are shown in Table 4, for the Scottsbluff experiment. Problems developed with molding in the wilted silage and this may have influenced the results. The two direct cut silages had desirable characteristics. The addition of the culture to the direct cut silage resulted in similar amounts of dry matter being preserved.

There was a slightly higher amount of protein preserved and a higher level of lactic acid for the treated silage. Higher amounts of dry matter and protein were preserved in the wilted as compared to either of the direct cut silages. The level of lactic acid was lower.

Steers About The Same

Performance of the steers on the direct cut treated and untreated silage did not vary significantly. There was a tendency for the gain to be a little higher and feed consumption a little lower for steers fed the treated silages. Coupled with a lower dry matter content the treated silage gave an apparent increase in efficiency of gain. Statistically this was not significant. However, the feeding of the treated silage would appear to possibly influence animal performance under the conditions of this study.

The feeding of the wilted silage supported performance lower than the others but, as previously noted, molding makes intrepetation impossible.

The overall effect of the addition of cultures containing Aspergillus oryzae or Bacillus subtilis would suggest slight differences in favor of the treated products.

Since there was considerable variation encountered further work is planned.

Get Your Money Back

The economics of the practice of silage additives cannot be assessed from the data. However, based on a 9.3% decrease in feed required per unit gain, this would suggest you would get your money returned if the cost of the treatment did not exceed 9.3% of the cost of the silage.

The opportunity for greater advantages than this does not appear likely based upon the data collected in this study. More work is required to present a clear picture of total advantages of silage additives.

Table 4. Nutrient preservation and performance of steers.[a]

	Alfalfa silage		
	Direct cut	Direct cut plus preservative	Wilted
Composition of material going into silo %			
Dry matter	26.3	24.0	52.9
Protein—% of dry matter	15.6	15.3	14.2
Composition of silage during feeding period %			
Dry matter	26.3	25.1	52.5
Protein—% of dry matter	13.8	14.4	15.1
Dry matter preserved—%[b]	86.0	86.8	90.6
Protein preserved—%[b]	76.0	81.4	96.9
Lactic acid—% of dry matter	3.3	5.4	.9
No. steers	21	21	21
Daily gain, lb.	2.23	2.34	2.13
Daily feed consumption, lb.			
Corn	8.0	8.0	8.0
Silage—as fed basis	51.1	50.2	26.8
Silage—dry matter basis	13.4	12.6	14.1
Silage dry matter required/100 lb. gain	613	555	642

[a] Length of trial for steers fed direct cut and direct cut plus preservatives was 79 days and for steers fed wilted silage—70 days.
[b] Dry matter preserved calculated as pound of dry matter removed from silo as a percentage of pound of dry matter added to silo. The same calculation was made for protein.

Selection for Better Herds

By R. M. Koch,[1] K. E. Gregory,[2] J. E. Ingalls[2] and J. A. Rothlisberger[3]

Selection is the principal tool available to the breeder for improving the average merit of his herd. It involves keeping selected animals for future reproduction and discarding others.

Hopefully, those we keep have higher genetic merit than those we discard and therein lies the secret for rate of improvement. Selection effectiveness depends on how accurately we can determine *genetic* merit and how much all selected animals exceed the average of the group from which they came.

At Fort Robinson we are conducting an experiment to determine the effects when cattle are selected for (1) weaning weight, (2) yearling weight and (3) a combination of yearling weight and thicker muscling.

Cattle Lines Closed

Three closed lines of cattle originating from the same foundation stock were established in 1960. Since then replacement bulls and heifers have been selected on the criteria outlined above. Each line has about 150 cows. Six bulls are used each year. Two bulls and 25 heifers are selected to add to each line every year.

These criteria of selection (weaning weight, yearling weight, muscling and yearling weight) were chosen because:

(1) *The two ages represent* important ages for marketing cattle.

(2) *Pre-weaning and post-weaning* growth represent distinct phases of production.

(3) *We need to know* the correlated response in feed efficiency, longevity, carcass merit and rate of maturity when selection for growth rate is emphasized.

(4) *The traits, easily* measured, represent simple objectives.

(5) *Previous research indicates* these traits are heritable and should respond to selection.

Not Overnight

The experiment is long term in nature and will likely take 20 years for adequate evaluation.

The experiment began in 1960 but it was not until 1965 that all of the calves were sired by bulls selected from each line. It is too soon for much of a trend in production to show itself clearly. However, there are indications already that selection is effective.

In 1963 and 1964 when both foundation sires and their high performing sons produced progeny in the same year, the sons were equal to or superior to their sires.

A good breeding bull should produce a son that is superior to himself if progress is to be made.

Further, compare the weaning and yearling weights of bulls as shown in the table of performance. Yearly differences in environment cause the average to vary considerably.

Improvement Expected

The average weaning weights by line compared with the overall average weaning weight indicate the most improvement occurred in Line 21, selected for weaning weight, even though some genetic improvement in weaning weight was expected in the other two lines. Similarly, compare the average yearling weights by line of the calves born in 1960-61-62 and those born in 1964 and 1965.

Note that the bulls from the line selected for yearling weight, Line 22, exceeded the overall average by the largest amount, followed by Line 23, selected for muscling and yearling weight.

A change in the length of the performance period from 550 days to 452 days accounts for the large difference in yearling weights for 1964 and 1965 as compared with the previous years.

Must Measure, Select

We expect progress to be slow but we can make progress if we will but measure the traits of importance and select for them.

Future work planned in the experiment will involve comparisons of foundation sires with selected sires born five years later by using semen frozen and stored over the years. These comparisons will be started in 1968 or 1969.

Table 1. Weaning and yearling weight performance of bulls in selection lines.

	200-Day Weight							Average	Average
	1960	1961	1962	1963	1964	1965	1966	1960-61-62	1964-65-66
Line 21[a]	437	436	464	446	444	446	464	446	451
Line 22[b]	427	433	472	444	427	447	444	444	439
Line 23[c]	418	460	457	443	421	451	447	445	440
						Average Over All Lines		445	443

	Yearling Weight (550-Day Weight in 1960-61-62-63; 452-Day Weight in 1964-65)						Average	Average
	1960	1961	1962	1963	1964	1965	1960-61-62	1964-65
Line 21[a]	1208	1214	1180	1192	955	937	1201	946
Line 22[b]	1206	1212	1213	1235	956	983	1210	970
Line 23[c]	1200	1210	1182	1210	953	968	1197	960
					Average Over All Lines		1203	959

[a] Selected for weaning weight.
[b] Selected for yearling weight.
[c] Selected for muscling and yearling weight.

[1] Department of Animal Science, University of Nebraska.

[2] Animal Husbandry Research Division, ARS, USDA.

[3] Nebraska Agricultural Experiment Station, Fort Robinson Beef Cattle Research Station, Crawford, Nebraska.

Cooperative between the Beef Cattle Research Branch, Animal Husbandry Research Division, ARS, USDA and the Nebraska Agricultural Experiment Station.