7-1-1997

Development of Replacement Heifers using Combinations of Three Forage Types and Feed Supplements (with or without Broiler Litter)

R. B. Simpson
Southwest Research and Extention Center

J. M. Phillips
Southwest Research and Extention Center

C. F. Rosenkrans Jr.
University of Arkansas, Fayetteville

A. H. Brown Jr.
University of Arkansas, Fayetteville

D. W. Kellogg
University of Arkansas, Fayetteville

Development of Replacement Heifers

Using Combinations of Three Forage Types and Feed Supplements (with or without Broiler Litter)

R.B. Simpson, J.M. Phillips, C.F. Rosenkrans, Jr.,
A.H. Brown, Jr. and D.W. Kellogg

ARKANSAS AGRICULTURAL EXPERIMENT STATION

Division of Agriculture | University of Arkansas

July 1997 | Bulletin 955

Development of Replacement Heifers Using Combinations of Three Forage Types and Feed Supplements (with or without Broiler Litter)

R.B. Simpson
Former Assistant Professor
Department of Animal Science
Hope, Arkansas

J.M. Phillips
Center Director
Southwest Res. & Ext. Center
Hope, Arkansas

C.F. Rosenkrans, Jr.
Associate Professor
Dept. of Animal Science
University of Arkansas

A.H. Brown, Jr.
Professor
Dept. of Animal Science
University of Arkansas

D.W. Kellogg
Professor
Dept. of Animal Science
University of Arkansas

Arkansas Agricultural Experiment Station
Fayetteville, Arkansas 72701

CONTENTS

INTRODUCTION 5
Replacement Heifers 5
Grazing Systems for Developing Replacement Heifers 6
Broiler Litter 7
PROCEDURES 8
Year 1 8
Year 2 10
Statistical Analyses 11
RESULTS AND DISCUSSION 11
Year 1 11
Year 2 20
CONCLUSIONS 23
Forage Type 23
Feed Treatments 24
LITERATURE CITED 25

Technical editor: Nancy G. Wyatt

Agricultural Experiment Station, University of Arkansas, Division of Agriculture, Fayetteville. Milo J. Shult, Vice President for Agriculture and Director; Charles J. Scifres, Associate Vice President for Agriculture. PS1.2M797PM.

ISSN: 0097-3491 CODEN:AKABA7

Development of Replacement Heifers Using Combinations of Three Forage Types and Feed Supplements (with or without Broiler Litter)

R.B. Simpson, J.M. Phillips, C.F. Rosenkrans, Jr., A.H. Brown, Jr. and D.W. Kellogg

INTRODUCTION

Replacement Heifers

The proper management of replacement heifers is an essential component of successful cow/calf operations. The level of management and nutrition applied to replacement heifers as calves and yearlings can impact their subsequent reproductive performance and productivity.

It is generally recommended that heifers be managed and developed to allow for breeding at 14 to 15 months of age and to calve at 23 to 24 months of age. This practice results in more total pounds of calf weaned per cow and a greater lifetime productivity. Also, heifers that calve early during their initial calving season generally maintain that pattern and have higher lifetime productivity than late-calving heifers (Lesmeister et al., 1973).

Byerley et al. (1987) reported that heifers bred at their third estrus (i.e., heat) had higher pregnancy rates than heifers bred at first estrus. Based on those results, and given the goal of managing heifers to conceive by 14 to 15 months of age, the percentage of heifers that reach puberty prior to their first breeding season is a critical factor in determining reproductive success during the first year.

Replacement heifers should be developed to attain 65 to 70% of their mature body weight at 14 to 15 months of age. Supplemental feed usually is required for heifers to reach this target weight by this age.

Low rates of gain after weaning often result in delayed onset of puberty, lower conception rates and increased calving problems in heifers. Conversely, overfeeding is expensive and can result in over-conditioned heifers with excess fat deposited around the mammary glands, thus limiting their potential for milk production in the future.

In management programs that develop heifers to calve at 23 to 24 months of age, the greatest challenge may be to achieve rapid rebreeding following parturition (calving). In primiparous (first-calf) cows, nutrients are partitioned toward lactation and maintenance of bodily function along with continued skeletal growth. This partitioning of nutrients creates a "competition" for nutrients that are available for reproductive function (i.e., return to estrus after parturition). If nutrient requirements are not met, postpartum reproductive performance will be adversely affected.

Grazing Systems for Developing Replacement Heifers

Tall fescue is a base pasture for much of the beef cattle population in Arkansas. Most research concerning animal performance on tall fescue has involved aspects of cow/calf production and growing steers. Most of the tall fescue pastures in Arkansas are infected (approximately 80% infection rate) with the fungal endophyte *Acremonium coenophialum* Morgan-Jones and Gams. High levels of this fungal endophyte in tall fescue result in poor animal performance, including decreased reproductive performance (Porter and Thompson, 1992).

Weaned heifers are often placed on fescue pastures and/or fed fescue hay as a roughage source. However, fescue alone will not provide adequate gains for heifers being bred at 15 months of age, and they must be supplemented with grain between weaning and breeding. Research involving development of replacement heifers on tall fescue is limited. Washburn et al. (1989) and Washburn and Green (1991) reported that Angus heifers grazing endophyte-infected fescue exhibited a delayed onset of puberty.

The process of accumulating (i.e., stockpiling) growth of tall fescue in the fall for late-fall and winter grazing is well suited to cow/calf programs (Chessmore, 1979). With this approach, pastures are clipped, and 50 to 75 lb/acre of nitrogen fertilizer is applied during early to mid September. In most years, nighttime air temperatures begin to decline and adequate rainfall occurs soon after fertilization. Research in Tennessee demonstrated that the stockpiling of tall fescue provided approximately 1,000 lb of forage/acre (at a digestibility of 60 to 65%) for late fall and winter grazing (Fribourg and Loveland, 1978). More recently, Phillips et al. (1993) reported production of 3,000 to 3,500 lb/acre of tall fescue in October and November in southwestern Arkansas with little or no nitrogen fertilization. The ranges in crude protein (13.4 to 28.7%) and total digestible nutrients (TDN, 56.8 to 75.1%) in that study indicated that the forage was of high quality. These results are similar to those reported by Matches (1979), Huneycutt et al. (1988) and Eck et al. (1981).

A combination of winter annuals such as overseeded rye/ryegrass provides high-quality grazing during the late winter and spring period. Phillips et al. (1991) reported that steer gain for endophyte-infected tall fescue and winter annuals was 209 and 341 lb/acre, respectively, during a 63-day spring grazing period. In southern Arkansas, the fall production of forage with this system is most limited by establishment method, lack of rainfall after establishment and continued warm temperatures in the fall, which allow bermudagrass to continue growth and thus compete against the newly established winter annuals.

Broiler Litter

In 1994, Arkansas produced over 1 billion broilers (Arkansas Agricultural Statistics Service, 1995) with approximately 2 lb of manure produced per bird during a standard seven-week production cycle (Malone et al., 1992). In Arkansas, a vast majority of the broiler litter that is removed from broiler houses is applied to pastures as a source of fertilizer. However, calculations reveal that broiler litter is approximately four times more valuable as a feed source for cattle than it is as a source of fertilizer (Stephenson et al., 1990).

The potential use of broiler litter as a feed resource for beef cattle has long been recognized. Noland et al. (1955) evaluated the potential of using chicken litter as a feed source for ewes and steers. Since that time, numerous other studies have been conducted that involved the use of litter in cattle diets. Ray (1978) summarized such studies conducted in Arkansas, all of which involved litter fed to growing or finishing steers or to brood cows.

The composition of nutrients in broiler litter is highly variable (Ruffin and McCaskey, 1991) with wide ranges observed for crude protein, TDN, crude fiber, ash, calcium, phosphorus and other nutrients.

Calves have been successfully wintered on a ration of 50% broiler litter and 50% ground corn along with hay fed free choice (Gerken, 1977). Cross et al. (1978) reported that concentrations of plasma urea nitrogen in beef steers fed a diet containing 50% broiler litter silage were about 50% higher than those in steers fed a control diet containing no broiler litter.

In order to obtain body weight gains that are necessary for fall-weaned heifers to conceive at 14 to 15 months of age and subsequently deliver their first calf at two years of age, producers must supplement grass pasture- or hay-based diets with grain. Considering the availability and low cost of broiler litter, any portion of grain or protein supplementation that could be replaced by broiler litter would represent a savings to the producer (assuming acceptable performance).

Potential effects of broiler litter on reproductive function in heifers or cows have not been thoroughly explored. Shemesh and Shore (1994) suggested that high concentrations of estrogen and testosterone typically found in broiler litter could adversely affect fertility in cattle. They cited data that implicated higher intakes of chicken manure (and testosterone in the manure) in delayed onset of puberty in dairy heifers. However, in a long-term study that compared broiler litter-based diets to a hay-based diet for beef females, Webb et al. (1980) found no difference in the number of calves born during a five-year period between cows fed diets with or without broiler litter.

The objectives of this experiment were to determine the effects of forage type and supplement (with or without broiler litter) on gain, cost of gain, hip height, body condition score, blood concentrations of urea nitrogen and non-esterified fatty acids and the onset of puberty in replacement heifers. A further objective was to evaluate the same forage and supplement combinations with the same heifers during their first calving season and through their second breeding season.

PROCEDURES

Year 1

Following a two-week, post-weaning adjustment period, crossbred heifers (n = 72; 242 ± 2 days of age; 495 ± 7 lb) at the Southwest Research and Extension Center, near Hope, Arkansas, were randomly assigned within age and breed component into one of nine forage type and concentrate supplement combinations. Breed composition of the heifers was Simmental x Brangus (n = 21), Simmental x Brahman-Hereford F_1 (n = 21), Simmental x Simmental (n = 21) and Brangus x Angus (n = 9). All heifers were dewormed with ivermectin at weaning. On 28 October 1992 (day 0 of experiment), heifers were placed onto one of three dormant, warm-season grass pastures with access to free-choice hay and received one of the following supplements:

1. 100% Grain sorghum (S) - Heifers (n = 24) received 5 lb grain sorghum/head/day.
2. 75% Grain sorghum/25% Broiler litter (SL75/25) - Heifers (n = 24) received 5 lb/head/day of this mixture plus 0.2 lb/head/day of animal fat.
3. 50% Grain sorghum/50% Broiler litter (SL50/50) - Heifers (n = 24) received 5 lb/head/day of this mixture plus 0.4 lb/head/day of animal fat.

Animal fat was included as a component of the SL75/25 (80 lb fat/ton of supplement) and SL50/50 (160 lb fat/ton of supplement) supplements in an effort to balance the amount of energy among the three supplements, minimize dustiness and increase the palatability of the broiler litter supplements.

The nutrient content (dry matter [DM] basis) of the grain sorghum, SL75/25 and SL50/50 supplements, respectively, for Year 1 were as follows: crude protein (10.2, 13.1 and 15.5%), NEgain (0.61, 0.52 and 0.50 Mcal/lb) and crude fat (3.5, 6.7 and 10.7%).

Beginning on experiment day 28 (25 November 1992), eight heifers from each of the above supplement groups were placed on one of three 4-acre pastures consisting of stockpiled fescue (SFES). These pastures had been clipped and then fertilized with 34 lb of nitrogen in early September. The resulting growth was allowed to accumulate during September, October and early November. The heifers remained on these pastures throughout the winter. An additional 51 lb N/acre was applied 11 March 1993.

On experiment day 56 (23 December 1992), eight additional heifers from each of the above supplement groups were placed on one of three 4-acre pastures consisting of rye/ryegrass (R/RG), which was no-till drilled into warm-season grass on 14 September 1992. During Year 1, forage samples were collected from SFES and R/RG pastures at regular intervals to monitor nutrient content of these forages over time.

Nitrogen was applied to R/RG pastures on 3 November 1992 (51 lb N/acre), 2 February 1993 (51 lb N/acre) and 11 March 1993 (51 lb N/acre). All nitrogen applied in the study was in the form of ammonium nitrate. Heifers on the SFES and R/RG pastures received a minimal amount of grass hay during the winter when forage availability was limited.

The remaining eight heifers in each of the above supplement groups remained on the original, conventional warm-season pasture and were allowed *ad libitum* access to warm-season grass hay (15.4% crude protein [CP], 38.5% acid detergent fiber, 61.0% TDN, DM basis; CONV) for the remainder of Year 1. Heifers in all three forage types (SFES, R/RG and CONV) were continuously grazed, and the stocking rate remained constant. The feed supplements (S, SL75/25 and SL50/50) were fed each day of the 231-day study.

Pre-feeding body weight, hip height and condition score were recorded at 28-day intervals. Body condition scores were based on the system described by Richards et al. (1986) with a range of 1 (emaciated) to 9 (extremely fat). In Year 1 only, blood samples were collected via jugular venipuncture from 63 heifers (Simmental x Brangus, n = 21; Simmental x Brahman-Hereford F_1, n = 21; Simmental x Simmental, n = 21) on experiment days 0, 28, 56, 84, 168 and 231 to determine serum concentration of blood urea nitrogen (BUN) and non-esterified fatty acids (NEFA).

Internal pelvic areas were measured using a Rice Pelvimeter on experiment day 161 (when heifers were 403 ± 2 days of age). The pelvic area of each heifer was divided by a division factor (division factor of 2.1 for heifers weighing less than 750 lb and 2.3 for heifers weighing 750 or more) to derive an estimated calf birth weight that the heifer should be able to deliver as a two year old without assistance (referred to herein as the estimated critical birth weight).

During the three weeks preceding the initiation of the breeding season, single blood samples were collected at seven-day intervals for determination of progesterone concentrations via solid-phase double-antibody enzyme immunoassay as described by Kesler et al. (1990). Heifers with progesterone concentration greater than 1 ng/mL for any two of the three sampling dates were considered to be pubertal. Percentage of heifers that obtained puberty by initiation of the first breeding season (on 14 April 1993, when heifers averaged 410 ± 2 days of age) was calculated. The proportion of heifers that became pregnant during the breeding season was compared between heifers that had or had not reached puberty by the first day of the breeding season.

A 63-day breeding season extended from 14 April to 16 June 1993. Heifers remained on their respective pastures throughout the breeding season and were exposed to natural service while in their experimental groups (8 heifers/breeding group). Nine Angus bulls were used in the breeding season and were rotated at 21-day intervals within one of the three forage types (i.e., any given bull stayed on the same forage type for the entire breeding season and was rotated among the three supplement treatments at 21-day intervals so that he was exposed to each supplement treatment within that forage type). During the breeding season, bulls were individually fed a corn-based supplement (12% CP; 5 lb/head/day) at the same time that heifers were fed their supplements.

From 16 June 1993 (the conclusion of the Year 1 breeding season) to 27 October 1993 (the beginning of Year 2 of the study), all heifers were managed as a single group and allowed to graze common bermudagrass/dallisgrass pastures without any feed supplementation. To monitor growth after the breeding season, heifer body weights were recorded 25 August 1993.

Year 2

In Year 2 of the study, heifers were assigned to the same feed supplement and forage treatments (exact same pastures) that they had been on during Year 1, with two exceptions: 1) in Year 2, only 25 lb of animal fat/ton of supplement was added to the SL75/25 and SL50/50 supplements, and 2) in Year 2, only ryegrass was used in the R/RG pasture treatment. Broiler litter used in Year 2 was from the same deep stack that was used during Year 1.

The nutrient content (DM basis) in Year 2 for the grain sorghum, SL75/25 and SL50/50 supplements, respectively, was as follows: crude protein (11.1, 13.0 and 17.9%), NEgain (0.49, 0.44 and 0.44 Mcal/lb) and crude fat (3.5, 3.7 and 3.7%).

Beginning 27 October 1993, heifers were divided into three groups and fed the same three feed supplements (S, SL75/25 and SL50/50; n = 24/group) they were fed during Year 1 of the study. For the first 28 days of Year 2, all heifers were placed on the CONV forage type.

Beginning 24 November 1993, eight heifers from each of the above feeding groups were placed on one of three 4-acre pastures consisting of SFES. Prior to grazing, tall fescue had been allowed to accumulate as described for Year 1.

On 16 March 1994, eight additional heifers from each of the above feeding groups were placed on one of three 4-acre pastures consisting of R/RG (ryegrass only) that had been sod-drilled into native grass the previous September.

The remaining eight heifers in each of the above feeding groups remained on CONV pasture and hay (12.3% CP, 34.0% acid detergent fiber, 60.6% TDN) for the remainder of Year 2.

During Year 2, heifer body weights, hip heights and condition scores and calf body weights were recorded at 28-day intervals. The calving season extended from 14 January 1994 to 17 March 1994. Similar to Year 1, a 63-day breeding season was implemented (13 April to 15 June 1994). As in Year 1, at the conclusion of the breeding season, heifers were managed as a single group and placed onto common bermudagrass/dallisgrass pastures. No supplemental feed was fed after this point. Pregnancy was determined via rectal palpation on 1 September 1994. The study concluded when calves were weaned and weighed on 19 September 1994. Cow efficiency (%) was defined by dividing the adjusted 205-day calf weaning weight (ADJWW; Beef Improvement Federation, 1990) by the actual 19 September cow weight and multiplying by 100.

Statistical Analyses

Heifer growth and performance data and metabolite data from Year 1 and weaning weight and cow efficiency from Year 2 were analyzed using general linear model prodedures (SAS, 1985). The model consisted of supplement treatment, forage type, breed of dam and appropriate interactions.

Retrospective analyses were conducted across all treatments on variables of interest (weaning weight, day-168 NEFA and BUN concentrations and day-168 body weight, hip height and condition score) between heifers that had or had not reached puberty by day 168 and between heifers that did or did not deliver a calf during the calving season. Multivariate analysis of variance was used to evaluate the relationship between NEFA and BUN concentrations and body condition scores on day 168. This allowed comparisons between these variables after accounting for differences that were due to forage type.

The effect of treatment on the calving percentage (Year 1) and on the percentage of primiparous cows that were palpated as pregnant (Year 2) was determined by chi-square analysis (SAS, 1985). During Year 2, the effect of treatment on calf gain was determined by comparing adjusted calf weights on 15 June 1994 (end of grazing period on the three different forage types - CONV, SFES and R/RG) and ADJWW among the treatments.

RESULTS AND DISCUSSION

Year 1

Appendix 1 shows the mean nutrient analyses over time from deep-stacked broiler litter that was cleaned out after three batches of birds and used in the present study. The nutritional quality of this litter remained high over a period of approximately 17 months. With proper storage, the quality of broiler litter can remain high for several years (Ruffin and McCaskey, 1991).

At the initiation of this study, the heifers averaged 495 ± 7 lb. The target breeding weight was 750 lb, so the goal was to put 255 lb on the heifers in 168 days (28 October 1992 to 14 April 1993).

Feed treatment did not affect the average daily gain of the heifers over the experimental period: S = 1.60 lb/day; SL75/25 = 1.66 lb/day; SL50/50 = 1.60 lb/day. However, forage type influenced average daily gains of heifers within some of the individual 28-day periods and for the overall study (Table 1). Cumulative average daily gain for the 231-day study was higher in R/RG than in CONV heifers and higher in CONV than in SFES heifers. Heifer body weights for the respective forage treatments over time are shown in Fig. 1.

Nutrient analyses of forage samples collected from SFES and R/RG pastures are shown in Appendix 2. The quality of each forage type was quite high throughout Year 1 of the study. Crude protein and TDN values were notably higher in R/RG than in SFES pastures during the winter and fall; however, these were much closer in numerical value from the March sampling through the remainder of the spring. Forage phosphorus concentrations remained above nutritional requirements (National Research Council, 1984) for growing heifers in each forage type for the entire duration of the study.

Comparisons for heifer gain per head followed the same pattern as average daily gain because stocking rates were constant over time. Heifer gain per head was highest in R/RG, followed by CONV and SFES heifers (Table 2). These gains were higher than previously reported gain on pasture alone at this location (Phillips et al., 1990, 1991). Although type of feed supplement did not affect heifer gain, the cost/lb of gain declined as the percentage of broiler litter in the supplement was increased.

As with average daily gain, supplement treatment did not affect heifer hip height or body condition score. Hip heights of heifers were similar among forage types until experiment day 140, when R/RG heifers were taller than SFES heifers, with CONV heifers being intermediate (Fig. 2). Similarly, body condition scores did not differ among forage types until experiment day 168 (first day of breeding season), when R/RG heifers had a higher body condition score than SFES heifers and CONV heifers were intermediate (Fig. 3). By day 231 (last day of breeding season), R/RG heifers had higher condition scores than CONV and SFES heifers.

The distribution of the percentage of heifers by pelvic area ranges is shown in Fig. 4. Pelvic area measurements ranged from 143 to 240 cm^2, with a mean of 196 cm^2. Pelvic area measurements (cm^2) were larger ($P < 0.06$; SE = 5 cm^2) in Simmental-sired heifers out of Brangus (210) and Brahman-Hereford F_1 (207) dams than in Simmental heifers (184) and were smallest in Brangus x Angus heifers (167). After accounting for differences due to treatment and breed, heifer body weight and pelvic area measurement were closely related ($r = 0.63$; $P < 0.01$), as were hip height and pelvic area measurement ($r = .70$; $P < 0.01$). Regression analysis revealed that for every 10-lb increase in body weight, pelvic area increased by 1.9 cm^2; and for every 1-in. increase in hip height, pelvic area increased by 11 cm^2. In order to maintain equal num-

Table 1. Heifer average daily gain from three forage types during Year 1 of the study.

Period (1992-93)	CONV*	SFES†	R/RG‡	SE§
	--------------------lb/hd/day---------------------			
10/28-11/25	1.75	----	----	.08
11/25-12/23	1.17 a¶	.90 a	----	.09
12/23-1/20	1.28 a	1.24 a	1.39 a	.14
1/20-2/17	1.44 b	1.28 b	2.01 a	.06
2/17-3/17	1.61 a	1.07 b	1.99 a	.05
3/17-4/14	1.55 b	1.71 b	2.50 a	.20
4/14-5/5	2.79 a	2.04 b	2.91 a	.18
5/5-5/26	1.51 a	1.33 a	2.12 a	.23
5/26-6/16	1.64 a	1.23 a	1.28 a	.17
231-day Cumulative ADG# (10/28-6/16)	1.61 b	1.37 c	1.88 a	.06

*CONV heifers were fed hay free choice for the entire study.
†SFES heifers were fed hay free choice until assigned to stockpiled tall fescue pasture 25 November 1992.
‡R/RG heifers were fed hay free choice until assigned to rye-ryegrass pasture 23 December 1992.
§Pooled standard error.
¶Means within the same row with different letters are different ($P < 0.05$).
#ADG = Average daily gain.

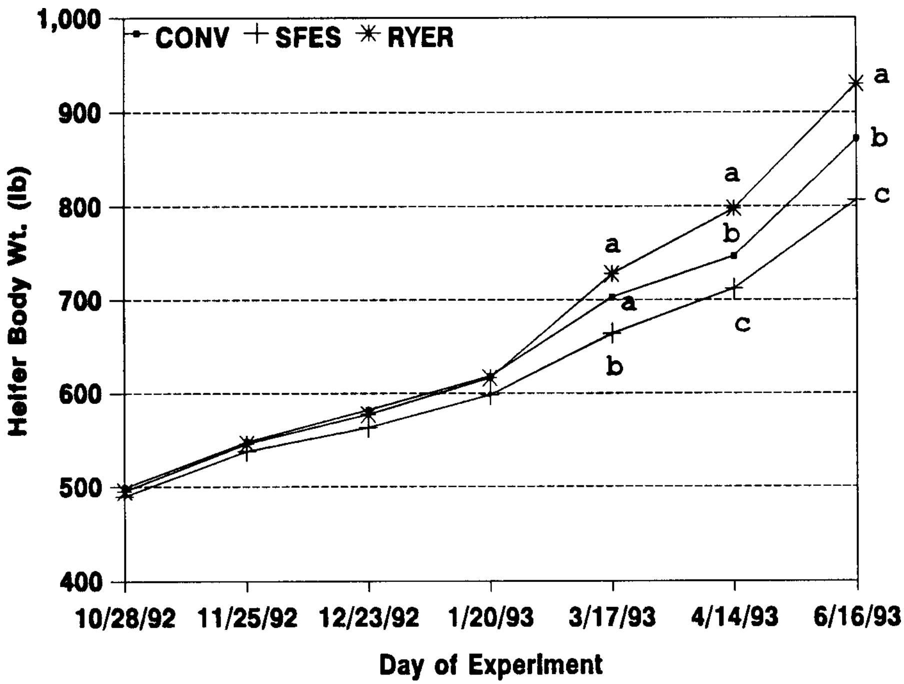

Fig. 1. Heifer body weight by forage type over time (CONV = warm-season grass hay; SFES = stockpiled fescue; R/RG = rye/ryegrass mixture) over time (Year 1). Means on a given date with different letters are different ($P < 0.05$). Forage type x Date, $P < 0.05$.

Table 2. Heifer gain per head and cost per pound of gain as affected by forage types and feed supplement.

Feed supplement	Forage regime			
	CONV*	SFES[†]	R/RG[‡]	Average
Grain sorghum	370[§] ($0.27)[¶]	316 ($0.25)	425 ($0.21)	370 ($0.24)
75% Grain sorghum 25% Litter	372 ($0.27)	328 ($0.23)	450 ($0.19)	383 ($0.23)
50% Grain sorghum 50% Litter	377 ($0.26)	307 ($0.23)	430 ($0.17)	371 ($0.22)
Average	373 ($0.27)	317 ($0.24)	435 ($0.19)	

*CONV heifers were fed hay free choice for the entire study.
[†]SFES heifers were fed hay free choice until assigned to stockpiled tall fescue pasture 25 November 1992.
[‡]R/RG heifers were fed hay free choice until assigned to rye-ryegrass pasture 23 December 1992.
[§]Gain/head (lb).
[¶]Cost/lb of gain.

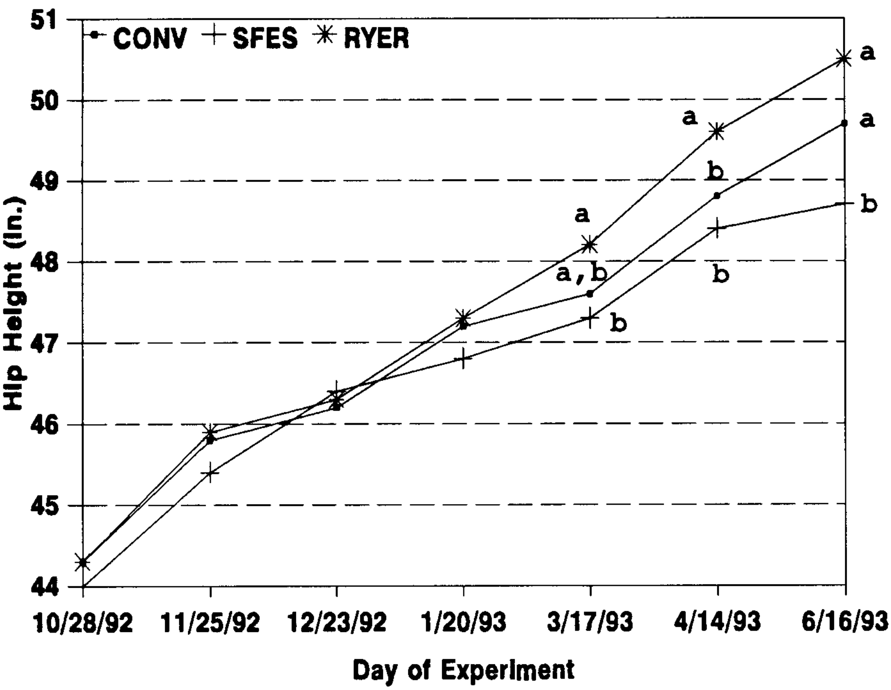

Fig. 2. Heifer hip height by forage type over time (CONV = warm-season grass hay; SFES = stockpiled fescue; R/RG = rye/ryegrass mixture) over time (Year 1). Means on a given date with different letters are different (*P* < 0.05). Pooled SE = 0.3. Forage type x Date, *P* < 0.01.

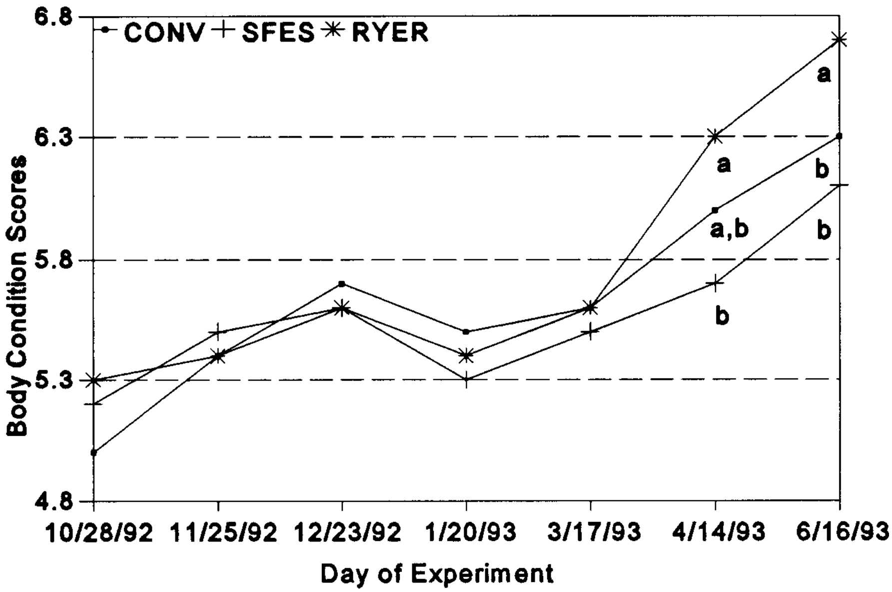

Fig. 3. Body condition scores by forage type over time (CONV = warm-season grass hay; SFES = stockpiled fescue; R/RG = rye/ryegrass mixture) over time (Year 1). Means on a given date with different letters are different (*P* < 0.05). Forage type x Date, *P* < 0.01. Body condition scale: 1 = emaciated, 9 = obese.

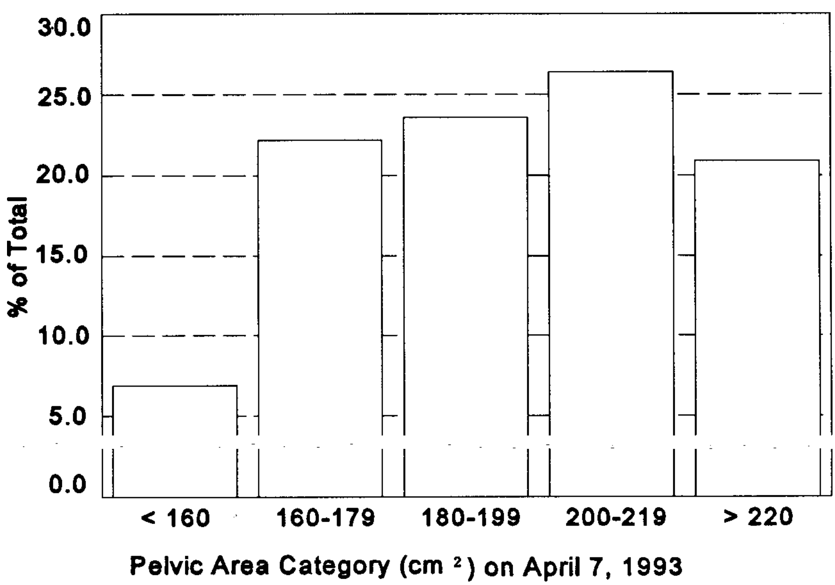

Fig. 4. Percent distribution of heifers (n = 72) by pelvic area measurements. Pelvic measurements were recorded 7 April 1993, when heifers were 403 ± 2 days of age.

bers of heifers for Year 2 of this study, no heifers were culled based on pelvic area measurements.

The proportion of heifers reaching puberty by the beginning of the breeding season did not differ ($P > 0.10$) among supplemental feed treatments (S, 13/24; SL75/25, 10/24; SL50/50, 8/24) or forage types (CONV, 11/24; SFES, 12/24; R/RG, 8/24). In the process of equalizing the energy content of the three feed supplements, the levels of broiler litter and animal fat in the supplements were confounded, with the crude fat percentage being 3.5, 6.7 and 10.7% for S, SL75/25 and SL50/50, respectively. High-lipid diets have been shown to increase blood progesterone in Holstein heifers (Talavera et al., 1985). However, Carr et al. (1994) found no differences in progesterone concentrations or reproductive performance in post-partum cows fed supplemental dietary lipid via whole cottonseed. The effect of the animal fat on pubertal onset (if any) in the SL75/25 and SL50/50 heifers is not known.

A breakdown of the heifers by body weight at the beginning of the breeding season is shown in Fig. 5. Surprisingly, even though approximately two-thirds of the heifers weighed at least 700 lb, only 31 out of the 72 heifers (43%) had reached puberty by this critical time. With larger-framed, later-maturing heifers, a target breeding weight of 700 lb is obviously not high enough. For example, many of today's commercial beef cows reach a mature weight of 1250 lb. Thus, a target breeding weight of 875 lb would be appropriate for a heifer with this type of projected mature weight.

None of the variables that were evaluated in the retrospective analyses differed between heifers that had (n = 31) or had not (n = 41) reached puberty by day 168 (first day of breeding season). These variables included heifer weaning weight (547 vs 547 ± 11 lb), body weight on day 168 (747 vs 761 ± 15 lb), hip height on day 168 (48.9 vs 49.6 ± 0.4 inches) and body condition score on day 168 (5.9 vs 6.0 ± 0.1) for pubertal and prepubertal heifers, respectively.

The effect of pubertal status on the first day of the Year 1 breeding season on whether or not heifers became pregnant during the breeding season is illustrated in Table 3. Chi-square analysis showed no difference in the proportion becoming pregnant between the two groups of heifers. This finding is somewhat surprising, given that beef heifers have been found to have higher pregnancy rates when bred at third estrus than when bred at their first (i.e., pubertal) estrus (Byerley et al., 1987). Thus, we expected the heifers that were pubertal at the beginning of breeding to have higher pregnancy rates than prepubertal heifers.

For those heifers that were prepubertal on the first day of the Year 1 breeding season but still became pregnant, it is likely (although not certain) that many of them conceived at their first estrus, especially given the limited 63-day breeding season. One might assume that for them to have reached puberty and become pregnant during the breeding season, their body weight gains during

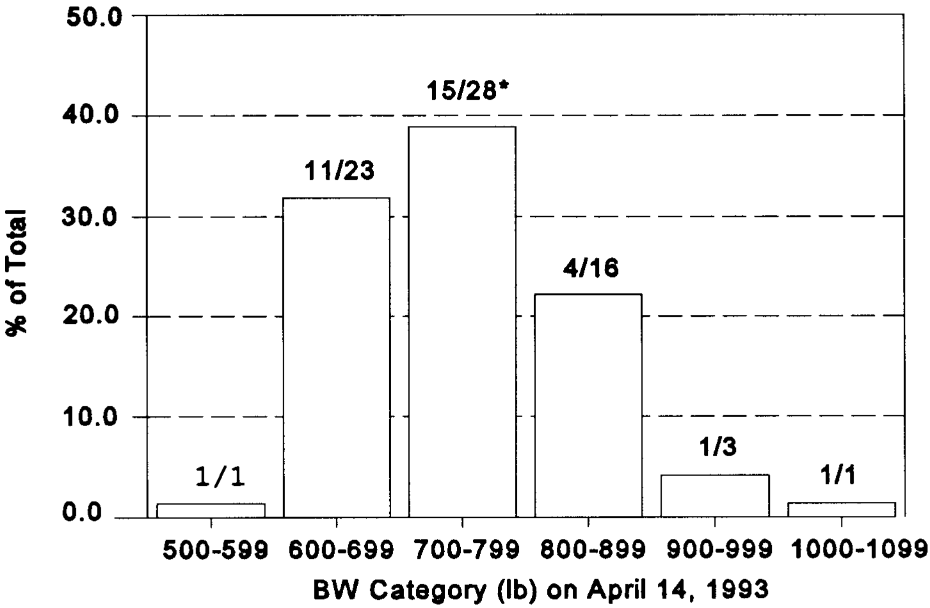

Fig. 5. Distribution of heifers by body weight at beginning of first breeding season. The numbers at the top of each bar indicate the proportion of heifers in each weight category that were pubertal. For example, 14 out of 28 heifers weighing from 700 to 799 were pubertal by 14 April 1993.

Table 3. Proportion of pubertal and pre-pubertal (on the first day of the Year 1 breeding season) heifers that became pregnant during the 63-day breeding season (14 April to 16 June 1993).

Pubertal status on April 14, 1993	Became pregnant	Remained open
Pre-pubertal*	31/41 (75.6%)	10/41 (24.4%)
Pubertal	25/31 (80.6%)	6/31 (19.4%)

*Pubertal status determined by serum progesterone concentrations in samples collected at seven-day intervals for three consecutive weeks prior to the first breeding season.

the breeding season may have been higher than those of the heifers that did not become pregnant. However, the 63-day average daily gain during the breeding season did not differ between prepubertal heifers that became pregnant and those that did not (1.89 vs 2.19 ± 0.13 lb/day, respectively; P = 0.12).

Type of feed supplement did not influence serum NEFA concentrations. The effect of forage type on serum NEFA is illustrated in Fig. 6. On day 84 (20 January 1993), serum concentrations of NEFA (μEq/L) were higher in SFES heifers (486) than in R/RG heifers (302) and were intermediate in CONV (365)

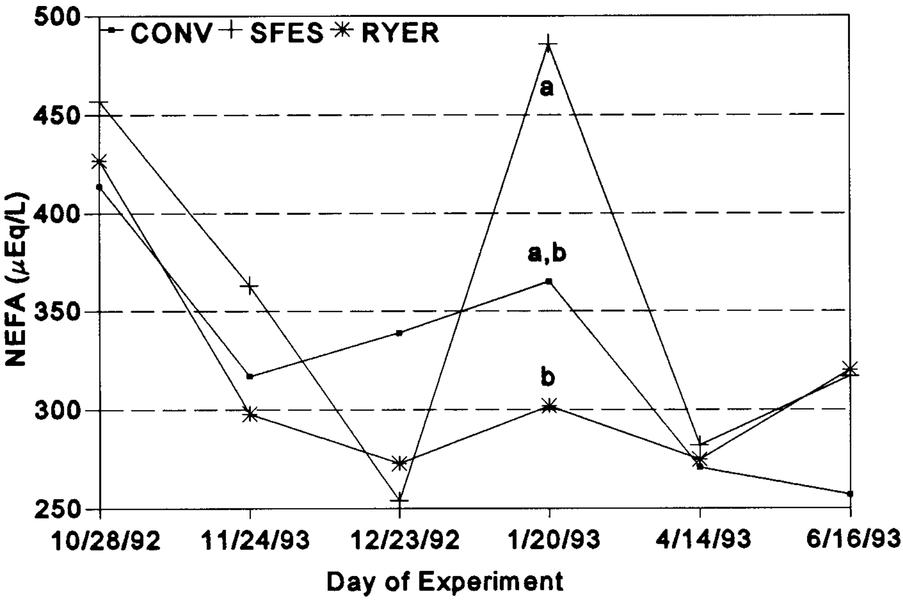

Fig. 6. Serum concentrations of non-estrified fatty acids (NEFA) over time in heifers provided warm-season grass hay (CONV), stockpiled fescue pasture (FES) or a rye/ ryegrass mixture pasture (R/RG). Means on a given date with different letters are different (*P* < 0.05) Pooled SE = 45. Forage type x Date, *P* = 0/08.

heifers ($P < 0.05$; SE = 0.44). Elevated NEFA concentrations are associated with nutritional stress and the mobilization of body fat stores that result from such stress. Consistent with this, multivariate analysis of variance revealed that day-168 serum NEFA concentrations were negatively correlated with body condition scores on day 168 (r = -0.29; $P < 0.03$). By day 84, in mid-winter and after heifers had been on SFES for 56 days, availability and quality of SFES was limited, resulting in those heifers likely receiving a lower plane of nutrition.

Retrospective analyses revealed that serum NEFAs on day 168 (first day of breeding season) were lower in heifers that subsequently delivered a calf than in heifers that failed to calve (256 vs 343 ± 30 μEq/L; $P < 0.02$). It is possible that, as early as day 168, the heifers that subsequently conceived and delivered a calf were under a more adequate state of metabolism to allow for conception than heifers that did not subsequently deliver a calf. More research is needed to determine the repeatability of this observation. If a single blood test at the initiation of the breeding season could be utilized as a predictor of heifers that may conceive during the breeding season, this would be beneficial to producers in the cow/calf industry.

Forage nitrogen content affects BUN in grazing cattle (Hammond, 1992). Blood urea nitrogen was higher in SFES heifers than in R/RG and CONV heifers on day 56 and again on day 168 (14.40, 7.45 and 7.71 ± 0.41 and 27.5, 24.3 and 20.5 ± 0.88 mg/dL, respectively; $P < 0.01$; Fig. 7). Carver et al. (1978) reported similar ranges of BUN concentrations in steers grazing bermudagrass pastures. Higher BUN in SFES heifers on day 56 was expected due to nitrogen fertilization for stockpiling fescue. On day 84, there was no difference between SFES and R/RG for BUN, as each was higher than for CONV heifers. Concentrations of BUN between 11 and 15 mg/dL have been associated with maximum rates of gain in growing steers (Byers and Moxon, 1980). Hammond et al. (1993) reported that in growing cattle, BUN concentrations below 9.0 mg/dL indicate an insufficient amount of protein intake relative to dietary energy, and concentrations about 12.0 mg/dL indicate excess protein in the diet.

Another goal in managing heifers to calve at 23 to 24 months of age is for heifers to weigh 90% of their mature weight by the time they calve. This generally requires a gain of about 1 lb/day between breeding and calving. Access to medium-quality summer and fall pasture is usually adequate to achieve

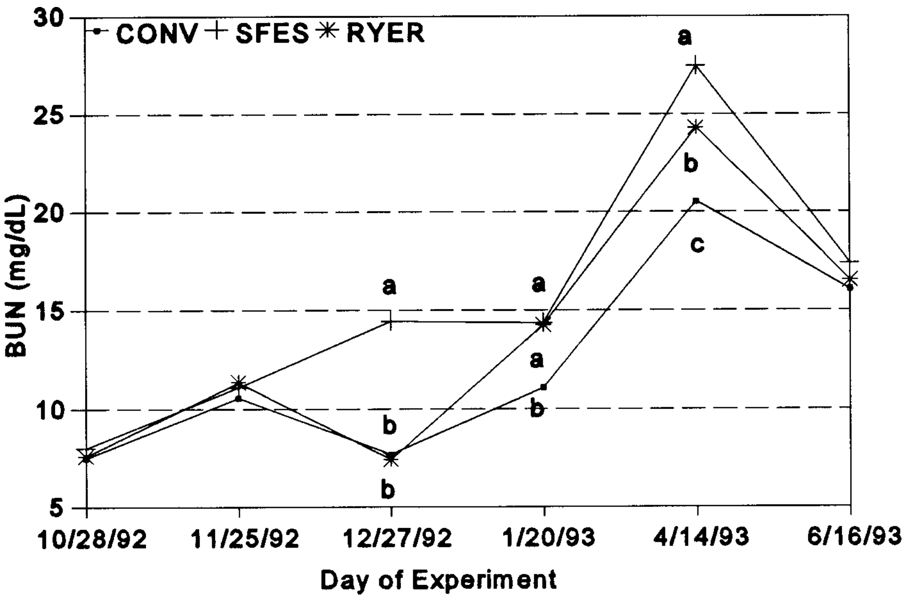

Fig. 7. Serum concentrations of blood urea nitrogen (BUN) over time in heifers provided warm-season grass hay (CONV), stockpiled fescue pasture (SFES) or a rye/ryegrass mixture pasture (R/RG). Means on a given date with different letters are different ($P < 0.05$). Pooled SE = 1.0. Forage type x Date, $P < 0.01$.

this level of gain, and this goal should not be a problem except during times of drought or unusual circumstance. However, in the present study, average daily gains were quite low during the 70-day period from 16 June to 25 August 1993 (0.60, 0.47 and 0.26 ± 0.10 lb/day for heifers that had been on CONV, SFES and R/RG pastures, respectively; $P > 0.10$). Even though gain during this period varied numerically among treatments, the 25 August body weight of CONV and R/RG heifers was higher than that of SFES heifers (914 and 948 vs 840 ± 9 lb; $P < 0.01$). Weight gains improved during the 63-day period from 25 August to 27 October 1993 (1.46, 1.65 and 1.66 ± 0.11 lb/day for heifers that had been on CONV, SFES and R/RG pastures, respectively; $P > 0.10$). There were no differences in body weight or gains at any point during the summer among heifers that had received S, SL75/25 and SL50/50 feed supplements during Year 1.

Year 2

At the beginning of Year 2 (27 October 1993), body weights (lb) were higher ($P < 0.01$) in heifers that had been on R/RG (1052) than in those on CONV (1006), which was higher than those of heifers that had been on the SFES (944) forage type during Year 1. This illustrates the fact that the way heifers are managed as yearlings will influence their body weight (and, potentially, their productivity) during their first year of production.

Chi-square analysis showed that the proportion of heifers delivering a calf was similar ($P > 0.10$) among CONV (16/24), R/RG (20/24) and SFES (20/24) heifers. In order to maintain equal numbers and stocking rate among treatments during Year 2, the 16 heifers that did not deliver a calf were kept with the others and were exposed to the breeding season of Year 2. Of these 16 heifers, nine became pregnant during the second breeding season, and seven were open again. This observation supports the general recommendation to cull heifers that do not conceive after the first breeding season. Body condition was evidently not a factor influencing whether or not these 16 open heifers from Year 1 became pregnant during Year 2, as condition scores on 13 April 1994 (first day of breeding season in Year 2) did not differ between the nine that became pregnant and the seven that remained opened a second year (6.2 vs 6.0 ± 0.4, respectively; $P > 0.10$).

One heifer became disabled immediately after parturition and was removed from the study, leaving a total of 71 heifers that were used in Year 2 of the study. Fifty-seven of the 71 heifers (57/71; 80.28%) became pregnant during the Year 2 breeding season, and neither feed supplement treatment (S, 20/23; SL75/25, 18/24; SL50/50, 19/24) nor forage type (CONV, 19/24; SFES, 19/24; R/RG, 19/23) had an effect ($P > 0.10$) on the proportion of heifers becoming pregnant during Year 2.

Changes in heifer body weight during Year 2 were variable among forage types and time of year (Table 4). During the first 28-day period after being

Table 4. Mean change in heifer body weight (lb/day) for three forage types during Year 2.

Period (1993-94)	CONV*	SFES†	R/RG‡	SE§
	----------------------------	lb/head/day	----------------------------	
10/27 - 11/24	.32	----	----	.08
11/24 - 12/22	.16 b¶	1.09 a	----	.09
12/22 - 1/19	.01	- .13	----	.21
1/19 - 3/16	- .18 b	- 1.01 a	----	.09
3/16 - 4/13	1.88	1.11	1.33	.29
4/13 - 5/4	1.99 a	.61 b	1.70 a	.30
5/4 - 5/25	- 1.70 b	1.08 a	1.05 a	.31
5/25 - 6/15	.08	- .42	- 1.82	.44
63-day ADG# during Year 2 Breeding Season	.14	.41	.30	.29

*CONV heifers were fed hay free choice for the entire study.
†SFES heifers were fed hay free choice until assigned to stockpiled fescue pastures on 24 November 1993.
‡R/RG heifers were fed hay free choice until assigned to ryegrass pastures on 16 March 1994.
§Pooled standard error.
¶Means within the same row with different letters are different ($P < 0.05$).
#ADG = Average daily gain.

placed on pasture (24 November 1993, to 22 December 1993), which was during the last trimester of pregnancy, SFES heifers gained more weight ($P < 0.05$) than CONV heifers. During the first three weeks of the breeding season, CONV and R/RG heifers gained more weight than SFES heifers. However, no difference was detected among forage types for body weight change during the 63-day breeding season of Year 2.

As in Year 1, feed supplement treatment during Year 2 did not influence the hip heights or body condition scores of heifers. However, forage type and date affected hip height, with CONV and R/RG heifers being taller than SFES heifers (Table 5; forage type x date interaction, $P > 0.10$). Again, as in Year 1, a forage type x date interaction was detected for body condition score (Fig. 8); on the December and January weigh days, SFES heifers had higher condition scores than CONV heifers, with R/RG heifers being intermediate on those two dates. The fact that these two dates were 28 and 56 days, respectively, after SFES heifers were placed on stockpiled fescue (and when R/RG heifers were still on CONV pastures prior to their placement on R/RG pastures on 16 March 1994) is indicative of the quality of SFES during the first one to two months of grazing.

Adjusted 205-day calf weaning weights and cow efficiencies (as measured by ADJWW divided by actual cow weight at weaning) are shown in Table 6. Feed supplement treatment did not affect either variable. However, forage type tended to influence ADJWW, with calves suckling R/RG cows having higher ADJWW than calves suckling SFES cows, and CONV being intermediate. Cow efficiency percentages were very close to the 50% level that is generally tar-

Table 5. Hip heights of heifers representing three forage types in Year 2.

Date	CONV*	SFES†	R/RG‡	Mean§
	----------------------------------	in.	--------------------------------------	
27 October 1993	51.6	50.4	52.2	51.4 d
24 November 1993	51.7	50.5	52.2	51.5 d
22 December 1993	52.1	51.0	52.6	51.9 c
19 January 1994	52.8	51.5	53.5	52.6 b
16 March 1994	53.1	52.0	53.8	53.0 a
13 April 1994	53.5	52.5	54.0	53.3 a
15 June 1994	53.5	52.6	54.0	53.4 a

*CONV heifers were fed hay free choice for the entire study.

† SFES heifers were fed hay free choice until assigned to stockpiled fescue pastures on 24 November 1993.

‡ R/RG heifers were fed hay free choice until assigned to ryegrass pastures on 16 March 1994.

§ Effect of Date ($P < 0.01$); means within the same column with different letters differ.

Effect of Forage Type ($P < 0.01$); CONV and R/RG did not differ for hip height, but were taller than SFES heifers.

Forage Type x Date interaction was not significant ($P > 0.10$).

Pooled SE = .3

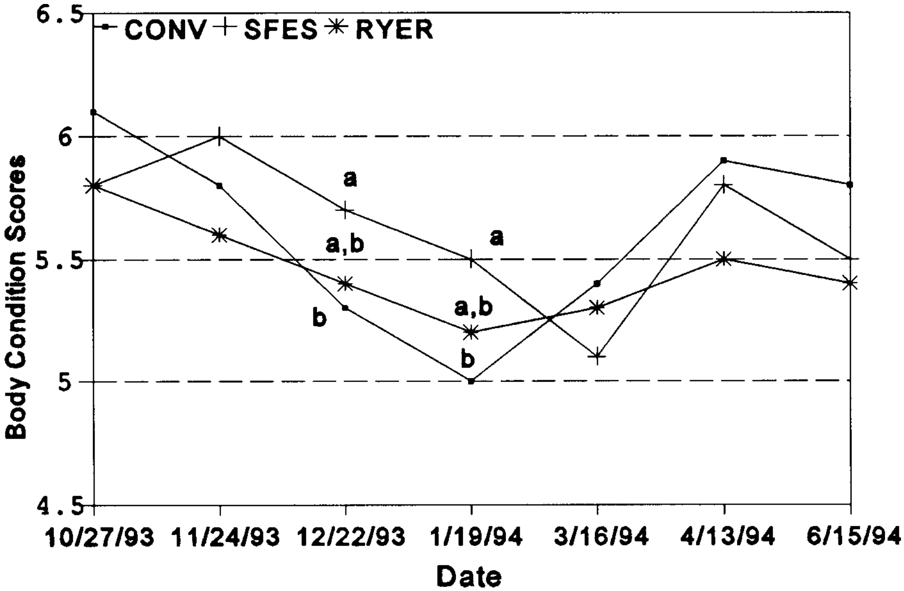

Fig. 8. Heifer body condition score by forage type (CONV = warm-season grass hay; SFES = stockpiled fescue; R/RG = rye/ryegrass mixture) over time (Year 2). Means on a given date with different letters are different ($P < 0.05$). Body Condition Score Scale: 1 = emaciated; 9 = very fat.

Table 6. Adjusted 205-day calf weaning weight (ADJWW) and cow efficiency by feed supplement treatment and by forage type.

Variable	S*	SL75/25	SL50/50	SE	Probability
ADJWW (lb)	489	505	520	15	> 0.10
Cow efficiency (%)	48.0	49.0	51.0	1.9	> 0.10
	CONV[†]	SFES	R/RG	SE	Probability
ADJWW (lb)	506 ab[‡]	482 b	526 a	15	0.09
Cow efficiency (%)	49.3	48.8	49.9	1.8	> 0.10

*S = 100% Grain sorghum - Heifers (n = 24) received 5 lb grain sorghum/head/day; SL75/25 = 75% Grain sorghum / 25% Broiler litter - Heifers (n = 24) received 5 lb/head/day of this mixture plus 0.2 lb/head/day of animal fat; SL50/50 = 50% Grain sorghum / 50% Broiler litter - Heifers (n = 24) received 5 lb/head/day of this mixture plus 0.4 lb/head/day of animal fat.

[†]CONV = heifers were fed hay free choice for the entire study; SFES = heifers were fed hay free choice until assigned to stockpiled fescue pastures on 24 November 1993; R/RG = heifers were fed hay free choice until assigned to ryegrass pastures on 16 March 1994.

[‡]Means within the same row with different letters are different ($P < 0.10$).

geted. This may be the case for the majority of primiparous, two-year-old cows in production settings.

CONCLUSIONS

In general, Arkansas beef cattle producers can be successful in calving heifers for the first time at two years of age because they don't have the stress of lactation prior to and during the breeding season. It is more difficult for producers to attain satisfactory conception rates during the second breeding period because of the added demand on the heifer's body as she is lactating and still growing. Heifer development is even more critical when heifers are mismatched with feed resources. If the forage is not in adequate supply and/or not of sufficient quality, then supplemental feed must be supplied. This study involved the management of replacement heifers for reproductive efficiency from weaning through the second breeding season. Growth and development of heifers in this study involved management of heifers with three supplemental feed treatments (S, SL75/25 and SL50/50) and three forage types (R/RG, CONV and SFES). Below are the conclusions from this study:

Forage Type

1. Cumulative average daily gain and gain per head of heifers for the 231-day study were higher in R/RG heifers than in CONV heifers and higher in CONV heifers than in SFES heifers.
2. The proportion of heifers reaching puberty by the beginning of the breeding season did not differ among forage types (R/RG, 8/24; CONV, 11/24; SFES, 12/24).
3. Forage type did not affect heifer hip height and body condition score prior to first exposure for breeding, but by the end of the breeding

season, heifers on R/RG had higher body condition scores than heifers on CONV and SFES forages.

4. The proportion of heifers delivering a calf from first gestation was similar among R/RG (20/24), CONV (16/24) and SFES (20/24) forage types. Forage type did not affect the number of heifers pregnant from second exposure to breeding (R/RG, 19/23; CONV, 19/24; and SFES, 19/24).
5. Forage type tended to influence adjusted weaning weight (ADJWW) during first lactation, with calves nursing R/RG heifers having higher ADJWW than calves nursing SFES heifers and CONV being intermediate.
6. Forage type affected hip height of heifers, with heifers consuming CONV and R/RG being taller than SFES heifers. Also, there was a forage type by date interaction for body condition score. Body condition score changed among the three forage types from the beginning of the third trimester through the second breeding period.

Feed Treatments

7. Heifer performance was not affected by feed treatment. Daily and cumulative gains were similar for heifers receiving 100% S, SL75/25 and SL50/50. Although type of feed supplement did not affect heifer gain, the cost per pound of gain declined as the percentage of broiler litter in the supplement increased.
8. The proportion of heifers reaching puberty by the beginning of the first breeding season did not differ among supplemental feed treatments (S, 13/24; SL75/25, 10/24; SL50/50; 8/24). Feed treatment did not influence the number of heifers becoming pregnant during the first breeding period.
9. Feed supplement treatment did not influence hip height or body condition scores of the heifers.
10. Feed supplement treatment did not affect adjusted 205-day weaning weights and cow efficiencies (as measured by ADJWW divided by actual cow weight at weaning).
11. There were no differences in body weights or gains at any point during the summer following first exposure to breeding among heifers that had received S, SL75/25 and SL50/50 feed supplements.
12. Fifty-seven of the 71 heifers (80.28%) became pregnant during the second breeding season, and feed supplement treatment had no effect on the proportion of heifers becoming pregnant (S, 20/23; SL75/25, 18/24; SL50/50, 19/24).
13. After accounting for differences due to treatment and breed, heifer body weight and pelvic area measurements were closely related, as

were hip height and pelvic area measurement. Regression analysis revealed that for every 10-lb increase in body weight, pelvic area increased 1.9 cm^2, and for every 1-in. increase in hip height, pelvic area increased by 11 cm^2. The consistency and dependability of yearling pelvic measurements to predict which heifers may require assistance at calving was relatively low.

14. Even though heifers in this study had seemingly satisfactory average daily gains and body weights, a surprisingly low percentage of them reached puberty by the beginning of their first breeding season.

LITERATURE CITED

Arkansas Agricultural Statistics Service. 1995. Arkansas Agricultural Statistics, 1994. Arkansas Agricultural Experiment Station, Report Series 325. September, 1995.

Beef Improvement Federation. 1990. Guidelines for uniform beef improvement programs. Sixth Edition. F.H. Baker (ed.).. University of Georgia, Athens, Georgia.

Byerley, D.J., R.B. Staigmiller, J.G. Berardinelli and R.E. Short. 1987. Pregnancy rates of beef heifers bred either on pubertal or third estrus. J. Anim. Sci. 65:645.

Byers, F.M., and A.L. Moxon. 1980. Protein and selenium levels for growing and finishing beef cattle. J. Anim. Sci. 50:1136.

Carr, D.L., J.C. Spitzer, T.C. Jenkins, G.L. Burns and B.B. Plyler. 1994. Effect of dietary lipid supplementation on progesterone concentration and reproductive performance in suckled beef cows. Theriogenology 41:423.

Carver, L.A., K.M. Barth, J.B. McLaren, H.A. Fribourg, J.T. Connell and J.M. Bryan. 1978. Plasma urea nitrogen levels in beef steers grazing nitrogen-fertilized bermudagrass and orchardgrass-ladino pastures. J. Anim. Sci 47:927.

Chessmore, R.A. 1979. Profitable pasture management. The Interstate Printers and Publishers, Inc. Danville, Illinois.

Cook, B.R., M.W. Tess and D.D. Kress. 1993. Effects of selection strategies using heifer pelvic area and sire birth weight expected progeny difference on dystocia in first-calf heifers. J. Anim. Sci. 71:602.

Cross, D.L., G.C. Skelley, C.S. Thompson and B.F. Jenny. 1978. Efficacy of broiler litter silage for beef steers. J. Anim. Sci. 47:544.

Eck, H.V., G.C. Wilson and Tito Martinez. 1981. Tall fescue and smooth bromegrass. II. Effects of nitrogen fertilization and irrigation regimes on quality. Agron. J. 73:453-456.

Fribourg, H.A., and R.W. Loveland. 1978. Production, digestibility, and perloline content of fescue stockpiled and harvested at different seasons. Agron. J. 70:745.

Gerken, H.J. 1977. Feeding broiler litter to beef cattle and sheep. Coop. Ext. Serv. Publ. 754. Virginia Poly. Inst. and State Univ., Blacksburg.

Hammond, A.C. 1992. Use of blood urea nitrogen concentration to guide protein supplementation in cattle. pp. 9-18. *In:* Third Annual Florida Ruminant Nutrition Symposium. January 23-24, 1992, Gainesville, Florida.

Hammond, A.C., W.E. Kunkle, D.B. Bates and L.E. Sollenberger. 1993. Use of blood urea nitrogen concentration to predict response to protein or energy supplementation in grazing cattle. pp. 1989-1991. *In:* Proc. Of the XVII International Grassland Congress, Palmerston North, New Zealand. New Zealand Grassland Association, Palmerston North, New Zealand.

Huneycutt, H.J., C.P. West and J.M. Phillips. 1988. Responses of bermudagrass, tall fescue, and tall fescue-clover to broiler litter and commercial fertilization. Arkansas Agric. Exp. Sta. Bull. 913. 20 pp.

Kesler, D.J., H. Khayali and R.J. Favero. 1990. Quantification of steroids via a polymer linked second antibody enzyme immunoassay system: Methods in linking anti-rabbit IgG to polystyrene. *In:* C.G. Gebelsin and R.L. Dunn (eds.). Progress in Biomedical Polymers. p. 157. Plenum Publishing, New York.

Kriese, L.A., L.D. Van Vleck, K.E. Gregory, K.G. Boldman, L.V. Cundiff and R.M. Koch. 1994. Estimates of genetic parameters for 320-day pelvic measurements of males and females and calving ease of 2-year-old females. J. Anim. Sci. 72:1954.

Lesmeister, J.L., P.J. Burfening and R.L. Blackwell. 1973. Date of first calving in beef cows and subsequent calf production. J. Anim. Sci. 36:1.

Malone, G.W., N. Gedamu and J.T. Sims. 1992. Delmarva broiler litter production rates. Poultry Sci. 71:52 (abstr.).

Matches, A.G. 1979. Management. *In:* R.C. Buckner and L.P. Bush (eds.). Tall fescue. Amer. Soc. Of Agronomy Monograph No. 20, pp. 171-200. Madison, Wisconsin.

National Research Council. 1984. Nutrient Requirements of Beef Cattle (6th Edition). National Academy Press, Washington, DC.

Noland, P.R., B.F. Ford and M.L. Ray. 1955. The use of ground chicken litter as a source of nitrogen for gestating-lactating ewes and fattening steers. J. Anim. Sci. 14:860.

Phillips, J.M., A.H. Brown, Jr., W.C. Loe, R.W. Parham and R.L. Smith. 1990. Steer performance as affected by implanting while grazing tall fescue. *In:* Elaine Williams (ed.). Current topics on beef cattle research in Arkansas. Univ. of Arkansas Agricultural Exp. Sta. Spec. Rpt. 151:17.

Phillips, J.M., A.H. Brown, Jr., W.C. Loe, R.L. Smith and R.W. Parham. 1991. Cell grazing with steers on tall fescue and small grains overseeded into bermudagrass. *In:* P.R. Noland (ed.). Current topics on beef cattle research in Arkansas. Univ. of Arkansas Agricultural Exp. Sta. Spec. Rpt. 147:5.

Phillips, J.M., T.L. Kirkpatrick and R.B. Simpson. 1993. Seasonal yield distribution, nitrogen recovery and forage quality of tall fescue as influenced by nitrogen fertilization. *In:* Wade Faw (ed.). Amer. Forage and Grassland Conf. Proc. 2:150.

Porter, J.K., and F.N. Thompson, Jr. 1992. Effects of fescue toxicosis on reproduction in livestock. J. Anim. Sci. 70:1594.

Ray, M.L. 1978. Value of broiler litter for feeding beef cattle. Arkansas Experiment Station, Bulletin 832.

Richards, M.W., J.C. Spitzer and M.B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. J. Anim. Sci. 62:300.

Ruffin, B.G., and T.A. McCaskey. 1991. Feeding broiler litter to beef cattle. Alabama Cooperative Extension Service Circular ANR-557.

SAS. 1985. SAS/STAT Guide for Personal Computers (6th Ed.). SAS Inst., Inc., Cary, North Carolina.

Shemesh, M., and L.S. Shore. 1994. Effect of hormones in the environment on reproduction in cattle. pp. 287-297. *In:* M.J. Feils and R.S. Sand. Factors Affecting Calf Crop. CRC Press, Inc., Boca Raton, Florida.

Stephenson, A.H., T.A. McCaskey and B.G. Ruffin. 1990. A survey of broiler litter composition and potential value as a nutrient resource. Biological Waste 34:1.

Talavera, F., C.S. Park and G.L. Williams. 1985. Relationship among dietary lipid intake, serum cholesterol and ovarian function in Holstein heifers. J. Anim. Sci. 60:1045.

Washburn, S.P., and J.T. Green, Jr. 1991. Performance of replacement beef heifers on endophyte-infected fescue pastures. *In:* Proc. 40th Annual Conf. North Carolina Cattlemen's Assoc. February 25-26, 1991. North Carolina State University, Raleigh.

Washburn, S.P., J.T. Green, Jr. and B.H. Johnson. 1989. Effects of endophyte presence in tall fescue on growth, puberty, and conception in Angus heifers. p. 80. *In:* Proc. Tall Fescue Toxicoses Workshop. November 13-14. Southern Region Information Exchange Group 37 (SRIEG-37). Atlanta, Georgia.

Webb, K.E., Jr., J.P. Fontenot and W.H. McClure. 1980. Performance and liver copper levels of beef cows fed broiler litter. Virginia Polytechnic Institute and State University Research Division Report 156, pp. 130-133.

Appendix 1. Nutrient analyses of deep-stacked broiler litter utilized in this study. Each number represents the mean of two samples that were sent to two different laboratories for analysis. Broiler litter from the same deep-stack was used during both years of the study.

Date Sampled	DM	CF	ADF	ASH	CP	Ca	P	Mg	Na	K	S	Cu	Zn	Fe	Mn
	%	----------------DM Basis, %----------------										-------DM Basis, ppm-------			
10/20/92	80.2	17.2	22.3	25.5	22.1	2.9	1.68	.59	.84	2.64	1.10	546	415	2723	609
11/25/92	77.9	15.5	29.6	26.6	23.2	3.1	1.82	.52	.82	2.34	1.23	522	444	2298	605
12/23/92	77.1	16.2	28.5	25.9	22.6	2.7	2.82	.54	.85	2.49	1.16	478	402	2582	673
01/28/93	75.5	15.9	29.4	28.4	24.6	2.9	1.77	.59	.79	2.35	1.18	579	401	1727	599
02/17/93	76.7	11.1	26.5	26.9	24.0	2.0	1.75	.58	.90	2.18	1.32	602	453	3278	657
03/17/93	77.4	12.1	29.8	28.6	25.4	2.7	1.72	.56	.82	2.45	1.14	474	525	2314	614
04/17/93	76.7	---	29.0	28.6	26.9	3.3	1.89	.79	.97	2.90	1.31	783	700	2826	610
06/16/93	80.1	18.8	---	25.3	22.0	3.5	2.21	.70	.81	2.52	1.36	564	528	3343	724
08/31/93	84.1	12.6	27.7	26.5	23.0	3.9	2.12	2.11	.89	3.20	1.51	663	612	2497	906
11/10/93	84.9	17.1	30.3	31.0	26.2	3.5	1.96	.76	.85	2.94	1.40	576	500	2715	701
03/02/94	81.7	--	38.2	26.4	22.1	3.4	1.97	.64	.83	2.83	1.18	582	461	2454	639

Appendix 2. Nutrient analyses from forage samples collected from stockpiled fescue (SFES) and rye/ryegrass (R/RG) pastures.

Date Sampled	Forage Type	CP	ADF	TDN	Ca	P	K	Mg
		-----------	-----------	% Dry Matter Basis	-----------	-----------	-----------	-----------
11/25/92	SFES	16.33	30.27	62.60	.47	.32	2.32	.22
12/23/92	SFES	15.00	32.07	60.40	.35	.26	1.79	.18
	R/RG	23.70	20.70	73.50	.64	.43	2.94	.20
1/27/93	SFES	13.67	32.50	58.87	.28	.22	1.24	.13
	R/RG	16.03	27.00	64.27	.39	.30	2.14	.13
2/17/93	SFES	15.03	32.27	60.40	.34	.29	1.29	.14
	R/RG	20.03	25.97	67.47	.45	.40	2.11	.15
3/26/93	SFES	26.73	13.97	80.20	.37	.50	3.33	.15
	R/RG	25.83	17.70	72.43	.44	.46	2.87	.19
4/26/93	SFES	24.37	18.37	75.87	.36	.42	3.48	.20
	R/RG	24.47	21.07	69.60	.53	.48	3.48	.18
6/1/93	SFES	18.97	24.60	67.67	.43	.29	3.22	.20
	R/RG	17.17	28.07	63.80	.49	.36	3.39	.17
6/16/93	SFES	12.77	33.00	57.73	.29	.30	2.58	.20
	R/RG	9.73	34.33	58.63	.38	.32	2.37	.17

Appendix 3. Metric conversion for weights and measures used in this bulletin.

Measurement	Conversion Factors	
Length	1 millimeter (mm)	= 0.04 in.
	1 centimeter (cm)	= 0.39 in.
	1 meter (m)	= 3.28 ft
	1 kilometer (km)	= 0.62 mile
	1 inch	= 25.40 mm
	1 inch	= 2.54 cm
	1 foot	= 0.30 m
	1 yard	= 0.90 m
	1 mile	= 1.60 km
Area	1 sq cm (cm^2)	= 0.16 sq in.
	1 sq meter (m^2)	= 10.76 sq ft
	1 hectare	= 2.47 acres
	1 sq in	= 6.50 cm^2
	1 sq ft	= 0.09 m^2
	1 acre	= 0.40 hectare
Mass	1 gram (g)	= 0.035 oz
	1 gram (g)	= 0.0022 lb
	1 kilogram (kg)	= 2.205 lb
	1 metric ton	= 1.102 ton
	1 oz (dry)	= 28.30 g
	1 pound	= 453.60 g
	1 pound	= 0.45 kg
	1 ton	= 907.20 kg
Volume	1 teaspoon	= 5 milliliters
	1 fl. oz	= 29.60 ml
	1 qt (liq)	= 0.95 liter (l)
	1 gallon	= 3.78 liters
	1 ml	= 0.2 teaspoon
	1 liter	= 0.91 qt (dry)
	1 liter	= 1.06 qt (liquid)
	1 liter	= 0.264 gal