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Beef Cows and Calves--1979: A Summary of Research

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CONTENTS

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Response of Fall-Born Calves to Monensin on Orchardgrass/Alfalfa or Tall Fescue/Alfalfa Pastures, by F. M. Byers, C. F. Parker, and R. W. Van Keuren ---------- 3

Effects of Forage System and Breed Type on the Performance of Fall Calving Cows, by C. F. Parker and R. W. Van Keuren ---------- 7

Forage Management for Beef Production, by R. W. Van Keuren, C. F. Parker, and E. W. Klosterman ---------- 11

Breeding and Management Systems to Optimize Beef Breeding Herd Productivity, by E. W. Klosterman, R. W. Van Keuren, C. F. Parker, and F. M. Byers ---------- 17

Voluntary Feed Intake of Mature Cows as Related to Breed Type, Condition, and Forage Quality, by E. W. Klosterman, F. M. Byers, and C. F. Parker ---------- 21

Weight and Condition Changes of Pregnant Beef Cows Wintered on Corn Stover Stacks, by G. R. Wilson, J. G. Gordon, J. H. Cline, K. M. Irvin, and E. W. Klosterman ---------- 24

Estrus Synchronization of Beef Cows and Heifers with Prostaglandin $F_{2}\alpha$ Under Field Conditions, by G. R. Wilson, T. L. Benecke, K. M. Irvin, T. M. Ludwick, C. E. Marshall, and R. A. Wallace ---------- 27

ON THE COVER: Cows and fall-born calves at Jackson Branch.

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Response of Fall-Born Calves to Monensin on Orchardgrass/Alfalfa or Tall Fescue/Alfalfa Pastures[1]

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SUMMARY

A rotational grazing summer study lasting 105 days and conducted with 60 fall-born crossbred steer and heifer calves investigated the response to monensin on pasture of two types, *i.e.*, alfalfa/orchardgrass or alfalfa/tall fescue. Response to monensin was significant for the alfalfa/orchardgrass pastures with a 13% (0.22 lb/day) increase in average daily gain over the 105 days. Both extensive and intensively raised cattle (pre-weaning environment) were grazed on the alfalfa/tall fescue pastures. Neither group responded to monensin during any of the 28-day interim weigh periods or over the duration of the study. While calves from the extensive pre-weaning system did show some compensatory growth, they recovered only 26 lb of the 105 lb differential that existed between extensive and intensively raised calves at weaning, underscoring the importance of adequate pre-weaning nutrition in optimizing performance and growth in forage beef production systems.

INTRODUCTION

A variety of wintering nutrition systems are currently used in carrying, growing, and feeding calves during this period. While the eventual success of fall calving programs is dependent on winter forage systems used, the relative impact of various wintering nutritional levels on subsequent anmal growth during summer grazing has not been clearly established.

Previous research indicates compensatory growth can be expected from cattle following restricted feeding periods (1). However, since grazing forage intake is also a function of an animal's size and digestive tract capacity, restricted pre-weaning growth may disallow maximal forage consumption and utilization, placing a limit on the extent of growth compensation possible. Pasture forage quality will likely influence this response. Whether monensin, a compound reported to increase animal gain on forage and pasture feeding systems, would also influence the growth response of well-fed vs. restricted calves is not known. The following study was designed to address these questions.

EXPERIMENTAL PROCEDURES

Sixty crossbred steer and heifer calves from the OARDC Jackson Branch fall calving herd completed this study. Forty-two calves had been raised on an intensive forage system and 18 calves were from an extensive forage system. The intensively raised calves were 105 lb heavier (481 vs. 376) than extensive calves at the initiation of this study.

The intensive winter forage system was a program with alfalfa-tall fescue harvested three times as hay in large round bales and field stored for winter feeding. The beef cows and their fall-born calves grazed on the fall-saved alfalfa-tall fescue from late November until late December, at which time bale feeding was started.

The extensive winter forage system was a program of unfertilized grass (orchardgrass, bluegrass, and miscellaneous weeds) harvested once as small round bales and field stored for winter feeding. The beef cows and their calves were wintered on bales plus summer and fall regrowth from late October until late December. At that time large round bales of tall fescue were fed to this herd in the same winter pasture until spring. Neither herd received supplemental feed.

The intensive calves were allotted by weight and breed to either of two pastures (alfalfa/orchardgrass or alfalfa/tall fescue) with or without added monensin. The extensive calves were allotted to the alfalfa/tall fescue pasture with or without monensin. Monensin[3], where used, was provided in a corn-mineral supplement (Table 1) fed at 1.0 lb/head/day to provide monensin at 100 mg for the first 7 days and 200 mg/head/day thereafter. All cattle were implanted with synovex[4] on the day of allotment. The pastures were rotationally grazed for 105 days, at which point the pastures were exhausted and the experiment terminated. The calves grazed these pastures from April 27 to August 9.

The alfalfa-tall fescue/monensin group and the alfalfa-tall fescue/no monensin group were each rotationally grazed over separate pastures. Each pasture was subdivided into three lots. In addition, the

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[3]Monensin-sodium distributed as Rumensin by Elanco, Indianapolis, Ind.

[4]Synovex S and H used for steers and heifers, respectively; products of Syntex Agribusiness, Des Moines, Iowa.

TABLE 1.—Percentage Composition of Supplements Fed.

Item	Monensin	
	None	200 mg/day
Corn, ground shelled	80.00	79.33
Dicalcium phosphate	7.50	7.50
Trace mineral salt	5.00	5.00
Dried molasses	7.50	7.50
Monensin premix, 30 g/lb		0.67

two groups were switched between two pastures upon completing a grazing rotation so as to reduce pasture differences between groups. All lots had generally excellent stands of tall fescue and good to excellent stands of alfalfa. One lot of each pasture was cut for hay in June to utilize surplus growth not needed by the calves. The same grazing procedure was followed with the alfalfa/orchardgrass pastures. All lots had from good to excellent stands of orchardgrass and fair to excellent stands of alfalfa.

The varieties in the pastures were Kentucky 31 tall fescue, Potomac orchardgrass, and Vernal alfalfa. Average composition of these forages during the previous year is shown in Table 2. There was some volunteer white clover in all pastures. The moisture conditions during the grazing period were below average and markedly reduced pasture production. While 71 calves were started on this experiment, 10 head had to be removed midtrial to reduce grazing pressure and thus data reported include only animals completing the trial. One calf in a group receiving no monensin died of pneumonia after only 10 days on trial and thus was also excluded. Data were analyzed via least squares (2) procedures, including appropriate variables.

RESULTS AND DISCUSSION

Results with intensively raised calves (Table 3) indicate that response to monensin varied with pasture type. Rate of gain over the entire experiment was increased 0.22 lb/day (13%) with monensin for calves grazed on the alfalfa/orchardgrass paddocks. No response was observed with monensin on alfalfa/tall fescue pastures. While reasons for this dichotomy in response are not immediately obvious, the lack of a gain response to monensin with tall fescue may reflect the lower rate of digestion of fescue. A reduction in rumen turnover rate with monensin (3) and an increase in retention time would be expected to be less beneficial with feedstuffs and grasses with slower rates as well as less extent of digestion (Table 2) such as fescue as compared to alfalfa or orchardgrass. Responses in each of the 28-day interim

TABLE 2.—Chemical Composition of Several Forage Species and Varieties Harvested at Jackson, Ohio, 1976 (Seeded 1975).

Species and Variety	Harvest Date	DM Percent*	DMD Percent†	ADF Percent‡	DDM Percent**	CP Percent††	ADF-N Percent‡‡	Undigested Protein Percent***	DP Percent†††	CWC Percent‡‡‡
Alfalfa, Jackson										
Vernal	5-20	22.8	61.22	37.93	61.80	18.12	0.25	0.09	18.10	46.65
	6-28	18.0	68.62	31.85	67.57	22.56	0.27	0.07	22.54	38.00
	8-9	18.9	65.48	40.58	58.77	17.69	0.21	0.07	17.68	47.45
	9-13	19.6	69.10	33.62	66.06	22.66	0.24	0.07	22.64	40.42
Orchardgrass, Jackson										
Potomac	5-20		51.09	37.28	61.87	10.62	0.14	0.08	10.61	60.05
	6-28	17.0	58.72	35.11	63.46	20.97	0.31	0.09	20.95	60.22
	8-10	18.3	54.38	39.18	59.25	14.81	0.16	0.07	14.80	64.25
	9-14	20.7	56.35	34.74	63.79	17.19	0.27	0.10	17.17	58.10
Tall fescue, Jackson										
Kentucky 31	5-20		49.60	37.96	61.62	11.53	0.14	0.08	11.52	62.55
	6-28	17.8	52.41	34.60	63.90	18.25	0.18	0.06	18.24	63.12
	8-10	18.8	48.44	38.60	59.93	13.63	0.19	0.09	13.62	64.20
	9-14	20.6	55.22	33.46	64.83	13.88	0.14	0.06	13.87	56.68

*Percent dry matter.
†DMD, dry matter disappearance, Tilley and Terry, in vitro measure of digestibility.
‡ADF, acid-detergent fiber.
**DDM, digestible dry matter determined from ADF, using regression equation for alfalfa, $DDM = 71.1 + 0.593\ ADF - 0.0221\ ADF^2$; for grass first cut, $DDM = 41.9 + 2.15\ ADF - 0.0433\ ADF^2$; and for grass aftermath, $DDM = 49.7 + 1.67\ ADF^2$; from Rohweder, Jorgensen, and Barnes, 1976 (5).
††Percent crude protein, Kjehldahl procedures, N x 6.25.
‡‡ADF-N, acid-detergent nitrogen.
***Undigestible protein, calculated as percent ADF-N/total N.
†††Percent digestible protein, calculated as CP (100% undigestible protein).
‡‡‡CWC, cell wall constituents.

Calves on alfalfa-tall fescue summer pasture at Jackson Branch.

TABLE 3.—Response of Calves Previously Raised on an Intensive Forage System to Supplemental Monensin on Alfalfa Pastures.

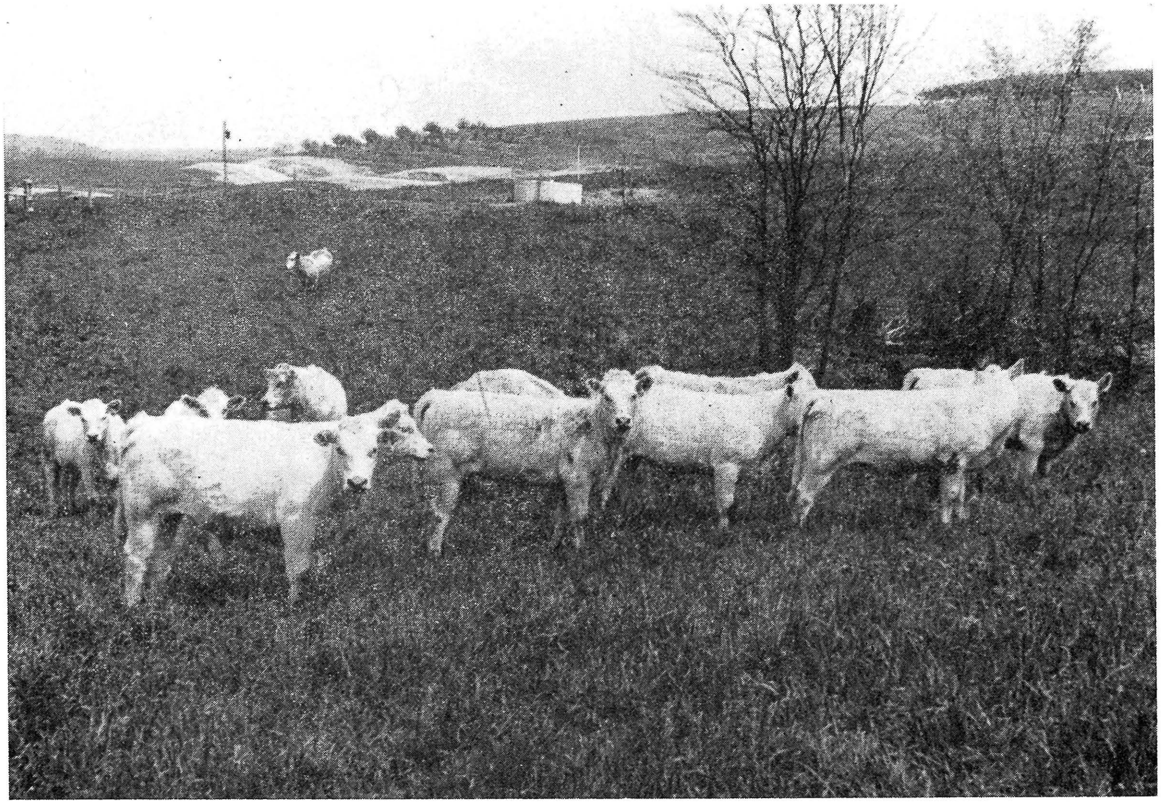
Item	Pasture type:	Alfalfa-Orchardgrass		Alfalfa-Tall Fescue		
	Monensin:	None	200 mg	None	200 mg	SEM
No. of cattle		10	10	11	11	
Initial weight, lb		483.7	490.3	472.3	483.7	16.7
Final weight, lb		658.4	686.6	649.1	656.8	
Gain, lb		174.7	196.3	176.8	173.1	20.7
Days		105	105	105	105	
Average daily gain, lb*		1.65	1.87	1.70	1.63	0.07

*Interaction of pasture type X Monensin was significant ($P < .06$).

TABLE 4.—Response of Calves Previously on Intensive or Extensive Forage Systems to Monensin on Alfalfa-Tall Fescue Pastures.*

Item	Previous Nutrition:	Intensive		Extensive		
	Monensin:	None	200 mg	None	200 mg	SEM
No. of cattle		11	11	9	9	
Initial weight, lb		474.2	478.9	374.7	378.9	17.8
Final weight, lb		652.2	653.5	572.9	578.0	20.7
Gain, lb		178.0	174.6	198.2	199.1	
Days		105	105	105	105	
Average daily gain, lb		1.70	1.65	1.89	1.87	0.07

*Least squares means.
†Previous nutrition significantly ($P < .01$) affected rate of gain.



Weaned calves on alfalfa-orchardgrass at Jackson Branch.

weigh periods concurred with the overall response with regard to monensin effects.

Comparisons of intensive and extensive calves on the alfalfa/tall fescue pastures (Table 4) indicate that no monensin response was evident with either class of calves on these pastures. Calves previously managed in the intensive system grew slower (1.65 vs. 1.89 lb/day) ($P < .01$) than extensive calves but were still about 79 lb heavier than extensive calves at the end of this grazing study. When classified by breed type (size), large size cattle gained significantly ($P < .05$) faster than small or average size cattle.

No significant interactions of monensin with breed type, sex, or previous nutrition were found in this study.

CONCLUSIONS

Fall-born calves, raised on the extensive wintering system, were unable to compensate during the summer grazing period for the period of restricted growth as nursing calves. This observation has important ramifications with regard to the importance of providing a good winter feeding program for nursing cows and calves, to allow calves to grow to optimal size to fully utilize high quality spring pastures and at least reach yearling weights following grazing. Calves raised on an intensive winter feeding program were 105 lb heavier at weaning and still 79 lb heavier following the 105-day spring-early summer grazing period where any compensation possible by restricted (extensive) calves would have to have already occurred since summer grazing following this period is always less than ideal.

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Effects of Forage System and Breed Type on the Performance of Fall Calving Cows

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SUMMARY

A 6-year fall calving study involving two forage production systems and two breed types was conducted on 333 cow records at the OARDC Jackson Branch. An improved forage production system is basic for a successful fall calving program. Early conception, high calving percentages, and calf livability were realized from fall calving cows reared on an improved forage system. The calf crop percentage (86.6) for cows maintained on the intensive forage system resulted in 13 more calves per 100 breeding cows in comparison to cows on the unimproved system. The 205-day weight and grade were markedly increased for calves reared on improved forages. Maternal heterosis was not evident from the data for calving percentage or 205-day weight and grade for the intensive forage managed herd. The F_1 dairy X beef cows produced calves with the heaviest 205-day weights. Calf weights were improved by the breed types having the highest milk and growth potential when specifically managed on the intensive forage system. It can be concluded from this study that a fall calving program offers a feasible management alternative for increased beef production from improved forage systems in Ohio.

INTRODUCTION

Increased cost of production is a continuous challenge for profitability to livestock producers. The intensification of resources (land, labor, capital, and management) is closely associated with unit production costs and total productivity. Alternate strategies for improved economic production become more specific with intensification where optimum resource utilization is desired.

The advanced technology for increased forage yield and quality through the use of adapted species, fertilization, and harvesting management is of particular importance to the further improvement of beef production systems. The impact of this technology interrelates with other beef management components and therefore requires evaluation before new production system alternatives can be developed.

The system of fall calving provides a non-traditional management alternative that may be compatible with improved forage production and management. Davis and Wheeler (1) reported on the economic feasibility of fall calving in Montana. Their analysis showed in general that optimal beef production decisions relative to calving season are directly affected by the balance of available feed and the calf crop percentage. Fall calving was a realistic economic alternative system where the availability of feed sources for winter feeding were greater than 55% of the annual feed requirement of the beef enterprise. Linear programming results indicated that market weight of fall calves should be at least 144% of spring-born calf market weight; for each 2% decrease in the fall-spring weight ratio, the fall calf crop must be 1% higher than the spring calf crop percentage for herds where 65% of the annual feed is available for winter feeding.

Mueller and Harris (3) and Raleigh *et al.* (5) noted a number of management advantages for fall calving, including the reduced incidence of disease in young calves that is commonly reported in spring calving herds. Fall-born calves provide additional opportunities for increasing forage utilization and greater marketing flexibility as reported by Van Keuren and Parker (6). Kartchner *et al.* (2) showed that fall-born calves have a greater capacity for the direct utilization of high quality forage during the spring and summer grazing periods. The average daily forage dry matter intake during the 125-day grazing-nursing period in their study was 9.4 and 2.1 lb for the fall and spring-born calves, respectively. Parker *et al.* (4) found that fall-born steers weaned at 289 days of age achieved 59% of their slaughter weight from milk and forage. This additional weight advantage from forage reduced the total feed needed in drylot by approximately 35% of that required by spring-born calves going directly into the feedlot at weaning.

The objectives of the study were to evaluate calf crop percentage and calf growth performance from fall calving cows of different size and milking potential maintained under two systems of forage production.

PROCEDURES

This study was initiated at the Ohio Agricultural Research and Development Center's Jackson Branch, in southern Ohio, during the fall of 1973. Two forage management programs were established. The extensive forage production system consisted of unfertilized summer and winter pastures typical of the unimproved acreages for beef production in the area.

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The winter pastures contained a thin stand of bluegrass and orchardgrass, with some legume and a considerable amount of weedy grasses. Generally a single crop of hay was harvested into round bales and left in the field with deferred fall growth for winter feeding.

The intensive forage system was developed to increase total forage production, forage quality, and therefore carrying capacity. New seedings of tall fescue-alfalfa and orchardgrass-alfalfa were established. Two and three hay harvests were baled from these improved areas for winter feeding, with the fall regrowth pastures deferred from grazing until the fall calving and breeding periods.

The forage crude protein values generally ranged from 7% to 9% for the hay and deferred regrowth pasture on the extensive system and an average of 12.5% from the intensive forage system. Average herds of 25 and 50 cows were maintained on the extensive and intensive forage systems, respectively. Neither cow herd received supplemental feeding nor had access to housing at any time during the experiment. Mature aged cows were primarily used in the study.

Cow herds have included straightbred Angus and Charolais and crossbred F_1 cows from these two breeds. F_1 Jersey X Angus, Brown Swiss X Angus, and Brown Swiss X Charolais were also included to study the importance of size and increased milk production potential for fall calving herds. Cow breeds and types were stratified across the two forage systems.

The initial breeding season was scheduled from Nov. 15 to Jan. 15 with subsequent calving during September and early October. Bulls were rotated within the breeding season across herds to minimize individual effects. Charolais, Simmental cross, and Hereford bulls were used in 2 or more years during the study. The same breed of bull was used across herds within years. Since 1976 the breeding period has been from Nov. 1 to Dec. 15 (45 days).

Calf weights were taken at birth and the weaning data recorded when the calves averaged approximately 7 months of age. This date was generally in early April and corresponded with the end of the winter stored feeding period and prior to the availability of spring grazing. Calf weights were adjusted for age of calf and the experimental data statistically analyzed by the least squares analysis of variance method.

RESULTS AND DISCUSSION

The productive trait of major interest in the study was calf crop percentage. The results for cow reproductive performance and calf livability are presented in Table 1. The data in this table are summarized by the extensive and intensive forage management herds for a 6-year period. Breed type and herd averages are presented for the block of years where direct comparisons can be made.

The calving percentage differences between the two forage management herds are large and of importance for evaluating the potential of a fall calving program. The comparison of the overall averages for calving percentage between forage systems is 93.8 vs. 79.2 for the 6-year period. For the 1977 to 1979 period, the difference was considerably larger (90.7 vs. 60.0) between the two forage management herds. This period included two severe winter seasons and in addition the total cow records were further reduced

TABLE 1.—Cow Calving, Calf Livability, and Calf Crop Percentages for Fall Calving Herds.

	Forage Program					
	Extensive			Intensive		
Calving Percentage	**Exposed**	**Calving**	**Percent**	**Exposed**	**Calving**	**Percent**
Overall Breeds (1977-79)*						
Cows (n)	50	30	60.0	150	136	90.7
Beef	25	14	56.0	60	54	80.0
F_1 Beef	11	8	72.7	38	34	89.5
F_1 Dairy X Beef	14	8	57.1	52	48	92.3
Overall years (1974-79)*	125	99	79.2	208	195	93.8
Beef	98	82	83.7	108	117	92.3
F_1 Beef	13	9	69.2	91	87	95.6
Calf Livability						
Overall breeds (1974-78)	**Born**	**Survived**	**Percent**	**Born**	**Survived**	**Percent**
Calves (n)	100	93	93.0	188	174	92.6
Calf Crop Percentage (Calving Percent X Percent Livability)			**Percent**			**Percent**
Overall Breeds			73.6			86.6

*The 1979 calving percentage values were based on rectal palpation diagnosis for pregnancy in the intensive herd only. Extensive herd values included the years 1974 through 1978.

for the extensive herd for 1979. Exclusion of these records was necessary since a portion of the extensive winter forage area was renovated during the summer of 1977 and therefore provided an improved forage environment for the 1978 breeding period. This improvement had an obvious positive effect on the conception rate (88.0%) as determined by rectal palpation. The comparative conception rate for the intensive forage management herd during the past breeding season was 94%. These calving percentage differences between the test herds show the importance of an improved forage production program on the reproductive performance of fall calving cows.

Differences among breed type within or between herds were not large for cow calving percentage. There was limited evidence of hybrid vigor for calving percentage between the straightbred beef and F_1 crossbred beef cows in the intensive herd. The F_1 dairy X beef crossbred cows had the highest calving percentages during the 1977-1979 comparison period. The F_1 beef crosses between the Angus and Charolais breeds produced the highest calving percentages (95.6) during the overall 6-year period. The data were too limited to make meaningful comparisons among the cow types in the extensive herd.

Calf livability from birth to weaning averaged 93% and was the same for herds of the two forage management systems. These results show the forage program effects were not reflected in calf livability but directly affected those factors associated with the percentage of cows calving. The combined effects of calving percentage and calf livability determine the calf crop percentage or the number of calves produced annually per breeding cow in the herd. The net effect of the improved forage system on cow reproductive performance was the production of 13 more calves annually per 100 cows exposed for breeding.

Calf growth performance in this study was evaluated on the basis of 205-day weight adjusted for age of calf. Factors included in the statistical model for the least squares analysis of variance were: year of calf birth, age and breed of dam, sex of calf, forage system, and day of birth.

The forage management system had a pronounced effect on the weight ($P < .01$) and grade of calves ($P > .18$) at 205 days of age. Table 2 presents the data for crossbred calves reared by Angus cows on extensive and intensive forage systems. Of particular importance is the changing contrast between the herd performances across the years from 1975 to 1978. Larger differences in calf weight and grade existed in the beginning years closer to the initial establishment of the legume-grass seedings for the intensive forage production herd. The differences between herds for 1978 reflect the improvement of forage quality from the pasture renovation during the summer of 1977 for the extensive forage area.

These data show that pasture improvement had a strong influence on 205-day weight and grade, with declining differences associated with the reduction of legumes in the available forage. The latter observation is supported by the first year after seeding comparisons of calf performance between herds for the years 1975 and 1978. During the first 3 years, calves reared on the intensive system averaged 20.4% (398.7 vs. 332.9) heavier and graded 1.1 higher (12.7 vs. 11.6) at 205 days of age.

The effects of breed and type of cow on calf performance are shown in Tables 3 and 4. There was little difference within the intensive forage herd between the averages of the two breed cross calves suckling straightbred Angus and Charolais cows and the performance of the three breed cross calves reared by F_1 Charolais X Angus and Angus X Charolais for either weight or grade. This lack of maternal heterosis for weight and grade of calves produced in the intensive herd is similar to the results obtained from comparing straightbred and F_1 cows for calving percentage. These findings suggest that under favorable nutritional conditions the importance of hybrid vigor in the crossbred cow is reduced for cow-calf production.

The heaviest calves were produced by the F_1

TABLE 2.—Weaning Performance of Crossbred Fall-Born Calves from Angus Cows (LSM).*

	Year of Production							
	1975		1976		1977		1978	
	205 day							
Forage Program	wt lb	Grade†	wt lb	Grade†	wt lb	Grade†	wt lb	Grade†
Intensive (60)	421	12.9	396	13.0	397	12.2	358	12.5
Extensive (57)	325	11.1	320	11.7	355	11.9	374	13.6
	P, LSM, sd: wt P < .01, 357, 35.8; grade P < .01, 12.1, 1.1							

*Least squares means adjusted for the effects of year, age of dam, sex of calf, and day of birth.
†Grade score: 11 = Good +, 12 = Choice —; 13 = Choice.

TABLE 3.—Weaning Performance of Fall-Born Calves from Straightbred and Crossbred F_1 Beef and Dairy X Beef Cows, Intensive Forage System (LSM), 1975-76.*

	Breeding of Cows				
Trait: (at 205 days) (n)	**Angus (A)** 30	**Charolais (C)** 18	**F_1CA, AC** 33	**Brown Swiss X Angus** 6	**Brown Swiss X Charolais** 7
Weight (lb)	395	413	410	422	469
Grade†	12.8	13.2	13.0	13.1	13.2
	P, LSM, sd: wt P < .01 417; 38.8; grade P.17, 13.0, .77				

*Least squares means adjusted for the effects of year, age of dam, sex of calf and day of birth.
†Grade score: 11 = Good +; 12 = Choice —; 13 = Choice.

TABLE 4.—Weaning Performance of Fall-Born Calves from Straightbred and Crossbred F_1 Beef and Dairy X Beef Cows, Extensive and Intensive Forage Systems (LSM), 1975-78.*

	Breeding of Cow			
Trait: at 205 days (n)	**Angus (A)** 102	**F_1 Beef (CA, AC)** 69	**Jersey X Angus** 31	**B.own Swiss X Angus** 31
Weight (lb)	340	392	393	395
Grade†	12.0	13.0	12.8	12.6
	P, LSM, sd: wt P < .01, 382, 45.7; grade P < .10, 12.7, 1.2			

*Least squares means adjusted for the effects of year, age of dam, sex, herd, and day of birth.
†Grade score: 11 = Good +; 12 = Choice —; 13 = Choice

Brown Swiss X beef cows located on the improved forages. Breed types were compared between the two forage systems during a 4-year period (Table 4). Breed differences were primarily influenced by the similar superiority of the calves suckling F_1 beef and dairy X beef cows in comparison to the two breed cross calves from the smaller type Angus cows. Charolais cows were not available for this comparison. The average effects of the F_1 Jersey X Angus and Brown Swiss X Angus were similar for 205-day weight and grade. However, when the comparison was made between the two crossbred types within forage system, the F_1 Brown Swiss X Angus cows on the improved forage system produced calves that were 7.8% heavier (411 vs. 381 lb) than the F_1 Jersey X Angus cows. Therefore, the larger F_1 beef X dairy cows were more sensitive to the forage system and specifically required an improved forage program for achieving their optimum performance.

The results from this study show that an improved forage management program is basic to the success of a fall calving management system. Calf weight can be further improved by selecting breed types having higher milk and growth rate potential when combined with higher quality forages. A fall calving program offers real potential for increased beef production from improved forage systems in Ohio.

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Forage Management for Beef Production

R. W. VAN KEUREN, C. F. PARKER, and E. W. KLOSTERMAN[1]

SUMMARY

A long-term study of summer and winter forage feeding systems for beef herds is currently being conducted in Ohio. The carrying capacity of summer pastures varied widely from 59 beef cow and calf days per acre (3.13 acres per cow and calf) for unfertilized low fertility pastures with thin grass stands to more than 200 days per cow (0.90 A/cow-calf) for highly fertilized pastures with high yielding species. The acres per cow-calf are based on a 184-day grazing period. Feeding square bales in drylot took the least hay daily (23 lb dry matter per 1000-lb cow per day) but the most labor. Utilizing fall-saved regrowth and field-stored round bales required less labor but somewhat more feed per day compared with feeding in drylot. Legumes were found to persist satisfactorily in winter pasture programs, using a combination of late fall-early winter grazing of the fall-saved regrowth, followed by utilization of field-stored bales. Fall-born calves and mature cows were shown to winter satisfactorily on the legume-grass winter programs. Stocker steers gained satisfactorily on summer pasture, particularily if a good percentage of legumes was present.

INTRODUCTION

There are about 4 million acres of permanent and cropland pasture in Ohio plus several million more acres which have reverted back to brush and trees. Much of the grazing land is not producing near its capability. Ohio also has thousands of acres of crop residues that beef cattle could utilize and convert into meat for human consumption. Forage and roughage production and utilization could be markedly improved, along with expanding beef production, if the demand and economic incentives were present. Currently, there are about half a million beef cows in Ohio.

Economic returns from cow and calf production have traditionally been low and subject to wide periodic variations in prices. All costs must therefore be kept to a minimum. Feed production and utilization is an area over which each producer has a great deal of control. Since feed costs make up a large percentage of total cost, producers should thoroughly evaluate their total feed programs.

The average beef cow herd is small in number. A recent survey of six eastern states including Ohio (2) showed an average herd size of 29 cows. Beef cows are often a means of utilizing crop residues and rough land not suitable for crop production, supplementing other farm enterprises. Many beef cow producers work full-time or part-time off the farm or are retired and keep beef cows to utilize the land. The herd provides both a source of income and a continuing activity in agriculture. Another option for Ohio landholders who don't wish to invest in animals is to rent out their pasture. This provides income and keeps the land open, rather than letting brush encroach. Such pasture can be utilized for backgrounding stocker cattle, bringing them up to size and weight for feedlot finishing.

SUMMER PASTURE FOR BEEF COWS

Researchers have looked at several summer pasture programs for beef cows in Ohio, including those typical of what producers are using.

Table 1 shows the carrying capacity of beef cows and spring-born calves of summer pastures located at several Ohio Agricultural Research and Development Center branches in eastern Ohio. Under low soil fertility conditions typical of many unfertilized pastures in Ohio, pasture A takes more than 3 acres to carry a cow and calf. The major limitation of this pasture is the very low phosphorus (P) and potassium (K) levels. It has a thin stand of bluegrass and orchardgrass, scattered red clover, and is weedy. Pasture B is also low in fertility, but the levels of P and K are somewhat higher than pasture A, so the general stand and vigor of the bluegrass and orchardgrass are improved. There are more legumes and the pasture is less weedy. The result is that it takes about 2 acres per cow and calf. With moderate levels of P and K (30-45 lb available P and 200 lb available K) and a modest application of nitrogen (50 lb in early spring), mixed grass pasture C has a 20% increase in summer carrying capacity compared with pasture B with no nitrogen.

It took 130 lb of N per acre annually in two applications to get a carrying capacity of a cow and calf per acre with orchardgrass (pasture E). A good grass-legume pasture (pasture F) gave about the same carrying capacity as the grass plus N, and in this case the calves also weaned heavier from the orchardgrass-alfalfa (50 lb and a grade higher) than from the orchardgrass alone. Going to a higher rate of nitrogen on orchardgrass, 200 lb of N annually in three applications (pasture G), gave an increase over

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TABLE 1.—Carrying Capacity of Summer Pastures for Beef Cows and Spring-Born Calves.

Pasture	Fertility Level and Forages	Cow-Calf Days/ Acre	Acres/ Cow-Calf*
A	Low fertility, location 1 mixed grass, no fertilizer	59	3.13
B	Low fertility, location 2 mixed grass, no fertilizer	89	2.08
C	Moderate fertility mixed grass, 50 lb N, early spring	106	1.74
D	Moderate fertility mixed grass, 68-130 lb N, 1-2 applications	155	1.19
E	Moderate fertility orchardgrass, 130 lb N, 2 applications	184	1.00
F	Moderate fertility alfalfa-orchardgrass	189	0.97
G	High fertility orchardgrass, 200 lb N, 3 applications	204	0.90

*Based on 184 days, April 20-Oct. 20.

TABLE 2.—Average Amount of Feed Available per Day for Wintering Beef Cows on Several Systems and the Range Over Several Years in Ohio Studies.

		Lb DM/1000 Lb Cow/Day		
Winter Feed Program	Hay/Winter Pasture	Average	Range	Hay Portion
A. Spring Calving Cows, Several Locations, 1966-78				
1. Square bales, in barn fed daily in manger	timothy-red clover	23	20-26	23
2. Square bales, on pasture fed daily on ground	orchardgrass-alfalfa	25	21-27	25
3. Large bales on pasture with racks, 3 X weekly	orchardgrass-alfalfa	24‡		24
4. Small bales (one cut)* + fall-saved regrowth	tall fescue	34‡	29-43	18**
5. Small bales (one cut)* + fall-saved regrowth	tall fescue-red clover	35‡	29-42	18**
6. Large bales (one cut)* + fall-saved regrowth, no racks	tall fescue	34‡	32-37	17**
7. Large bales (two cuts)† + fall-saved regrowth, racks	tall fescue	30‡	26-35	17**
8. Large bales (two cuts)† + fall-saved regrowth, racks	tall fescue-red clover	28‡	22-34	19**
B. Fall Calving Cows and Calves,†† Jackson Branch, 1975-78				
		Cow-calf units		
1. Large bales (three cuts)† + fall-saved regrowth, electric-fence used to control bale consumption	tall fescue-alfalfa	46‡	40-51	29**
		Animal units		
		35‡	29-41	22**

*Bales left in field where dropped by baler.
†Bales moved to edge of field, fenced away from the herd.
‡Includes field storage losses.
**Hay portion of total forage available, remainder from the fall-saved pasture.
††Calves are 400 lb by spring and consuming considerable hay.

orchardgrass with 130 lb of N and over orchardgrass-alfalfa, but would not be an economical program.

In a summer pasture improvement program, the first step would be to take soil tests and determine the fertility status. Lime and phosphorus are usually the first limiting factors, as shown in the results presented above. The next step would be to apply nitrogen, although for long-term improvement, interseeding legumes would be the most economical because of the savings in nitrogen fertilizer and in the improvement in pasture quality.

WINTER FORAGE FOR BEEF COWS

Spring Calving Herds

Table 2 compares several methods of wintering mature beef cows at several locations in Ohio. The first eight comparisons are with spring calving herds. The data are in pounds of dry matter per 1,000-lb cow per day in total forage available with an average for several years, the range over the period of the studies, and the hay portion. In the first three programs, only hay was fed; in the second five, both hay and fall-saved regrowth were available.

In program 1, square bales were manger fed daily in an open barn. Hay was fed to need, with care taken to avoid overfeeding. The higher amount in the range, 26 lb per day, reflects a generally colder winter when energy demands of the cows were greater. About a half ton of bedding per cow was also used each winter to bed down the loafing area.

Feeding square bales out on a pasture field all winter (program 2) required slightly more hay per cow as might be expected. It did, however, eliminate the need for bedding and for manure hauling. The wintering field, after 5 years of such a program, is showing a thinning of the pasture stand and increasing weediness, particularly annual grassy weeds. It appears that if such a wintering program is followed, it should be rotated over several fields if possible. This would reduce the long-term damage to the pasture and spread the manure over more area. The effect of wintering a 25-cow herd on this 7-acre field for five winters is showing up in the soil test results, primarily as an increase in available potassium.

Feeding large bales in racks three times a week out on a pasture gave results similar to feeding square bales in the barn, but these figures are for only one winter (program 3). Additional information is being obtained on this feeding method.

Program 4 represents the results of 8 years of one crop of small round bales dropped in the field and the regrowth utilized as winter feed. It is Kentucky 31 tall fescue fertilized with N and the grass generally maintained a good stand. The 34 lb per day per cow is based on the total forage produced in the pastures including bale field storage losses, feeding losses, and trampling and "winter-burn" of the regrowth. The hay portion of the feed available averaged 18 lb per cow per day. In winters when the fields were drier or the ground frozen most of the winter, the forage required was much less than in years with wet muddy conditions. This is shown in the range, with the 43 lb per day representing generally very poor field conditions most of the winter. Although the small round bale and regrowth program required more feed compared with the three hay programs discussed, it resulted in a great savings in hay harvesting and handling and eliminated manure disposal. A labor savings of 75% resulted in comparison with the barn-feeding program (program 1), plus the savings in bedding. Comparing program 4 with program 3 (large bales on pasture), some savings in the amount of hay was seen, as well as in equipment costs if one owns a small round baler compared with purchasing a large round baler.

Using a tall fescue-red clover mixture in a field-stored small round bale and regrowth program (program 5) gave similar results as using tall fescue (program 4). Only slightly more total feed on the average was required, probably representing primarily the winter deterioration of the red clover regrowth. The grasses hold their leaves better than do the legumes. The current effort in winter programs with good legume stands is to graze the standing regrowth first and then go to field-stored bales to utilize the legume-grass regrowth early in the winter feeding period.

Program 6 was similar to program 4 but used large bales instead of small bales. The results were very similar. In program 7, two cuts of hay were made as large round bales and fed later in the winter in racks at the edge of the pastures. The cows have both the fall regrowth and the bales available as winter feed. Program 8 was the same as program 7 but with a tall fescue-red clover mixture rather than tall fescue alone. In programs 7 and 8, the regrowth could be grazed first in late fall-early winter before allowing access to the bales, making somewhat better use of the regrowth. However, it is generally found that the animals graze the regrowth very closely by spring.

All of the above programs were found to be excellent for wintering mature spring-calving cows. Bred heifers could be kept on such programs until about Jan. 1 with the herd, but then should probably be separated and fed separately. They could then be fed the best quality hay available and may, in addition, need supplemental grain plus protein depending on the quality of the hay, the condition of the heifers, and the severity of the winter. They should also have access to a barn for the calving period.

The use of round bales permits leaving the feed in the field and eliminates much of the handling of the hay. In most instances, the losses from outdoor storage are compensated for by the savings in the storage costs if square bales are the alternative. Field feeding eliminates some of the handling and also eliminates manure disposal compared with drylot feeding. Square bales can be field fed, but require daily hauling and feeding. Feeding square bales every other day was tried but little savings in time and labor were found because the herd had to be checked every day anyway. The big advantage in the round bale programs with field storage and feeding is primarily in the labor saved. This is at some cost in feed, but it appears that, at the availability and cost of labor, this is a viable economic trade-off.

Fall Calving Herd

As the beef cow wintering studies progressed and legumes were included with the grass, a study of fall calving to utilize the higher quality legume-grass feed was initiated. Such a study using alfalfa-tall fescue was initiated at the Jackson Branch in 1974. Beginning in the winter of 1978-79, studies with fall calving cows on red clover-tall fescue were also initiated at the Jackson Branch and on birdsfoot trefoil-tall fescue at the Mahoning County Farm.

Three years' results from the fall calving cows on the alfalfa-tall fescue winter feed program are shown in Table 2 (program B-1). In this program, three cuts of hay are usually made and the large round bales moved to the edge of field. An electric fence is put around the bales. In late October, the cows and calves are put on wintering fields and graze the fall-saved regrowth. Before the regrowth is completely grazed, the cows are allowed access to a portion of the bales as needed. The use of electric fence to control bale utilization has proven satisfactory. As shown in program B-1, the cows (animal unit basis) had available, on the average, 35 lb of feed with 22 lb of that as hay. These are lactating cows so their requirements are higher than the spring-calving cows. On the basis of cow-calf units, the feed available was 46 lb per day on the average, with 29 lb of that as hay. The calves are 400 lb or so by spring and are also consuming considerable hay. The values given include the field storage and feeding losses.

The use of a legume-grass mixture in such winter feeding programs has been shown to be successful for fall-calving mature cows. First-calf heifers can be left with the herd until the fall regrowth is consumed or even until about the first of January, depending on the weather. It may then be advisable to separate them from the herd and feed some grain to maintain condition and pregnancy because they are still grow-

TABLE 3.—Average Birth Dates, Weaning Dates, Weaning Weights, and Grades of Fall-Born Calves from Two Winter Forage Programs at Jackson Branch, 1974-78.

	Alfalfa-Tall Fescue					Unfertilized Mixed Grasses				
1. Forage:	Alfalfa-Tall Fescue					Unfertilized Mixed Grasses				
2. Winter program:	Large Round Bales and Fall Regrowth					Small Round Bales and Fall Regrowth				
3. Herd size:	50 cows					25 cows				
Year	Av Birth Date	Weaning Date	Av Wean Wt, lb*	Av Grade	205-Day Adj. Wt, lb†	Av Birth Date	Weaning Date	Av Wean Wt, lb*	Av Grade	205-Day Adj. Wt, lb†
1974-75	9-11-74	6-23-75	592	12.6	438	9-12-74	6-23-75	530	11.6	353
1975-76	9-8-75	5-24-76	513	13.9	444	9-11-75	5-24-76	434	12.7	373
1976-77	9-14-76	4-19-77	455	13.6	447	9-12-76	4-19-77	356	12.0	354
1977-78	8-26-77	4-5-78	430	12.7	415	8-30-77	4-5-78	410	12.6‡	405

*Note weaning dates.
†205-day adjusted wt., also adjusted for age of dam.
‡Extensive system calves creep-fed grain 1-3-78 to 4-5-78.

ing as well as lactating. If the hay quality is only fair, protein supplement will also be needed.

The persistence of the alfalfa under the winter forage program at the Jackson Branch has proven to be good where the soil drainage is adequate. In wet, poorly drained areas, the alfalfa has not persisted. It is not desirable to use poorly drained fields for wintering programs under any conditions, however.

Fall Calf Data to Weaning

An earlier report (1) discussed the advantages of fall calving for Ohio producers. Further results obtained from fall calving at the Jackson Branch will be discussed here. Two fall-calving herds are being maintained at this location. A 50-cow herd is being wintered on alfalfa-tall fescue using large round bales and fall-saved regrowth as described in the section on the fall-calving herd.

Another herd of 25 cows has also been wintered on hay and fall-saved regrowth from unimproved fields at the same location. The fields used had a thin stand of orchardgrass and bluegrass, some legume, a considerable amount of annual weedy grasses (crabgrass, foxtail, and fall panicum), and broadleaf weeds. The first crop of hay was made into small round bales and left in the field where dropped by the baler. The regrowth was allowed to accumulate until the winter feeding period. The 4-year average hay production was 0.64 ton per acre of dry matter and the fall regrowth 0.62 ton, a total annual forage yield of 1.26 tons per acre. The feed was generally adequate for the mature cows as shown by the animal wintering condition. Feed analysis of the hay and regrowth also showed that it was adequate for mature cows going into winter in good condition. It was not of sufficient quality for bred or lactating heifers.

The response of the fall-born calves to the two kinds of winter feed is shown in Table 3. The calves of the cows on the alfalfa-tall fescue always weaned at a higher weight and grade than those of the cows on the unimproved forage. For the first 3 years, 1974-77, the calves from the alfalfa-tall fescue winter program averaged 521 lb and a grade of 13.4, compared with an average weight of 440 lb and a grade of 12.1 for the calves from the unimproved winter forage. In 1977-78, the calves on the unimproved forages were creep-fed from Jan. 3 until weaning in April. Despite this, they were still 20 lb lighter at weaning time than the calves from the alfalfa-tall fescue forage which did not receive creep.

The calves were weaned at different dates each year. In 1974-75, the calves remained with the cows until June 23 and were weaned at 596 and 530 lb for the improved and unimproved winter feed programs, respectively. The next year the calves were weaned in late May and were 513 and 434 lb from the improved and unimproved winter feed programs, respectively. In the last 2 years, the calves were weaned prior to spring pasture so that the animals could go on summer feeding studies, and again the calves from the improved program were higher in weaning weight than those from the unimproved.

Stocker Steer Gains on Summer Pasture

Some producers are interested in summer pasture for backgrounding steers to achieve heavier weights for feedlot finishing. Some have pasture of their own to use, while others may want to contract pasture for so much per pound of gain. For landholders who have pasture but no livestock, renting pasture provides a market for the unused feed and some income without the investment in animals.

TABLE 4.—Stocker Steers on Bluegrass-Trefoil Summer Pasture, Wooster, 1958-1963.

Year	Period	Winter Drylot Daily Gain		Initial Pasture Weight		Final Pasture Weight		Total Gain per Head on Pasture	ADG	Steers Gain
		lb/Day	±SD	lb	±SD	lb	±SD	lb	lb/Day	lb/A
1958	5/3-9/4 (124 days)	1.39	0.18	624	42	807	51	183	1.48	278
1959	5/6-9/9 (126 days)	0.60	0.44	783	35	942	44	159	1.26	271
1960	5/6-9/15 (132 days)	0.97	0.31	803	60	906	62	103	0.83	238
1961	5/15-9/14 (122 days)	1.24	0.24	838	26	961	31	123	1.00	230
1962	5/11-8/25 (106 days)	0.73	0.22	838	57	926	55	88	0.97	142
1963	5/15-9/4 (112 days)	1.01	0.20	789	24	893	42	104	0.99	187
Average		0.99		779		906		127	1.09	224

TABLE 5.—Stocker Steers on Bluegrass-Trefoil Summer Pasture, Wooster, 1965-1968.

Year	Period	Winter Drylot Daily Gain		Initial Pasture Weight		Final Pasture Weight		Total Gain per Head on Pasture	ADG	Steers Gain
		lb/Day	±SD	lb	±SD	lb	±SD	lb	lb/Day	lb/A
1965	5/18-8/20 (94 days)	0.71	0.11	749	27	898	28	149	2.01	316
1966	5/17-9/1 (107 days)	1.07	0.26	726	76	862	48	136	1.27	291
1967	5/31-9/6 (99 days)	1.17	0.23	688	52	781	46	93	1.07	235
1968	5/2-9/16 (134 days)	0.76	0.25	699	33	873	49	174	1.37	302
Average		0.93		716		854		138	1.43	286

Tables 4 and 5 show pasture gains of Hereford stocker steers over a number of years on bluegrass-trefoil pasture at Wooster. The pastures were renovated in 1964 with a bluegrass-trefoil reseeding, and the second series of studies initiated. The cattle were wintered on corn silage and hay prior to going on summer pasture. The winter daily gains averaged slightly less than 1 lb a day, ranging from 0.60 to 1.39 lb. The total gain per head on pasture averaged 131 lb over the 10 years, ranging from 88 to 183 lb per head. The average daily gain was 1.22 lb, ranging from 0.83 to 2.01 lb per day. The highest total gains and highest average daily gains generally occurred in the first several years after seeding, reflecting the higher percentage of legume in the pasture.

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Breeding and Management Systems to Optimize Beef Breeding Herd Productivity

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SUMMARY

Feed requirements to maintain a beef breeding herd are a major part of total needs and a tremendous overhead which the beef industry must carry. This article briefly reviews previous research and outlines an experiment designed to determine the effects of breed type, rate of cow replacement, and season of calving upon breeding herd productivity. Beef herds at four of the OARDC branches are being used to compare Hereford x Angus with Charolais x Simmental criss-cross mating systems, a normal, 20% annual cow replacement rate to keeping all heifer calves through breeding as yearlings, and spring vs. fall calving. Each herd is evaluated on reproductive rate, weight of animals maintained, cow and calf gain, herd productivity (wt gain/wt maintained), weight of the various classes of beef marketed, and an estimation of TDN requirements per unit of gain. Results obtained to date indicate that the amount of feed required to maintain a beef breeding herd can be reduced by increasing the number of heifers retained for breeding and reducing the number of mature cows in the herd. By combining reproduction with growth of the dam, beef productivity can be significantly increased.

INTRODUCTION

Beef industry productivity may be defined as a ratio of live weight gain to inventory weight which must be maintained. Thus, productivity may be improved by an increase in gain or a decrease in maintenance. Although significant improvements have been made through feeding, breeding and management, increases in efficiency of gain have been relatively slow.

The metabolic processes by which feed nutrients are converted to animal products are difficult to change. Rather standard amounts of feed nutrients are required to maintain a given weight and condition of animal, produce a pound of lean, fat, milk, etc. Inputs are required if outputs are to be expected. However, the problem of increasing efficiency of nutrient utilization, over and above maintenance requirements, has not been limited to the beef industry. Increased production of milk, eggs, broiler meat, corn, forages, etc. is dependent upon increased inputs of food nutrients.

Progress in plant and animal productivity has been realized primarily by increasing yield of product obtained above maintenance costs. According to Bray (1), beef productivity (wt gain/inventory wt) increased from 0.30 in 1930 to 0.43 in 1975. Much of this increase was due to increased numbers of slaughter cattle going through feedlots and marketed at 2 years of age or less instead of 4-6 years of age. Most efficient production of market animals is to produce maximum weight of a desired grade at a young age, thus minimizing individual maintenance needs. However, in beef production, this procedure increases the percentage of animals required in breeding herds and accentuates the importance of optimizing their productivity.

A multitude of beef and forage production and management systems, cattle types, and forage species may be utilized for beef production. In recognition of the apparent difficulty of altering those metabolic processes which determine the efficiency of converting fertilizer elements into forage and plant nutrients into beef, it seems important that increased research effort be directed toward the reduction of maintenance requirements of beef herds.

OBJECTIVES

The objectives of this research are to determine the effects of the following breeding and management systems upon total productivity and feed requirements per unit of beef produced:

1. Hereford x Angus vs. Charolais x Simmental criss-cross mating systems.
2. A normal 20% per year cow replacement rate vs. a maximum replacement rate in which all heifers are retained through breeding as yearlings.
3. Spring vs. fall calving.

PREVIOUS RESEARCH AT OARDC

Numerous experiments have been conducted to compare various breed types and sizes of cattle (4, 5, and others). In general, larger type cattle will eat more feed per head daily, gain at a faster rate, and mature or finish at an older age than smaller type cattle. When fed to similar grade, there has been little difference among types in efficiency of gain. However, most of the research with different types

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has been with growing-finishing cattle post-weaning. Very little research has been conducted with breeding herds where possible differences in reproductive rate and maintenance of animals varying in size may be highly important.

It has been shown that the beef industry must carry about two animals in breeding herds for each calf produced (2). Thus, reproductive rate is one of the major problems. Heifers will frequently breed at a young age, and in fact pregnancy is one of the major reasons heifers are discriminated against as feeder cattle. With this discrimination, it seems logical that heifers be used to help solve the reproductive problem.

Heifers will reproduce prior to maturity and thus, through growth, add weight to their own body while producing a calf. Therefore, feed costs of producing beef (cow beef and feeder calves) can be reduced by combining reproduction with the growth of immature cows.

As a heifer grows to maturity she increases in weight, which increases her feed requirements for maintenance. Data in Table 1 were obtained from a Hereford-Charolais crossbreeding experiment in which heifers were bred first as yearlings and were kept on experiment for three calf crops (4). One-half of the calves were creep-fed and hence the creep feed requirements listed are averages of those which did and did not receive creep feed. As expected, weaning weight of calf increased with age. However, as the heifers' weight increased, their feed requirements increased at a faster rate, so that TDN required per pound of calf weight increased with age of dam. At the same time, these immature cows were producing cow beef which is a marketable product. These data question the importance of longevity as a measure of cow efficiency.

Two experiments were conducted at the USDA North Appalachian Experimental Watershed, Coshocton, to study drylot calf production systems. Major goals of this project were to better utilize the entire corn plant and reduce feed requirements for maintenance of the breeding herd by combining heifer growth with reproduction. One experiment was conducted in which Hereford x Angus first-cross heifers were bred and full-fed limestone-urea treated corn silage until calving and then marketed at good-choice grade. As compared to open, control heifers, final carcass weight was reduced with no improvement in carcass quality as the result of pregnancy. Main disadvantages were the long feeding period required to include gestation, difficulties in calving finished heifers, labor requirements, and low value of new-born calves at that time.

In the second experiment, heifers were fed hay and limited corn silage during gestation, were full-fed corn silage following calving, and remained in the herd to nurse their calves. With facilities available, calf losses were quite high. This drylot, calf production system, utilizing immature heifers, is not recommended due to high labor requirements and problems associated with confinement rearing of calves in a barn and unpaved lot under humid, eastern Cornbelt conditions. The combination of heifer growth with reproduction may be better suited to a pasture management system and the production of open, long yearling, feeder heifers or cow grinding beef rather than finished beef.

In addition to an aid in reproductive rate, reducing maintenance and producing grinding beef,

TABLE 1.—Total Digestible Nutrients Required per Pound of Weaning Weight by 2, 3, and 4-Year-Old Cows (Average of Approximately 50 Hereford and 50 Charolais).

	Age at Calving, Years		
	2	3	4
TDN Required per Head to:			
Winter cow	1160	1508	1872
Pasture cow	1640	1896	2233
Pasture calf	872	964	1029
Creep feed	244	222	207
Total TDN	3916	4590	5341
Percent of 2-yr-old		117	136
Weaning Weight	513	526	549
TDN/Weaning Weight	7.63	8.73	9.73
Percent of 2-yr-old		114	128
Av Cow Weight	904	1006	1087
Gain		102	81

there are other advantages in keeping all heifers through the first breeding season. Grazing yearlings permits herd size adjustment to changes in pasture conditions and phases of the cattle cycle; two yearlings are approximately equivalent in gain and feed needs to one mature cow-calf pair. It has been shown that heifers are well adapted to forage utilization (5). Keeping larger numbers of replacements also reduces the generation interval which will increase the rate of herd improvement through sire selection or a change in breeding program.

Primary disadvantages of breeding more yearlings are calving problems with first calf heifers and a need for higher quality feed when growth and reproduction are combined. Closer supervision and better management are required than with mature cows.

Depending upon feed supplies, location, and facilities available, there can be advantages to either spring or fall calving. Spring calving generally has been followed in Ohio. However, excellent results have been obtained at the Jackson Branch with fall calving (6). Some of the advantages of fall calving include: calving occurs during favorable weather, rebreeding has been excellent, and the calves are large enough by spring to utilize pasture effectively during the period when pasture is at its peak of quality and quantity. However, since they are milking, a higher quality winter feed supply is needed than with a spring calving herd.

Additional research is needed to compare spring and fall calving under Ohio conditions. Studies are needed at different locations, with different cattle types, and with various forage production and management systems.

PROCEDURE

Cow herds used for forage production and management experiments at the Southern and Jackson Branches, North Appalachian Experimental Watershed at Coshocton, and the Mahoning County Farm are used in these studies. The general design of the experiment is:

	Breed Cross			
	Hereford x Angus		Charolais x Simmental	
Calving Season	Spring	Fall	Spring	Fall
Replacement Rate				
20%	25*	25	25	25
Maximum	25	25	25	25
Branch Location	Southern	Jackson	Coshocton	Mahoning

*Approximately 25 mature, cow-calf pair equivalents are included in each comparison. Thus more females (yearlings) will be exposed to breeding in those herds with the maximum replacement rate.

The two herds at each location are managed during the breeding season in such a way that the criss-cross breeding system indicated can be followed. During the remainder of the year they are divided into herds to best utilize the pastures and meet the objectives of the forage experiments.

The breeds of cattle and calving seasons indicated at the various locations have been established. Since the facilities available at any one location are not sufficiently large to include all comparisons, several years' data will be required to obtain meaningful information on breed types and calving seasons.

The comparison of two female replacement rates was initiated at the Southern Branch at weaning time in the fall of 1977; however, the herds were not culled until after calving in the spring of 1978. This part of the experiment was started at the other branches at the appropriate weaning time in 1979.

Data to be used to compare the various herds include reproductive rate, weight of animals maintained during the year, cow and calf gain in weight, herd productivity (wt gain/wt maintained), and weight of the various classes of beef marketed each year. In addition, the amount of TDN required per unit of gain is calculated from the average weight maintained and gained according to the formula, $TDN = 0.036\ W^{0.75}\ (1 + 0.57\ \text{gain})$, (3).

TABLE 2.—Effect of Female Replacement Rate Upon Annual Production of the Breeding Herd (Southern Branch, Fall 1977-Fall 1978).

	Replacement Rate	
	20%	Maximum
No. of Females		
Yearlings	5	11
2 yr old	2	2
3 yr old	0	0
Mature	16	16
No. cow-calf pair units (C-CU)*	20.5	23.5
No. calves weaned	18	18
Gain per C-CU, lb		
Cow	110	192
Calf	363	319
Total	473	511
Av wt maintained/C-CU	1215	1204
Wt gain/wt maintained	0.389	0.424
TDN per lb gain†	12.08	11.51
Beef marketed per C-CU, lb		
Steer calf	213	177
Heifer calf	89	0
Yearling heifer	39	33
Cow	65	236
Total	406	446

*Two yearling heifers approximately equivalent to one 2 yr + cow-calf pair.
†$TDN = 0.036W^{0.075}\ (1 + 0.57\ \text{gain})$.

RESULTS

Results presented in Table 1 show, due to less body weight to maintain, that immature females will produce 1 cwt of calf at weaning with less feed than a mature cow and at the same time produce grinding beef by increasing their own body weight. The increase in TDN per unit of calf weaning weight was 14% for each year of increased age of dam, while the increase in dam weight was approximately 10% per year.

Data in Table 2 are results of 1 year with the Hereford x Angus herd at the Southern Branch. It should be noticed that this herd was primarily mature cows with only a limited number of replacements in recent years. Although there was a 9% increase in productivity (wt gain/wt maintained) in favor of the maximum replacement rate herd, this difference would be expected to increase as the difference in age of dam between the two herds increases.

As indicated previously, due to variation in location among the various herds, several years' data will be required to obtain meaningful comparisons between the two breed types and seasons of calving.

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Voluntary Feed Intake of Mature Cows as Related to Breed Type, Condition, and Forage Quality

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SUMMARY

Two experiments were conducted with individually fed Angus and Charolais type cows to measure voluntary dry matter intake of forages varying in quality. Variation in intake among individuals of either type of cow was about 10% to 12% with alfalfa or grass hay, but increased to 16% with corn stover. There was a definite, positive relationship between the weight to height ratio of the cows and their forage intake per head daily, indicating that fatter cows have greater appetites than thinner ones. Larger type cows generally ate more forage and gained more per head than smaller cows; however, on a constant weight basis, these differences were relatively small. Although not conclusive from these experiments, there was an indication that, per unit body weight, Angus type cows ate more high quality forage but less of poor quality than Charolais type cows.

INTRODUCTION

With the introduction of many new breeds in recent years, there is now a wide variety of cows of different breed types and sizes available for beef production in the United States. When their calves have been finished to similar carcass grade, differences among types and sizes in total efficiency of beef production have been relatively small (1, 3). However, based largely on feedlot experiments with growing-finishing cattle, different types appear best adapted to different rations and systems of management (3). Smaller, earlier maturing types were found to consume more feed per unit of body weight than larger, later maturing types. This suggested that early maturing cattle would best utilize lower energy rations or deferred management systems, and if high grain rations were to be fed at young ages, later maturing types would produce heavier, leaner carcasses.

Within most herds of beef cows being grazed and fed as one group, there is considerable variation in condition among individuals. Much of this variation can be related to production, age, general health, etc. However, some cows are frequently referred to as "easy keepers," staying in good condition in spite of good production. Very little information has been available on the possible variation in feed intake among individual cows of similar or diverse breed type and condition.

Two experiments were conducted to measure the voluntary feed consumption of mature, non-lactating cows of two breed types when full-fed forages of different quality.

PROCEDURE

Mature Angus and Charolais type cows were used in these experiments. They were cows from a prior breeding experiment and were either open or generally in the early stages of pregnancy. After being accustomed to individual feeding stalls and the forage to be fed, they were full-fed each forage for a period of 8 weeks. They were placed in the stalls once daily for a period of 4 hours and offered at least 10% more forage than they would consume. Refused feed was weighed back each day with fresh forage offered the next day.

The cows were weighed weekly. Initial and final weights and 8-week gains for each cow were estimated from straight lines fitted to these weekly weights. Height of each cow at the hooks was measured and the weight/height ratio calculated as a measure of cow condition (2).

Coarsely ground, 17% protein, dehydrated alfalfa in ¼-inch pellets was fed in both experiments. This was compared to corn stover in the first experiment and to late-cut, mixed grass hay in the second. The stover and hay were harvested and stored in large, round bales. Prior to feeding they were ground in a tub grinder and then cubed. Dry matter contents of the forages determined each week were reasonably constant, except for the corn stover which was highly variable. The cows had access to water, salt, and minerals when not in the feeding stalls, but the forages received no other supplementation.

As the objective of these experiments was to compare the forage intake of individual cows rather than to compare forages, all cows were fed alfalfa pellets during the first 8-week period and then switched to the alternate forage for the second period.

The data obtained were analyzed by the method of least-squares, with weight/height ratio included as an independent variable.

RESULTS

Experiment 1

This experiment was conducted during the period of February-June, 1978. Of the ten smaller type

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TABLE 1.—Voluntary Feed Intake of Two Breed Types Fed Alfalfa or Corn Stover, Least-Square Means Adjusted for Weight/Height Ratio.

	Alfalfa		Corn Stover	
	Angus	Charolais	Angus	Charolais
No. of Cows	10	9	10	10
Initial wt, lb	906	1100	944	1153
Final wt, lb	977	1190	950	1190
Gain, lb	71	90	6	37
Wt/ht ratio, lb/in	20.4	22.7	20.6	23.2
Intake, per head				
As fed, lb	22.4	20.8	16.8	18.7
Dry matter, lb	20.3	19.1	11.1	12.1
Intake, per 100 lb body wt				
As fed, lb	2.23	1.91	1.64	1.75
Dry matter, lb	2.04	1.74	1.07	1.15

cows referred to as Angus type, five were straight bred Angus and five were Jersey x Angus first-cross cows. Nine of the Charolais were straight bred and one was a Brown Swiss x Charolais first-cross. After the start of the experiment, one of the Charolais cows was found to be in late pregnancy and calved prior to the end of the alfalfa feeding phase; hence results of this cow are not included. However, the calf was removed from the cow the second day after birth and this cow was included in the stover feeding phase.

Least-square means of the results obtained are presented in Table 1.

Experiment 2

All Angus cows used in this experiment were straight bred and were all different cows from those used in the first experiment. Of the ten Charolais type included, four, including the Brown Swiss x Charolais crossbred, had been included in the first study. Of the six new cows, one was a ¾ Simmental. These comparisons were made during July-November, 1978. Data obtained in this experiment are given in Table 2.

DISCUSSION

Voluntary feed consumption among cows of different types fed different forages was highly variable. However, as would be expected, much of the total variation was due to differences in quality of forage. In both experiments, when fed pelleted alfalfa hay, cows consumed significantly more dry matter than when fed the poorer quality roughages. When fed either the alfalfa or grass hay, the coefficient of variation among individual cows of either breed type was approximately 11%. However, with corn stover this variation increased to about 16% for both types of cow. Therefore, when fed the same forages, there appears to be little or no difference within or between the two cow types with respect to individual variation in feed intake.

In both experiments, the ratio of weight/height had a highly significant, positive relationship with

TABLE 2.—Voluntary Feed Intake of Two Breed Types Fed Alfalfa or Grass Hay, Least-Square Means Adjusted for Weight/Height Ratio.

	Alfalfa		Grass Hay	
	Angus	Charolais	Angus	Charolais
No. of Cows	10	10	10	10
Initial wt, lb	990	1154	1084	1268
Final wt, lb	1069	1244	1076	1283
Gain, lb	79	90	—8	15
Wt/ht ratio, lb/in	22.3	23.6	23.4	25.1
Intake, per head				
As fed, lb	21.5	22.9	21.1	23.6
Dry matter, lb	19.7	21.0	17.5	19.5
Intake, per 100 lb body wt				
As fed, lb	1.94	1.90	1.92	2.00
Dry matter, lb	1.78	1.75	1.58	1.65

feed intake per head daily. This ratio could be increased by increased rumen capacity or fill. However, as reported previously (2), it is also a reasonable estimate of condition. As a cow increases fat stores, weight increases without a change in height. The positive relationship of this ratio to feed intake indicates that, within a group of cows of similar age and production level, those cows in higher condition are likely to be consuming more feed than the average in that group.

Appetite is a desirable trait in growing and finishing cattle since level of feed intake is related to efficiency of production. Thus, it should also be a desirable trait in the dam if it does not lead to excessive fatness which interferes with production. Certainly a cow which is fat because of poor production is not a good candidate to remain in the herd.

Although not conclusive, the results of these two experiments show some possible differences in feed consumption between the two types of cow. In all four comparisons the larger type cows gained more weight, and in three they consumed more feed per head daily. When related to body weight, however, differences in gain were relatively small.

Results obtained in the first experiment when alfalfa pellets were fed are a bit conflicting. In this comparison the Angus type cows ate more alfalfa, but gained slightly less than the Charolais. No clear explanation for this difference is readily apparent. It may have been simply experimental error or may have been due to the Angus type cows being thinner, smaller weight/height ratios, and thus possibly having a higher maintenance requirement per unit of weight (3). Although not shown in the table, feed intake of the straight Angus and the Jersey x Angus cross cows included in the Angus type were nearly identical. Neither did the stages of pregnancy involved appear to have an influence on feed intake.

In either one of the two experiments, there was no significant difference between the two types of cow in total dry matter intake when measured as a percentage of body weight. However, in the first experiment (Table 1), there was a highly significant interaction between cow type and forage quality. When fed pelleted alfalfa, the Angus type cows consumed more than the Charolais type, but with corn stover the reverse was true. Although the differences were rather small and not statistically significant, the same trends may be noted in the second experiment (Table 2).

The alfalfa intake per unit of body weight of the Angus type cows in the first experiment was considerably greater than in the second, whereas intake of the Charolais was nearly identical in both studies. Since the greater alfalfa consumption by the Angus cows in the first experiment contributed much to the interaction in that study and with the poor repeatability between experiments in alfalfa intake by the Angus cows, it is not clear if the interaction among cow types and forage quality is real or not.

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Weight and Condition Changes of Pregnant Beef Cows Wintered on Corn Stover Stacks

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SUMMARY

Corn stover preservative treated stacks were used for wintering pregnant beef cows. Acid treatment of the stover stacks at the 4 lb per ton level tended to reduce initial temperature rise, spoilage, and mold formation at moisture levels of less than 30%. No toxic molds were found in any stacks and mold formation did not inhibit cow intake. Extreme temperatures in the areas considered optimum for heat damage of protein were observed in two stacks of 40% moisture. Analysis of three samples of lower moisture levels (25%-27%) and temperatures (35° C) showed borderline values for heat damage. It is recommended that nontreated stover would be best harvested at less than 25% moisture. Moisture levels of greater than 30% were considered to be too high for either treated or untreated storage, as spoilage and heating were a direct result of increased moisture levels.

Cows wintered on corn stover stacks tended to lose an average of 40.5 lb per cow during the 113-day wintering period. Controlled cows wintered on a corn silage ration gained an average of 108.6 lb per cow. Cows on stover were wintered for about one-half the feed costs and less than one-half the labor and equipment costs of cows on corn silage.

INTRODUCTION

The cost of wintering beef cows must be kept at a minimum. One of the most economical feeds available is corn stover. Although stover is a low quality feed, it can be supplemented with protein and used to carry beef cows through the winter. The use of low quality roughages to winter beef cows carries with it several points of consideration. The management practices to be followed, method of harvest, and storage and feeding are all technically and economically important considerations. Determination of forage quality and methods of preserving and/or enhancing this quality are also problems which give varied, and often conflicting, answers. The question of whether stovers can satisfy the nutrient requirements of gestating beef cows, and the selection of the proper nutritional plane for these cows, also are important.

Perry (8) indicated that, while protein content of stover remained constant through the fall and winter, digestible dry matter and residue yields were reduced through leaching and erosion.

Interest has been shown in utilizing hay stackers to harvest corn stover residue and thus reduce waste. Henderson (3) at Nebraska indicated that stover yields would be about 1 ton of stover for each 30 to 35 bushels of corn grain.

Varying levels of crude protein have been published for corn stover, with N.R.C. (7) values at 5.9% crude protein being at near the high end of observed values. Vetter (9), in showing an average 4.0% crude protein (range 2.1 to 5.1) figure for corn stalklage, indicated that much of the variation in crude protein content of corn residue could be attributed to leaf content.

In order to minimize storage and feeding costs of a low quality feedstuff like corn stover, compressed stacks of stover can be stored outside during the entire wintering period. Proper moisture for storage has been the object of recent interest. Vetter (9) found that, as a "rule of thumb," within a range of 25 to 30% moisture, corn residue has twice the moisture of the attendant corn grain; *e.g.* grain at 28% moisture would have a stover moisture level of about 56%. Ayres (1) found indications that stacks made at more than 40% moisture had heated and showed visible molding. It was not recommended to harvest stover to be stacked and stored as dry feed until it had dried to below 40% moisture. This occurred usually between 3 and 4 days after combining.

Since weather conditions in Ohio at the time of stacking are often not conducive to a 3 or 4-day drying time, the idea of using chemical preservatives was considered to have some merit.

McGuffey, *et al.* (5) found that treatment of baled alfalfa hay lowered temperature 2 to 15° C during the first 1 to 3 weeks of storage. Mold counts were less for treated bales.

Temperature rise has also been considered essential to control in that high temperatures have been related to protein damage in stored forages. Goering and Van Soest (2) reported that at 60° C, a heating period of only 24 hours resulted in protein heat damage.

Protein contents of wintering diets for pregnant cows have been recognized as being minimal in requirement. Klosterman *et al.* (4) stated that a low level of protein (6.9%) was adequate to maintain weight of mature open and dry beef cows, while

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N.R.C. (7) levels of protein for dry pregnant mature beef cows indicated that 5.9% was adequate. Most observers have found that crude protein levels are less important for performance than energy levels.

Energy, however, has received the greatest attention in the literature. The maintenance requirements for energy for lactating cows has been estimated at 38 to 41% greater than for nonlactating cows (6). N.R.C. (7) values for energy are given as 1.80 Mcal/kg of body weight of metabolizable energy (ME) for the dry cows and 2.06 Mcal/kg for the cow during the first 4 months of lactation.

MATERIALS AND METHODS

A trial was conducted to evaluate the harvest, storage, and preservative treatment of corn stover, and the effects of wintering pregnant beef cows on the stover. Twenty cows of the Angus, Hereford, and Shorthorn breeds were weighed and measured at the hooks to evaluate condition and allotted to the stover program. Fourteen cows of similar age and breeds were also weighed and measured and allotted to a corn silage ration. Stacks of stover at varying moisture levels were treated with either 4 or 8 lb of acid preservative per ton of forage. Temperature changes, mold counts, and nutrient analyses were compared with nontreated stacks.

Acid treatment of corn stover stacks at the 4 lb per ton level tended to reduce initial temperature rise, spoilage, and mold formation at moisture levels of less than 30%. All stacks at all moisture levels showed evidence of molding after harvest. No toxic molds were found in any samples and mold formation did not inhibit cow intake. Extreme temperatures in the areas considered optimum for heat damage of protein (greater than 60° C) were observed in two stacks of 40% moisture. Analysis of three samples of lower moisture levels (25 to 27%) and temperature (35° C) showed borderline values for heat damage.

It was determined that nontreated stover would be best harvested at less than 25% moisture. Moisture levels of greater than 30% were considered to be too high for either treated or untreated storage, as spoilage and heating were a direct result of increased moisture levels.

The cows were started on the trial in late November. The treatment cows' ration consisted of mature corn stover stored in 3-ton stacks fed *al lib*. A two-wheel lick tank was installed which contained 32% nonprotein nitrogen (NPN) liquid supplement (Pro-Las; Landmark, Inc.) to provide adequate protein. The control cows were fed an estimated 44 lb of corn silage a day that contained approximately 6 bushels of corn per ton. Trace-mineralized salt in block was available to both groups.

RESULTS AND DISCUSSION

Treatment cows feeding from the stacks tended to lose an average of 40.5 lb per cow during the 113-day wintering period. Condition scores, while slightly lower after wintering, were still indicative of a moderately well-fleshed cow. This acceptable condition after wintering seemed to indicate that cows in adequate condition in the fall could over-winter on low quality stover. The control cows on a corn silage ration gained an average of 108.6 lb per cow and also increased condition score slightly. On subjective evaluation, the control cows appeared to be fatter than the treatment group.

Average condition scores of the treatment and control cows were calculated by a height/weight ratio described by Klosterman *et al.* (4). The average initial condition scores were not significantly different ($P > .20$) and were, in fact, nearly identical (Table 1). Final condition scores were significantly different ($P < .10$) and were lower for the treatment group. It is interesting to note, however, that the average score was still above 4. On the scale of 1-thin to 5-fat, all of the cows in the trial succeeded in maintaining an acceptable condition score. It would appear from a study of the condition scores that the treatment cows did not appreciably change in condition, while the control cows in fact gained in condition and were fatter.

Simple correlations among weight and condition score changes and measurements are found in Table 2. The highest significant positive correlations were found among absolute weight and score measures. Initial weight and initial score (0.9542) and final weight and final score (0.9466) were the most highly

TABLE 1.—Means and Standard Deviations of Measurements.

	Overall Mean	Standard Deviation	Control Mean	Treatment Mean
Initial weight (lb)	1098	85.8	1095	1089
Initial score	4.19	0.31	4.19	4.195
Final weight (lb)	1121	120.5	1203	1064
Final score	4.2	0.40	4.4	4.05
Weight change (lb)	20.7	96.0	108	—40.5
Score change	0.006	0.34	0.22	—0.145

TABLE 2.—Simple Correlations Among Weight and Score Measurements.

Measurement	Initial Score	Final Weight	Final Score	Weight Change	Score Change
Initial weight	0.9542	0.6044	0.6130	—0.1175	—0.1449
Initial score		0.5406	0.5669	—0.1453	—0.2408
Final weight			0.9466	0.7074	0.6241
Final score				0.6281	0.6630
Weight change					0.8720

correlated. This would be expected, as score is given to be a function of weight and height and any measure of weight will affect this ratio. Also highly correlated, and explained by the relationship of weight to the ratio making up the score, would be weight change and score change. Therefore, greater weight would mean a higher condition score, both initially and at the end of the trial. Also, the more weight changed, the greater the amount of change in score.

Smaller positive correlations were found among initial weight and both final weight and score (0.6044 and 0.6130, respectively). It would thus appear that the heavier cows tended to remain heavier and in better condition. When this is coupled with the small (although insignificant) negative correlations between initial score and both weight change and score change (— 0.1175 and — 0.1449, respectively), one could assume that the heavier and fatter cows would tend to gain weight and condition, while the lighter cows might more readily lose weight and condition.

Since there was little difference in the change in condition scores of the two groups, and since past work has shown that moderately conditioned cows tended to perform as well or better reproductively than cows in a higher condition, the economic advantages of utilizing a less costly ration became apparent. Cows on stover could be wintered for about one-half the feed cost and less than one-half the labor and equipment costs of cows on corn silage. In addition, it became evident that beef cows could utilize a roughage that normally would go to waste on many farms.

More work needs to be done with long-term effects of a stover wintering program on reproductive efficiency. Ease of calving, percent calf crop, milk production, length to first estrus, services per conception and calving interval are all traits that merit further study in the context of a stover program. In addition, more detailed study of methods of harvest, preservative treatment, and storage of stover is needed to determine how best to use stacked stover for beef cows.

(The silage preservative used in this experiment was Silage Saver furnished by Kemin, Inc.)

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Estrus Synchronization of Beef Cows and Heifers with Prostaglandin $F_2\alpha$ Under Field Conditions

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SUMMARY

Four estrus synchronization trials were conducted during the summer of 1976 to ascertain the feasibility of using prostaglandin $F_2\alpha$ to synchronize beef cows and heifers that were artifically inseminated under field conditions. The treated females were given two 25-mg injections of Prostin (furnished by The Upjohn Company) 11 days apart. Sixty-five and 87.6 percent of the prostaglandin $F_2\alpha$ treated females responded to the first and second injections, respectively. Of the cows and heifers responding to the second injection, 70% were in heat 48 to 60 hours post injection. First-service and 30-day pregnancy rates were analyzed and the treatment did not have a statistically significant effect on first service pregnancy rate. The 30-day pregnancy rate for trial 1 was 67.9% for females bred 80 hours after the second injection, 71.4% for the females bred 12 hours after detected in estrus, compared to 75.9% for the control. Means for the intervals from the beginning of the breeding season to conception was 18.6 days for those bred 80 hours after a second injection, 15.7 days for those bred 12 hours after detection of heat compared with 23.9 days for the controls. Estrus synchronization showed much merit for efficient practical beef herd management. Time required to detect estrus and breed the synchronized females was reduced considerably and synchronized females were bred earlier in the breeding season. Pregnancy rates were not significantly lowered in the prostaglandin treated females when bred 12 hours after estrus was detected or 80 hours after second injection.

INTRODUCTION

During the last two decades the use of artificial insemination for beef cattle has increased significantly. It allows the producer to utilize a larger variety of genetically superior bulls than would be financially feasible under a natural breeding program. Artificial insemination also reduces the chances of transmission of disease.

One of the major drawbacks to artificial insemination is the time required to sufficiently diagnose the estrus period in the cow. Efficiency of labor is also low when the cattleman or technician inseminates only a few cows each day. Synchronization of the estrous cycle would reduce the time required to detect estrus and maximize labor efficiency by breeding all cows in a short period of time. Synchronization would also concentrate calving into short intervals which would allow for closer observation during calving. However, to be practical the method of synchronization must be precise, easy to administer, and inexpensive without reducing fertility.

Prostaglandins were first isolated from human seminal plasma in the early 1930's. Since the compound was believed to be produced in the prostate gland, it was termed prostaglandin. Early work with prostaglandin was centered around the ability of seminal fluid to stimulate contractions or relaxation of the uterus. In the ensuing years researchers have found prostaglandins present in numerous tissues throughout the body and that they initiate a wide spectrum of action. The production, release, mode of action, and control of prostaglandins are still not completely understood.

Since 1968 prostaglandin $F_2\alpha$ has been shown to be luteolytic in numerous species including both laboratory and domestic farm animals. Luteolysis by injection of $PGF_2\alpha$ has been demonstrated in the intact ewe (5, 16); cow (4, 7, 8, 12, 13, 14); gilt (3, 6); and mare (6, 9). Demonstrating a luteolytic effect in intact females failed to differentiate between $PGF_2\alpha$ as the luteolysin from the uterus or a compound which stimulated production or release of the luteolysin. Therefore, La Voie (*et al.*) (11) gave hysterectomized cows injections of $PGF_2\alpha$ and induced luteolysis. This lent stronger support for $PGF_2\alpha$ as the indogenous luteolysin.

Synthesis of prostaglandin $F_2\alpha$ occurs in the endometrium of the uterus. Its production and release appear to be controlled by progesterone and estradiol. Caldwell *et al.* (1) attempted to duplicate the normal progesterone and estradiol secretion patterns in ovariectomized ewes. $PGF_2\alpha$ levels were similar in controls and treated ovariectomized ewes. Estradiol injections caused a rapid increase in peripheral levels of $PGF_2\alpha$.

Fertility of cows and heifers after synchronization with prostaglandin has not been significantly different from controls in most experiments. Roche (14) obtained pregnancy rates of approximately 73% for controls and treated heifers when inseminated 12 hours after heat detection. Pregnancy rates of 58% and

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53% for controls and 59% and 52% for $PGF_2\alpha$ treated were reported in two experiments by Lauderdale (10). Lauderdale (10) compared the fertility of controls, $PGF_2\alpha$ treated cows inseminated 12 hours after heat was detected, and $PGF_2\alpha$ treated cows inseminated 72 and 90 hours post-treatment. The compiled results of pregnancy rates of 289 cows from four locations were controls, 53.3%; detected estrus treated cows, 52.2%; and treated cows inseminated 72 and 90 hours, 55.8%.

One of the major drawbacks of prostaglandins for estrus synchronization is that it requires a viable corpus luteum. Prostaglandin $F_2\alpha$ is ineffective on days 1-4 of the cycle when a new CL is forming and after day 17 when the CL has already started to regress. Two programs have been developed to overcome this problem. One is a combined progestogen-prostaglandin treatment and the second a series of two injections of $PGF_2\alpha$ 10-13 days apart.

PROCEDURES

Data for this study were compiled from four trials using a total of 325 beef cows and heifers from The Ohio State University, Columbus, and the Old Home Farm herds, Trenton, Ohio. The University herd was predominantly purebred Angus and Polled Hereford but also included purebred Charolais and Shorthorn and Simmental, Charolais, Chianina, Limousin, and Maine-Anjou crossbred females. Both heifers and cows were used from the University herd. All females at Old Home Farm were Angus cows.

Three treatment groups were used in each of the four trials. Treatment 1 (controls) were to be checked twice daily and bred artificially 12 hours after estrus was detected. The breeding period for controls was to begin on the day of the second injection of prostaglandin in the other treatments and continue for a minimum of 30 days. Treatment 2 (PG-2) and treatment 3 (PG-3) females were given two 25-mg injections of Prostin (The Upjohn Company) 11 days apart. Treatment 2 females were bred 80 hours after the second injection regardless of when estrus was detected. Cows and heifers in treatment 3 were bred 12 hours after detected in estrus following the second injection. The day of the second injection of prostaglandin was designated as day 1.

Trial one consisted of 48 early calving cows from the University herd. Trial two consisted of 45 yearling and 2-year-old heifers at the University and trial three consisted of 52 late calving beef cows at the University. Trial four was conducted at Old Home Farm using 80 Angus cows.

TABLE 1.—Interval from Prostaglandin $F_2\alpha$ Injection to Estrus Response in Beef Heifers and Cows.†

	First Injection		Second Injection	
Hours	No.	Percent	No.	Percent
24	1	1.2	0	0
36	4	4.7	1	1.2
48	11	12.9	22	25.9
60	14	16.5	30	35.3
72	13	15.3	9	10.6
84	4	4.7	6	7.1
96	4	4.7	1	1.2
108	2	2.4	2	2.4
120	0	0	2	2.4
132	1	1.2	1	1.2
No Response	31	36.5	11	12.4
	$\bar{X}_1 = 65.6$		$\bar{X}_2 = 64.8$	
	$s_1 = 20.7$*		$s_2 = 17.5$*	

*Significant $P < .10$.
†The Ohio State University heifers and cows, Trials I, II and III.

RESULTS AND DISCUSSION

Estrus responses to prostaglandin $F_2\alpha$ injections in trials I, II, and III are recorded in Table 1. Sixty-five percent of PG-2 and PG-3 females were detected in heat by the sixth day after the initial injection. Of those responding, 44.7% were detected in heat between 48 and 72 hours. Average interval from injection to estrus was 65.6 ± 20.7 hours. Response to the second injection of prostaglandin saw 87.6% of the females in estrus by the sixth day post-injection. Eighty-two percent (61/74) of the cows and heifers responding came into heat at 48 to 72 hours and 70.3% (52/74) between 48 and 60 hours after the second $PGF_2\alpha$ injection. Average interval from second injection to estrus was 64.8 ± 17.4 hours.

Synchronization after the second injection was more precise than after the first injection. The variance of the second injection was significantly lower than the variance of the first at $P < .10$ level. This supports the findings of Cooper (2) who reported earlier and more precise synchronization in heifers following the second injection of a $PGF_2\alpha$ analogue. The higher variance after the first injection is due in part to the higher incidence of heat at 24-36 hours. Females who demonstrated heat during this period probably were on days 19-20 of the estrus cycle and normal regression of the CL had occurred before $PGF_2\alpha$ injection. At the second injection no female should have been at this stage of the cycle. Some of the reduction in variance could also be attributed to the fact that females were in the same general stage of the estrus cycle (days 8-16 with 45% on days 8 and 9) when the second injection was given.

Four of the 11 females who did not respond to the second injection came into estrus 8-10 days after the first injection. These females should have responded to the first injection of $PGF_2\alpha$. Possibly a full dose was not administered or the injection was made into the subcutaneous fat. Another four were not detected in estrus during the A.I. breeding period and were open or serviced by the bull. Of the three remaining females who failed to show estrus, two were in estrus 24 days after the second $PGF_{2}\alpha$ injection and one conceived from the 80-hour service. These three appear to have been in silent heat. One advantage to breeding at a predetermined time is the possibility of settling cows and heifers who are in silent heat.

Cows and heifers in trials I-IV which returned into estrus after synchronization were in heat 21 to 29 days after the second injection. Twenty-two (81%) of the 27 females returning into heat did so on days 24-27. Distribution of heats from days 24-27 were 3, 5, 8, and 6, respectively. This was later than expected. The majority of synchronized females were in estrus on day 3 after the second injection. If 21-day cycles followed, the return heats should cluster around day 24 instead of day 26.

It was thought that this may be explained by the females' first estrus after the second injection. Heifers and cows which were in estrus 84-132 hours after the second injection in the PG-2 (80-hour) treatment group most likely would not conceive at first service. If these made up a large percentage of the females returning into estrus, it would explain the distribution obtained. However, this does not appear to be true. Only a small percentage of the females returning into heat were from the PG-2 group which were in estrus 84-132 hours after the second injection. Also, the distribution and mean of the initial estrus response of those females returning into heat closely followed the distribution and mean of all prostaglandin treated females.

Pregnancy rates at first service as determined by rectal palpation are shown in Table 2. Pregnancy rates of PG-2 are noticeably lower in trials I and IV. In trial I, five of the 11 cows in the PG-2 treatment did not show estrus after the second injection. Two of these were believed to be silent heats. The remaining three were assumed not to be in estrus due to the date of return heat or condition of the reproductive tract at the time of insemination. This could explain the low pregnancy rate for trial I. In trial IV, three cows appear to have not been in estrus in response to the prostaglandin injections. Another three did not come into heat until after insemination had occurred.

The analyses of variance for first service pregnancy rates for trials I-III were calculated. Within The Ohio State University herd, treatment did not approach statistical significance on the first service pregnancy rate ($P > .75$). The heifer/cow effect, however, was significant at a $P < .025$ level. Least-square means for treatments were controls, 0.468; PG-2, 0.398; and PG-3, 0.464.

The analysis of the Old Home Farm data yielded mean squares of 0.470833 for treatment and 0.0204532 for the remainder. The F-ratio of 2.30 was not statistically significant at the $P < .10$ level but was approaching significance at this level.

The analysis of variance for all cows was calculated and treatment effects were not significant at $P < .10$ level. Location was significant at the $P < .05$ level. No significant interaction between treatment and location was found. Least-square means for controls, PG-2, and PG-3 are 0.637, 0.534, and 0.715, respectively. Location least-square means for the Ohio State herd were 0.546 and the Old Home Farm herd were 0.711.

Results obtained from the analysis of first service pregnancy rates are similar to previous reports using a control, a predetermined insemination time treated group, and a 12-hour inseminated treated group. Pregnancy or conception rates are generally lower for the predetermined insemination time group but not statistically significant. Since 70% of the females were in heat by 60 hours, a higher conception rate may have been achieved breeding at 72 hours.

The analysis of 30-day pregnancy rate for the University herd and all cows was calculated. Treatment and remainder mean square for Old Home Farm were 0.252083 and 0.159576, respectively. The F-test ratio was 1.58. No source of variance was significant at a $P < .10$ level in any of the analyses.

The means and standard deviation in days for the interval from the beginning of the breeding season to first service were:

TABLE 2.—First Service Pregnancy Rates of Cows and Heifers in the Three Treatment Groups Over the Four Trials.

	Control		PG-2		PG-3		Mean	
	Percent	No.	Percent	No.	Percent	No.	Percent	No.
Trial I*	64.0	(16/25)	27.3	(3/11)	58.3	(7/12)	54.2	(26/48)
Trial II†	42.9	(6/14)	31.3	(5/16)	40.0	(6/15)	37.8	(17/45)
Trial III*	47.6	(10/21)	68.8	(11/16)	53.3	(8/15)	55.8	(29/52)
Trial IV‡	70.8	(17/24)	55.0	(11/20)	87.5	(14/16)	70.0	(42/60)
Total	58.3	(49/84)	47.6	(30/63)	60.3	(35/58)	55.6	(114/205)

*The Ohio State University cows.
†The Ohio State University heifers.
‡Old Home Farm cows.

Control	11.1 ± 7.3
PG-2	4.3
PG-3	5.0 ± 2.9

Values obtained for the t distribution for testing equality of means of the treatment groups and degrees freedom (df) were: control and PG-2, 8.54 (84); controls and PG-3, 6.91 (118); PG-2 and PG-3, 2.62 (58). Mean intervals for the treatment groups were statistically significant at a $P < .01$ level.

The means and standard deviations for the interval from beginning of the breeding season to conception were:

Control	23.9 ± 8.7
PG-2	18.6 ± 18.0
PG-3	15.7 ± 12.4

The t values and degrees of freedom (df) for treatments were: control and PG-2, 1.89 (107); control and PG-3, 3.55 (87); and PG-2 and PG-3, 1.09 (36). The means of the intervals are significantly different for controls and PG-3 at the $P < .01$ level. The difference in the means of the controls and PG-2 was significant at the $P < .05$ level. The PG-2 and PG-3 means were not significantly different at a $P < .2$ level.

The mean interval from the beginning of the breeding season to first service was computed to determine if synchronization with prostaglandin would aid in getting beef cows and heifers inseminated earlier in the breeding season. This can be important if one is trying to shorten the calving season or make the calving season progressively earlier in the year. According to the results, synchronization could make the calving season an average of 6-7 days earlier if conception rates were the same.

The mean interval from beginning of the breeding season to conception was computed to take into account possible differences in first service conception rates. Even though the first service pregnancy rates were not statistically significant between the treatment groups, the lower first service pregnancy rate of PG-2 was reflected in the interval. Instead of having the lowest interval to conception, as seen in the interval to first service, PG-2 was intermediate in the interval to conception.

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