CONTENTS

GENETICS—ANIMAL BREEDING

Age and Weight at Puberty for Purebred and Crossbred Gilts 1
L. K. Hutchens, R. L. Hintz and R. K. Johnson

Relationship Between Pubertal and Growth Characteristics in Gilts 3
L. K. Hutchens, R. L. Hintz and R. K. Johnson

Performance Trends of Boars Tested at the Oklahoma Swine Evaluation Station 5
D. S. Buchanan, W. G. Luce, D. G. McLaren, M. L. Kalka and S. E. Everett

The Relationship Between Measures of Performance and Selling Price in Tested Boars 9
D. S. Buchanan, W. G. Luce, D. G. McLaren, M. L. Kalka and S. E. Everett

Fall Lambing Performance of Dorset X Finnish Landrace Sheep 12
K. A. Ringwall, J. V. Whiteman, R. P. Wettemann and G. A. Robson

Repeatability of Ewe Reproductive Performance 14
J. V. Whiteman and J. M. Dzakuma

Ewe Weight and Condition at Breeding Time as Related to Mating Performance and Reproductive Rate 18
J. V. Whiteman and M. Detten

A Comparison of Different Age of Dam and Sex Correction Factors for Birth, Weaning, and Yearling Weights in Beef Cattle 23
C. G. Chenette and R. R. Frahm

Reproductive Performance of Various Two-Breed Cross Cow Groups 27
D. M. Marshall, R. R. Frahm and C. G. Chenette

Productivity Comparisons Among Various Two-Breed Cross Cow Groups 30
R. R. Frahm, D. M. Marshall and C. G. Chenette

Performance to Weaning of Three-Breed Cross Calves Sired by Charolais and Limousin Bulls 34
D. M. Marshall, R. R. Frahm and C. G. Chenette

FOODS AND CARCASS EVALUATION

Carcass Trends in an Oklahoma Youth Barrow Show 37
W. G. Luce, R. L. Hintz, M. L. Scott, V. L. Stevens F. K. Ray

Trends in Oklahoma Swine Carcass Contests 42
W. G. Luce, R. L. Hintz, L. E. Walters, V. L. Stevens, M. L. Scott and F. K. Ray

Preliminary Development of Yield Grade and Dressing Percentage Prediction Equations for Beef Steers 49
L. E. Walters and R. L. Hintz

The Growth of Three Fiber Types in Beef Longissimus Muscle as Influenced by Breed and Age 51
J. J. Guenther, K. K. Novotny and R. D. Morrison
A Comparison of Collagen Content and Organoleptic Attributes of Grain- vs. Forage-Finished Cattle 54
L. E. Bulgerin, J. E. Williams, T. H. Liao, L. L. Ebro, J. J. Guenther, L. E. Walters and D. G. Wagner
Carcass Characteristics of Ram Lambs at Four Slaughter Weights 57
A. E. Sents, J. V. Whiteman and L. E. Walters
Enumeration and Identification of Lactobacilli in Feed Supplements Marketed as Sources of *Lactobacillus Acidophilus* 61
S. E. Gilliland

NUTRITION—COW-CALF AND STOCKER

Effects of Early Weaning on Calf Performance and on Reproduction in Mature Cows 64
K. S. Lusby and A. A. Parra
Influence of Month of Calving on Daily Milk Yield: Progress Report on Development of a Model of a Cow-Calf System 68
R. L. Hintz, K. S. Lusby and R. Totusek
Potential of Near Infrared Reflectance Spectroscopy for Measuring Forage Quality 73
F. E. Barton, II and S. W. Coleman
Effect of Level of Supplement and Amount of Supplemental Crude Protein on Intake and Digestibility of Untreated Wheat Straw by Lambs 77
G. W. Horn, D. W. Pace and C. L. Streeter
Ammoniation of Wheat Straw and Prairie Hay 79
G. W. Horn, C. L. Streeter, G. Manor, D. G. Batchelder and G. L. McLaughlin
Effect of Source of Supplemental Protein and Level of Supplement on Voluntary Intake and Performance of Lambs Fed Ammoniated Wheat Straw Silage 84
C. L. Streeter, G. W. Horn, D. G. Batchelder and G. Manor
Effect of Protein Level and Supplement Level on Voluntary Intake and Performance of Lambs Fed Ammoniated Wheat Straw Silage 88
C. L. Streeter, G. W. Horn and D. G. Batchelder
Alkaline Treatment of Wheat Straw Before Ensiling 91
W. A. Phillips and F. P. Horn
Forage Production and Digestibility of Small Grain Forages 93
G. W. Horn, W. E. McMurphy and R. L. Mitchell
Effect of Initial Weight on Daily Gain of Stocker Cattle Grazed on Wheat Pasture 94
G. W. Horn, T. L. Mader, R. W. McNew, C. L. Streeter and S. L. Armbruster

Effect of Feeding Wheat Straw or Sorghum-Sudan Hay on Gains and Wheat Forage Utilization of Stocker Cattle 96
T. L. Mader, G. W. Horn and W. E. Phillips
Yeast Culture in a Free-Choice Mineral Supplement for Stocker Cattle Grazing Wheat Pasture 101
C. L. Streeter, G. W. Horn and J. E. McClung

Ensiling of Whole Wheat Plant at Different Maturities and Dry Matter 106
W. A. Phillips, L. C. Pendlum and F. P. Horn
The Impact of Farm of Origin and Post-Shipment Diet on the Performance of Stocker Calves 108
W. A. Phillips and J. B. McLaren
Weight Changes During Transportation of Stocker Calves 110
W. A. Phillips and K. B. Leining
Steer Weight Gains on Midland and Hardie Bermudagrass Pastures 112
G. W. Horn and W. E. McMurphy

Relationship of Steer Daily Gains on Bermudagrass to Rate of Forage Digestion 116
M. Cannon, R. L. Hintz, G. W. Horn and W. E. McMurphy
Effects of Reimplantation for Grazing Calves 119
S. R. Rust, D. R. Gill and C. W. Nichols

NUTRITION—DAIRY

The Feeding Value of Heated Soybean Meal for Lactating Dairy Cows 122
J. W. Ward, L. J. Bush and G. D. Adams

NUTRITION—FEEDLOT

Avoparcin, Monensin and Implants for Growing Heifers 125
F. N. Owens and D. R. Gill
Thiopeptin or High Roughage in Starting Rations for Feedlot Steers 131
D. R. Gill, F. N. Owens, R. W. Fent and R. K. Fulton
Corn Silage Ammoniation Time and Protein Solubility 139
F. N. Owens, W. M. Sharp and George Davis
Roughage Levels in Feedlot Rations 141
D. R. Gill, F. N. Owens, J. J. Martin, D. E. Williams, R. A. Zinn and R. J. Hillier
Influence of Level of Feed Intake on Digestive Function: I. Nitrogen Metabolism 146
R. A. Zinn and F. N. Owens
Captan and Ruminal Metabolism 149
R. G. Teeter and F. N. Owens

Ruminal Availability of Phosphorus and Its Effect on Digestion 151
K. E. Witt and F. N. Owens
The Effect of Additional Nitrogen Fertilization on the Nutritive Value of Grain Sorghum 158
C. A. Hibberd, D. E. Weibel, D. G. Wagner and R. L. Hintz
Roughage-Concentrate: Associative Effects .....
R. G. Teeter, F. N. Owens and D. R. Gill
Finishing Steers on Conventional Grain Diets vs. Forage Plus Grain, With and Without Monensin 165
S. C. Ostlie, D. G. Wagner and P. Sims
The Effects of Decoquinate on Gains of Stressed Cattle 167
S. R. Rust, D. R. Gill, E. J. Richey and F. N. Owens
Effects of Anthelmintics and Leptospirosis Vaccination on Performance of Feedlot Cattle 169
S. R. Rust, D. R. Gill and J. J. Martin

NUTRITION—SWINE

A Preliminary Report on the Effect of Increased Feed Intake During Late Gestation 171
W. R. Walker, C. V. Maxwell, R. L. Hintz and K. Brock
Effects of Fat Supplementation on Performance of Creep-Fed Pigs 173
W. R. Walker, C. V. Maxwell, R. L. Hintz, N. J. Lawrence and K. Brock
Effect of Dietary Fat Source on the Performance of Colostrum-Deprived Neonatal Pigs 180
N. J. Lawrence, C. V. Maxwell and D. S. Buchanan

PHYSIOLOGY

The Effect of Environmental Temperature and Thyrotropin Releasing Hormone on the Concentration of Thyroxine in Steers 183
B. R. Pratt and R. P. Wettemann

RESEARCH IN PROGRESS

Evaluation of an Index for Boar Selection 187
D. S. Buchanan, H. R. Gaugler and R. Vencl
Reproductive Development and Performance of Hereford Heifers Calving at 24 and 30 Months of Age 189
E. J. Turman, R. P. Wettemann, K. S. Lusby and J. Magee
Effect of Environment and Diet on Endocrine Responses in Calves 190
K. B. Leining

An Evaluation of Wheat Pastures as Related to Metabolic Anomalies in Cattle 191
V. R. Bohman, F. P. Horn, B. A. Stewart, A. C. Mathers, D. L. Grunes and E. T. Littledyke

Improved Procedure for Challenging Neonatal Dairy Calves with Enteropathogenic *Escherichia Coli* 192
S. E. Gilliland, L. J. Bush and R. D. Contreras

Effect of Pasteurization of Colostrum on Absorption of Immune Globulins by Newborn Dairy Calves 194
L. J. Bush, S. E. Gilliland and R. D. Contreras

AUTHORS 195

ACKNOWLEDGEMENTS 197

TABLE OF EQUIVALENTS ..... **Inside Back Cover**

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GENETICS—ANIMAL BREEDING

Age and Weight at Puberty for Purebred and Crossbred Gilts

L. K. Hutchens, R. L. Hintz and R. K. Johnson

Story in Brief

Data from 737 purebred and crossbred gilts of Duroc, Yorkshire, Landrace and Spot breeding farrowed during fall, 1976, spring and fall, 1977, and spring, 1978, were collected. All gilts were self-fed on pasture or in confinement until they reached 200 lb at which time they were weighed off test and placed in pasture lots. After placement in pasture lots, gilts were checked daily for estrus activity with the aid of a teaser boar. For this study, puberty was defined as a gilt's first detectable estrus as indicated by a standing response when mounted by a teaser boar.

Crossbred gilts were younger (7.9 days) and heavier (2.6 lb) at puberty than purebreds. Duroc-Landrace and all crosses involving Spot breeding were significantly younger at puberty than their respective purebred averages. Spring-born gilts were younger at puberty than fall-born gilts. Gilts fed in confinement adjacent to boars were younger at puberty (5.5 days) than gilts fed on pasture with barrows. Differences in weight at puberty due to season effects varied with management system and year.

Introduction

Age at puberty in gilts is a growing concern since interest in maximizing productivity has increased as swine production has intensified. Reducing the age when gilts are bred without reducing their performance can result in savings in both feed and labor. Some environmental factors which have been found to influence age at puberty include nutrition level, season of birth, fenceline contact between gilts and boars, different mixtures of gilts and housing.

The knowledge of genetic factors for age at puberty is also important. Accurate estimates of heritability will indicate the effectiveness of selection for reduced age at puberty. Previous research has shown genetic difference between breeds and heterosis are important for reproductive performance. However, little information on age and weight at puberty is available.

Therefore, the purpose of this study was to compare purebreds and crossbreds of Duroc, Yorkshire, Landrace and Spot breeding for age and weight at puberty. This information will be valuable when evaluating the overall efficiency of different production and crossing systems.

Experimental Procedure

The data were obtained from 737 gilts which were purebred and two-breed crosses of Duroc, Spot, Yorkshire and Landrace breeding. The gilts were raised at the Stillwater Experimental Swine Farm during fall, 1976, spring, 1977, fall, 1977, and spring, 1978. Each season boars were mated at random to at least one female of each of the four breeds (Table 1).

Table 1. Number of litters of each mating type produced during each season at the Stillwater Experimental Swine Farm

Breed of sire	Number of sires	Breed of dam			
		D	Y	L	S
Duroc (D)	4	6	4	4	4
Yorkshire (Y)	4	4	6	4	4
Landrace (L)	4	4	4	6	4
Spot (S)	4	4	4	4	6

All pigs were farrowed in a central farrowing unit and weaned at six weeks of age. Creep was provided at approximately three weeks of age. Approximately two weeks after weaning, gilts were randomly allotted within litters to either pasture lots or confinement pens for finishing. All gilts were self-fed until they reached 200 lb at which time they were weighed off test, probed for backfat and placed in pasture lots. After placement in pasture lots, gilts were checked daily for estrus activity with the aid of a teaser boar. For this study puberty was defined as a gilt's first detectable estrus as indicated by a standing response when mounted by a teaser boar. Age and weight were recorded when a gilt's first estrus was detected. Each season gilts were checked daily until the youngest gilts were 219 days of age. Eighty-two out of 819 gilts (10 percent) were not detected by the time the youngest gilts were 219 days of age. Gilts which displayed obvious signs of disease or lameness before reaching 219 days of age were omitted from the analyses.

Results and Discussion

Crossbreds (189.4 days) were significantly younger than purebreds (197.2 days) at first observed estrus (Table 2). Crossbreds were 2.6 lb heavier than the purebreds. The percentage of gilts never observed in estrus was lower among crossbreds (7.8 percent) than among purebreds (16.4 percent).

Breed of sire and breed of dam interaction significantly affected age and weight at puberty. Since differences between reciprocal crosses for either age or weight at puberty were not significant, the reciprocal crosses were combined (Table 2).

All crosses had an advantage over their respective purebred average (measure of heterosis) for age at puberty. This crossbred advantage was significant for all crosses

Table 2. Average performance for gilts of each breed group [1]

Breed group[2]	Number detected	Age at puberty (days)	Weight at puberty (lb)	Number undetected[3]
Duroc (D)	43	201.2^{d}	215.0^{ab}	19
Yorkshire (Y)	34	198.9^{abcd}	200.4^{ab}	8
Landrace (L)	54	194.5^{abcd}	197.6^{a}	5
Spot (S)	47	194.3^{abcd}	205.3^{a}	3
DxY	88	197.3^{ac}	216.4^{ab}	9
DxL	99	183.5^{bd}	201.5^{b}	9
DxS	99	185.0^{a}	206.7^{a}	0
YxL	85	196.0^{abcd}	208.9^{ab}	12
YxS	94	189.1^{ab}	207.4^{a}	11
LxS	94	185.4^{bcd}	202.3^{ab}	6

[1]Means in the same column that do not share at least one superscript differ statistically ($P<.05$).
[2]Reciprocals combined (DxY = DxY and YxD).
[3]Number of gilts which were not observed in estrus. Youngest gilts were 219 days of age when estrus detection was terminated.

except Duroc-Yorkshire and Landrace-Yorkshire crosses. The Duroc-Landrace cross had the largest heterosis advantage (14.3 days) for age at puberty, and all crosses involving Spot breeding had a notable advantage over their respective purebred averages.

All crosses were heavier than their respective purebred averages for weight at puberty except the Duroc-Landrace cross. The difference between the Landrace-Yorkshire cross and their respective purebred average (9.9 lb) was the only significant heterosis effect for weight at puberty.

Gilts raised in confinement (188.6 days) during the finishing phase were significantly younger at puberty than gilts raised on pasture (194.1 days). A significant interaction between management system and season affected weight at puberty. Spring-born gilts raised on pasture were heavier at puberty (207.3 lb) than fall-born (202.2 lb). However, no notable season effect existed in gilts raised in confinement (201.1 lb in the fall vs. 198.7 lb in the spring). Comparisons among management systems should be viewed carefully because gilts in confinement were penned adjacent to boars of similar age and gilts on pasture were penned with barrows.

Table 3. Average performance for gilts born during different year-seasons

Year-season	Age at puberty (days)	Weight at puberty (lb)
1976 - Fall	195.0	206.6
1977 - Spring	188.6	214.8
1977 - Fall	198.8	205.5
1978 - Spring	183.3	199.8

A significant interaction between year and season existed for age and weight at puberty (Table 3). Spring-born gilts were 6.4 days younger in the first year and 15.3 days younger in the second year. Spring-born gilts were 8.2 lb heavier in the first year and 5.7 lb lighter in the second year.

Breed differences for age at puberty are indicated in these data. The information on the breed comparisons should aid in evaluating the efficiency of production systems.

Relationship Between Pubertal and Growth Characteristics in Gilts

L. K. Hutchens, R. L. Hintz and R. K. Johnson

Story in Brief

Data from 737 crossbred and purebred gilts of Duroc, Landrace, Yorkshire and Spot breeding were used to estimate the heritability of age and weight at puberty and their genetic and phenotypic correlations with birth weight, weaning weight, post-weaning daily gain, adjusted age at 200 lb and adjusted backfat thickness at 200 lb.

The paternal half-sib heritability estimate for age at puberty was .19. The genetic and phenotypic correlations between age at puberty and birth weight, weaning weight,

postweaning daily gain, backfat thickness at 200 lb and age at 200 lb were favorable. The favorable correlations indicate continual selection for increased growth rate would result in a correlated decrease in age at puberty.

Introduction

Costs of replacement gilts can be reduced by bringing gilts into production at an earlier age, which can be accomplished by decreasing the age at puberty. Present selection practices stress increased growth rate and decreased backfat thickness. With this current selection emphasis, the magnitude and direction of the correlated response of age at puberty is of interest. Also, the effectiveness of selection for decreased age at puberty is of interest.

Therefore, the purpose of this paper is to present estimates of heritability of age at puberty and genetic and phenotypic correlations of age at puberty with growth traits. Heritability measures the proportion of phenotypic differences due to genetic causes. Phenotypic correlation measures how closely two traits vary together and genetic correlation measures the association among traits due to genetic causes (genetic correlation results from a gene influencing more than one trait). This information may be valuable in evaluating the contribution of selection programs to the efficiency of production.

Experimental Procedure

The data were obtained from 737 crossbred and purebred gilts of Duroc, Spot, Yorkshire and Landrace breeding. Information on the mating structure and management of sows, litters and gilts can be found in the preceeding paper in this report.

Results and Discussion

The paternal half-sib heritability estimate for age at puberty was .19 (Table 1). This estimate is lower than the average (.34) from the literature. The paternal half-sib heritability estimate for weight at puberty was .35. This estimate is close to the average (.31) in the literature. Even though the heritabilities are not high, the estimates indicate change in age and weight at puberty can be achieved through selection.

The genetic correlations of age at puberty with birth weight (−.07), weaning weight (−.25), postweaning daily gain (−.38) and age at 200 lb (.56) increased in size as the age when growth was measured increased (Table 1). The direction of the genetic correlations indicates that continued selection for increased growth rate would tend to decrease age at puberty. The phenotypic correlations of age at puberty with growth

Table 1. Heritabilities and genetic and phenotypic correlations of pubertal and growth traits[a]

	AGEPUB[b]	WTPUB[b]	BW[b]	WW[b]	ADG[b]	AGE[b]	BF[b]
AGEPUB	.19	−.03	−.07	−.25	−.38	.56	.27
WTPUB	.54	.35	.46	.69	.81	−.70	.28
BW	−.09	.24	1.53	.54	.50	−.61	.19
WW	−.19	.29	.51	1.20	.49	−.88	−.01
ADG	−.34	.34	.29	.31	.69	−.73	.16
AGE	.38	−.38	−.42	−.58	−.83	.60	.00
BF	.01	.01	−.03	−.04	.05	.01	.51

[a]Heritabilities on the diagonal, genetic correlations above the diagonal and phenotypic correlations below the diagonal.

[b]AGEPUB = age at puberty, WTPUB = weight at puberty, BW = birth weight, WW = weaning weight, ADG = average daily gain, AGE = adjusted age at 200 lb and BF = adjusted backfat at 200 lb.

traits also generally increased with age at which growth was measured. These correlations indicate that gilts exhibiting a faster growth rate would tend to reach puberty at earlier ages. The genetic and phenotypic correlations between age at puberty and backfat were low and positive indicating little relationship.

The genetic and phenotypic correlations between weight at puberty with growth are favorable. Thus, selection for increased growth rate would tend to increase weight at puberty. Also gilts exhibiting a faster growth rate would tend to be heavier at puberty. The phenotypic and genetic correlations between weight at puberty and backfat are low and positive indicating little relationship.

These data indicate that continual selection for growth rate would result in a correlated decrease in age at puberty.

Performance Trends of Boars Tested at the Oklahoma Swine Evaluation Station

D. S. Buchanan, W. G. Luce
D. G. McLaren, M. L. Kalka and S. E. Everett

Story in Brief

Performance data collected from 1731 boars tested at the Oklahoma Swine Evaluation Station have been analyzed. Average changes in performance have been estimated for several breeds from 1971 through 1979. Traits measured were average daily gain, pen feed efficiency, backfat thickness and loin eye area. There was a general increase in average daily gain and a decrease in pounds of feed per pound of gain, backfat thickness and loin eye area. Average changes in such a population should, to some extent, indicate changes in the swine industry. If these data are reflective of the swine industry, they indicate improvement in all traits evaluated except loin eye area.

Introduction

Improvement of production efficiency in the swine industry is dependent upon accurate identification of individuals with superior performance. Swine testing stations have been established to aid in that identification. The Oklahoma Swine Evaluation Station began testing in 1971. Such a station provides opportunities for comparison of individuals from different farms and also gives the individual breeder an opportunity to evaluate the performance of his own stock. Examination of time trends in a swine testing station will indicate the general changes in average performance of pigs at the station. These changes may be due to a variety of factors including genetic changes.

Materials and Methods

The Oklahoma Swine Evaluation Station was built in 1970. The station originally had one barn with 24 open-front pens measuring 5 by 15 ft. A second barn was constructed in 1975 which increased capacity to 48 pens.

Pens of three boars and one barrow or two boars and two barrows were tested until 1974. After that time all pens contained three boars. Pigs within a pen were the progeny

of one sire. One test in the spring and one in the fall were conducted through 1974. After that time there were two tests conducted each season. Pigs were put on test when the pen averaged 70 lb. There has been a change in off-test weight from 220 lb to 230 lb during the life of the station.

Data collected when the pigs reached off-test weight included average daily gain, pen feed efficiency and an ultrasonic scanogram estimate for loin eye area and backfat thickness. The instrument used was an Ithaco Scanogram, Model 721. Feed efficiency for pens containing barrows was adjusted to a boar-equivalent basis. Backfat thickness was the average of measurements taken at the shoulder, the last rib and the last lumbar vertebra. Loin eye area was measured at approximately the tenth rib. For this study all backfat thickness and loin eye area estimates were adjusted to a 230-lb basis with adjustment factors recommended by the National Swine Improvement Federation.

The data for these analyses include 1731 boars from eight breeds that completed the tests from 1971 through 1979. The number of boars from each breed and year is shown in Table 1. The increase in numbers in 1975 was due to the completion of the second building.

Analyses were conducted that allowed estimation of breed x year subclass means that were adjusted for the effects of season, test group (after 1974) and initial weight. These analyses also provided estimates of regression coefficients on year (average change per year) for Chester White, Duroc, Hampshire, Spot and Yorkshire boars. There were insufficient numbers of boars from the other three breeds to provide useful estimates of the regression coefficients.

Results and Discussion

The average daily gain for boars of each breed in each year is shown in Table 2. Average pen feed efficiencies for the boars are presented in Table 3. There appears to have been a general increase in growth rate and improvement of feed efficiency for the boars tested. However, these changes were not consistent from year to year.

Average loin eye area and backfat thickness for the boars of each breed in each year are shown in Tables 4 and 5. There was a general decrease in amount of backfat over the 9 years of testing. There was also a fairly consistent decrease in loin eye area in each of the breeds.

Phenotypic time trends were estimated by regressing performance on year. These regressions (Table 6) estimate the average change per year in each of the traits. Such estimates were available for five of the eight breeds tested. There were no Berkshire, Poland or Landrace boars tested in some years, and that prevented adequate estimation of average change in those breeds.

The estimates of change per year supported what the means indicated. There was a significant increase in average daily gain and improvement of feed efficiency for each of the five breeds except the Spot. There was a significant decrease in backfat thickness and loin eye area in each breed.

These changes may be due to any of a number of factors. It is likely that at least part of the trend was due to real genetic changes in the purebred swine industry. It is also likely that climatic differences from year to year contributed as well as management changes at the station. Some possible additional sources of change, particularly in the later years, are that breeders were learning how to better manage the boars (pre-test) and that they were more conscientious in selecting boars to go to the station. Both of these may have resulted in pigs that performed better.

Table 1. Number of boars of each breed in each year

Breed	Year of test								
	1971	1972	1973	1974	1975	1976	1977	1978	1979
Berkshire	4			6		3	8		9
Chester White	11	8	11	17	38	42	31	30	20
Duroc	31	34	42	45	62	66	71	90	94
Hampshire	28	29	32	17	32	50	28	43	27
Poland	11	4		3			3		9
Spot		9	23	21	37	49	61	28	34
Yorkshire	6	17	20	25	39	60	58	53	75
Landrace					1			14	12

Table 2. Average daily gain[a] for boars of each breed in each year

Breed	Year of test									Overall average
	1971	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	1.89			2.07		1.65	1.83		1.76	1.85
Chester White	1.59	1.78	1.84	1.84	1.96	1.89	1.90	1.77	1.84	1.86
Duroc	2.00	1.94	1.96	2.09	2.00	2.07	2.03	2.11	1.99	2.03
Hampshire	1.89	1.91	1.87	1.90	2.08	1.99	2.01	2.09	2.09	1.99
Poland	1.75	1.68		1.99			1.99		1.96	1.85
Spot		1.90	1.96	2.00	2.10	2.00	1.95	1.96	2.00	1.99
Yorkshire	1.78	2.01	1.95	2.04	2.04	2.00	2.02	2.13	2.14	2.05
Landrace					2.12			2.01	2.08	2.05
Overall average	1.87	1.92	1.93	2.01	2.03	1.99	1.98	2.04	2.03	

[a]lb per day.

Table 3. Average pen feed efficiency[a] for boars of each breed in each year

Breed	Year of test									Overall average
	1971	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	3.01			2.41		2.78	2.87		2.98	2.82
Chester White	2.97	2.72	2.78	2.55	2.38	2.70	2.75	2.71	2.67	2.68
Duroc	2.82	2.56	2.59	2.46	2.40	2.60	2.52	2.50	2.51	2.58
Hampshire	2.85	2.65	2.67	2.56	2.40	2.49	2.52	2.43	2.47	2.57
Poland	3.12	2.63		2.76			3.14		2.81	2.93
Spot		2.82	2.80	2.53	2.42	2.68	2.82	2.78	2.71	2.69
Yorkshire	2.95	2.56	2.64	2.52	2.42	2.62	2.63	2.54	2.48	2.55
Landrace					2.37			2.70	2.62	2.65
Overall average	2.90	2.62	2.67	2.51	2.40	2.62	2.66	2.56	2.56	

[a]lb feed per lb gain.

Table 4. Average loin eye area[a] for boars of each breed in each year

	Year of test									
Breed	1971	1972	1973	1974	1975	1976	1977	1978	1979	Overall average
Berkshire	5.71			6.05		5.62	5.62		5.16	5.48
Chester White	5.63	5.72	6.09	5.68	5.57	5.56	5.25	5.14	4.97	5.45
Duroc	5.54	5.56	6.03	5.74	5.43	5.46	5.32	5.22	4.96	5.39
Hampshire	6.02	5.91	6.25	6.22	5.82	5.80	5.62	5.51	5.12	5.78
Poland	5.81	5.84		5.66			4.61		4.93	5.75
Spot		5.89	6.12	5.71	5.42	5.44	5.36	5.08	4.94	5.60
Yorkshire	5.47	5.61	5.92	5.45	5.38	5.46	5.12	5.12	4.99	5.48
Landrace					5.32			5.11	4.64	4.91
Overall average	5.73	5.72	6.09	5.75	5.50	5.54	5.29	5.22	4.97	

[a]in.^{2}.

Table 5. Average backfat thickness[a] for boars of each breed in each year

	Year of test									
Breed	1971	1972	1973	1974	1975	1976	1977	1978	1979	Overall average
Berkshire	1.01			1.05		.94	.86		.75	.89
Chester White	1.04	.98	1.07	1.02	.86	.97	.92	.77	.84	.91
Duroc	1.03	.97	1.02	1.09	.94	.96	.89	.78	.80	.91
Hampshire	.85	.85	.89	.91	.82	.79	.74	.63	.75	.80
Poland	1.02	.83		.86			.99		.92	.95
Spot		.91	.98	.96	.94	.97	.92	.79	.83	.91
Yorkshire	1.18	.97	1.02	1.01	.91	.93	.84	.79	.81	.88
Landrace					.94			.92	.91	.92
Overall average	.98	.93	.98	1.02	.90	.93	.87	.76	.81	

[a]in.

Table 6. Average change in performance per year for boars of five breeds[a]

Breed	Trait			
	Avg. daily gain, lb	Lb of feed/ lb gain	Loin eye area, in.^{2}	Backfat thickness, in.
Chester White	.020**	−.013*	−.107**	−.031**
Duroc	.010**	−.022**	−.083**	−.033**
Hampshire	.033**	−.031**	−.107**	−.024**
Spot	.033	.006	−.083**	−.007**
Yorkshire	.032**	−.034**	−.075**	−.040**
Overall average	.019**	−.021**	−.088**	−.029**

[a]Berkshire, Poland and Landrace boars not included due to small numbers of boars tested.
*Average change per year is significantly different from zero, $P < .05$.
**Average change per year is significantly different from zero, $P < .01$.

If these phenotypic trends reflect changes that were occurring in the swine industry, they indicate improvement in growth rate, feed efficiency and backfat thickness. There is currently concern about the extent to which loin eye area has been changed. While it is possible that many hogs were too heavily muscled ten years ago, it is also possible that the total reduction has been too severe since then.

The Relationship Between Measures of Performance and Selling Price in Tested Boars

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D. G. McLaren, M. L. Kalka and S. E. Everett

Story in Brief

Performance records and sale prices of 901 boars that sold from the Oklahoma Swine Evaluation Station from 1971 through 1979 were used to evaluate the effect that performance had on selling price. Measures of performance that were included were age at final weight, average daily gain, feed efficiency, back fat thickness and loin eye area.

None of the traits was highly correlated with selling price. Average changes in price per unit change in each trait indicated that less than half of the variation in selling price was explained by variation in the performance traits. Generally one of the measures of growth rate had the most important impact on selling price.

Introduction

Performance testing of swine has been increasing for several years. One of the methods of performance testing is the central test station. Such a station enables potential buyers to have an evaluation of boars that have been managed under uniform

conditions but come from various breeders. It would be helpful to potential buyers if they knew the extent to which various performance traits contributed to selling price. Sufficient numbers of boars have been tested at the Oklahoma Swine Evaluation Station to analyze the relationship between selling price and those performance traits that are evaluated at the station.

Materials and Methods

The Oklahoma Swine Evaluation Station began testing boars in 1971. There were 1731 boars that completed the test through 1979, and of those, 901 sold at auction following completion of each test. There were several reasons why the remaining boars did not sell. Approximately 20 percent of the boars did not meet minimum performance standards and were not offered for sale. In addition, several boars were excluded from sale because of structural unsoundness. Beyond those exclusions some boars did not sell because the breeder elected not to sell his animal, or no bid was received above a predetermined minimum sale price.

Sale catalogs were available to potential buyers prior to the sale. These catalogs included identification of each boar including sire, dam and breeder name. Performance traits included were: age at final weight (either 220 or 230 lb), average daily gain, probe backfat thickness (average of shoulder, last rib and last lumbar vertebra) and a scanogram estimate of loin eye area. In addition, feed efficiency (lb feed/lb gain) was presented for each pen. In all cases a pen consisted of three or four pigs by the same sire. Boars were sold according to their rank based on an index of average daily gain, backfat thickness and feed efficiency. This index changed several times during the period under consideration.

These analyses included all those performance records and sale prices of boars that sold from the Chester White, Duroc, Hampshire, Spot and Yorkshire breeds. Berkshire, Poland and Landrace boars were also tested but were excluded from these analyses because of the very limited numbers of boars from those breeds.

The relationship between selling price and the performance traits was evaluated by calculating the correlation between price and each trait after accounting for the variation due to breed, year, season and test group.

Contributions of each trait to selling price for each breed was independently evaluated by obtaining partial regressions of price on each performance trait. These regressions were obtained simultaneously for all the traits after accounting for the variation due to year, season and test group. The trait that contributed the least in each breed was removed from consideration, and the analyses were repeated until only those traits that made significant contributions to selling price remained. In this way the traits could be ranked by order of their effect.

Results and Discussion

Correlations between various performance traits and selling price are shown in Table 1. All are significantly different than 0 and are in the desired direction. Despite this, all are relatively small with the largest being .277 for average daily gain.

Table 1. Correlations between selling price and performance traits of tested boars

	Performance traits				
	Age at final wt	Average daily gain	Pen feed efficiency	Backfat thickness	Loin eye area
Price	−.236	.277	−.227	−.142	.090

The average change in price per unit of change in each performance trait is shown in Table 2. These are shown for each breed separately. Missing values indicate traits that did not make significant contributions to selling price. The regression coefficients indicate the amount of change in selling price that is associated with the change in that trait. The column headed with R^2 shows the proportion of the variation in price that can be explained by the performance traits indicated. For example, in Chester White boars there was a $13.24 decrease in price for each day increase in age at final weight, and there was a $63.33 decrease in price for each .1 in. increase in backfat thickness. Variation in these two traits explained 44 percent of the variation in the price of Chester White boars. All the regression coefficients are in the desired direction except for loin eye area in Yorkshire boars. Performance traits do not explain more than half of the variation in selling price in any breed.

A rather crude ranking of the traits can be obtained through these analyses (Table 3). These rankings indicate very little pattern except that one of the two measures of growth (age at final weight or average daily gain) generally had quite an important effect on selling price.

Both the sale order and the physical appearance of the boars may have had a profound effect on these results. Selling the boars in order of some performance index highlights the boars that are superior, but it may also inflate the price of the highest performing boar because of a desire to own the winner of the test. Certain boars have physical characteristics which may either lead or mislead a buyer at sale time. The extent to which visual appraisal was used to determine a boar's price is unknown but was probably quite large. In addition to these, certain breeders and lines of breeding may have a large impact on selling price of a boar.

Table 2. Partial regressions[a] of sale price on various performance traits

	Performance traits					
Breed	Age at Final wt ($/day)	Average daily gain ($/.1 lb)	Pen feed efficiency ($/.1 unit)	Backfat thickness ($/.1 in)	Loin eye area ($/.1 in.^{2})	R^2[b]
Chester White	−13.24**			−63.33**		.44
Duroc	−4.0*	22.84*	−18.91**	−68.24**		.42
Hampshire		70.10**		−61.34**	13.35*	.38
Spot		56.95**				.28
Yorkshire		58.99**	−56.73**	−18.15**	−14.35**	.47

[a]Change in price per unit of change indicated for each trait.
[b]Proportion of variation in price accounted for by traits having coefficients for that breed.
*P < .05.
**P < .01.

Table 3. Ranking of five performance traits in order of their importance as contributors to sale price

	Performance traits				
Breed	Age at final wt	Average daily gain	Pen feed efficiency	Backfat thickness	Loin eye area
Chester White	1	4	3	2	5
Duroc	2	4	3	1	5
Hampshire	4	1	5	2	3
Spot	5	1	4	3	2
Yorkshire	5	1	2	4	3

Fall Lambing Performance of Dorset x Finnish Landrace Sheep

K. A. Ringwall, J. V. Whiteman, R. P. Wettemann and G. A. Robson

Story in Brief

This report summarizes the reproductive performance of Dorset x Finnish Landrace (Finn) crossbred ewes. These ewes form the base group of sheep to be selected for fertility and prolificacy under fall lambing conditions.

Mating records indicate 90.0, 88.6, 72.4, 93.1 and 78.0 percent of the F_2 ewes mated during the springs of 1976 to 1980. April is more conducive to breeding than May or June. Percent lambed were 40.0, 17.1, 25.9, 44.4 and 50.0 during the past five falls. Plasma progesterone levels in 1979 indicated approximately 20 percent of the mated ewes failed to ovulate, 20 percent of the ewes that ovulated failed to conceive or maintain early pregnancy and 20 percent of the ewes that were pregnant 60 to 80 days postmating failed to lamb. Lambs per F_1 ewe lambing in the fall are 1.75, 2.00, 2.13, 1.75 and 1.63 from 1976 to 1980. Preliminary observations on F_2 ewes are also reported.

Dorset x Finn crossbred ewes and rams vary considerably in spring reproductive behavior. Some individuals perform excellently, others not at all. The reproductive variation will make selection possible when numbers are increased. Future research will attempt to develop procedures to identify the more fertile rams and ewes in each generation.

Introduction

The Rambouillet, Dorset or Dorset x Rambouillet cross are the only major sheep types currently suitable for fall lambing. However, the fall lamb production from these types does not equal spring lamb production because of fewer twins (lower prolificacy).

The Rambouillet is readily available, has excellent wool and has a long productive life. The Dorset has a higher lambing rate than the Rambouillet and produces a good market lamb. The Dorset x Rambouillet cross ewe combines the previously mentioned traits and produces more lambs than most straight-bred Dorset or Rambouillet ewes. Western Rambouillet ewes bred to Dorset rams is the common method used to produce the cross.

A ewe that is ¼ Dorset x ¼ Finn x ½ Rambouillet should have the potential to produce more twins in the fall. The addition of the ¼ Finn would utilize the high prolificacy of the Finn. However, the Finn does not breed well in the spring. Thus, fewer ewes would be expected to lamb in the fall, but the ewes that lamb should have more twins. Western Rambouillet ewes would need to be bred to ½ Dorset x ½ Finn crossbred rams to produce the ¼D¼F½R ewe.

Dorset x Finn rams selected for the fall lambing trait of Dorsets and increased twins of the Finn would help overcome the poor spring breeding aspects of Finn and Finn crossbreds. These selected rams would form a superior sire line to breed to western Rambouillet ewes to produce better fall-lambing ¼D¼F½R ewes. Currently, sufficient numbers of selected Finn-Dorset rams do not exist, and improvement is still needed.

The purpose of this project is to develop a superior fall-lambing, highly prolific line of Finnish Landrace x Dorset crossbred sheep to produce rams to breed to commercial Rambouillet ewes. The ewe lambs from this cross would be kept as improved ¼D¼F½R ewes for fall lamb production. This is a progress report on the project.

Materials and Methods

Fifteen different sources of breeding stock were used to establish the genetic base for developing the Finn x Dorset line. Future germ plasm will be added as needed. Currently, the flock numbers 179 Finn x Dorset ewes and 55 Finn x Dorset rams.

All F_1 ewes are exposed to F_1 rams for two consecutive springs to check their willingness and ability to breed in the spring. Following this check they are exposed in the fall to increase the number of second generation (F_2) lambs available.

All F_2 and future generations are exposed only in the spring, and selection of fall lambing ewes will be based on the progeny from these matings. Selection procedures to detect the most fertile rams are being developed. No hormone therapy will be used.

Ewes bred in the spring of 1979 and 1980 were bled 6 to 12 days and 60 to 80 days following matings. Plasma progesterone levels over 1 nanogram per milliliter was interpreted to mean that a ewe ovulated or was pregnant. Plasma progesterone levels were used to classify nonlambing ewes. The classifications were: mated but failed to ovulate, ovulated but failed to conceive or maintain early pregnancy and fetus lost late in pregnancy.

The crossbred line will be managed under Oklahoma pasture systems utilizing grass and wheat pasture. Supplemental feeding will be used as needed.

Results and Discussion

Table 1 shows the reproductive performance of the F_1 ewes. Spring mating activity averaged slightly less than the fall mating activity. Individual variation is accounting for a large portion of ewes in the "percent lambed" column of Table 1. Some ewes routinely breed in the spring while others will not. The lambs per ewe lambing is high for the F_1 ewes; however, lamb mortality has been high.

In 1979, 59 F_1 ewes were bled for plasma progesterone and this procedure helped explain the difference between ewes mated and ewes lambed. Fifty one of the ewes ovulated during estrus, while eight ewes expressed estrus, bred, but failed to ovulate. Thirteen of the 51 ewes that ovulated failed to conceive or maintain early pregnancy. Thirty eight of the original 59 cycling ewes maintained pregnancy 60 to 80 days, but only 30 of the ewes lambed.

In summary of the blood analysis data, approximately 20 percent of the ewes that bred failed to ovulate, approximately 20 percent of the ewes that ovulated failed to

Table 1. Reproductive performance of F_1 ewes

Breeding season	Ewes exposed	Percent mated	Percent lambed	Lambs per ewe lambing	Average birth wt
Spring 1976	10	90.0	40.0	1.75	5.23
Spring 1977	35	88.6	17.1	2.00	5.86
Spring 1978	58	72.4	25.9	2.13	5.70
Fall 1978	31	90.3	35.5[a]	2.27	6.97
Spring 1979	72	93.1	44.4	1.75	5.36
Fall 1979	53	88.0	81.1	2.33	6.66
Spring 1980	32	78.0	50.0	1.63	6.22

[a]Not a true estimate of fall breeding potential; several rams were found to be infected with Brucellosis ovis (epididymitis) following the breeding season. These rams were relatively infertile or sterile.

conceive or maintain early pregnancy and approximately 20 percent of the ewes that maintained pregnancy for 60 to 80 days lost their lambs prior to lambing. These observations involve small numbers, but do imply some of the problems when breeding nonadapted sheep during the spring.

Table 2 represents the reproductive performance of young, unselected F_2 ewes. The performance is similar to the F_1 ewes; however, lamb livability is lower. The last column in Tables 1 and 2 indicates the light birth weights, especially on the fall-born lambs and F_2 ewes. Finnish Landrace breeding, summer heat stress and nutritional complications are probably the principal factors involved in the light birth weights.

Table 2 indicates the early maturing patterns involving Finn crossbred sheep. Three-fourths of the 8-month-old ewe lambs bred in the spring at weights under 100 lb and one-third lambed.

A few ewes in the flock continue to be excellent producers during the fall and spring. These are the ewes that the selected line will be based upon to develop a superior reproductive line of fall-lambing sheep.

Table 2. Reproductive performance of F_2 ewes

Breeding season	Ewes exposed	Percent mated	Percent lambed	Lambs per ewes lambing	Average birth wt
Spring 1979	20	95.0	50.0	1.50	4.47
Spring 1980					
Aged ewes	17	64.0	29.4	1.80	5.24
Ewe lambs[a]	19	73.7	31.6	1.67	4.52[b]

[a]Ewes less than 9 months old.
[b]Only six recorded birth weights.

Repeatability of Ewe Reproductive Performance

Joe V. Whiteman and J. M. Dzakuma

Story in Brief

Lifetime reproductive records of the crossbred ewe flock (initially 263 ewes) at the Southwest Livestock and Forage Research Station were analyzed to investigate the consistency (repeatability) of reproductive performance of the ewes. The ewes were born in 1971 and 1972 during the spring and bred to lamb at 1 year of age. They lambed one or two more times during late winter, lambed twice during the fall (1974 and 1975) and then followed an accelerated lambing program involving six lambings during the next 4 years. Thus, the 75 to 80 percent of the ewes surviving had 10 or 11 lambing opportunities.

The first analysis determined average subsequent reproductive rates of ewes that produced 0, 1 or 2 lambs at 1 year of age to be 1.33, 1.49 and 1.60 respectively. The performance of the ewes at 1 year was a much better indicator of average lifetime performance than was the ewes' second record where ewes producing 0, 1, 2 or 3 lambs subsequently produced an average of 1.36, 1.42, 1.47 and 1.56 lambs per opportunity.

The third analysis calculated repeatability of reproductive rate to be 0.14 indicating an individual record chosen at random to be a poor indication of the average reproductive rate of a ewe. Only the relative reproductive rate of ewes at their first lambing opportunity (first analysis) appears to be a reasonably reliable indicator of lifetime reproduction.

Introduction

In the process of trying to develop a flock of highly productive sheep, producers select certain ewe lambs as replacements and/or cull certain producing ewes. The effectiveness of the culling is proportional to the extent that poor observed performance is an indicator of future performance, ie., how consistent animals are in their performance for different characteristics. In animal breeding terminology this consistency is referred to as the repeatability of a trait. For instance, if a producer measures the amount of wool that each ewe produces in 1 year and then measures each of the same ewes the next year, he will find there is a strong tendency for the ewes that produced the heavier fleeces the first year to produce heavier fleeces the second year and for producers of the lighter fleeces to repeat their ranking of lighter fleeces. Wool production is said to have a high repeatability, and culling a flock for poor wool production will be effective in increasing wool production.

The traits of greatest importance in determining ewe flock productivity where lambs are the principal product is the rate of reproduction or percent lamb crop. To cull ewes for poor productivity, a producer might cull on the basis of the ewe's performance at her first opportunity (lambing) or at other lambings. To know how effective this technique would be in increasing the productivity of the flock, it is necessary to determine the repeatability of reproduction rate.

The purpose of this study was to determine the value of a ewe's (1) first, (2) second or (3) any record as an indication of her overall reproductive performance.

Materials and Methods

In March and April of 1971 and 1972, 263 crossbred ewes of five combinations of Finnsheep (F), Dorset (D) and Rambouillet (R) breeding were produced at the Southwest Livestock and Forage Research Station (Ft. Reno), El Reno, Oklahoma. The five breed combinations represented were: ½D½R (55); ¼D¾R (59); ¼F½D¼R (54); ¼F¼D½R (56); and ¼F¾R (39). The ¼F¾R ewes were produced in 1972 only. The reproductive performance of these ewes when lambing in the winters of 1972, 1973, 1974 and the fall of 1974 and 1975 has been reported in *Animal Science and Industry Research Reports* of 1974, 1975 and 1976. The ewes' productivity under two cycles of accelerated lambing or lambing every 8 months (1976-1979) was reported in 1980.

The ewes were first lambed at yearly intervals in spring, 1972, late winter, 1973, and winter, 1974. In 1974, they were again bred in May and June to lamb in fall, 1974. In May-June, 1975, they were bred to lamb in fall of 1975. They were bred in winter (January-February), 1976, to lamb for the first time in summer, 1976, and after that they were bred every 8 months. The fall breeding season was (September-October) leading to winter lambing. The late-spring season (May-June) was the third breeding time for the accelerated lambing program. The ewes went through two cycles of accelerated lambing each with three breeding and lambing seasons.

During the 1971, 1972 and 1973 fall breeding seasons, purebred rams of Suffolk and Hampshire breeding were used. Starting with the late-spring, 1974, breeding, four purebred and four crossbred rams were used each season. They were of Suffolk, Hampshire, Suffolk x Hampshire or Hampshire x Suffolk breeding and were a minimum of 15 months old at breeding time.

The project was terminated after the fall of 1979 lambing at which time some of the ewes had had as many as 10 or 11 lambing opportunities.

A repeatability estimate needs to be interpretable to a normal flock consisting of one breed of ewes and rams lambing at one time of year. In order to put the data from the experimental flock on that basis, the production records of the ewes were adjusted to remove breed of ewe and breed of ram differences and also those seasonal differences that affected ewe reproductive performance.

The adjusted data were then used to determine how good an indicator of average ewe performance some records were. The *first* analysis determined the average productivity at each subsequent lambing of those ewes that produced 0, 1 or 2 lambs at their first lambing opportunity at 12 months of age. The *second* analysis ignored each ewe's first lambing and determined the average productivity at each subsequent lambing of those ewes that produced 0, 1, 2 or 3 lambs at their second lambing opportunity at about 23 months of age. The *third* analysis attempted to determine the average relationship of any individual lambing record to all other records of the ewe.

Results

If producers raise their own ewe replacements, they can treat all ewe lambs raised in any year uniformly and measure their reproductive rate under their own conditions. In order to determine how valuable a ewe's first production records would be, the first analysis was done. The results are presented in Table 1. These data indicate that ewe lambs that did not lamb at their first opportunity produced an average of 1.33 lambs per opportunity for the rest of their lives as compared to an average production of 1.49 for those producing a single or 1.60 for those producing twins at their first opportunity.

Table 2 presents the average subsequent production of ewes that produced 0, 1, 2 or 3 lambs at their second opportunity. The increase in subsequent average production for each additional one lamb produced at the second opportunity was much less than the increases shown in Table 1. This indicates that the performance of a replacement ewe at about 1 year of age is a much better predictor of her lifetime production than is her record at about 2 years of age.

The third analysis as indicated earlier was an analysis to estimate the average relationship (agreement) among many measures (records) on the same individual throughout a lifetime. The number that comes out of the analysis is called the repeatability and will always be between 0 and 1.0. A value near 0 indicates there is little consistency of performance and suggests that one record on the individual chosen at random would not be expected to be a good predictor. A value near 1.0 would suggest

Table 1. Average number of lambs born per subsequent lambing opportunity of ewes that produced 0, 1 or 2 lambs at 12 months of age

	First production rate		
Item	0	1	2
No. ewes	93	144	25
Av. subseq. prod.	1.33	1.49	1.60

Table 2. Average lambs born per subsequent opportunity to ewes producing 0, 1, 2 or 3 lambs at about 23 months of age

	Second production rate			
Item	0	1	2	3
No. ewes	45	92	109	5
Av. subseq. prod.	1.36	1.42	1.47	1.56

consistent performance, and one record at random would be a good indicator of average performance. The value that came out of the third analysis for repeatability of reproductive rate from the adjusted record for these ewes was 0.14. Since this value is near zero, these data suggest that one reproductive rate record chosen at random on one of these ewes was not a good indicator of her average reproductive performance.

Discussion

The results from analyses of the records on the lifetime performance of these ewes are in remarkable agreement with similar analyses made by other scientists under other conditions. The results from the first analysis indicate that when ewe lambs are raised under uniform conditions, and the number of lambs that they have at their first opportunity is used as an indicator of their average lifetime productivity, the predictability of that first measurement is pretty good. The ewe's lifetime performance for reproduction is the best measure that we have of her inherent fertility. The fact that at the first lambing opportunity these ewes were sorted into three groups with such widely different average lifetime productivity indicates that the first record was a reliable tool for sorting the ewes on inherent fertility.

There has been research in Australia, Canada and one or two other areas around the world using similar records either with early maturing sheep 12 months old or later maturing sheep, such as Merinos, 24 months old that indicates the first record of reared replacements has about the predictability that these analyses show, which is considered to be good predictability. Analyses of data of Rambouillet yearling ewes purchased several years ago at this station showed similar results. When these ewes were lambed first, at about 19 months of age, those yearling ewes that had twins the first time they had an opportunity to lamb were considerably more fertile, on the average, for the rest of their lifetimes than were the other ewes. These results suggest that those producers who would like to improve the productivity of their ewe flock can do so. They can produce their own ewe lambs, rear them under uniform conditions, rear more than they need and then on the basis of the first productivity of these ewes, sell those that do not lamb. Permanent identification of those that have twins would be a good idea also because such ewes should produce future replacements.

The second analysis indicates that there is some value to a ewe's second lambing record, but it is not nearly as great as the value of the first record. Producers might not find it beneficial to have their young ewes produce two lamb crops before they cull them because the second record may not give enough additional value over the first one to make the increased accuracy worthwhile. Other scientists who have studied such production records, seem to agree on the lower value of the second record.

The third analysis, which found the repeatability of .14, agrees with general opinion that as far as reproduction is concerned, one record chosen at random on an individual is not a very good predictor of reproductive performance of the individual. Because of the unreliability of such predictions, few animal breeders would recommend that older ewes be culled just because they fail to lamb one time. Among mature ewes, whether or not a ewe lambs or whether she has twins is not believed to be a very good indicator of her inherent fertility.

Ewe Weight and Condition at Breeding Time as Related to Mating Performance and Reproductive Rate

Joe V. Whiteman and Mark Detten

Story In Brief

The prebreeding weights and condition scores, mating behavior and reproductive performance of about 250 ewes involved in 8 breeding and lambing seasons over a 6-year period were studied in an effort to determine what interrelationships existed among the traits.

The relationships between breeding weights and scores and reproductive rate were of special interest. Differences in weights of different breeding groups bore no relationship to reproductive rate. However, when breed was ignored, it was found that ewes producing triplets were a little heavier than ewes producing twins, which in turn were a little heavier than ewes producing singles. Relative to the relationship of any prebreeding condition score with reproduction, the results were very dependent upon which season was involved. There was a strong tendency for fatter ewes to be more likely to conceive during the spring season and produce more lambs as compared to the thinner ewes. There appeared to be no clear relationship between the condition score and fertility or lambing rate (prolificacy) when mating was in September and October. When the breeding season was in January and February, the conception rate was high, and there was little evidence of a relationship with condition score. In contrast, there was a strong relationship between score and lambing rate with ewes scoring 4 or below producing at a considerably lower rate than those scoring higher.

Mating behavior as indicated by days to first estrus or days to conception did not appear to be related to weight or condition score but indicated a tendency for more prolific ewes to be more fertile when the breeding seasons began.

Introduction

Many opinions exist about the relationships between the weight and condition of ewes at breeding time and their reproductive performance. With reproductive rate the most important contributor to a successful sheep operation, it is obvious that any knowledge leading to a better understanding of the reproductive process might aid in developing better management practices. During the period from 1974 until 1979, a flock of ewes was managed in an intensive lambing program at the Southwest Livestock and Forage Research Station (Ft. Reno) near El Reno, Oklahoma. The flock represented five kinds of crossbred ewes, which were quite variable in weight and condition and were bred at different times during the year. They also varied widely in reproductive rate.

This study represents an effort to relate the weight and condition (degree of fatness) of the ewes of different breed crosses at breeding time to their mating behavior and reproductive rate during the different seasons.

Materials and Methods

The ewes involved in the study were various crosses of Finnish Landrace (F), Dorset (D) and Rambouillet (R) that were produced and raised at the station during 1971 and 1972. The five crosses and the initial numbers in each group were½D½R (55), ¼D3/4R (59), ¼F½D¼R (54), ¼F¼D½R (56) and ¼F3/4R (39). During 1972, 1973 and 1974 the ewes lambed during the early spring or winter. They were then switched to a fall lambing program and lambed during the fall in 1974 and 1975. This was followed by four years of accelerated lambing with a winter (Jan.-Feb.) breeding season followed by an early fall (Sept.-Oct.) breeding season followed by a late-spring (May-June) breeding season. The data for this report came from the seasons beginning with the May-June breeding season of 1974, at which time the younger ewes were about 26 months old, and ending with the May-June season of 1979 when the ewes were 8 or 9 years old.

The ewes were mated to yearling or 2-year-old Hampshire, Suffolk or blackfaced crossbred rams in single ram breeding pastures containing between 30 and 36 ewes per pasture. The mating seasons were of about 45 days duration. The ewes were examined each morning, and those with fresh chalk marks recorded.

Prior to allottment to the breeding pastures, the ewes were individually weighed and scored for condition. The scoring was on a 9-point scale where scores 1,2 and 3 were for thin ewes (extremely emaciated to thin, but strong) 4, 5 and 6 were ewes in average condition (a bit of fat over the fore rib and rump to considerable fat in these areas) and 7, 8 and 9 were for fat ewes (from a moderate cover to extremely fat). During the last 4 years of the study under accelerated lambing, most of the ewes scored from 2 to 7 prior to breeding.

Careful records were kept at lambing, and in seasons when there were many twins and some triplets, most of the ewes raised two lambs. The lambs were creep-fed and weaned at about 10 weeks of age except that a few late-born lambs were weaned as early as 7 weeks to allow their mothers to go into the breeding pastures on schedule. (There was no detectable relationship between the time during the lambing season when a ewe lambed and whether or when she conceived during the subsequent breeding period.)

The mating records of interest were 1) days to first mating and 2) days to conception. The first is an indication of the cycling behavior of the ewes when the breeding season started. If the ewes are all cycling, the average days to first mating should be about 8 or 9. Larger numbers mean that some ewes were not cycling but started during the mating period. Days to conception considered with days to first mating is an indication of conception rate. If all ewes conceive at their first mating, the two values will be the same. The larger the difference between the values, the lower the conception rate.

Results

The information in Table 1 is presented to show the average values as they existed at the different breeding periods and the reproductive rate resulting from breeding at those times. The values for the May-June season are the averages over all breeding groups for 4 years. The averages for the other two seasons are also from all breeding groups but for only 2 years each. It can be seen that the average weight of the ewes did not vary appreciably between seasons even though the ewes scored thinner just before the Sept.-Oct. breeding season. The average days to first mating were the same for the Sept.-Oct. and Jan.-Feb. seasons and indicated that practically all of the ewes were cycling at the beginning of the breeding season. The value of 15 for the May-June season indicated that many of the ewes were not cycling when the breeding season began.The average days to conception shows that the conception rate was very high in

Table 1. Average weights, scores, days to first mating, days to conception, fertility and lambing rate by season of breeding for the ewes in the study

	May-June	Sept.-Oct.	Jan.-Feb.
No. ewe records	896	419	435
Av. weight (lb)	140	144	147
Av. score	5.4	3.9	5.2
Days to 1st mating	15	9	9
Days to conception	23	19	10
No. not mating	87	15	5
Percent lambing	60.5	87.3	92.3
Lambing rate	1.43	1.77	1.66

Jan.-Feb. The value for Sept.-Oct. shows relatively poor conception, but part of this was due to rams infected with epididymitis during one fall breeding season. The conception rate was not as high during the other season when there was no health problem as it was during the winter breeding period, however. The value of 23 for the May-June period results from both fewer ewes cycling at the beginning of the breeding season and a lower conception rate of those cycling, indicating a generally lower level of fertility in the flock during the late spring season. Percent ewes lambing was good from Sept.-Oct. and Jan.-Feb. and low from May-June mating. Lambing rate was highest from Sept.-Oct. mating, lower but still pretty good from Jan.-Feb. mating and low from May-June mating. The number of ewes not mating also reflects the generally lower fertility during late spring.

Any effort to find a relationship between ewe weight and/or score and reproductive performance on a seasonal basis, i.e., from the values in Table 1, appears fruitless. Ewe weights were similar during the different breeding seasons, and condition scores were lowest prior to the most productive (most lambs) breeding season.

The data were considered on the basis of the breed of the ewes. These data are presented in Table 2. The values for the different ewe groups are the average over all lambing seasons. A study of the values shows that the different breed groups were similar in condition but varied considerably in weight. The Dorset x Rambouillet crossbred ewes were lightest in weight but were the most fertile. The ¼ Dorset 3/4 Rambouillet ewes were among the heaviest and were least prolific due probably to too much Rambouillet breeding. These differences are a reflection of the different characteristics of the breeds involved relative to fertility (percent ewes lambing) and prolificacy (lambs born per ewe lambing.) When considered over all seasons, there were no important differences in the average mating behavior of the various breed groups.

Table 2. Average weights, scores, days to first mating, days to conception, fertility and lambing rate for the different crossbred ewe groups

	½D½R	¼D3/4R	¼F½D¼R	¼F¼D½R	¼F3/4R
No. ewe records	392	444	327	393	276
Av. weight (lb)	131	149	140	144	149
Av. score	4.9	5.0	5.1	5.0	5.1
Days to 1st mating	11.6	12.4	11.2	12.2	13.4
Days to conception	18.0	18.2	17.4	18.6	18.0
Ewes not mating	18	22	19	28	20
Percent lambing (fert.)	80.4	76.2	72.0	69.8	73.0
Lambing rate (prolificacy)	1.56	1.46	1.65	1.71	1.62

The next summary considered was an examination of the weights, scores, and mating behavior of ewes that had different numbers of lambs. These values are presented in Table 3 and represent the averages of all seasons. There were 6 sets of triplets born from the 896 ewes mated during May-June compared to 17 from 435 ewes mated during Jan.-Feb. and 34 from 419 ewes mated during Sept.-Oct. These data show that for the ewes that lambed, there was a tendency in all breeding groups for ewes producing triplets to be heavier but no fatter at breeding time and to gain more weight before lambing than ewes producing twins, which were in turn larger and gained more than ewes producing singles. Ewes not lambing weighed about the same as those producing twins and singles and were in about the same condition. Perhaps the most significant values in Table 3 are those reflecting mating behavior and conception. There was a relationship between number of lambs produced and days to mating and conception. The data strongly suggest a relationship between fertility (willingness to mate at the beginning of the breeding season) and prolificacy (lambing rate). More fertile ewes also tend to be more prolific. Most of the ewes that did not lamb were not cycling at the beginning of the breeding season but did mate before the season was over.

These summaries have not shown any pattern of relationship between the condition score of the ewes at breeding and their mating behavior or reproductive rate. To determine if such a relationship existed within the breeds or seasons, a summary was done by sorting the data on a breeding score basis. Table 4 illustrates the relationship between scores and weights prior to the three breeding seasons. It is obvious that there is a strong relationship. Since any fat that an animal has stored is a part of the animal's weight, the fatter animals weighed more. The animals scored as thin (1-3) generally averaged between 100 and 140 pounds with some variation between seasons. Ewes in average condition (scores 4-6) tended to weigh between 130 to 160. Ewes scored as fat (7-8) generally averaged from 160 to 180.

Table 3. Average breeding and lambing weights and scores and days to first mating and conception for ewes producing triplets, twins, singles and no lambs

Item	Triplets	Twins	Singles	No lambs
No. ewes	57	664	575	536
Brdg. wt. (lb)	153	144	140	143
Lmbg. wt. (lb)	177	167	161	151
Brdg. score	4.9	5.1	5.0	5.0
Lmbg. score	4.9	5.3	5.4	5.2
Days to 1st mating	7.7	10.7	12.4	14.4
Days to conception	12.4	16.4	20.1	—

Table 4. The relationship between prebreeding condition score and weight of the ewes for the three seasons

Breeding Score	May-June		Sept.-Oct		Jan.-Feb.	
	no.	wt.	no.	wt.	no.	wt.
1	8	108	12	117	4	118
2	31	123	77	129	18	125
3	68	134	125	139	51	127
4	79	132	79	151	63	140
5	205	130	33	149	87	143
6	308	142	49	154	109	153
7	172	157	36	166	86	161
8	20	170	6	181	7	174

Relationships between prebreeding scores and reproductive performance were of greatest concern. These summaries are presented in Table 5 for the three seasons because there appeared to be different relationships in the different seasons. During the May-June breeding season the thin ewes were lower in both fertility and prolificacy, suggesting that better feeding prior to breeding might have improved reproduction. There was a suggestion that a score of about 6 was best for fertility and a score of 8 best for prolificacy during the spring breeding season. This breeding season followed the heaviest lambing season (winter), and it is possible that more feed would have aided recovery from lactation and preparation for breeding.

During the September-October breeding season there was no clear relationship between the score and either fertility or prolificacy. The low fertility of the ewes scoring 8 only involved six ewes and could easily have been due to chance although ewes scoring 8 were lower in fertility during all seasons. It has been observed previously in other data that fat ewes more often have lower conception rates and high lambing rates for those that do lamb.

Table 5. The reproductive performance of ewes with varying condition scores prior to the three breeding seasons

Breeding	May-June			Sept.-Oct.			Jan.-Feb.		
Score	No.	Fert.	Prolif.	No.	Fert.	Prolif.	No.	Fert.	Prolif.
1	8	12.5	1.00	12	66.7	1.63	4	100.0	1.75
2	31	29.0	1.22	77	76.6	1.85	18	94.4	1.41
3	68	36.8	1.32	125	76.0	1.73	51	94.1	1.50
4	79	50.6	1.35	79	78.5	1.68	63	95.2	1.53
5	205	62.9	1.43	33	66.7	1.68	87	89.7	1.68
6	308	68.2	1.45	63	69.4	1.85	109	96.3	1.75
7	172	58.7	1.46	36	72.2	1.92	86	90.7	1.82
8	20	45.0	1.67	6	33.3	2.00	7	71.4	2.20

During the January-February breeding season fertility was high as indicated previously. The summaries by score in Table 5 show no strong relationship between score and fertility except the previously-noted lower fertility of the few ewes scoring 8. There does appear to be a relationship between score and lambing rate. Ignoring the value for score 1 (4 ewes), there is a distinctly lower lambing rate from ewes scoring 4 or lower. This suggests that better feeding of thin ewes to be bred during early winter might be beneficial.

This summary of the records by score of the ewes prior to breeding also included the average days to first mating and days to conception. There did not appear to be any relationships between score and these values except those noted in Table 1 between season and days to first mating and conception.

A Comparison of Different Age-of-Dam and Sex Correction Factors for Birth, Weaning and Yearling Weights in Beef Cattle

Carla G. Chenette and R. R. Frahm

Story in Brief

Preweaning performance records of 2747 Angus and 1267 Hereford calves and postweaning performance records of 2591 Angus and 1178 Hereford calves were analyzed to obtain age-of-dam and sex correction factors for birth, weaning and yearling weights. Calves were born from 1964 through 1979 as part of the beef cattle selection study.

Additive age-of-dam adjustments for Hereford birth weights were +8, +3 and +2 lb and for Angus birth weights, +11, +4 and +1 lb for 2-, 3- and 4-year-old cows, respectively. Age-of-dam correction factors for 205-day weaning weight were different for each sex and breed. Additive age-of-dam correction factors for 205-day weight of bull calves were +100, +48 and +12 lb for Hereford and +70, +40 and +19 lb for Angus from 2-, 3- and 4-year-old cows, respectively. Age-of-dam correction factors for 205-day weight of heifer calves were +70, +33 and +10 lb for Hereford and +55, +32 and +12 lb for Angus from 2-, 3- and 4-year-old cows, respectively. In the case of bull calves on full feed postweaning, age-of-dam effects were not significant on postweaning gain. Thus, the effect of age of dam on yearling weight was of the same magnitude as on weaning weight. Consequently, adjusted yearling weight for bulls can be calculated by adding 160 times postweaning ADG to the 205-day weaning weight, adjusted for age of dam. In the case of heifer calves maintained on a lower plane of nutrition, age-of-dam effects on 425-day weight were different from those obtained at weaning. Thus, age-of-dam effects should be made directly on heifer yearling weights adjusted to 425 days of age. The additive age-of-dam correction factors obtained in this study for heifer 425-day weight were +44, +24 and +5 lb for Hereford and +34, +21 and +7 lb for Angus from 2-, 3- and 4-year-old cows, respectively.

When it is necessary to compare birth and weaning weights of calves of different sexes, a multiplicative correction factor is more appropriate. The appropriate procedure to correct heifer birth weights to a bull basis from these data was to multiply heifer birth weights by 1.06 for both Hereford and Angus calves. To correct heifer 205-day weaning weights to a bull basis, Hereford heifer weights should be multiplied by 1.06 and Angus heifer weights by 1.07.

Introduction

The genetic improvement obtained from selection of replacement stock is largely dependent upon the extent to which true genetic differences are expressed in performance among calves. Since environmental differences tend to reduce the effect of selection, it is desirable to minimize as many environmental sources of variation as

possible. There are many environmental factors which breeders have little control over; however, the use of correction factors to adjust for nongenetic differences among calves for age of dam and sex of calf will reduce the total effect of environmental factors and thus permit more accurate comparisons of genetic merit. The use of such factors is recommended by the Beef Improvement Federation (BIF) as well as many breed associations.

The purpose of this study was to develop correction factors for differences in age of dam and sex of calf from a large number of Hereford and Angus records and to compare these correction factors with recommendations of the Beef Improvement Federation.

Materials and Methods

The data used in this study were collected from 1964 to 1979 as part of the beef cattle selection study at the Southwestern Livestock and Forage Research Station at El Reno. Table 1 presents the number of calf records that were analyzed to obtain age-of-dam and sex correction factors for birth, weaning and yearling weights. The selection lines were established in the early 1960's to measure direct and correlated responses to selection for weaning and yearling weights in Hereford and Angus cattle. One line of Hereford cattle was selected for increased weaning weight and another for increased yearling weight. The Angus herd was divided into four lines: two selected for increased weaning weights, one for increased yearling weight and an unselected control line.

Calves were born from early February through April of each year, and actual calf weights were recorded within 24 hr of birth. Calves were maintained with their dams on native and bermudagrass pastures without creep feed until weaning at an average age of 205 days. Following a 2-week warm-up period after weaning, all bull calves were placed on full feed for a 160-day gain test through 1971 and a 140-day test in subsequent years. Heifers were grazed out on wheat pasture, supplemented with prairie hay, alfalfa and concentrate to gain from .75 to 1.00 lb/day, and long yearling weights were taken at an average age of 425 days.

Calf records were analyzed by least squares procedures with year, sex, age of dam and all two-factor interactions in the full model to obtain age-of-dam and sex correction factors. Calf records from dams over 10 years of age were eliminated from the analysis.

Results and Discussion

Additive vs. multiplicative correction factors

Both additive and multiplicative correction factors have been used to adjust calf weights for differences due to environmental factors such as age of dam and sex. Additive factors are derived by choosing a standard such as average calf weaning weight from mature dams and using the difference between the standard and another particular sub-class average such as average weaning weight from calves raised by 2-year-old cows as the correction. The appropriate sub-class difference is added to a particular calf's birth, weaning or yearling weight to make adjustment to the standard basis. With multiplicative factors, calf weight is multiplied by the ratio of standard (i.e.

Table 1. Number of observations for each trait by breed and sex of calf

	Angus			Hereford		
Trait	Bulls	Heifers	Overall	Bulls	Heifers	Overall
Birth weight	1417	1330	2747	635	632	1267
Weaning weight	1417	1330	2747	635	632	1267
Yearling weight	1332	1259	2591	567	611	1178

average calf weaning weight from mature cows) to the particular sub-class average (i.e. average weaning weight from calves raised by 2-year-old cows).

Additive correction factors are the same regardless of calf weight while multiplicative adjustments increase or decrease weight proportional to the existing weight of the calf. Both types of corrections are approximately the same for calves that have average or near-average weights but are different for animals at extreme heavy or light weights. The type of factor also affects variation within adjusted groups in different ways. Additive corrections do not alter variance within adjusted groups while multiplicative factors raise or lower variance depending on whether factors are larger or smaller than 1.00. Ideally, correction factors should equalize both the averages between adjusted groups and variances within adjusted groups.

BIF recommendations for age-of-dam corrections are additive factors. The data from this study also indicate additive factors are most appropriate when variances between age-of-dam subclasses for a particular breed are approximately equal for each trait considered. Multiplicative factors would cause the variances to diverge, which is undesirable. However, when considering sex adjustments, BIF recommends multiplicative factors. These data are again in agreement as variances of heifer subclasses for each trait are consistently smaller than bull subclasses; therefore, multiplicative factors would tend to give more equality of variance within adjusted groups.

Birth weight

Birth weight is of importance to producers because of its strong relationship with calving difficulty. It is well documented that calf birth weight increases with advancing cow age and that bull calves tend to weigh more than heifer calves. Therefore, to compare differences in calf birth weights, adjustments for age of dam and sex should be made.

The sex by age-of-dam interaction was not significant, indicating that the same age-of-dam adjustment is appropriate for both bulls and heifers. Table 2 presents additive age-of-dam correction factors for birth weight. On the average, Angus calves raised by 2-year-old cows were 8 lb lighter at birth than calves from mature Angus cows, which agrees with BIF recommendations; however, Hereford calves from first-calf heifers were 11 lb lighter than calves from mature cows. To adjust birth weights for calves from 3-year-old cows to a mature-dam basis, 3 and 4 lb for Angus and Hereford calves, respectively, should be added to actual birth weights, while adjustments for calves from 4-year-old cows are 2 and 1 lb, respectively. These adjustments are in agreement with BIF, that suggests 5- and 2-lb corrections for calves from 3- and 4-year-old cows, respectively.

Heifer calves can be adjusted to a bull basis by multiplying their birth weight by 1.06 for both Hereford and Angus breeds (Table 5). The recommendation of BIF is slightly higher (1.07).

Weaning weight

A trait of major economic importance to breeders is calf weaning weight as it represents pounds of saleable product. It is also important to evaluate weaning weights

Table 2. Additive age of dam correction factors for birth weight

	OSU data		
Age of dam	Angus (lb)	Hereford (lb)	BIF (lb)
2-year-old	+8	+11	+8
3-year-old	+3	+4	+5
4-year-old	+2	+1	+2
5- to 10-year-old	0	0	0

to obtain estimates of differences in cow mothering ability and calf growth potential to aid in selection of replacements and culling of cows. Weaning weights in this study were first adjusted to an average calf age of 205 days by the following formula:

$$\text{205-day weaning weight (lb)} = \frac{\text{actual weaning wt - birth wt}}{\text{age in days}} \times 205 + \text{actual birth weight}$$

Since the age-of-dam by sex interaction was significant ($P<.05$) for both Hereford and Angus calves, separate age-of-dam corrections were developed for each sex within each breed (Table 3). Adjustments to put weaning weights on a mature-dam basis for Angus bulls were +70, +40 and +19 lb for calves from 2-, 3- and 4-year-old cows, respectively, while heifer calf adjustments were smaller at +55, +32 and +12 lb, respectively. Weaning weight adjustments for Hereford calves differed from Angus correction factors. Additive corrections for Hereford bull calves were +100, +48 and +12 lb for 2-, 3- and 4-year-old dams, respectively. Heifer adjustments, like the Angus data, were smaller at +70, +33 and +10 lb, respectively.

BIF recommendations (Table 3) tend to be lower for 2-year-old dam adjustments, approximately the same for 3-year-old dams and slightly higher for 4-year-old dams. Part of these differences may be explained by the range conditions on which cows and calves were maintained. Milk-producing ability of 2-year-old dams may have been hindered by nutritional conditions common in Oklahoma while BIF recommendations are generalized for the average of calves throughout the entire country.

Once weaning weights have been adjusted to a constant calf age and mature-dam basis, producers may wish to adjust for sex differences so comparisons of cows' progeny may be made. This can be done by multiplying 205-day, age-of-dam-adjusted heifer weaning weights by 1.07 for Angus and 1.06 for Hereford to put them on a bull standard basis (Table 5).

Yearling weight

Yearling weight is an important indicator of growth performance and thus receives considerable attention in many performance testing programs. Only animals that have been treated alike since weaning should be compared for this trait. Normally, yearling weights are computed and reported for each sex separately since heifer and bull calves usually are placed under different postweaning management systems. Yearling weights adjusted to 365 and 425 days for bulls and heifers, respectively, were analyzed to determine age-of-dam correction factors.

Table 4 presents age-of-dam adjustments for postweaning ADG and yearling weights. Age of dam had no significant effect for bull calves of each breed on postweaning ADG. Age-of-dam effects on 365-day yearling weights for bull calves are of approximately the same magnitude as age-of-dam effects at weaning. For these reasons, this study is in agreement with BIF and suggests adjusted 365-day weight for Hereford and Angus bull calves on full feed postweaning should be calculated as follows:

$$\text{adjusted 365 day weight (lb)} = \frac{\text{actual final wt - actual wn wt}}{\text{numbers of days between wts}} \times 160 + \text{205-day, age of dam adj wn wt}$$

Table 3. Additive age of dam correction factors for weaning weights

	OSU data					
	Angus (lb)		Hereford (lb)		BIF (lb)	
Age of dam	Bulls	Heifers	Bulls	Heifers	Bulls	Heifers
2-year-old	+70	+55	+100	+70	+60	+54
3-year-old	+40	+32	+48	+33	+40	+36
4-year-old	+19	+12	+12	+10	+20	+18
5- to 10-year-old	0	0	0	0	0	0

Table 4. Additive age of dam correction factors for postweaning ADG and yearling weights

Trait	Age of dam	OSU data			
		Angus		Hereford	
		Bulls[a]	Heifers	Bulls[a]	Heifers
Postweaning ADG(lb/day)	2	0	−.09	0	−.11
	3	0	−.05	0	−.04
	4	0	−.02	0	−.02
	5	0	0	0	0
Yearling wt (lb)[b]	2	+71	+34	+81	+44
	3	+44	+21	+49	+24
	4	+16	+7	+1	+5
	5				

[a]Overall F test for age of dam not significant (P< .25).
[b]365-day adjusted weights for bulls and 425-day adjusted weights for heifers.

Table 5. Multiplicative correction factors to correct heifer weights to a bull basis

	OSU data		BIF
	Angus	Hereford	
Birth weight	1.06	1.06	1.07
205-day weaning weight	1.07	1.06	NA[a]

[a]Not available; no BIF recommendation for sex correction of weaning weights.

However, this study suggests that when considering adjustments for long yearling weights of heifer calves managed at a lower nutritional level after weaning, other calculations should be used. Yearling weight correction factors for Angus heifers are +34, +21 and +7 lb for 2-, 3- and 4-year-old dams, respectively, while Hereford heifer adjustments are +44, +24 and +5 lb, respectively (Table 4). The postweaning ADG age-of-dam adjustments suggest a compensatory gain of heifers raised to weaning by younger cows in both Hereford and Angus breeds. Also, the magnitude of age-of-dam correction factors for heifers at weaning is larger than for those used to adjust 425-day weight. Therefore, this study indicates heifer weights adjusted to 425 days of age should be directly adjusted for age-of-dam effects rather than adding the postweaning gain to age-of-dam adjusted weaning weights as recommended for bulls.

Reproductive Performance of Various Two-Breed Cross Cow Groups

D. M. Marshall, R. R. Frahm and C. G. Chenette

Story in Brief

Eight crossbred cow groups (Hereford-Angus, Angus-Hereford, Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus, Brown Swiss-Hereford, Jersey-Angus and Jersey-Hereford) were mated to Charolais and Limousin bulls to produce three-breed cross calves over a 2-year period. A total of 404 and 390 crossbred cows were exposed to breeding for the 1978 and 1979 calf crops, respectively.

The percentage of cows exposed to breeding that weaned a calf was similar for Brown Swiss-Angus, Jersey cross and Hereford-Angus cows (averaged 77.8 percent). Angus-Hereford, Brown Swiss-Hereford and Simmental cross cows were similar and weaned a lower percentage of calves (averaged 68.4 percent).

Birth weights were heaviest for calves from Brown Swiss cross and Simmental cross cows (82.3 lb) followed by reciprocal Hereford-Angus cross cows (77.3 lb) and Jersey cross cows (72.8 lb).

Simmental cross and Hereford-Angus cows required the most calving assistance (13.5 percent) followed by Angus-Hereford, Brown Swiss cross and Jersey-Hereford cows (6.7 percent) and Jersey-Angus cows (3.7 percent).

Introduction

Reproductive efficiency must be maximized to achieve economic success in a commercial cow-calf operation. Research has shown that planned crossbreeding systems can effectively increase the percent calf crop weaned and pounds of calf weaned per cow exposed to breeding.

A large portion of this increased productivity through crossbreeding is due to using a crossbred cow. An extensive study is thus in progress at the Oklahoma Agricultural Experiment Station to evaluate the lifetime productivity of various two-breed cross cows when mated to bulls of a third breed. The purpose of this study was to compare the reproductive performance of various two-breed cross cow groups over two calving seasons.

Experimental Procedure

Angus and Hereford cows were mated to Angus, Hereford, Simmental, Brown Swiss and Jersey bulls to produce two-breed cross calves in 1973, 1974 and 1975. Four different sires of each breed were used each year. All heifer calves (a total of 434) produced by these matings were kept in the herd for evaluation of lifetime productivity as cows. Productivity as 2- and 3-year-olds has been reported by Belcher *et al.* (1978) and Frahm *et al.* (1979). Two-breed cross cows were mated to Charolais and Limousin bulls to produce three-breed cross calves in the spring of 1978 and 1979. A total of 404, 3-, 4- and 5-year-old cows were exposed to breeding to produce the 1978 calves, with 390 of these cows being exposed to breeding the following year as 4-, 5- and 6-year-olds. Eight different Limousin bulls were used each year, while a total of thirteen Charolais sires were used over the 2 years (three of the Charolais bulls were used both years).

The cow herd was managed on native and bermudagrass pasture at the Lake Carl Blackwell Research Range west of Stillwater. However, 35 cows produced and reared their 1978 calves in drylot at the Southwestern Livestock and Forage Research Station at El Reno. Calves were born primarily in February and March of each year and remained with their dams until weaning at an average age of 205 days.

Results and Discussion

Reproductive performances are summarized in Table 1. Overall, 82.1 percent of all cows exposed to breeding calved and 73.1 percent weaned a calf. There was a 4.9 percent calf mortality rate at or within one day of birth and an additional 4.1 percent death loss to weaning. The 73.1 percent calf crop weaned is lower than expected primarily due to the fact that half of the cow herd was artificially inseminated without benefit of clean-up bulls.

The percentage of cows exposed to breeding that weaned a calf was similar for Brown Swiss-Angus, Jersey cross and Hereford-Angus cows, averaging 77.8 percent.

Table 1. Reproductive performance of two-breed cross cows

Crossbred cow group	No. cows exposed	% calving[2]	% live calves born[2]	% calves weaned[2]
Hereford-Angus	87	86.2	83.9	78.2
Angus-Hereford	101	81.4	76.4	69.6
Simmental-Angus	121	77.7	72.0	67.0
Simmental-Hereford	84	77.2	69.9	67.6
Brown Swiss-Angus	90	81.1	81.1	78.9
Brown Swiss-Hereford	86	75.4	69.5	69.5
Jersey-Angus	111	91.0	84.7	78.5
Jersey-Hereford	114	86.9	79.8	75.5
Overall	794[1]	82.1	77.2	73.1

[1]In 1977, 404 cows were exposed to breeding to produce calves in 1978; 390 of these cows were exposed to breeding the following year.
[2]Based on number of cows exposed to breeding.

Table 2. Calving difficulty and birth weight from two-breed cross cows

Crossbred cow group	No. calves born	Birth wt (lb)	Calving difficulty score[2]	Calving difficulty, % 1978	1979	Average
Hereford-Angus	75	78.5^{cd}	1.38^{a}	12.8	11.3	12.1
Angus-Hereford	82	76.1^{de}	1.23^{abc}	12.4	2.3	7.4
Simmental-Angus	94	80.9^{bc}	1.33^{ab}	16.6	10.0	13.3
Simmental-Hereford	65	81.6^{abc}	1.26^{abc}	18.4	11.9	15.2
Brown Swiss-Angus	73	82.1^{ab}	1.18^{abc}	11.9	2.7	7.3
Brown Swiss-Hereford	65	84.7^{a}	1.13^{bc}	7.7	4.2	6.0
Jersey-Angus	101	72.2^{f}	1.05^{c}	5.4	1.9	3.7
Jersey-Hereford	99	73.5^{ef}	1.10^{c}	5.4	6.6	6.0
Total or average	654	78.7	1.21	11.3	6.4	8.9

[1]Percent calving difficulty is based on cows calving and is the percentage of births receiving a calving difficulty score of 3, 4 or 5.
[2]Calving difficulty scores: 1= no difficulty, 2= little difficulty, 3= moderate difficulty, 4= major difficulty and 5= caesarian.
^{abcdef}Means in the same column that do not share at least one superscript are significantly different at the .05 probability level.

On the average, 9.4 percent fewer Angus-Hereford, Brown Swiss-Hereford and Simmental cross cows weaned calves, averaging 68.4 percent.

Table 2 presents calf birth weight, calving difficulty score and percent cows requiring calving assistance for each crossbred cow group. Calf birth weights were heaviest from Brown Swiss cross and Simmental cross cows (averaged 82.3 lb) followed by reciprocal Hereford-Angus cows (averaged 77.3 lb). Jersey cross cows produced calves with the lightest birth weights, averaging 72.8 lb.

A calving difficulty score was assigned by the herdsman for each birth. Overall, calving score averaged 1.21, ranging from 1.38 for Hereford-Angus cows to 1.08 for Jersey crosses. The lower incidence of calving difficulty in Jersey crosses is probably due in part to the lower average birth weight (72.9 lb) of their calves as compared to the other crossbred groups. However, while calves from Brown Swiss cross cows had the highest average birth weight (83.4 lb), they did not experience as much difficulty in calving as the Simmental cross or Hereford-Angus reciprocal cross cows. Calving

difficulty is probably more closely related to calf birth weight in relation to dam weight than to calf birth weight alone. Percent calving difficulty is the percentage of births requiring assistance from the herdsman. Calving scores of 3 or higher were classified as difficult births based on a scoring system ranging from 1 = no assistance to 5 = caesarian birth or abnormal presentation. Due to the substantially higher incidence of calving difficulty in 1978 over 1979 (11.3 percent vs. 6.4 percent), means are presented separately for the two years. The cows being a year older in 1979 likely accounted for the decrease in percentage of difficult births from the previous year. The means for the 2 years are averaged for comparison purposes. Calving difficulty averaged 8.9 percent across all crossbred cow groups. Simmental cross and Hereford-Angus cows required the most calving assistance (13.5 percent) followed by Angus-Hereford, Brown Swiss cross and Jersey-Hereford cows (6.7 percent). Only 3.7 percent of the Jersey-Angus cows required assistance calving.

Literature Cited

Belcher, C. G.,R. R. Frahm, L. W. Knori and E. N. Bennett. 1978. Okla. Agr. Exp. Sta. Res. Rep. MP-103:105.

Frahm, R. R., C. G. Belcher; L. Knori and E. N. Bennett. 1979. Okla. Agr. Exp. Sta. Res. Rep. MP-104:125.

Productivity Comparisons Among Various Two-Breed Cross Cow Groups

R. R. Frahm, D. M. Marshall and C. G. Chenette

Story in Brief

Productivity was measured on eight different two-breed cross cow groups (Hereford-Angus, Angus-Hereford, Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus, Brown Swiss-Hereford, Jersey-Angus and Jersey-Hereford) when mated to Charolais and Limousin bulls. Preweaning performance was analyzed on the three-breed cross calves produced by 404 cows in 1978 and 390 cows in 1979.

Brown Swiss cross and Simmental-Angus cows produced calves that were 67 lb (12.3 percent) heavier and Simmental-Hereford and Jersey cross cows produced calves 34 lb (7.2 percent) heavier at weaning than reciprocal Hereford-Angus cows. Conformation scores were average choice or higher for calves from all crossbred cow groups.

Herd productivity, measured as pounds of calf weaned per cow exposed to breeding, was similar for Simmental cross and reciprocal Hereford-Angus cows. Productivity was highest for Brown Swiss-Angus cows, exceeding that of reciprocal Hereford-Angus cows by 20.9 percent. Jersey cross and Brown Swiss-Hereford cows were more productive than reciprocal Hereford-Angus cows by 10.9 and 4.9 percent, respectively.

Cow efficiency, measured as the ratio of calf weaning weight to cow metabolic size, favored Jersey cross cows over reciprocal Hereford-Angus cows by 16.7 percent. Brown

Swiss cross and Simmental cross cows were more efficient than reciprocal Hereford-Angus cows by 9.4 and 4.0 percent, respectively.

Introduction

Increasingly, crossbreeding is being utilized to increase efficiency in beef production. Considerable research has indicated planned crossbreeding systems can result in an increase in herd productivity of 20 to 25 percent. Over half of this increased productivity results from using crossbred cows. Consequently, an extensive research program is in progress at the Oklahoma Agricultural Research Station to compare lifetime productivity of various two-breed cross cows when mated to bulls of a third breed. The purpose of this study was to compare productivity of various two-breed cross cows when mated to Charolais and Limousin bulls.

Experimental Procedures

Eight different two-breed cross cow groups (Hereford-Angus, Angus-Hereford, Simmental-Angus, Simmental-Hereford, Brown Swiss-Angus, Brown Swiss-Hereford, Jersey-Angus and Jersey-Hereford) were mated to Charolais and Limousin bulls to produce calves in the spring of 1978 and 1979. Eight different Limousin bulls were used each year and a total of 13 Charolais bulls were used over the two years, three of them being used both years. In 1978 the herd consisted of 404 three-, four- and five-year-old cows, and in 1979 the herd consisted of 390 four-, five- and six-year-old cows.

Cows were managed on native and bermudagrass pasture at the Lake Carl Blackwell Research Range west of Stillwater, with the exception of 35 cows maintained in drylot at the Southwestern Livestock and Forage Research Station at El Reno for the 1978 calf crop. Cows were exposed to breeding from May 1 to July 15 each year; thus, calves were born primarily in February and March. Calves remained with their dams without creep feed until weaning in the fall at an average age of 205 days.

All traits were analyzed by general least squares procedures. Production traits presented for each crossbred cow group have been adjusted for all significant main effects and two-factor interactions, as appropriate, based on preliminary analyses.

Results and Discussion

Performance to weaning for the three-breed cross calves produced by each crossbred cow group are presented in Table 1. For ease of comparison, averages for each crossbred cow group are presented in actual units and also as a percentage of the average performance of the Hereford-Angus reciprocal crosses. Calves from Hereford-Angus reciprocal cross cows averaged 1.85 lb/day from birth to weaning. Higher levels of lactation achieved by Simmental, Brown Swiss and Jersey cross cows (Belcher *et al.*, 1980) resulted in 6.7 to 12.7 percent more rapid calf growth from birth to weaning. Most rapid gain was achieved by calves from Brown Swiss-Angus, Simmental-Angus and Brown Swiss-Hereford cows (averaged 2.06 lb/day). Calves from Jersey cross and Simmental-Hereford cows gained slightly less rapidly (averaged 1.99 lb/day).

The average 205-day weaning weight for all calves (averaged over two years and both sexes) was 500 lb. The more rapid preweaning growth rate of calves from Simmental, Brown Swiss and Jersey cross cows resulted in weaning weights ranging from 5.8 to 13.1 percent heavier at weaning time than the calves from reciprocal Hereford-Angus cross cows, which averaged 466 lb. Heavier birth weights also contributed to the heavier weaning weights of calves from Brown Swiss cross and Simmental cross cows. Calves from Brown Swiss-Angus, Simmental-Angus and Brown Swiss-Hereford cows were heaviest at weaning, averaging 523 lb (67 lb heavier than

Table 1. Performance to weaning of calves produced by two-breed cross cows mated to Charolais and Limousin bulls[1]

Crossbred cow group	No. calves	Preweaning ADG lb/day	Preweaning ADG %HA,AH	205-day weaning weight[2] lb	205-day weaning weight[2] %HA,AH	Weaning score conformation[3]	Weaning score condition[4]
Hereford-Angus	66	1.82^{d}	98.1	462^{e}	99.1	13.7^{c}	5.1
Angus-Hereford	69	1.89^{d}	101.9	470^{e}	100.9	13.8^{bc}	5.1
Simmental-Angus	79	2.06^{ab}	111.1	523^{a}	112.2	14.2^{a}	5.2
Simmental-Hereford	56	2.01^{bc}	108.4	508^{bc}	109.0	14.0^{b}	5.1
Brown Swiss-Angus	70	2.09^{a}	112.7	527^{a}	113.1	13.9^{bc}	5.0
Brown Swiss-Hereford	59	2.04^{abc}	110.0	520^{ab}	111.6	14.0^{b}	5.0
Jersey-Angus	87	1.98^{c}	106.7	493^{d}	105.8	13.4^{d}	5.1
Jersey-Hereford	85	1.98^{c}	106.7	498^{cd}	106.9	13.5^{d}	5.1
Total or average	571	1.98	—	500	—	13.8	5.1

[1]Crossbred cow group means are presented in actual units and, for ease of comparison, are also presented as a percentage of the average performance of the reciprocal Hereford-Angus crosses.
[2]Weaning weights adjusted for age of dam and averaged over sexes.
[3]Conformation score: 13= average choice and 14= high choice.
[4]Condition score: 1= very thin to 5= average to 9= very fat; differences among crossbred cow groups were not significant.
[a,b,c,d,e]Means in a column that do not share at least one common superscript are significantly different at the .05 probability level.

Table 2. Herd productivity, cow weights and measures of cow efficiency[1]

Crossbred cow group	Lbs of calf weaned per cow exposed lbs	Lbs of calf weaned per cow exposed %HA,AH	Avg cow weight[2] lbs	Avg cow weight[2] %HA,AH	Calf wn wt ÷ cow wt ratio	Calf wn wt ÷ cow wt %HA,AH	Calf wn wt ÷ cow metabolic wt[3] ratio	Calf wn wt ÷ cow metabolic wt[3] %HA,AH
Hereford-Angus	361	104.9	929^{cd}	101.6	.488^{f}	97.6	2.69^{f}	98.0
Angus-Hereford	327	95.1	900^{d}	98.4	.512de	102.4	2.80^{de}	102.0
Simmental-Angus	350	101.7	964^{ab}	105.4	.524^{cd}	104.8	2.91^{cd}	106.0
Simmental-Hereford	343	99.7	990^{a}	108.3	.500^{ef}	100.0	2.80^{e}	102.0
Brown Swiss-Angus	416	120.9	932^{c}	101.9	.550^{b}	110.0	3.04^{b}	110.7
Brown Swiss-Hereford	361	104.9	943^{bc}	103.1	.538^{bc}	107.6	2.97^{bc}	108.2
Jersey-Angus	387	112.5	795^{e}	86.9	.606^{a}	121.2	3.21^{a}	116.9
Jersey-Hereford	376	109.3	797^{e}	87.2	.603^{a}	120.6	3.20^{a}	116.6
Average	365	—	906	—	.540	—	2.95	—

[1]Crossbred cow group means are presented in actual units and, for ease of comparison, are also presented as a percentage of the average performance of the reciprocal Hereford-Angus crosses.
[2]Average of spring weights after calving and prior to breeding and fall weight after weaning.
[3]Metabolic cow weight equals cow weight raised to the .75 power.
[a,b,c,d,e,f]Means in the same column that do not share at least one common superscript are slightly different at the .05 probability level.

calves from reciprocal Hereford-Angus cows). Weaning weights of calves from Simmental-Hereford and Jersey cross cows averaged 34 lb heavier than calves from reciprocal Hereford-Angus cows.

In spite of the great diversity among crossbred cow groups, overall, the calves were very uniform and had acceptable conformation. Differences among crossbred cow groups, although significant, were not large (ranging from average to low choice). Apparently, Charolais and Limousin bulls are able to compensate for lack of muscling in some crossbred cow groups and produce growthy calves with adequate conformation to make them desirable as feeder cattle. Condition scores were similar for calves from all crossbred cow groups.

Cow weights, herd productivity and cow efficiency are presented in Table 2. Comparisons among crossbred cow groups in total productivity for the breeding herd were made by combining the percentage of cows exposed to breeding that weaned calves with the respective weaning weights to obtain pounds of calf weaned per cow exposed in the breeding herd. There was a rather large, unexpected and unexplainable difference of 34 lb in productivity of reciprocal Hereford-Angus crosses. In spite of this sizable difference, reciprocal Hereford-Angus crosses were averaged for purposes of comparison with other crossbred groups. On this basis the Simmental crosses and reciprocal Hereford-Angus crosses had similar productivity per cow exposed to breeding (averaged 345 lb). Herd productivity was highest for Brown Swiss-Angus, exceeding reciprocal Hereford-Angus cows by 20.9 percent. Jersey cross and Brown Swiss-Hereford cows were more productive than reciprocal Hereford-Angus cows by 10.9 and 4.9 percent, respectively.

Cow weights are the average of spring weight after calving and prior to breeding and fall weight after weaning. Thus, only cows weaning a calf are included in the calculation of cow weights. Average cow weights were lightest for Jersey cross cows (796 lb) followed by Brown Swiss cross and reciprocal Hereford-Angus cows (averaged 926 lb). Simmental cross cows were heaviest at 977 lb. Since these cow weights are the average of 1978 (based on 3-, 4- and 5-year-old cows) and 1979 (based on 4-, 5- and 6-year-old cows), mature weights for each crossbred cow group will likely be heavier than these values.

Larger cows require more feed for body maintenance, and, thus, need to wean larger calves in order to be competitive with smaller cows in efficiency of production. Two different measures of cow efficiency are presented in Table 2. Both measures rank the crossbred cow groups in exactly the same order.

One measure of cow efficiency is the ratio of calf weaning weight to cow weight. Larger ratios are indicative of more efficient cows. On this basis, Jersey cross cows were most efficient, weaning calves 60.4 percent of their body weight followed by Brown Swiss cross cows that weaned calves 54.6 percent of their body weight. Simmental cross and reciprocal Hereford-Angus cross cows were similar and weaned calves 50.6 percent of their body weight on the average.

Nutritional requirements to maintain a cow of a particular size depend upon the metabolic body size of the animal, which can be estimated as the animal's weight taken to the 0.75 power. Since differences in feed requirements among crossbred cow groups should be estimated with more precision when based on metabolic cow size, the ratio of calf weaning weight to cow metabolic body weight was calculated as a second measure of cow efficiency. On this basis, Jersey cross cows were most efficient (16.7 percent more efficient than Hereford-Angus crosses). Brown Swiss cross and Simmental cross cows were 9.4 and 4.0 percent more efficient than reciprocal Hereford-Angus cows.

These data suggest some relatively large differences in herd productivity among crossbred cows approaching maturity. These differences in herd productivity and

measures of cow efficiency are similar to what was obtained when these cows were younger (Belcher *et al.*, 1978; Frahm *et al.*, 1979, for productivity of 2- and 3-year-old cows, respectively).

Literature Cited

Belcher, C. G., R. R. Frahm, L. W. Knori and E. N. Bennett. 1978. Okla. Agr. Exp. Sta. Res. Rep. MP-103:105.

Belcher, C. G., R. R. Frahm, D. R. Belcher and E. N. Bennett. 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:6.

Frahm, R. R., C. G. Belcher, L. Knori and E. N. Bennett. 1979. Okla. Agr. Exp. Sta. Res. Rep. MP-104:125.

Performance to Weaning of Three-Breed Cross Calves Sired by Charolais and Limousin Bulls

D.M. Marshall, R.R. Frahm and C.G. Chenette

Story in Brief

Various two-breed cross cow groups were mated to Charolais and Limousin bulls to produce a total of 574 three-breed cross calves over a two-year period. Average birth weights were 81.2 lb and 76.2 lb for calves produced from Charolais and Limousin sires, respectively. Calving assistance was required for 12.4 percent of Charolais-sired calves and 4.0 percent of the Limousin-sired calves. Charolais-sired calves outgained Limousin-sired calves by .11 lb/day from birth to weaning (2.04 **vs.** 1.93 lb/day) and were 29 lb heavier at weaning (515 **vs.** 486 lb). At weaning, calves from both sire breeds were very uniform and had quite acceptable conformation scores.

Introduction

Previous research has well established that systematic crossbreeding can substantially increase efficiency of beef production. An extensive research program is in progress at the Oklahoma Agricultural Experiment Station to evaluate lifetime productivity of various two-breed cross cows when mated to bulls of a third breed. The breed of sire used in this type of system is important to produce growthy, efficient three-breed cross calves which will perform adequately in the feedlot and have desirable carcasses. The purpose of this study was to compare the performance to weaning of three-breed cross calves sired by Charolais and Limousin bulls.

Experimental Procedure

Charolais and Limousin bulls were mated to eight different crossbred cow groups (Hereford x Angus, Angus x Hereford, Simmental x Angus, Simmental x Hereford,

Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus and Jersey x Hereford) to produce three-breed cross calves in the spring of 1978 and 1979. The cow herd consisted of 3-, 4- and 5-year-old and 4-, 5- and 6-year-old cows at the time of calving in 1978 and 1979, respectively. A different set of eight Limousin sires was used each year, while a total of 13 Charolais sires were used over the two breeding seasons (three of the Charolais sires were used both seasons). A total of 291 calves were sired by Charolais bulls over the two years while Limousin bulls sired 283 calves over the same period.

The cow herd is located at the Lake Carl Blackwell Research Range west of Stillwater and managed on native and bermudagrass pastures. However, 35 of the calves produced in 1978 were born and reared to weaning in drylot at the Southwest Livestock and Forage Research Station at El Reno. Calves were born primarily during February-March each year. For each calving, a score was assigned by the herdsman to indicate level of calving difficulty on a scale ranging from 1 = no difficulty to 5 = caesarian birth or abnormal presentation. Birth weights were also obtained within 24 hours of calving. Calves were weaned at an average age of 205 days, at which time each calf was weighed and assigned a subjective condition score and conformation score by a panel of at least three persons.

Results and Discussion

Means of the various traits measured to weaning for the crossbred calves of each sire breed are presented in Table 1. Mean performance has been averaged over both sexes for the 2 years. On the average, Charolais-sired calves were 5.0 lb heavier at birth than calves produced by Limousin sires. This difference in birth weight likely accounts for most of the 8.4 percent higher incidence of calving difficulty experienced by calves sired by Charolais bulls. Percent calving difficulty is the percentage of births receiving a calving score of 3, 4 or 5.

Growth performance to weaning significantly favored Charolais-sired calves. Calves sired by Charolais bulls outgained Limousin-sired calves by .11 lb/day from birth to weaning. Heavier birth weight and more rapid rate of growth resulted in

Table 1. Performance to weaning of three-breed cross calves sired by Charolais and Limousin bulls

	Breed of sire[1]		Difference
Trait	Charolais	Limousin	Charolais-Limousin
Number of calves	291	283	—
Birthweight, lb	81.2	76.2	5.0**
Calving difficulty score[2]	1.31	1.11	.20**
Calving difficulty, %[3]	12.4	4.0	8.4**
Preweaning ADG, lb/day	2.04	1.93	.11**
205-day weaning weight, lb[4]	515	486	29**
Weaning conformation score[5]	13.9	13.8	.10*
Weaning condition score	5.2	5.0	.20**

[1]Means are averaged over years and sexes.
[2]Calving difficulty: 1= no difficulty, 2= little difficulty, 3= moderate difficulty, 4= major difficulty and 5= caesarian.
[3]Percent calving difficulty is the percentage of births receiving a calving difficulty score of 3,4 or 5.
[4]Weaning weights were adjusted for age of calf and age of dam.
[5]Conformationscore equivalents: 12= low choice, 13= average choice and 14= high choice.
[6]Condition score equivalents: range from 1= very thin to 5= average to 9= very fat.
*Differences significant at the .05 probability level.
**Differences significant at the .01 probability level.

Charolais-sired calves averaging 29 lb heavier at weaning than Limousin-sired calves. Average conformation scores were quite acceptable for calves from both sire breeds with the Charolais-sired calves having only a slight advantage. Charolais-sired calves also had a slightly higher condition score.

In spite of the large diversity in the kinds of crossbred cow groups involved, calves from both sire breeds were very uniform and quite acceptable as feeder calves. There is good rationale for selecting either sire breed. Charolais would be the sire breed of choice on the basis of weaning weight, whereas Limousin would be the breed of choice on the basis of lighter birth weight and less calving difficulty.

As a group, the three-breed cross calves performed quite well to weaning and were a uniform, desirable set of feeder calves that performed quite satisfactorily in the feedlot. Feedlot performance and carcass evaluation of the crossbred calves born in 1978 were reported by Frahm *et al.*,(1980).

Literature Cited

Frahm, R.R., S.H. Peterson, D.L. Beerwinkle, L.E. Walters and J. Eason, 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:1.

FOODS AND CARCASS EVALUATION

Carcass Trends in an Oklahoma Youth Barrow Show

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Story in Brief

Data from 803 barrows—97 Berkshire, 104 Chester White, 117 Duroc, 112 Hampshire, 90 Poland China, 70 Spot, 101 Yorkshire and 112 Crossbreds—slaughtered in the Oklahoma City 4-H and FFA Livestock Shows from 1972 to 1979 were analyzed to determine the average change in carcass traits over time. The barrows were the top end of each respective breed selected by a judge in the live show.

Average increase in carcass length per year for all breeds was .284 in. ($P<.01$) with each individual breed group showing significant increases. All breeds tended to decrease in loin eye area with the average change being a decrease of .098 sq. in. per year with only the Yorkshire having a significant decrease ($P<.05$) of .187 sq. in. Little change (−.002 in. per year) was noted over time in backfat thickness except for Spots which had an average increase of .016 in. ($P<.05$ per year). All breeds except the Berkshire decreased in percent ham with the average change across breeds being .090.

Introduction

Many individuals involved in the swine industry, including swine producers, educators, meat processors and others, have expressed concern over the apparent change in the type of animal selected by live show judges in barrow shows. These barrows appeared to be longer, taller, larger frame and less bulging in their muscling and are thought by many to be less desirable in carcass merit. Thus, data were analyzed on the barrows slaughtered in the Oklahoma City 4-H and FFA Livestock Shows from 1972 to 1979 to determine if changes had occurred over time in various carcass measurements.

Materials and Methods

The Oklahoma City 4-H and FFA Livestock Show has from 1400 to 2000 barrows exhibited each year. From 1972 to 1979, the top three to five animals of each breed weight class were slaughtered. The actual number slaughtered per breed weight class was the same within any one given year. However, the number slaughtered per breed each year varied depending on the number of weight classes per breed.

The barrows were slaughtered at Cornett Packing Company, Oklahoma City, and processed at Schwab's Meats, Oklahoma City. Adjusted slaughter weights, carcass length, backfat thickness, loin eye area, percent ham and ham-loin index were obtained.

The adjusted slaughter weight was based on using cold carcass weights and a standard dressing percentage of 71.7, 72.0, 72.4, and 72.7 percent for carcasses weighing 143 lb and below, 144-168, 169-176 and 177 lb and up, respectively. The average adjusted slaughter weights were 221.2, 223.6, 224.7, 235.1, 251.8, 253.0, 241.6 and 242.9 lb for years 1972 to 1979, respectively. Increases in maximum weights allowed in the show in 1975 and 1976 account for the marked increases in adjusted slaughter weights for years 1975 and 1976. Carcass length, backfat thickness and loin eye area were adjusted to a 220-lb equivalent each year using adjustments recommended by the National Association of Swine Records.

Results and Discussion

Records on 803 barrows that were slaughtered from 1972 to 1979 were analyzed (Table 1). The Spot breed was not recognized as a separate breed class until 1974. Prior to 1974 Spots were considered Polands and were in the Poland class.

The average adjusted length for barrows of each breed and each year is present in Table 2. The overall average each year for all the tables does not include the Spots since they were not represented each year. There has been a general increase in carcass length over time, probably reflecting the increased emphasis by purebred breeders, live show judges and others to produce a longer hog.

The average adjusted loin eye area and adjusted backfat thickness for barrows of each breed and each year are shown in Tables 3 and 4, respectively. A definite trend in decreased loin eye areas is noted from 1975 to 1979. Less obvious change seems to be occurring for backfat thickness.

The average percent ham and ham-loin index values for barrows of each breed and each year are shown in Tables 5 and 6, respectively. Definite trends are not obvious.

To better estimate the phenotypic time trends that have occurred since 1972, the breed means for each year were regressed to estimate the average change in performance per year for each trait measured. These regression coefficients are presented in Table 7. Average increase in carcass length per year for all breeds was .284 in. ($P<.01$) with each individual breed group showing significant increase.

All breeds tended to decrease in loin eye area with the average change being a decrease of .098 sq. in. per year with only the Yorkshires having a significant decrease ($P<.05$) of .187 sq. in. per year. Little change (−.002 in. per year) was noted over time in backfat thickness except for the Spot breed which had an average increase of .016 in. ($P<.05$) per year. All breeds except the Berkshire decreased in percent ham with the average change across breeds being .09. All breeds decreased in ham-loin index over time with an average change of 1.854.

Table 1. Number of barrows of each breed slaughtered each year

Breed	Year of show								Total
	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	12	9	14	14	12	12	12	12	97
Chester	15	13	15	15	12	12	12	10	104
Duroc	15	13	14	15	12	12	20	16	117
Hampshire	15	15	15	15	12	11	16	13	112
Poland	14	12	5	14	11	12	11	11	90
Spot	—	—	9	15	12	12	12	10	70
Yorkshire	13	13	15	15	11	12	13	9	101
Crossbred	14	15	15	15	12	12	15	14	112
Total	98	90	102	118	94	95	111	95	803

Table 2. Average adjusted carcass length for pigs of each breed for each year (in.)

Breed	Year of show								Overall avg.
	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	31.43	31.30	31.66	31.34	32.57	32.38	32.70	33.21	32.07
Chester White	31.37	31.58	31.96	31.34	31.95	32.03	32.51	33.12	31.98
Duroc	30.93	31.32	31.72	31.34	32.44	32.53	33.31	33.35	32.12
Hampshire	31.21	31.53	32.18	31.63	32.08	32.48	33.01	33.28	32.17
Poland	30.66	30.94	31.83	30.78	31.52	32.24	32.22	32.57	31.60
Spot			32.05	31.53	32.32	32.59	32.93	33.15	32.43
Yorkshire	31.79	32.38	32.46	32.13	32.90	32.88	33.78	34.31	32.83
Crossbred	31.15	31.64	31.83	31.36	32.15	32.42	33.25	33.14	32.12
Overall avg.[a]	31.22	31.53	31.95	31.42	32.23	32.42	32.97	33.28	

[a]Spot breed not included since Spots were not represented each year.

Table 3. Average adjusted loin eye are of pigs of each breed for each year (sq. in.)

Breed	Year of show								Overall avg.
	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	5.76	5.33	5.87	5.98	5.47	5.06	6.01	4.98	5.56
Chester White	5.98	5.51	5.79	5.82	5.69	5.51	5.90	4.83	5.63
Duroc	6.08	5.42	5.60	5.46	5.84	5.31	6.01	5.26	5.62
Hampshire	6.59	5.81	6.27	6.20	6.02	5.41	6.38	5.29	6.00
Poland	6.02	5.56	5.13	6.30	5.92	5.48	5.71	4.94	5.63
Spot			5.50	5.87	5.42	5.17	5.64	4.40	5.33
Yorkshire	5.98	5.78	5.48	5.99	5.49	5.43	5.50	4.03	5.46
Crossbred	6.40	5.94	6.36	6.62	5.80	5.74	6.22	4.91	6.00
Overall avg.[a]	6.12	5.62	5.79	6.05	5.75	5.42	5.96	4.89	

[a]Spot breed not included since Spots were not represented each year.

Table 4. Average adjusted backfat thickness of pigs of each breed for each year (in.)

Breed	Year of show								Overall avg.
	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	1.33	1.05	1.11	1.15	1.09	1.13	1.11	1.14	1.14
Chester White	1.25	1.00	1.02	1.07	1.07	1.05	1.07	1.17	1.09
Duroc	1.20	1.05	1.04	1.00	0.99	1.07	0.98	1.10	1.06
Hampshire	1.03	0.91	0.96	1.01	0.98	0.99	1.13	1.01	1.00
Poland	1.15	1.08	1.05	1.11	1.11	1.05	1.22	1.07	1.10
Spot			1.09	1.14	1.15	1.13	1.18	1.18	1.15
Yorkshire	1.29	1.00	1.07	1.08	1.03	1.04	1.09	1.13	1.09
Crossbred	1.17	0.94	0.99	1.03	1.06	1.02	1.04	1.15	1.05
Overall avg.[a]	1.20	1.00	1.03	1.06	1.05	1.05	1.09	1.11	

[a]Spot breed not included since Spots were not represented each year.

Table 5. Average % ham of pigs of each breed for each year

Breed	Year of show								Overall avg.
	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	15.76	16.30	16.93	15.83	16.00	16.08	16.90	16.37	16.27
Chester White	17.54	18.20	18.54	17.80	17.38	17.39	17.79	17.20	17.71
Duroc	17.78	18.13	18.68	17.43	16.90	17.46	18.18	16.79	17.67
Hampshire	17.48	18.33	18.25	17.79	17.22	18.02	18.23	16.83	17.77
Poland	17.08	17.71	18.38	17.09	16.47	17.71	17.77	16.24	17.31
Spot			18.21	17.01	16.45	17.26	17.22	16.14	17.05
Yorkshire	16.84	17.83	18.34	17.12	16.80	17.45	17.29	16.10	17.22
Crossbred	17.46	18.60	18.50	17.71	17.42	17.66	17.62	16.63	17.70
Overall avg.[a]	17.13	17.87	18.23	17.23	16.89	17.40	17.69	16.60	

[a]Spot breed not included since Spots were not represented each year.

Table 6. Average ham loin index of pigs of each breed for each year[a]

Breed	Year of show								Overall avg.
	1972	1973	1974	1975	1976	1977	1978	1979	
Berkshire	115.15	116.31	128.06	118.11	113.87	111.40	129.12	113.52	118.20
Chester White	135.29	137.19	143.30	137.44	130.72	130.91	139.07	120.39	134.29
Duroc	138.99	135.85	142.78	132.21	127.89	127.72	141.88	120.55	133.48
Hampshire	140.72	141.43	145.17	139.95	132.48	135.13	146.16	121.45	137.81
Poland	131.01	132.71	135.18	133.88	123.88	131.87	134.85	111.78	129.40
Spot			136.89	128.62	118.67	124.27	129.07	105.44	123.82
Yorkshire	128.18	136.08	138.21	131.11	122.95	129.74	127.90	101.37	126.94
Crossbred	138.54	145.39	148.58	143.27	132.20	135.84	138.42	115.38	137.20
Overall avg.[b]	132.55	134.99	140.18	133.71	126.28	128.94	136.77	114.92	

[a]Formula for ham-loin index is: (% Ham - 10) X 10 + Adjusted Loin Eye Area X 10.
[b]Spot breed not included since Spots were not represented each year.

Table 7. Average change in trait per year for pigs of each breed

Breed	Trait				
	Carcass length, in.	Backfat thickness, in.	Loin Eye area sq. in.	%Ham	Ham-loin index
Berkshire	.272**	−.012	−.060	.059	− .018
Chester	.211**	−.001	−.084	−.096	−1.652
Duroc	.362**	−.012	−.039	−.129	−1.767
Hampshire	.277**	.012	−.107	−.076	−1.773
Poland	.259**	.002	−.073	−.099	−1.712
Spot	.284*	.016*	−.183	−.254	−4.294
Yorkshire	.317**	−.010	−.187*	−.129	−3.121
Crossbred	.292**	.006	−.139	−.161	−2.932
Overall avg.	.284**	−.002	−.098	−.090	−1.854

* Average change per test is significantly different from zero, P<.05.
** Average change per test is significantly different from zero, P<.01.

The data from the barrows slaughtered in this show reveals a trend of longer pigs with less loin eye area, decreased ham percent, a decreased ham loin index and little change in backfat thickness except for the Spot breed. Although the barrows slaughtered in this show cannot be considered a representative sample of the industry, they do reveal a trend that many people feel alarming in that the carcass traits of loin eye area and percent ham seem to be declining in all breeds.

Trends in Oklahoma Swine Carcass Contests

W. G. Luce, R. L. Hintz, L. E. Walters, V. L. Stevens, M. L. Scott and F. K. Ray

Story in Brief

Data from 677 market hogs—183 Durocs, 275 Hampshires and 219 Crossbreds—entered by producers in the State Fair of Oklahoma "Golden Pork Chop Contest" (a swine carcass contest) from 1968 to 1979 were analyzed to determine the average change in carcass traits over time. Average increase in carcass length per year for all breeds was .184 in. (P<.01). Average decrease in backfat thickness for all breeds was .011 in. per year (P<.01). No significant change over time was noted for loin eye area or percent ham.

Data from 281 market hogs—44 Durocs, 72 Hampshires and 165 Crossbreds—entered by producers in the Oklahoma National Barrow Show Performance Contest from 1975 to 1978 were also analyzed to determine the average change in carcass traits over time. Average increase in carcass length per year for all breeds was .383 in. (P<.01). Average decrease in loin eye area per year for all breeds was .423 sq. in. (P<.05). No significant changes were noted in backfat thickness, percent ham or average daily gain; however, the trend for all breeds was a decrease in backfat thickness and an increase in percent ham and average daily gain.

Introduction

There has been considerable concern recently that less emphasis is being placed on carcass merit by swine breeders. It appears that some carcass traits such as loin eye area may be actually becoming inferior as reported by the popular press. Thus, data were analyzed on the pigs slaughtered in the Golden Pork Chop Contest, an Oklahoma State Fair Swine Carcass Contest, from 1968 to 1979 and the Oklahoma National Barrow Show Performance Contest from 1975 to 1978 to determine if changes had occurred over time in various carcass traits.

Materials and Methods

The Golden Pork Chop Contest and the Oklahoma National Barrow Show Performance Contest are open to any pork producer in the world; however, the vast majority of entries have been from Oklahoma. In the Golden Pork Chop Contest, the animal's are slaughtered at Cornett Packing Company, Oklahoma City, and processed at Schwab's Meats, Oklahoma City, while in the Oklahoma National Barrow Show Performance Contest, the animals are slaughtered and processed at Wilson Foods, Oklahoma City.

Slaughter weights, carcass length, backfat thickness, loin eye area, percent ham and ham-loin index were obtained in both contests. The adjusted slaughter weight was determined by using carcass weights and a standard dressing percentage of 71.7, 72.0, 72.4 and 72.7 percent for carcasses weighing 143 lb and below, 144-168, 169-175, 176 and up, respectively. Carcass length, backfat thickness and loin eye area were adjusted to 220 lb equivalent each year using adjustments recommended by the National Association of Swine Records. Premium winners in both contests were required to have acceptable pork quality and to meet certification standards adopted by the National Association of Swine Records.

Golden Pork Chop Contest

All animals entered in the Golden Pork Chop Contest were supposed to be farrowed after March 1 of each year and were exhibited and slaughtered in September of the same year. Only barrows were exhibited from 1968 to 1977 with both barrows and gilts being exhibited in 1978 and 1979. Winners in the contest were determined by the ham-loin index. No attempt was made to verify average daily gain or to consider any growth data in the contest.

The average adjusted slaughter weights were 208.2, 214.3, 213.8, 224.3, 222.6, 217.8, 232.3, 231.5, 237.4, 241.7, 236.9 and 226.4 lb for each year from 1968 through 1979, respectively. Increase in maximum weight allowed in the contest from 240 to 250 lb accounts for the large increase in slaughter weight in 1974.

Oklahoma National Barrow Show Performance Contest

All animals entered in the Oklahoma National Barrow Show Performance Contest were farrowed after February 1 and weighed in and identified with an ear tattoo at one of approximately 14 weigh stations in Oklahoma in early April. The animals were then exhibited, weighed and slaughtered in Oklahoma City in August. Both barrows and gilts were accepted in the contest.

Winners were determined by considering carcass merit, average daily gain and soundness using the following formula: Daily Gain $\times$ 75 + Ham-Loin Index + Soundness Score. Soundness scores were determined by a committee of three people using a range of scores from 1 to 20 with 20 being ideal.

Table 1. Number of pigs of each breed for each year at the Golden Pork Chop Contest

	Year of show												
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	Total
Berkshire	0	0	0	0	0	0	0	0	0	0	1	0	1
Chester White	4	2	3	1	9	3	3	8	2	1	5	0	41
Duroc	11	16	12	23	19	19	19	18	12	6	17	11	183
Hampshire	34	42	30	52	14	13	22	14	19	20	9	6	275
Poland	6	6	6	6	4	3	6	2	2	1	0	1	43
Spot	0	0	0	0	1	0	4	0	2	1	3	6	17
Yorkshire	3	2	4	0	0	0	0	4	1	0	4	2	20
Crossbred	17	13	20	17	24	20	33	18	24	9	9	15	219
Total	75	81	75	99	71	58	87	64	62	38	48	41	799

Table 2. Average adjusted carcass length for each year at the Golden Pork Chop Contest (in.)

	Year of show												Overall
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	avg.
Duroc	30.25	30.56	30.01	30.66	30.22	31.33	31.35	31.30	31.33	31.96	32.46	32.38	31.15
Hampshire	30.31	30.76	30.40	30.82	30.50	31.31	31.42	31.52	31.77	31.46	32.06	32.63	31.25
Crossbred	31.01	30.92	30.70	30.84	30.79	31.25	31.10	31.51	31.35	32.16	32.26	32.61	31.37
Overall avg.	30.52	30.74	30.37	30.77	30.51	31.30	31.29	31.45	31.48	31.86	32.26	32.54	

Table 3. Average adjusted backfat thickness for each year at the Golden Pork Chop Contest (in.)

	Year of show												Overall
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	avg.
Duroc	1.21	1.25	1.23	1.15	1.19	1.17	1.13	1.11	1.13	1.22	1.03	1.10	1.16
Hampshire	1.12	1.12	1.14	1.14	1.07	1.06	1.04	0.97	1.08	1.11	0.98	1.04	1.07
Crossbred	1.16	1.18	1.18	1.13	1.10	1.12	1.07	1.13	1.13	1.07	1.18	0.99	1.12
Overall avg.	1.16	1.18	1.18	1.14	1.12	1.12	1.08	1.07	1.11	1.13	1.06	1.04	

The average starting weights were 32.6, 48.4, 41.9 and 45.1 lb for the years 1975 through 1978, respectively. The average adjusted slaughter weights were 233.3, 241.3, 241.8 and 262.9 lb for the years 1975 through 1978, respectively.

Results and Discussion

Golden Pork Chop Contest

The number of pigs of each breed slaughtered each year from 1968 to 1979 in the Golden Pork Chop Contest is shown in Table 1. Statistical analysis was conducted only on the Duroc, Hampshire, and Crossbred pigs because the number of pigs representing the other breeds was small. These three breeds represented 677 of the 799 total number of animals slaughtered.

The average adjusted length of each year for Duroc, Hampshire, and Crossbreds is shown in Table 2. There has been a general increase in carcass length over time, probably reflecting the increased emphasis of purebred breeders, live show judges and others to produce longer hogs.

Average adjusted backfat thickness for each year is shown in Table 3. There has been a general decrease in backfat thickness over time, reflecting the emphasis of leaders in the industry on increasing percent lean and decreasing percent fat in market hogs.

Average adjusted loin eye areas and average percent ham are shown in Tables 4 and 5, respectively. Data for loin eye area are presented only from the years 1973 to 1979 as loin eye area values were not obtained in all pigs slaughtered previous to 1973. Definite trends are not apparent for either loin eye area or precent ham.

To better estimate the phenotypic time trends that have occurred since 1972, the breed means for each year were regressed to estimate the average change in performance per year for each trait measured. The regression coefficients are presented in Table 6. Average increase in carcass length per year for those breeds analyzed was .184 in. ($P<.01$) with each individual breed showing significant increases.

Average decrease in backfat thickness per year for the three breeds analyzed was .011 in. ($P<.01$) with each individual breed showing significant decreases. Little change over time was noted for loin eye area or percent ham. However, all breeds analyzed tended to increase in percent ham, and only the crossbreds failed to increase in loin eye area.

National Barrow Show Performance Contest

The number of pigs of each breed evaluated each year from 1975 to 1978 in the Oklahoma National Barrow Show Performance Contest is shown in Table 7. Statistical analysis was conducted on the Duroc, Hampshire and Crossbred pigs, which represented 281 head of the 322 total evaluated.

The average daily gain of pigs for each year is shown in Table 8. No apparent trend in average daily gain is evident. Values for average adjusted backfat thickness and adjusted carcass length are shown in Table 9. Backfat thickness tended to decrease and length to increase over time. This probably reflects a trend of purebred swine breeders, live show judges and others who are selecting longer and leaner pigs.

Values for percent ham and adjusted loin eye area for each year are shown in Table 10. A definite trend of a decrease in size of loin eye areas is evident. The percent ham appears to be declining since 1976.

Average changes in performance per year are shown in Table 11. Average decrease in loin eye area per year was .423 square inches ($P<.05$), with all three breeds following the same trend. Average increase in carcass length per year was .383 in. ($P<.01$), with all three breeds following the same trend. No significant changes were

Table 4. Average adjusted loin eye area for each year at the Golden Pork Chop Contest (sq. in.)

	Year of show							Overall
	1973	1974	1975	1976	1977	1978	1979	avg.
Duroc	5.14	6.23	5.93	5.62	5.52	5.81	5.78	5.72
Hampshire	5.58	6.50	6.41	6.14	6.26	6.02	6.07	6.14
Crossbred	5.34	6.28	6.12	6.21	5.42	5.61	5.94	5.85
Overall avg.	5.35	6.34	6.15	5.99	5.73	5.81	5.93	

Table 5. Average percent ham for each year at the Golden Pork Chop Contest

	Year of show												Overall
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	avg.
Duroc	16.02	16.66	17.84	16.34	17.53	17.53	17.63	17.19	16.92	17.03	16.12	16.86	16.97
Hampshire	16.21	16.63	17.47	16.71	17.17	17.83	17.22	17.08	16.48	17.22	16.25	17.48	16.98
Crossbred	16.03	16.46	17.27	17.01	17.22	17.48	17.47	16.62	16.66	17.15	16.22	17.62	16.94
Overall avg.	16.09	16.59	17.53	16.69	17.31	17.61	17.44	16.97	16.69	17.14	16.20	17.32	

noted in average daily gain, percent ham or backfat thickness. However, all three breeds tended to increase in average daily gain, increase in percent ham and decrease in backfat thickness.

General

Pigs in both contests tended to increase over time in carcass length and decrease in backfat thickness probably reflecting an industry trend towards producing longer and leaner market hogs. Although nonsignificant, pigs in both contests tended to increase over time in percent ham. Pigs in the Oklahoma National Barrow Show had a significant decrease over time in loin eye area while little change was noted for pigs in the Golden Pork Chop Contest. However, a slight decrease in loin eye area occurred from 1975 to 1978 for the Golden Pork Chop Contest, which covers the same years analyzed for the Oklahoma National Barrow Show Performance Contest.

Table 6. Average change in trait per year for the Golden Pork Chop Contest

Breed	Lgth	BF	LEA	% Ham
	in.	in.	sq. in.	%
Duroc	.213**	−.013**	.024	.002
Hampshire	.184**	−.010*	.014	.023
Crossbred	.155**	−.009*	−.009	.038
Overall avg.	.184**	−.011**	.010	.021

* Avg change per test is significantly different from zero, $P<.05$.
** Avg change per test is significantly different from zero, $P<.01$.

Table 7. Number of pigs for each year at the Oklahoma National Barrow Show Performance Contest

	Year of show				
Breed	1975	1976	1977	1978	Total
Berkshire	0	2	0	0	2
Chester White	2	5	1	2	10
Duroc	10	15	12	7	44
Hampshire	18	25	15	14	72
Poland	0	0	0	1	1
Spot	1	6	7	5	19
Yorkshire	0	0	9	0	9
Crossbred	17	46	55	47	165
Total	48	99	99	76	322

Table 8. Average daily gain for each year at the Oklahoma National Barrow Show Performance Contest[ab]

	Year of show				Overall
Breed	1975	1976	1977	1978	avg.
Duroc	1.59	1.51	1.58	1.58	1.57
Hampshire	1.56	1.46	1.56	1.66	1.56
Crossbred	1.57	1.57	1.61	1.64	1.60
Overall avg.	1.58	1.51	1.58	1.63	

[a]Avg starting weights were 32.6, 48.4, 41.9 and 45.1 lb for 1975 through 1978, respectively.
[b]Avg final weights were 233.3, 241.3, 241.8 and 262.9 lb for 1975 through 1978, respectively.

Table 9. Average adjusted backfat thickness and carcass length for each year at the Oklahoma National Barrow Show Performance Contest

Breed	Year of show								Overall avg.	
	1975		1976		1977		1978			
	BF[a]	Lgth[b]	BF[a]	Lgth[b]	BF[a]	Lgth[b]	BF[a]	Lgth[b]	BF[a]	Lgth[b]
Duroc	1.19	31.06	1.24	30.69	1.13	31.62	1.08	32.28	1.16	31.41
Hampshire	1.11	31.19	1.17	31.65	1.06	31.57	1.00	32.14	1.09	31.64
Crossbred	1.23	30.91	1.15	31.67	1.12	31.65	1.11	32.29	1.15	31.63
Overall avg.	1.18	31.06	1.19	31.34	1.10	31.61	1.06	32.24		

[a]BF = Carcass backfat thickness expressed in inches.
[b] Lgth - Carcass length expressed in inches.

Table 10. Average % ham and adjusted loin eye area for each year at the Oklahoma National Barrow Show Performance Contest

Breed	Year of show								Overall avg	
	1975		1976		1977		1978			
	% Ham	LEA[a]	% Ham	LEA[a]	% Ham	LEA[a]	% Ham	LEA[a]	% Ham	LEA[a]
Duroc	16.48	5.69	18.13	5.13	17.52	4.61	17.17	4.41	17.33	4.96
Hampshire	16.32	6.13	18.42	5.42	17.84	4.87	16.93	4.93	17.38	5.34
Crossbred	16.28	6.22	18.37	5.48	17.23	4.71	17.04	5.07	17.23	5.37
Overall avg	16.36	6.01	18.31	5.34	17.53	4.73	17.05	4.81		

[a]LEA = Loin eye area expressed in square inches.

Table 11. Average change in trait per year for the Oklahoma National Barrow Show Performance Contest

Breed	ADG	% Ham	LEA	BF	Lgth
	lb	%	sq. in.	in.	in.
Duroc	.004	.146	−.436*	−.043	.460
Hampshire	.038	.127	−.413	−.045	.276
Crossbred	.026	.115	−.420	−.039	.412
Overall avg	.023	.130	−.423*	−.042	.383**

*Avg change per test is significantly different from zero, P<.05.
**Avg change per test is significantly different from zero, P<.01.

Preliminary Development of Yield Grade and Dressing Percentage Prediction Equations for Beef Steers

L. E. Walters and R. L. Hintz

Story in Brief

Equations to predict yield grade and dressing percentage from average daily gain, days on feed and final weight information for beef steers were developed. The equations could serve as a tool to help determine when to slaughter a pen of cattle to achieve the desired yield grade and/or dressing percentage. When tested against a small amount of data, the yield grade equation did a reasonable job in predicting yield grade. On the average, the predicted yield grade was within .13 of the actual yield grade values. However, both equations need further testing and examination to assess their accuracy.

Introduction

There has been an increased demand for leaner beef. The amount of lean beef from an animal may be indicated by the animal's yield grade and/or dressing percentage. Thus, identification of variables in beef production that influence yield grade and dressing percentage would be useful in producing leaner beef with higher cutability. The animals and time involved in conducting experiments to obtain data so that prediction equations for yield grade and dressing percentage can be developed are costly. Another approach is to assimilate data which have already been reported to establish mathematical relationships among variables influencing yield grade and dressing percentage. The purpose of this report is to present equations for predicting yield grade and dressing percentage.

Materials and Methods

The approach in this study was to use data reported by the U.S. Meat Animal Research Center (MARC)[1] to develop prediction equations for yield grade and dressing percentage. The dressing percentage reported in the MARC data was equal to hot

[1]Cattle Germ Plasm Evaluation Program Progress Reports 1-5, 1974-1977, U.S. Meat Animal Research Center, U.S.D.A., Clay Center, Nebraska.

carcass weight divided by final weight on feed and water (without shrink). The steers in these MARC studies were placed on feed at weaning. Breed, final weight, days on feed and average daily gain were used to develop prediction equations for yield grade and dressing percentage. Independent data other than the MARC data were used to test the accuracy of the yield grade prediction equation.

Results and Discussion

The following equation is the average of equations developed for Angus, Hereford and Hereford-Angus cross steers:

$$\text{Yield grade} = -7.1527 + .0068 \times \text{DAY} - .000237 \times \text{DAY}^2 + .000000263 \times \text{DAY}^3 + .0042 \times \text{FWT} + .2257 \times \text{ADG}$$

DAY = days on feed.
FWT = final weight.
ADG = average daily gain.

The predicted yield grades agree with reported values (Table 1). Based on these preliminary data, on the average, the predicted yield grade values were found to deviate from actual values by 0.13 yield grade.

The following equation is the average of equations developed for Angus, Hereford and Hereford-Angus cross steers:

$$\text{Dressing percentage} = 52.0903 - .0102 \times \text{DAY} + .0000269 \times \text{DAY}^2 - .00000008 \times \text{DAY}^3 + .0123 \times \text{FWT} - .7741 \times \text{ADG}$$

DAY = days on feed.
FWT = final weight.
ADG = average daily gain.

The equation explained 60 percent of the variation in dressing percentage.

The usefulness of these equations can best be explained with an illustration using hypothetical data. Suppose we purchase a pen of Angus, Hereford and/or Hereford-Angus cross steers weighing 700 lb with 4 percent shipping shrink and put them on feed. After 84 days on feed with an average daily gain of 3.26 lb, these steers will weigh about 946 lb. The predicted average yield grade and dressing percentage are 1.6 and 60.5, respectively (Table 2). We can use the equations to estimate the expected yield grade and dressing percentage if the cattle were slaughtered after longer feeding periods. Therefore, the equations serve as a tool to help determine when to slaughter a pen of cattle to achieve the desired yield grade and/or dressing percentage.

The accuracy of the yield grade equation only has been tested against a small amount of data (Table 1). Both equations need to be tested with several independent data sets to determine their accuracy and limitations. Further research in this area will hopefully refine and improve these prediction equations.

Table 1. Predicted vs. reported yield grade on Hereford steers

Data source	Days on feed	Final weight	Average daily gain	Yield grade	Predicted yield value
(2)[a]	112	1103	3.29	3.1	2.9
	112	1065	3.66	3.1	2.9
	112	1061	3.22	2.6	2.7
(3)[b]	237	975	2.34	3.3	3.3

[a]W. L. Braman, J. Anim. Sci., 1973, 37:1010.
[b]L. L. Wilson, J. Anim. Sci., 1963, 22:699.

Table 2. Predicted yield grade and dressing percentage from hypothetical data on Angus, Hereford and Hereford-Angus cross steers

Hypothetical data			Predicted	
Days on feed	Average daily gain (lb)	Final weights (lb)	Dressing percentage	Yield grade
84	3.26	946	60.5	1.6
112	3.19	1029	61.4	2.8
140	3.09	1105	62.2	3.6
168	2.98	1173	62.9	4.2
181	2.92	1201	63.2	4.4

The Growth of Three Fiber Types in Beef Longissimus Muscle as Influenced by Breed and Age

J. J.Guenther, K. K. Novotny and R. L. Hintz

Story in Brief

Changes in the areas of α-white, α-red and β-red fibers from the Longissimus dorsi muscles of Angus and Charolais calves slaughtered at 25, 240 and 650 days of age were determined. At 25 days all three fiber types from the Angus calves were notably larger than those from the Charolais. This size difference was maintained throughout the growing periods. For the α-white fibers, however, the breed difference lessened with increased age. In the Angus, the β-red fibers were slightly larger at 25 days than the α-reds; yet as the growing period was extended, the α-reds became significantly larger than the β-reds. These findings may explain how the musculature of beef animals maintains its increased energy need during growth. There was a progressive increase, favoring the Charolais, in percent fiber area, the α-reds of both breeds showing the greatest percent increase. The α-white fibers of the Charolais had a greater net increase per day, suggesting a faster overall muscle growth rate for this breed. During the latter part of the growth phase (240 to 650 days), the β-red fibers of the Angus enlarged at a significantly faster rate per day, which could be related to the Angus' capacity to "marble."

Introduction

The ultimate muscle size or mass in beef animals may be due largely to the extent of radial growth or increase in area of the basic structural units of muscle, the individual muscle fibers.

Beef muscle is not uniform in its fiber composition; rather, it is believed to contain a heterogenous mixture of at least three types of fibers, which may be distinguished by their different metabolic characteristics. Research data to determine the influence of breed type on the extent and rate of enlargement of the different muscle fiber types during growth is limited. Thus, the present study was conducted to evaluate changes occurring in the size of three types of muscle fibers, α-white, α-red and β-red, taken from the Longissimus dorsi of Angus and Charolais calves at three stages of maturity.

Materials and Methods

A total of 15 Angus and 15 Charolais calves were used for this study. Six calves (three Angus and three Charolais) were slaughtered at 25 days of age, 12 (six Angus and six Charolais) at 240 days and 12 (six Angus and six Charolais) at 650 days. All calves were selected from the same herds and calving groups.

Immediately after each calf was slaughtered, a section of the right Longissimus dorsi (12th rib to the 4th lumbar vertebra) was removed, trimmed of external fat, wrapped in aluminum foil, frozen in liquid nitrogen and stored at -20°C until sectioning was accomplished. From each muscle a transverse section (approximately 1 cm wide) was removed at a location 50 percent of the long axis of the muscle. This section was visually divided into quadrants, and a core 6.35 mm in diameter was removed, at random, from one of the quadrants. The core was thawed in buffered saline, fixed to a microtome chuck and refrozen. Two sections were cut (12 microns thick) from each core, afixed to separate glass slides and stained via an alkaline ATPase procedure.

The stained fibers were projected onto an A/O Visopan screen. The periphery of 5 α-white, α-red and β-red fibers (from each of the two sections), selected at random, was traced onto transparent paper strips. The inner area was made opaque with white liquid paper fluid and the area of all fiber tracings was determined with a LiCor meter.

Results and Discussion

The average areas for three fiber types, α-white, α-red and β-red, determined on the Longissimus dorsi muscles of Angus and Charolais calves at 25, 240 and 650 days of age are presented in Table 1. These data show that at all age groups and for all three fiber types, the Angus calves had larger fiber areas than the Charolais. At 25 days

Table 1. Effect of breed and age on fiber area of Longissimus dorsi muscle

		Fiber type		
Age[1]	Breed	α- White	α- Red	β- Red
25	Angus	.717[2,3]	.415	.430
	Charolais	.513	.263	.283
240	Angus	1.147	.657	.542
	Charolais	1.043	.532	.503
650	Angus	2.210	1.930	1.490
	Charolais	2.120	1.380	1.250

[1]Days.
[2]Average of ten measurements, units in cm^2.
[3]Values are uncorrected for magnification.

Table 2. Effect of breed and growth phase on the percent increase in fiber area of Longissimus dorsi muscle

		Fiber type		
Growth phase[1]	Breed	α- White	α- Red	β- Red
25-240	Angus	60.0[2]	58.3	26.0
240-650		92.7	122.1	174.9
25-650		208.2	365.1	246.5
25-240	Charolais	92.1	102.3	77.7
240-650		103.3	159.4	148.5
25-650		290.4	424.7	325.8

[1]Days.
[2]Percent increase during indicated intervals.

of age the average fiber area (across all fiber types) was 1.4 times greater for the Angus. This advantage in fiber area for the Angus was maintained throughout the entire growing period, though the difference between the two breeds became smaller with increased age in the α-white fibers, suggesting that the more numerous muscle fibers of the Charolais (reported previously) were "catching-up" in size as the growth period was extended.

For both breeds and at each age period, the α-white fibers were considerably larger in area than either the α-red or β-red fibers. This difference did not lessen until the animals reached market weight. Conversely, at 25 days of age the β-red fibers of the Angus and Charolais were slightly larger than their respective α-red fibers; however as age was increased, the α-red fibers became notably larger than the β-red fibers. These observations, particularly the latter, might be due to the muscles' increased need to maintain oxidative and ATPase activity during growth and may suggest a possible mechanism for these events.

The influence of breed and growth phase or increasing age on the percent change in fiber area are given in Table 2. These results show a progressive increase in percent fiber area with age. While the Angus had larger fiber areas in all cases (Table 1), the Charolais' muscle fibers showed a greater percentage increase, except in the β-red comparison during the 240-650 day growth phase, suggesting an overall advantage in rate of muscle growth in the Charolais calves. The largest percent increase in fiber area occurred during the 240-650 day period (weaning-market weight).

When the increase in fiber area was expressed on the basis of net change per day (Table 3), a somewhat different picture was obtained. For the α-white fibers, the largest increase in area occurred during the 240-650 day growth phase (post-weaning). The net area increase per day of the α-white fibers was significantly lower during the 25-240 day period (pre-weaning), as well as for the 25-650 day period (overall). In each case, however, the net change in α-white fiber area was greater for the Charolais, indicative of a faster muscle growth rate for these calves.

The net increase in area per day of the α-red and β-red fibers for the two breeds followed a different course than that of the α-whites. During the 25-240 day period, the Charolais showed a larger net increase in fiber area than the Angus. However, during the 240-650 day growth phase, the Angus' β-red fibers enlarged at a significantly faster rate per day. Also, the overall increase in size per day in these fibers was greater for the Angus calves (25-650 day period). These findings may be related to the Angus calves' ability to deposit intra-muscular or "marbling fat" at an earlier age and lighter weight than the Charolais.

Table 3. Effect of breed on increase in fiber area per day of age

		Fiber type		
Growth phase[1]	Breed	α- White	α- Red	β - Red
25-240		2.00[2,3]	1.12	0.52
240-650	Angus	2.59	3.10	2.31
25-650		2.39	2.42	1.70
25-240		2.32	1.25	1.02
240-650	Charolais	2.63	2.07	1.82
25-650		2.52	1.79	1.55

[1]Days.
[2]Average of ten measurements, units in $cm^2 \times 10^{-3}$
[3]Values are uncorrected for magnification.

A Comparison of Collagen Content and Organoleptic Attributes of Grain-vs. Forage-Finished Cattle

L.E. Bulgerin, J.E. Williams, T.H. Liao, L.L. Ebro, J.J. Guenther, L.E. Walters, D.G. Wagner

Story in Brief

Collagen content of muscle tissue and organoleptic attributes of steaks were compared in Brangus crossbred steers reared under different management systems. Twenty steers were randomly assigned to two treatments: 1) a conventional 90-percent concentrate finishing ration for 161 days, or 2) a sorghum-sudan and wheat pasture finishing system for 190 days prior to slaughter. After slaughter, samples were taken from the longissimus dorsi muscle at the 13th rib and the semitendinosus muscle (eye of round) for collagen analyses and organoleptic evaluation. Collagen was extracted from the muscle tissue and expressed on the basis of hydroxylysine content. Steaks were evaluated by nine trained panelists using an 8-point hedonic scale. Collagen content was higher in the semitendinosus muscle (2.9 and 2.5 mg collagen/g of wet tissue) and lower in the longissimus dorsi muscle (1.4 and 1.6 mg collagen/g of wet tissue) of grain-than forage-finished cattle. Steaks from semitendinosus muscle had higher scores for tenderness and lower amounts of connective tissue for grain- than forage-finished cattle. Organoleptic evaluation of the longissimus dorsi muscle revealed slight differences in tenderness and connective tissue between Treatments 1 and 2.

Introduction

Tenderness is one of the most important quality attributes of beef palatability. Due to increasing world grain shortages, there is a current trend for more forage-finished beef production. It has been established by several researchers (Bowling *et al.*, 1977,Cross *et al.*,1975) that beef finished on forage is less tender than beef finished on grain. Beef tenderness can be divided into three components; actomyosin effects, intramuscular fat and moisture effects, and background effects which are due to the quantity and/or chemical state of the intramuscular collagen. This study was undertaken to determine whether intramuscular collagen plays a major role in the tenderness of grain- vs. forage-finished beef.

Materials and Methods

This study was conducted over a 2-year period. Each year 20 Brangus X Hereford-Angus crossbred steers, at weaning, were randomly allotted (10 per treatment) to one of two production systems: 1) a 90-percent conventional corn grain diet for 161 days, or 2) a high quality sorghum-sudan and wheat pasture mixture for 190 days prior to slaughter (no grain).

After slaughter, carcasses from both groups were chilled 48 hours or longer at 1° C. Longissimus dorsi (LD) muscle from (short loin) at the area of the 13th rib and semitendinosus (ST) muscle from the round were taken from the right side of the carcass for collagen analyses and organoleptic evaluation. The steaks for collagen analyses were trimmed of all external fat, ground through a ⅛-inch plate and frozen prior to analyses. Crude intramuscular collagen was extracted from the muscle tissue

using the Texas A&M procedure of Wu, Dutson and Carpenter (unpublished data). The total amount of collagen in each muscle sample was determined by amino acid analysis using hydroxylysine as the standard amino acid. Soluble collagen was determined using the procedure of Goll (1964). Sensory quality attributes were evaluated by 9 trained panelists using the 8-point hedonic scale. Organoleptic evaluation of steaks compared tenderness and amount of connective tissue associated with the two feeding treatments.

Results and Discussion

Organoleptic evaluation showed steaks from the grain-finished steers ranked higher (Table 1) than steaks from the forage-finished steers in both years and for both muscles studied. Significant differences were found between the LD steaks in the 1978 (first) study. Here grain-finished LD steaks were significantly more tender and had much less connective tissue than forage-finished LD steaks. In the 1978 study there were greater differences between the grain- and forage-finished LD muscles than the ST muscles. In the 1979 study greater differences were seen between the ST muscles than the LD muscles.

Total collagen content, expressed in mg collagen/g of wet tissue, and percentages of total collagen solubilized are presented in Tables 2 and 3. There were no significant differences between forage- and grain-finished steers. In the 1978 study (Table 2) the average LD muscle from the forage-finished steers contained more collagen (3.20 vs. 1.01 mg collagen/g wet tissue) than from the grain-finished steers; however the ST muscles show the reverse trend (1.98 vs. 3.20 mg collagen/g wet tissue). In the 1979 study (Table 3) collagen content was lower in the LD muscle (1.56 vs. 1.80 mg collagen/g wet tissue) and higher in the ST muscle (3.07 vs. 2.58 mg collagen/g wet tissue) for forage- than grain-finished beef. The collagen was more soluble in the grain-finished beef in each muscle except the LD muscle in the 1978 study as shown in Tables 2 and 3.

The percent soluble and insoluble collagen on a wet muscle tissue basis are

Table 1. Organoleptic evaluation of steaks

Sensory quality attributes	Muscle	1978 Forage-finished	1978 Grain-finished	1979 Forage-finished	1979 Grain-finished
Tenderness**	LD	4.53	5.88*	4.67	5.02
	ST	3.78	4.69	4.62	5.49
Amount of connective tissue**	LD	4.22	5.60*	4.47	4.76
	ST	3.51	4.31	4.31	4.98

*significantly different $P < .05$.
**8 = most desirable 1 = least desirable.

Table 2. 1978 collagen analyses of ST and LD muscles from forage-vs. grain-finished beef

	Muscle	Forage-finished	Grain-finished
Collagen content (mg/g fresh muscle tissue)	LD	1.71± 0.43	1.01± 0.24
	ST	1.98± 0.48	3.20± 0.85
% of total collagen solubilized	LD	20.64± 1.81	17.30± 1.53
	ST	9.94± 0.72	10.06± 0.94

Table 3. 1979 collagen analyses of ST and LD muscles from forage-vs. grain-finished beef

	Muscle	Forage-finished	Grain-finished
Collagen content (mg/g fresh muscle tissue)	LD	1.56± 0.22	1.80± 0.17
	ST	3.07± 0.77	2.58± 0.18
% of total collagen solubilized	LD	28.40± 1.93	29.40± 2.93
	ST	16.22± 1.97	20.97± 1.76

Table 4. 1978 collagen solubility of ST and LD muscles from forage-vs. grain-finished beef

	Muscle	Forage-finished	Grain-finished
% soluble collagen in the muscle	LD	0.03± 0.009	0.02± 0.003
	ST	0.02± 0.009	0.03± 0.007
% insoluble collagen in the muscle	LD	0.14± 0.035	0.09± 0.024
	ST	0.18± 0.043	0.29± 0.080

Table 5. 1979 collagen solubility of ST and LD muscles from forage--vs. grain-finished beef

	Muscle	Forage-finished	Grain-finished
% soluble collagen in the muscle	LD	0.05± 0.007	0.06± 0.009
	ST	0.05± 0.014	0.05± 0.005
% insoluble collagen in the muscle	LD	0.11± 0.016	0.12± 0.011
	ST	0.26± 0.064	0.20± 0.015

presented in Tables 4 and 5. The percent soluble collagen in the muscle tissue was very similar between feeding treatments. The collagen remaining in the muscle tissue after the steak has been cooked is the insoluble collagen. In the 1978 study (Table 4) there was more insoluble collagen remaining in the LD muscle (.14 vs. .09 percent) and less in the ST muscle (.18 vs. .29 percent) of the forage-finished than the grain-finished beef. In the 1979 study (Table 5) the percent insoluble collagen in the LD muscle was similar between feeding treatments. There was considerably more insoluble collagen in the ST muscle of the forage-finished than the grain-finished beef (.26 vs. .20 percent). In general, there did not appear to be any strong relationships between the collagen analyses and the organoleptic evaluation of the steaks from the different feeding treatments.

Literature Cited

Bowling, R.A., G.C. Smith, Z.L. Carpenter, T.R. Dutson and W.M. Oliver. 1977. J. Anim. Sci. 45:209.

Cross, H.R. and G.C. Smith. 1975. Proc. Southern Regional Forage-Fed Beef Research Workshop., New Orleans, Louisiana.

Goll, D.E., W.G. Hoekstra, and R.W. Bray. 1964. J. Food Sci. 29:615.

Carcass Characteristics of Ram Lambs at Four Slaughter Weights

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Story in Brief

Over a 3-year period, 144 crossbred ram lambs from three lambing seasons were slaughtered at 100, 120, 140 and 160 lb to study changes in carcass characteristics as slaughter weight increased. Lambs to be slaughtered were trucked from the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma, to the Oklahoma State University Meat Laboratory. After slaughter, the carcasses were evaluated for USDA carcass quality and yield grades. They also were evaluated for composition by measures of lean, fat and bone and for tenderness by the Instron conversion of the Warner-Bratzler Shear.

The rate of lean growth in terms of pounds continued to increase at a rather constant rate throughout the range of slaughter weights. For each 20-lb increase in live weight, rib eye area increased about .25 square inches and retail cut weight about 4.0 lb. Fat thickness, kidney and pelvic fat, USDA yield grade and total fat trim all increased steadily as live weight increased. Fat thickness increased .05 inches and total fat trim 4.2 lb for each 20-lb increase in live weight. In addition, bone weight increased .9 lb with each 20-lb increase in live weight. Fat accounted for 6.6 percent more of the carcass from ram lambs at 160 lb slaughter weight than at 100 lb, and lean accounted for 5 percent less. The largest change in percentage composition occurred between 100 and 120 lb when retail cuts were found to decrease from 46.5 to 43.3 percent of the carcass. Dressing percent, however, increased with heavier live weights. This higher dressing percent largely offset the higher fat content at heavier weights to account for the yield of retail cuts on a live weight basis being similar for those lambs in the three heavier weight groups.

Observation of Warner-Bratzler Shear force means indicates that the largest change in tenderness occurred between 100 and 120 lb slaughter weight. However, shear force values for all weight groups were found to be at a highly acceptable level from a tenderness standpoint.

Introduction

The continuous decline in lamb production in the United States during recent years has led to the absence of lamb in many retail meat counters, where lamb promotion tends to be discouraged because of the lack of an adequate supply. Given the current limited number of lambs produced annually one of the obvious ways to increase the supply of lamb is to feed lambs to heavier market weights. The superiority of ram lambs over ewe and wether lambs in live performance and carcass merit is well recognized. However, the pattern of the growth and development of ram lambs fed to heavy market weights is not well understood. Also, possible changes in tenderness in ram lambs of these weights have not been evaluated.

The objectives of this study were (1) to study changes in carcass composition in ram lambs over a range of weights and (2) to determine what changes, if any, occur in tenderness as measured by the Warner-Bratzler Shear as ram lambs are taken to heavier slaughter weights.

Materials and Methods

Crossbred ram lambs produced from Suffolk, Hampshire, Suffolk x Hampshire or Hampshire x Suffolk sires mated to dams of various levels of Rambouillet, Dorset and Finnsheep breeding were selected from an 8-month lambing interval project in progress at the Southwestern Livestock and Forage Research Station. This study evaluated 144 lambs produced in four groups over three different seasons. When 12 lambs similar in weight averaged 70 lb, they were started as a pen on a finishing ration of 45 percent alfalfa, 50 percent milo and 5 percent molasses. When a pen of 12 lambs averaged 100 lb, the lambs were sorted into upper, average and lower one-third weight groups, and one lamb from each group was chosen at random for slaughter. The same procedure was followed at average pen weights of 120 and 140 lb, and the last three lambs were slaughtered when their average weight reached 160 lb. This procedure allowed each lamb an equal chance of being one of the lambs slaughtered at any weight. Because lambs were slaughtered when the average pen weight reached a certain point, this method also spread the individual weights over a wide range. All lambs were shorn sometime before slaughter, and the slaughter weight for all lambs was determined by adding fleece weight to actual live weight. Therefore, dressing percentage was calculated as if the lambs had not been shorn.

Lambs ready for slaughter were shipped to the OSU Meat Laboratory and held overnight without feed. The live weight used to compute dressing percentage and other calculations was the Fort Reno weight (fleece included) obtained the day before slaughter. The right sides of the carcasses were cut into the major wholesale cuts using the standard cutting method, with minor modifications, described by the American Meat Science Association. The leg and shoulder were separated into lean, fat and bone portions, and the retail rack and loin were closely trimmed but left "bone-in." The boneless, closely trimmed weights of the leg and shoulder were combined with the closely trimmed, "bone-in" retail rack and loin weights to estimate the major portion of high-valued retail cuts in the carcass.

The neck, foreshank, breast and flank were all separated into lean, fat and bone. The riblets of the rack and flank portion of the loin were closely trimmed of all external fat but were left "bone-in." Fat trim from all cuts was used as the estimate of carcass fat, and the bone from all cuts boned out was considered the estimate of carcass bone.

A Warner-Bratzler Shear mounted on an Instron measuring device was used to evaluate tenderness. Two 1½-inch chops were taken from each carcass, one from the posterior end of the rack and the other from the anterior end of the loin. These chops were frozen, thawed at a later date and then cooked in a 275°F convection oven to an internal temperature of 155°F. After the chops had cooled overnight, two ½-inch cores were removed from each chop, and two shears were made on each core.

Results and Discussion

Carcass lean

Pounds of carcass lean as measured by the amount of closely trimmed, partially boneless retail cuts and rib eye area as described earlier in this report continued to increase throughout the range of slaughter weights studied. The data presented in Table 1 indicated that pounds of retail cuts in the carcasses increased 3.4, 4.0 and 4.6 lb, respectively, for each 20-lb slaughter weight increase above 100 lb. Rib eye area was found to increase about .25 square inches for each 20-lb increase in slaughter weight.

Carcass fat and bone

The amount of fat in the carcasses (Table 1) was found to increase 4.3, 4.2 and 4.2 lb, respectively, for each 20-lb slaughter weight increase above 100 lb. Fat thickness over the 12th rib and kidney and pelvic fat are important components in determining

the USDA Yield Grade in lambs. (Lower numerical yield grade values are associated with higher percentages of trimmed, boneless retail cuts in the carcass). In these ram lambs, fat thickness at the 12th rib increased quite steadily over slaughter weight groups at about .05 in. per 20-lb increase in slaughter weight. Similarly, pounds of kidney and pelvic fat increased quite steadily at about .55 lb per 20-lb increase in slaughter weight (Table 1). As expected in lambs of normal and uniform growth rates, pounds of bone increased steadily with heavier weight as did the soft tissues in the carcass (lean and fat). However, the percentage of bone in the carcass decreased gradually as heavier slaughter weights were reached (Table 2).

Carcass quality and tenderness

Quality grade as determined largely by firmness, feathering and fat streaking (these associated with fatness) and maturity generally contribute to the palatability of lamb cuts. As shown in Table 1, carcass quality grade increased gradually from near average choice to low prime as the ram lambs were fed from 100 to 160 lb live weight. Lower Warner-Bratzler Shear Force values are associated with more tenderness while higher values indicate that more force was required to shear the ½-inch cooked meat core. Thus, the higher values are interpreted as representing less tenderness in the meat product. The shear force value data presented in Table 1 point out that, in these

Table 1. Measures of carcass composition and quality among ram lambs at four slaughter weights

Slaughter wt (lb)	100	120	140	160
Carcass lean				
Retail cuts[a](lb)	23.4	26.8	30.8	35.4
Rib eye area[b]	2.16	2.41	2.67	2.92
Carcass fat				
Fat thickness[c]	.16	.22	.27	.32
Kidney/pelvic fat (lb)	1.39	1.93	2.48	3.02
USDA yield grade	2.9	3.3	3.7	4.1
Fat trim (lb)	10.2	14.5	18.7	22.9
Carcass bone				
Bone (lb)	6.4	7.3	8.2	9.1
Carcass quality				
Quality score[d]	11.8	12.2	12.6	13.0
Shear force (kg)	2.50	3.44	3.27	3.28

[a]Boneless leg, shoulder, bone-in rack and loin, riblets and flank portion removed, virtually all fat removed.
[b]12th rib, sq in.
[c]12th rib, in.
[d]Average Choice = 11, High Choice = 12, etc.

Table 2. Carcass components as a percentage of live and carcass weights

Slaughter wt (lb)	100	120	140	160
Dressing percent[a]	50.3	51.6	52.6	53.3
Retail cuts (% of carcass)[bc]	46.5	43.3	41.8	41.5
Fat (% of carcass)[c]	20.3	23.4	25.4	26.9
Bone (% of carcass)[c]	12.7	11.8	11.1	10.7
Retail cuts (% of slaughter wt)	23.4	22.3	22.0	22.1

[a]Hot carcass weight ÷ live weight x 100.
[b]Boneless leg, shoulder, bone-in rack and loin, riblets and flank portion removed, virtually all fat removed.
[c]Based on hot carcass weight.

studies, the greatest change occurred between 100 and 120 lb and that beyond the 120-lb slaughter weight, only minor differences in tenderness were observed. Shear force values for all slaughter weight groups were found to be well below the 4.0 kg shear force considered by some to be near the upper limit for "highly" acceptable tenderness.

Percentage changes in lean and fat

As is shown in Table 1, pounds of fat and pounds of retail cuts both increased steadily with heavier live weights, but the relative increase in fat was greater than that of lean. As shown in Table 2, the percentage of fat in the carcass was found to increase as live weight increased while the percentage of trimmed, boneless retail cuts decreased. The greatest percentage change in fat and retail cuts of the carcass occurred between 100 and 120 lb when the percent fat rose from 20.3 to 23.4, and the percent of retail cuts declined from 46.5 to 43.3. The percentage change in lean and fat was somewhat lower between the other slaughter weights but followed the same trend. However, as shown in Table 2, dressing percent also increased by 3 percent with increasing live weight from 100 to 160 lb. Part of this increase in dressing percent is due to more total lean as well as fat in relation to the "dress-off" items in the live animal. Therefore, the relative change in retail cut yield on a live weight basis was much less pronounced than the relative change noted on a carcass basis. The data used to prepare Figure 1 are presented in Table 2 and show that across slaughter weights, retail cut yield declined 5 percent on a carcass basis but only 1.3 percent on a live weight basis. Since the principal contributor to the value of a live lamb is the portion that can be sold retail, the live value per pound, according to these data, should not be greatly different as lambs go to heavier weights.

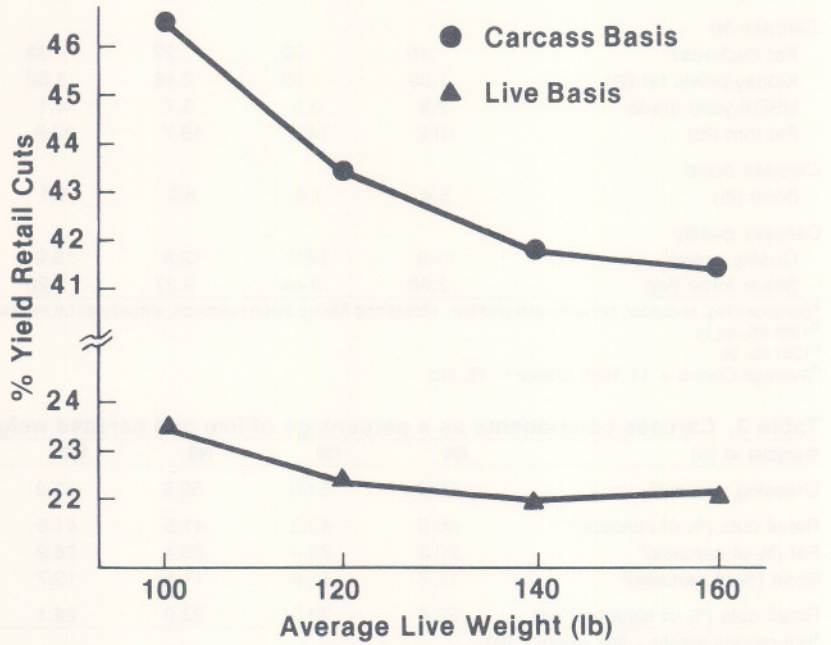


Figure 1. Decline in yield of very closely trimmed retail cuts with increasing live weight

Enumeration and Identification of Lactobacilli in Feed Supplements Marketed as Sources of *Lactobacillus Acidophilus*

S. E. Gilliland

Story in Brief

In recent years much interest has been demonstrated in using products containing *Lactobacillus acidophilus* as feed supplements to improve animal health. This interest has been partially due to the possibility that use of antibiotics in animal feeds may be banned. Fifteen of these feed supplements marketed by eight different manufacturers under various trade names were analyzed for numbers and types of lactobacilli. There was a wide variation with regard to the numbers of lactobacilli contained in the products. Very few of the products contained the organism, *Lactobacillus acidophilus* although they did contain other species of lactobacilli. Three of the products contained no detectable lactobacilli, and many of the others contained such low numbers of lactobacilli that it is doubtful that they would be beneficial when added to the feed for animals.

Introduction

In recent years much emphasis has been given to the possibility of using *Lactobacillus acidophilus* or certain other intestinal lactobacilli as dietary adjuncts for humans and animals to help control intestinal infections. A good deal of this interest in regard to livestock has been based on the possible banning of antibiotics as routine feed supplements.

There are many feed supplements on the market today which are being sold as sources of lactobacilli and other microorganisms reported to be beneficial to the intestinal well being of the animals. These preparations are indicated to be useful in preventing the occurrence of scours as well as improving growth and performance of livestock. Most of the products are marketed as dry materials designed to be mixed with the desired animal ration for usage. If the lactobacilli contained in such products are to establish and/or grow in the intestinal tract of the animal and thus help prevent the occurrence of intestinal infection, they should be viable. While there is no conclusive evidence available regarding the numbers of such lactobacilli required to be beneficial to the animal, it is generally accepted that a relatively high number of the organisms should be fed to the animal. The idea or basis for using organisms such as *L. acidophilus* as a dietary adjunct to help prevent the occurrence of intestinal infections is a good one; however, unless the appropriate species of lactobacillus is used in sufficient numbers, beneficial effects may not be realized.

Due to our interest in the use of *L. acidophilus* as a dietary adjunct, not only for humans but for animals, we obtained a number of commercially available products being marketed as feed supplements to be analyzed for the numbers and types of lactobacilli.

Materials and Methods

The products were prepared and analyzed for numbers of facultative and bile-resistant lactobacilli according to procedures published by Gilliland and Speck (1977). The numbers of bile-resistant lactobacilli are important since it is necessary that the lactobacilli be resistant to bile in order to grow in the intestinal tract. The bacteriological media used for the enumeration were lactobacillus selection (LBS) agar (prepared according to formulation of BBL, Division of Becton, Dickinson and Co., Cockeysville, MD) and lactobacillus selection agar plus 0.2 percent oxgall (LBSO) agar. The desired dilutions of each sample were plated with the appropriate agar, and the plates were incubated in a carbon dioxide atmosphere for 5 days before counting the colonies. For most of the samples which exhibited colonies of lactobacilli, two colonies from each media per sample were isolated for identification. The isolated lactobacilli were identified using methods described by Gilliland and Speck (1977). In addition to the test reported by them, each isolate was also tested for the presence of catalase and for the ability to grow at 15°C. Characteristics for the lactobacilli presented in the 8th Edition of *Bergey's Manual of Determinative Bacteriology* were used as bases for identification of the isolates. The identification involved 20 to 22 characteristics of each isolate.

Results and Discussion

There was a wide range in the numbers of lactobacilli identified in the 15 products tested. The populations ranged from <100/g up to 1.8×10^7/g (Table 1). Three of the products contained no detectable lactobacilli. A fourth one contained no detectable bile-resistant lactobacilli. There were only two products which contained more than one million viable lactobacilli per gram. Of these two products only one contained more than one million bile-resistant lactobacilli per gram.

If directions supplied by the manufacturers of the products were followed in feeding them, the animal would receive very few lactobacilli, based on the number of viable lactobacilli detected in this study. Of the eight products from which lactobacilli were isolated for identification, only one (Product No. 5) contained *L. acidophilus*. The

Table 1. Enumeration and identification of lactobacilli in feed supplements sold as sources of *Lactobacillus acidophilus*

	Count/g		Predominating species isolated	
Product[a]	LBS AGAR	LBSO AGAR	LBS AGAR	LBSO AGAR
1	7.8×10^5	3.0×10^5	*L. brevis*	*L. brevis*
2	2.0×10^5	2.0×10^5	—	—
3	4.0×10^3	3.7×10^3	*L. plantarum*	*L. plantarum*
4	1.1×10^7	7.5×10^6	*L. brevis*	*L. brevis*
5	7.3×10^3	2.1×10^4	*L. acidophilus*	*L. acidophilus*
6	1.8×10^7	2.5×10^4	*L. lactis*	*L. brevis*
7	4.0×10^2	<100	—	—
8	1.6×10^4	1.6×10^4	*L. brevis*	*L. brevis*
9	<100	<100	—	—
10	3.5×10^4	3.0×10^4	*L. brevis*	*L. brevis*
11	6.9×10^4	1.0×10^5	*L. brevis*	*L. brevis; L. casei*
12	7.0×10^2	9.0×10^2	—	—
13	<100	<100	—	—
14	<100	<100	—	—
15	1.2×10^3	1.6×10^3		

[a]All products were dry; each was given a code number prior to analyses.

number of lactobacilli in this product was quite low. The species of lactobacillus most often encountered in other products was *L. brevis*. While some of the manufacturers indicated more than one species of lactobacillus to be present in their products, *L. brevis* was not mentioned as one that was present in any of them. The species most often mentioned as being present in the animal feed supplements were *L. acidophilus* and *L. plantarum*.

Based on past research, the use of *L. acidophilus* and/or other intestinal lactobacilli appears to be a feasible means for helping control intestinal infections in livestock. However, this author is not aware of any studies involving the use of *L. brevis* or *L. plantarum* in this manner. If the organisms used as dietary adjuncts are to grow in the intestine and thus help prevent the occurrence of intestinal infections, they must first be viable in a product fed to the animal, and they must be present in sufficient numbers so that they may establish and/or manifest their action in the intestinal tract. While the minimum number required has not been established, it is generally accepted that a relatively high number must be ingested in order to have a beneficial effect. The numbers of lactobacilli detected in the products in the present study would most likely not be adequate to be beneficial.

There have been a number of studies reported in which feed supplements such as those reported in this study were tested for their effectiveness in controlling intestinal infections in various species of livestock. Results from these studies have been variable. Some have indicated positive results, others negative results. More often than not, these reports have not contained data showing the numbers of lactobacilli contained in the product, nor have they confirmed the identification of the organism(s) present. Another aspect not included has been the challenge of treated animals with pathogens that cause the intestinal infection. These are factors which must be considered in testing the effectiveness of feed supplements which are supposed to contain lactobacilli that are to function in the intestine.

Research must be conducted to develop procedures for preparing feed supplements which contain adequate numbers of the desirable lactobacilli in order to be useful in controlling intestinal infections in livestock. Factors which must be considered are: the viability of the organism during preparation and storage of the feed supplements, the numbers of lactobacilli that are necessary in the product and the most desirable species of the organism for such use. Most research to date would indicate that *L. acidophilus* would be the most desirable species; however, it is possible that some of the other species which can survive and grow in the intestinal tract might be equally as effective.

Literature Cited

Buchanan, R. E., and N. E. Gibbons. 1974. Bergey's Manual of Determinative Bacteriology (8th Ed.). Williams and Wilkins Co., Baltimore, MD.

Gilliland, S. E. and M. L. Speck. 1977. Appl. Envir. Microbiol. 33:1289.

Gilliland, S. E. and M. L. Speck. 1977. J. Food Protection. 40:760.

NUTRITION—COW-CALF AND STOCKER

Effects of Early Weaning on Calf Performance and on Reproduction in Mature Cows

K. S. Lusby and Angel A. Parra

Story in Brief

Calves from 24 mature Hereford cows were early weaned at 6-8 weeks of age while an additional 24 cows raised their calves to weaning. Early weaned cows rebred faster after calving (46 days vs. 81 days) and had a higher conception rate (100 percent vs. 83 percent). Early weaned calves weighed more at normal weaning age than calves raised by their dams (435 vs. 347 lb). Early weaned calves may be efficiently raised to a normal weaning weight with minimal labor and facilities.

Introduction

Early weaning has been shown to be an effective tool for achieving high conception rates and short intervals from calving to breeding. Management of the early weaned calves (6-8 weeks old) has been the principal factor limiting the use of early weaning in situations where poor rebreeding performance is expected.

In a previous study (Lusby and Wettemann, 1980) rebreeding rates of very thin first-calf heifers were increased from 58 percent to 97 percent in early weaned heifers compared to heifers that raised calves to normal weaning age. Weaning weights of calves raised in drylot were equal to weights of calves raised by their dams. The early weaning system used was simple and required minimal labor and facilities.

The objectives of the research reported here were to improve the rations fed to early weaned calves and to study the feasibility of using early weaning to move late calving mature cows into sequence with the earliest calving cows in the herd.

Experimental Procedure

Fifty-eight mature Hereford cows, most calving late in the calving season, were assigned by date of calving to either have their calves early weaned or to raise their calves to a normal weaning age of 7 months. Calves were early weaned at 2-week intervals beginning at the time the oldest calf was 8 weeks old so that all early weaned calves were weaned at between 6 and 8 weeks of age.

At the time of early weaning all calves (early and normally weaned) were weighed and vaccinated for Blackleg, malignant edema, IBR and PI-3. Males were banded at birth. Calves to be normally raised were returned to their dams and maintained on bermuda pasture throughout the summer. Dams of early weaned calves were returned to bermuda pasture but were kept separate from nursing females for 4 weeks to prevent any calves from nursing early weaned cows.

All cows were exposed to Hereford bulls for a 62-day period from May 13 to July 14. Bulls were equipped with chin-ball markers for heat detection.

Early weaned calves were placed in a covered barn with a 20 by 20 foot outside pen. Water and feed were easily available at all times. The starter ration (Table 1) was high in energy and protein and contained 10 percent cottonseed hulls as the sole roughage source. Two calves 4-5 months old were kept with each new group of early weaned calves since the 1980 study showed that the older calves seemed to reduce the stress of early weaning and lead the new calves to feed and water.

After 10 to 14 days on the starter ration, the early weaned calves were moved to a half-acre drylot pen and fed to weaning from a self feeder. Ration II was fed in the self feeder for about 6 weeks after which time Ration III was fed until weaning.

All calves were weaned at 7 months plus-or-minus 7 days of age in October and November. All cow and calf weights were taken after overnight withdrawal from feed and water. One calf on pasture was removed due to an abcessed leg, and one early weaned calf died of atypical interstitial pneumonia in October. Data from both calves and their dams were discarded.

Results

Early weaning rations used in the previous early weaning study were more complex than the rations used in this trial and included oats and alfalfa pellets. The simpler rations using cottonseed hulls as the sole roughage source appear to be more readily consumed and less prone to the sorting problems encountered with the more complex rations.

The use of two older calves during the critical first two weeks of early weaning again appears beneficial since the young calves are often seen to follow the older calves to feed and water.

It must be remembered that early weaned calves should be started with a ration high in energy and protein and gradually changed to a grower-type ration as their total intake increases. Calves in this study consumed only about 1.5 lb/day of the starter ration during the first 10-14 days of early weaning. The calves were changed from Ration II to Ration III when intake of Ration II had increased sufficiently to cause some scouring. This occurred after about 6 weeks on Ration II.

Other than the cases noted in the procedure section, the only health problem encountered during the study was the incidence of coccidiosis in two early weaned

Table 1. Early weaning rations used in 1980

Ingredient	Ration		
	Starter	Ration II	Ration III
	%	%	%
Rolled corn	64.0	56.5	50.0
Soybean meal	20.0	17.0	12.0
Cottonseed hulls	10.0	20.0	33.0
Cane molasses	5.0	5.0	3.0
Dicalcium phosphate	—	—	.5
Limestone	0.5	0.5	0.5
Potassium chloride		0.5	0.5
Salt	0.5	0.5	0.5
Vit A (30,000 IU/gm)	1 lb/ton	1 lb/ton	½ lb/ton
Deccox (for prevention of coccidiosis)	1 lb/ton	0.8 lb/ton	

calves in late October. Both quickly responded to treatment. A coccidiostat was fed for the first few weeks of early weaning and probably should have been fed again during the last portion of the trial to the early weaned calves.

Average daily gains of early weaned calves were greater ($P<.01$) than gains of normal reared calves (1.77 vs. 1.27 lb/day, Table 2). Feed conversions in drylot were very efficient, 4.5 lb dry matter/lb gain. These efficient gains were also seen in the previous study and were expected since calves of this age are primarily depositing lean instead of fat. More rapid gains could have been achieved by feeding a higher level of concentrate in Ration III, but the possibility of founder and the probability of getting the calves too fat may reduce the desirability of more rapid gains. Average weaning weights of early weaned calves were 435 lb, 88 lb more ($P<.01$) than the calves raised by their dams. The relative difference in weaning weights of early and normal weaned calves will obviously depend on forage conditions, weaning rations, growth potential of the calves and milking ability of the cows.

The effects of early weaning on cow performance are shown in Table 3. The conception rate of early weaned cows was 100 percent compared to 83 percent for cows that raised calves. The interval from calving to first observed estrus was 46 days for

Table 2. Performance of normal reared and early weaned calves

No. of calves	23	23
Calf weights, lb		
At birth	71	68
At early weaning	145	155
At weaning, (205 day, steer equiv.)	347[a]	435[b]
Avg daily gain, early weaning to 205 days, lb (158 days)	1.27[a]	1.77[b]
Avg daily feed, lb		8.84
Lb feed/lb gain,		
As fed basis		5.00
Dry matter basis		4.50

[ab]Means on a line with different superscript letters differ ($P<.01$).

Table 3. Effects of early weaning on cow performance

	Treatments	
	Normal weaned	Early weaned
No. of cows	23	23
Cow weight, lb		
Time of early weaning (Avg. date, May 19)	816	832
End of breeding, July 7	922[a]	968[b]
At weaning	920[a]	1040[b]
Condition scores		
Time of early weaning	5.04	5.07
End of breeding	5.69	6.29
At weaning	5.99	6.82
Interval from calving to first observed estrus, days	81	46
No. cows pregnant/exposed	19/23 (83%)	23/23 (100%)

[ab]Means on line with different superscript letters differ ($P<.01$).

early weaned cows compared to 81 days for cows with calves. Early weaned cows frequently cycled within 3 days after calf removal.

All cows gained weight and increased in condition during the summer. As expected, the non-lactating, early weaned cows gained more weight ($P<.01$) and were fatter at the end of the summer than the cows that raised calves. The better condition of the early weaned cows would reduce the supplement requirements of the early weaned cows during the following winter.

Results of this study as well as results of the previous study (Lusby and Wettemann, 1980) show that calves can be successfully weaned at 6-8 weeks of age and efficiently raised to a normal weaning weight in drylot. Early weaning will permit high conception rates and rapid rebreeding in cows. While early weaning is certainly not recommended as standard practice, it should be useful in times of drought when purchased feed may more efficiently be fed directly to the calf than to the lactating cow. Early weaning may, as well, offer cattlemen a chance to achieve high conception rates in cows too thin to rebreed otherwise.

An economic analysis of early weaning is shown in Table 4. A spring calving

Table 4. Costs and returns analysis for early weaning vs. normal weaning of calves born in February of 1981: the impact on returns for 1981 and 1982

	Meet cow's requirements				Do not meet cow's requirements			
	Adequate forage		Inadequate forage		Inadequate forage		Inadequate forage early wean	
	CSM	Hay	CSM	Hay	CSM	HAY	CSM	Hay
1980-81, lb/hd/day								
Oct. 15-Jan. 1	2	—	2	5	2		1	
Jan. 1-Feb. 15	3	4.5	3	10	3	4.5	2	4.5
Feb. 15-May 1	4	4.5	3	15	4	4.5	1	4.5
Total lb fed	588	400.	514	1955	588	400	317	400
Cost for cow	$95.38		$147.59		$95.38		$58.80	
Cost for early weaned calf							$112.00	
1980-81 Returns								
Avg weaning wt, lb	400		400		375		434	
Calving rate	88		88		88		88	
Weaned wt/cow, lb	352		352		330		382	
Returns, 80¢/lb	$282.		$282.		$264.		$306.	
Net (calf-feed costs)	$186.62		$134.41		$168.62		$135.20	
1981-82 costs[1]	$ 95.38		$ 95.38		$ 95.38		$ 80.0	
1981-81 returns								
Avg weaning wt, lb	400		400		400		400	
Calving rate, %	88		88		60		98	
Weaned wt/cow, lb	352		352		240		392	
Returns, 80¢/lb	$282.		$282.		$192.		$314.	
Net (calf-feed costs)	$186.62		$186.62		$96.62		$234.00	
			2-year summary					
1981-81 returns	$373.24		$321.03		$265.24		$369.20	

[1]For 1981-82, assume costs are the same as in 1980-81 and that forage is adequate. Wintering costs will be slightly lower for early weaned cows due to their added condition going into the winter. Ingredients costs: Corn, $4.00/bu.; SBM, $300/ton; Hulls, $80/ton; Molasses, $130/ton; Dical, $13/cwt; Limestone, $1.50/cwt; Kcl, $5/cwt; Salt, $2/cwt.

program is used in which calving begins about February 15. The type of forage is range or bermuda. An 88 percent calf crop with 400-lb weaning weights is considered average for cows raising their calves. Rations I, II, and III are priced at $186, $175, and $159/ton, respectively. The ingredient prices used to arrive at the ration costs are shown at the bottom of Table 4. A $20/ton markup is included.

The feasibility of early weaning is evaluated under four situations:

a. There is adequate standing roughage, and the cow's nutrient requirements can be met with cottonseed meal and some supplemental hay during periods when ice and snow covers forage.
b. There is a shortage of standing roughage, but grass hay will be fed along with cottonseed meal to meet the cow's nutrient requirements.
c. There is inadequate standing roughage, but the hay supply is inadequate to meet the cow's requirements. Cows will be in poor condition at breeding in the spring of 1981.
d. Same as c, but we will early wean at 6-8 weeks of age in the spring of 1981.

For cows we intend to early wean, we will maintain sufficient condition to insure that the cows can calve and nurse for 6 weeks.

Note that for 1981, early weaning about breaks even with purchasing grass hay in situations where forage is scarce. Assuming a 98 percent calf crop the following year from early weaned cows along with their lower wintering cost, early weaning shows a $48 advantage for the 2-year period over purchasing hay in 1980-81. Early weaning netted a $104 advantage over living through poor conception rates with underfed cows.

The most likely place for early weaning is in a situation where poor condition rates are expected. Depending on concentrate and hay prices, early weaning might be profitable when large amounts of hay must be purchased for the cow.

Literature Cited

K. S. Lusby and R. P. Wettemann. 1980. Okla. Ag. Exp. Station. MP-107:55.

Influence of Month of Calving on Daily Milk Yield: Progress Report on Development of a Model of a Cow-calf System

R. L. Hintz, K. S. Lusby and Robert Totusek

Story in Brief

Daily milk yields of 2-, 3- and 4-year-old Holstein, Holstein-Hereford cross and Hereford cows were used to develop equations to describe the lactation curve. Then, the equations were used to predict the average daily milk yield for different weeks of the lactation. Breed, year and month of calving affected average daily milk yield for each week of lactation.

Introduction

Milk yield is affected by environmental factors such as season of calving and age of cow, but how some of these environmental factors affect the shape of the lactation curve is uncertain. Therefore, the purpose of this paper is to report the influence of month of calving on the shape of the lactation curve.

Experimental Procedure

Hereford, Holstein x Hereford cross and Holstein cows that were maintained on tallgrass native range or under completely confined drylot conditions weaned calves in 1971, 1972 and 1973 as 2-, 3- and 4-year-olds at the Southwestern Livestock and Forage Research Station. Within each breed, groups of cows were fed a moderate or high level of winter supplement, and, in addition, a group of Holstein cows received a very high level of winter supplement. Moderate, high and very high levels represented the amount of winter supplement believed essential to maintain a high level of reproduc-

Table 1. Number of cows in drylot used in estimating lactation curves

Breed	Year calf was weaned	Month of calving				Total
		November	December	January	February	
Holstein	1971	2	7	3		12
	1972	1	7	6	1	15
	1973	2	4	5	3	14
	Total	5	18	14	4	41
Holstein-Hereford cross	1971	2	4	4		10
	1972		4	4	1	9
	1973		3	5	1	9
	Total	2	11	13	2	28
Hereford	1971	2	6	2		10
	1972		4	5	1	10
	1973		5	4		9
	Total	2	15	11	1	29

Table 2. Number of cows on range used in estimating lactation curves

Breed	Year calf was weaned	Month of calving				Total
		November	December	January	February	
Holstein	1971	6	16	10		32
	1972		11	4	1	16
	1973	2	7	10	13	32
	Total	8	34	24	14	80
Holstein-Hereford cross	1971	7	12	6	1	26
	1972		12	7	2	21
	1973	1	3	10	10	24
	Total	8	27	23	13	71
Hereford	1971	2	10	10	2	24
	1972		11	9	2	22
	1973	1	2	8	16	27
	Total	3	23	27	20	73

Table 3. Predicted average daily milk yield of cows in drylot

Breed	Week of lactation	Calves weaned in 1971 and born in month			Calves weaned in 1972 and born in month				Calves weaned in 1973 and born in month			
		Nov	Dec	Jan	Nov	Dec	Jan	Feb	Nov	Dec	Jan	Feb
Holstein	4	25.4	22.0	25.4	30.9	20.9	11.9	22.8	33.6	27.7	24.9	15.9
	8	29.6	26.8	27.5	33.7	24.1	20.6	26.4	28.9	28.8	25.6	24.7
	12	29.4	27.4	27.3	35.7	26.4	26.7	29.8	26.6	28.7	25.4	27.3
	16	27.5	26.0	26.2	37.4	28.4	30.9	33.4	25.1	28.1	24.8	26.3
	20	24.8	23.7	24.7	38.8	30.2	33.5	37.1	24.1	27.3	24.1	23.5
	24	21.8	21.1	23.0	40.2	31.9	34.9	41.2	23.3	26.3	23.2	20.1
	28	18.9	18.4	21.2	41.5	33.5	35.4	45.6	22.7	25.2	22.3	16.5
	32	16.3	15.9	19.5	42.7	35.1	35.1	50.3	22.3	24.1	21.3	13.3
Holstein-Hereford cross	4	24.1	20.2	23.6		17.8	12.1	19.2		23.8	21.9	18.2
	8	24.2	21.6	21.6		19.4	16.4	17.2		26.0	21.1	19.2
	12	22.7	21.1	19.3		20.3	18.6	16.6		25.7	20.3	19.2
	16	20.7	19.8	17.1		20.9	19.7	16.5		24.4	19.4	18.8
	20	18.6	18.3	15.1		21.3	19.9	16.6		22.6	18.5	18.2
	24	16.5	16.6	13.2		21.5	19.7	16.8		20.7	17.7	17.4
	28	14.6	15.0	11.5		21.7	19.1	17.2		18.7	16.8	16.6
	32	12.8	13.4	10.0		21.8	18.3	17.7		16.8	16.0	15.8
Hereford	4	10.8	11.7	14.4		17.0	14.5	14.6		18.7	15.2	
	8	12.5	14.2	14.8		16.5	15.2	20.9		17.0	17.6	
	12	11.8	13.9	13.6		15.5	15.3	22.1		16.2	17.5	
	16	10.3	12.4	11.8		14.4	15.3	20.7		15.7	16.3	
	20	8.5	10.6	10.1		13.3	15.1	18.2		15.3	14.7	
	24	6.9	8.8	8.5		12.3	14.8	15.3		15.0	13.0	
	28	5.4	7.1	7.0		11.3	14.6	12.5		14.8	11.3	
	32	4.2	5.6	5.8		10.3	14.2	10.0		14.6	9.7	

Table 4. Predicted average daily milk yield of cows on range

Breed	Week of lactation	Calves weaned in 1971 and born in month				Calves weaned in 1972 and born in month			Calves weaned in 1973 and born in month			
		Nov	Dec	Jan	Feb	Dec	Jan	Feb	Nov	Dec	Jan	Feb
Holstein	4	29.0	25.9	20.0		26.6	18.8	34.4	24.2	26.5	28.3	23.7
	8	24.1	23.3	24.0		31.5	31.8	41.3	23.3	29.3	31.0	28.2
	12	22.9	22.6	25.5		33.4	37.0	39.8	23.7	29.6	30.9	28.8
	16	23.0	22.7	25.9		33.9	37.1	35.1	24.6	28.8	29.6	27.6
	20	23.8	23.2	25.7		33.6	34.1	29.5	25.8	27.5	27.8	25.7
	24	25.1	24.0	25.0		32.8	29.8	24.0	27.3	25.8	25.8	23.3
	28	26.9	25.0	24.1		31.7	25.1	19.2	29.0	24.1	23.7	20.8
	32	29.0	26.2	23.0		30.4	20.6	15.0	31.0	22.3	21.6	18.4
Holstein-	4	27.3	20.3	18.7	18.0	21.7	19.6	21.9	23.0	21.0	20.6	17.1
Hereford	8	20.1	18.6	18.9	21.5	22.6	24.2	22.6	20.1	20.4	24.4	20.7
cross	12	17.9	18.0	18.5	21.8	22.8	25.1	22.6	19.1	20.2	24.8	21.5
	16	17.2	17.8	17.9	20.8	22.6	24.2	21.8	18.8	20.2	23.8	21.0
	20	17.2	17.8	17.2	19.1	22.2	22.5	20.7	18.8	20.2	22.1	19.8
	24	17.7	18.0	16.5	17.1	21.7	20.4	19.5	19.1	20.3	20.1	18.3
	28	18.6	18.2	15.7	15.1	21.1	18.2	18.1	19.5	20.4	18.0	16.7
	32	19.7	18.5	15.0	13.2	20.5	16.0	16.8	20.0	20.5	15.9	15.0
Hereford	4	14.6	12.1	14.7	17.6	14.7	12.7	17.8	14.7	17.4	16.4	15.3
	8	11.8	12.0	14.8	15.2	14.8	16.5	19.1	14.4	18.1	16.7	17.0
	12	10.9	11.9	14.4	13.8	14.5	17.2	17.3	14.0	16.5	15.8	16.4
	16	10.7	11.8	13.6	12.9	14.0	16.3	14.6	13.5	14.3	14.4	15.0
	20	10.7	11.7	12.8	12.1	13.4	14.7	12.0	13.0	12.0	13.0	13.3
	24	10.9	11.6	12.0	11.5	12.7	12.9	9.5	12.4	9.9	11.5	11.6
	28	11.3	11.5	11.2	11.0	12.1	11.0	7.5	11.9	8.1	10.1	9.9
	32	11.8	11.3	10.4	10.5	11.4	9.3	5.8	11.4	6.5	8.9	8.4

tion in Hereford, Holstein x Hereford cross and Holstein cows, respectively. The performance of these cows is summarized, and the detailed description of management practices is presented by Kropp *et al.* (1973a), Kropp *et al.* (1973b), and Holloway *et al.* (1975).

Seven estimates of daily milk yield obtained at approximately 1-month intervals were obtained and used to estimate (non-linear least squares procedure) the parameters a, b and c of the Gamma function, $Y = a\, n^{b} e^{-cn}$, where Y is the average daily milk yield during the n^{th} week of lactation. The a, b and c parameters determine the shape of the lactation curve. The Gamma function was used because the estimation of the parameters is relatively easy, and the sum of the squared differences between actual and predicted values is smaller with the Gamma function than with other equations (Wood, 1967; Cobby, 1978). Average daily milk yields per cow for Week 4 through Week 32 of lactation were predicted with the developed equations. In the analysis of the predicted average daily milk yields for Weeks 4 through 32 of lactation, breed, year and month influenced milk yield each week of the lactation while level of winter supplement did not significantly influence predicted milk yields. Then, the averages of the predicted daily milk yields for each breed, year of weaning and month of calving subclasses were used to estimate the parameters a, b and c of the Gamma function. Thus, an equation describing the lactation curve of each breed, year of weaning and month of calving was developed.

Results and Discussion

The majority of the cows calved in December or January (Tables 1 and 2). When examining the predicted average daily milk yield of cows in drylot (Table 3) and on range (Table 4) several trends were apparent:

1. Breed influenced the average daily yield, with Holsteins producing the largest amount.
2. Year influenced the average daily yield, with year 1972 having the largest production. However, year effects are confounded with age of cow and breed of the calf's sire.
3. Cows on range calving in January produced more milk than cows calving in December during the middle part of lactation (approximately Weeks 8 through 20). Some of the predictions for cows on range calving in November and December indicate an increase in milk production at the end of lactation. Month of calving influenced milk yield of cows in drylot, but a consistent trend was not noted.

Development of equations that describe the lactation curve is one phase of the development of a model to describe a cow-calf system. These equations will be used to simulate milk yield.

Literature Cited

Cobby, J. M., *et al.* 1978. Anim. Prod. 26:127.
Holloway, J. W., *et al.* 1975. J. Anim. Sci. 40:114.
Kropp, J. R., *et al.* 1973a. J. Anim. Sci. 36:797.
Kropp, J. R., *et al.* 1973b. J. Anim. Sci. 37:1222.
Wood, P. D. P. 1976. Nature. 216:164.

Potential of Near Infrared Reflectance Spectroscopy for Measuring Forage Quality

F.E. Barton, II and S.W. Coleman

Story in Brief

Research on the application and potential uses of near infrared (NIR) reflectance spectroscopy has been initiated at Ft. Reno. The instrumentation has been set up and preliminary studies begun to evaluate the instrument and develop the appropriate calibration data to predict chemical and nutritive composition of forages. Emphasis will be placed on forages native to or grown in the southwestern U.S. Results have been obtained for *in vitro* dry matter digestibility (IVDMD) and crude protein (CP) of "Old World" bluestem. All laboratories participating in the NIR network project have obtained good calibrations for IVDMD, CP and fiber from a set of thirty samples which have been analyzed by all locations. The precision of the instrument allows researchers to obtain more accurate data than is possible using conventional wet chemistry techniques, i.e., Wende, Van Soest, etc. The results of the analyses indicate that we can predict forage quality accurately and rapidly with NIR. Potential uses of NIR spectroscopy include general forage analysis and better screening methods for plant breeders, resulting in more reliable, less costly means of balancing rations.

Introductions

Over a century ago the Wende proximate analysis system was developed. This system consisted of five measurements: dry matter (DM), by oven drying; fat, by ether extraction; ash, by incineration; crude protein (CP), by Kjeldahl analysis for nitrogen; and crude fiber (CF), by successive extraction with dilute alkali and acid. These procedures are still in use today for the analysis of forages and other fibrous materials. In 1963 Tilley and Terry published their two-state *in vitro* dry matter digestibility (IVDMD) procedure. This technique has been adapted worldwide as the best laboratory measurement of feed digestibility. During the mid 1960's Van Soest introduced the detergent fiber analysis which included acid detergent fiber (ADF), neutral detergent fiber (NDF), and lignin. These analyses more closely define the components of plant structural carbohydrates than the Wende System and provide a means of predicting animal performance from analysis of the feed the animal consumes.

All of the standard laboratory wet chemistry procedures for forage analysis have two things in common. They are time consuming and labor intensive. When a sample is analyzed by standard wet chemical methods for CP, NDF, ADF, lignin, and IVDMD, the time required per sample will be two to three weeks before all the analyses are complete. During this time the samples are weighed and dried and transferred numerous times with the ever-increasing chance for human error. Even so, these methods are far more time and labor efficient than using tons of forage over several months to obtain animal feeding data, the only way to obtain forage nutritive value. The time to know the nutritive value of a forage is not, however, several weeks after the last bale has been fed.

Considerable progress has been made in the laboratory by constructing facilities to do multiple repetitive analyses. Laboratories can usually process 500 tube IVDMD

runs which will give the results of 250 samples/week. This analysis, however, is the only one that a group of 2-4 technicians can handle. To conduct all of the analyses mentioned would require 10-12 people and at least 3 weeks for 250 samples.

Near-infrared (NIR) reflectance spectroscopy has been used to predict the quality of forages and their chemical composition. The NIR method is fast and requires much less labor. On a properly calibrated instrument, an operator and one person to prepare samples are all the labor needed to analyze a sample in 40 sec. and predict 10 compositional or animal performance factors. If automated, the instrument could analyze several hundred samples a day, and its initial cost ($50,000 to $100,000) could quickly be regained. The NIR method has been accepted by Canada and the U.S. as the method of choice for measuring protein content of grains.

Currently, the Southwestern Livestock and Forage Research Station is participating in a National NIR Network system utilizing a monochromator and a computer to collect, process and analyze the spectral data. As part of the network, researchers at the Ft. Reno station and at five other locations will be evaluating identical new instruments. Further, we will evaluate laboratory procedures which are used to obtain calibration data. Results of the studies conducted at Ft. Reno can be compared with those from the other five locations. These will make possible the standardization of all six instruments and the rapid exchange of data among locations.

Experimental Procedures

Sample preparation

Thirty samples of forages were assembled form three locations, University Park, Pennsylvania; Athens, Georgia; and El Reno, Oklahoma. The samples included alfalfa (*Medicago sativa*), orchardgrass (*Dactylis glomerota L.*), Clair Timothy (*Phleum pratense L.*), tall fescue (*Festuca arundinacea* Schreb.) and bermudagrass (Cynodon dactylon(L.) Pers.). Fresh frozen, freeze-dried samples and sun-cured hay samples of various qualities were included. Each was analyzed for crude protein (CP), ash, dry matter (DM), acid detergent fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), and permanganate lignin (PML). *In vitro* dry matter disappearance was determined by a modification of Tilley and Terry procedures. A second set of 130 samples of "Old World" bluestems (*Botriochloa*) was analyzed by the same procedures.

The 30 samples, referred to as Near Infrared Network (NINW) samples, were ground through a 1mm screen in a Wiley Mill prior to being packed in the cups while the "Old World" bluestem samples (OWBS) were ground a second time through a 1mm screen in a Udy cyclone grinder.All samples were packed into sample cups approximately 5 cm in diameter and 1cm thick. A foam-filled poster board backing was used to seal the cups.

Instrument description and operation

The instrument system is comprised of two parts—the spectrometer and the computer. The spectrometer is a Neotec model 6100 monochromator. It produces monochromatic light in the near infrared region from 1100 nm to 2500 nm with a holographically ruled grating and uses lead sulfide detectors. The spectrometer is unique because of its high energy throughput and rapid scan time as compared with other monochromators such as the Cary 14 or J-Y HRS-2. Sixty-four scans of each sample are taken and averaged. Seven hundred data points at 2.0 nm intervals are recorded.

The computer is a Digital Equipment Corporation PDP/11-03, 16-bit word, 32K mini-computer. In its current configuration it has one RL01 hard 5.2M byte disk, dual 512K byte floppy disks and Decwriter III and Decwriter II hard-copy terminals. The

operating softwear was developed at Pennsylvania State Univesity and consists of eight programs to scan the samples, create files of the data, add calibration data, perform mathematical transformations and stepwise linear multiple regression analyses, make statistical comparison of actual vs. predicted data, and measure instrument noise and wavelength accuracy.

Results and Discussion

Table 1 contains data obtained from 30 samples which were circulated to six NIR laboratories for wet chemical analysis as an inter-laboratory check on accuracy of results and precision of laboratory procedures. The standard error of calibration (SEC) is quite low for such a diverse sample population, and the coefficient of determination R^2 values are good, particularly for protein and IVDMD. Repeatability is an estimate of similarity of multiple readings by the NIR instrument for each sample and is a measure of what the error limits (precision) for the instrument would be for any one sample. The last two columns contain data on 10 samples which came from Ft. Reno, Oklahoma. These were five samples, three bermudagrass and two fescue hays, submitted as duplicates. The SDP is the average standard deviation between duplicates for predicted values, and SDA is the average standard deviation between duplicates for the laboratory or "actual" analysis for IVDMD, CP, ADF and ADL. Only in the case of CP was the laboratory analysis more precise than NIR, reflecting the precision of analysis for nitrogen by the Kjeldahl method.

The most critical factor in NIR analysis is the quality of the laboratory analysis used for calibration, The study with the NIR network sample described above has shown that NIR can be used to find erroneous results. In fact, the SDA for IVDMD in Table 1 is large primarily for a difference of 10 percentage units between one set of duplicates. Statistical analysis of the residuals from "actual" analytical values of Location 1 versus predicted values using equations generated from Location 2 calibration data, and vice versa, have shown biases and errors which otherwise would have been ignored. Such things as differences in the diet of rumen fluid donor animals will bias IVDMD. Consistantly high NDF values are usually obtained because samples were not filtered while still boiling. Titrating to a different end point will bias crude protein, especially between operators. These biases affect the calibration value but really do not affect the prediction capability as much as would be expected since the prediction equation line is "averaged" through all calibration samples.

Table 2 contains data obtained from 100 "Old World" bluestem hay samples. In this case IVDMD was rerun several times on those samples with prediction values that differed by more than 25 percent from the laboratory value. In all cases the laboratory value was found to be wrong. When a set of good (consistent in three runs) IVDMD

Table 1. Calibration of NIR instrument for a broad spectrum of samples

Analysis	N[2]	SEC[3]	R^2	Repeatability	SDP[4]	SDA[5]
IVDMD	3	1.74	.92	0.16	0.37	1.72
CP	2	0.72	.98	0.02	0.22	0.09
ADF	3	1.6	.88	0.08	0.24	0.28
ADL	3	0.78	.87	0.06	0.12	0.29

[1]Set of 30 samples included 13 bermudagrass, 5 alfalfa, 4 orchardgrass and 1 timothy grass. Twenty were hays and 10 were fresh-frozen and freeze-dried.
[2]Number of wavelengths.
[3]SEC is standard error of calibration.
[4]SDP is the average standard deviation of the predicted values of the 10 El Reno samples which were duplicated, i.e. 5 different samples.
[5]SDA is the average standard deviation of the actual laboratory values for the 10 Ft. Reno samples which were duplicated.

Table 2. Standard errors of calibration and prediction for IVDMD of Old World Bluestem[1]

	Number of 's in equation		
Error	2	3	4
Calibration	1.65	1.52	1.50
Prediction	1.81	1.98	2.00
R^2	0.84	0.86	0.86
Repeatability	0.06	0.07	0.08

[1]Calibration was made on 60 Old World Bluestem samples and the resulting equations were used to predict IVDMD of a different set of 40 samples.

data for 60 samples was used for calibration, the results were those obtained in Table 2. These calibration equations were applied to the spectra of a different set of 40 "Old World" bluestem samples. The standard error of prediction, i.e. how far these samples deviate from the calibration regression line, is 1.81-2.00 (Table 2) equations using 2-4 wavelengths. These results are about as good as we can hope to do in the laboratory.

Conclusions

The near infrared method has potential in several areas. First, as a means of rapid laboratory analysis it is extremely valuable. It takes 5 minutes or less to run a sample and get 10 different analytical results. With automation, several hundred per day could be run. These analyses would be conducted with prediction equations generated from broad sample sets so that many species could be analyzed with the same set of equations. Alternatively, the computer, through the use of discriminant functions, could be programmed to choose the appropriate equation for a given sample's spectra.

Second, plant breeders could use the NIR technology as a rapid means of screening many samples. Here, specific calibrations would be required for each line of germ plasm. In many instances the extreme values would be the ones of most interest to the breeder, and the statistical routines could be modified to provide that information.

Third, the NIR spectra could be interpreted to the extent that wavelengths could be physically related to particular chemical entities in the plant giving an absolute analysis. This, in turn, could be related to an animal performance factor. This aspect will be an undertaking of a least one of the laboratories participating in the NIR network.

Finally, the concept of chemametric analysis, analysis by prediction, is just now becoming an accepted analytical procedure. There exists an unlimited potential for using the computer and regression analysis with a host of non-destructive, rapid spectroscopic methods which will provide detailed information more rapidly in the future.

Effect of Level of Supplement and Amount of Supplemental Crude Protein on Intake and Digestibility of Untreated Wheat Straw by Lambs

G. W. Horn, D. W. Pace
and C. L. Streeter

Story in Brief

Sixty lambs with a mean initial weight of 64 pounds were individually fed untreated chopped wheat straw free-choice and increasing amounts of low- or high-protein supplements that supplied .128 or .256 lb supplemental crude protein per day. Straw DM intake and digestibility decreased ($P<.001$) with increased level of supplement. Feeding additional supplemental protein increased straw intake ($P<.05$) and straw DM digestibility ($P<.001$). The level of supplement by amount of supplemental crude protein interaction was not significant ($P>.35$). Straw DM intake of lambs fed .88 lb of the low- and high-protein supplements were 1.92 and 2.27 percent of body weight, respectively. Respective straw DM digestibilities at this level of supplement feeding were 40 and 46 percent.

Introduction

Crop residues represent a large potential feed resource for ruminant animals. They are characterized as having a low digestibility and, therefore, low feeding value. Treatment of crop residues to increase their feeding value has been a long-standing goal. Treatment of crop residues increases their cost and can result in a loss of competitiveness with other feedstuffs.

Supplementation of crop residue-based diets with concentrates increases total energy intake. The effect of supplementation on intake and utilization of crop residues is of concern. The objective of this trial was to determine the effect of amount of supplement and supplemental crude protein on intake and digestibility of untreated wheat straw by lambs.

Experimental Procedure

Sixty ram and ewe lambs with a mean initial weight of 64 pounds were randomly assigned, within sex, to six treatments. The lambs were individually fed untreated chopped wheat straw free-choice and .88 or 1.32 lb of supplement per day that supplied .128 (low-protein supplements) or .256 (high-protein supplements) lb crude protein. Two additional supplements that supplied .128 and .256 lb crude protein, respectively, were fed at levels of .44 and .66 lb per day, respectively. It was not possible to formulate (using 44 percent crude protein soybean meal and corn) a supplement that when fed at .44 lb per day would supply .256 lb crude protein. Therefore, supplement number 4 (Table 1) was included in the trial. Ingredient composition of the supplements is listed in Table 1. The 36-day trial consisted of a 15-day preliminary period for the lambs to adapt to the diets and a 21-day period in which straw consumption was measured. Total fecal excretion of four ram lambs per treatment was measured during the last 6

This work was conducted as a part of Research Agreement No. 58-7B30-9-87 between the USDA (SEA/AR; Southwestern Livestock and Forage Research Station, El Reno, OK) and the Okla. Agr. Exp. Sta.

days of the trial. Straw dry matter digestibility was calculated by "difference" (Schneider and Flatt, 1975) using calculated digestibilities of the supplements. The lambs were weighed at the beginning and end of the trial after feed and water were withheld for 30 and 8 hours, respectively.

Results and Discussion

The interaction between level of supplement fed and amount of supplemental crude protein was not significant (P>.35) for any of the lamb response criteria. Straw intake, averaged across levels of supplement, was increased (P<.05) by supplemental crude protein from 1.89 to 2.09 percent of body weight. Increasing the level of supplement fed decreased (P<.001) straw intake (Table 1 and Figure 1). The rate of reduction of straw intake with increasing supplement was similar (P>.77) for the low- and high-protein supplements (Figure 1). Straw DM consumption of lambs fed the low- and high-protein supplements was decreased by .45 and .50 lb per 1 lb of supplement fed as follows:

Table 1. Ingredient composition and crude protein content (% of DM) of supplements

Level of supplement fed,	Supplemental crude protein/lamb/day, lb (g)					
	.128 (58)[a]			.256(116)[b]		
lb/day: g/day:	.44 (200)	.88 (400)	1.32 (600)	.66 (300)	.88 (400)	1.32 (600)
Supplement #:	1	2	3	4	5	6
Soybean meal	61.34	18.01	3.56	87.86	59.57	31.28
Corn, ground	23.90	73.3	89.77	2.53	32.56	62.59
Molasses	3.00	3.00	3.00	3.00	3.00	3.00
Dicalcium phosphate	7.87	3.42	1.95	3.52	2.39	1.27
Calcium carbonate	2.88	1.77	1.39	2.42	1.98	1.53
Trace-mineralized salt	1.00	.50	.33	.67	.50	.33
Crude protein	32.5	16.2	10.8	43.3	32.5	21.7

[a]Low-protein supplements.
[b]High-protein supplements.

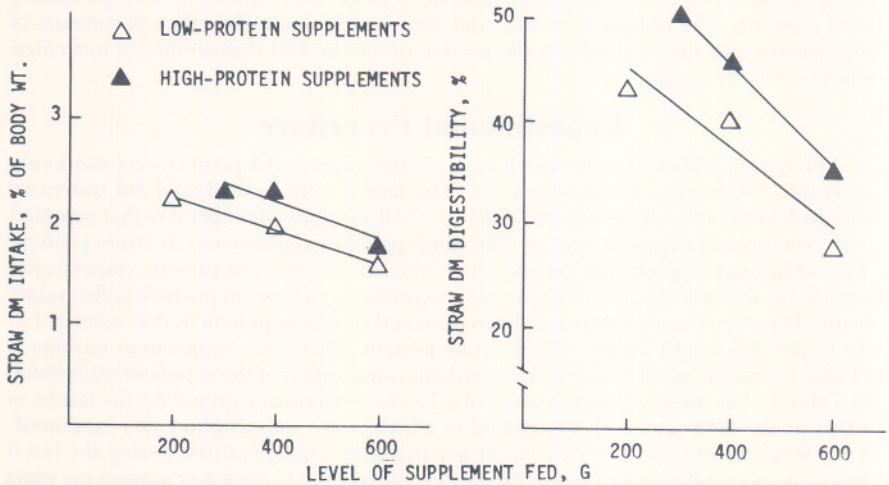


Figure 1. Effect of level of supplement on wheat straw intakes and digestibility

Table 2. Straw intake digestibility and gains of lambs

Level of supplement fed,	Supplemental crude protein/lamb/day, lb (g)					
	.128(58)[a]			.256(116)[b]		
lb/day:	.44	.88	1.32	.66	.88	1.32
g/day:	(200)	(400)	(600)	(300)	(400)	(600)
Mean lamb wt during trial, lb	66	67	67	68	64	69
Straw DM intake[c]						
lb/day	1.44	1.29	1.04	1.54	1.44	1.21
% of body wt	2.20	1.92	1.55	2.26	2.27	1.74
Lamb daily gains[d], lb	.038	.139	.250	.136	.182	.254
Straw DM digestibility[e], %	43.2	40.0	27.5	50.3	46.0	35.4

[a]Low-protein supplements.
[b]High-protein supplements.
[c]Significant protein level (P<.05) and supplement level (P<.001) effects.
[d]Significant supplement level (P<.001) effect.
[e]Significant protein level (P<.001) and supplement level (P<.001) effects.

Low-protein supplements: Straw DM intake = 1.65 lb - .45 (lb supplement fed)
High-protein supplements: Straw DM intake = 1.88 lb - .50 (lb supplement fed)

Straw dry matter digestibility (DMD) was decreased (P<.001) with increasing level of supplement (Table 1 and Figure 1), and feeding additional protein increased (P<.001) straw DMD. The rate of reduction of straw DMD with increasing supplement was similar (P>.19) for the low- and high-protein supplements (Figure 1) as follows:

Low-protein supplements: Straw DMD = 52.29 - 17.8 (lb supplement fed)
High-protein supplements: Straw DMD = 65.71 - 22.9 (lb supplement fed)

Gains of lambs were not increased (P>.25) by amount of supplemental crude protein indicating that the low-protein supplements met the protein needs for the low rates of gain that were achieved. Gains were increased (P<.001) with increasing levels of supplement, which would be attributable to increased energy intake.

Literature Cited

Schneider, Burch H. and William P. Flatt. 1975. The Evaluation of Feeds Through Digestibility Experiments. Univ. Georgia Press, Athens.

Ammoniation of Wheat Straw and Prairie Hay

G. W. Horn, C. L. Streeter, G. Manor,[1] D. G. Batchelder and G. L. McLaughlin

Story in Brief

Wheat straw and prairie hay were treated with ammoniated water (aqua-ammonia) during baling of large round bales. The effects which 1) crimping and 2)

This work was conducted as a part of Research Agreement No. 58-7B30-9-87 between the USDA (SEA/AR; Southwestern Livestock and Forage Research Station, El Reno, OK) and the Okla Agr. Exp. Sta.

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adding a surfactant to the aqua-ammonia had on crude protein content and *in vitro* dry matter digestibility (IVDMD) were studied. Crude protein content of non-treated straw was 2.82 percent. Mean crude protein content of ammoniated straw after storage ranged from 5.84 to 7.28 percent, and was increased ($P<.004$) by addition of surfactant. The effect of surfactant on crude protein content of straw was greater for the crimped straw, which was increased by 1.44 percentage units. The effect of crimping was not significant ($P>.10$). Adding surfactant or crimping the straw did not increase ($P>.10$) IVDMD of ammoniated straw, which was increased only about 10 percent. The small improvement in IVDMD may be due to the low level of ammonia (1.7 percent of straw DM) that was applied. Prairie hay readily absorbed the aqua-ammonia, and the crude protein content was increased from about 4.7 to 13.9 percent by ammoniation. The ammoniated hay contained about 29 percent water after baling and molded during storage in the open. IVDMD was increased only 3.1 percentage units by ammoniation. Loss of the more digestible nutrients during heating of the hay which accompanies mold growth would result in a smaller improvement in IVDMD. The water content of ammoniated prairie hay probably should not exceed 24 percent.

A device for 1) mixing water and anhydrous ammonia on the tractor and 2) applying the aqua-ammonia during baling was developed and is described.

Introduction

For each acre of wheat that yields 20 to 25 bushels of grain, an estimated ton of wheat straw is available as a potential feedstuff (Anderson, 1978). Both the digestibility and crude protein content of wheat straw are generally low. Chemical treatment of crop residues with various alkalis, such as sodium hydroxide and potassium hydroxide, has increased digestibility and often has increased intake and animal performance (Klopfenstein and Woods, 1970; Klopfenstein *et al.*, 1972; Ololade *et al.*, 1970; Singh and Jackson, 1971). Ammoniation of wheat straw has the potential of 1) reducing the chemical cost of treatment and 2) increasing the crude protein content of the straw as well as increasing the digestibility of the treated straw.

In our first attempt (Horn *et al.*, 1979) to ammoniate wheat straw during baling of large round bales, water and ammonia were applied separately. Water was sprayed onto the straw as it traveled over the pickup frame of the baler. The USS Cold-Flo Converter (Model K-3S) was used to convert anhydrous ammonia to liquid ammonia. Liquid ammonia was applied evenly across the bale width directly *behind* the large rubber compression roller and in *front* of the starter roller at the entrance of the bale chamber of a John Deere Model 510 baler. Ammonia loss during application was about 74 percent.

During the 1980 wheat harvest we treated wheat straw with a solution of ammonia in water (aqua-ammonia) in hopes of reducing ammonia loss during the baling operation. Because of the slick nature of wheat straw, penetration of the straw by the aqua-ammonia is believed to be a problem. Effects which 1) crimping the straw during baling and 2) adding a surfactant to the aqua-ammonia had on penetration of the straw by the aqua-ammonia were studied. Prairie hay was also treated with aqua-ammonia during baling in late July.

Experimental Procedure

Wheat straw

Aqua-ammonia was produced in the field by adding anhydrous ammonia to water through a perforated pipe submerged to the bottom of a 200-gallon water tank. The aqua-ammonia was added directly to two tanks of about 78 gallons each mounted over the front tractor wheels. A small air compressor, driven by the front-end tractor PTO,

was used to pressurize the aqua-ammonia tanks. An in-line flow controller was used to control application rate of the aqua-ammonia at 3.6 gallons per minute during a baling time of 3 minutes per bale. The aqua-ammonia was sprayed onto the straw through 8 Tee Jet SS 8010 nozzles spaced 7 inches apart across the baler. Positioning of the nozzles on the baler was the same as the previous year. The aqua-ammonia solutions were sampled in the field and tested for ammonia concentration by drop-wise titration with an HCl-indicator solution. The aqua-ammonia solutions contained about 8 percent ammonia.

Crimping was accomplished by changing the original chain sprocket (33 teeth) of the platform lower belt drive roller of the baler to a sprocket of 36 teeth to obtain a slower speed of the lower belt drive roller by .92 (33/36).

Six-hundred (600) ml of a surfactant, Super Kem Flak Liquid[2], was added directly to the aqua-ammonia tanks on the tractor prior to baling straw to make a concentration (v/v) of .2 percent surfactant in the aqua-ammonia.

Core samples of the bales were taken immediately after baling (July 1, 1980) and after storage on August 29, 1980 (59 days after baling) for dry matter, crude protein and *in vitro* dry matter digestibility (IVDMD) determinations. The bales were stored on the ground with no shelter after baling. Crude protein content of the samples was determined prior to drying to avoid ammonia losses.

Prairie hay

A device for 1) mixing water and anhydrous ammonia and 2) applying the aqua-ammonia to the hay during baling was developed. The device is shown in Figure 1 and consisted of the following:

A. Anhydrous ammonia tank suitable for mounting on a tractor.
B. Ammonia flow meter on high pressure side of pressure regulator(D).
C. Electronic readout of ammonia flow meter.

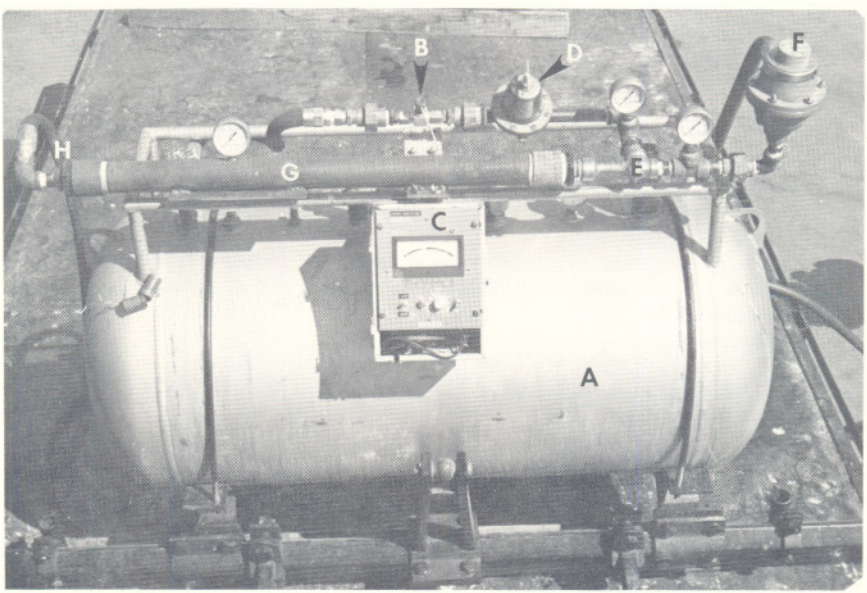


Figure 1. A device for mixing water and anhydrous ammonia for applying aqua-ammonia to prairie hay

[2]Kemin Industries, Inc., Des Moines, Iowa.

D. Pressure regulator. Replacement of the pressure regulator with an ammonia flow rate controller will be evaluated as an improvement to the aqua-ammonia mixer/applicator.
E. Eductor or other suitable device for mixing anhydrous ammonia and water to form aqua-ammonia.
F. Water Flow Rate Controller. Water was delivered by hose from water tanks mounted on tractor. Pressure was maintained on water tanks by PTO-powered air compressor.
G. Cooling device for aqua-ammonia.
H. Hose to deliver aqua-ammonia to nozzle system mounted on baler.

Results and Discussion

Wheat straw

The crude protein content of the straw was increased from 3.06 percent (non-treated straw) to 6.24 to 7.46 percent immediately after baling (Table 1). Addition of the surfactant to the aqua-ammonia increased the crude protein content ($P<.10$) and nitrogen retention ($P<.002$) of the straw during baling. The effect of crimping was not significant ($P>.10$). Mean crude protein content of the ammoniated straw after storage (i.e., 59 days after baling) ranged from 5.84 to 7.28 percent, and was significantly

Table 1. Analyses of non-treated and ammoniated (1.7 percent NH_3 on DM basis) wheat straw

Wheat straw:	Non-treated	Ammoniated			
		Non-crimped		Crimped	
Surfactant[a]:		−	+	−	+
Number of bales	7	7	7	7	7
Sampling time					
After baling					
Bale wt, lb	447	563	540	409	504
Bale DM, %	93.1	87.6	85.4	85.8	86.1
Crude protein[b], %	3.06	6.24	7.24	7.13	7.46
N retention[c], %	—	41	52	37	51
After storage[d]					
Bale wt, lb	440	526	500	382	471
Bale DM, %	93.8	92.9	92.0	93.5	92.7
Crude protein[e], %	2.82	6.09	6.41	5.84	7.28
N retention[f], %	—	39	41	26	49
IVDMD[g]	35.2	37.1	39.2	40.9	37.8

[a]Super Kem Flak Liquid. Kemin Industries, Inc. Des Moines, Iowa.
[b]Significant surfactant effect ($P<.10$).
[c]Nitrogen retention during application = $\frac{\text{Increase N content of bale}}{\text{Amount of } NH_3\text{– N added}} \times 100$
Significant surfactant effect ($P<.002$).
[d]59 days after baling.
[e]Significant surfactant effect ($P<.004$) and surfactant by crimping interaction ($P<.06$).
[f]Nitrogen retention after storage = $\frac{\text{Increased N content of bale}}{\text{Amount of } NH_3\text{– N added}} \times 100$
Significant surfactant effect ($P<.0001$) and surfactant by crimping interaction ($P<.0004$).
[g]*In vitro* dry matter digestibility.
Significant surfactant by crimping interaction ($P<.018$).

increased (P<.004) by addition of surfactant. The effect of surfactant on the crude protein content of straw was greater for the crimped straw, which was increased by 1.44 percentage units. Mean IVDMD of ammoniated straw after storage ranged from 37.1 to 40.9 percent (Table 1). Crimping or addition of surfactant did not (P>.10) increase IVDMD of ammoniated straw. The mean IVDMD (38.8) of ammoniated wheat straw of all four treatments was greater (P<.01) than that of non-treated straw (35.2). The magnitude of the increase in IVDMD of ammoniated straw (about 10 percent) was considerably less than the improvement of about 33 percent observed in previous studies (Solaiman *et al.*, 1979 and Horn *et al.*, 1979) in which wheat straw was treated with 3.5 percent ammonia. This reduced response in IVDMD due to ammoniation would be attributable to the lower level of ammonia (i.e., 1.7 percent of straw DM) that was applied.

Prairie hay

Results of the analyses of prairie hay are shown in Table 2. The crude protein content and IVDMD of prairie hay were increased from about 4.7 to 13.9 percent (P<.0001) and 46.2 to 49.3 percent (P<.10), respectively. The prairie hay was treated with a greater amount of ammonia (7.6 percent NH_3 on a DM basis) than planned due to a malfunction of the ammonia flow meter. Therefore, retention of the added nitrogen was less (i.e., 26 percent) than that observed for wheat straw. Three of the seven ammoniated bales showed clear evidence (i.e., odor and darkened color) of mold growth when they were sampled after storage, which would be attributable to the greater than anticipated amount of water that was added. The ammoniated hay contained about 29 percent water (Table 2) after baling. The small improvement in IVDMD due to ammoniation would be attributed to loss of the more digestible nutrients during heating of the hay which accompanies mold growth. While we have not conducted studies with different levels of water applied to prairie hay, the water content after baling probably should not exceed 24 percent.

Ammoniation of hay that has become too mature prior to baling, and therefore is of low quality, appears to be an alternative for improving its nutritive value. Penetration of grass hay by aqua-ammonia appears to be less of a problem than with wheat straw since it does not have a slick surface.

Literature Cited

Anderson, D. Craig. 1978. J. Anim. Sci. 46:849.

Horn, G. W. *et al.* 1979. Proc. Beef Cattle Field Day, Oklahoma State University, Stillwater. p. K-1.

Table 2. Analyses of prairie hay

	Non-treated		Ammoniated[a]	
Sampling time:	After baling	After storage[b]	After baling	After storage[b]
Number of bales	5	5	7	7
Bale wt, lb	796	744	872	732
Bale DM, %	87.8	93.2	71.3[c]	84.6[c]
Crude protein, % of DM	4.41	5.02	13.92[d]	13.81[d]
N retention, %	—	—	26	26
IVDMD[e]	—	46.2	—	49.3[f]

[a]7.6% NH_3 on a DM basis.
[b]32 days after baling.
[c]Significantly (P<.0002) less than non-treated hay.
[d]Significantly (P<.0001) greater than non-treated hay.
[e]*In vitro* dry matter digestibility.
[f]Significantly (P<.10) greater than non-treated hay.

Klopfenstein, T. J. and W. R. Woods. 1970. J. Anim. Sci. 31:246 (Abstr.).
Klopfenstein, T. J. *et al.* 1972. J. Anim. Sci. 35:418.
Ololade, B. G. *et al.* 1970. Can. J. Anim. Sci. 50:657.
Singh, M. and M. G. Jackson. 1971. J. Agr. Sci. 77:5.
Solaiman, S. G. *et al.* 1979. J. Anim. Sci. 49:802.

Effect of Source of Supplemental Protein and Level of Supplement on Voluntary Intake and Performance of Lambs Fed Ammoniated Wheat Straw Silage[1]

C. L. Streeter, G. W. Horn, D. G. Batchelder and G. Manor[2]

Story in Brief

Wheat straw was chopped, moistened to 38 percent dry matter (DM), ammoniated with 8.4 percent w/w anhydrous ammonia and stored in an Ag-Bagger. The resultant "ammoniated straw silage" was individually fed *ad lib* to lambs with a negative control supplement containing only molasses and minerals, two levels of a soybean meal-based supplement or two levels of a corn gluten meal-based supplement. Lambs fed the negative control supplement consumed 2.48 percent of their body weight as straw DM and lost 0.07 lb/day. Source of supplemental protein did not affect ($P>.05$) gain or straw consumption. Level of supplement increased ($P<.01$) gains but did not affect ($P>.05$) ammoniated straw DM consumption. Lambs fed the ammoniated straw silage and 0.44 lb/day of a 36-percent crude protein-soybean meal supplement ate more ($P<.01$) and gained faster ($P<.01$) than the control lambs. The ammoniated straw silage contained 2.10 percent of the DM as free ammonia, which was 56.8 percent of the total nitrogen. Acid detergent fiber-bound nitrogen represented 19.7 percent of the total nitrogen. The cellulose content of the silage was 47.3 percent of the DM and was 60 percent digestible *in vivo* when fed with the low level of the soybean meal supplement. The hemicellulose content of the silage was 9.7 percent and was completely digested.

Introduction

Dry treatment of crop residues with anhydrous ammonia has been reported to improve digestibility and voluntary consumption by ruminant animals (Streeter and Horn, 1980). However, few ammoniation studies have been conducted with crop residues that have been moistened to a dry matter (DM) content of 30 to 40 percent so

[1]This work was conducted as a part of Research Agreement No. 58-7B30-9-87 between the USDA (SEA/AR; Southwestern Livestock and Forage Research Station, El Reno, OK) and the Okla. Agr. Exp. Sta.
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that the resultant feed can be stored and handled as silage. Most treated crop residues are lacking sufficient protein and available energy to support performance above maintenance. Supplementation of such treated material with concentrates to improve performance may have a negative effect on fiber digestibility and reduce crop residue consumption. Supplementation with a high rumen by-pass protein might increase performance if there is sufficient ammonia present in the treated residue to support microbial protein synthesis.

It was the objective of this experiment to evaluate the effect of two sources of supplemental protein—soybean meal and corn gluten meal—and two levels of supplement intake on lamb performance and voluntary consumption of ammoniated wheat straw that had been moistened to 38 percent DM during ammoniation.

Materials and Methods

Wheat straw was chopped with a conventional grinder mixer to approximately 1-inch lengths, moistened to 38 percent DM and delivered into the hopper of an Ag-Bagger[3] for storage. Anhydrous ammonia was applied under water on the floor of the Ag-Bagger hopper at 8.4 percent w/w of the straw DM. The straw remained in the Ag-Bag for 30 days prior to feeding and is hereafter termed ammoniated straw silage even though fermentation was limited because of the high pH.

The silage was individually fed *ad lib* to 60 ram or ewe lambs randomly assigned by sex to five supplement treatments. The lambs received their supplements mixed with the silage for 28 days. The daily supplements included: 1) a negative control containing 0.11 lb of liquid molasses and minerals; 2) 0.44 lb of a 36-percent crude protein, soybean meal-based supplement; 3)0.88 lb of an 18-percent crude protein, soybean meal-based supplement; 4) 0.44 lb of a 36-percent crude protein, corn gluten meal-based supplement; or 5) 0.88 lb of an 18-percent crude protein, corn gluten meal-based supplement. The ingredient composition of each supplement is shown in Table 1. Daily supplemental crude protein intake was the same for treatments (2) through (5).

Lamb gain over the 28-day feeding period was calculated from initial and final shrunk weights. *Ad lib* silage DM intake was calculated on the last 6 days of the trial because large daily fluctuation during the early phase of the trial precluded precise intake measurements.

Ruminal fluid was collected via a suction tube from three ram lambs receiving each treatment. Collections were made immediately prior to feeding and 4 hours thereafter on the 28th day of the trial. The ammonia concentration of the ruminal fluid was determined spectrophotometrically using the reagents of Chaney and Marbach(1962).

Table 1. Ingredient composition and crude protein content (DM basis) of supplements fed with ammoniated straw silage

		Source of supplemental protein			
	Negative control	Soybean meal		Corn gluten meal	
Supplement level, lb/day	0.11	0.44	0.88	0.44	0.88
Ground shelled corn, %	X	X	60.5	25.0	68.0
Soybean meal, %	X	75.0	25.0	X	X
Corn gluten meal, %	X	X	X	50.0	17.5
Molasses, %	8.7	4.0	4.0	4.0	4.0
Dicalcium phosphate, %	69.6	16.0	8.0	16.0	8.0
TM salt, %	21.7	5.0	2.5	5.0	2.5
Crude protein, %	X	36	18	36	18

[3]Ag-Bag Corporation, Astoria, Oregon.

The form of nitrogen present in the ammoniated straw silage was determined on a composite sample of silage fed during the last 6 days of the trial. The analysis was conducted on undried frozen samples and included total Kjeldahl nitrogen, nitrogen bound to acid detergent fiber (Goering and Van Soest, 1970) and free ammonia nitrogen as determined by a modification of the magnesium oxide method (Horwitz, 1975). A portion of the same composite was dried at 130°F for 48 hours and ground through a Wiley mill with a 2 mm screen. The neutral detergent fiber, acid detergent fiber and permanganate lignin content of the above sample were measured as described by Goering and Van Soest (1970). Cellulose was assumed to be the difference between acid detergent fiber and lignin, and hemicellulose was calculated from the difference between neutral detergent fiber and acid detergent fiber.

Four different ram lambs weighing 61.6 lb were placed in metabolism crates and fed the same ammoniated wheat straw silage described above and 0.44 lb per day of the soybean meal supplement containing 36 percent crude protein described in Table 1. After 50 days of *ad lib* silage feeding, the silage intake was restricted to 1.49 lb of dry matter for 10 days. During the last 7 days total fecal collections were made and digestibility of dry matter and cell wall constituents determined. Straw DM digestibility was calculated by difference using 64 percent DM digestibility for the supplement. Supplement DM digestibility was calculated from total digestible nutrient values reported by the National Research Council (1976).

Results and Discussion

Lambs fed ammoniated straw silage and a negative control supplement consisting of 0.11 lb of a molasses-mineral mixture consumed 2.48 percent of their body weight as straw DM (Table 2). Source of protein and level of supplement did not affect (P>.05) straw DM consumption. There was also no interaction (P>.15) between source of protein and supplement level with respect to straw consumption. Lambs receiving 0.44 lb/day of the 36-percent crude protein-soybean meal supplement ate 2.79 percent of their body weight as ammoniated straw DM, which was greater (P<.01) than that of lambs fed the negative control supplement. Straw consumption of lambs fed the other three supplements was not different (P>.05) from that of lambs fed the negative control supplement.

Table 2. Effect of source of supplemental protein and level of supplement on straw silage DM intake and average daily gain

		Source of supplemental protein			
	Negative control	Soybean meal		Corn gluten meal	
Supplement level, lb/day	0.11	0.44	0.88	0.44	0.88
Mean body wt., lb	57.9	59.8	60.1	61.8	61.4
Straw silage intake,					
lb/day[abc]	1.43	1.68	1.52	1.54	1.52
% body wt.[abc]	2.48	2.79	2.48	2.51	2.46
Average daily gain,					
lb/day[def]	-0.070	0.120	0.228	0.124	0.219

[a]Main effects of source of protein and supplement level not significant (P>.05).
[b]No interaction (P>.15) between source of protein and supplement level.
[c]Only lambs fed 0.44 lb soybean meal-based supplement ate more (P<.01) straw DM than negative controls.
[d]Main effect of source of protein not significant (P>.05), main effect of supplement level significant (P<.01).
[e]No interaction (P>.15) between source of protein and supplement level.
[f]All supplemented lambs gained more (P<.01) than negative controls.

Lambs fed the negative control supplement lost 0.07 lb/day (Table 2). Source of supplemental protein did not affect (P>.05)gain. If corn gluten meal by-passed the rumen more than soybean meal, it either was not more readily absorbed in the lower tract or did not have as good an amino acid balance. However, energy, not protein, may have been the factor limiting growth.

Level of supplement increased (P<.01) gain as would be expected because of the greater overall consumption of available energy. There was no interaction (P>.15) between source of protein and level of supplement with respect to average daily gain.

The total Kjeldahl nitrogen content of the ammoniated straw silage was 3.70 percent of the DM (Table 3), which is equivalent to 23.1 percent crude protein. The question of the utilization of this nitrogen by the ruminant animal is a difficult one to answer. The nitrogen was present mainly (56.8 percent) as free ammonia with substantial amounts of acid detergent-bound nitrogen (19.7 percent). Ruminal ammonia levels were high at 0 and 4 hours after feeding (Table 4) but were not affected (P>.05) by level or source of supplement. The improvement in weight gain of lambs supplemented with soybean meal or corn gluten meal indicates limited utilization of the nitrogen in the ammoniated straw silage. However, additional energy was also added with supplement, and energy intake may have been first-limiting with respect to growth.

The DM and cell wall constituent contents and digestibilities of the ammoniated straw silage fed in the digestion trial are shown in Table 5. The DM content of the silage was 38 percent, and the DM was 58.9 percent digestible. Cellulose constituted 47.3 percent of the straw DM and was 60.0 percent digestible. The hemicellulose content of

Table 3. Form of nitrogen present in ammoniated straw silage

Form	% of DM	% of Total N
Total Kjeldahl	3.70	100.0
ADF bound	0.73	19.7
Free ammonia	2.10	56.8
Undetermined	0.87	23.5

Table 4. Effect of source of supplemental protein and level of supplement on ruminal ammonia levels (mg%)

Sampling time[a] (hr)	Supplement level, lb/day	Negative control	Source of supplemental protein: Soybean meal		Corn gluten meal	
		0.11	0.44	0.88	0.44	0.88
0		16.3[b]	29.4	29.8	22.8	15.6
4		22.3	45.1	42.2	37.0	34.4

[a]Ruminal samples collected 0 and 4 hr after feeding on last day of trial from three sheep per treatment.
[b]No difference (P>.05) in main effects or interactions and values for supplemented lambs were not different (P>.05) from negative controls.

Table 5. Dry matter and cell wall constituent content and digestibility of ammoniated straw silage

Constituent	Content: As fed	Content: Dry matter	Digestibility
Dry matter, %	38.0	100.0	58.9
Cellulose, %	18.0	47.3	60.0
Hemicellulose, %	3.7	9.7	100.0
Lignin, %	5.1	13.3	34.0

the straw was only 9.7 percent, and digestibility was apparently 100 percent because the acid detergent fiber content of the feces was greater than the neutral detergent fiber content. Lignin was 13.3 percent of the straw DM and had a digestibility of 34.0 percent.

The results of this study would indicate that lambs will not eat enough ammoniated wheat straw silage to maintain body weight. Supplementing the ammoniated straw silage with either soybean meal or corn gluten meal resulted in similar increased silage DM consumption and gain. Doubling the supplement level but maintaining protein intake resulted in a doubling of lamb gain with no effect on silage intake. The ammoniated straw silage DM was 59 percent digestible and contained only 10 percent hemicellulose and 3.70 percent Kjeldahl nitrogen.

Literature Cited

Chaney, A.L. and E. P. Marbach. 1962. Clin. Chem. 8:130.

Goering, H.K. and P.J. Van Soest. 1970. Ag. Handbook. No. 379. ARS, USDA.

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

NRC. 1976. Nutrient Requirements of Beef Cattle. Natl. Acad. of Sci., Washington, D.C.

Streeter, C.L. and G.W. Horn. 1980. Okla. Agr. Exp. Sta. Res. Rep. P-795.

Effect of Protein Level and Supplement Level on Voluntary Intake and Performance of Lambs Fed Ammoniated Wheat Straw Silage

C. L. Streeter, G. W. Horn and D. G. Batchelder

Story in Brief

Lambs were fed a basal ration of wheat straw that had been chopped, moistened to approximately 35 percent dry matter (DM), ammoniated with anhydrous ammonia and ensiled in an Ag-Bagger. Lambs were fed one of three levels of supplement, each with .128 or .256 lb of crude protein per day. Protein level did not affect ($P>.05$) silage DM consumption, but there was significant ($P<.15$) supplement level- by-protein level interaction. Silage dry matter intake decreased as level of supplement increased from .44 to 1.32 lb, regardless of the amount of protein fed. Silage dry matter consumption was only 68 percent of that observed during a previous study. The reduced intake was attributed to the large ammonia intake or less desirable ensiling conditions. Average daily gain was not affected ($P>.05$) by protein level but increased ($P<.01$) with supplement level.

This work was conducted as a part of Research Agreement No. 58-7B30-9-87 between the U.S.D.A. (SEA/AR; Southwestern Livestock and Forage Research Station, El Reno, OK) and the Okla. Agr. Exp. Sta.

Introduction

A previous study (Streeter *et al.*, 1981) showed that lambs ate more dry matter (DM) from ammoniated straw silage when supplemented with .44 lb/day of a 36-percent crude protein, soybean meal-based supplement than when supplemented with only molasses and minerals. Feeding twice as much of an 18-percent crude protein, soybean meal-based supplement did not affect DM consumption of the straw.

It was the objective of this study to evaluate the effect of protein level and level of supplementation on lamb performance and DM consumption of ammoniated straw silage.

Materials and Methods

Wheat straw was chopped through a 1-inch screen in a tub grinder. Water was added with the straw to provide a dry matter (DM) content of approximately 35 percent. The straw and water were delivered into the hopper of an Ag-Bagger[1] for storage. Anhydrous ammonia was added to the straw with a manifold attached to the floor of the Ag-Bagger hopper. The ammonia was delivered under water to minimize vaporous ammonia loss.

Weight loss of the anhydrous ammonia tank indicated that 3.4 percent ammonia w/w was actually applied. Initially, it was felt that this quantity of ammonia would be adequate based on reported values for dry ammoniation (Sundstol *et al.*, 1978). Samples of the ensiled material were analyzed for Kjeldahl nitrogen 10 days after ammoniation. The straw was found to contain only 1.36 percent nitrogen and had no ammonia odor. The contents of the Ag-Bag were thus re-ammoniated 2 weeks after the first ammoniation. Anhydrous ammonia was added to the contents of the bag with a ¾ inch perforated steel pipe. The pipe was passed through the bag and ammonia applied at six locations approximately 1.5 ft above ground level and 6 ft apart. The ammonia tank was weighed before and after the application, and 1170 lb of ammonia were applied to approximately 13,000 lb of straw or 9 percent ammonia w/w. The ammoniated straw was left in the Ag-Bag for 30 days prior to feeding. Silage was removed from the bag every 3 to 4 days, mixed in a mixer wagon and stored in sealed plastic drums prior to feeding. Heating during this storage period did not occur as had been experienced in the previous trial when the ambient temperature was higher (60 vs. 100°F).

The form of the nitrogen present in the ammoniated straw silage was evaluated as described in the previous experiment.

The silage was individually fed *ad lib* to 60 ewe and wether lambs randomly assigned by sex to six supplement treatments. The silage and supplements were mixed prior to feeding. The supplements were fed at three levels of intake (.44, .88 and 1.32 lb/day) at a low protein level (.128 lb/day) and at three levels of intake (.66, .88 and 1.32 lb/day) at a high protein level (.256 lb/day). The low level of supplement had to be increased from .44 lb to .66 lb when used with the high protein level to prevent changing ingredients. The ingredient composition of each supplement is shown in Table 1.

Voluntary silage DM intake was measured for 20 days following a 12-day adaptation. Average daily gain (ADG) was calculated from weights taken 30 hours off feed and 12 hours off water at the beginning and end of a 40-day feeding period.

Results and Discussion

Lambs fed .44 lb of the low-protein supplement consumed 1.17 lb per day (1.70 percent of their body weight) of ammoniated straw silage DM (Table 2). Protein level did not affect ($P>.05$) silage DM consumption. Supplement level, however, had a

[1]Ag-Bag Corporation, Astoria, Oregon.

Table 1. Ingredient composition and crude protein content (DM basis) of supplements fed with ammoniated straw silage

	Crude protein level, lb/day					
	0.128			0.256		
Supplement level, lb/day	0.44	0.88	1.32	0.66	0.88	1.32
Soybean meal, %	61.34	18.01	3.56	87.86	59.57	31.28
Ground shelled corn, %	23.90	73.3	89.77	2.53	32.56	62.59
Molasses, %	3.00	3.00	3.00	3.00	3.00	3.00
Dicalcium carbonate, %	7.87	3.42	1.95	3.52	2.39	1.27
Calcium carbonate, %	2.88	1.77	1.39	2.42	1.98	1.53
TM-salt, %	1.00	0.50	0.33	0.67	0.50	0.33
Crude protein, %	32.5	16.2	10.8	43.3	32.5	21.7

Table 2. Effect of level of supplement and crude protein level on ammoniated straw silage DM intake and average daily gain

	Crude protein level, lb/day					
	0.128			0.256		
Supplement level, lb/day	0.44	0.88	1.32	0.66	0.88	1.32
Mean lamb wt, lb	69.1	71.3	73.0	69.7	70.4	74.6
Straw silage DM intake,						
lb/day[ab]	1.17	1.01	0.94	1.08	0.95	1.01
% body wt[ab]	1.70	1.42	1.29	1.55	1.35	1.35
Average daily gain, lb/day[ab]	0.059	0.146	0.234	0.069	0.100	0.263

[a]Main effect of protein level was not significant (P> .05) but main effect for supplement level was significant (P<.01).
[b]Interaction between protein level and supplement level was significant (P<.15).

Table 3. Form of nitrogen present in ammoniated straw silage

Form	% of DM	% of total N
Total Kjeldahl	4.25	100
ADF-bound	0.49	11.5
Free ammonia	3.34	78.6
Undetermined	0.42	9.9

significant (P<.01) effect on silage DM intake. The supplement level-by-protein level interaction was significant (P<.15) for silage DM intake. Silage DM intake decreased as level of supplement increased. The linear relationship between lb of silage DM intake (I) and lb of supplement fed (S) was: $I_1 = 1.27 - (.273)\ (S_1)$ with the low-protein supplement and $I_2 = 1.09 - (.0833)\ (S_2)$ with the high-protein supplement. There was no difference (P>.10) between the regression coefficients.

ADG of lambs fed .44 lb of the low-protein supplement was .059 lb/day (Table 2). Protein level did not affect (P>.05) ADG. The lack of gain response with additional protein can be interpreted to mean that the low level of supplemental protein was sufficient for the limited amount of available energy in the straw. Supplement level had a significant (P<.01) effect on ADG at the two higher levels of supplement with both protein levels. The increased gain with added supplement can be attributed to a greater supply of readily available energy. The protein level-by-supplement level interaction was significant (P<.15) for ADG.

The silage DM intake for lambs consuming .44 lb of a 32.5-percent crude protein, soybean meal-based supplement was only 68 percent of that found previously when .44 lb of a 36-percent crude protein, soybean meal-based supplement was fed (Streeter *et*

al., 1981). The silage in the present trial contained more Kjeldahl nitrogen (4.25 vs. 3.70 percent of DM), and more of this nitrogen was present as free ammonia (78.6 vs. 56.8 percent—Table 3). The present study was also conducted during cooler weather, which may have resulted in less vaporization of ammonia and a greater intake of ammonia by lambs. The lower silage intake in the present study could also be attributed to chemical differences in the silage resulting from fermentation following the first ammoniation treatment.

Literature Cited

Streeter, C. L., G. W. Horn, D. G. Batchelder and G. Manor. 1981. Okla. Agr. Exp. Sta. Res. Rep. MP-108.

Sundstol, F., E. Coxworth and D. N. Mowat. 1978. World Anim. Rev. 26:13.

Alkaline Treatment of Wheat Straw Before Ensiling

W. A. Phillips and F. P. Horn

Story in Brief

Wheat straw was ground and reconstituted to 35 percent dry matter, then treated with sodium hydroxide, potassium hydroxide or a 50:50 mixture of both at five concentrations (0, 2.5, 5.0, 7.5 and 10.0 percent of the straw dry matter). Addition of alkali significantly increased the initial pH of the ensiling material and maintained a pH above 7 throughout the 45-day fermentation period (Table 1). Although alkali treatment increased the amount of available fermentable material, insufficient organic acids were produced to neutralize the added base. As a result of the poor fermentation, mold was found in silos with more than 2.5 percent added alkali. Thus, even though alkali treatment did dramatically increase *in vitro* dry matter digestibility, the benefit of increased digestion was offset by potentially poor stability of the product and undesirable effects of handling large amounts of hydroxide.

Introduction

Alkali treatment of low quality forage improves the use of otherwise low productivity feedstuffs. Such forages would be well suited as emergency feeds for stocker cattle grazing winter wheat pasture, as a roughage source in receiving diets for transported calves or as extenders of wheat and summer pastures. Because addition of alkali to wheat straw requires handling of the straw, ensiling the material would appear logical. This experiment was conducted to determine the effects of two hydroxide sources at various concentrations on wheat straw digestibility and fermentation characteristics.

Experimental Procedure

Baled wheat straw harvested and stored for one year was ground (1 inch) and reconstituted to 35 percent dry matter by addition of water, then treated with one of five

USDA, Science and Education Administration, Southern Region, in cooperation with the Oklahoma Agricultural Experiment Station.

concentrations of alkali from each of three sources. Alkali concentrations were 0, 2.5, 5.0, 7.5, 10.0 percent of straw dry matter. The alkaline sources were potassium hydroxide, sodium hydroxide and a 50:50 mixture of both. The treated high moisture straw was then ensiled for 45 days in 1-gallon cardboard containers lined with two plastic bags. The ensiling material was packed with a hand operated press to expel as much air as possible, and each bag was separately sealed with a twist tie. Three silos were prepared for each treatment combination and allowed to ferment for 45 days. At the end of the fermentation period, each silo was opened and samples taken for determination of the dry matter content, *in vitro* dry matter digestibility and pH. Data were analyzed as a 3 by 5 factoral arrangement.

Results and Discussion

Initial dry matter of treated wheat straw (Table 1) was not affected by source or amount of alkali used and averaged 34.4 percent. Wheat straw is not easily reconstituted because the physical structure of the straw does not allow for the rapid uptake of added water. The fact that the dry matter content of the ensiled material was less than initially observed reflects the fermentation of organic matter to acids, water and gases. The addition of increasing amounts of alkali decreased dry matter loss during ensiling.

As anticipated, the addition of increasing amounts of alkali increased ($P<.10$) the initial pH of the treated straw. After 45 days of fermentation, the pH of each treatment combination had decreased, but only the control and 2.5 percent alkali treatment had a final pH below 7. The alkali treated straw did ferment, but organic acids were not produced in sufficient amounts to neutralize the added base. The amount of pH reduction of treated straw was actually 2.8 times greater than that of the control or water-only treatments.

In vitro dry matter digestibility (IVDMD) is a relative measurement of digestibility. When IVDMD values for alkali treated straw were compared to the control treatment, each increment of alkali addition above 2.5 percent resulted in an increase ($P<.10$) in IVDMD, but the amount of increase was less with each addition of alkali. With equal amounts of each source of alkali, differences were noted in final pH and IVDMD. Sodium hydroxide had a higher final pH (7.9) than potassium hydroxide (7.1) as well as higher IVDMD (46.41 percent vs. 30.53 percent, respectively). The hydroxide part of the alkali breaks down the indigestible components in wheat straw, and since sodium hydroxide contains more hydroxide units (43 percent) than potassium hydroxide (30 percent) on a weight basis, sodium hydroxide should be more effective in increasing IVDMD than potassium hydroxide.

Table 1. Dry matter, pH and digestibility (IVDMD) of alkali treated wheat straw

	Amount of alkali added (% of DM)				
	0	2.5	5.0	7.5	10.0
Dry matter (%):					
Initial	33.8	34.8	34.5	34.7	34.4
Final	33.0^{ab}	33.1^{ab}	32.6^{a}	33.7^{bc}	34.3^{c}
pH:					
Initial	6.71^{a}	9.79^{b}	10.55^{c}	11.35^{d}	11.64^{d}
Final	5.46^{a}	6.39^{b}	7.67^{c}	8.36^{c}	9.61^{d}
IVDMD[e](%)	28.96^{a}	31.43^{a}	43.57^{b}	53.48^{c}	59.21^{d}

[abcd]Means in the same row with different superscripts are significantly different ($P<.10$).
[e]*In vitro* dry matter disappearance.

Forage Production and Digestibility of Small Grain Forages

G. W. Horn, W. E. McMurphy and R. L. Mitchell

Story in Brief

Forage production of four varieties of wheat, Kerr barley, Walken oats and Bonel rye was measured on two harvest dates, November 13, 1979, and March 18, 1980. *In vitro* dry matter digestibility (IVDMD) of the forages harvested on March 18, 1980, was also measured. Forage production (pounds of oven-dried forage per acre) of the four wheats ranged from 623 to 227 (11-13-79) and 1129 to 664 (3-18-80). Bonel rye produced the most forage on both harvest dates. IVDMD of the four wheats ranged from 74.5 to 68.4 percent. Digestibility of Bonel rye was 73.2 percent even though it was jointed and in the pre-boot stage of growth. These data indicate that varietal differences among wheats may be important in regard to amount of forage produced and its digestibility.

Introduction

Production of sufficient small grain forage in the fall prior to reduced forage growth in the winter is critical to achievement of good stocker weight gains. Planting date greatly affects fall forage production. Varietal differences may also be important. The objective of this study was to obtain data relative to forage production and digestibility of some small grains.

Experimental Procedure

The forage production data is from the small grain variety test conducted at the Agronomy Research Station (Perkins, Oklahoma) during the 1979-80 season on a Teller loam soil. Planting date was August 24, 1979, at a seeding rate of 100 to 120 pounds per acre. Phosphorus fertilizer was applied August 23, 1979, based upon soil test results. Ammonium nitrate fertilizer was applied in the amount equivalent to 52 pounds of actual N per acre on August 23 plus two more applications of 60 pounds of actual N per acre on November 29, 1979, and March 20, 1980.

The small grains were grown in a randomized complete block design with four replications. Plots were 5 x 20 feet with rows 12 inches apart. The yield sample was taken from the three center rows with a flail mower set to a cutting height of 1½ inches. Precipitation for most of the growing season was below the long-term average. Forage production of other entries in the test is reported in OSU Current Report 2060.

In vitro dry matter digestibility (IVDMD) was determined on forage samples from the March 18, 1980, harvest date. The wheat varieties and Kerr Barley were in vegetative stages of growth and just beginning to joint. The leaf tips of Walken oats were brown from frost damage, which probably reduced digestibility. Bonel rye was jointed and in the pre-boot stage of growth.

Results and Discussion

Forage production (lb oven-dried forage per acre) of the four wheats ranged from 623 to 227 on November 13 and was about 2.2 times greater for Triumph 64 wheat as

compared with the other wheat varieties (Table 1). Forage production of Bonel rye was similar to that of Triumph 64 wheat. On the March 18, 1980, harvest date forage production of Tam 101 was the greatest among the four wheat varieties. Bonel rye produced the most forage.

Dry matter digestibility (IVDMD) of the four wheats ranged from 74.5 to 68.4 percent (Table 1). Digestibility of Bonel rye was 73.2 percent even though it was jointed and in the pre-boot stage of growth.

Production of digestible dry matter (DDM) on the March 18 harvest date was similar for Tam 101 and Newton wheats (i.e., 771 and 696 pounds per acre) and was about 46 percent greater than Triumph 64 and Osage wheats. Bonel rye produced the greatest amount of DDM per acre.

These data indicate that varietal differences among wheats, in regard to amount of forage production and digestibility, may be important.

Table 1. Forage production and *in vitro* dry matter digestibility (IVDMD) of small grain forages[a]

	Wheat				Kerr	Walken	Bonel
	Triumph 64	Tam 101	Newton	Osage	barley	oats	rye
Forage production[f], lb/acre							
Harvest date							
11-13-79	623[a]	280[bc]	334[bc]	227[c]	401[b]	350[bc]	664[a]
3-18-80	750[cd]	1129[b]	933[bc]	664[d]	684[cd]	532[d]	1982[a]
IVDMD, %							
Harvest date							
3-18-80	72.0[ab]	68.4[c]	74.5[a]	69.9[bc]	65.8[d]	64.8[d]	73.2[a]
DDM[g] produced, lb/acre							
Harvest date							
3-18-80	541[cd]	771[b]	696[bc]	464[de]	452[de]	345[e]	1454[a]

[abcde]Means in a row with common-lettered superscripts are not different (P > .05).
[f]Pounds of oven-dried forage per acre.
[g]Digestible dry matter (DDM).

Effect of Initial Weight on Daily Gain of Stocker Cattle Grazed on Wheat Pasture

G. W. Horn, T. L. Mader, R. W. McNew, C. L. Streeter and S. L. Armbruster

Story in Brief

The relationship between initial weight and gain of fall-weaned steer calves that grazed wheat pasture during the past 4 years was examined by regression. With the exception of Year 2, regression coefficients (measures of the change in daily gain expressed as pounds for each 100 lb increase in initial steer body weight) ranged from

−.13 to −.22. The results indicate that daily gains of lightweight steers (e.g., 300 lb) on wheat pasture are greater than those of heavier steers (e.g., 500 lb). Since a greater number of lightweight steers than heavier steers could be grazed on a given acreage of wheat pasture, total gains per acre would be greater for lightweight steers. The extent to which differences in fleshiness of the steers may have influenced the results is not known. Also, since only calves were used, the results are not applicable to the question of differences in gain between calves and yearlings.

Introduction

The relationship between initial weight of stocker cattle and their subsequent weight gain on wheat pasture is a frequent point of discussion. The data reported herein are relative to this question.

Experimental Procedure

The data used consisted of initial weights and daily weight gains of fall-weaned steer calves that grazed wheat pasture, as a part of other research projects over the past 4 years, at the Southwestern Livestock and Forage Research Station (El Reno, Oklahoma).

Data relative to wheat pasture grazing interval, breed of cattle, number of steers, range in initial weight and mean daily gains are listed for each of the years in Table 1. Steers of Years 1 and 2 were purchased at auction, whereas those of Years 3 and 4 were from a single ranch.

The steers grazed clean-tilled wheat pasture and were not fed any supplemental feed. Bermudagrass hay was fed for 29 days (Year 2) and alfalfa hay was fed for 36 days (Year 3) due to snow and/or ice cover of wheat forage.

Daily gain of the steers was regressed on initial body weight. Initial steer weight, year and weight-by-year interaction were included in the model.

Results and Discussion

Regression coefficients (i.e., measures of the change in daily gain expressed as pounds for each 100-lb increase in initial steer body weight) are listed in Table 2. With the exception of Year 2, all the regression coefficients were negative and indicated that daily gain of steers was decreased by .13 to .22 lb (depending on year) for each 100-lb increase in initial steer weight. The initial steer weight-by-year interaction was not significant ($P>.22$). The regression coefficient for the data pooled across the 4 years was −.14 and was significantly different ($P<.001$) from zero.

Table 1. Data relative to each of the wheat pasture years

Year	Wheat pasture grazing interval	Breed[a]	Number of steers	Range in initial wt (lb)[b]	Mean daily gain, lb
1	11-16-76 to 3-16-77(119 days)	H x A	57	305-510	1.88
2[c]	11-9-77 to 3-29-78(140 days)	H x A	47	385-555	1.16
3[d]	11-17-78 to 3-28-79(131 days)	H	19	225-535	1.66
4	11-27-79 to 4-22-80(147 days)	H	22	255-495	1.92
		Total:	145		

[a]H x A = Hereford x Angus and H = Hereford.
[b]At the time the steers began grazing wheat pasture.
[c]Bermudagrass hay was fed to steers on wheat pasture for a total of 29 days due to snow and/or ice cover of wheat forage.
[d]Alfalfa hay was fed to steers on wheat pasture for a total of 36 days due to snow and/or ice cover of wheat forage.

Table 2. Regression coefficients of regressions of daily gain on initial body weight of steers grazed on wheat pasture

Year	Regression coefficient[a]	Probability level[b]
1	−.22	.001
2	.002	.98
3	−.13	.10
4	−.15	.06
All 4 years	−.14	.001

[a]Change in daily gain (lb) for each 100-pounds increase in initial steer body weight.
[b]Probability that regression coefficient is significantly different from zero.

The data used in this study were from fall-weaned steer calves that were placed on wheat pasture. The results do not apply to the question or differences in gain of calves versus yearlings. Also, the extent to which differences in fleshiness of the steers may have influenced the results is not known.

The results indicate that daily gains of lightweight steers (e.g., 300 lb) on wheat pasture will be greater than those of heavier steers (e.g., 500 lb). Since a given acreage of wheat pasture can be stocked with more lightweight than heavy steers, total gains per acre would be greater for lightweight steers.

Effect of Feeding Wheat Straw or Sorghum-Sudan Hay on Gains and Wheat Forage Utilization of Stocker Cattle

T.L. Mader, G.W. Horn and W.E. Phillips

Story in Brief

Grazing and metabolism trials were conducted during the 1979-80 wheat pasture grazing season to determine the effect which feeding wheat straw (WS) or sorghum-sudan hay (SS) to wheat pasture stockers had on gains and wheat forage intake and utilization. Live and carcass daily weight gains were not significantly altered by feeding either WS or SS. A single pulse dose of Ytterbium-labeled wheat forage was used as a particulate phase marker to measure total gastrointestinal tract (GIT) dry matter (DM) turnover rates of wheat forage (percent/hr) and fecal outputs. Wheat forage intakes were calculated by dividing estimates of fecal outputs (corrected for the undigested portion of WS or SS in feces) by wheat forage indigestibility (one minus estimated *in vivo* digestibility). In the grazing trial, steers were grazed on a single wheat pasture and fed nothing (control) or WS or SS. Wheat forage intakes were significantly ($P<.05$) greater for steers fed SS; however, GIT DM turnover rates of wheat forage were not significantly ($P>.05$) different among treatments. In a metabolism stall trial, steers were fed 90 percent *ad libitum* of harvested wheat forage (control) or harvested wheat forage plus SS. Differences in wheat forage intake and digestibility and total GIT turnover rates were not significant ($P>.05$). The data indicate that feeding WS or SS to wheat pasture stockers does not alter wheat forage utilization or significantly decrease wheat forage intake.

In cooperation with USDA, Science and Education Administration, Southern Region.

Introduction

Low-quality roughages such as wheat straw are commonly fed *ad libitum* to stocker cattle on wheat pasture. Reasons cited by producers for feeding low-quality roughages on wheat pasture include the following: 1) extension of wheat pasture, 2) a means of slowing rate of passage and thereby increasing the efficiency of utilization of "washy" wheat forage, 3) heat (e.g., to increase the heat of ruminal fermentation), and 4) reduction of the incidence of bloat.

During the fall of 1978 a 3-year project was initiated to obtain information relative to the effect of feeding low-quality roughages to wheat pasture stockers. Measured were:

1. Live and carcass weight gains
2. Wheat forage intake
3. Incidence of bloat
4. Wheat forage dry matter digestibility
5. Total ruminal dry matter turnover rate

Results obtained during the first year of the project have previously been reported (Mader *et al.*, 1979 and 1980). Results of the second year of the project are reported herein. Research relative to the above objectives has been partitioned into an extensive phase (Objectives 1 and 3) and an intensive phase (Objectives 2, 4 and 5). Data relative to Objective 5 was not obtained in the second year of this study; however, total gastrointestinal tract dry matter turnover rate of wheat forage was determined.

Experimental Procedure

Extensive phase

Fifty-seven (57) fall-weaned Hereford steer calves that weighed 365 lb were randomly assigned to five groups. Two groups of steers grazed clean-tilled wheat pasture for 147 days (November 27 to April 21) and two groups of steers grazed wheat pasture and were fed *ad libitum* sorghum-sudan hay. Due to a shortage of wheat pasture, only one group of 12 steers was grazed on wheat pasture and fed wheat straw *ad libitum*.

Straw and hay intakes for the respective steer groups were measured every two weeks. Straw and hay were added to feeders and sampled at 2-week intervals for dry matter, *in vitro* dry matter digestibility determinations, and other chemical analyses. A mineral mixture that consisted of two-thirds salt and one-third ground limestone was fed free-choice in "whirlwind" type mineral feeders. No additional salt was fed to the steers. All steers were observed twice daily throughout the trial and assigned a bloat score of 0 to 3.[1]

Initial, intermittent and final shrunk live weights (overnight stand without feed or water) were measured. Three intermittent weights were taken (January 9, February 22 and March 19) so as to bracket major changes in climatic growing conditions for wheat, and, therefore, major changes in wheat forage quality and /or maturity. In the previous year, steers were removed from wheat pasture in March, however, as of the March weigh date, no bloat had been observed for any of the steers on trial. Therefore, an additonal grazing period of 34 days was utilized in an effort to acquire additional data relative to the incidence of bloat.

Samples of available wheat forage in all pastures were taken by hand-clipping at 2- to 4-week intervals throughout the trial. Carcass weight gains were calculated from the mean dressing percentage of an initial slaughter group of four steers, and the mean dressing percentages of final slaughter groups of three steers randomly selected from each of the three treatment groups.

[1]0 - No visible signs of bloat; 1 - Slight distention of left side; 2 - Marked distention of left side; 3 - Left and right sides distended.

Intensive phase

GRAZING TRIAL—Nine Hereford x Angus steer calves that weighed 765 lb were used in three 3 x 3 Latin square designs with periods on wheat pasture and treatment as factors. During each period all steers grazed a single wheat pasture for 9 hr each day. The steers were removed from wheat pasture, placed in individual feeding stalls, fed 1) nothing, 2) wheat straw or 3) sorghum-sudan hay *ad libitum* overnight and returned to wheat pasture the following morning. Each period consisted of 11- and 5-day preliminary and collection phases, respectively. At the beginning of each collection phase, all steers were fed a single pulse dosage of wheat forage (.124 lb dry matter basis) labeled with Ytterbium chloride (1.46 g Yb/steer), a particulate phase marker. Fecal samples were then obtained from the rectum of each steer at 0800 and 1600 hr daily during the collection phase. Daily fecal output and total gastrointestinal tract dry matter turnover rate were estimated using the single dose marker technique described by Faichney (1975) and Ellis *et al.* (1977). Details of the marker technique have previously been discussed (Mader and Horn. 1980). Wheat forage intakes were calculated by dividing estimates of fecal output (corrected for the undigested portion of low-quality roughage in feces, as determined by *in vitro* dry matter digestibility (IVDMD) prodedures) by wheat forage indigestibility. Wheat forage indigestibility was calculated by subtracting *in vivo* digestibility of hand-clipped wheat forage samples from one. *In vivo* digestibility was estimated from the average IVDMD of the wheat forage samples.

METABOLISM STALL TRIAL—Ten Hereford steers that weighed 634 lb were utilized in a completely randomized design and were fed harvested wheat forage (control) or harvested wheat forage plus sorghum-sudan hay. Wheat forage was harvested every 2 or 3 days using a small flail harvester. After harvesting, the forage was placed in large plastic bags (approximately 40 lb/bag), excess air was removed and the bags were tied off with string. The bagged forage was stored at 2°C and usually fed within 1 to 3 days after harvesting. Samples of wheat forage fed to steers were taken daily during the fecal collection phase of the trial and frozen for later analysis.

The trial included a 7-day preliminary period, in which wheat forage intake was adjusted to achieve *ad libitum* intake, and a 5-day fecal collection period, in which wheat forage was fed at 90 percent *ad libitum*. Wheat forage dry matter digestibility was measured from wheat forage intakes and total collections of fecal output. Total feces of steers fed sorghum-sudan hay was adjusted for the amount of hay dry matter appearing in the feces, which was determined by multiplying the amount of hay fed by the indigestible portion (one minus estimated *in vivo* digestibility) of sorghum-sudan hay. The single dose marker technique, using ytterbium-labeled wheat forage, was used to estimate fecal output and total GIT DM turnover rate. Fecal outputs estimated by the marker technique were compared to those from total collection.

Results and Discussion

Extensive phase

Roughage consumption (lb DM/head/day) and average daily gains of the steers are shown in Table 1. Roughage intake was greatest in Period 2 and decreased thereafter. Over the 113-day period (11-27-79 to 3-18-80), steers consumed .20 lb of wheat straw per head per day and .52 lb of sorghum-sudan hay per head per day.

Live weight gains were lowest in Period 1, averaging 1.31 lb/head/day and tended to increase over the grazing season, averaging 2.49 lb/head/day in Period 4. Daily gains tended to be greater for the control steers during Periods 1 and 2 but lower for the control steers during the remaining periods. Only in Period 3 were gains significantly

different ($P<.05$) between the control and roughage-fed steers. Over the entire 147-day grazing season, carcass daily gains of 1.42, 1.40 and 1.47 lb/head/day, respectively, for the control steers and those fed wheat straw and sorghum-sudan hay were not significantly different ($P>.05$). Although steers were observed for bloat twice daily during the trial, no incidence of bloat was noted for any steers among the treatment groups.

Intensive phase

GRAZING TRIAL—Roughage and wheat forage intakes and total GIT DM turnover rates are shown in Table 2. Intakes (expressed as percentage of metabolic

Table 1. Roughage intake and daily gains of wheat pasture stockers fed low-quality roughages[a]

Item	Control	Wheat straw[b]	Sorghum-sudan hay[b]
Roughage consumption, lb DM/head/day			
Period 1 (11-27-79 to 1-8-80)	—	.21	.32
Period 2 (1-9-80 to 2-21-80)	—	.22	.74
Period 3 (2-22-80 to 3-18-80)	—	.13	.49
Period 4 (3-19-80 to 4-21-80)	—	.07	.16
Periods 1-3 (113 days)	—	.20	.52
% metabolic body weight	—	.15	.40
Average daily live gains, lb			
Period 1 (11-27-79 to 1-8-80)	1.43[c]	1.27[c]	1.24[c]
Period 2 (1-9-80 to 2-21-80)	2.08[c]	1.88[c]	1.98[c]
Period 3 (2-22-80 to 3-18-80)	2.06[c]	2.14[d]	2.23[e]
Period 4 (3-19-80 to 4-21-80)	2.25[c]	2.98[c]	2.25[c]
Periods 1-4 (147 days)	1.92[c]	2.00[c]	1.87[c]
Average daily carcass gains, lb			
Periods 1-4 (147 days)	1.42[c]	1.40[c]	1.47[c]

[a]Mean values represent two groups of 11 or 12 steers per group for the control and sorghum-sudan hay treatment and one group of 12 steers for the wheat straw treatment.
[b]Mean crude protein and estimated TDN contents were 3.44 ± .11 and 37.24 ± 1.70 for the wheat straw and 8.24 ± .27 and 52.66 ± .67 for the sorghum-sudan hay, respectively.
[cde]Means with a common lettered superscript are not significantly different ($P>.05$)

Table 2. Roughage and wheat forage intake and total gastrointestinal tract (GIT) DM turnover rate of steers grazed on wheat pasture

Item	Control	Wheat straw[a]	Sorghum-sudan hay[a]
Roughage intake			
lb DM/day	—	.73	1.63
% of metabolic body weight	—	.41	.96
Wheat forage intake			
lb DM/day	11.05[b]	11.19[b]	13.52[c]
Total GIT DM (wheat forage) turnover rate, %/hr	4.46[b]	4.36[b]	4.75[b]

[a]Estimated *in vivo* digestibilities are equal to 36.87 and 54.29% for wheat straw and sorghum-sudan hay, respectively.
[bc]Means in a row with a common-lettered superscript are not different ($P>.05$).

Table 3. Wheat forage intake and digestibility, total GIT dry matter turnover rate and fecal output of steers in metabolism stall trial

Item	Control	Sorghum-sudan hay[a]
Roughage intake		
lb DM/day	—	1.42
% of metabolic body weight	—	.93
Wheat forage intake, lb DM/day	12.22[b]	12.23[b]
Wheat forage digestibility, %	75.25[b]	74.70[b]
Total GIT DM (wheat forage) turnover rate, %/hr	9.13[b]	10.38[b]
Daily fecal output of undigested wheat forage, lb DM/day		
Measured by total collection	3.02[b]	3.08[b]
Estimated by pulse dose of Ytterbium	2.88[b]	3.14[b]

[a]Estimated *in vivo* digestibility is equal to 58.24%.
[b]Means in a row with a common-lettered superscript are not different (P>.05).

body wt) of wheat straw and sorghum-sudan hay were greater than those observed in the extensive phase. Wheat forage intakes compared to control steers were slightly greater (11.05 vs. 11.19 lb/head/day) for steers fed wheat straw and significantly (P<.05) greater (11.05 vs.13.52 lb/head/day) for steers fed sorghum-sudan hay. This would indicate that low-quality roughage fed at these levels tended to either maintain or stimulate wheat forage intake rather than decrease it. Total GIT DM turnover rate of wheat forage was not different (P>.05) among treatments. However, steers fed sorghum-sudan hay had the fastest GIT DM turnover rate (4.75 percent /hr), which may be due to the increased wheat forage intake.

METABOLISM STALL TRIAL—Sorghum-sudan hay intake, wheat forage intake and digestibility, total GIT dry matter turnover rate, and fecal output of steers fed wheat forage in metabolism stalls are shown in Table 3. The sorghum-sudan hay intake of 1.42 lb DM/head/day, when expressed as a percent of metabolic body weight was similiar (.93 vs. .96 percent) to that observed during the grazing trial. Wheat forage intakes were very similiar (12.22 vs. 12.23 lb/head/day) for both the control steers and those fed sorghum-sudan hay. Although total GIT DM turnover rate of wheat forage was not significantly different (P>.05), the average turnover rate of steers fed sorghum-sudan hay was higher (10.38 vs. 9.13 percent /hr) than that of control steers. The greater turnover rate may be attributed to the intake of sorghum-sudan hay since wheat forage intake was similiar, An explanation for the large difference in GIT DM turnover rate of wheat forage between steers of the grazing and metabolism stall trials is not apparent.

Regardless of the differences in wheat forage turnover rate, wheat forage digestibility was not changed (P>.05) by feeding sorghum-sudan hay. Estimated vs. measured daily fecal outputs of undigested wheat forage were similiar for both steer groups. Fecal output of undigested wheat forage, averaged across both groups, was 3.06 lb/head/day whereas fecal output estimated from the pulse dose marker technique was 3.01 lb/head/day. The data indicate that intake is not decreased and that utilization of wheat forage (digestibility and rate of passage through the gastrointestinal tract) is not significantly altered by feeding wheat straw or sorghum-sudan hay to wheat pasture stockers. Daily gains over the entire grazing season were similiar for steers of all treatments.

Literature Cited

Ellis, W.C. 1977. Annual Meetings ASAS, Abstr. No. 578.

Faichney, G. J. 1975. *Digestion and Metabolism in the Ruminant.* Univ. of New England, Armidale, Australia. p. 277.

Mader, T.L. and G.W. Horn. 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:80.

Mader, T.L. *et al.* 1979. Range Cow Research Center Proceedings. Anim. Sci. Dept., Okla, State Univ., Okla. Cattlemen's Assoc. p. H-1.

Yeast Culture in a Free-Choice Mineral Supplement for Stocker Cattle Grazing Wheat Pasture

C. L. Streeter, G. W. Horn and J. E. McClung[1]

Story in Brief

Steer and heifer calves were grazed on wheat pasture from December to mid-March. Two groups were allowed access to a commercial mineral supplement, and two groups received the same supplement with added cultured yeast. The addition of 50-percent cultured yeast in the mineral mixture increased daily mineral consumption threefold from 0.08 to 0.24 lb per head.

The increased mineral consumption did not significantly ($P>.05$) affect the average daily gain of the cattle. However, limited available wheat herbage in one pasture replicate may have influenced these results. There was no difference in the calcium or magnesium status of blood or hair among the animals fed mineral alone or mineral with cultured yeast, but both appeared to be considerably below reported levels. Phosphorus levels were considered to be adequate. Herbage sodium was found to vary with pasture, and the sodium content of the hair but not serum of animals varied accordingly. Little treatment differences were found in herbage, serum or hair concentrations of potassium, iron, copper and zinc. Future studies with blood and hair samplings should involve a greater number of animals for a more sensitive statistical analysis.

Introduction

Early wheat pasture studies with grazing stocker cattle in the panhandle of Oklahoma indicated that there was a possible deficiency of calcium and magnesium (McMillen and Langham, 1942). Consumption of mineral supplements by cattle grazing wheat pasture has generally been relatively low. Mader *et al.* (1979) reported that steers grazing wheat pasture consumed only 0.26 lb per head daily of a 2:1 mixure of salt and limestone. A technique is needed to increase mineral consumption to meet calcium and magnesium requirements.

Ruf *et al.* (1953) showed that the inclusion of 5-percent live yeast in the diet of lambs increased feed consumption by 0.6 lb and daily gains by 0.16 lb. Feeding yeast

[1]Formerly with Diamond V Mills, presently with McClung Enterprises, Cedar Rapids, Iowa.

would, therefore, appear to stimulate feed intake. It is also believed that yeast cells aid in utilization of excess ruminal ammonia by converting it to yeast cell protein (Stone, personal correspondence). Better utilization of ruminal ammonia, which is characteristically high in cattle grazing wheat pasture, should increase nitrogen balance and shift the microbial population from amylolytic to cellulolytic and, hence, increase fiber digestion.

The objectives of this trial were to determine if 1) cultured yeast would increase the voluntary consumption of a free-choice mineral supplement supplied for stocker cattle grazing wheat pasture and 2) the increased consumption of the cultured yeast and mineral supplement affected weight gains.

Materials and Methods

Steers (243 head) and heifers (259 head) with an average weight of 422 lb were allocated to two treatments with two pasture replicates per treatment. Replicates consisted of one group of steers and one group of heifers because of an insufficient number of one sex. Treatments were 1) free choice high-calcium, high-magnesium commercial mineral supplement[2] and 2) the same mineral supplement mixed with cultured yeast[3]. The mineral composition is shown in Table 1, and the nutrient composition of the cultured yeast is shown in Table 2. The mineral was mixed with cultured yeast at a ratio of 2:1 during the month of December and changed to 1:1 thereafter to increase total supplement consumption. The amount of supplement

Table 1. Mineral composition of mineral supplement and supplemental feed

Element	Mineral supplement	Supplemental feed
CA, %	16.40	0.62
Mg, %	7.70	0.12
P, %	4.20	0.55
Na, %	9.10	0.073
K, %	0.06	1.16
Fe, %	960	1622
Cu, %	20	16
Zn, %	360	56

Table 2. Nutrient composition of cultured yeast

Constituent	
DM, %	89.0
Crude protein, %	14.0
Crude fat, %	2.5
Crude fiber, %	8.0
Ash, %	4.0
Ca, %	0.28
Mg, %	1.02
P, %	0.71
Na, %	1.76
K, %	1.60
Fe, mg/lb	204
Cu, mg/lb	58
Zn, mg/lb	32

[2]Farmland Industries, Kansas City, Missouri.
[3]Diamond V Mills, Inc., Cedar Rapids, Iowa.

consumed was measured weekly. The stocking rate of each pasture was based on the amount of available wheat forage rather than on acreage *per se*.

The experiment was conducted on wheat pasture near Enid, Oklahoma, from the first week of December until the middle of March for a 100-day period. All pastures were fertilized in the fall with 100 lb of anhydrous ammonia per acre and with 90 lb of 10-30-0 applied to the two pastures on which the steers grazed.

All cattle also had access to a free-choice supplemental feed because of decreased growth of wheat forage resulting from limited fall precipitation. The mineral and ingredient composition of the supplemental feed are shown in Tables 1 and 3, respectively.

Samples of wheat herbage and cattle hair were obtained from eight head in each pasture at the initiation and completion of the trial. The samples were analyzed for calcium, phosphorus, magnesium, sodium, potassium, iron, copper and zinc by atomic absorption spectrophotometry as an indication of the animal's mineral status. Serum samples were also collected from the eight animals described above at the completion of the trial. Similar mineral analyses were conducted with the exception of phosphorus. The crude protein content of the herbage was also measured.

Results and Discussion

The mean daily consumption of mineral alone was 0.08 lb per head throughout the trial (Table 4). Daily consumption of mineral in the (2:1) mixture of mineral and cultured yeast was 0.14 lb per head. Consumption of the mineral in the mixture increased to 0.24 lb per head when the ratio of mineral to yeast was changed to 1:1.

Table 3. Ingredient composition of supplemental feed[1]

Ingredient	%
Ground shelled corn	20.0
Milo	32.0
Wheat middlings	21.0
Rice mill by-product	22.0
Molasses	5.0
	100.0

[1]Rumensen was added at level of 20 g/T.

Table 4. Mineral and cultured yeast consumption of cattle

Period	Mineral	Intake (lb/day)		
	Cultured yeast	Mineral	Mineral +	Cultured yeast
Dec. 2 - Jan. 5	2:1	0.08[a]	0.14[b]	0.07[a]
Jan. 6 - Mar. 15	1:1	0.08[a]	0.24[b]	0.24[b]

[ab]Means in a row with different superscripts differ significantly (P<.05).

Table 5. Performance and supplemental feed consumption of cattle

	Method of feeding mineral					
	Alone			With cultured yeast		
Pasture no.	1	2	X	3	4	X
Cattle sex	Steers	Heifers		Heifers	Steers	
No. cattle	100	143	122	116	143	130
ADG, lb/day	1.24	1.00	1.12[a]	0.98	1.40	1.19[a]
Supplemental feed, lb/day	0.41	0.43	0.42[a]	1.48	0.84	1.16[b]

[ab]Means in a row with different superscripts differ significantly (P<.05).

There was no significant (P>.05) overall effect on average daily gain resulting from method of mineral feeding (Table 5). However, the low gain of the cattle on Pasture 3 was attributed to a reduced amount of available herbage as indicated by higher consumption of supplemental feed.

The mean calcium content of the herbage sampled in this study was 0.34 percent (Table 6). F. P. Horn *et al.* (1974) reported a similar wheat herbage calcium level of 0.42 in a report from the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma. Both values are near the recommended dietary calcium level of 0.40 (N.R.C., 1976). The mean calcium content of the serum of all cattle involved in this study was 5.4 mg percent (Table 7). F. P. Horn *et al.* (1974) reported serum calcium levels of 5.8 mg percent. Both reports are considerably below the "normal" serum calcium values of 8.4 to 9.6 mg percent quoted by Stevens (1975) and 9.1 mg percent reported by McMillen and Langham (1942). The calcium content of the hair of cattle at the end of this study was 0.18 percent (Table 8), which is also lower than reported values of 0.2 to 0.3 percent (Combs *et al.*, 1979). There was no significant (P>.05) effect on the calcium content of the serum or hair resulting from method of feeding mineral.

The magnesium content of the pasture increased significantly (P<.05) from 0.20 in December to 0.25 percent in March (Table 6) and was above the N.R.C. requirement of 0.15 percent throughout the study. F. P. Horn *et al.* (1974) reported similar values of 0.25 percent magnesium in wheat pasture. The serum magnesium level was lower than the normal range of 1.8 to 2.4 mg percent reported by Stevens (1975). The magnesium content of the hair was also less than the 0.3 to 0.8 percent values reported by Combs *et al.* (1979). Methods of feeding mineral did not affect serum magnesium level (1.0 mg percent) or the magnesium content of the hair (0.10 percent).

Table 6. Crude protein and mineral composition of wheat pasture herbage dry matter

	Method of feeding mineral			
	Alone		With cultured yeast	
Pasture no.	1,2	1,2	3,4	3,4
Nutrient	12/1/79	3/9/80	12/1/79	3/9/80
Crude protein, %	25.0	30.0	26.5	30.2
Ca, %	0.34	0.32	0.32	0.36
Mg, %	0.20	0.24	0.19	0.26
P, %	0.38	0.55	0.43	0.52
Na, %	0.073[a]	0.075[a]	0.018[b]	0.020[b]
K, %	2.57	3.14	3.03	3.01
Fe, ppm	354[a]	1807[b]	413[a]	1490[b]
Cu, ppm	10	13	9	16
Zn, ppm	28	38	31	43

[ab]Means in a row with different superscripts differ significantly (P<.05).

Table 7. Mineral composition of lamb blood serum on March 9, 1980

	Method of feeding mineral	
Element	Alone	With cultured yeast
Ca, mg %	5.9	4.8
Mg, mg %	1.0	1.1
Na, mg %	400	399
K, mg %	25.9	29.2
Fe, ppm	36.8	26.4
Cu, ppm	2.5	1.5
Zn, ppm	2.9	2.0

Table 8. Mineral composition of hair

Element	Method of feeding mineral			
	Alone		With cultured yeast	
	12/1/79	3/9/80	12/1/79	3/9/80
Ca, %	0.31	0.16	0.30	0.19
Mg, %	0.06	0.11	0.05	0.10
P, %	0.05	0.05	0.04	0.04
Na, %	0.18[a]	0.16[a]	0.15[a]	0.09[b]
K, %	0.07	0.06	0.06	0.04
Fe, ppm	288[a]	1863[b]	342[a]	1548[b]
Cu, ppm	8.9	12.40	9.4	11.70
Zn, ppm	142	140	136	137

[ab]Means in a row with different superscripts differ significantly (P<.05).

The phosphorus content of the herbage increased from 0.40 in December to 0.54 percent in March (Table 6) and was above the N.R.C. requirement of 0.32 percent throughout the study.

The March herbage in the two pastures grazed by cattle that received mineral alone had significantly higher (P<.05) sodium (0.075 percent) than the herbage in the two pastures with cattle fed mineral and cultured yeast (0.020 percent - Table 6). The difference in herbage sodium content was not found in the serum (Table 7) as might be expected because of the homeostatic mechanisms present in the blood. However, the hair of cattle grazing in the two pastures in which the mineral was supplied alone had a higher (P<.05) sodium content than that of cattle receiving mineral and cultured yeast. The difference in sodium content of the herbage and hair is not attributed to the treatments imposed, but more likely was a result of differences in soil fertility at different locations.

Potassium, iron, copper, and zinc concentrations were found to be relatively consistent in the herbage, serum and hair with both methods of feeding mineral.

Literature Cited

Combs, D. K., R. D. Goodrich, T. S. Kahlon and J. C. Meiske. 1979. Minnesota Beef Cattle Feeders Report B-261:54.

Horn, F. P., D. G. Wagner, R. R. Oltjen, T. Rumsey and A. D. Tillman. 1974. Okla. Agr. Exp. Sta. Res. Rep. MP-92:7.

Mader, T. L., G. W. Horn, W. E. Phillips, S. L. Armbruster and J. MaGee. 1979. Proc. Beef Cattle Field Day, Okla. State Univ., Stillwater, OK

McMillen, W. N. and Wright Langham. 1942. J. Anim. Sci. 1:14.

N.R.C. 1976. Nutrient Requirements of Beef Cattle. Natl. Acad. Sci., Washington, D.C.

Ruf, E. W., W. H. Hale and Wise Burroughs. 1953. J. Anim. Sci. 12:731.

Stevens, J. B. 1975. Anim. Nutr. and Health. 30:14.

Ensiling of Whole Wheat Plant at Different Maturities and Dry Matter

W. A. Phillips, L. C. Pendlum and F. P. Horn

Story in Brief

Wheat forage was harvested with a forage chopper and ensiled in 1-gallon experimental silos. Maturity of the wheat was late boot, milk and soft dough; within each maturity, dry matter levels were 25, 35 or 45 percent. All combinations of maturity and dry matter resulted in adequate reduction of the pH to preserve the forage. Later maturities had more available non-structural carbohydrates for fermentation than earlier maturities had, as evidenced by the lower final pH, and resulted in less dry matter loss during fermentation. Addition of 1 percent of forage dry matter as formic acid (FA) before ensiling resulted in lower final pH values and less dry matter loss than in forage not treated with FA, especially at natural field dry matter. Fermentation was improved if wheat forage was ensiled at the milk or soft dough stage of maturity rather than at the boot stage. Within each maturity, dry matter content had no effect on any fermentation characteristic except final pH.

Introduction

Levels of beef production have been acceptable when silages are used as a major part of the ration. The advantages of harvesting wheat forage as a silage rather than as a hay include reduced field losses and increased mechanization. The quality of the silage after fermentation is dependent upon the maturity at which it was ensiled. Information on the effect of dry matter content on the fermentation of wheat forage is limited because maturity and dry matter levels are usually not considered independently. The objective of this research was to determine the effects of maturity and dry matter, independently and collectively, on fermentation characteristics of ensiled wheat forage.

Experimental Procedure

Wheat forage from one field was harvested with a forage chopper at three stages of maturity (late boot, milk and soft dough) and ensiled in 1-gallon, cardboard containers at 25, 35 or 45 percent dry matter. The field dry matters at the time of harvesting were 27, 33 and 44 percent for late boot, milk and soft dough stages of maturity, respectively. As maturity increased, so did dry matter, so water had to be added to forage prior to ensiling to achieve the desired experimental dry matters. Before the wheat forage was ensiled, one half of each maturity and dry matter combination was treated with formic acid (FA) at a level of 1 percent of the dry matter. The other half was the untreated control. All silos were packed with a hand operated press to expel as much air as possible. Each silo was lined with two individually sealed plastic bags. Three silos were filled for each treatment combination. Forage was allowed to ferment for 60 days; then each silo was opened, mixed and sampled. Data were analyzed as a 3 by 3 factorial arrangement of treatments within FA control and treated groups.

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Results and Discussion

The pH of each maturity and dry matter combination plus dry matter loss during fermentation are presented in Table 1. Within each of the control groups, lower dry matter content resulted in a lower final pH value. In the fermentation process, the reduction in pH from the initial value is the result of microbial fermentation of highly digestible, non-structural carbohydrates (sugars). As maturity increases, the plant becomes more reproductive and begins to develop seed heads that are higher in non-structural carbohydrates and provide more fermentable substrates than when less mature. This characteristic was evident in this trial. No differences in final pH values due to either maturity or dry matter were noted when FA was added before ensiling. Adding organic acids to forage materials at ensiling is one way of rapidly lowering the pH to preserve the material without using fermentable products of the plant.

The conversion of energy stored in the plant material to end products of fermentation is dependent upon the type of bacteria present and is 95 to 99 percent efficient. The end products are organic acids, alcohol and carbon dioxide. Energy is lost when the end products of the fermentation process escape as gases to the atmosphere or as water soluble products within run-off or seepage. This loss is dramatized by a loss in the amount of dry matter remaining after fermentation. The dry matter loss in this study decreased by 50 percent as maturity increased. With increased maturity, more readily available substrates were available for fermentation; thus, less dry matter was required to produce the acids necessary to lower the pH and preserve the remaining material. Because the dry matter content before and after fermentation was determined by heating the samples, the losses could also in part reflect volatile compounds that were driven off by the heat. Apparently, the stage of maturity determined the end products of fermentation. The addition of FA before ensiling reduced dry matter loss at milk and soft dough stages of maturity, as reflected by the overall means across all dry matter levels. Reduction of such losses was marked at dry matters of 25 and 35 percent for milk stage silage and 45 percent for soft dough silage. The optimum dry matter levels for FA addition correspond with the natural field dry matter of that maturity, but it was apparent that FA would be beneficial if added to wilted silage also.

Table 1. Fermentation characteristics of wheat forage ensiled at three maturities and dry matter (DM) levels with and without formic acid (FA)

	Late boot stage		Milk stage		Soft dough stage	
DM Levels, %	C[a]	FA	C	FA	C	FA
			Final pH			
25	5.24	4.39	4.76	4.76	4.47	4.52
35	5.16	6.06	4.95	4.39	4.51	4.72
45	5.89	4.89	5.24	4.84	4.98	4.41
Mean	5.43	5.11	4.98	4.66	4.65	4.55
			DM loss (%)			
25	22.10	32.98	10.84	2.94	.48	2.59
35	19.85	24.98	9.08	4.06	1.03	5.77
45	18.83	19.88	14.62	9.16	14.66	1.73
Mean	20.26	25.95	11.51	5.39	5.39	3.36

[a]C = Control.

The Impact of Farm of Origin and Post-Shipment Diet on the Performance of Stocker Calves

W. A. Phillips and J. B. McLaren[1]

Story in Brief

The impacts of farm of origin (FO) and post-shipment diet were studied using 194 stocker calves (averaging 440 lb) assembled from 9 FO's, subjected to auction barn (AB) and order-buyer barn (OBB) environments, then shipped 850 miles. Upon arrival, the calves were fed three post-shipment diets.

The FO had a significant effect on transit weight loss. Overall weight loss during transit was 7.5 percent of the pre-shipment weight or 33 lb per calf. Total gains during the first 21 days after shipment were increased (15.4 lb) when a diet that contained 1.5 percent potassium was fed. Changing the supplemental protein from soybean meal to corn gluten meal had little effect on weight gains. Feed intake was increased by adding potassium to the basal diet, and feed efficiency was improved by 22 percent. The FO affected post-shipment weight gains but not feed intake.

Introduction

Each year during the fall, young calves in the southeastern part of the U.S. are weaned and moved into the marketing and transportation system that provides calves for wheat pasture stocker operations. From both an economic and management standpoint, these calves should be purchased before wheat pastures are available. However, to do so requires that a receiving diet be fed after shipment until wheat pasture is available. The composition of this diet can have a dramatic effect upon the performance of recently stressed stocker calves. This experiment was conducted to (1) determine the effects on performance of the amount of dietary potassium and the source of supplemental protein in the receiving diet and (2) evaluate the effect of farm of origin (FO) on health and post-transit performance.

Experimental Procedure

A total of 194 calves representing 9 FO's were assembled at a commercial auction barn in Tennessee 4 days before shipment. During the first 24-hour of assembly no feed or water was provided, and the calves were allocated 10 to 15 sq ft of pen space per calf to simulate an AB (auction barn) environment. Hay was fed during the last 3 days of assembly, and larger pens (25 to 30 sq ft/calf) were used to simulate a OBB(order-buyer barn) environment. Two commercial double-deck livestock trailers transported the calves 850 miles from Algood, Tennessee, to El Reno, Oklahoma. Upon arrival, each calf was weighed and assigned one of three post-shipment diet treatments presented in Table 1. The control diet (C) was supplemented with potassium chloride to

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Table 1. Composition of post-shipment diets

Ingredient[a]	Diet[b] C	HK	PP
Cottonseed hulls	39.4	37.4	39.4
Corn	51.0	51.6	52.0
Soybean meal	8.0	8.0	—
Corn gluten meal	—	—	6.6
Molasses, dry	1.0	1.0	1.0
Limestone	.6	.6	.7
Potassium chloride	—	1.4	.3
Nutrient composition of dry matter			
Crude protein (%)	11.1	11.1	11.0
TDN (%)	69.8	69.6	69.2
NE-maintenance (Mcal/lb)	.79	.79	.79
NE-gain (Mcal/lb)	.43	.43	.43
Calcium (%)	.36	.35	.36
Phosphorus (%)	.28	.28	.26
Potassium (%)	.79	1.50	.78

[a]Percentage of as-fed diet.
[b]C = control, HK = high potassium, PP = protected protein.

provide the second or high potassium (HK) diet with a potassium level of 1.5 percent. The soybean meal in the control diet was replaced by a "rumen bypass" protein, corn gluten meal, to produce the third or "protected protein" (PP) diet. Treatment groups (FO and receiving diets) were randomly assigned to 1 of 27 pens with the restriction that calves from the same farm would be in the same pen but not in the adjacent pens.

Calves were fed once each day, and the daily ration was increased to allow for maximum intake during the 21-day period. Weight losses were calculated as the difference between pre-shipment and arrival weights and expressed as a percentage of pre-shipment weight. The 21-day gains were calculated using a filled weight taken before the morning feeding minus arrival weight. Feed intakes were determined weekly and expressed as the amount of dry matter consumed per calf per day.

Results and Discussion

The amount of weight lost during transit was affected ($P<.01$) by the FO. The 194 calves averaged 441 pounds before shipment (on-truck weight) and lost an average of 33 pounds during transit, which represented 7.5 percent of their initial body weight. Losses varied from 5.7 percent to 10.0 percent, depending upon the FO. After 1 day in the AB and 3 days at the OBB, the impact of the FO was still significant in this study.

Feeding a high potassium diet after shipment increased the gain by over .73 lb/head/day or 15.4 lb over the 21-day period. During transit, calves excrete body water and body potassium. Feeding higher levels of potassium quickly replaces body potassium and increases the retention of water. Thus, the gains associated with potassium supplementation are expected to be largely body water. Quick restoration of body water with supplemental potassium did not decrease the incidence of respiratory disease.

The FO also had an effect on weight gain. Within the control group, 21-day gains ranged from 42.8 lb to 75.2 lb as a result of FO. Response to HK was positive in all except animals from one FO. Response to the protected protein diet (PP) was more variable than the HK diets. The PP diet had a positive response in calves from five of

Table 2. Effects of farm of origin on transit weight losses and effects of post-shipment diet on gains and feed intake during the first 21-day period post-shipment

Farm of origin	Weight losses (%)	Body weight gain (lb)			Feed intake (lb/head/day)		
		C	HK	PP	C	HK	PP
1	7.58	42.89	79.84	63.65	10.7	11.1	10.3
2	7.94	68.53	73.65	33.49	11.2	11.6	9.9
3	7.10	51.56	69.76	58.16	10.9	11.1	10.3
4	7.10	75.21	87.92	71.23	11.2	11.6	10.8
5	8.58	69.32	80.93	73.71	11.1	11.5	10.7
6	7.17	48.48	65.97	48.07	10.4	11.6	10.2
7	9.95	57.74	53.19	47.98	10.6	11.1	10.2
8	6.07	54.85	88.51	71.32	10.5	11.4	10.6
9	5.66	50.07	58.78	66.34	10.8	10.5	10.1
X	7.46	57.7	73.1	59.4	10.8	11.3	10.3

the FO's, no response in one and a negative response in calves from three FO's. The response to the PP diet was more dependent upon FO than were the responses to other diets. The percentage of animals treated for respiratory disease ranged from 20 to 65 percent, depending upon FO.

During assembly and transportation, calves use body stores of energy and protein. The rumen, which contains the microorganisms for protein synthesis and the release of energy from feedstuffs, may not be able to meet the needs of the recently stressed calf. The usually low feed intakes during the first 2 or 3 weeks in the new environment compound the nutritional problem. Feed dry-matter intakes for the first 21 days post-shipment for the study are presented in Table 2. FO did not significantly affect intake, but diet did. Intakes were higher for calves fed the HK diet than for those fed either the C or PP diet. Average daily consumption of the HK diet was higher than the other two diets, and feed efficiency was improved by 22 percent over the control group. Thus, the HK diet not only improved gains but also increased intake and improved feed efficiency. Calves fed the PP diet consumed .5 lb less feed/head/day than the C calves and feed efficiency was improved by 7 percent as compared to the C calves.

Weight Changes During Transportation of Stocker Calves

W. A. Phillips and K. B. Leining

Story in Brief

Sixty-four stocker calves weighing an average of 621 lb were used to determine the effect of transportation (250 miles) and pre-shipment diet on body weight changes and blood constituents. Feed and water deprivation alone accounted for 63 percent of the

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weight losses noted during transit. Transit resulted in an additional 1.42 percent loss (2.44 vs. 3.86 percent) in pre-shipment body weight. Although consumption of the pre-shipment diet was low (1.8 lb/head), the diet significantly decreased weight loss during transit. The fact that transit elevated rectal temperature by 1° F showed that transported calves have a higher normal temperature upon arrival than calves not transported. Post-shipment feedlot performance was not particularly affected by any treatment. Thus, feeding a high density (over 60 percent Total Digestible Nutrients) diet before shipment can reduce the amount of body shrink in short haul (250 miles) stocker calves.

Introduction

Each spring a large number of heavy stocker calves that have been grazing winter pasture are shipped to finishing lots. Morbidity and mortality of these stockers is usually low because of their large size, age, previous exposure to virial and bacterial agents and immunization. The greatest loss as a result of shipping is body weight. The objective of this experiment was to determine the amount of shrinkage due to feed and water deprivation and that due to transit. A pre-shipment diet was also evaluated in terms of its ability to reduce shrinkage.

Experimental Procedure

Sixty-four yearling steers that had previously grazed winter wheat pasture for 100 days were assigned to one of three treatment groups. Assignment was based on body weight and breed. Average weight of the steers was 621 lb. Treatments were as follows: 1) "assembled but not transported" (22 of the 64 steers were removed from wheat pasture to the assembly point and housed in an outside pen without feed and water while other cattle were being transported; 2) "assembled and transported" (21 of the 64 steers were assembled with group 1 steers but transported 250 miles); 3) "assembled, fed and transported" (21 steers were assembled and fed on an experimental diet of 32 percent alfalfa pellets, 32 percent cottonseed hulls, 32 percent shelled corn and 4 percent formaldehyde-treated soybean meal, and then transported).

Calves in Treatment Groups 2 and 3 were transported 250 miles on a single deck livestock trailer. Departure and arrival points were both at the location of Treatment Group 1. Blood samples were collected, and rectal temperature and body weights were determined before and after shipment. After arrival, all groups were placed in a feedlot and fed a finishing ration.

The 64 calves had originated from four cow-calf farms, and these farms served as blocks. Data were analyzed as a randomized block with multiple observations.

Results and Discussion

Calves in Group 3 were allowed 3 hours before shipment to consume the experimental diet, but consumption was low (1.8 lb/head). It is important to note that these calves were not accustomed to eating from a trough. The soybean meal in the experimental ration was treated with 0.5 percent formaldehyde to create a rumen bypass protein. There was no odor of formaldehyde on the ration, and formaldehyde probably did not affect intake.

Weight losses as a result of water and food deprivation amounted to only 2.44 percent of the pre-shipment weight (Table 1). With the additional stress of transportation added to that of fasting, an additional 1.42 percent body weight loss was noted when Groups 1 and 2 were compared. Although consumption was low, the preshipment diet reduced the amount of weight lost during transportation (2.94 percent vs. 3.86 percent). Weight gains after shipping are presented in Table 1. These were

Table 1. Effects of transit and feeding prior to transit

Parameter	Treatment groups[a] 1	2	3
Weight Lost (%)	2.44[b]	3.86[c]	2.94[b]
Weight gain (lb)			
28 days	119.5	122.4	119.2
56 days	210.0	223.1	221.8
Rectal temperature (F)			
Pre-shipment	102.5	102.7	102.5
Post-shipment	102.1[b]	102.9[c]	103.2[c]
Packed cell volume (%)[d]			
Pre-shipment	40.7	41.1	41.9
Post-shipment	43.5	43.3	44.2

[a]Group 1 - assembled, not transported. Group 2 - assembled and transported. Group 3 - assembled, fed and transported.
[bc]Means in the same row with different superscripts are significantly different ($P<.01$).
[d] Amount of red blood cells as percentage of total blood.

calculated using arrival weight and a weight at 28 and 56 days, at which times calves were removed from water for 16 hours. Total weight gains at 28 and 56 days were not affected by any treatment, but calves in Group 3 were slightly heavier than those in Group 2 because they had less weight loss during transit and yet gained an equal amount in the feedlot. As expected, rectal temperatures were not different among the three groups before shipment, but were significantly elevated as the result of shipping 250 miles. Health status was not altered during the 5-hour transportation phase, but the stress of shipping elicited an increase in body temperature. Thus, the normal temperature was 1° F higher in calves that were shipped than in calves subjected to the same period of fasting without being shipped.

Packed cell volume (PCV) shows the amount of red blood cells as a percentage of the total blood. As the body loses water, the percentage of red blood cells or PCV will increase. Average PCV before the transportation phase was 41.2 percent and was not different among the treatment groups. Post-shipment PCV was not significantly affected by treatment but was higher than pre-shipment PCV. These results show that body water losses were the same among treatment groups and were the result of water and feed deprivations. An additional weight loss noted in Group 2 steers must have been either from the body mass or the gut fill. The pre-shipment diet could have reduced total weight losses by preventing the mobilization of body stores. The effect of feeding a pre-shipment diet or of transit on morbidity could not be determined in the study because no animals got sick or died.

Steer Weight Gains on Midland and Hardie Bermudagrass Pastures

G. W. Horn and W. E. McMurphy

Story in Brief

A grazing trial with steers on four bermudagrass varieties (Midland, Hardie, Oklan and SS-16) began in 1977. Winter death loss of Oklan and SS-16 was so severe in 1979 that these two varieties were deemed unsuitable, and tests on them were discon-

tinued. Average daily gain was 1.39 lb for Midland and 1.57 lb for Hardie during a 111-day grazing season starting May 14, 1980.

Stocking rate was adjusted to utilize available forage and totaled 245 and 265 steer days per acre for Midland and Hardie bermudagrass, respectively. This was an average of 2.2 and 2.4 steers per acre for Midland and Hardie, respectively. Total beef production per acre was 351 lb for Midland and 454 lb for Hardie.

These results emphasize the importance of pasture management in maintaining an immature growing forage, combined with steer selection, implanting and parasite control for maximum gain. The vulnerability to drought of this program was also apparent.

Introduction

Bermudagrass has not been promoted as a pasture for stockers. The selection and release of two new bermudagrass varieties, Hardie and Oklan, were based upon laboratory tests for forage quality. The purpose of this study was to compare these grasses with Midland bermudagrass in regard to animal performance. We report herein results of steer grazing trials conducted in 1980, plus a summary of results from 1977, 1978, and 1979.

Experimental Procedure

The trials were conducted at the Agronomy Research Station, Perkins, Oklahoma. Two blocks of pastures, each containing one pasture apiece of the hybrid bermudagrass varieties Midland, Hardie, Oklan and SS-16 (an unreleased experimental strain), were used in a randomized complete block design. The soils were the Dougherty, Konowa and Teller fine sandy loams (Arenic Haplustafs, Ultic Haplustafs and Udic Argiustolls). Soil tests revealed that the pH was 5.7 to 6.5, and soil phosphorus and potassium were very high.

The pastures were sprigged in 1975, and grazing trials began in 1977. Each of the pastures was about three acres and was subdivided with electric fences into three paddocks to facilitate rotational grazing during the grazing trials. The rotational grazing objective was 1-week grazing of the paddocks followed by a 2-week deferment. Thus, throughout most of the bermudagrass growing season, the forage was 2, and never over 3, weeks of age.

In early June of each year, when steers were rotated, each paddock was mowed to remove cool season annuals. The pastures were fertilized with 150 lb of actual nitrogen in three equal applications in early April, late June and early August.

Steers for the 1980 trial were purchased at a livestock auction in March and grazed on small grain with limited forage until the trial began. Average daily gain during this pretrial period was about 0.8 lb. Hereford steers were used in 1980.

All steers (Hereford and Hereford x Angus) for the 1978 and 1979 trials were purchased at a livestock auction in March. The steers were grazed on small-grain pasture with limited forage until the trial began and were in thin condition at the beginning of the trial.

Steers from two sources were used in the 1977 grazing trial. Forty-five were raised on the research station. They had grazed small-grain pasture for 2 months prior to the trial and were in fleshy condition at the beginning of the trial. Fifteen steers were purchased at a livestock auction on May 2; they were in thin condition and were placed directly on bermudagrass. The steers, Hereford and Hereford x Angus, were assigned to treatment groups on the basis of source, breed and weight.

Daily gains were calculated from weight gains of steers that remained in the pastures throughout each grazing trial (tester steers). Average initial weight (mean ± SEM) of all tester steers in 1977 was 518±8.4 lb; in 1978, 520±6.3 lb; in 1979,

486±10.9 lb; and in 1980, 453.5±9.1 lb. Stocking rates on the pastures were adjusted according to the amount of available forage throughout the grazing trials by use of put-and-take steers. For calculation of total steer gain, put-and-take steers were assigned daily gains of tester steers during each period. Steer weights were measured after about a 16-hour overnight shrink without feed or water.

All 1980 steers were implanted with Ralgro at the beginning of each trial. In previous years the steers were implanted with diethylstilbestrol. Injectable Tramisol (levamisole phosphate) was given for internal parasite control on April 10, 1980. Excellent fly control was achieved during each trial by spraying the steers on each weigh date, except July 1 when a pour-on insecticide for grub control was applied, and by keeping dust bags in the pastures. Steers in all pastures had access to trees or constructed shades. A commercial mineral supplement that contained 12 percent calcium and 12 percent phosphorus was fed free-choice during the trials.

The data were examined by analysis of variance. Where F values were significant ($P<.05$), the differences between Midland and Hardie bermudagrasses were marked by the * in Table 2.

Results and Discussion

Rainfall recorded at the station during the first 9 months of each year is compared with the long-term average in Table 1. This 9-month total has varied from 73 to 106 percent of the long-term average. The driest season was in 1978, and the greatest total precipitation was in 1980 although distribution of rainfall in 1980 was very poor. Precipitation was above normal until June 20, 1980, after which the temperatures were extremely hot and precipitation very scarce. By July 21, 1980, the growth rate of the bermudagrass was reduced to the extent that rotation grazing was discontinued, and the study was terminated early on September 2 because regrowth was very slow.

Details of the results for 1977 through 1979 seasons were published by Horn and McMurphy (1979, 1980). The winter of 1978-79 was severe enough that Oklan bermudagrass suffered over 90 percent winterkilling. Oklan bermudagrass was dropped from the test. The SS-16 had about 40 percent winterkilling, and it was dropped from the test by mid-1979. Production from it was so low that it should not be considered for northern Oklahoma. The test is now an evaluation of Midland and Hardie bermudagrass, both varieties being quite winterhardy.

Average daily gains (Table 2) were highest in May and lowest in July. The differences between Hardie and Midland have not been statistically significant. The

Table 1. Seasonal precipitation (inches) for Agronomy Research Station, Perkins

Month	1977	1978	1979	1980	Long-term average
January	0.22	0.92	2.11	2.14	1.53
February	1.16	2.63	0.25	0.86	1.46
March	2.50	1.46	3.80	2.39	2.20
April	2.23	1.85	3.42	4.07	3.16
May	8.46	7.28	6.83	7.57	5.09
June	1.90	4.59	3.01	8.78	4.58
July	3.15	0.90	0.42	0.05	3.45
August	2.88	0.53	1.62	1.56	3.19
September	1.77	0.49	1.94	2.88	3.81
Total	24.27	20.65	23.40	30.30	28.47

Table 2. Average daily gains (ADG) of steers, total steer grazing days per acre, and total gain per acre for intervals in 1980 with 3 years of seasonal averages

Grazing interval	Number of days	ADG, lb		Total steer days/acre		Total gain/acre, lb	
		Midland	Hardie	Midland	Hardie	Midland	Hardie
5-14 to 6-3	20	2.43	2.98	88*	188	36	63
6-3 to 7-2	29	1.67	1.64	94	87	156	143
7-2 to 8-1	30	1.62	1.97	56	56	90	109
8-1 to 9-2	32	0.30	0.25	59	59	17	14
1980 Season	111	1.39	1.57	245	265	351	454
1979 Season	147	1.83	1.99	381	406	658*	861
1978 Season	114	1.82	1.84	242*	259	419	487
1977 Season	153	145	1.73	281	313	416*	552

*Indicates a significant difference (P = 0.05) between Midland and Hardie.

1980 season average daily gains were 1.39 lb for Midland and 1.57 lb for Hardie. These were the lowest seasonal gains in the 4-year study, and a contributing factor was probably the lack of forage in August. July was a very hot month; grass regrowth was occurring early in July, and steer gains were good that month. The average daily gains are a product of environment plus good animal and pasture management practices. The animal management includes selection of good steers, implantation with growth hormones, excellent internal and external parasite control, shade and mineral supplement. Pasture practices of nitrogen fertilization, proper stocking rates and rotation to provide young forage between 2 and 3 weeks of age are also factors favorable to good steer gains.

Stocking rates are expressed as steer days per acre. Dividing steer days per acre by the number of days in that interval gives a quotient of steers/acre for that interval. Thus, Midland bermudagrass for the entire 1980 season had an average stocking rate of 2.2 steers per acre (245/111). Producers do not have the option to adjust stocking rates as freely as in our research. The only way most producers can use this program and keep the available forage young will be with rotation grazing and hay removal at peak growth periods. Therefore, the lowest stocking rate at any grazing interval becomes an important value to a producer. A producer must not run out of forage. For both varieties the lowest stocking rate was in August with 1.8 steers per acre. The Hardie bermudagrass has been consistent every year in providing about twice as much forage (measured in steer days per acre) in May.

Total gain per acre was 454 lb of beef for Hardie and 351 lb of beef for Midland. These results are much lower than the previous year. While the nitrogen fertilization rate each year has been the same (150 lb of actual nitrogen per acre each year), the late summer drought in both 1978 and 1980 made the August application of 50 lb of nitrogen per acre ineffective. The 1979 season results may well reflect residual nitrogen from the previous year.

These results reveal excellent average daily gains in some years. The results emphasize the importance of a complete program for both steer and pasture management to provide and maintain high quality young forage to steers capable of producing. There will be great fluctuations in total forage production from year to year as measured in steer days per acre. However, the minimum stocking rate of about 1.8

steers per acre appears to be consistent with hay removal at peak growth periods. The August average daily gains reveal the vulnerability of the program to excessive heat and drought with no appreciable bermudagrass regrowth available.

Literature Cited

Horn, G. W., and W. E. McMurphy. 1979. Okla. Agr. Exp. Sta. Res. Rep. MP-104:104.

Horn, G. W., and W. E. McMurphy. 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:89.

Relationship of Steer Daily Gains on Bermudagrass to Rate of Forage Digestion

M. Cannon, R. L. Hintz, G.W. Horn and W. E. McMurphy

Story in Brief

Relationships of daily gain of steers grazed on bermudagrass and extent and rate of forage dry matter (DM) digestion were examined. Steer gain data were from grazing trials on Midland, Hardie, Oklan and SS-16 bermudagrass pastures during 1977 and 1978. Rate of digestion and digestibility accounted for a small part of the variation in average daily gain. After variety, month and year were considered, relationships between rate of digestion, digestibility and average daily gain were small and of little value in predicting daily gains of steers on bermudagrass.

Introduction

Identification of indices of forage quality which would be useful in predicting animal performance has been a long-standing research goal. Early studies indicated that forage intake was more closely related to extent of digestion at early time periods (i.e., 6 to 12 hours) of *in vitro* incubation than longer time periods. The objective of this study was to obtain data relative to the relationship between daily gain of steers grazed on bermudagrass and extent and rate of forage dry matter (DM) digestion.

Experimental Procedure

The steer gain data obtained during grazing trials on Midland, Hardie, Oklan and SS-16 (an unreleased experimental strain) bermudagrass pastures during 1977 and 1978 were used. The pastures, consisting of two blocks of the four bermudagrass varieties, are located at the Agronomy Research Station (Perkins, Oklahoma). Details of cattle and pasture management and results of the trials have been previously reported (Horn and McMurphy, 1979).

Hand-clipped forage samples were taken at about monthly intervals from each pasture during the 1977 and 1978 grazing trials. Each sample consisted of clippings from 14 locations within each pasture of about 3 acres. The forage samples were dried, ground, and placed in the rumen of three ruminally cannulated steers for periods of 6, 12, 24, 48, and 72 hours. Forage dry matter digestibility (percent) was calculated from dry matter losses during the ruminal incubations.

The rate of digestion was examined by two methods. The first method was to calculate the regression coefficient (slope) of the log of digestibility on time for each year, month and pasture subclass. The rate of digestion from 6 to 72 hours was estimated as the regression coefficient (slope) of the log of digestibility on time. The second method was to estimate the parameters A and k of the nonlinear function, $Y = A(1-e^{-kt})$, for each year, month and pasture subclass. In the nonlinear function, Y is the observed digestibility at time t. The rate of digestion at time t was estimated as the value of the first derivative of the nonlinear function (slope of the curve) at time t. Correlations between average daily gain and observed digestibility, rate of digestion from 6 to 72 hours (method 1), and rate of digestion at time t (method 2) were calculated.

Results and Discussion

Variety, month, year and variety by year interaction influenced ($P<.05$) the rate of digestion from 6 to 72 hours and therefore were included in the model. The partial correlation (.045) between the rate of digestion from 6 to 72 hours and average daily gain was small and not significantly different ($P>.8$) from zero.

The rate of digestion at time t was affected ($P<.05$) by variety, year, month and all interactions. However, the objective of this report was to investigate the possibility of using the observed digestibility or rate of digestion to predict average daily gain. Therefore, partial correlations between average daily gain and observed digestibility and rate of digestion at time t were calculated (Table 1). All partial correlations were small and not significantly ($P>.05$) different from zero. A reason for the low correlations may be that variety, month and year explained the majority of the variation (i.e., 92-98 percent) in observed digestibility and rate of digestion at time t (Table 2). Variety, month and year explained 81 and 86 percent of the variation in average daily gain and rate of digestion from 6 to 72 hours, respectively. The amount of variation in average daily gain explained by rate of digestion from 6 to 72 hours, rate of digestion at time t or observed digestibility along with variety, month and year was 81 percent

Table 1. Partial correlation coefficients[a,b]

Correlation of average daily gain with	Time period				
	6 hr	12 hr	24 hr	48 hr	72 hr
Observed digestibility	−.11	−.15	−.02	−.31	−.01
Rate of digestion at time t	−.19	−.17	.004	.09	.14

[a]Variety, month, year and all interactions were included in the model for average daily gain, observed digestibility and rate of digestion at time t.
[b]None of the correlations were significantly ($P > .05$) different from zero.

Table 2. Percent of variation in observed digestibility and rate of digestion at time t explained by variety, month and year

Trait	Time period				
	6 hr	12 hr	24 hr	48 hr	72 hr
Observed digestibility	94	98	96	96	97
Rate of digestion at time t	98	97	92	93	93

except with observed digestibility at 48 hours (82.5 percent). Therefore, rate of digestion from 6 to 72 hours, rate of digestion at time t or observed digestibility explains very little of the variation in average daily gain after month, variety and year are considered. Whether or not rate of digestion from 6 to 72 hours, rate of digestion at time t, or observed digestibility are included with variety, month and year in the model to predict average daily gain, the standard error on the overall mean daily gain (1.78 lb) ranged from .043 to .045 lb.

Correlations, not adjusted for variety, year and month (simple correlations), between observed digestibility and rate of digestion at time t and average daily gain were also calculated (Table 3). Simple correlations between observed digestibility and average daily gain indicate that as digestibility increases, average daily gain tends to increase. Simple correlations between rate of digestion at time t and average daily gain were very small at 24, 48 and 72 hours. The simple correlation (-.003) between average daily gain and rate of digestion from 6 to 72 hours was small and not significantly different from zero. Rate of digestion from 6 to 72 hours alone explained none of the variation (0 percent) in average daily gain. Observed digestibility or rate of digestion at 6 or 12 hours alone explained between 14 and 36 percent (Table 4) of the variation in average daily gain while rate of digestion at 24, 48 or 72 hours explains very little (0 to 3 percent). Therefore, rate of digestion from 6 to 72 hours, rate of digestion at time t or observed digestibility does not account for much of the variation in average daily gain. Using rate of digestion from 6 to 72 hours to predict average daily gain gives a standard error of .07 lb. If observed digestibility at time t is used to predict average daily gain, the standard error of the overall mean daily gain (1.78 lb) ranges from .058 to .067 lb. Rate of digestion at time t predicts average daily gain with a standard error ranging from .06 at 6 or 12 hours to .07 at 24, 48 or 72 hours. The standard error of the mean of 64 average daily gains (1.78 lb) was .071 lb (standard error calculated from the raw average daily gain data without taking into account any sources of variation).

Based on these data, digestibility or rate of digestion does not account for much of the variation in average daily gain whether or not variety, year and month are considered. Therefore, rate of digestion at time t, rate of digestion from 6 to 72 hours or

Table 3. Simple correlation coefficients[a]

Correlation of average daily gain with	Time period				
	6 hr	12 hr	24 hr	48 hr	72 hr
Observed digestibility	.37[b]	.50[b]	.57[b]	.52[b]	.60[b]
Rate of digestion at time t	.57[b]	.50[b]	−.03	−.17	−.13

[a]Simple correlation between average daily gain and rate of digestion from 6 to 72 hours (method 1) was −.003 (not significantly different from zero).
[b]Significantly different from zero ($P < .05$).

Table 4. Percent of variation in average daily gain explained by observed digestibility or rate of digestion at time t

Source of variation	Time period				
	6 hr	12 hr	24 hr	48 hr	72 hr
Observed digestibility	14	25	32	27	36
Rate of digestion at time t	32	25	0	3	2

observed digestibility does not appear useful in prediciting average daily gain. However, year and month accounted for a major proportion of the variation, and only 2 years were represented in these data. Therefore, further replications are needed to obtain more precise estimates of the relationship between rate of digestion, digestibility and average daily gain.

Literature Cited

Horn, G.W., *et al.*1979. Okla. State Univ. Ag. Exp. Sta. Res. Rep. MP-104:104.

Effects of Reimplantation for Grazing Calves

S. R. Rust, D. R. Gill and C. W. Nichols

Story in Brief

One hundred ten steer and heifer calves were used to study the effects of Ralgro[1] implants on calves grazing native pastures. Administration of Ralgro implants increased weight gains 31 lb over a 449-day grazing period. This improved performance yielded $22.40 more profit per calf. Equal responses were noted for calves reimplanted at 90- and 180-day intervals. In yearlings, response to an implant was equal for calves implanted for the first time and calves which had received implants previously. Ralgro implants appeared most beneficial when pastures supported rapid growth.

Introduction

High interest rates, combined with increasing fertilizer and land costs have reduced the profit margins of cattle-growing operations. The use of growth-stimulating implants is one method which may be used to increase rate of gain and total profits. Ralgro implants have been shown to increase gains in pasture cattle in many trials. However, the effect of frequency and number of implants has not been thoroughly studied. The purpose of this study was to determine the weight gain response of beef calves to Ralgro implants over a period of approximately 15 months.

Materials and Methods

A total of 110 crossbred (½ Charolais, ¼ Angus and ¼ Hereford) calves (200 lb) were used in three different sequences of implantation with Ralgro.

Steer and heifer calves were randomly allotted between treatments. Calves were nursing and later grazing two different pasture types. Pasture one has deep sand and is primarily tall grass species. Pasture two has predominantly red clay soil with short grass species. Calves were born between January 1 and April 1, 1978.

The three sequences of Ralgro implantation are presented in Table 1. One set of calves was not implanted until 1 year of age. Calves on Treatments 2 and 3 received their first implants in April of 1978 when the calves were branded, dehorned and castrated. Treatment 2 calves received subsequent implants at 180-day intervals while calves in Treatment 3 were reimplanted with Ralgro approximately every 90 days. The

[1]IMC Chemical Group, Inc., Terre Haute, Indiana.
[2]Davison and Sons Cattle Company, Arnett, Oklahoma.

Table 1. Treatment schedule

Date	Days	Treatment 1	2	3
April, 1978	0	—	Implant	Implant
July, 1978	90	—	—	Implant
October, 1978	167	—	Implant	Implant
January, 1979	266	—	—	Implant
April, 1979	371	Implant	Implant	Implant

fall implantation was given at the time of weaning. The summer and winter implants in Treatment 3 were inserted at times when the cattle are not normally worked on this ranch[2]. The following spring (April, 1979) all three treatment groups were implanted with Ralgro. All calves were weighed at approximately 90-day intervals.

Results and Discussion

Weight of the calves at the end of each 90-day period is shown in Table 2. The comparison of weight gained over 371 days indicated that reimplantation at 90 or 180 days increased weight gain by an average of 31 pounds. If one assumes this gain is worth $75 per hundred weight, Ralgro increased the value of the calf by $23, which more than covers the 60-cent cost of the implant. A 26-pound advantage after 449 days was evident for calves implanted every 90 or 180 days as compared to calves given a single implant as yearlings in Treatment 1. This suggests that growth stimulants are beneficial for young calves and that the early gain advantage for Ralgro is maintained throughout the grazing period even with later implantation. Steers gained 53 pounds more than heifers in this trial. Though not significantly different, the gain response to Ralgro the first 371 days appeared greater with heifers (10 percent) than with steers (6 percent). Repeated use of Ralgro for replacement heifers may reduce subsequent breeding performance (Muncy, 1979).

Ralgro implantation increased gain of 200-pound calves by 7 percent during the first 90 days (Table 3). Reimplantation after 90 days continued to increase gains as compared to cattle without implants. However, cattle which were implanted the first 90

Table 2. Effects of reimplantation with Ralgro on weight by periods

Item	Treatment 1	2	3	Pasture 1	2	Sex[a] H	S
Cattle no.	39	35	36	56	54	54	56
Weight, lb							
Initial	217	221	217	233	205	215	223
90 days	429	448	444	453	426	435	445
167days	540	563	570	576	538	545^{b}	569^{c}
266 days	574^{b}	601^{c}	607^{d}	617	569	581^{b}	605^{c}
371 days	603^{b}	636^{c}	635^{c}	647	600	613^{b}	635^{c}
449 days	805^{e}	834^{f}	832^{f}	848	797	791^{b}	853^{c}
Weight gained to 371 days	385^{b}	415^{c}	417^{c}	414	395	398^{e}	412^{f}
Total weight gained, 449 days	587^{b}	613^{c}	614^{c}	616	592	577^{b}	630^{c}

[a]H = Heifer, S = Steer.
[bcd]Means in a row within a heading with different superscripts differ statistically ($P<.05$).
[ef]Means in a row within a heading with different superscripts differ statistically ($P<.10$).

Table 3. Effect of reimplantation with Ralgro on daily gain within periods

	Treatment			Pasture		Sex[a]	
Item	1	2	3	1	2	H	S
Cattle no.	39	35	36	56	54	54	56
ADG by period							
90 days	2.35[b]	2.52[c]	2.51[c]	2.45	2.46	2.45	2.45
77 days	1.44[b]	1.50[c]	1.64[d]	1.59[f]	1.46[e]	1.43[e]	1.62[f]
99 days	.33	.39	.37	.42[c]	.30[b]	.37	.36
105 days	.28	.33	.26	.28	.30	.30[b]	.28
78 days	2.58	2.55	2.52	2.58	2.52	2.29	2.80
Overall ADG	1.31[b]	1.37[c]	1.37[c]	1.37[f]	1.32[e]	1.28[g]	1.40[h]

[a]H = Heifers, S = Steers.
[bcd]Means in a row within a heading with different superscripts differ statistically (P<.01).
[ef]Means in a row within a heading with different superscripts differ statistically (P<.05).
[gh]Means in a row within a heading with different superscripts differ statistically (P<.10).

days but not reimplanted continued to outgain the non-implanted cattle. This suggests that the effective life of the Ralgro implant may exceed 90 days. A 4.6 percent advantage in gain was evident for reimplanted cattle over the 449-day trial. Calves which received an implant first as yearlings (371 days) gained weight the next 78 days at a rate equal to calves which had received implants earlier during growth. Examination of periods of rapid and slow growth, which reflect forage quality or quantity, indicated that implantation with Ralgro produced little effect on gain during time periods of slower growth. This suggests that an adequate feed supply is essential to obtain an advantage from Ralgro implants.

Literature Cited

Muncy, C.D., *et al.* 1979. Okla. Agr. Exp. Sta. Res. Rep. MP-104:152.

NUTRITION—DAIRY

The Feeding Value of Heated Soybean Meal for Lactating Dairy Cows

J. W. Ward, L. J. Bush and G. D. Adams

Story in Brief

Twenty-four lactating dairy cows were utilized in a feeding trial to evaluate the effects which the amount of heat-treatment of soybean meal (SBM) during processing had on animal performance. Three rations were formulated containing either regular SBM, extra-heat SMB or extra-heat SBM plus urea. Response criteria were feed intake, yield and composition of milk, weight change and concentration of rumen ammonia.

SBM protein accounted for approximately 41 percent of total protein intake by cows fed the regular SBM and 45 percent of the protein in the ration containing extra-heat SBM. Milk yield and composition were similar for cows fed the different rations.

Introduction

The feeding value of soybean meal subjected to different amounts of heating has been investigated in recent years. Previous work at OSU and other universities has demonstrated an increase in milk production during the first 15 weeks of lactation when extensively heated SBM replaced regular SBM. This response was presumed to result from an increase in amino acids at the site of absorption due to greater ruminal by-pass of feed protein. More extensive heating of SBM during processing lowered the solubility of protein and reduced microbial degradation of it in an *in vitro* system. An increase in proportion of the protein digested by enzymes in a second phase of the test nearly offset the decrease in microbial digestion. Assuming the same effect in the digestive system of a cow, the effect of more extensive heating of SBM would be to shift the site of digestion of a portion of the protein to avoid the loss of nitrogen which commonly occurs when a high proportion of feed protein is degraded in the rumen.

The objective of this study was to compare the feeding value of regular SBM with meal heated more extensively during processing with or without the addition of urea.

Materials and Methods

Feeding Trial

Regular SBM, designated PDI-40, and more extensively heated SBM, designated PDI-10, were compared in a feeding trial using lactating dairy cows. The PDI value is a measure of protein solubility used in the feed trade. Three rations containing either regular SBM (PDI-40), extra-heat SBM (PDI-10), or extra-heat SBM with .5 percent urea were compared. The rations were formulated so that energy content, expressed as the net energy for lactation (NE$_l$), was kept constant. The complete rations were calculated to provide 85 percent of the protein specified by the National Research Council (NRC) feeding standard, with the grain mix containing 18 percent protein on a

dry matter basis (Table 1). All three rations consisted of 60 percent grain mix, 28 percent sorghum silage and 12 percent sudangrass hay on a dry basis.

Prior to initiating the study, 24 cows (20 Holsteins, 4 Ayrshires) were adjusted to rations with 60:40 concentrate-to-forage ratio. The cows ranged from 8 to 9 weeks postpartum when started on trial. A switchback design with 4-week periods allowed each cow to be fed the rations in a planned sequence. Only the data collected during the last 3 weeks of each period were used in comparing treatments to minimize carryover effects between periods. Initial feed allowances were based on size of cow, age, and production during the preliminary period; these were reduced by 5 percent at the end of each period. Cows were fed in individual stalls twice daily, and feed weighbacks were recorded daily. Cows were weighed on 3 consecutive days at the end of the preliminary period and at the end of each experimental period.

Representative samples of all feeds used in the trial were analyzed for dry matter and protein. Individual cow milk yields were recorded twice daily, and samples were collected at four consecutive milkings each week for analysis of total solids, milk fat, and protein. Samples of rumen fluid were obtained by stomach tube 2 hours after feeding during the last week of each period to determine the concentration of ammonia.

Results and Discussion

Intake of dry matter by cows was similar in all SBM treatment groups as expected since feed allowances were controlled (Table 2). SBM protein represented approximately 41 percent of the total protein intake of cows fed the regular SBM (PDI-40) and 45 percent of the total protein intake of cows fed the more extensively heated SBM

Table 1. Composition of concentrate mixtures

Item	SBM treatment		
	PDI-40	PDI-10	PDI-10 + urea
	(%, as fed)		
Ingredients			
Corn, ground	79.0	79.0	78.5
Soybean meal	18.5	18.5	18.5
Urea	—	—	.5
Dicalcium phosphate	1.0	1.0	1.0
Limestone	1.0	1.0	1.0
Salt	.5	.5	.5
Calculated protein content	16.4	16.4	17.8

Table 2. Feed intake and milk yield of cows

Item	SBM treatment		
	PDI-40	PDI-10	PDI-10 + urea
Feed intake			
Total DM, lb/day	37.6	37.8	37.5
Total protein, lb/day	5.42	5.35	5.67
SBM protein, % of total	41	45	42
Milk yield			
Milk, lb/day	52.0	51.7	51.6
Fat, %	3.84	3.80	3.85
Protein, %	3.12	3.11	3.09
Milk/feed DM	1.38	1.37	1.37
Rumen ammonia, mg/dl	8.8	8.9	11.8
Weight change, lb/day	-.03	.63	-.01

(PDI-10). SBM protein in the PDI-10-plus-urea ration accounted for approximately 42 percent of the total protein equivalent. In all groups, SBM protein comprised a high enough percentage of the total protein to have an effect on production responses.

It was planned that protein intake by the cows would meet approximately 85 percent of NRC requirements; however, milk yields were lower than anticipated, resulting in higher protein intake than planned, relative to requirements. Protein intake averaged 92 percent of the requirement during the first period of the experiment but was higher, i.e., 98 and 110 percent, during the second and third experimental periods. Decreasing the feed allowances by 5 percent at the start of the second and third 4-week periods was not sufficient to keep protein intake at the desired level because persistency of milk production was less than predicted. Over the entire experiment, protein intake was 99, 98 and 104 percent of NRC requirements for the regular SBM, extra-heat SBM, and extra-heat-plus-urea groups. Since urea was added to the ration for the latter group without replacement of soybean meal (Table 1), its protein equivalent value was included in the calculation of total protein intake by this group.

Yield and composition of milk were similar for cows fed the regular SBM and those fed SBM heated more extensively (Table 2). This result was in contrast to results of a previous experiment in which milk yield of cows fed extensively heated SBM was higher than that of cows fed regular SBM (Bush *et al.*, 1980). One possible explanation for the difference observed in the two experiments is that protein intake of cows in the previous experiment was approximately 94 percent of NRC requirement compared to 98 percent in this trial. During the first period of this trial, where protein intake averaged 92 percent of requirements, milk yield, adjusted by covariance analysis for differences in pre-trial yields, was 58.8, 61.2 and 57.8 lb/day for the regular SBM, extra-heat SBM and extra-heat SBM-plus-urea groups. However, there was sufficient variability within groups that differences among these means cannot be regarded as true effects of the ration treatments.

The extent to which the PDI-10 SBM was heated may have been a factor affecting results of this feeding trial. The solubility of nitrogen in a NaCl solution was 7 percent of total nitrogen in the more extensively heat-treated SBM available for the trial compared to 12 percent for the regular SBM. In a previous trial solubility of nitrogen in heat-treated SBM was substantially lower than that of the regular SBM which may account for different results in the two trials. Solubility of feed proteins in a NaCl solution may not adequately characterize the protein of SBM subjected to different amounts of heating during processing; however, it does appear that SBM may need to be heated more extensively than that which was available for this trial to be of benefit in rations for lactating dairy cows.

Whereas the cows in the PDI-10 group gained some weight, weight changes of cows in the PDI-40 and PDI-10-plus-urea groups were negligible. Although the changes in body weight of the different groups were somewhat different, they were too variable within groups to be of real importance.

A difference in concentration of rumen ammonia was observed (Table 2). Concentrations of rumen ammonia were higher in cows on all the rations than that generally considered ideal for efficient microbial synthesis of protein. Values for cows fed the PDI-10 and PDI-40 rations were very similar. The higher concentration of rumen ammonia observed in cows fed the PDI-10-plus-urea ration could be expected since adequate nitrogen evidently was available for synthesis of microbial protein without the addition of non-protein nitrogen as urea. However, under conditions where protein intake is lower relative to that needed for milk production, addition of urea might be beneficial.

Literature Cited

Bush, L. J. *et al.* 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:96.

NUTRITION—FEEDLOT

Avoparcin, Monensin and Implants For Growing Heifers

F. N. Owens and D. R. Gill

Story in Brief

An experimental feed additive, Avoparcin, was fed to 126 growing heifers (509 lb) for 112 days after cattle were adapted to rations. For comparison, half the heifers were implanted with Ralgro, and the heifers in two pens were fed monensin. Avoparcin fed at 60 g per ton of feed decreased feed intake by 11.5 percent and rate of gain by 6.8 percent (3.26 vs. 3.04 lb/day) for a feed efficiency improvement of 5.1 percent (5.7 vs. 5.4). Similar values for monensin at 30 g per ton of feed were a 4.6 percent decrease in feed intake, a 1.5 percent increase in rate of gain and a 6.0 percent improvement in feed efficiency. Heifers fed Avoparcin tended to be fatter than those fed other rations. Fecal pH tended to be lower and fecal starch higher with Avoparcin feeding. Implanting Ralgro twice during the trial increased both rate and efficiency of gain by 3.1 percent. Effects of Avoparcin and implants on feed efficiency were both positive with the combination increasing feed efficiency by 9 percent.

Introduction

Avoparcin is a new feed additive being widely tested for feedlot cattle. It is not commercially available yet. Similar to monensin, Avoparcin increases propionate concentrations in the rumen and generally improves efficiency of feed use by 6 to 11 percent. Avoparcin also has increased rate of gain in some trials. The objectives of this trial were: 1) to determine if Avoparcin effects were enhanced by a) adding a growth stimulating implant and b) feeding antibiotics to newly arrived cattle and 2) to compare performance and carcass characteristics of heifers fed Avoparcin, monensin or no feed additive.

Materials and Methods

One hundred twenty-six Charolais by black baldy heifers (509 pounds) were trucked from Arnett, Oklahoma, to Stillwater. Upon arrival they received vaccinations for bovine rhinotracheitis, leptospira pomona, bovine virus diarrhea, parainfluenza 3, blackleg and malignant edema. The heifers were randomly assigned to 18 pens and adapted to a high concentrate ration by stepwise removal of cottonseed hulls (Table 1) with rations switched on days 4, 17 and 22 of the starting period. The starting ration for 10 of the pens had 140 g AS-700 added per ton of feed which was decreased to 118 in the two subsequent rations. Heifers in ten of the pens were ear implanted with 36 mg of Ralgro initially and again 84 days later. After 28 days on feed, cattle were weighed, AS-700 removed from the feed and Avoparcin (60 g/ton) or monensin (30 g/ton) added. Cattle were weighed thereafter at monthly intervals, Avoparcin was removed after 112 days and cattle were slaughtered 61 days later. Fecal samples from three or four heifers per pen were obtained after 29 and 111 days of feeding Avoparcin or monensin.

Table 1. Composition of rations

Item	Rations			
	Starting	2	3	Top
Corn, rolled	41.0	53.5	63.5	71.5
Cottonseed hulls	30.0	20.0	12.0	11.0
Alfalfa dehy	15.0	15.0	15.0	8.0
Soybean meal	12.5	10.0	8.0	8.0
Limestone	.75	.75	.75	.75
Dical	.25	.25	.25	.25
Salt	.50	.50	.50	.50
Vitamin A	+	+	+	+
Trace minerals	+	+	+	+
AS–700[a]	+–	+–	+–	0
Additive[b]	0	0	0	+–

[a]To contain 70, 59 and 59 g of aureomycin and similar amounts of sulfamethazine per ton of feed.
[b]To provide 60 g avoparcin or 30 g monensin per ton of feed.

Table 2. Additive and implant effects on heifer performance

	Avoparcin, ppm		Raigro, mg		AS-700		
	0	66	0	36	0	350	
Days	0-112		0-84		-28-0		LSD
Heifers	56	56	56	56	56	56	—
Pens	8	8	8	8	8	8	—
Initial weight, lb	515	512	516	511	516	511	—
Daily gain, lb							
–28–0	—	—	2.99	3.20	3.23	2.96	.38
0–56	3.49[a]	3.17[b]	3.37	3.28	3.35	3.30	.19
56–112	3.02	2.91	2.80[a]	3.13[b]	2.93	3.00	.33
0–112	3.26[a]	3.04[b]	3.09	3.21	3.14	3.15	.17
–28–173	2.97	2.89	2.88	2.97	2.96	2.90	.11
Daily feed, lb DM							
–28–0	—	—	12.7	13.0	12.9	12.9	.83
0–56	17.6[a]	15.6[b]	16.9	16.4	16.7	16.6	1.05
56–112	19.2[a]	17.0[b]	17.9	18.2	18.0	18.1	.87
0–112	18.4[a]	16.3[b]	17.4	17.3	17.3	17.4	.70
–28–173	17.4[a]	16.1[b]	16.8	16.8	16.7	16.8	.62
Feed/gain							
–28–0	—	—	4.32	4.11	4.07	4.37	.46
0–56	5.07	4.93	5.02	4.99	4.98	5.03	.38
56–112	6.41[a]	5.89[b]	6.43	5.88	6.21	6.09	.64
0–112	5.66	5.37	5.64	5.40	5.52	5.51	.34
–28–173	5.88[a]	5.57[b]	5.82[a]	5.64[b]	5.66	5.80	.11
Feces							
1st pH	6.03[a]	6.51[b]	6.18	6.37	6.47[a]	6.07[b]	.28
1st DM, %	24.5	25.4	25.0	25.0	23.6[a]	26.3[b]	2.60
1st starch, %	11.1	14.1	12.9	12.3	11.8	13.4	7.29
2nd pH	5.78	5.73	5.73	5.78	5.79	5.72	.42
2nd DM, %	22.1[a]	24.3[b]	23.1	23.3	22.7	23.6	2.05
2nd starch, %	11.4	14.9	12.8	13.4	11.9	14.3	6.17

[ab]Means in a comparison with different superscripts differ significantly ($P<.05$).

Table 3. Additive and implant effects on carcass characteristics

	Avoparcin, ppm		Ralgro, mg		AS-700		
	0	66	0	36	0	350	
Days:	0-112		0-84		−28−0		LSD
Carcass wt, lb	689	678	679	687	688	678	17
Dressing %	63.8	63.6	63.5	63.9	63.6	63.8	.91
Liver abscesses							
Incidence, %	7.4	0	5.7	1.8	2.1	5.4	10.4
Severity[a]	.16	0	.11	.54	.02	.14	.24
Rib eye area							
Sq. inches	12.9	13.1	12.8	13.2	13.0	12.9	.68
in^2/cwt	1.89	1.94	1.89	1.93	1.91	1.92	.10
Fat thickness, in	.51	.54	.51	.54	.55	.51	.07
KHP, %	2.96	2.90	3.02	2.85	3.00	2.87	.33
Marbling[b]	16.0[f]	13.8[e]	15.5	14.3	15.4	14.4	1.34
Quality grade[c]	13.7[e]	12.9[f]	13.5[e]	13.1[f]	13.5	13.1	.45
Yield grade[d]	3.43[e]	3.57[f]	3.42[e]	3.57[f]	3.57[e]	3.43[f]	.14
Cutability	50.2	50.3	50.2	50.3	50.0	50.4	.95

[a]Single abscess = 1; severe abscess = 3.
[b]Small minus = 13; small = 14.
[c]Choice minus = 13; choice = 14.
[d]Federal yield grade.
[ef]Means in a comparison with different superscripts differ significantly (P<.05).

Table 4. Avoparcin and Ralgro for feedlot heifers

Avoparcin, g/ton Implant	0 0	0 Ralgro	60 0	60 Ralgro	interaction probability
Heifers	28	28	28	28	—
Pens	4	4	4	4	—
Daily gain, lb					
0−112	3.20	3.31	2.97	3.10	.92
−28−173	2.91	3.03	2.86	2.92	.11
Feed/gain					
0−112	5.86	5.47	5.41	5.33	.34
−28−173	5.99	5.77	5.64	5.50	.51

The design was a 2^3 factorial with all combinations of AS-700 in the receiving ration, Avoparcin in the top ration and Ralgro implants. In addition to the 16 pens (duplicate pens on each combination), two pens of heifers which had been fed AS-700 and implanted with Ralgro were fed 30 g of monensin per ton of feed. Data were analyzed as a 2^3 factorial for AS-700, implant and Avoparcin effects. For contrast of Avoparcin with monensin, only heifers fed AS-700 and implanted were compared.

Heifers had feed available *ad libitum* from self feeders. In order to calculate feed efficiency, feed was removed and weighed when rations were changed and when steers were weighed. All calculations are for feed dry matter. Cattle were weighed shrunk initially and before slaughter and full otherwise. Final weights were calculated from carcass weight based on dressing percentage of 62.

Results and Discussion

Effects of Avoparcin feeding on performance are presented in Table 2. During the 112 days of Avoparcin feeding, cattle fed this compound consumed 11.5 percent less feed and gained 6.8 percent less weight, but efficiency of feed use was improved by 5.1 percent. Fecal samples obtained 29 days after the start of Avoparcin feeding revealed that feces from cattle fed Avoparcin had a higher pH than feces from control cattle. In a

Table 5. Feed additive comparison: performance

	Control	Avoparcin	Monensin	LSD
Heifers	14	14	14	
Pens	2	2	2	
Weights				
Initial	506	509	511	
Final	1083	1051	1103	
Carcass	693	675	709	83.0
Daily gain, lb				
–27–0	2.97	2.94	2.94	.66
0–56	3.28	3.25	3.55	1.41
56–112	3.30	3.12	3.13	0.60
0–112	3.29	3.18	3.34	1.01
–28–173	3.05	2.88	3.15	0.57
Daily feed, lb DM				
0–56	17.09	15.59	16.75	5.10
56–112	18.97	17.43	17.68	3.09
0–112	18.03	16.51	17.21	3.72
–28–173	17.69	16.04	17.02	2.87
Feed/gain				
0–56	5.24	4.80	4.75	1.54
56–112	5.76	5.59	5.64	0.32
0–112	5.49	5.19	5.16	0.90
–28–173	5.81	5.56	5.40	0.16
NE_g 0–112	68.8	72.5	73.5	9.95
–28–173	71.3[a]	73.7[ab]	76.2[b]	4.30

[ab]Means in a row with different superscripts differ significantly (P<.05).

Table 6. Feed additive comparison: carcass and fecal characteristics

	Control	Avoparcin	Monensin	LSD
Carcass weight, lb	693	675	709	83.01
Dressing %	64.0	64.3	64.3	2.86
KHP, %	2.71	2.82	3.18	0.66
Fat thickness, in.	.50	.56	.48	0.30
Abscesses				
Incidence, %	7.1	0	7.1	26
Severity[a]	.21	0	.21	0.79
Marbling[b]	14.2	12.9	14.2	2.74
Ribeye, in^2	13.0	13.3	13.5	0.59
in^2/cwt	1.89	1.97	1.91	0.26
Cutability	50.34	50.31	50.49	2.73
Grade[c]	13.07	12.64	13.14	1.14
Choice, %	78.6	71.4	100	41.5
Yield grade[d]	3.36	3.69	3.48	0.70
% YG 4 & 5	0[e]	28.6[f]	7.1[ef]	18.5
Feces analysis				
1st pH	6.20	6.09	6.56	2.63
1st Dry matter, %	26.6	26.1	24.7	7.4
1st Starch, %	9.1	20.7	13.6	13.6
2nd pH	5.92	5.68	6.04	1.20
2nd Dry matter, %	24.2	24.4	23.3	11.4
2nd Starch, %	12.4	18.6	13.6	23.7

For footnotes see table 3.

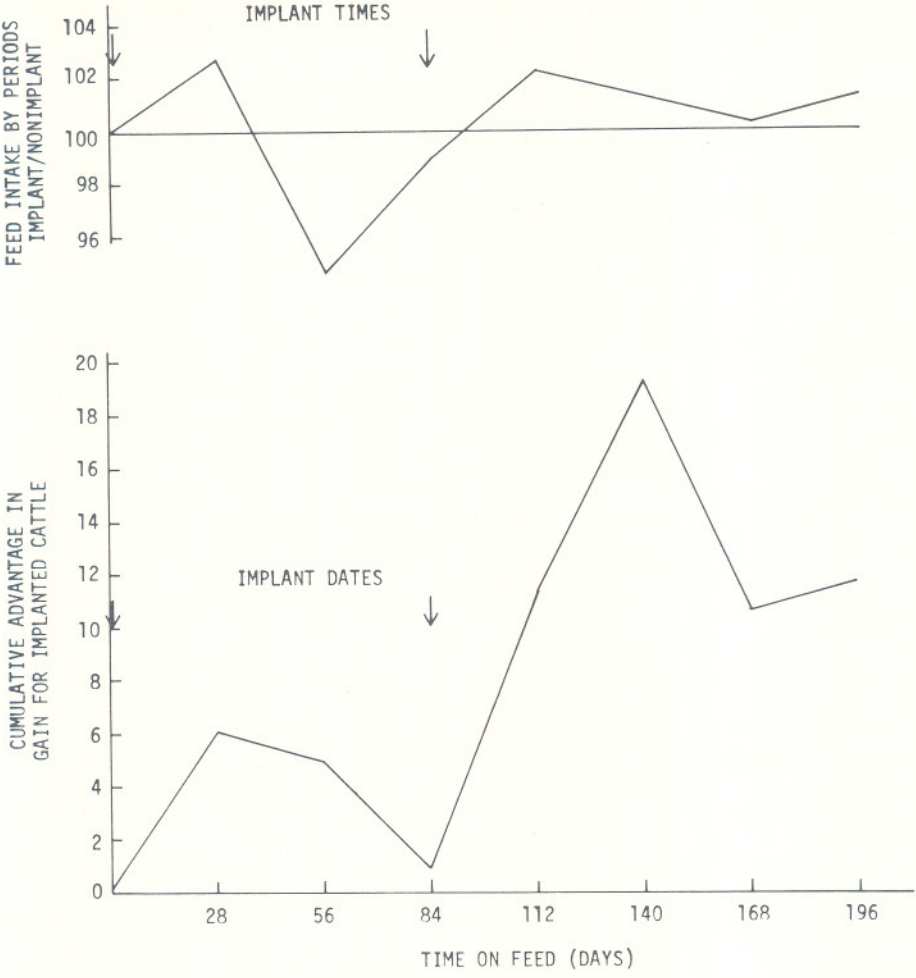


Figure 1. Ralgro and gains and feed intake

sample obtained later as well, Avoparcin-fed cattle tended to have more starch in feces. Slaughter data (Table 3) collected 61 days after withdrawl of Avoparcin indicated that cattle fed Avoparcin had less marbling and lower carcass grade than control cattle.

Effects of Ralgro implants on performance are presented in Table 2. Implants increased overall weight gain by 3.1 percent without altering feed intake for a feed efficiency improvement of 3.1 percent. Subdividing effects by periods (Figure 1) illustrates that feed intakes of implanted cattle were increased during the first month after implanting but that feed intake and weight advantages deteriorated with time after implantation. Only during periods of higher feed intakes did implanted cattle gain more than those not implanted. The tendency for greater response to the second than to the first implant may be due to sensitization of the cattle from the first implant or greater metabolic effect of implants with cattle having greater maturity or finish. Had a

second implant not been given, little if any advantage from the first implant would be expected. Implanted heifers tended to have less marbling and a lower grade than non-implanted heifers (Table 3).

Feeding AS-700 for the first 28 days had no influence on performance, feed intake, feed efficiency or carcass characteristics. However, feces obtained from heifers three weeks after withdrawl of AS-700 were lower in pH (6.05 vs. 6.47) and contained less moisture (74 vs. 76 percent). Percent of fecal starch was unchanged. Two months later,

Table 7. Avoparcin - implant interactions

Avoparcin, g/ton Implant, mg/heifer	0 0	60 0	0 +	60 +	LSD
Heifers	56	56	56	56	
Pens	4	4	4	4	
Initial weight, lb	518	515	511	510	
Daily gain,					
0–56	3.67[f]	3.08[e]	3.31[e]	3.26[e]	.322
56–112	2.73	2.87	3.32	2.94	.558
0–112	3.20[ef]	2.97[e]	3.31[f]	3.10[ef]	.290
–28–173	2.91	2.86	3.03	2.92	.187
Daily feed					
0–56	18.15[f]	15.64[e]	17.12[ef]	15.60[e]	1.80
56–112	19.26[f]	16.56[e]	19.07[f]	17.36[e]	1.49
0–112	18.70[f]	16.10[e]	18.10[f]	16.48[e]	1.20
–28–173	17.40[f]	16.12[e]	17.48[f]	16.08[e]	1.06
Feed/gain					
0–56	4.96	5.08	5.19	4.78	.65
56–112	7.07[f]	5.78[e]	5.76[e]	5.99[e]	1.10
0–112	5.86	5.41	5.47	5.33	.59
–28–173	5.99[g]	5.64[ef]	5.78[f]	5.50[e]	.19
Carcass weight, lb	683	675	694	681	28.5
KHP, %	3.09	2.95	2.84	2.86	.56
Fat thickness, in	.49	.52	.53	.56	.12
Abscesses					
Incidence	11.3	0	3.6	0	17.7
Severity[a]	.22	0	.107	0	.41
Marbling[b]	16.7[f]	14.3[e]	15.3[ef]	13.3[e]	2.29
Rib eye area, in^2	12.72	12.87	13.12	13.27	1.16
Cutability, %	50.11	50.21	50.23	50.28	1.61
Quality grade[c]	13.95[f]	13.13[e]	13.43[ef]	12.75[e]	.77
Percent choice	100.0[f]	76.8[ef]	85.7[ef]	67.9[e]	31.6
Yield grade[d]	3.37[e]	3.48[ef]	3.49[ef]	3.66[f]	.24
4 & 5, %	7.7	3.6	17.9	25.0	25.7
Dressing, %	63.8	63.2	63.8	64.0	1.5
Fecal analysis					
1st pH	5.87[e]	6.48[f]	6.18[ef]	6.52[f]	.51
1st DM	24.1	25.9	24.6	25.3	4.5
1st starch					
2nd pH	5.70	5.77	5.87	5.70	.71
2nd DM	21.7	24.4	22.4	24.2	3.5
2nd starch	11.7	14.0	11.0	15.8	10.5
NE_m –28–173	110[e]	118[fg]	115[ef]	122[g]	6.2
NE_g –28–173	70[e]	73[f]	72[ef]	74[f]	2.4

For footnotes see table 3.

no differences in composition of feces were observed. Results suggest that antibiotic feeding may alter site of digestion or acid production by microorganisms in the large intestine.

The effects upon cattle performance of Avoparcin, Ralgro and their combination is shown in Table 4. A report from Nebraska suggests that Avoparcin is more effective when cattle are implanted. The two materials produced additive effects on rate of gain and feed efficiency in our trial. Comparison of Avoparcin (60 g per ton) with monensin (30 g per ton) in this trial is presented in Table 5. Most previous trials have demonstrated that Avoparcin depresses feed intake less than does monensin when added to a ration and thereby increases rate of gain. In this study, feed intake was depressed more with Avoparcin than monensin. Also, gains of heifers fed Avoparcin were 3.3 percent less than control cattle while with monensin, gains were 1.5 percent above that of control cattle. Feed efficiencies for the 112 days of Avoparcin feeding were improved by 5.5 and 6.0 percent with the two compounds. Avoparcin tended to reduce fecal pH and increase fecal starch whereas monensin had opposite effects. Carcasses of cattle fed Avoparcin tended to be fatter and have a higher fat cover and yield grade than other cattle (Table 6).

Results of four earlier trials in various states with feedlot heifers fed Avoparcin have shown increased rates of gain (3.7 percent) and an improvement in feed efficiency (7.2 percent) with Avoparcin at 60 g per ton. Why gains and feed intakes were depressed during feeding and after Avoparcin withdrawl for cattle fed Avoparcin in this trial is unclear, but improvements in efficiency of feed use indicate that Avoparcin will be a useful, effective feed additive which will act equally well with or without an anabolic implant.

Thiopeptin or High Roughage in Starting Rations for Feedlot Steers

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Story in Brief

Thiopeptin was fed at 0 or 11 ppm to two groups of 560-pound growing steers not adapted to a high concentrate ration, and a third group of steers was started on a ration diluted with roughage (40 percent cottonseed hulls for 10 days followed by 20 percent cottonseed hulls for 10 days). Six pens of seven steers were fed each of the three rations. Over the first 28 days, gains were 14 percent greater and feed efficiency was 10 percent improved ($P<.05$) by thiopeptin addition to the 90-percent concentrate ration. Thiopeptin was removed from the ration on day 28. The advantage of 16 pounds for cattle fed thiopeptin at 28 days increased to 32 pounds by day 160. Over the 160-day feeding trial, thiopeptin improved ($P<.05$) gain and feed efficiency by 7 and 6 percent respectively. Carcass characteristics were unchanged with thiopeptin feeding. Performance and carcass characteristics of the steers started on the roughage ration and those fed the high concentrate ration with added thiopeptin were similar.

Introduction

Thiopeptin (Merck product MK-747) is a narrow spectrum antibiotic (Muir and Barreto, 1979) which decreases acidosis in sheep (Kezar and Church, 1979) and cattle (Mies *et al.*, 1978) and may increase rate of gain in cattle (Gill *et al.*, 1979). Previous

trials had fed thiopeptin at 11 ppm throughout the feeding trial. Since the acidosis is generally most prevalent during the first several weeks of a feeding trial, thiopeptin was fed for only the first 28 days in this trial. For comparison with these steers abruptly started on a high concentrate ration, another set of steers was gradually adapted to the high concentrate ration by stepwise reduction of roughage concentration in the ration. The objectives of this experiment were to determine the effect of supplemental thiopeptin on feedlot health, performance and carcass characteristics of growing-finishing steers.

Materials and Methods

One hundred twenty-six steer calves (560 lb) were stratified by breed (Hereford, Angus, Hereford by Angus cross) and blocked by weight into 6 blocks. Treatments were randomly assigned within each block of three pens to one pen of seven animals. Steers received thiabendazole paste as well as vaccination for bovine rhinotracheitis, leptospira pomona, bovine virus diarrhea, parainfluenza 3, blackleg and malignant edema following arrival by truck from Kansas. Cattle received no estrogenic implants. Steers had been fed a high roughage pelleted ration for several weeks prior to shipment.

Ration compositions are presented in Table 1. Cattle hereafter designated as "control" were fed the ration with 10 percent cottonseed hulls following processing until slaughter. The "thiopeptin" cattle received the 10 percent cottonseed hull ration with 11 ppm added thiopeptin from the time of processing for the first 28 days and the 10 percent cottonseed hull ration without thiopeptin thereafter (day 29 to slaughter). The "standard" cattle were fed the 40 percent cottonseed hull ration for 10 days, the 20 percent cottonseed hull ration for the subsequent 10 days and the 10 percent cottonseed hull ration from day 21 until slaughter. Feed was available *ad libitum* through self-feeders. Feed was removed from feeders and weighed when rations were changed and when cattle were weighed. Cattle were weighed individually on arrival in December of 1979 and 28, 84, 112 and 159 days later. For the first 28 days, steers were appraised for health status (nasal discharge, diarrhea, incoordination, bloat, gaunt appearance), and the incidence of sick days was tabulated. Cattle were trucked to Booker, Texas, and slaughtered after 160 days on feed. At that time liver abscesses were scored and carcass

Table 1. Ration composition

Item	Roughage level, %		
	40	20	10[a]
	----------	%	----------
Corn grain, steam rolled	9.25	47.25	72.25
Cottonseed hulls	40	20	10
Alfalfa meal, dehydrated	40	20	4
Soybean meal	5	7	7.5
Molasses, cane	5	5	5
Calcium carbonate	0	.50	1.00
Salt	.25	.25	.25
Vitamin A[b]	+	+	+
Trace mineral mix	+	+	+
Metabolizable energy, Kcal/g	2.27	2.76	3.06

[a]With or without 11 ppm thiopeptin added for days 0 to 28.

[b]To contain 33,200 IU per kg of ration.

characteristics recorded. Final weight was calculated from hot carcass weight and a mean dressing percentage of 62.

Results and Discussion

Daily gains of cattle fed thiopeptin the first 28 days of the trial exceeded ($P<.05$) those of control cattle fed the high concentrate ration by 16 pounds (Table 2). This difference increased to 36 pounds over the subsequent 128 days. Standard cattle brought onto feed gradually had rates of gain virtually equal to the cattle fed thiopeptin. Feed intake was greatest for cattle brought onto feed gradually, especially during the first 28 days when extra roughage was present in the ration ($P<.05$). The amount of non-roughage feed consumed by these cattle, however, was least ($P<.05$) for this group. Feed efficiencies tended to favor the cattle fed thiopeptin during all intervals of the trial with superiority over control and standard workup cattle of 6.5 and 1.8 percent respectively.

Table 2. Cattle performance with thiopeptin

Item	Control	Thiopeptin	Regular	LSD
Pens	6	6	6	
Steers	42	42	42	
Weight, lb				
Initial	560	559	562	2.4
28 day	672	687	692	
159 day[a]	1011	1043	1050	
160 day[b]	1004[a]	1039[b]	1038[b]	21.1
Daily gain, lb				
0-28	3.98[a]	4.54[b]	4.66[b]	.404
28-159[d]	2.78[a]	2.92[b]	2.93[b]	.086
0-159[d]	2.81[a]	3.02[b]	3.05[b]	.106
0-160[e]	2.78[a]	3.00[b]	2.97[b]	.124
Feed intake, lb DM/day				
0-28	15.5[a]	15.8[a]	19.1[b]	1.28
0-28 (conc)[f]	15.5[b]	15.8[b]	12.7[a]	1.29
28-159	18.9	19.1	19.3	.78
0-159	18.3[a]	18.5[a]	19.2[b]	.72
0-159 (conc)	18.3	18.5	18.1	.74
Ration ME (calc)	3.06	3.06	2.99	
Feed/gain				
0-28	3.89[b]	3.48[a]	4.10[b]	.25
0-28 (conc)	3.89[c]	3.48[b]	2.73[a]	.21
28-159	6.80	6.53	6.59	.31
0-159[a]	6.50[b]	6.12[a]	6.31[ab]	.26
0-160[b]	6.59[b]	6.16[a]	6.47[b]	.23
Determined ME	2.94[a]	3.06[b]	2.97[a]	.071
Sickness				
Days, mean	3.2[b]	1.9[a]	1.7[a]	.94
Incidence,%	86	76	79	12.4
Duration, days	3.7[b]	2.5[a]	2.1[a]	1.0

[abc]Means in a row with different superscripts differ statistically ($P<.05$).
[d]Based on full live weight.
[e]Based on carcass weight/.62.
[f]After subtraction of extra roughage.

Incidence of sickness tended to be lowest for cattle fed thiopeptin. Control cattle fed the high concentrate ration from the start of the trial were more likely to be sick for a longer period than cattle fed the other two rations.

Carcasses of cattle abruptly fed the high concentrate ration were lighter ($P<.05$) in weight (Table 3) and tended to have a greater incidence and severity of liver abscesses. Muscling reflected carcass weight differences though internal and external fat tended to be lower for cattle started on the high roughage ration.

Performance of cattle subdivided by weight groups is presented in Table 4. Feed intake and rate of gain increased with initial weight. For every 100 pounds increased initial weight, feed intake increased by 2.4 pounds per day ($P<.01$) and rate of gain for the trial increased .27 pounds per day ($P<.01$). The weight spread between groups increased as the trial progressed from an initial difference of 99 lb to a final spread of 137 lb. Daily feed intake, as a percentage of body weight, progressively declined with increase in body weight from 2.43 to 2.36 percent of body weight. Nevertheless, feed intake was predicted well using the gain projection formulas derived by Gill (1979). Feed efficiency was slightly better for the lighter than heavier groups of calves. Carcass weights were greater for calves which started the trial heavier, but dressing percentages were not different among weight groups (Table 5). Measured rib eye area increased with carcass weight. For every 100 lb increase in hot carcass weight, rib eye area increased 1.5 square inches ($P<.01$). Rib eye area expressed per unit of carcass weight, however, decreased as carcass weight increased. Rib eye area per hundred pounds of carcass decreased by .07 square inches with a carcass weight increase of 100 pounds. Grade tended to increase with carcass weight ($P<.06$).

A previous trial (Gill *et al.*, 1979) with continuous thiopeptin feeding demonstrated a 5.3 percent benefit in rate of gain and 7.8 percent in feed efficiency. This compares with 7.9 and 6.5 percent respectively in this trial (Figures 1 and 2). Marked similarity of results from the two trials both in gain and efficiency suggests that thiopeptin advantages were as great with 28-day feeding (1980) as continuous feeding (1979). In both trials, most of the performance and efficiency advantage was observed during the first month on feed.

Table 3. Carcass characteristics with thiopeptin feeding

Item	Control	Thiopeptin	Regular	LSD
Carcass weight, lb	623[a]	644[b]	643[b]	13.1
Dressing percentage	61.6	61.8	61.3	.96
Abscess				
Incidence, %	40.5	21.4	31.0	24.1
Severity[c]	.79	.36	.50	.49
Rib eye area				
Square inches	11.89[a]	12.24[b]	12.41[b]	.29
In.^{2}/100 lb carcass	1.92	1.91	1.93	.42
Fat thickness over rib, in.	.58	.64	.58	.102
Kidney-heart-pelvic fat, %	3.12	3.13	3.07	.25
Marbling score[d]	15.2	15.3	14.2	1.15
Federal grade[e]	12.9	12.9	12.9	.24
Cutability, %[f]	49.5	49.3	49.8	.76

[ab]Means in a row with different superscripts differ statistically ($P<.05$).
[c]No abscess = 0; one small abscess = 1.
[d]Small = 13; small plus = 14.
[e]Good plus = 12; choice minus = 13.
[f]From standard formula.

Table 4. Performance by weight group

Item	Weight group 1	2	3	4	5	6	LSD
Pens	3	3	3	3	3	3	
Steers	21	21	21	21	21	21	
Weight, lb							
Initial	514[a]	537[b]	549[c]	566[d]	583[e]	613[f]	3.3
28 days	631	659	679	689	705	739	
159 days[g]	973	998	1024	1035	1068	1108	
160 days[h]	964[a]	993[b]	1016[bc]	1030[cd]	1056[d]	1101[e]	29.9
Daily gain, lb							
0-28	4.16	4.35	4.67	4.38	4.34	4.47	.572
28-159[a]	2.81[a]	2.78[a]	2.82[a]	2.84[a]	2.98[b]	3.03[b]	.122
0-159[a]	2.87[a]	2.88[ab]	2.97[abc]	2.94[ab]	3.03[bc]	3.09[c]	.150
0-160[b]	2.81[a]	2.85[ab]	2.92[abc]	2.90[abc]	2.96[bc]	3.05[c]	.160
Feed intake, lb DM/day							
0-28	15.4[a]	16.6[ab]	17.0[ab]	17.0[ab]	16.5[ab]	18.2[b]	1.81
28-159[a]	18.1[a]	18.6[ab]	19.0[ab]	18.9[ab]	19.6[bc]	20.2[c]	1.10
0-159[a]	17.6[a]	18.3[ab]	18.7[ab]	18.6[ab]	19.1[bc]	19.8[c]	1.02
Projected[i]	18.2	18.6	18.8	19.0	19.3	19.7	
Feed/gain							
0-28	3.71	3.82	3.66	3.88	3.81	4.05	.35
28-159[a]	6.46	6.69	6.74	6.67	6.59	6.67	.44
0-159[a]	6.16	6.34	6.30	6.34	6.30	6.42	.37
0-160[b]	6.28	6.42	6.40	6.40	6.44	6.50	.32
Metab. energy, mcal/kg	2.95	2.95	2.97	3.00	3.02	3.05	.10
Sickness							
Sick days, mean	1.8	2.6	2.1	2.0	2.6	2.4	1.5
Incidence, %	71	76	86	81	81	86	17.5
Duration, days	2.3	3.4	2.4	2.5	3.2	2.8	1.3

[abcdef]Means in a row with different superscripts differ statistically ($P < 1.05$).

[g]Based on full live weight.

[h]Based on carcass weight /.62.

[i]Based on equation of Gill (1979).

Table 5. Carcass characteristics by weight group

Item	Weight group 1	2	3	4	5	6	LSD
Carcass weight, lb	598[a]	616[b]	629[bc]	638[cd]	655[d]	683[e]	18.5
Dressing percentage	61.5	61.7	61.5	61.7	61.4	61.6	1.35
Abscess							
Incidence, %	29[ab]	52[b]	10[a]	43[ab]	19[ab]	33[ab]	34.2
Severity[f]	.57	.76	.24	.71	.38	.62	.69
Rib eye area							
Square inches	11.7[a]	11.9[a]	11.9[a]	12.0[a]	12.5[b]	13.1[c]	.41
in 2/cwt carcass	1.97[c]	1.94[bc]	1.89[ab]	1.87[a]	1.91[ab]	1.91[ab]	.06
Fat thickness over rib, in.	.59	.63	.61	.60	.58	.61	.144
Kidney-heart-pelvic fat, %	3.07	3.02	3.24	3.02	3.14	3.14	.35
Marbling score[g]	15.0[ab]	14.2[a]	13.8[a]	14.0[a]	16.2[b]	16.4[b]	1.63
Federal grade[h]	12.8[ab]	12.8[ab]	12.7[a]	12.9[ab]	12.9[ab]	13.1[b]	.35
Cutability, %[i]	49.6	49.4	49.3	49.4	49.7	49.7	1.07

[abcde]Means in a row with different superscripts differ statistically ($P<.05$).
[f]No abscess = 0; one small abscess = 1.
[g]Small = 13; Small plus = 14.
[h]Good plus = 12; choice minus = 13.
[i]From standard formula.

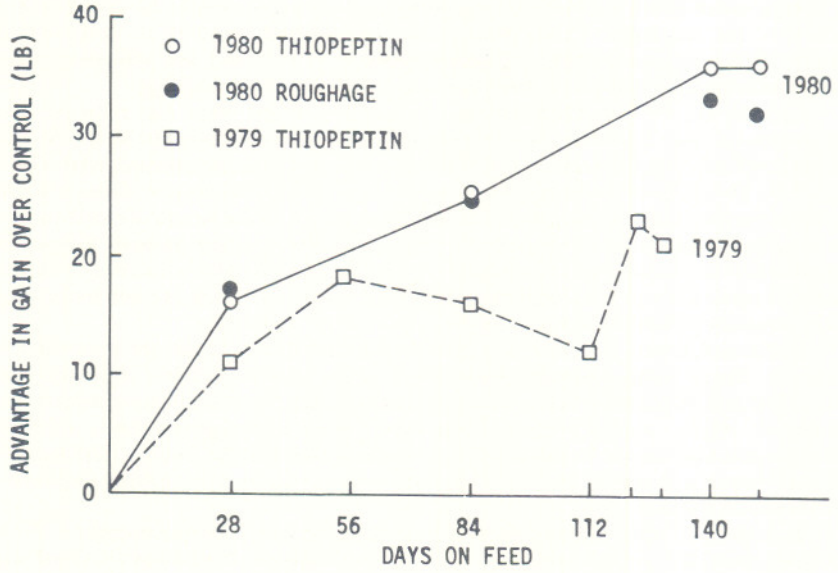


Figure 1. Cumulative gain effects.

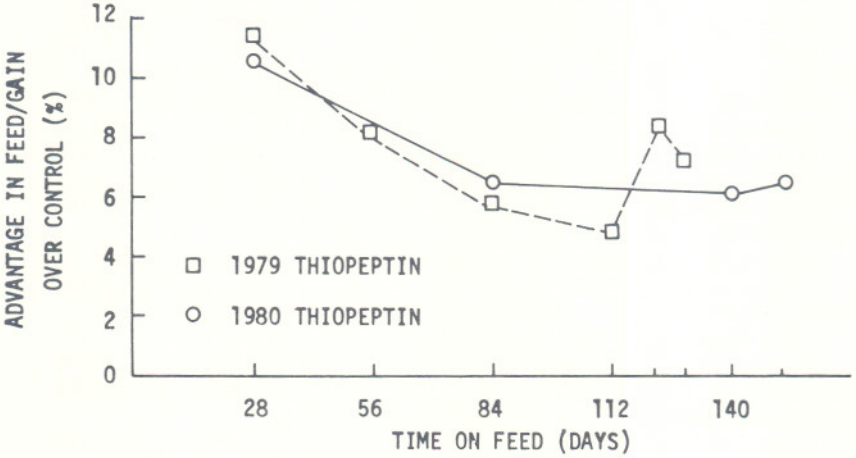


Figure 2. Cumulative feed efficiency effects.

Performance and carcasses of cattle fed a high concentrate ration with thiopeptin were very similar to those of cattle started on a roughage ration and gradually switched to a high concentrate ration. This suggests that thiopeptin might be considered a substitute for roughage. Thiopeptin rations are generally simpler to prepare and handle than roughage rations and with equal cost of gain and feed efficiency, most feedlot managers would prefer feeding thiopeptin to feeding roughage.

In both the 1979 and 1980 trials, the number of sick days was reduced with thiopeptin feeding. Incidence and severity of liver abscesses tended to be lower with thiopeptin feeding in this trial though this was not observed in the previous trial (Gill *et al.*, 1979). Health benefits during the early part of a feeding trial may be responsible for much of the benefit from thiopeptin feeding. Comparison of the health of cattle started on roughage with those started on the high concentrate ration without thiopeptin suggests that large intakes of concentrate are associated with sickness in newly received cattle. If cattle are not fed a well processed high energy ration or are not consuming large amounts of feed, thiopeptin might appear to be ineffective.

Performance and carcass characteristics subdivided by breed are presented in Table 6. Angus steers generally had slower gains, greater sickness (but not liver abscesses) and carcasses with less muscling and more fat. Heterosis in gain uncorrected for initial weight was 5.6 percent. Most other values were approximately midway between parental breeds. Incidence of sickness suggests that the Angus steers used in this trial were more susceptible to sickness and thereby may have been more responsive to thiopeptin feeding.

Effectiveness of thiopeptin for starting cattle on feed raises several questions. First, are thiopeptin effects cumulative with 1) estrogenic implants, 2) antibiotics in feed and

Table 6. Performance by breed of steers fed

Item	Breed			
	Angus	Hereford	Angus x Herford	LSD
Daily gain, lb				
0-28	4.23	4.53	4.41	.45
28-160	2.75[a]	2.85[ab]	2.98[b]	.20
0-160	2.80[a]	2.88[ab]	3.00[b]	.16
Sickness				
Mean days	3.1[b]	1.5[a]	2.1[a]	.96
Incidence,%	89	78	76	19
Duration, days	3.5[b]	2.0[a]	2.8[a]	.91
Carcass weight, lb	630	636	640	—
Dressing percentage	61.7	61.2	61.5	.78
Liver abscess				
Incidence, %	25	39	30	20
Severity	1.7	1.9	1.6	.40
Rib eye area				
Square inches	11.9[a]	12.5[b]	12.2[ab]	.50
in 2/cwt carcass	1.89[a]	1.97[b]	1.91[ab]	.076
Fat over rib, in.	.65[b]	.52[a]	.63[b]	.082
Kidney-heart-pelvic fat, %	3.3[b]	3.0[a]	3.1[ab]	.22
Marbling score	15.3	14.3	15.1	1.30
Federal grade	12.9	12.8	12.9	.2
Cutability	49.0[a]	50.3[b]	49.4[a]	.70

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

3) monensin supplementation? Secondly, what would the relative economics of thiopeptin versus roughage feeding show? Third, might addition of thiopeptin to preconditioning and sale barn rations help prevent stress and shipping fever of cattle? Fourth, is feeding of all concentrate rations feasible with thiopeptin? Potential benefits would be expected since roughages normally depress intestinal starch digestion and reduce efficiency use. Finally, health of newly received cattle deserves further attention to determine why ruminal or intestinal damage reduces later performance. If the magnitude of carryover effects is quantitated, livestockmen may pay more attention to this critical period.

Literature Cited

Gill, D.R. 1979. Okla. Cattle Feeders' Seminar, p. C-1.
Gill, D.R. *et al.*, 1979. J. Anim. Sci. 49:1145.
Kezar, W.W. and D.C. Church. 1979. J. Anim. Sci. 49:1396.
Mies, W.L. *et al.*, 1978. J. Anim. Sci.47(Suppl 1):431.
Muir, L.A. and A. Barreto, Jr. 1979. J. Anim. Sci. (Submitted).

Corn Silage Ammoniation Time and Protein Solubility

F. N. Owens, W. M. Sharp and George Davis[1]

Story in Brief

Chopped corn plants (27 to 34 percent dry matter) were ensiled with addition of ammonia at various times following chopping. Insoluble crude protein content was increased by ammonia addition. Delaying ammonia treatment for up to 4 hours after chopping did not greatly reduce the effect of ammoniation on protein solubility. Addition of urea had effects on protein solubility similar to ammonia addition with higher recovery of added protein.

Introduction

In freshly chopped corn plant material, only a small proportion of the protein is in a soluble form. In silage, 40 to 80 percent of the protein (nitrogen) is soluble. The chance for ruminal bypass of soluble protein is small, and protein bypass for ruminants is generally desirable. In research conducted at Michigan State, protein solubilization has been attributed primarily to continued action of plant enzymes the first few hours after harvest. Therefore, if plant enzymes can be inhibited, the protein value of corn silage for cattle should be improved. Since ammonia will inhibit plant enzymes rapidly, ammonia treatment of corn silage, besides providing an economical source of nitrogen, may improve the protein value of corn silage. If rapid inhibition of plant enzymes is desired, it may be necessary to treat silage immediately after chopping. The objectives of these two laboratory trials were to test the effects of 1) ammonia treatment at various times after chopping and 2) various nitrogen sources and levels and energy addition on protein solubility of corn silage.

[1]Kansas Agricultural Experiment Station, Garden City.

Materials and Methods

In the first trial, whole plant corn material (34 percent dry matter) was chopped at Garden City, Kansas, and ensiled immediately or held for 30, 60 or 240 minutes prior to ensiling in plastic bags. Ammonium hydroxide (1 percent of dry matter) was applied to half of the samples prior to ensiling. In the second trial, corn silage (27 percent dry matter) delivered to a feedlot in Garden City, Kansas, was ensiled in plastic bags without additives or with added urea (.5, 1.0, 1.5 percent of wet matter), ammonium hydroxide (.2, .4, .6 or .8 percent of wet matter) or glucose (1, 2, 4 or 8 percent of wet matter). Samples were analyzed for dry matter, total nitrogen and nitrogen which was soluble in .15 M NaCl.

Results and Discussion

Results of the first trial are presented in Table 1. The pH declined with fermentation but remained higher with ammoniation. Solubility of protein of the corn material was doubled by fermentation. The amount of insoluble, potential bypass protein was decreased 24 percent by fermentation. Addition of ammoniated water increased total and soluble protein content, but the insoluble protein was increased as well. The amount of insoluble protein remaining after fermentation decreased only slightly when ammoniation was delayed up to 4 hours. This suggests that ammonia addition 4 hours

Table 1. Protein fractions following ammonia treatment (trial 1)

Sample	Time (min)	pH	Crude protein fractions, %			*In vitro* digestibility, %
			Total	Soluble	Insoluble	
Fresh frozen	—	5.51	6.79	1.71	5.09	62.7
Untreated	—	4.26	7.31	3.49	3.82	63.5
Ammoniated	0	4.35	10.32	5.24	5.08	67.9
Ammoniated	30	4.19	10.92	5.72	5.20	71.2
Ammoniated	60	4.70	10.74	5.77	4.97	65.2
Ammoniated	240	4.37	10.37	5.48	4.90	64.6

Table 2. Protein fractions following ammonia treatment (trial 2)

Item	% of wet	% of dry	*Crude protein, % of DM*			
			Total	Calculated	Soluble	Insoluble
Untreated	0	0	8.84		3.34	5.50
ammonia	.21	.78	12.06	(13.7)[a]	5.31	6.75
	.36	1.33	14.19	(17.2)	7.02	7.17
	.57	2.11	17.41	(22.0)	10.22	7.19
	.72	2.66	19.75	(25.5)	12.12	7.62
Urea	.5	1.85	14.25	(14.0)	7.62	6.62
	1.0	3.70	19.19	(19.3)	11.69	7.49
	1.5	5.56	25.75	(24.5)	17.17	8.58
	2.0	7.40	27.97	(29.7)	20.28	7.69
Glucose	1	3.7	9.50		3.25	6.25
	2	7.4	8.87		3.29	5.58
	4	14.8	8.25		2.50	5.75
	8	29.6	7.93		2.91	5.03

[a]Calculated from added nitrogen.

after harvest had almost as much effect on protein as ammoniation during chopping. *In vitro* digestibility tended to be greater with ammoniation.

In the second trial, very high levels of ammonia, urea or glucose were added. Levels of insoluble protein were much higher in this trial than the other. This reflects the high variability of corn silage. Recovery of nitrogen added as ammonia averaged 82 percent while all of the nitrogen added as urea was recovered. The amounts of insoluble crude protein present increased similarly with addition of both urea and ammonia. Addition of soluble carbohydrate (glucose) had no effect on insoluble protein content. Results suggest that NPN addition to corn silage may increase the content of insoluble, potential bypass protein. Whether this increased insoluble protein does escape ruminal digestion remains to be proven. A number of feeding studies from Michigan with ammoniated corn silage suggest that ammoniated corn silage is used more efficiently by cattle. If increased protein bypass is responsible, ammoniation should prove most useful for starting cattle fed low protein rations.

Roughage Levels in Feedlot Rations

**D. R. Gill, F. N. Owens,
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R. A. Zinn and R. J. Hillier**

Story in Brief

Five levels of roughage (8 to 24 percent of ration dry matter) were fed with three corn types (high-moisture, steam-flaked and a mixture of the two) to 240 steers (747 pounds initially) for 121 days. Roughage was one-third ground alfalfa hay and two-thirds corn silage. Feed intake was about 7 percent less and metabolizable energy about 8.7 percent greater with steam-flaked than with high-moisture corn in the ration. Gains and efficiencies of feed use were greatest for steers fed 8-percent roughage with steam-flaked grain, 12-percent roughage with the corn mixture and 16-percent roughage with high-moisture corn grain. Although addition of roughage to the 8-percent roughage ration increased feed intake and replaced corn energy for steers fed high-moisture corn, it actually increased the amount of steam-flaked grain required per pound of gain. The greatest advantage for steam-flaked grain was with the lowest roughage level. Rumination tended to increase with added roughage, but ruminating steers gained weight at a slower rate (3.30 vs. 3.38 pounds daily) than non-ruminating penmates. The optimal level of roughage in a feedlot ration appears to depend on grain processsing.

Introduction

Roughages are included in high-concentrate rations for several reasons. First, dilution of the ration or the rumen contents with roughage helps avoid acidosis and founder. Second, added roughage increases rumination, which may increase digestion in the rumen both by reducing particle size and by increasing saliva flow and ruminal pH. Roughage may also aid ruminal mixing to avoid abnormal or slimy types of fermentation. Certain roughages also contribute protein, minerals and vitamins to the ration.

However, feeding high levels of roughage to feedlot cattle is not always advantageous. High roughage levels will decrease gains and feed efficiency of feedlot cattle by reducing 1) feed and energy intake and/or 2) fiber or starch digestion in the rumen or small intestine. In addition, certain regions of the US have a deficiency of roughage, and roughage is an expensive dietary constituent. Finally, the influence of roughage level on liver abscess incidence and animal behavior is an area needing further investigation. The objective of this experiment was to determine the influence of corn processing and roughage level on performance of growing feedlot steers.

Materials and Methods

Two hundred forty steers with an initial weight of 747 pounds were allocated to 30 pens of eight steers each at Panhandle State University, Goodwell, Oklahoma. One Angus, three black baldy, two Hereford and two exotic cross steers were in each pen. Steers were implanted with Ralgro at the start of the experiment (April, 1980) and again on day 56 of the trial. Two types of processed grain, high-moisture corn (24 percent moisture) or steam-flaked corn (26 lb/bushel), were each fed to 10 pens of steers. A mixture of 50-percent high-moisture and 50-percent steam-flaked grain was fed to another 10 pens of steers. Five levels of roughage were fed—8, 12, 16, 20 and 24 percent of ration dry matter (Table 1). The roughage consisted of 67 percent corn silage and 33 percent tub-ground alfalfa hay. This mixture permitted one supplement to be used across roughage levels with little change in protein, potassium or calcium concentrations. To bring steers on feed, the roughage level was 40 percent for the first 4 days, 30 percent for the next 5 days with further reduction by 4 percent each subsequent 5 days until the final roughage level was reached. All rations contained monensin and tylosin (Table 1). The number of animals ruminating during a 12-hour period was determined on day 118. Steers were fed for 121 days and then trucked to Booker, Texas, for slaughter. Carcass measurements were obtained at slaughter.

Results and Discussion

Daily gains of steers are presented in Tables 2 and 3. Roughage level and grain processing had little effect on live weight gain, but similar to most trials with various roughage levels, less roughage produced slightly higher dressing percentages, which gave the lower roughage level an advantage when gain was calculated from carcass

Table 1. Ration composition

Item	%
Roughage	
Alfalfa hay, tub ground 1/3 Corn silage 2/3	8-24
Concentrate	
Corn grain	69-85
Soybean meal	2.4
Cottonseed meal	2.6
Urea	.35
Limestone	.80
Dicalcium phosphate	.20
KC1	.15
Dehydrated alfalfa meal	.20
Salt	.30

Trace mineral mix, monensin (30 g/ton), tylosin (9 g/ton), vitamin A. added.

Table 2. Daily gain (final live wt – 4 percent)

Corn	Roughage level (% of DM) 8	12	16	20	24	$\bar{x}$
HMC	3.04	3.07	3.20	3.01	3.11	3.09
½ HMC, ½ SF	3.06	3.22	3.05	3.21	3.12	3.13
SF	3.26	3.09	3.07	3.05	3.10	3.11
$\bar{x}$	3.12	3.13	3.10	3.09	3.11	

Table 3. Daily gain (carcass wt/62 percent)

Corn	Roughage level (% of DM) 8	12	16	20	24	$\bar{x}$
HMC	3.31	3.45	3.48	3.36	3.34	3.39
½ - ½	3.52	3.57	3.34	3.50	3.49	3.48
SF	3.70	3.35	3.33	3.28	3.49	3.43
	3.51	3.45	3.38	3.38	3.44	

Table 4. Daily feed

Corn	Roughage level (% of DM) 8	12	16	20	24	$\bar{x}$
HMC	19.5	20.0	20.3	20.8	21.7	20.5^{c}
½ - ½	19.0	20.3	19.5	20.9	19.6	19.8^{b}
SF	18.6	18.1	19.1	19.0	20.2	19.0^{a}
	19.0^{a}	19.5^{a}	19.7^{ab}	20.2^{b}	20.5^{b}	

^{abc}Means in a row or column with different superscripts differ significantly ($P<.05$).

Table 5. Daily concentrate intake

Corn	Roughage level (% of DM) 8	12	16	20	24	$\bar{x}$
HMC	17.3	17.1	16.7	16.4	16.4	16.8
½ - ½	16.8	17.4	16.1	16.5	14.7	16.3
SF	16.4	15.5	15.8	15.0	15.2	15.6
	16.8	16.7	16.2	16.0	15.4	

weight. The optimal roughage level for rate of gain differed with grain processing. With high-moisture corn, 16 percent roughage produced the greatest gain while with steam-flaked corn, gain was greatest with 8 percent roughage in the ration. Feed and concentrate intakes were about 7 percent less for steam-flaked than high-moisture grain. Since gains were equal, this indicates that the increased energy availability was reducing feed intake.

Feed and concentrate intakes are presented in Tables 4 and 5. Averaged across corn type, for every percentage of the ration in which roughage substituted for grain, feed intake increased by .5 percent. Amounts of feed and concentrate required per pound of gain are presented in Tables 6 and 7. As a higher roughage level was used, feed required per pound of gain increased. Flaking half the grain improved feed efficiency by 5.7 percent, and total flaking improved feed efficiency by 8.2 percent compared with high-moisture grain. Metabolizable energy (ME) provided by the rations, calculated from steer weights and gains, is presented together with standard values from the literature in Table 8. Metabolizable energy was 6.3 percent greater for steam-flaked

Table 6. Feed/gain (based on carcass gain)

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	5.92	5.80	5.83	6.18	6.52	6.05^{b}
½ - ½	5.39	5.69	5.85	5.96	5.60	5.70^{a}
SF	5.03	5.41	5.75	5.79	5.78	5.55^{a}
	5.47^{a}	5.63^{ab}	5.81^{bc}	5.98^{c}	5.97^{c}	

^{abc}Means in a row or column with different superscripts differ significantly ($P<.05$).

Table 7. Feed/gain (concentrate portion only)

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	5.24	4.96	4.85	4.88	4.91	4.96^{b}
½ - ½	4.78	4.87	4.82	4.71	4.22	4.68
SF	4.45	4.63	4.74	4.57	4.36	4.55^{a}
	4.82	4.82	4.78	4.72	4.50	

^{ab}Means in a column with different superscripts differ significantly ($P<.05$).

Table 8. Metabolizable energy of ration (Kcal/g)

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	3.28	3.23	3.23	3.09	3.02	3.16^{a}
½ - ½	3.36	3.31	3.21	3.20	3.27	3.27^{b}
SF	3.57	3.39	3.28	3.27	3.26	3.36^{c}
	3.38^{a}	3.31^{ab}	3.24^{bc}	3.19^{c}	3.19^{c}	
Literature value for rations	3.11	3.08	3.05	3.02	2.99	

^{abc}Means in a row or column with different superscripts differ significantly ($P<.05$).

Table 9. Metabolizable energy advantage of rations above literature values (%)

	Roughage level (% of DM)					
Corn	8	12	16	20	24	$\bar{x}$
HMC	+ 5.4	+ 4.9	+ 5.9	+ 2.3	+ 1.0	+ 3.6
½ - ½	+ 8.0	+ 7.5	+ 5.2	+ 6.0	+ 9.4	+ 7.2
SF	+14.8	+10.1	+ 7.5	+ 8.3	+ 9.0	+10.2
	+ 8.7	+ 7.5	+ 6.2	+ 5.6	+ 6.7	

than high-moisture rations, so the grain alone had 8.7 percent more metabolizable energy in the flaked than in high-moisture form. Literature values for the ME of the ration were lower than the observed ME in all cases. Added roughage decreased metabolizable energy value of the ration by an average of .35 percent for every 1 percent roughage. Comparisons with specific rations are shown in Table 9. The advantage in ME for steam-flaked grain and the mixture of grains was greatest with 8-percent roughage while with the high-moisture corn, the 16-percent roughage exceeded calculated ME the most. Results again indicate that adding 8-percent roughage to high-moisture corn tends to replace the corn whereas adding a similar amount of roughage to steam-flaked corn is detrimental. This suggests that the associative effect of adding

Table 10. Carcass traits or measurements across roughage levels

Corn	HMC	½ - ½	SF
Carcass wt	719	722	721
Dress, %	61.4	61.8	61.5
Liver abscess incidence, %	7.5	5.2	6.2
Cooler shrink, %	1.6	1.7	1.5
Rib eye area, in.^{2}	12.1	12.4	12.3
Fat thickness, in.	.59	.62	.60
KHP, %	3.14	3.05	3.06
Marbling score[a]	14.1	14.2	14.0
Cutability, %	48.8	48.8	48.9
Dark cutters, %	5.2	5.0	7.5
Fed grade[b]	13.0	13.0	12.9
Choice, %	74.8	74.8	73.8

[a]13 = small minus; 14 = small.
[b]12 = high good; 13 = low choice.

Table 11. Carcass traits and rumination averaged across corn types

Roughage, %	8	12	16	20	24
Carcass weight	723	722	716	721	723
Dress, %	62.0	61.5	61.3	61.4	61.6
Liver abscess, %	6.2	6.2	6.2	8.6	4.2
Cooler shrink, %	1.6	1.6	1.5	1.7	1.5
Rib eye area, in.^{2}	12.5	12.3	12.4	12.1	12.1
Fat thickness, in.	.58	.63	.57	.62	.62
KHP, %	3.03	3.03	3.09	3.17	3.07
Marbling score	13.7	13.8	13.9	14.0	14.8
Cutability, %	49.1	48.7	49.1	48.5	48.6
Dark cutters, %	8.6[a]	8.3[a]	4.1[ab]	8.3[a]	0.0[b]
Federal grade	12.9	12.9	12.9	12.8	13.2
Choice, %	76.8	70.8	77.1	70.5	77.1
Ruminating, %	17	22	37	31	45

[ab]Means in a row with different superscripts differ significantly (P<.05).

roughage to grain varies with grain processing, being greater with steam-flaked than with high-moisture grains. Previously, it had been assumed that one would expect adverse effects of roughage with poorly processed grain only. Since roughages differ in their ruminal retention time, digestibility and effect on intestinal transit time, the degree of any associative effect also varies with the type of roughage fed (Teeter *et al.*, 1980).

Grain type and roughage level effects on rumination and carcass composition were small (Tables 10 and 11). The percentage of steers observed ruminating during a 12-hour observation period tended to increase with roughage level in the ration. Incidence of liver abscesses was greatest with 20-percent roughage rather than the lower roughage levels. This suggests that liver abscesses probably reflect feed management, engorgement and acidosis more than ration composition.

Because incidence of ruminantion increased with roughage level in the ration, performance and carcass characteristics of steers ruminating were compared with non-ruminating penmates (Table 12). Despite the trend for increased rumination of cattle fed higher roughage levels, there is no indication that performance or health was superior for ruminating steers. Ruminating steers actually gained weight less rapidly than non-ruminating steers and had a slightly higher incidence of abscessed livers.

Table 12. Comparison of ruminating with non-ruminating penmate steers

Item	Non-ruminating	Ruminating
Daily gain	3.38[a]	3.30[b]
Abscess incidence, %	6.7	7.4
Marbling score	14.3	14.2
Cutability, %	48.7	48.9
Fat thickness	.62[c]	.58[d]
Choice, %	76	76

[ab]Means differ at the 5 percent probability level.
[cd]Means differ at the 10 percent probability level.

Higher roughage rations will simplify management, but, again, the type and form of roughage may be more important than the level of roughage in the ration. Some recent trials with high intakes of high-concentrate rations indicate that no fiber is digested in the rumen. If roughage simply dilutes grain in the rumen to prevent acidosis, the amount of roughage needed depends primarily on the residence time of the roughage. If roughages are fed as a safety factor, price premiums for more digestible forage for feedlot cattle are not justified. Instead, factors influencing ruminal retention time, such as particle size, density and bulk of the roughage, are of major interest.

Literature Cited

Teeter, R. G. *et al.* 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:156.

Influence of Level of Feed Intake on Digestive Function. I. Nitrogen Metabolism

R. A. Zinn and F. N. Owens

Story in Brief

Four Angus steers (568 pounds) equipped with "T" cannulas in the proximal duodenum and distal ileum were used to study the influence of feed intake level on nitrogen metabolism. Treatments consisted of an 80-percent concentrate diet fed at 1.6, 1.8, 2.0 and 2.2 percent of body weight. Increasing level of intake from 1.6 to 2.2 percent resulted in a 52-percent increase in bypass and a 59-percent increase in metabolizable protein content of feed. There was an apparent curvilinear relationship between level of feed intake and bypass which led to the following conclusions: 1) under the given conditions of this study, the break point at which feed intake is directly related to rumen retention occurs in the neighborhood of 1.8 percent body weight; 2) as feed intake

approaches those typically encountered under feedlot conditions (>2.6 percent body weight), simple nitrogen solubility estimates may adequately reflect ruminal digestion. In a practical sense it was further surmised that microbial protein synthesis and, thus, net protein nutrition would be optimized in diets containing .6 to .65 percent soluble or otherwise available N.

Introduction

Aside from any associative effects on general fermentation and subsequent digestion, the value of feed protein for ruminants is directly related to the amount of protein which escapes breakdown in the rumen and still is digested and absorbed from the small intestine. The effect of feed intake on bypass has not been studied.

Recent trials (Zinn and Owens, 1980) have indicated that increasing feed intake from 1.5 to 2.0 percent of body weight increased bypass of feed N by 45 percent. Since this N represents an otherwise degradable fraction, percent uptake of N reaching the small intestine was also increased (13 percent), which increased metabolizable nitrogen (intestinal supply of digestible crude protein) content of the feed by 88 percent. As level of feed intake increases, the time for rumen digestion decreases, and bypass increases (Zinn *et al.*, 1981). Thus, metabolizable N content of the feed will increase.

The objective of this research was to determine the influence of level of feed intake on site of N digestion.

Materials and Methods

Four Angus steers (568 pounds) with "T" cannulas in the proximal duodenum and distal ileum were used in a 4 by 4 Latin square design experiment to measure the influence of feed intake level on nitrogen metabolism. Treatments consisted of an 80-percent concentrate ration (Table 1) fed at 1.6, 1.8, 2.0 and 2.2 percent of body weight. Steers were fed at 8 a.m. and 8 p.m. Experimental periods consisted of 10 days for ration adjustment followed by 2 days for collection of fecal and intestinal samples. All estimates of digestion were based on analysis of composites of intestinal or fecal material samples obtained simultaneously. Chromic oxide was fed as a digestive marker.

Results and Discussions

The influence of level of feeding on nitrogen metabolism in the rumen, small intestine and cecum plus large intestine is presented in Table 2. Increasing feed intake

Table 1. Ration composition

Ingredient	%
Dry rolled corn	62.6
Dehydrated alfalfa pellets	6.0
Cottonseed hulls	14.0
Soybean meal	10.0
Cane molasses	5.0
Trace mineral salt	.5
Limestone	.5
Dicalcium phosphate	.5
Aurofac-10	.1
Ammonium chloride	.5
Urea	.1
Cr_2O_3	.2

Table 2. Influence of level of feed intake on apparent nitrogen metabolism in the rumen, small intestine and cecum plus large intestine

Item	Treatments 1	2	3	4	(CV)
Intake, g/day					
N	61.8	83.6	100.4	117.4	
Pepsin insoluble N	13.2	17.8	22.6	26.4	
Leaving abomasum, g/day					
N	57.8	82.1	119.0	141.5	(8.9)
Non-ammonia N	52.6	74.7	109.8	132.4	(9.3)
Nucleic acid N	5.1	6.9	9.5	9.9	(9.3)
Microbial N	25.5	34.6	47.8	49.5	(9.3)
Bypass of feed N, %	43.8	48.0	61.9	70.6	(18.3)
Leaving ileum, g/day[a]					
N	17.6	26.6	31.2	38.8	(14.7)
Pepsin insoluble N	14.4	21.3	25.8	32.6	(11.7)
Nucleic acid N	.6	1.0	1.1	1.2	(26.2)
Digestion in small intestine, %					
N	65.9	64.1	71.4	70.8	(7.6)
Nucleic acid N	88.2	85.5	88.4	87.9	(4.8)
Bypass feed N	64.5	62.3	74.8	73.1	(14.1)
Fecal excretion, g/day					
N	18.3	24.0	33.1	29.0	(11.5)
Pepsin insoluble N	12.7	17.2	22.5	24.1	(9.8)
Digestion in large intestine, %					
N leaving ileum	−3.7	8.7	−7.5	21.5	(441)
Total tract digestion, %					
N fed	70.3	71.2	67.0	75.3	(2.5)
Pepsin insoluble N fed	3.7	3.4	.4	8.7	

[a]Treatment 4 ileal estimates were corrected for recovery of duodenal ADF.

from 1.6 to 2.2 percent of body weight increased bypass of feed nitrogen by 52 percent. This increase is similar in magnitude to that observed in previous experiments (Zinn and Owens, 1980) where increasing level of feeding from 1.5 to 2.0 percent body weight increased bypass by 45 percent. The increase in bypass appeared curvilinear (Figure 1). The greatest increase occurred between 1.8 and 2.0 percent level of feeding. This range may be considered the breakpoint above which feed intake more greatly influences retention time. Further extrapolating our data to a feedlot plane of nutrition (2.6 to 3.0 percent body weight), results would suggest only the soluble or immediately available nitrogen fraction will reflect nitrogen digestion in the rumen. This observation suggests that protein solubility may be a useful indicator of protein value for feedlot steers. Indeed, the proportionately reduced microbial growth occuring at the highest level of feeding may reflect a deficiency of available nitrogen for optimal rumen fermentation.

While differences in apparent digestibility of N in the small intestine were not significant ($P>.05$), digestibility tended to be higher for the 2.0 and 2.2 percent level of feeding. Thus, net metabolizable nitrogen content of the diet was increased by 59 percent. Neither the crude protein nor the digestible protein system reflects the importance of feed intake on protein supplementation though intake appears extremely important, and new protein systems will need to be structured around this factor also.

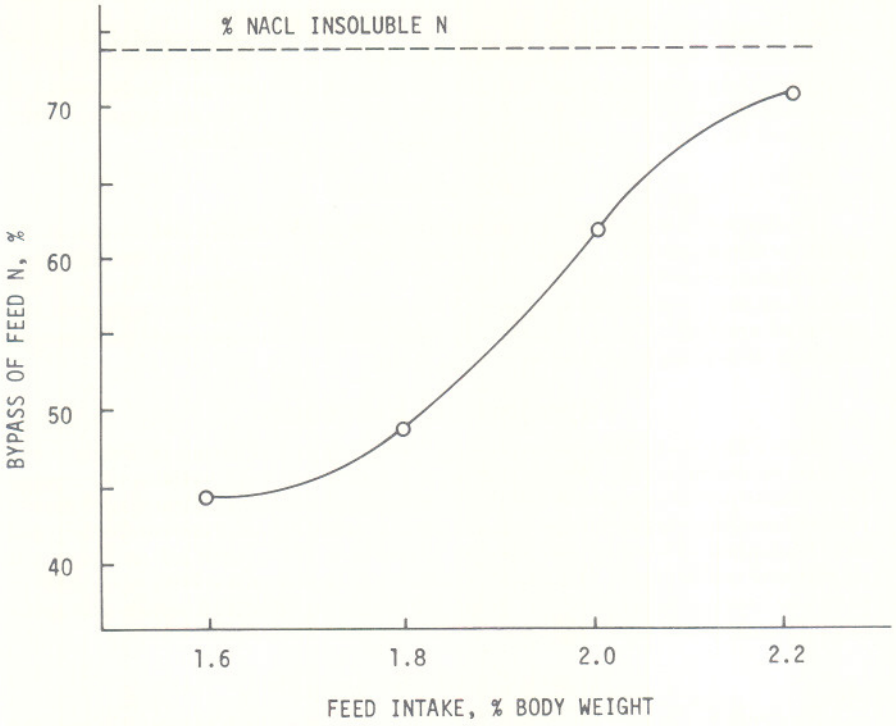


Figure 1. Feed intake versus bypass of feed N.

This and previous studies also suggest that for feedlot cattle consuming predominantly corn-based high concentrate diets, optimal performance should occur (particularly early in the finishing period) with diets containing .6 to .65 percent soluble or otherwise readily available N.

Literature Cited

Zinn, R. A. and F. N. Owens. 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:150.
Zinn, R. A. 1981. J. Anim. Sci. (in press).

Captan and Ruminal Metabolism

R. G. Teeter and F. N. Owens

Story in Brief

Four ruminally and abomasally cannulated growing steers, each weighing 783 lb, were fed four different dietary concentrations (0, 160, 320, and 640 ppm) of Captan mixed in an 85-percent concentrate ration. The purpose was to determine the influence of Captan on ruminal and total-tract digestibility of dry matter, starch and protein and on the retention of nitrogen. Captan tended to linearly increase ruminal starch and dry

matter digestibility (4.4 percent, 9.8 percent), decrease abomasal passage of starch and dry matter (37.2 percent, 27.2 percent), decrease abomasal passage of non-ammonia nitrogen (13.1 percent) and increase nitrogen retention (8.5 percent). No differences in total-tract digestibility of nitrogen of dry matter were detected. Results suggest that this compound may enhance ruminal fermentation of concentrate diets.

Introduction

Feeding trials with steers fed concentrate rations in Colorado and ruminants fed forage in Minnesota have shown increased digestibility, rate of gain or feed efficiency with Captan, a new feed additive being tested for use in cattle feeding. It has been used in the past as a fungicide for seed corn. The purpose of this study was to determine if increased ruminal outflow of protein is responsible for the increased performance observed with animals fed low levels of Captan.

Experimental Procedure

Four 783-pound Hereford steers fitted with rumen and abomasal fistulas were allotted to treatments (0, 160, 320, 640 ppm Captan) in a 4 x 4 Latin square design. Each 14-day period consisted of 5 days adaptation feeding in pens followed by 9 days in metabolism stalls (days 1-3, adaptation to stall; days 4-8, fecal and urine collection; and day 9 sampling of ruminal and abomasal contents). Steers were fed an 85-percent concentrate ration (Table 1) containing solid and liquid flow markers, twice daily in pens and every 3 hours in stalls. Fecal, abomasal and acidified rumen and urine samples were frozen until analyzed.

Results and Discussion

No significant differences were detected (Table 2), but trends suggest that ruminal fermentation of starch and dry matter may have been enhanced by Captan. Total-tract digestibility was not affected by Captan. In this study dry matter intakes were limited such that equalized intake could be achieved across treatments. Reduced intake will slow rate of passage and minimize differences in total-tract digestibility. *Ad libitum* feeding conditions could overload the intestinal digestive capacity, in which case enhanced ruminal fermentation might increase total-tract nitrogen and dry matter digestibility. Ruminal outflow of nitrogen tended to decline with the added drug. Such a decline with increased ruminal digestibility and an increased outflow rate is surprising. Whether this change is in plant microbial nitrogen is unclear.

Table 1. Ration composition

Item	As fed basis, %
Corn, rolled	76.3
Cottonseed hulls	10.0
Alfalfa meal	5.00
Molasses	4.00
Cottonseed meal	2.00
Limestone	0.75
Urea	0.50
Salt	0.30
Dical	0.15
Marker mix	1.00
	100.00

Table 2. Trial results

Item	Concentration of Captan, ppm			
	0	160	320	640
Dry matter digestibility (%)				
Ruminal	65.1	72.8	69.4	74.3
Total	82.1	81.9	82.4	82.0
Starch digestion (%)				
Ruminal	87.7	93.6	89.3	92.2
N digestibility	74.8	72.1	77.3	74.8
Non-ammonia nitrogen				
Ruminal outflow, g/day	142.1[b]	132.8[ab]	126.7[ab]	110.6[a]
Ruminal ammonia, mg/dl	3.4	3.6	4.3	2.5
Nitrogen retention, g/day	45.2	47.8	50.4	49.2
Urine volume, liter	25.2	27.7	26.8	27.4
Abomasal passage				
Liquids, liter/day	66.4	80.8	80.8	75.2
Organic matter, g/day	1316	968	1136	947
Starch, g/day	306	138	256	183

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

Ruminal Availability of Phosphorus and Its Effect on Digestion

K. E. Witt and F. N. Owens

Story in Brief

The phosphorus concentration in ruminal fluid was determined for steers limit-fed rations with phosphorus concentrations ranging from .06 to .17 percent. Ruminal phosphorus concentration was increased with phosphorus intake at dietary concentrations below .12 percent for steers. This relationship was employed to estimate the ruminal availability of phosphorus from four phosphorus sources. Compared with sodium phosphate, assumed to have a ruminal phosphorus availability of 100 percent, a 21-percent phosphorus mono-dical, an 18.5-percent phosphorus mono-dical, and a defluorinated rock phosphate were found to be 59, 42 and 28 percent as available in the rumen. Phosphorus solubility in solutions buffered at pH 5, 6 and 7 paralleled the apparent availability in the rumen. Low ruminal dietary phosphorus did not reduce total tract or ruminal digestibility greatly, however, suggesting that ruminal concentrations above 210 mg per liter are adequate for microbial digestion in the rumen.

Introduction

Phosphorus in the form of some inorganic phosphorus supplement is added to most livestock rations to help meet the requirement of animals. With non-ruminant animals, the phosphorus requirement is often assessed by feeding trials and growth measurements. Ruminants require phosphorus both for growth of tissue and bone, as well as multiplication of microorganisms within the rumen. Phosphorus availability,

thereby, becomes important at two sites for the ruminant. Rate of growth of bacteria and rate of digestion of feed components within the rumen may be limited by phosphorus supply. Through reduced microbial activity, a deficiency of phosphorus may precipitate deficiencies of energy or protein. This concept is supported by the observation that loss of appetite is one of the first clinical signs of a phosphorus deficiency in ruminants. Two added factors in phosphorus metabolism are peculiar to ruminant animals. First, ruminal phytase liberates bound phytin phosphate. Phytin phosphate is of low availability for non-ruminant animals. Secondly, pancreatic ribonuclease is secreted into the small intestine of ruminant animals in large amounts. Ribonuclease will liberate phosphorus from nucleic acids for recycling to the rumen via saliva.

Ruminal microbes obtain needed phosphorus from ruminal fluid and from feedstuffs being digested. Phosphorus in ruminal fluid is derived from solubilized or degraded feed ingredients as well as from recycling to the rumen.

Little information has been published on ruminal phosphorus concentrations and ruminal availability of various phosphorus sources. Therefore, these trials were designed 1) to determine if ruminal phosphorus concentration was linearly related to phosphorus intake so that it might be used to evaluate ruminal availability of phosphorus from various phosphorus sources, 2) to estimate ruminal availability of various phosphorus sources for mature cattle, 3) to measure solubility of phosphorus sources in a buffer solution as influenced by pH and time and 4) to determine if low dietary phosphorus levels decrease digestion in the rumen or the total digestive tract.

Materials and Methods

Standard curve

Six mature ruminally cannulated Hereford steers (1122 lb) were individually fed 7.1 lb of a basal ration (Table 1) twice daily. Sodium phosphate was added as the standard phosphorus source to provide ration phosphorus concentrations of .068, .123 and .173 percent. After a five-day adaptation period, a ruminal fluid sample was collected via ruminal cannula for analysis of inorganic phosphorus concentration. The line relating ruminal phosphorus concentration to ration phosphorus concentration was used to determine the relative ruminal availability of various phosphorus sources fed in the availability trial.

Ruminal availability of phosphorus sources

Steers used in the standard curve trial were individually fed 13.9 lb per day of a basal ration (Table 1) supplemented with phosphorus from sodium phosphate (a

Table 1. Basal ration composition

Item	Trial		
	Steer std curve	Steer avail.	Steer digestibility
	% of ration		
Cottonseed hulls	97.0	97.0	77.9
Supplement	3.0	3.0	22.1
Dehy cane molasses	0	0	20.1
Urea	1.6	1.6	1.1
TM salt	.5	.5	.5
$CaCo_3$	.07	.07	0
P source + $NaHCO_3$	.85	.85	.44
Vitamins A & D	+	+	+

standard source), a mono-dicalcium phosphate with 21 percent phosphorus[1], a mono-dicalcium phosphate with 18.5 percent phosphorus[2], or a defluorinated rock phosphate with 18 percent phosphorus[3] (Table 2). Steers were fed twice daily for a five-day adaptation period. On day six, a ruminal fluid sample was collected via ruminal cannula and analyzed for inorganic phosphorus concentration. Relative ruminal availability of the various sources of phosphorus was calculated by relating ruminal phosphorus concentrations to the standard curve for sodium phosphate generated in the previous trial.

In vitro solubility of phosphorus sources

Each of the four phosphorus sources was incubated in Ohio buffer at a pH of 5, 6 or 7. Samples were taken at 30 minutes, 1, 2 and 3 hours. Samples were analyzed for inorganic phosphorus, and solubilities relative to the standard (sodium phosphate) were calculated.

Phosphorus and ruminal digestion

Four Hereford-Brown Swiss and two Hereford-Angus steers (1527 lb) housed in metabolism stalls were individually fed at maintenance based on body weight, a basal ration (Table 1) containing .118 percent phosphorus or supplemented with sodium phosphate to achieve a phosphorus level of .227 percent in the ration. After a seven-day ration adaptation period, total feces were collected for five days. On the fifth day of the collection period, ruminal fluid samples were obtained, and nylon bags containing ground corn, cottonseed hulls or cotton duck strips were incubated in the rumen for a 24 hour period. Ruminal fluid and fecal samples were analyzed for inorganic phosphorus. Nylon bags and cotton duck strips were thoroughly washed, dried, and weighed to determine disappearance rate of dry matter.

Results and Discussion

Standard curve

Cattle fed diets with sodium phosphate added to obtain.068, .123 and .173 percent phosphorus had ruminal phosphorus concentrations of 264, 406 and 434 mg phosphorus per liter of ruminal fluid (Figure1). The higher level of phosphorus addition increased ruminal phosphorus only slightly, suggesting that concentration may have begun to plateau.

Table 2. Supplement composition

Phos. source	Trial								
	Steer	std	curve[a]	Steer avail.[a]				Steer dig.[b]	
	% of ration								
$Na_2HPO_4 \cdot 7H_2O$	0	.43	.85	.85	—	—	—	—	—
Na_2HPO_4	—	—	—	—	—	—	—	0	.44
21% P dical	—	—	—	—	.47	—	—	—	—
18.5% P dical	—	—	—	—	—	.54	—	—	—
Defluor. P	—	—	—	—	—	—	.55	—	—
$NaHCO_3$	.85	.42	0	0	.38	.31	.30	0	0

[a]Added to urea, limestone, trace mineralized salt and vitamin mix to form the total supplement.
[b]Added to dehydrated cane molasses, urea, trace mineralized salt and vitamin mix to form the total supplement.

[1]Occidental Chemical Co., Houston, Texas.
[2]International Minerals and Chemical Corp., Mundelein, Illinois.
[3]Borden Chemical/Borden Inc., Norfolk, Virginia.

Ruminal availability of phosphorus sources

Sodium phosphate, 21 percent phosphorus mono-dical, 18.5 percent phosphorus mono-dical or defluorinated rock phosphate were added to a basal ration (.067 percent phosphorus) to increase the phosphorus level to approximately .17 percent. Ruminal fluid phosphorus concentrations of the three commercial sources were compared with the sodium phosphate standard curve for steers (Figure 1). Estimates for ruminal availability relative to sodium phosphate at 100 percent were 59.3 percent for 21 percent phosphorus mono-dical, 42.2 percent for 18.5 percent phosphorus mono-dical, and 28.4 percent for defluorinated rock phosphate. Ration and ruminal fluid phosphorus concentrations for the three phosphorus sources are presented in Table 3.

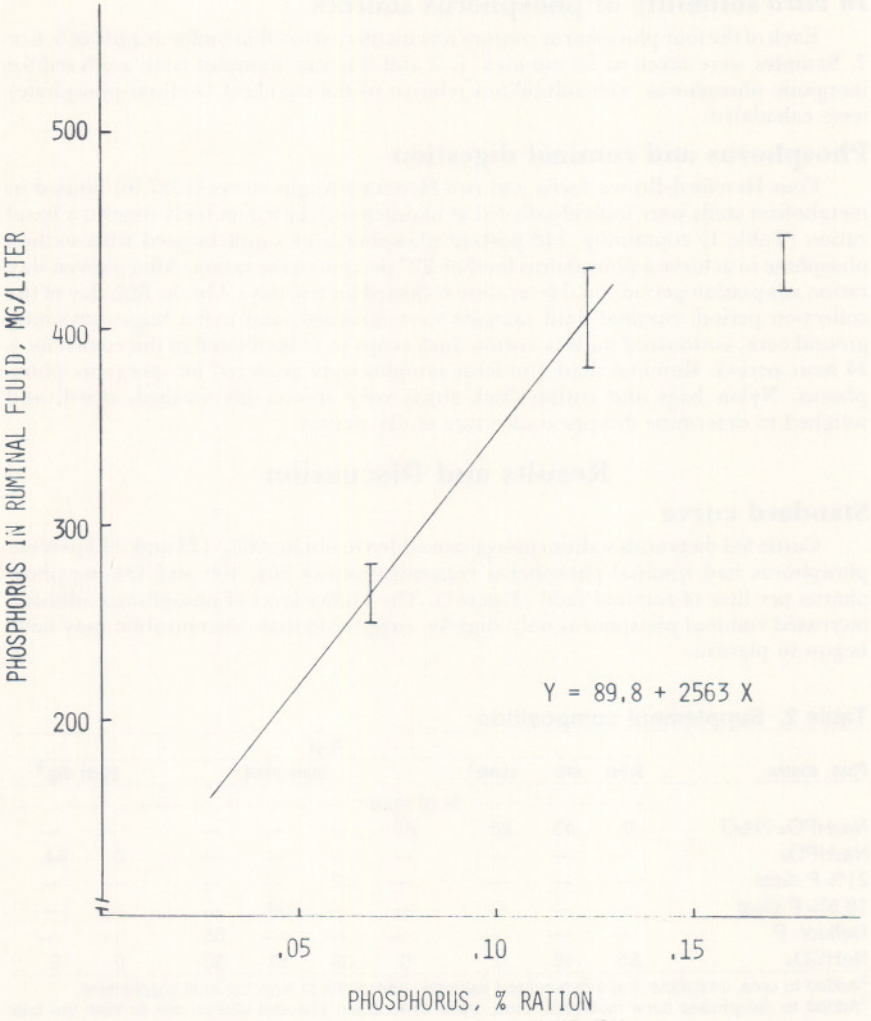


Figure 1. Ruminal fluid phosphorus concentrations in steers vs. phosphorous intake

In vitro solubility of phosphorus sources

Phosphorus sources differed ($P<.01$) in solubility. Sodium phosphate was virtually all soluble in the buffer solution, while the 21 percent phosphorus mono-dical was more soluble (46.4 percent) than 18.5 percent phosphorus mono-dical (28.8 percent). Deflourinated rock phosphate was virtually insoluble (2.5 percent, Figure 2). This order of solubility for the four phosphorus sources is identical to the order of ruminal availability (Figure 3).

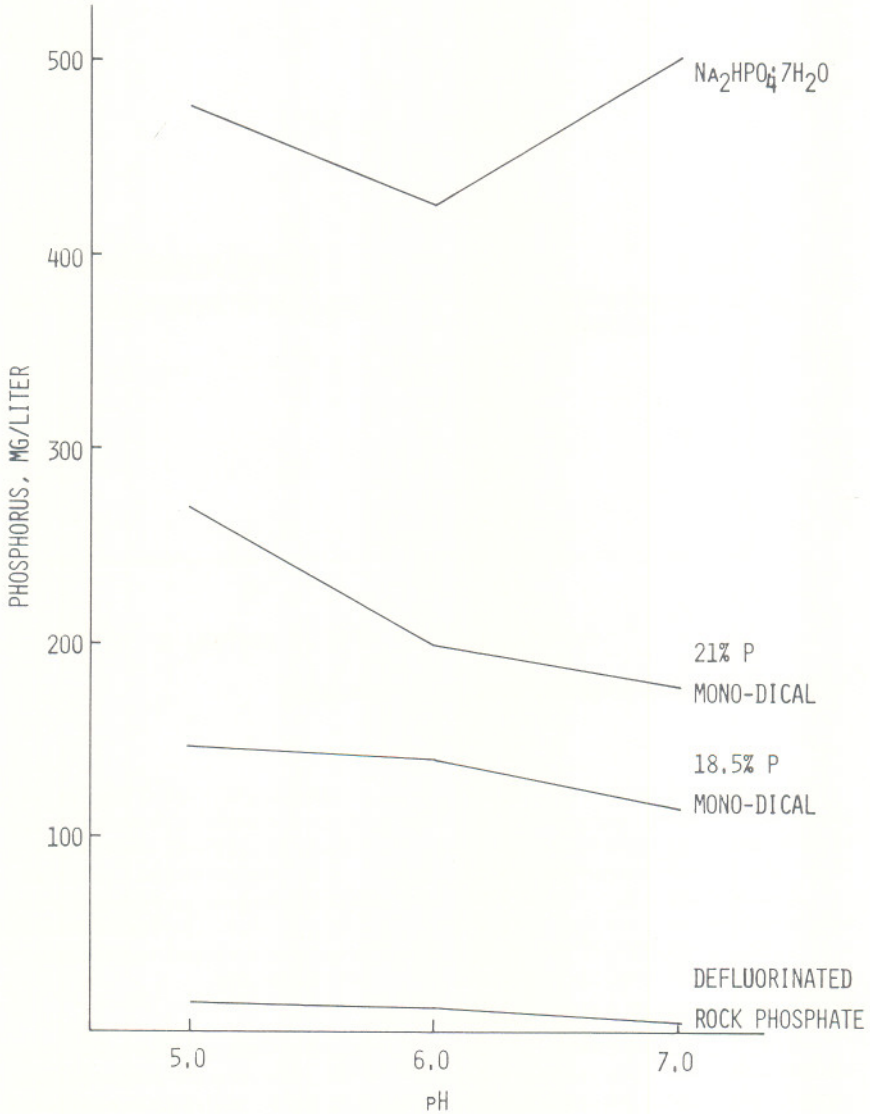


Figure 2. Effect of pH phosphorous solubility

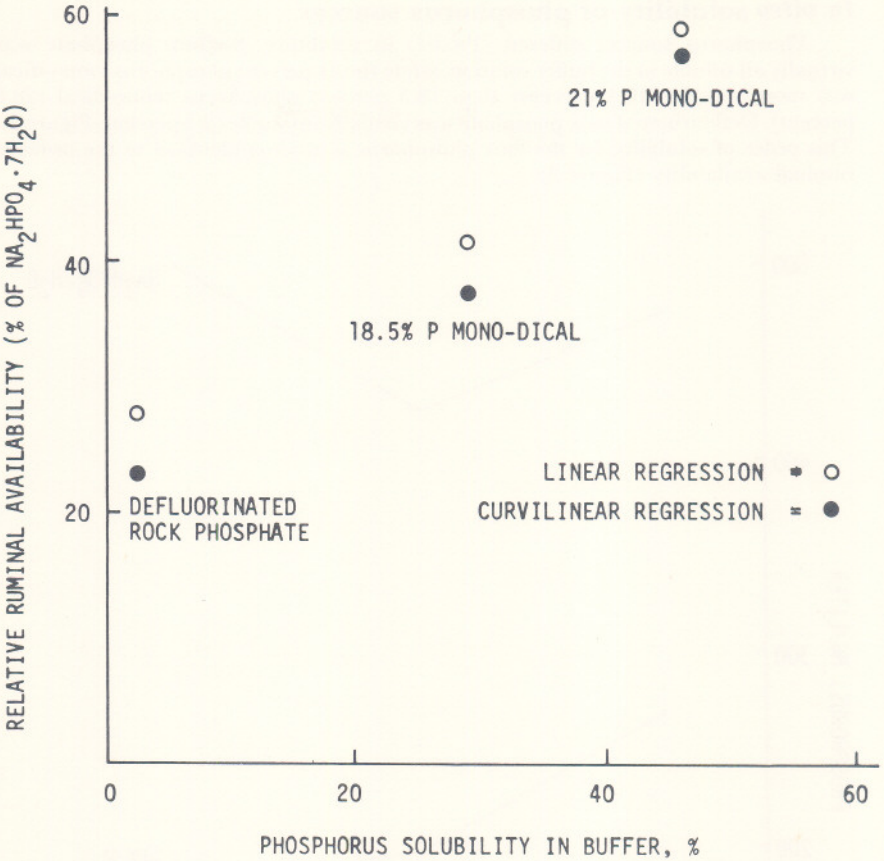


Figure 3. Ruminal availability vs. buffer solubility

The standard sodium phosphate was more soluble at pH 5 and 7 than at pH 6. Both mono-dicalcium phosphates exhibited increased solubility at lower pH values. Defluorinated rock phosphate was virtually insoluble at all pH levels. Over 90 percent of the phosphorus ultimately found in solution was in solution within two minutes.

Results indicate that phosphorus from commercial inorganic phosphorus sources may be more available in the rumen at lower ruminal pH values. The limited solubility of rock phosphate may need to be considered when using it as a supplemental source of phosphorus, if low ruminal phosphorus levels reduce digestion.

Phosphorus and ruminal digestion

Some workers have indicated that cellulose digestion and cell growth by ruminal microbes decrease when ruminal phosphorus is low. However, the ruminal requirement for phosphorus has not been quantitated. The dietary phosphorus requirement for maintaining beef cattle is listed as .18 percent of the dry ration (NRC Beef Cattle, 1976). In this study, rations containing phosphorus at levels of .119 percent and .227

Table 3. Calculation of ruminal availability of phosphorus sources

Phosphorous source	Phosphorus		Ruminal phosphorus	Ruminal availability[a]	Ruminal availability[b]
	Basal ration	Added			
	%	%	mg/1	%	%
$Na_2HPO_4 \cdot 7H_2O$	.067	.0560	406 ± 26	100	100
$Na_2HPO_4 \cdot 7H_2O$	.067	.1060	434 ± 14	100	100
21% P dical	.067	.0885	397 ± 16	59.3	57.1
18.5% P dical	.067	.1038	375 ± 25	42.2	37.6
Defluor. P	.067	.1000	336 ± 14	28.4	23.0
None	.067	.0000	264 ± 15	—	—

[a]Calculated from linear standard curve as follows:

$$\text{Availability} = 100 \times \frac{\text{Availability P}}{\text{Added P \%}} = 100 \times \frac{(\text{Ruminal P} - 264)/142 \times .056}{\text{Added P\%}}$$

[b]Calculated from curvilinear standard curve.

Table 4. Effect of phosphorus level on ruminal and total-tract digestibility

Item	Phosphorus in ration	
	.119%	.227%
Dry matter intake, g/day	8025	8075
Phosphorus intake, g/day	9.5[a]	18.3[b]
Fecal output, g/day	2857.0	2693.7
Fecal phosphorus, %	.307	.369
Phosphorus retention, g/day	1.0[a]	8.3[b]
Dry matter digestibility, %	64.8	67.0
Organic matter digestibility, %	64.8	66.9
Ruminal phosphorus mg/liter	208.1[a]	398.1[b]
Ruminal disappearance per day		
Cottonseed hulls, %	8.3	8.2
Cotton duck, %	22.5	23.2
Ground corn grain, %	42.2	41.0

[ab]Means in a row with different superscripts differ significantly ($P < .01$).

percent were fed to determine whether a phosphorus-deficient ration and low ruminal phosphorus would alter ruminal and total-tract digestibility. The low-phosphorus ration reduced daily phosphorus retention and phosphorus concentration in ruminal fluid (Table 4). However, differences in dry matter digestibility or organic matter digestibility for the two rations were very small. Ruminal digestion also appeared similar for the cattle fed the two rations.

Since no relationship was detected, this implies that a ruminal phosphorus concentration of 210 mg per liter is adequate for digestion, though inadequate for maximum phosphorus retention. This suggests that availability of phosphorus in the rumen is less important than availability of phosphorus in the total digestive tract. Consequently, phosphorus solubility at the acidic conditions of the abomasum may be more indicative of the value of phosphorus to ruminants than would be phosphorus solubility at the ruminal pH or ruminal phosphorus concentration.

The Effect of Additional Nitrogen Fertilization on the Nutritive Value of Grain Sorghum

C. A. Hibberd, D. E. Weibel, D. G. Wagner and R. L. Hintz

Story in Brief

Five varieties of grain sorghum were grown under dryland conditions to investigate the effect of additional nitrogen (N) fertilizer on chemical composition and relative digestibility of the sorghum. Addition of 50 extra pounds of nitrogen per acre increased berry size markedly and crude protein content slightly. Tannin content was decreased for the high tannin Darset variety. Although *in vitro* digestibility was not consistently increased by fertilizer addition, detrimental effects were not observed. Notably, these results were observed during a dry season when the benefits of additional fertilizer may not be as apparent as during a normal growing season.

Introduction

Several factors have been shown to affect the nutritive quality of grain sorghum. Specifically, variety (type), processing or location effects may alter the nutritive value of grain sorghum. Another major factor, which can be manipulated during the growing season, is the level of nitrogen fertilization. Extra nitrogen added during the growth stage of the sorghum plant could increase protein deposition, as well as yield. Because the protein matrix of the sorghum kernel appears to affect accessibility to the starch granules, increased protein deposition might hinder starch digestibility. Consequently, the purpose of this study was to investigate the effect of additional nitrogen fertilizer on the nutritive quality of several varieties of grain sorghum.

Experimental Procedure

Five varieties of grain sorghum (Table 1) were grown and harvested under identical dryland conditions at the Perkins Agronomy Research Station. Sorghum types represented were a waxy (Dwarf Redlan), a waxy bird resistant (1133), a normal (Redlan) and two normal bird resistants (ROKY 78 and Darset). Midway through the growing season, an additional 50 pounds of nitrogen per acre was added to half of the plots to provide the increased N treatment. After harvesting, each grain sample was finely ground in a Udy mill for chemical analysis or through a 20-mesh screen in a Wiley mill for evaluation of relative digestibility. Starch content was measured as α-linked glucose polymers via an enzymatic assay, and tannin content was determined by a modified vanillin-HCl assay. Relative digestibility was evaluated using a single stage *in vitro* dry matter disappearance (IVDMD) procedure. Grain samples were placed in 50 ml centrifuge tubes and inoculated with buffered rumen fluid. After a 24-hour incubation, the tubes were centrifuged and dried, and IVDMD was calculated by difference. An *in vitro* gas production (IVGP) procedure was used to measure relative starch availability. A small quantity of each grain sample was placed in a 50 ml Erlenmeyer flask and inoculated with an aqueous solution of amyloglucosidase (starch

Table 1. Descriptive characteristics of grain sorghum varieties

Variety	Seed coat color	Endosperm color	Endosperm starch	Classification
Dwarf Redlan	red	white	waxy	Waxy
1133	brown	yellow	waxy	Waxy-BR[a]
Redlan	red	white	normal	Normal
ROKY 78	brown	yellow	normal	Normal-BR
Darset	brown	white	normal	Normal-BR

[a]BR = bird resistant.

Table 2. Berry size, starch and tannin content of control and fertilized grain sorghum

Variety	Relative[1] berry size		Starch[2] content (%)		Tannin (cat. eq./g)	
	control	fertilized	control	fertilized	control	fertilized
Dwarf Redlan	3.09[b]	3.12[b]	67.4	66.0	.06[d]	.04[d]
1133	2.64[cd]	2.80[c]	63.1	64.1	.91[b]	.88[b]
Redlan	2.52[d]	3.46[a]	64.6	65.3	.05[d]	.04[d]
ROKY 78	3.48[a]	3.32[a]	64.3	64.1	1.00[b]	.92[b]
Darset	2.51[d]	3.01[b]	65.5	65.7	1.41[a]	.54
Mean	2.85	3.14	65.0	65.0	.68	.48

[1]Weight (g) of 100 kernels.
[2]No significant differences (P>.05).
[abcd]Means with different superscripts are significantly different (P<.05).

digesting enzyme) and commercial baker's yeast. Gas produced by the yeast was trapped in inverted burets and IVGP expressed as ml gas per gram of dry matter. Differences between varieties were estimated by method of least squares, and significant differences between varietal means were detected with Tukey's HSD test.

Results and Discussion

Minimal rainfall was recorded after the application of the additional nitrogen fertilizer. Consequently, the results of this study may not be as dramatic as might be expected. Some effects were noted, however, as additional nitrogen fertilizer did increase berry size in four of the five sorghums (Table 2). This increase was most dramatic (P<.05) for the Redlan (Normal) and Darset (Normal-BR). Starch content was not affected by fertilization for any of the varieties tested. In addition, fertilization appeared to beneficially decrease the tannin content of each sorghum (Table 2). Tannin content was decreased most drastically for the normally high tannin Darset variety (Normal-BR).

The effect of additional nitrogen fertilizer on crude protein content varied dependent on variety (Table 3). Percent crude protein was increased (P<.05) for the sorghums with waxy starch (Dwarf Redlan and 1133), resulting in increased protein deposition per kernel. Additional nitrogen fertilization increased protein deposition in the Redlan and Darset varieties by increasing berry size. Consequently, crude protein content per berry was increased in four of five sorghums via different mechanisms. Assuming that berry numbers were not changed by nitrogen addition, total protein yield per acre would be expected to increase dramatically.

Relative digestibility (IVDMD) of most varieties was not changed by the addition of nitrogen fertilizer (Figure 1). A small increase in IVDMD was observed for the high tannin Darset variety. This response may be a result of the decreased tannin content

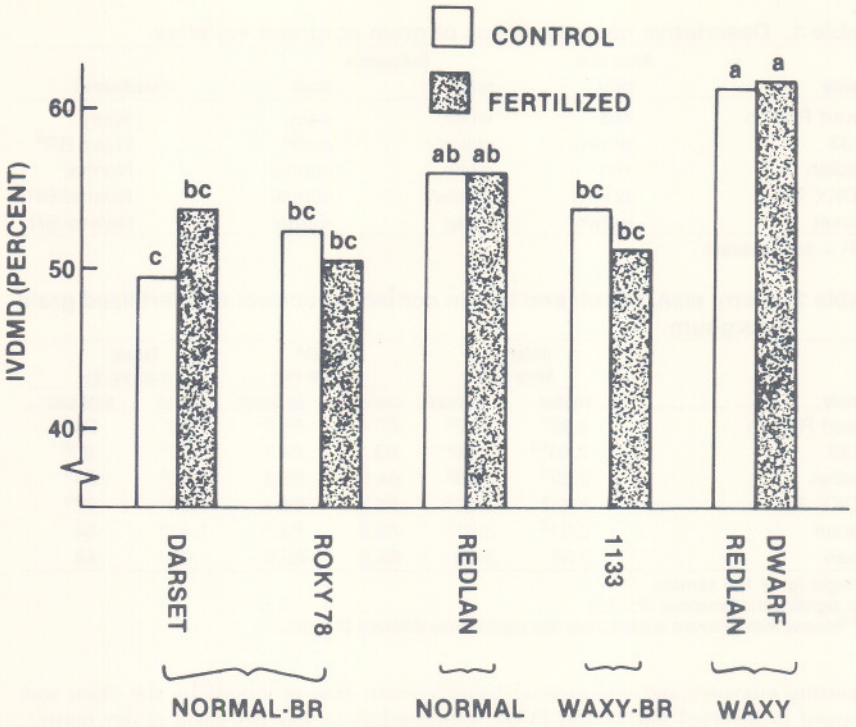


Figure 1. ***In vitro*** **dry matter disappearance of control and fertilized grain sorghums, (means with different superscripts are significantly different, P< .05).**

noted earlier. In addition, starch availability (measured by IVGP) was increased (P<.05) for the fertilized Darset variety although other sorghums were not markedly altered (Figure 2).

These studies suggest that the chemical composition of grain sorghum can be changed by supplying additional nitrogen fertilizer during the growth phase of the

Table 3. Protein content of control and fertilized grain sorghums

	Crude protein[1] control (%)		Crude protein[2] content (mg/berry)	
Variety	control	fertilized	control	fertilized
Dwarf Redlan	12.8^{e}	13.8^{cd}	3.96	4.30
1133	13.2^{de}	14.1^{bc}	3.48	3.95
Redlan	14.9^{a}	14.7^{ab}	3.75	5.09
ROKY 78	12.8^{e}	12.8^{e}	4.45	4.25
Darset	14.2^{bc}	14.3^{abc}	3.56	4.30
Mean	13.6	13.9	3.84	4.38

[1]Variety-by-fertilizer interaction significant (P<.05).
[2]Mg crude protein/berry = (relative berry size ÷ 100) × crude protein %.
^{abcde}Means with different superscripts are significantly different (P<.05).

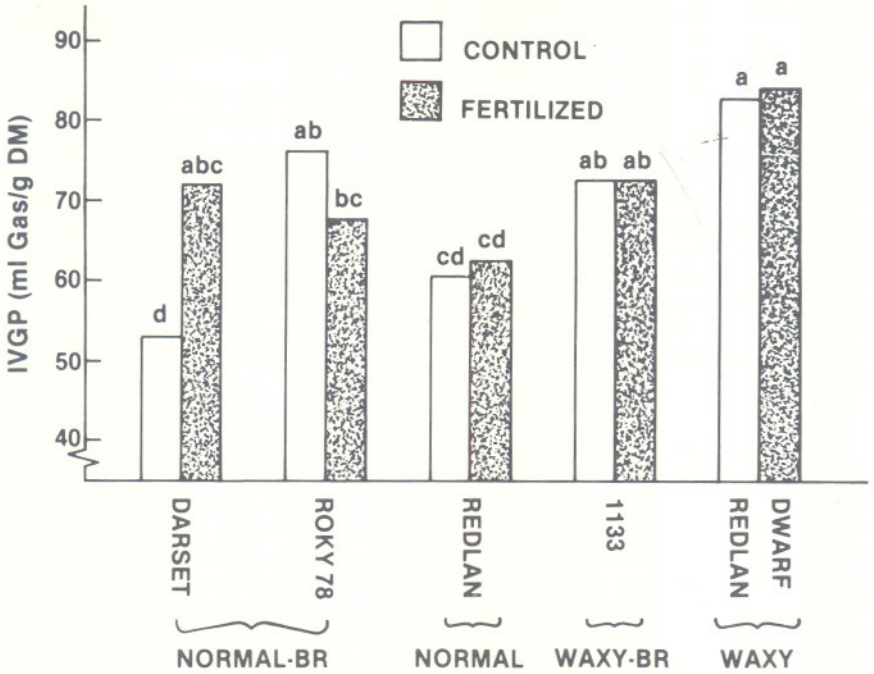


Figure 2. *In vitro* gas production of control and fertilized grain sorghums. (Means with different superscripts are significantly different, P<.05).

plant. Specifically, the decrease in tannin content noted for the Darset variety may be particularly beneficial. Additional fertilizer, however, did not have a consistent effect on digestibility (IVDMD). Because protein shielding of starch appears to be a major factor affecting the digestibility of grain sorghum, additional nitrogen fertilizer could theoretically increase protein content and subsequently decrease digestibility. Since no detrimental effects were observed, the addition of extra nitrogen to growing grain sorghum should not present a nutritional problem.

Roughage - Concentrate Associative Effects

R. G. Teeter, F. N. Owens
and D. R. Gill

Story in Brief

Twelve growing steers (657 lb) were fed whole shelled corn rations at two levels of feed intake. Cottonseed hulls or chopped alfalfa hay was added to the corn to form 10- and 40-percent roughage-supplemented rations for each roughage. Increasing ration

intake from a maintenance level to 1.8 times maintenance decreased dry matter digestibility from 87.1 to 83.3 percent. Roughage addition reduced fecal starch at high (10.1 vs. 6.6 percent) but not low ration intakes.

Starch digestibility at the maintenance level of intake decreased with addition of either roughage (.8 percent decrease for each percentage of added alfalfa and .07 percent for cottonseed hulls). Starch digestibility at the higher intake level increased with .10 percent added roughage (.10 percent for each percentage of added alfalfa and .26 percent for cottonseed hulls) and decreased with further addition of roughage (.06 percent for each 1 percent addition of alfalfa and .03 percent for cottonseed hulls). Whole corn kernels appearing in feces accounted for 22 percent of the total fecal starch with 40 percent cottonseed hulls in the ration in contrast to 69 percent for other treatments, indicating that whole kernels represent a large portion of the total fecal starch with these rations. Cottonseed hulls at a high level appear to increase starch digestion by increasing rumination and reducing the amount of whole corn passing through the tract.

Introduction

Roughages are included in feedlot rations to supply bulk to aid in prevention of acidosis and to enhance palatability. Many workers have examined roughage effects on animal performance. These studies usually have replaced grain with forage and thereby decreased concentrate intake while increasing dry-matter intake. Recent results have shown a marked positive effect of cottonseed hulls and a negative effect of chopped alfalfa hay on starch digestibility of whole shelled corn when a constant amount of corn was fed (Teeter, 1980). The objective of this study was to further examine starch digestibility of a whole shelled corn ration with added cottonseed hulls or chopped alfalfa hay.

Materials and Methods

Twelve growing hereford steers were allotted to five rations (Table 1) and fed at intake levels of maintenance or 1.8 times maintenance. The five rations were: 1) whole shelled corn (WSC), 2) WSC + 10 percent cottonseed hulls, 3) WSC + 40 percent cottonseed hulls, 4) WSC + 10 percent chopped alfalfa hay and 5) WSC + 40 percent chopped alfalfa hay. Steers were rotated among rations for four periods.

To examine the influence of roughages on particle size of starch in feces, fecal samples were sieved through .31-inch mesh screens and analyzed for starch.

Results and Discussion

Increasing feed intake from 1 to 1.8 times maintenance reduced dry-matter digestibility a mean of 4.4 percent (Table 2). This indicated that digestibility estimates

Table 1. Supplemented composition (pelleted)

	%
Dehydrated alfalfa meal	1.04
Soybean meal	60.0
Cottonseed meal	22.7
Calcium carbonate	10.5
Potassium chloride	2.5
Salt	2.7
Rumensin (60 gram)	0.17
Tylan 40	0.09
Vitamin A 10m/lb	0.15
Trace mineral	0.15

Table 2. Fecal and starch digestibility

	Dry matter digestibility		Fecal starch		Starch digestibility		1.8 X maintenance starch appearing as whole corn	
	Maintenance	1.8 X Maintenance	Maintenance	1.8 X Maintenance	Maintenance	1.8 X Maintenance	% of Fed	% of Fecal
Basal	93.1[a]	89.5[a]	6.2[ab]	19.0[a]	99.2[a]	96.3[bc]	3.2[a]	75[a]
10% alfalfa	89.4[b]	86.3[ab]	7.6[ab]	10.3[bc]	98.3[ab]	97.3[ab]	3.8[a]	68[a]
10% CSH	88.5[b]	84.7[b]	8.5[a]	5.0[bc]	98.1[ab]	98.9[a]	4.5[a]	67[a]
40% alfalfa	86.3[c]	83.3[b]	7.0[ab]	11.4[b]	96.5[b]	93.9[c]	4.6[a]	67[a]
40% CSH	78.4[d]	72.8[c]	3.7[b]	4.9[c]	97.9[ab]	96.6[ab]	.8[b]	22[b]

[abcd]Means in a column with different superscripts differ significantly ($P<.05$).

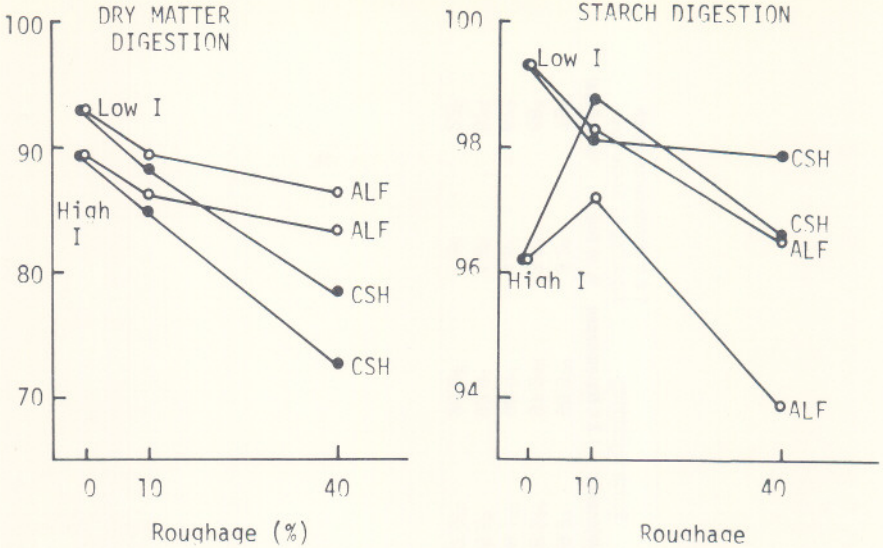


Figure 1. Effect of roughage addition on ration dry matter digestibility

Figure 2. Effect of roughage addition on starch digestibility

determined at low levels of intake may overestimate digestibility at higher, more practical feed intake levels. Fecal starch was low when rations were fed at maintenance levels of intake but increased with feed intake. Percent fecal starch was negatively related with starch digestibility though the relationship was not close. Fecal starch values without fecal output estimates appear to be a poor predictor of starch digestibility across levels of roughage.

Ration dry-matter digestibility (Figure 1) was reduced with roughage addition. These results indicate that roughages have a lower digestibility than corn grain. Roughage effects varied with level of intake, level of roughage and source of roughage (Figure 1). At maintenance intakes, addition of 10 percent roughage lowered starch digestibility while at 1.8 maintenance, 10 percent roughage addition enhanced starch digestibility. Adding 40-percent alfalfa hay reduced starch digestibility at both levels of intake while cottonseed hulls only had a depressing effect at the maintenance level of intake. With whole corn rations fed at a low level of feed intake, including a low level of roughage appears undesirable while adding roughage at a higher level of feed intake seems desirable. When higher roughage levels are fed, cottonseed hulls cause less depression in starch digestion than chopped alfalfa hay. From 22 to 75 percent of the starch in feces was found in particles caught by a .3-inch screen. These were primarily intact corn kernels. With 40-percent cottonseed hulls and the higher level of feed intake, the proportion of starch appearing as whole corn kernels in the feces of steers was much lower than with other rations fed. This may reflect increased chewing or rumination with cottonseed hulls in the ration. Further study of the effects of specific roughage sources and levels on starch digestion is needed.

Literature Cited

Teeter, R. G. and F. N. Owens. 1980. Okla. Ag. Exp. Sta. Res. Rep. 156.

Finishing Steers on Conventional Grain Diets vs. Forage Plus Grain, With and Without Monensin

S. C. Ostilie, D. G. Wagner and Phil Sims

Story in Brief

Twenty-nine crossbred steers were allotted to three treatments: 1) high-concentrate feedlot ration (no monensin), 2) sorghum-sudan pasture supplemented with concentrate at 1 percent (as-fed basis) of body wt or 3) Treatment 2, plus monensin at 150 mg/head/day. In this experiment all animals were slaughtered at the same time, eliminating age differences among treatment groups.

Steers receiving the high-concentrate finishing ration made faster gains ($P<.05$) and had higher ($P<.05$) carcass grades than either of the two groups on pasture. However, the feedlot animals had significantly smaller rib eye areas than the pasture animals. The feedlot steers and those receiving monensin on pasture showed similar but heavier carcass weights ($P<.05$) than those on pasture not fed monensin. Moreover, feeding supplemental monensin on pasture increased ($P<.05$) daily gain (+.23 lb/day), rib eye area, fat thickness and quality grade compared to those not receiving supplemental monensin. However, yield grade was lowered slightly. Steers receiving monensin on pasture required 0.83 lb less supplemental feed/lb of gain than those not fed monensin. Since the amount of supplement fed to cattle on the sorghum-sudan pasture was controlled, no difference in grain intake was noted.

Introduction

One of the major objections to finishing cattle on forage is that the animals tend to make slower gains than animals in a feedlot. In addition, the carcasses of forage-finished beef tend to grade lower due to a decreased amount of marbling. One way to overcome these difficulties might be to supplement animals on pasture with some grain. Another might be to feed supplemental monensin. The effect of monensin on certain carcass characteristics, however, has received little study.

The objective of this study was to compare the weight gains and carcass characteristics of animals finished on forage plus supplement, either with or without monensin, to those of animals in a feedlot situation. Although not reported here, detailed lipid analyses were also conducted to ascertain changes in fat composition.

Materials and Methods

Twenty-nine Brangus x Angus x Hereford steers were randomly allotted to three finishing programs: 1) a high-grain finishing ration, 2) sorghum-sudan pasture plus supplemental concentrate fed at 1 percent of body weight and 3) Treatment 2 plus 150 mg monensin per day. The ingredient composition of the feeds is given in Table 1. Steers on the two pasture treatments were grazed in two nearly identical pastures and then rotated to two new pastures as needed to insure an adequate forage supply. By the

In cooperation with the U.S. Southern Great Plains Field Station, Woodward, Oklahoma.

Table 1. Composition of feeds

Type of feed	Ingredient	% in feed
Supplement for animals on pasture[1]	Cracked corn	36.0
	Cracked milo	36.0
	Cottonseed meal	24.8
	Molasses	2.0
	Calcium carbonate	1.2
Feedlot ration	Cracked corn	40.0
	Cracked milo	40.0
	Cottonseed meal	7.0
	Cottonseed hulls	10.0
	Molasses	2.0
	Calcium carbonate	0.8
	Dicalcium phosphate	0.2

[1]Monensin was added to obtain a daily intake of 150 mg per day for one pasture treatment. No monensin was added to the feedlot ration.

last month of the study, the sorghum-sudan pasture had deteriorated through the loss of leaves via grazing but still produced an acceptable forage supply until cattle slaughter.

The steers averaged 771 lb when the experiment began on October 3, 1979. The animals were slaughtered on January 7, 1980, after a 96-day feeding period. The trial was conducted at the U.S. Southern Great Plains Field Station located at Woodward, Oklahoma. Weights on the animals were obtained after feed had been withheld for 24 hours.

Results and Discussion

The weight gains of the animals are presented in Table 2. Steers on pasture plus monensin made more rapid gains than those which did not receive monensin. While the weight gains for the feedlot group were generally low, these animals still gained considerably faster than either of the pasture groups. The lower-than-expected weight gains for the feedlot cattle may be due partly to the fact that the calves were very fleshy and young when the trial started. However, there was no difference in carcass weights between the feedlot group and the steers receiving monensin on pasture, both of which were somewhat heavier than pasture-fed steers receiving no monensin. There was some

Table 2. Performance data

	Treatment		
Item	Feedlot	Pasture + supplement no monensin	Pasture + supplement with monensin
No. animals	9	10	10
ADG, lb	1.64[a]	1.22[c]	1.45[b]
Initial weight, lb	771	771	771
Final weight, lb	928[a]	888[c]	910[b]
Feed intake/day, lb[d]	13.2	6.37	6.37
Feed/gain, lb/lb[d]	8.03	—	—
Supplement/gain, lb/lb[de]	—	5.23	4.40

[abc]Means without a line not sharing a common superscript differ significantly ($P < .05$).
[d]DM basis.
[e]Sorghum-sudan pasture fed *ad lib*.

Table 3. Carcass characteristics

Trait	Treatment		
	Feedlot	Pasture + supplement no monensin	Pasture + supplement with monensin
Carcass weight, lb	534.2[a]	520.2[b]	534.1[a]
Dressing percent	57.6[a]	58.6[b]	58.8[b]
Rib eye area, in.[2]	10.57[a]	10.80[b]	11.80[c]
Fat thickness, in.	.27[a]	.18[c]	.22[b]
Marbling score[1]	9.3[a]	6.7[b]	7.1[b]
Quality grade[2]	8.2[a]	7.1[c]	7.5[b]
Yield grade	2.31[a]	1.91[b]	1.87[b]

[1]Marbling score: 11 = average slight, 8 = average traces, 5 = average practically devoid.
[2]Quality grade: 10 = average good, 7 = average standard.
[abc]Means within a line not sharing a common superscript are significantly different (P<.05).

indication of greater muscling in the animals receiving monensin since their rib eye areas were significantly different from either of the other groups. The steers which were on pasture but received no monensin also had significantly greater rib eye areas than the feedlot steers. This probably indicates that the feedlot steer deposited more external fat than the pasture groups, but they also produced less lean tissue.

Monensin increased gains on pasture (P<.05) by .23 lb/day. Final weight, carcass weight, rib eye area, fat thickness and quality grade were all significantly increased by monensin. Moreover, monensin saved .83 lb of supplemental feed/lb of gain when fed to cattle on pasture. Monensin is presently legalized for use in both stocker and feedlot cattle.

The Effects of Decoquinate on Gains of Stressed Cattle

**S.R. Rust, D.R. Gill,
E.J. Richey and F.N. Owens**

Story in Brief

The influence of decoquinate, a coccidiostat, on gains of newly received cattle was measured in three trials with a total of 230 cattle. The coccidiostat was fed for approximately 30 days after which steers grazed native range. The addition of decoquinate did not alter performance during the first 30 days. During the subsequent 4 to 9 months of grazing, gain was increased by 9.9 percent in one trial, but the drug had less effect (+1.1 percent) in the other two trials.

Introduction

Severe infestations of coccidia can reduce cattle performance and thereby reduce profits. Decoquinate is a feed additive which effectively restricts coccidial growth in the intestinal tract of cattle. The purpose of this study was to determine the effect of decoquinate on gains of pasture cattle.

Materials and Methods

Three trials were conducted to determine the effectiveness of decoquinate administration on gains of stocker cattle purchased in and trucked from the southeastern U.S. Upon arrival, calves were allowed free access to prairie hay and water and fed two pounds of a 40-percent protein pellet (Table 1) per head daily in pens with about 10 head per pen. The decoquinate was incorporated into the protein pellet. After approximately 30 days in confinement, the calves in each trial grazed a common native Osage range for 4 to 9 months after which cattle were weighed.

Results and Discussion

The pelleted protein supplement in Table 1 has worked very well in our trials with stressed cattle at the Pawhuska Veterinary Research Station. Decoquinate treatment did not alter gains of calves during the first 30 days. During the 4- to 9-month grazing period, however, daily gains were increased by 9.9 percent in one trial, but treatment had little influence on gain in the other two trials. This suggests that some groups of cattle will respond more to treatment than others. Controlling the proliferation of coccidia of newly received cattle may reduce subsequent deleterious effects of coccidia at a later time.

Table 1. Supplement for receiving cattle[a]

Ingredient	%
Soybean meal	90.9
Deccox[b]	3.3
Salt	3.0
Dicalcium phosphate	2.8
Vitamin mineral premix	0.1

[a]Made into 3/16 inch pellet and fed at the rate of 2 lb/day.
[b]Trade name for Rhone-Poulene Inc., Atlanta, Georgia, 30342. The active ingredient is decoquinate.

Table 2. Effects of decoquinate on gains of stressed cattle

	Trial			Deccox[a]		Location[b]	
	1	2	3	—	+	Drylot	Trap
Days, No.	29	44	29	—	—	—	—
Early ADG	2.81[e]	1.39[c]	1.74[d]	2.00	2.00	2.04	1.97
Days, No.	167	280	137	—	—	—	—
Late ADG	1.58[d]	1.32[c]	1.93[e]	1.56[f]	1.61[g]	1.55	1.61
Days, No.	196	324	166	—	—	—	—
Overall ADG	1.75[d]	1.33[c]	1.91[e]	1.61[f]	1.67[g]	1.61	1.67

[a]Trade name for Rhone-Poulene Inc., Atlanta, GA 30342. The active ingredient is decoquinate.
[b]Type of confinement for first month after arrival.
Trap= 4 acres Drylot = 1/4 acre
[cde]Means in a row under a specific heading with different superscripts differ statistically (P< .01).
[fg]Means in a row under a specific heading with different superscripts differ statistically (P< .3).

Effects of Anthelmintics and Leptospirosis Vaccination on Performance of Feedlot Cattle

S.R. Rust, D.R. Gill, and J.J. Martin

Story in Brief

Two wormers (Tramisol[1] and Albendazole[2]) were administered to 125 crossbred steers (400 lb). The Tramisol was administered either as a liquid drench or injected intramuscularly and Albendazole was given as an oral bolus. The steers were given an IBR/Lepto[3]vaccination (for IBR and Leptospira pomona) upon arrival. Half the steers in each pen were given a Leptomune 5[4], a five-way Leptospirosis vaccination. Tramisol-treated steers gained slightly faster and were slightly more efficient than Albendazole-treated steers. The injectable and liquid forms of Tramisol had similar effects on animal performance. The additional leptospirosis vaccination tended to reduce daily gains.

Introduction

Internal parasites can reduce feedlot performance and increase cost of beef production. This study was conducted to compare two different chemical worming agents and determine if an injectable anthelmintic may produce superior performance. Finally, the relative effects on performance of a Leptomune 5 injection was measured. Only performance responses were monitored so drug effectiveness was not directly measured.

Material and Methods

Two different wormers (Tramisol and Albendazole) were administered during arrival processing to 125 crossbred steers (400 lb) obtained from the southeast U.S. The Tramisol was injected intramuscularly or given as a liquid drench. The Albendazole was administered as an oral bolus. Four pens of cattle were alloted to each treatment. Every animal received an IBR/Lepto vaccination upon arrival. Half the animals in each pen received an additional Leptomune 5 injection. The 60-percent concentrate, 13-percent crude protein diet (Table 1) was fed twice daily. The protein source in the supplement was soybean meal (Table 2). Final weights were obtained after 32 days on feed. A 4-percent pencil shrink was applied to the 32-day weights before the gain, and efficiency was calculated.

Results and Discussion

Feed intake, gain and feed efficiency results are presented in Table 3. Cattle receiving Tramisol by either administration method had 6.8 percent greater gains and

[1]American Cyanamid, Princeton, N.J.
[2]Smith Kline Animal Health Products, Philadelphia, Pennsylvania.
[3]Abbott Laboratories, North Chicago, Illinois.
[4]Beecham Laboratories, Bristol, Tennessee.

Table 1. Ration ingredients

Ingredient	%
Cottonseed hulls	20.00
Alfalfa	20.00
Steam-flaked corn	27.25
Oats	23.25
Supplement	3.00
Soybean meal	6.50

Table 2. Supplement composition

	%
Soybean meal	67.0
Salt	10.0
Limestone	23.0
Trace mineral	+
Rumensin (60 g/lb)	20 g/ton
Vitamin A	25,000 IU/hd/day

Table 3. Effects of wormer administration on cattle performance (32 days)

	Tramisol		
Item	Liquid	Injectable	Albendazole
Cattle, no.	41	42	42
Feed intake, lb/day	13.1	12.9	13.0
ADG, lb/day	2.96	3.03	2.81
Feed/gain	4.43	4.25	4.65

Table 4. Effects of leptospirosis vaccination on cattle performance

Item	Control	Vaccinated
Cattle, no.	59	66
ADG, lb/day	3.02	2.84

were 6.7 percent more efficient than cattle receiving Albendazole, though these differences were not statistically significant. The two forms of Tramisol had similar effects on ADG and efficiency. Administration of the Leptomune 5 vaccine reduced daily gains of steers by 6 percent (Table 4).

A Preliminary Report on the Effect of Increased Feed Intake During Late Gestation

W. R. Walker, C. V. Maxwell, R. L. Hintz, K. Brock

Story in Brief

The effects of increasing the feed intake of sows during late gestation were studied in a trial utilizing 34 Yorkshire sows and 29 Yorkshire gilts. Treatments were a normal level of feed intake (4 lb/head/day) throughout gestation and a high level of feed intake (7 lb/head/day) from 90 days of gestation to farrowing.

Based on this preliminary analysis, treatment did not significantly affect sow weight, litter size and survivability, pig weights and pig performance. Additional replications will give more precise comparisons.

Introduction

A low survival rate of baby pigs from birth to weaning is a major problem in the swine industry. Estimates of survivability range from 70 to 80 percent. One of the major factors that has been shown to influence survival in baby pigs is birth weight. Past research indicates heavier birth weight in pigs results in increased survival to weaning. Early studies demonstrate that most of the weight, protein, calcium and phosphorus is deposited in the fetuses during the last 21 days of pregnancy. Since birth weight may be related to energy intake of the sow during gestation, the level of nutrient intake during the last trimester of pregnancy should have an influence on the weight and composition of the newborn pig, thus having a major effect on the pig's chances for survival.

This study is being conducted to determine the effects that the nutrition of the sow during late gestation has on litter size, birth weight and survival of pigs and on subsequent performance of pigs. The purpose of this report is to present preliminary results obtained over the first half of this trial.

Materials and Methods

A feeding study was conducted with 34 Yorkshire sows and 29 Yorkshire gilts to determine the effect on subsequent productivity of increasing the level of nutrition during late gestation. Prior to breeding, gilts and sows were fed a standard 14-percent crude protein corn-soybean meal ration. The specific feeding regime for each treatment through the entire gestation period is explained in Table 1. After farrowing, all sows were allowed to consume the 14-percent protein diet on an *ad libitum* basis throughout lactation. Creep feed was provided to pigs at 3 weeks of age and continued until weaning at 6 weeks of age. After weaning all sows were returned to the prebreeding level of feed intake (4.0 lb/head/day) and rebred, when possible, on the first estrus.

Table 1. Feed intake for each treatment (lb)

	Treatment			
	1		2	
	Gilts	Sows	Gilts	Sows
Prior to breeding	5[a]	4[a]	5[a]	4[a]
After breeding (day 1-90)	4[a]	4[a]	4[a]	4[a]
90 days (gestation to farrowing)	4[a]	4[a]	7[a]	7[a]

[a]Feed increased 1 additional pound during the months of December to February.

Table 2. Least squares means of sow weights for each treatment

	Treatment	
	Normal intake (lb)	High intake (lb)
Breeding	394.4	371.2
90 days gestation	431.9	431.7
110 days gestation	452.5	458.5
Farrowing	425.8	429.5
21 days lactation	405.4	397.9
42 days (weaning)	415.8	400.9

Gilts and sows were kept in dirt lots throughout the breeding and early gestation period. Pens were equipped with individual feeding stalls and nipple waterers. Gilts and sows were fed once daily in the morning. Shelter was provided in each lot with foggers for cooling during periods of high temperature and straw for bedding during periods of cold temperature. At approximately 110 days of gestation, gilts and sows were moved to a farrowing unit and kept in farrowing crates until 21 days after farrowing. Heat lamps were provided to supply supplemental heat to pigs. At 21 days post-farrowing, sows and litters were moved to nursery pens where pigs were allowed access to creep feed and water *ad libitum*. Nursery pens were on concrete floors with shelter provided for both sow and pigs. At 42 days post-farrowing pigs were weaned and the sows returned to dirt lots. Measurements made included: 1) backfat probe of gilts and sows at breeding and at 90 days of gestation; 2) gilt and sow weight at breeding, 90 days and 110 days of gestation as well as within 24 hours of farrowing, on day 21 of lactation and at weaning; 3) individual pig weight at birth (live and dead pigs), 21 days and at weaning; 4) total and live pigs at birth, 21 days and at weaning; 5) feed consumption of sows from parturition to day 21; 6) consumption of creep feed by the baby pigs from 3 weeks until weaning; and 7) the number of days to first estrus after weaning.

Results and Discussion

At this time there are no statistically significant effects that can be attributed to the treatments applied for any of the traits analyzed. It appears, however, that sows on the higher level of total feed intake during late gestation may be heavier at 110 days of gestation (Table 2). Although the number of live pigs per litter at birth appears to be higher for sows on the normal level of intake, this difference is not apparent at 42 days (Table 3). Pigs from sows on the high level of feed intake appear heavier at birth; however, this difference also seems to disappear by 42 days of age (Table 4).

Table 3. Average litter size and survival rate

Treatment	Number of live pigs			Survival rate		
	Birth	21 days lactation	42 days (weaning)	Birth[1]	21 days lactation	42 days[3] (weaning)
Normal intake	9.5	7.6	7.1	90.8	80.9	76.4
High intake	8.7	7.5	7.1	88.8	86.9	82.2

[1]Number of pigs born alive ÷ total pigs born.
[2]Number of pigs alive at 21 days ÷ number of pigs born alive.
[3]Number of pigs alive at 42 days ÷ number of pigs born alive.

Table 4. Least square means of pig weights for each treatment

	Treatment	
	Normal intake (lb)	High intake (lb)
Birth	2.8	3.0
21 days	11.2	11.4
42 days (weaning)	22.5	22.5

This is a preliminary report on a study that is approximately one-half complete; therefore, additional replications of this study will provide more precise measurement of the effect of increased feed intake during late gestation.

Effects of Fat Supplementation on Performance of Creep-Fed Pigs

W.R. Walker, C.V. Maxwell, R.L. Hintz, N.J. Lawrence and K. Brock

Story in Brief

The effects of fat supplementation on the performance of creep-fed pigs from 3 to 6 weeks of age and on post-weaning performance from 6 to 10 weeks of age were studied in a trial utilizing 60 litters consisting of 425 Yorkshire pigs. The treatments were a non-supplemented 18 percent corn-soybean meal control diet and the control diet plus 5 percent choice white grease. Ration adjustments were made to maintain a constant ratio of energy to other nutrients. Treatment did not significantly affect survival rate or feed intake over the entire experiment but did significantly ($P<.05$) affect weight. In general, pigs on fat-supplemented rations attained heavier weights at 10 weeks of age. However, this general trend was not consistent for each season in which the litters were farrowed and for each parity of the dam. Based on the results of this experiment, it appears that adding 5 percent choice white grease to creep rations and to rations for pigs during the post-weaning period may be beneficial. However, with results not being consistent across seasons and parity groups, one should carefully consider the economical feasibility of adding choice white grease to creep rations since fat does increase ration cost.

Introduction

When pigs are weaned, they undergo a weaning stress period that is characterized by decreased gains or weight loss and increased death rate. Weaning stress may be attributed to a drastic change in diet as well as environment. It has been suggested that feeding diets supplemented with a high-quality fat may improve pig performance prior to weaning and may reduce weaning problems and improve feed conversion since fat is a major source of energy in sow's milk and would represent less of a dietary change for weaned pigs. Few studies have been conducted to determine the feasibility of increasing fat in creep ration. This study was conducted to determine the effect on pig survivability and performance of adding fat to creep rations.

Materials and Methods

A feeding experiment was conducted with a total of 425 Yorkshire pigs from 60 litters to evaluate the effects of fat supplementation in creep rations fed to pigs from 3 to 6 weeks of age and to pigs during the post-weaning period from 6 to 10 weeks of age. The treatments were a non-supplemented corn-soybean meal control diet containing 18-percent protein and the control ration supplemented with 5 percent choice white grease. Ration adjustments were made to maintain a constant ratio of energy to other nutrients. All litters were randomly assigned from within gilt or sow litters to non-supplemented control or control with 5 percent fat (Figure 1).

Figure 1. Treatment breakdown for 3-10 week period

	3 weeks to 6 weeks	6 weeks to 10 weeks
Gilt Litter	1. Odd litter - Non-supplemented creep	a. Non-supplemented b. Fat supplemented
	2. Even litter - Fat supplemented creep	a. Fat supplemented b. Non-supplemented
Sow Litters	3. Odd litter - Non-supplemented creep	a. Non-supplemented b. Fat supplemented
	4. Even litter - Fat supplemented creep	a. Fat supplemented b. Non-supplemented

The pigs were weaned at 6 weeks of age, and at this time each litter was again randomly assigned to a treatment with one-half of the litters receiving the same diet (a) they received from 3-6 weeks and the other half receiving the opposite diet (b). This provided a total of four treatments over the period of 3-10 weeks of age for gilt and sow litters.

Litters were maintained in pens with either solid concrete floors or oak slatted flooring. A hover area and heat lamps were available to provide heat for pigs during periods of low temperature. Foggers were provided for cooling the sow and litter during periods of high temperature. Creep feed and water were offered *ad libitum*. The quantity of feed offered and feed refused were recorded for the 3-6, 6-8 and 8-10 week period for each litter. Individual pig weights were recorded at birth, 3,6,8 and 10 weeks of age. All weights were taken at approximately the same time of day. The number of pigs born per litter, the number of pigs born alive per litter, sex of pigs in each litter and the number of live pigs per litter at 3,6,8 and 10 weeks were also recorded.

This experiment involved three farrowing seasons during 1979 and 1980 as follows: Farrowing Season 1 (January-March, 1980), Farrowing Season 2 (July-September, 1979), and Farrowing Season 3 (October-December, 1979).

Table 1. Least squares means of feed intake and weight for each treatment from 3-6 weeks, treatment from 6-10 weeks and farrowing season

Treatment 3-6 weeks	Treatment 6-10 weeks	Farrowing season	Feed intake[1] (lb)			Weight (lb)	
			6-8 week	8-10 week	3-10 week	8 week	10 week
Non-supp.	Non-supp.	Jan-Mar	195	212	444	34	53
Non-supp.	Non-supp.	Jul-Sept	229	283	527	35	46
Non-supp.	Non-supp.	Oct-Dec	99	288	428	31	49
		Average	174	261	467	33	49
Non-supp.	Fat-supp.	Jan-Mar	145	226	396	32	54
Non-supp.	Fat-supp.	Jul-Sept	171	271	468	39	56
Non-supp.	Fat-supp.	Oct-Dec	118	339	478	34	51
		Average	145	279	447	35	53
Fat-supp.	Non-supp.	Jan-Mar	144	241	438	38	57
Fat-supp.	Non-supp.	Jul-Sept	271	351	648	41	61
Fat-supp.	Non-supp.	Oct-Dec	129	208	373	30	45
		Average	181	267	486	37	54
Fat-supp.	Fat-supp.	Jan-Mar	142	255	431	36	59
Fat-supp.	Fat-supp.	Jul-Sept	153	257	446	41	53
Fat-supp.	Fat-supp.	Oct-Dec	81	238	328	30	46
		Average	125	250	402	36	53

[1]Mean litter intake corrected for litter size.

Table 2. Least squares means of feed intake and weight for each treatment from 3-6 weeks, parity of dam and farrowing season

Treatment 3-6 weeks	Parity of dam	Farrowing season	Feed intake[1] (lb)				Weight (lb)		
			3-6 week	6-8 week	8-10 week	3-10 week	6 week	8 week	10 week
Non-supp.	Gilt	Jan-Mar	29	163	188	401	21	32	51
Non-supp.	Gilt	Jul-Sept	26	225	319	565	24	32	47
Non-supp.	Gilt	Oct-Dec	27	116	317	448	23	32	49
		Average	27	168	275	472	23	32	49
Non-supp.	Sow	Jan-Mar	27	176	249	439	23	35	56
Non-supp.	Sow	Jul-Sept	21	175	235	430	27	41	54
Non-supp.	Sow	Oct-Dec	33	101	310	458	24	33	50
		Average	27	151	265	442	25	36	54
Fat-supp.	Gilt	Jan-Mar	53	129	282	474	24	37	59
Fat-supp.	Gilt	Jul-Sept	24	238	302	554	24	35	49
Fat-supp.	Gilt	Oct-Dec	14	108	155	284	22	28	41
		Average	30	158	247	437	23	33	50
Fat-supp.	Sow	Jan-Mar	30	156	213	396	25	37	57
Fat-supp.	Sow	Jul-Sept	36	186	306	540	30	47	65
Fat-supp.	Sow	Oct-Dec	34	102	290	417	26	33	50
		Average	33	148	270	451	27	39	57

[1]Mean litter intake corrected for litter size.

Table 3. Least squares means of feed intake and weight for each treatment from 6-10 weeks, parity of dam and farrowing season

Treatment 6-10 weeks	Parity of dam	Farrowing season	Feed intake[1] (lb)			Weight (lb)	
			6-8 week	8-10 week	3-10 week	8 week	10 Week
Non-supp.	Gilt	Jan-Mar	138	248	454	35	55
Non-supp.	Gilt	Jul-Sept	300	355	667	33	47
Non-supp.	Gilt	Oct-Dec	125	214	377	30	46
		Average	188	272	500	33	49
Non-supp.	Sow	Jan-Mar	200	204	428	37	55
Non-supp.	Sow	Jul-Sept	200	279	508	43	60
Non-supp.	Sow	Oct-Dec	104	283	424	30	47
		Average	168	255	453	37	54
Fat-supp.	Gilt	Jan-Mar	154	222	421	34	54
Fat-supp.	Gilt	Jul-Sept	162	267	453	35	50
Fat-supp.	Gilt	Oct-Dec	100	259	355	30	44
		Average	139	249	409	33	49
Fat-supp.	Sow	Jan-Mar	132	258	407	35	58
Fat-supp.	Sow	Jul-Sept	161	261	461	44	59
Fat-supp.	Sow	Oct-Dec	131	279	440	38	57

[1]Mean litter intake corrected for litter size.

Table 4. Least squares means of feed intake and weight for each treatment from 3-6 weeks, treatment from 6-10 weeks and parity of dam

Treatment 3-6 weeks	Treatment 6-10 weeks	Parity of dam	Feed intake[1] (lb)			Weight (lb)	
			6-8 week	8-10 week	3-10 week	8 week	10 week
Non-supp.	Non-supp.	Gilt	185	273	483	31	47
Non-supp.	Non-supp.	Sow	164	249	450	36	51
		Average	174	261	467	33	49
Non-supp.	Fat-supp.	Gilt	151	277	460	34	51
Non-supp.	Fat-supp.	Sow	138	280	435	37	56
		Average	145	279	477	35	53
Fat-supp.	Non-supp.	Gilt	191	271	516	35	52
Fat-supp.	Non-supp.	Sow	172	262	457	38	57
		Average	181	267	486	36	54
Fat-supp.	Fat-supp.	Gilt	126	222	359	32	47
Fat-supp.	Fat-supp.	Sow	124	278	445	39	58
		Average	125	250	402	36	53

[1]Mean litter intake corrected for litter size.

Results and Discussion

Treatment and sex of pig did not significantly affect survival rates or feed consumption during any period of this experiment. The overall mean survival rates were 97.7, 98.7, 97.1 and 93.6 percent for the 3-6, 6-8,8-10 and 3-10 week periods,respectively. Survival rates were calculated as the number of pigs alive at the end of the period divided by the number of pigs starting that period. The variation in the feed intake was so great that no significant differences in feed intake were found. Because of this large variation, drawing conclusions on feed intake could be very misleading.

In general, pigs fed the fat-supplemented diet attained significantly heavier weights ($P<.05$) at 8 and 10 weeks of age than pigs fed non-supplemented creep rations. However, the effect of fat appears to be influenced by the season in which the litter was farrowed. Supplemental fat tended to increase weight in litters farrowed in January-March and July-September but shows no beneficial effect in the October-December farrowing season (Table 1). Pigs from sows were significantly heavier ($P<.05$) than pigs from gilts regardless of treatment (Tables 2 and 3).

Pigs from sow litters fed fat-supplemented creep feed from 3-6 weeks of age were significantly heavier ($P<.05$) at 6, 8 and 10 weeks of age than pigs from sow litters fed the non-supplemented creep ration during this same period. Pigs from gilt litters did not differ significantly in weight between those fed fat-supplemented or non-supplemented creep feed from 3-6 weeks of age (Table 2). Weight is affected also by the season in which the litter is farrowed. Feeding fat-supplemented creep feed from 3-6 weeks of age tended to increase pig weight from both sow and gilt litters farrowed in January-March and July-September but seemed to have little effect on pigs farrowed in October-December (Table 2).

Within the October-December farrowing season, pigs from sow litters on fat-supplemented diets from 6-10 weeks of age were heavier ($P<.05$) at 8 and 10 weeks of age than those on non-supplemented diets (35 and 54 vs. 31 and 47 lb, respectively). This beneficial effect did not occur in the other two seasons (Table 3). Supplemental fat appeared to have little effect on pigs from gilt litters when fed from 6-10 weeks of age (Table 3).

Since only one year is represented in these data, differences in the effect of supplemented fat due to different seasons may not be real. Averaged over seasons, pigs from sow litters receiving fat-supplemented feed for the entire 3-10 week period tend to be heavier than pigs receiving non-supplemented feed while pigs from gilt litters showed little response to fat-supplemented feed (Table 4).

Based on these data, adding fat to creep rations could be beneficial. However, results have not been consistant across seasons and parity groups. Further studies are needed to determine whether fat supplementation is beneficial.

Effect of Dietary Fat Source on the Performance of Colostrum-Deprived Neonatal Pigs

N. J. Lawrence, C. V. Maxwell and D. S. Buchanan

Story in Brief

The effect of dietary fat source in liquid, semipurified diets was studied in a trial utilizing 22 Yorkshire pigs derived by cesarean section. The four treatment groups included diets containing 32 percent fat on a dry-matter basis. Fat sources used were butterfat, corn oil, coconut oil and lard.

There were no significant differences in feed efficiency for 0 to 14 days or 14 to 20 days. However, for the entire 20-day treatment period, feed efficiency values for coconut oil were lower than for corn oil ($P<.01$) and lard ($P<.06$). There were no significant differences in average daily gain (ADG) for 0 to 7 or 7 to 14 days. However, ADG from 14 to 20 and from 0 to 20 days was significantly affected by fat source. Pigs fed coconut oil had a higher ADG than pigs fed corn oil ($P<.03$) and lard ($P<.01$) during both time periods. These data suggest that the effectiveness of adding fat to diets for young pigs depends to a large degree upon the source of fat.

Introduction

Sow's milk contains approximately 30 percent fat on a dry-matter basis. Pigs perform well on their mother's milk, and this would suggest that young pigs are capable of utilizing a high-fat diet. It has been suggested that the ability of the neonatal pig to effectively utilize dietary fat is dependent upon fat source. This study was conducted to determine the effects of source of dietary fat on the performance of colostrum-deprived neonatal pigs.

Materials and Methods

The effect of dietary fat source in liquid, semipurified diets was studied in a trial utilizing 22 colostrum-deprived Yorkshire pigs that were derived by cesarean section. The cesarean sections were performed on approximately day 113 of gestation. The four treatment groups included diets containing 32 percent fat on a dry-matter basis. Fat sources used were butterfat, corn oil, coconut oil and lard (Table 1). Sources of fat were selected to vary both chain length and degree of unsaturation of fatty acids (Table 2). Pigs derived from two litters consisting of 11 and 17 pigs were assigned at random within litter and sex to treatment and to isolator.

Pigs were individually housed in sterile isolators from day 0 to 14. The temperature was maintained at approximately 95°F, and warmed air that passed through a micron filter flowed continuously through the isolators. Florescent lights remained on from 6 a.m. to 10 p.m. daily, and ultra violet lights remained on at all times. The initial feeding at approximately 2 hours post-delivery was 1.18 ounces. The amount of liquid diet fed was increased 0.17 ounces at 6 a.m. and 0.17 ounces more at 2 p.m. each day as long as the pigs appeared healthy and had cleaned up the previous meal. Pigs were fed the warmed diet five times daily at 6 a.m., 10 a.m., 2 p.m., 6 p.m. and 10 p.m. Feed

Table 1. Composition of liquid diets[a]

	Composition of liquid diets[b]
Water	103.45
Fat	11.49
Nutritek - 900 (sweet dairy whey)	7.97
Calcium caseinate (1.3% calcium)	10.62
Citric acid (monohydrate)	0.17
Choline chloride	0.03
Lecithin	0.04
Vitamin premix[c]	0.27
Mineral premix[d]	1.66
Calcium chloride	0.11

[a]Diets formulated to meet approximately 1.3 times NRC requirements for 2.2- to 11-lb pig.
[b]All values expressed as ounces/gallon.
[c]Vitamin premix supplied 0.938 g Vitamin A (500,000 IU/g), 0.094 g Vitamin D_2 (5,000,000 IU/g), 0.028 g thiamine hydrochloride, 0.639 g riboflavin, 4.688 g niacin, 3.012 g calcium pantothenate (92% Pantothenic acid), 0.032 g Vitamin B_6, 4.688 g Vitamin B_{12} (0.1% B_{12} in mannitol), 2.280 g PABA, 7.585 g ascorbic acid, 20.290 g inositol, 0.127 g folic acid (Folacin), 0.021 g biotin, 9.380 g Vitamin E (250 IU/g), 0.426 g Vitamin K and 945.77 g dextrose.
[d]Mineral premix supplied 200 g $NaHCO_3$, 520.20 g KH_2PO_4, 90 g $MgSo_4.7H_2O$, 0.2726 g $MnSo_4.H_2O$, 9.74 g $ZnSO_4.7H_2O$, 0.52 g $CuSo_4.5H_2O$, 8.4 g $FeSO_4$, 0.004 g KI, 170.80 g $CaCl_2$ and 0.016 g $Na_2SeO_4.12H_2O$.

Table 2. Fatty acid composition of fats and oils

	Percent fatty acids[a]							
Fat or oil	10[b]:0[c]	12:0	14:0	16:0	16:1	18:0	18:1	18:2
Butterfat	1.4	3.4	10.3	31.6	7.1	14.0	27.8	4.6
Corn oil		0.8		10.9		2.3	25.6	60.5
Coconut oil	4.2	32.7	26.1	16.3	1.6	3.7	12.3	1.5
Lard		1.3	1.5	21.5	4.0	11.5	46.1	14.1

[a]Fatty acid methyl esters were separated on a diethylene glycol succinate column in a Perkin-Elmer 990 gas-liquid chromatographic column instrument equipped with a hydrogen flame detector operated at 190°C column and 250°C injection port and dector temperature with a nitrogen flow rate of 31 ml/minute.
[b]Number of carbon atoms in fatty acid.
[c]Number of double bonds in fatty acids.

consumption was recorded, and pig weights were taken at 0, 7, 14 and 20 days of age. Pigs were transferred to the nursery room on day 14 where they were randomly allotted to pens and individually housed in elevated, open-topped metal pens until the completion of the trial on day 20. The temperature was maintained at approximately 79°F.

Results and Discussion

Overall survival rate was 84.6 percent, and six pigs per treatment completed the trial with the exception of the lard treatment, which consisted of four pigs. The effect of dietary fat source on the performance of colostrum-deprived neonatal pigs is shown in Table 3. For the entire 20-day trial, feed efficiency (gallons of diet/lb gain) of pigs fed coconut oil was lower than for those fed corn oil ($P<.01$) and lard ($P<.06$). However, there were no significant differences in feed efficiency for 0 to 14 days or 14 to 20 days. Feed efficiency values over the entire treatment period were .46, .52, .42, and .50 gallons/lb for butterfat, corn oil, coconut oil and lard, respectively. Average daily gain (ADG) from 14 to 20 and 0 to 20 days was significantly affected by fat source. There were no significant treatment differences in ADG for 0 to 7 ($P>.96$) or 7 to 14 days ($P>.21$). Pigs fed coconut oil had a higher ADG than pigs fed corn oil ($P<.03$) and lard ($P<.01$) during both time periods. ADG values for the entire treatment period were

Table 3. Effect of fat source on feed efficiency and rate of gain

Variables	Treatment			
Fat source	Butter fat	Corn oil	Coconut oil	Lard
Number of pigs	6	6	6	4
Feed intake (gallons)				
Litter one				
Day 0-20	3.07	3.07	3.07	3.07
Day 0-14	1.72	1.72	1.72	1.72
Day 14-20	1.35	1.35	1.35	1.35
Litter two				
Day 0-20	3.00	3.00	3.00	3.00
Day 0-14	1.73	1.73	1.73	1.73
Day 14-20	1.27	1.27	1.27	1.27
Feed efficiency (gallons/lb)				
Day 0-20	.458 ± .02^{ab}	.516 ± .02^{a}	.424 ± .02^{b}	.500 ± .03^{ab}
Day 0-14	.454 ± .02	.501 ± .02	.442 ± .02	.477 ± .03
Day 14-20	.470 ± .06	.572 ± .06	.416 ± .06	.560 ± .07
ADG (lb/day)				
Day 0-20	0.33 ± .02^{abc}	0.31 ± .02^{ac}	0.35 ± .02^{b}	0.31 ± .02^{ac}
Day 0-14	0.26 ± .02	0.24 ± .02	0.29 ± .02	0.26 ± .02
Day 14-20	0.46 ± .02^{abc}	0.42 ± .02^{ac}	0.53 ± .02^{b}	0.40 ± .02^{ac}
Day 0-7	0.15 ± .02	0.15 ± .02	0.15 ± .02	0.15 ± .02
Day 7-14	0.40 ± .02	0.35 ± .02	0.40 ± .02	0.37 ± .02

^{abc}Means in the same row with different superscripts differ significantly ($P<.05$).

.33, .31, .35 and .31 lb/day for butterfat, corn oil, coconut oil and lard respectively.

It has been suggested that differential utilization of dietary fat may be partially due to fatty acid composition. The fats used in this study were chosen to vary both chain length and degree of unsaturation of fatty acids. Generally, pigs fed coconut oil, which contains primarily short-chain, highly saturated fatty acids, performed better than pigs fed the other diets although they were not significantly different than those fed butterfat. Butterfat contains fatty acids which are intermediate in both chain length and degree of unsaturation and was used primarily as a control in this study. Pigs fed corn oil, which contains predominately long-chain, unsaturated fatty acids, tended to perform better than those fed lard, which contains predominately long-chain fatty acids, but is more saturated than corn oil.

Very little research has been conducted to study the utilization of fat by the neonatal pigs. However, data suggests that the neonatal pig can utilize liquid diets high (32 percent on a dry-matter basis) in butterfat and that energy from butterfat appears to be used as efficiently for growth as energy from glucose. The results of this trial indicated that the ability of the neonatal pig to utilize dietary fat may be influenced by the source of fat. The differential performance of pigs may be primarily due to fatty acid composition of the fat. More research is needed before the utilization of dietary fat may be predicted from its fatty acid composition.

PHYSIOLOGY

The Effect of Environmental Temperature and Thyrotropin Releasing Hormone on the Concentration of Thyroxine in Steers

B. R. Pratt and R. P. Wettemann

Story in Brief

Twenty-four steers (342±8 lb) were exposed in environmental chambers to either 40±1, 65±1 or 90±1°F for 4 days (eight steers/group) following a 3-day adjustment period at 65±1°F. Ambient temperature was changed at a rate of 3.6°F per hour for 7 hours, and steers were treated with thyrotropin releasing hormone (TRH) at 1 and 72 hours after exposure to their respective environmental temperatures. There was no difference in the concentration of thyroxine during the change in ambient temperature. There was a tendency ($P<.1$) for the concentration of thyroxine after treatment with TRH to be less with increased environmental temperature (84.3±3.7, 78.4±2.4 and 61.9±1.2 ng/ml for 40, 65 and 90°F, respectively). The concentrations of thyroxine at all environmental temperatures were greater ($P<.001$) after the first treatment with TRH compared to the second treatment (87.0±2.7 vs. 62.5±1.6 ng/ml, respectively).

Introduction

Environmental temperature has been demonstrated to alter the function of the thyroid gland and output of thyroid hormones in many species. In general, increased environmental temperatures decrease the concentration of thyroxine, whereas cool environmental temperatures increase thyroxine. Alterations in the concentration of thyroxine regulate the rate of body metabolism. Thyrotropin releasing hormone (TRH), normally produced by the hypothalamus, causes a release of thyroid-stimulating hormone from the pituitary gland, which in turn causes a release of thyroxine from the thyroid gland. The objectives of this study were to determine the effect of environmental temperature on the concentration of thyroxine and to evaluate the influence environmental temperature has on the concentration of thyroxine in response to treatment with TRH in steers.

Materials and Methods

Twenty-four Angus x Hereford steers weighing an average of 342±8 lb were assigned to environmental temperatures of 40±1, 65±1 or 90±1°F. Two environmentally controlled chambers with two steers per chamber were used in six replicates with two different environmental treatments represented in each replicate. The steers assigned to each replicate were penned indoors at a temperature of 65±5°F two weeks prior to being moved into the environmental chambers. Steers were acclimated to confinement in the environmental chambers at a temperature of 65±1° F three days

prior to exposure to the environmental treatments. Steers were fed 3 lb of ground alfalfa hay, 3 lb of cottonseed hulls and 1 lb of a 12-percent protein grain supplement per day with water available free choice. On the third day of acclimation to the environmental chambers, cannulae were inserted into the jugular vein of each steer. The morning following cannulation the temperature was changed at a rate of 3.6°F per hour until the steers were exposed to their preassigned environmental treatments (40, 65 or 90°F). Blood samples were collected via cannulae every hour 2 hours prior to and during the change in environmental temperature. One hour after steers were exposed to either 40, 65 or 90°F, they were treated with 50 μg of thyrotropin releasing hormone (TRH) administered intravenously. Blood samples were collected immediately prior to the first treatment with TRH, every 15 minutes for the first hour, hourly for the next 8 hours and every 8 hours for 3 days. Three days after the first treatment with TRH, steers were treated a second time with TRH, and blood samples were collected for 8 hours just as after the first treatment with TRH. Serum blood samples were quantified for thyroxine by radioimmunoassay validated in our laboratory.

Results and Discussion

During the change in ambient temperature there were no differences in the concentrations of thyroxine between the three environmental treatments (Figure 1). The average response of thyroxine after both treatments of TRH decreased ($P<.1$) as the ambient temperature increased, with thyroxine averaging 84.3±3.7 ng/ml for 40°F, 78.4±2.4 ng/ml for 65°F and 61.9±1.2 ng/ml for 90°F. The response of thyroxine to TRH was significantly greater after the first treatment with TRH compared to the

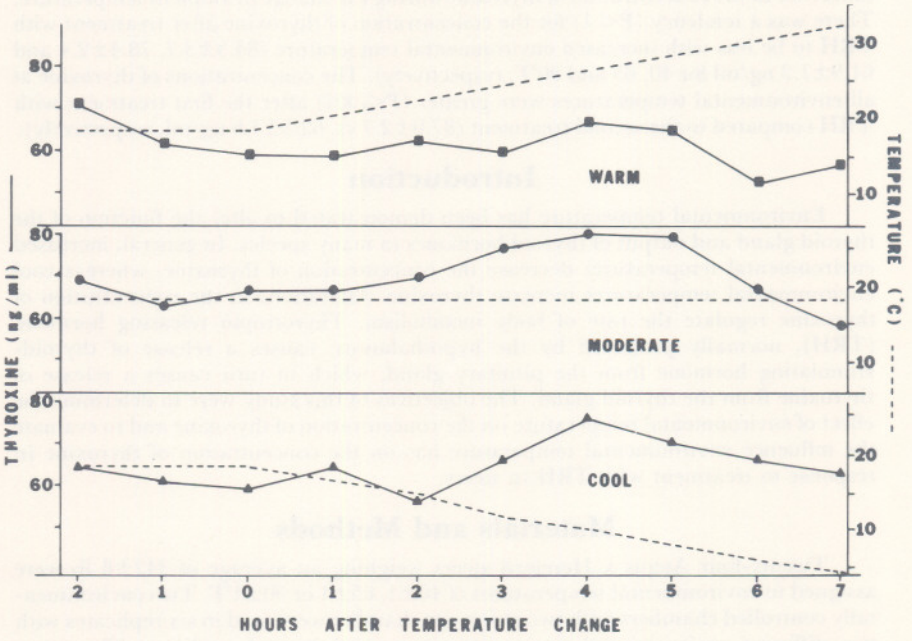


Figure 1. The concentration of thyroxine (ng/ml) during the change in ambient temperature (eight observations per treatment group)

second treatment (87.0±2.7 vs. 62.5±1.6 ng/ml; P<.001). The response of thyroxine to TRH was less (P<.05) at the 90°F over the 8-hour period after treatments of TRH compared to the moderate and cool environmental temperatures (Figures 2 and 4). This was particularly evident after the second challenge of TRH (Figure 4; P<.05). The concentration of thyroxine in samples collected every 15 minutes for 1 hour after

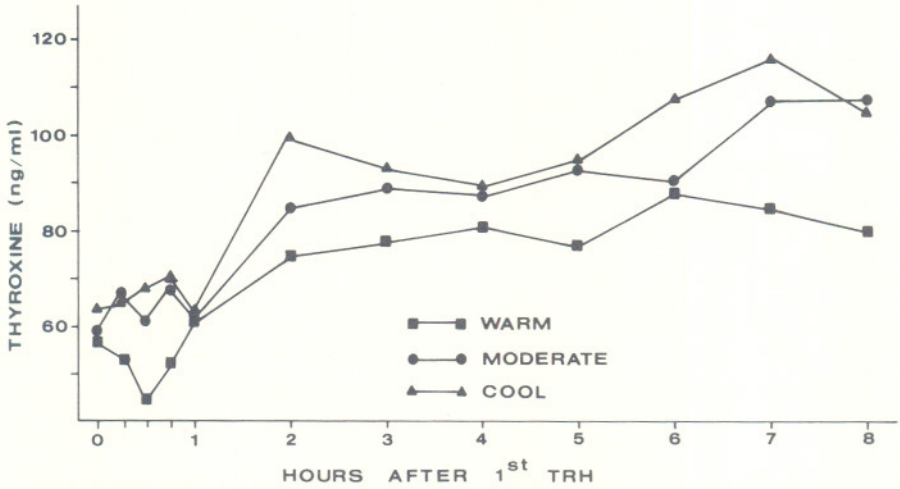


Figure 2. The concentration of thyroxine for 8 hours after the first treatment with TRH (50 µg; iv) in steers exposed to cool (40° F), moderate (65° F) or warm (90° F) environmental temperatures for 1 hour (eight observations per environmental temperature)

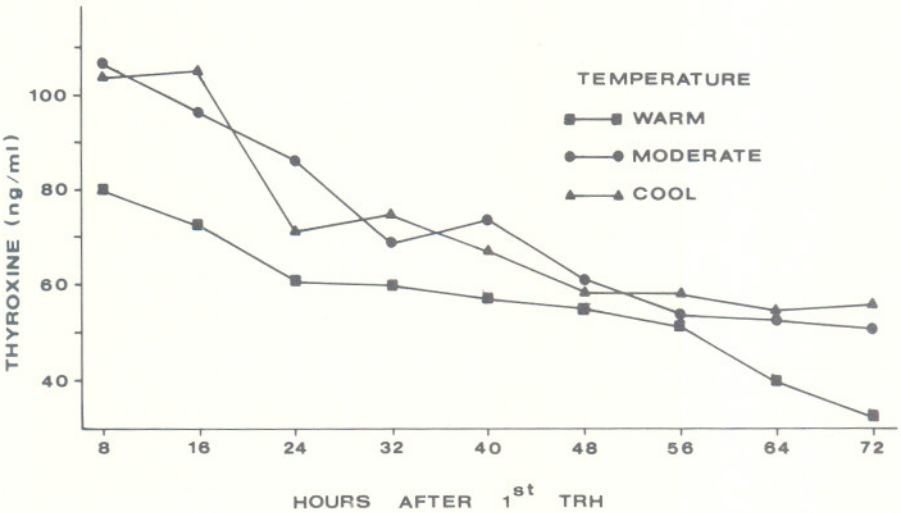


Figure 3. The concentration of thyroxine every 8 hours after the first treatment with TRH (50 µg; iv) in steers exposed to cool (40° F), moderate (65° F) or warm (90° F) environmental temperatures (eight observations per environmental temperature)

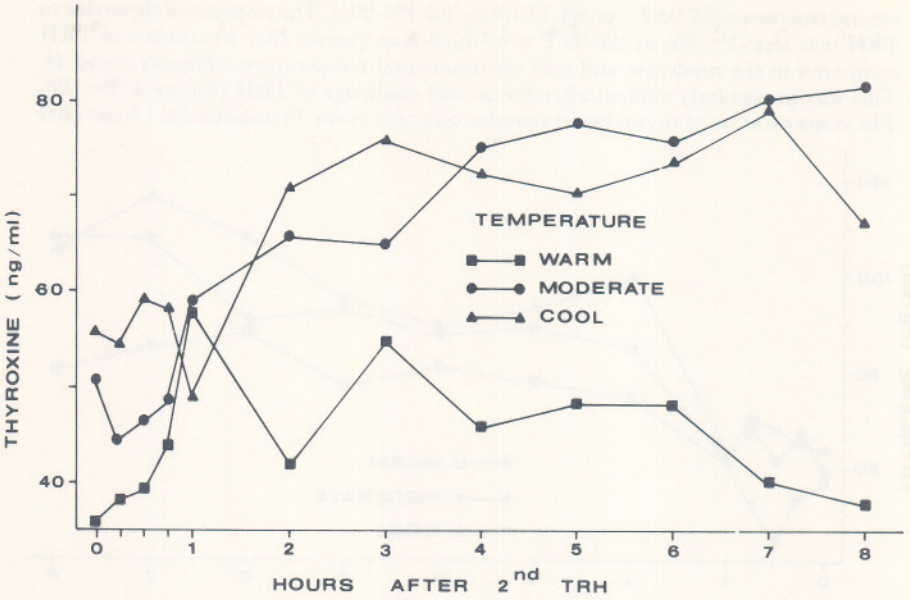


Figure 4. The concentration of thyroxine for 8 hours after the second treatment with TRH (50 µg; iv) in steers exposed to cool (40° F), moderate (65° F) or warm (90° F) environmental temperatures for 3 days (eight observations per environmental temperature)

both treatments with TRH varied over time ($P<.05$) but was not affected by ambient temperature (Figures 2 and 4). The concentration of thyroxine declined in samples collected every 8 hours for 72 hours after the first treatment with TRH in all environmental treatments (Figure 3).

Rectal temperature, respiratory rate and water intake increased from pre-exposure values ($P<.01$) in the steers exposed to 90°F. Hematocrit decreased in all groups throughout the trial ($P<.01$), but the decrease was more dramatic in the steers exposed to the high environmental temperatures. A more detailed description of the physiological changes in these steers has been reported previously (Pratt and Wettemann, 1980).

These results suggest that the functioning of the thyroid is affected by ambient temperature, with high environmental temperatures suppressing the output of thyroxine. The concentration of thyroxine was not significantly altered by exposure to 40°F compared to 65°F.

The reduced response in release of thyroxine after the second treatment with TRH compared to the first treatment may be due to a negative feedback to thyroxine on the hypothalamus and pituitary from the elevated concentration of thyroxine following the first treatment with TRH. This feedback mechanism may be responsible for the gradual decline of thyroxine observed in the samples collected every 8 hours for 3 days between the treatments with TRH (Figure 3).

Literature Cited

Pratt, B.R. and R.P Wettemann. 1980. Okla. Agr. Exp. Sta. Res. Rep. MP-107:170.

RESEARCH IN PROGRESS

Evaluation of an Index for Boar Selection

D. S. Buchanan, H. R. Gaugler and R. Vencl

A study was initiated in the summer of 1979 to evaluate the boar test station index recommended by the National Swine Improvement Federation: $I = 100 + 60(G-\bar{G}) - 75(F-\bar{F}) - 70(B-\bar{B})$ where I = index value; G = average daily gain; F = pounds of feed per pound of gain; B = average backfat at 230 pounds; $\bar{G}$, $\bar{F}$ and $\bar{B}$ are the within-test averages for the traits.

The index has a mean of 100 and an expected standard deviation of 25. This results in 68 percent of the boars having an index between 75 and 125.

Boars will be purchased in pairs from test stations that measure all three traits in the index. Each pair will include one boar with an index over 120 and one with an index below 90. During the first two seasons 12 Hampshire boars will be purchased and mated with crossbred gilts. Gilts sired by the Hampshire boars will be bred to 12 Duroc boars during each of the last two seasons.

At the present time both sets of Hampshire boars and one set of Duroc boars have been purchased. Average performance of these boars is presented in Table 1.

Progeny of these boars will be tested from 9 weeks until they reach 220 lb. They will be penned by sire groups so that feed intake can be measured and feed efficiency calculated. When they reach 220 lb, backfat thickness will be measured, and one barrow from each litter will be slaughtered for carcass evaluation. These progeny from high and low indexing boars can be compared to evaluate the effectiveness of the index as a tool for selecting boars.

Table 1. Average performance of tested boars[a] used to compare high and low indexing boars

		High indexing boars				Low indexing boars			
Season	Breed	Average daily gain lb/day	Lb feed per lb gain	Backfat thickness in.	Index	Average daily gain, lb/day	Lb feed per lb gain	Backfat thickness in.	Index
Fall 1979	Hampshire	2.27	2.34	.73	131.1	1.80	2.62	.74	82.7
Spring 1980	Hampshire	2.19	2.55	.69	128.3	1.87	2.84	.71	87.5
Fall 1980	Duroc	2.27	2.25	.77	136.7	1.91	2.59	.87	82.9

[a]Boars purchased at test stations in Oklahoma, Nebraska, Missouri and Iowa.

Reproductive Development and Performance of Hereford Heifers Calving at 24 and 30 Months of Age

E.J. Turman, R.P. Wettemann, K.S. Lusby and J. Magee

There are several major problems associated with calving heifers at 24 months of age which can be greatly reduced by delaying calving until the heifers are 36 months of age. However, it is very difficult, on an economic basis, to justify delaying the onset of a heifer's productive life by a year. There is the possibility that calving at 30 months of age would reduce the problems associated with earlier calving and also be economically feasible. There has been only a very limited amount of research conducted to date that has compared calving at 30 months of age with calving at 24 months from the standpoint of reproductive performance and economic returns.

This study was initiated at the Southwestern Livestock and Forage Research Station, El Reno, (Fort Reno) in the fall of 1979 and will continue until December 31, 1983. The objectives are: 1) to determine the effects of a low and moderate level of winter supplemental feeding on the growth, development and reproductive performance of heifers calving in the spring at 30 months of age; and 2) to compare the performance of heifers calving at 30 months of age with comparable heifers fed at a high level of winter supplemental feeding and calving in the spring at 24 months of age.

The heifers being utilized in this study are produced in experimental cow herds at the Lake Carl Blackwell Range Area. In these herds, cows of comparable breeding are calved in both the spring and fall and are bred to the same bulls in each season. This will permit a comparison of heifers of similar breeding calving in the same season at two different ages.

The total number of heifers that are available to be placed on experiment in a given year is limited. Therefore, in order to obtain sufficient numbers of heifers for the results to be meaningful, the study will consist of three replications. Three groups of weaner and yearling heifers will be obtained in the falls of 1979, 1980 and 1981. They will remain on trial until they wean their first calf. The group that was obtained in 1979 will calve starting in late February, 1981. The group obtained last fall will be bred for their first calf during a 60-day breeding season May 1-July 1, 1981. The third replicate will be started in the fall of 1981 and completed in fall of 1983, at which time the results for all three replicates will be analyzed and published.

Effect of Environment and Diet on Endocrine Responses in Calves

K. B. Leining

Experiments are currently underway at the Southwestern Livestock and Forage Research Station to evaluate the effects of common management practices on hormones in blood of cattle. Endocrinologists have found that changes in hormones often precede changes in body growth, and they have proposed that hormone data can be used to pinpoint management practices that minimize stress and maximize growth rates in beef cattle. Therefore, the principle objective of these studies is to determine if thyroid, pituitary and/or adrenal hormones are changed by weaning, transporting, changing feed composition or changing time of day of feeding cattle.

To date, hormone information has been collected from cattle which were part of feeding trials conducted under simulated feedlot conditions. In one study, four spring-weaned and four fall-weaned Charolais steers were sampled after 0, 7, 14, 28 and 56 days of high quality forage (HF; 60 percent digestible dry matter (DDM)) or low quality forage (LF; 50 percent DDM) growing rations. Glucocorticoids (CORT) decreased ($P<.05$) from day 0 to 7, and thyroxine (T_4) decreased ($P<.01$) from day 0 to 14. Hormones were not affected ($P>.10$) by age of steer or forage quality. In a second study, CORT and T_4 were measured in samples obtained at 0, 14, 28 and 56 days after eight Charolais and eight Angus steers were switched from HF or LF to 76 percent DDM feedlot diets. Concentrations of both hormones increased ($P<.01$) between days 0 and 56; however, neither breed of steer nor prior diet affected ($P>.10$) CORT and T_4 concentrations.

Additional studies have been conducted using 8-16 head of weanling steers in light and temperature controlled chambers. In previous studies, both light and temperature affected hormone concentrations. Since ambient temperatures can change rapidly within a day, as well as from day to day, control of temperatures is important so we can observe effects of other environmental factors which may change normal concentrations of hormones. Data collected from cattle in environmental chambers will pinpoint management practices which change hormone concentrations. Ideally, studies will then be designed to test these management practices using larger numbers of cattle under normal environmental conditions, with emphasis on growth rate rather than hormone information.

USDA, Science and Education Administration, Southern Region, in cooperation with the Oklahoma Agricultural Experiment Station.

An Evaluation of Wheat Pastures as Related to Metabolic Anomalies in Cattle

V.R. Bohman, F.P. Horn, B.A. Stewart, A.C. Mathers D.L. Grunes and E.T. Littledyke

Approximately one million head of cattle graze winter wheat pastures in Oklahoma annually. Wheat forage is of high nutritive value for the grazing ruminant. Nevertheless, approximately 3 percent of the cattle grazing this forage die annually. Stocker cattle usually die of bloat, and mature cows die of tetany. Studies were undertaken to compare the health, performance and tissue composition of mature beef cattle while grazing wheat forage with and without dietary supplements and to evaluate forage composition as related to animal health, performance and tissue composition of cattle.

Thirty-two head of aged, pregnant Hereford and Angus cattle were obtained from the Meat Animal Research Center at Clay Center, Nebraska. These cows were allocated to four treatments: supplemental calcium, magnesium, potassium or no supplement while grazing wheat pastures from December 6, 1979, to April 23, 1980. Blood and plant samples were obtained weekly in December, March and April and biweekly in January and February. Cerebrospinal fluid samples were obtained 6 times during this period. Plants were sampled by hand collection of forage from grazed pasture, by animal sampling and collection after removal of the contents of the rumen and reticulum via a rumen fistula and from non-grazed forage grown under a cage in the experimental pastures. Forage procured by these three methods was divided . Half was freeze-dried, and half was dried at 65°C. The forage was analyzed for dry matter, ash, *in vitro* digestibility, lipids, individual fatty acids from carbon 12 to 18 in length, sodium, potassium, calcium, magnesium, aluminum, iron, nitrates, transaconitic acid, nitrogen, phosphorus, total nonstructural carbohydrates and alkaline ash. Plant malic acid will yet be determined. Cattle weights were obtained at each plasma and plant sampling. Blood and cerebrospinal fluid were analyzed for calcium, magnesium, potassium, glucose, urea nitrogen and lactic acid. In addition, the blood was analyzed for phosphorus, alkaline phosphatase, hydroxy proline, beta hydroxy butyric acid, packed cell volume and parathyroid hormone.

Data from these analyses are currently being evaluated in relation to tetany in cattle. Some of the cattle developed tetany in the middle of March. Preliminary evaluation indicates that both plant and blood composition changed greatly at the time of tetany.

Improved Procedure for Challenging Neonatal Dairy Calves with Enteropathogenic *Escherichia Coli*

S. E. Gilliland, L. J. Bush and R. D. Contreras

A procedure for challenging animals with the intestinal pathogen of interest is necessary to evaluate the effectiveness of various preventative measures in controlling intestinal infections in newborn dairy calves. Enteropathogenic *Escherichia coli* is generally accepted as the pathogen most often involved in causing diarrhea in neonatal dairy calves. A common method for preparing an *E. coli* culture to be used as a challenge dose is to grow the organism in 10 ml volumes of a broth medium such as Trypticase Soy Broth. The entire 10 ml of culture is then fed to the test animal in an attempt to produce the infection. This represents a rather massive dose of the organisms since it would contain approximately 10 billion cells of *E. coli*. Such a challenge dose may merely overload the intestinal system of the animal with *E. coli* since it is not likely that the calf would be exposed to this large a dose of enteropathogenic *E. coli* in its natural environment. Furthermore, attempts to reproduce results which have been reported using such challenge procedures are often disappointing. We did not obtain satisfactory results in challenge studies using *E. coli* prepared in this manner and given to the animal at the indicated dosage level. A transient diarrhea was produced, but the calves remained alert and recovered quickly without treatment.

Enteropathogenic *E. coli* that contain the K-99 antigen have been identified as the strains being responsible for causing intestinal infections resulting in diarrhea in calves. Apparently the K-99 antigen is needed for the organism to attach to the intestinal wall enabling it to become established and grow to cause the infection. This antigen is often difficult to detect if the bacteria have been grown on a "nutrient-rich" medium, apparently because it is masked by excessive capsular material on the cells. The antigen appears to be more readily exposed on cells grown on a medium containing minimal nutrients due to a reduced amount of capsular material. Thus, growth of enteropathogenic *E. coli* on a minimal nutrient medium might provide a culture which would be more infective in calves and more useful in conducting successful challenge studies.

For our experiments the enteropathogenic *E. coli* cultures were grown on the surface of Minca Iso VitaleX agar as described by Guinee et al (1977). Twenty ml of the sterile medium was placed aseptically in sterile dilution bottles which were then laid on their sides to permit the medium to solidify. One-half ml of a 1:10 dilution of a Trypticase Soy Broth culture of the *E. coli* was spread over the surface of the solidified medium. The inoculated bottles were incubated 18 hours at 37° C. After incubation the cells were washed from the surface of the medium with 20 ml volumes of sterile physiological saline solution. The resulting cell suspensions were placed in an ice bath until needed. The challenge dose for each animal was prepared by diluting the cell suspension of *E. coli* 1:10 then adding 1 ml to milk to be fed to the animal. This resulted

in a challenge dose containing approximately 1 x 10^8 cells. The challenge doses were used the same day they were prepared.

Newborn Holstein or Ayrshire bull calves were used as test animals for evaluating the challenge procedure. After the challenge dose was administered, the animals were observed periodically during the next 24-hour period for the development of diarrhea. Two colostrum-deprived calves which were challenged at the first feeding after birth with a mixture of five strains of *E. coli* (1 x 10^8 cells of each) developed diarrhea within 12 hours. In additional experiments enteropathogenic *E. coli* B-44, which is the strain most often utilized in working with neonatal dairy calves, was used alone as a challenge dose. Challenge of two colostrum-deprived calves with this single strain (1 x 10^8 cells) also produced diarrhea within a 12-hour period. Three calves permitted to obtain colostrum from their dams soon after birth did not develop diarrhea after being given either the B-44 culture or a mixture of six strains of *E. coli* in milk at 12 or 24 hours after birth.

Challenge of colostrum-deprived neonatal dairy calves with enteropathogenic *E. coli* prepared as described above can provide a model system for studying some factors that may prevent infection by this organism. The doses used in this study represent a level of inoculation of the animal 100 times less than would be achieved by challenging the animals with 10 ml of a broth culture of the *E. coli*. Additional evaluation will be needed to determine whether smaller doses of the organism will produce desirable results.

An example of a way in which this challenge system might be utilized would be to determine the effectiveness of preparations containing *Lactobacillus acidophilus* in preventing infections caused by enteropathogenic *E. coli* in neonatal dairy calves. It would also provide a useful model for evaluating the relative merits of various procedures for processing colostrum to be used in feeding newborn calves. Additional work is needed to develop a challenge system effective for colostrum-fed calves because it is well known that infectious diarrhea does occur in such calves. Moreover, discovery of means for complementing the natural immunity of calves acquired by consumption of colostrum would have immediate application in raising dairy herd replacements.

Literature Cited

Guinee, P. A. M., J. Veldkamp and W. H. Jansen. 1977. Infection and Immunity. 15:676.

Effect of Pasteurization of Colostrum on Absorption of Immune Globulins by Newborn Dairy Calves

L. J. Bush, S. E. Gilliland and R. D. Contreras

Intake of colostrum by calves soon after birth is the means whereby passive immunity to infectious agents is transferred from cows to their calves. However, the colostrum of some cows may be heavily contaminated with large numbers of different types of pathogenic bacteria due to infection of the udder. There is concern about the possibly detrimental effect of these bacteria on the health of calves, especially in large operations where the colostrum is frequently given to the calf by drenching or by nipple bottle. Dairymen are advised to pasteurize colostrum prior to feeding it to calves.

In research at this station and elsewhere, enteropathogenic *Escherichia coli* did not cause infection in calves when administered with colostrum. No information is available concerning the effect of administering other types of pathogenic bacteria in colostrum. Therefore, pasteurization of colostrum before feeding to calves is recommended by some as a method for prevention of problems that could arise from feeding colostrum heavily contaminated with bacteria.

Work is underway to determine the effect of pasteurization of colostrum on absorption by newborn calves of immune globulins contained therein. Several batches of colostrum from cows in the O.S.U. dairy herd were collected. After mixing, one-half of each batch was pasteurized by heating to 145°F and holding for 30 minutes. Then it was cooled, packaged and frozen until needed. The unpasteurized colostrum also was packaged and frozen.

Fifty-two calves were obtained immediately after birth, before nursing, for the experiment. These were assigned at random within "blocks" to receive either pasteurized or unpasteurized colostrum, with each "block" consisting of a given breed of calves fed a specified batch of colostrum. The calves were fed colostrum at the rate of 10 percent of metabolic body size ($W^{.75}$) per feeding soon after birth and at 12 and 24 hours afterwards. Blood samples were obtained from each calf before the first feeding and at 12, 16, 20, 24, 28, 32 and 36 hours thereafter. These will be analyzed for specific immune globulins (IgG and IgM) to determine whether pasteurization of the colostrum influenced the amount of absorption which occurred in the calves.

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Studies at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, were conducted in cooperation with USDA-SEA-AR, Southern Region, Texas-Oklahoma Areas. Several studies were part of regional research projects.

The following is a listing of those who have contributed to the research program of the Animal Science Department during the preceding year.

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ASSOCIATED MILK PRODUCERS, INC., (Oklahoma Division) Oklahoma City, Oklahoma

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NORTH AMERICAN LIMOUSIN FOUNDATION, Denver, Colorado
OKLAHOMA CATTLEMEN'S ASSOCIATION
OKLAHOMA DAIRY HERD IMPROVEMENT ASSOCIATION, INC., Stillwater, Oklahoma
OKLAHOMA ECONOMIC DEVELOPMENT ADMINISTRATION
OKLAHOMA FEED MANUFACTURERS ASSOCIATION, Stillwater, Oklahoma
OKLAHOMA MEDICAL RESEARCH FOUNDATION, Oklahoma City, Oklahoma
OKLAHOMA SWINE BREEDERS ASSOCIATION, Stillwater, Oklahoma
PHILLIPS PETROLEUM CO., Bartlesville, Oklahoma
RALPHS PACKING CO., Perkins, Oklahoma
RALSTON PURINA, St. Louis, Missouri

RODEO MEATS, INC., Beef Division, Arkansas City, Kansas
SCHWAB AND CO., Oklahoma City, Oklahoma
SMITH KLINE ANIMAL HEALTH PRODUCTS, Philadelphia, Pennsylvania
SNELL SYSTEMS, INC., San Antonio, Texas
UPJOHN COMPANY, Kalamazoo, Michigan
USDA-SEA-ARS RANGE RESEARCH STATION, Woodward, Oklahoma
USDA SCIENCE AND EDUCATION ADMINISTRATION, Southern Region
USDA SCIENCE AND EDUCATION ADMINISTRATION, Western Region
U. S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, Washington D.C.
WILSON FOODS, Oklahoma City, Oklahoma