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University Demonstration Program for Developing Beef Replacement Heifers on Cool-Season Forages in Alabama

Abstract

Beef replacement heifer development programs offer a tool to Extension educators to demonstrate best management practices associated with nutrition and reproductive management of beef females. Using high-quality, regionally adapted forage species may help support animal growth and performance during the development phase and model an economical method of providing the nutritional base for heifers when these practices are adopted on-farm. An Extension demonstration program was developed at the Sand Mountain Research and Extension Center in Crossville, AL to demonstrate management techniques necessary for replacement heifers to reach target weights and breed successfully. Producers consign yearling heifers to the program for development on cool-season forage systems. Heifers are screened prior to arrival for temperament, body weight, and structural correctness. Beef heifers undergo estrous synchronization, artificial insemination (AI), and are exposed to a clean-up bull for a 60-day period 10 days post-AI. Heifers are diagnosed for pregnancy by a licensed veterinarian utilizing transrectal ultrasonography and returned to the consigner in late June. Consigners

receive performance reports after each data collection, at the conclusion of the development period, and an evaluation sheet for each heifer consigned to collect annual data and return to the program administrator once the heifer is culled from the herd. Conducting university demonstration-based educational programs related to heifer development improved consignor understanding, application, and use of best management practices on-farm following participation in the program.

Introduction

The Sand Mountain Elite Heifer Development Program was established to demonstrate recommended best management practices for replacement heifer development including the use of artificial insemination (AI) to Northeast Alabama commercial cattle producers using adapted forage-based systems options. Heifer development is an essential step in the longevity of a cow-calf enterprise due to replacement rates averaging 10 to 20% annually for cows. Critical attention to the management of heifers during development can have a sustained impact on long-term efficiency of a beef cattle operation. Due to reduced reproductive efficiency of young beef cows, development of replacement females to fit specific production environments is crucial for efficient cow-calf production (Meek et al., 1999).

Developing heifers to a target weight has been the standard in the past (Patterson et al., 1992), but with cost of production system inputs increasing, cattle producers may seek alternative methods of developing heifers. Utilizing production practices that minimize input costs and increase the selection for reproductively sound heifers may provide a viable opportunity for increased long-term efficiency of beef cattle production systems. Heifer grazing behavior and management practices that expose heifers to their long-term production environment during development may influence future performance. Research has reported that previous metabolic status during certain physiological events (maturation of reproductive tract includes ovaries and ovarian follicles; maturation of hypothalamus; frequency of release of luteal hormone pulses; oestradiol concentrations to stimulate behavioral estrus) influences their ability to reproductively respond later in life (Chagas et al., 2006; Roche et al., 2005). In the Southeast US, many beef producers have an opportunity to utilize high-quality cool-season forages to support heifer performance during the development phase, which may reduce the need for the use of supplemental feedstuffs to meet target gain goals prior to breeding.

The objective of this project was to develop a land-grant university-based demonstration program to educate beef cattle producers on the concepts of developing heifers from the yearling phase to conception on cool-season annual and perennial forages. The program is a partnership between the Alabama Cooperative Extension System (ACES) and the Auburn University Alabama Agricultural Experiment Station (AAES).

Methods

All animals sourced in this study belonged to AAES or private consignors. All procedures with animals were performed in accordance with the protocols approved by the Institutional Animal Care and Use Committee (PRN 2021-4021).

Program design and structure

The program is hosted at the Sand Mountain Research and Extension Center (SMREC) in Crossville, AL using rotational stocking of 2-acre paddocks (n = 17). This program was initiated in fall 2015 and has continued annually since the program inception. Data presented are from 4 consecutive years of forage and heifer response variables from January through June 2016 to 2019. This program is designed to develop replacement heifers in a forage-based system, utilizing proper animal husbandry and current reproductive technologies. Consignors agree that heifers in this program may be used in Extension programs for demonstration purposes during educational programs, as well as 4-H and FFA contests. A follow-up meeting/field day is held to summarize the project results to the consignors, and all interested cattle producers.

Heifers are nominated for the program and a selection committee, consisting of livestock Extension agents and specialists, screen the heifers for physical and behavioral parameters essential for success in the program. The heifers are nominated in November each year and selected by December for an early January arrival to the SMREC. Heifers must meet the following eligibility requirements for selection: birth month/year, with actual birthdate preferred (must be born prior to February 15); sire and dam (breed composition) of heifers should be known, with registration numbers of sires provided; heifers should weigh a minimum of 520 pounds (lb) at delivery.

Health is an important aspect of pre-conditioning cattle during the weaning process and guidance is given to consignors, along with their herd veterinarian, to ensure cattle arrive and stay healthy during the development process. Consignors are asked to dehorn cattle if needed, deworm with an approved anthelmintic, wean cattle a minimum of 45-d prior to arrival at the research station, and vaccinate and booster for IBR/BVD/PI3/BRSV, 7-Way Blackleg; 5-Way Leptosporosis, and Vibriosis (*Campylobacter fetus*). Before arrival to the SMREC, heifers are tested for persistently infected – BVD, and any heifers testing positive are removed from the program.

Daily care and management of beef heifers was provided by SMREC staff and ACES personnel. Consignors whose heifers need veterinary care and/or treatment beyond what is provided to all animals were billed as additional costs. The SMREC has a local herd veterinarian who was used according to IACUC (PRN 2021-4021) procedures. The development fee was $400 per head, where half was paid at delivery and the remaining balance was collected when heifers were returned to consigners. The development fee includes: feeding, breeding, routine health, carcass ultrasound, and pregnancy diagnosis.

Forage management

Heifers were developed primarily on grazed cool-season forages. In each year of the project, various cool-season forages were planted based on seed availability and local interest from consignors regarding individual forage species or multi-species mixtures that were readily commercially available. Species used during the program years described herein included 1) tall fescue (*Festuca arundinacea)* or 2) the following cool-season annuals planted alone or in mixtures (two to five-way mixtures): annual ryegrass (*Lolium multiflorum* Lam.), cereal rye (*Secale cereale* L.), white and black oat (*Avena* *sativa* L.), triticale (*Triticale hexaploide* Lart.), wheat (*Triticum aestivum*), turnips (*Brassica rapa*), and crimson clover (*Trifolium incarnatum* L.) planted in the fall utilizing a no-till drill into existing sod or prepared seedbeds. Seeding rates were based on recommendations reported in ANR-0149 Alabama Planting Guide for Forage Grasses (Dillard et al., 2019) and ANR-0150 Alabama Planting Guide for Planting Forage Legumes (Mason et al., 2019). Annual ryegrass was planted in each year of the demonstration project, and year-of-planting for additional forages used in the project are reported in Table 1.

Table 1. Forage species used as part of the cool-season grazing program for a university beef heifer development program.

Year	Forage Species Used
2016	Annual ryegrass, 'Jesup MaxQ' tall fescue, cereal rye
2017	Annual ryegrass
2018	Annual ryegrass; annual ryegrass and crimson clover; black oat; black oat and crimson clover; cereal rye; cereal rye and crimson clover; oat; oat and crimson clover
2019	Annual ryegrass; 'Martin II' tall fescue

Soil tests were conducted annually. Phosphorus and potassium were applied each year based on soil test recommendations from the Auburn University Soil, Forage and Water Testing Laboratory and nitrogen (N) fertilizer was applied at 60 lb N/acre after seedling emergence. In March, an additional 30 lb N/acre was applied to each of the paddocks. Feed supplementation with a least cost commodity feed blend (70% soybean hull pellets and 30% dried distillers' grains with solubles; as-fed basis) was provided as needed during the development phase to maintain 1.5 lb/day average daily gain (ADG).

Paddocks were managed using rotational stocking. Heifers were moved to a new paddock when 50% forage utilization had occurred (range 1 to 10 days) as determined by height of the forage. Within paddocks, heifers were allowed continuous access to water and mineral supplementation (Purina Wind and Rain® Storm Hi-Mag 4 Complete Beef Cattle Mineral, St. Louis, MO). During years of decreased forage growth, heifers were managed as a single group in a drylot system where they are fed annual ryegrass hay and pelleted 50% soybean hulls and 50% corn gluten feed to reach a target gain of 1.5 lb/d. Once forages reach a threshold of 8 to 10 inches in height, heifers were returned to the paddocks for grazing and rotated when 50% of the aboveground forage mass had been removed.

Heifer growth and performance characteristics

Once heifers arrived at the station, they were co-mingled with other consigned heifers and body weights and hip heights were collected. Each heifer received an ear tag for identification. After initial receiving and processing, heifers were divided into groups based on consigner and body weight to prevent social dominance among heifers and to better manage forage utilization in the paddocks. The number of groups was dependent on the total number of consigned heifers and available forage per paddock. Weights and hip heights were taken at 28-day intervals to ensure acceptable growth and body weight gain was achieved. In early March, carcass ultrasound was performed by a certified technician to evaluate carcass merit, and results were reported back to the consigners.

Reproduction

Approximately 30 days before the start of breeding season, heifers were evaluated for body condition score (BCS) [scale of 1-9 with 1 = emaciated and 9 = obese; (Wagner et al., 1988)] and assessed for reproductive tract score [RTS; scale of 1-5; 1 = pre-pubertal, 5 = pubertal, luteal phase; (Anderson et al., 1991)] as well as pelvic area [cm^2 using a Rice Pelvimeter; (Johnson et al., 1988)] by a single, experienced veterinarian. During the first week of April, heifers underwent estrous synchronization for artificial insemination utilizing the Select Synch + Controlled Intravaginal Drug Release (CIDR®, 1.38 g progesterone; Eazi-Breed®) protocol to begin their first breeding. Heifers received an injection of gonadotropin releasing hormone (GnRH) (i.m.; 100 µg; Cystorelin®) and insertion of a CIDR on day -9, followed by CIDR removal and an injection of prostaglandin F2α (PGF; i.m.; 25 mg; Lutalyse®) on day -2. All heifers then received a second GnRH injection (i.m.; 100 µg; Cystorelin®) and were inseminated with a dose of semen of proven fertility 12 hours after estrus detection or 74-h after injection of prostaglandin F2α (PGF; i.m.; 25 mg; Lutalyse®). Two professionals in random rotation were responsible for AI procedures for each year.

Ten days after AI, heifers were exposed to a fertile bull (calving-ease clean-up bull, leased from Auburn University Beef Teaching Center) for natural breeding. An experienced veterinarian performed initial pregnancy evaluation by transrectal ultrasonography on day 62 to 89 post AI. Presence or absence of a conceptus, alongside morphological features indicating fetal age were recorded, and heifers were classified as '"pregnant to AI," "pregnant to natural service," or "not pregnant."

Consignor impacts

To measure the short and long-term impacts of the program among consignors who had previously enrolled in the program, an online survey was created to collect feedback from program participants. The survey had ten questions related to potential benefits of the program to their beef cattle operation, increase in overall cattle production, factors that influenced participation in the program and new management practices adopted since participating in the program. Data was collected through a web-based survey platform (Qualtrics®, Provo, UT, 2021) which was distributed by the program administrator sent directly to all previous consignors (n= 12) by email. Previous consignors received the email inviting them to be a participant in the survey by following the link embedded in the email.

Statistical analysis

Beef heifer performance and reproductive characteristics were analyzed using the GLIMMIX procedure in SAS 9.4 (SAS Institute, Cary NC) for a completely randomized design. Independent variables included heifer body weight and ADG, hip height, age, weight, frame score and the interactions. Treatment means were separated using the PDIFF option of the LSMEANS procedure and were determined to be significant when $\alpha = 0.05$. Tendencies are defined as significant at $0.1 \geq P > 0.05$.

Results and Discussion

Characterization of program

Over the course of the Sand Mountain Elite Heifer Development Program, 155 heifers (2016 – 48 head; 2017 – 32 head; 2018 – 50 head; 2019 – 25 head) were consigned from 12 different consigners and 7 different Alabama counties in North Alabama. Ten of these consigners were within a 50-mile radius of the SMREC, and the furthest consigner was located 124 miles from the research station. Of the 12 consignors, 4 have consigned over multiple years. Since 2016, heifers were sired by 13 different sire breeds (Angus, Angus-Brahman, Beefmaster, Brangus, Charolais, Hereford, Hereford-Brahman, Red Angus, Red Poll, Santa Gertrudis, Simmental, Sim-Angus and Ultrablack).

Forage responses

Grazing was initiated when pastures reached an estimated height of 8 to 10 inches and was determined by using a grazing stick (or pasture ruler). In 2016, 2018 and 2019, cool-season grazing was available within 30 days of heifer arrival to the research farm following a planting date of cool-season forages in October. The number of grazing days per year was 143-d in 2016; 70-d in 2017; 139-d in 2018; 137-d in 2019. In 2017, cool-season forages did not reach a sufficient height for grazing until 56 days after heifers arrived to SMREC. Grazing season length for 2017 was the shortest (70-d) due to drought conditions which delayed fall planting. During the 2017 year, cool-season forages were planted late into the growing season (December 2016, February and March 2017, respectively) as a response to drought the previous fall. Grazing in 2017 did not persist past late-May. Annual ryegrass is the only common forage planted across years. Forage species used in the demonstration project provided sufficient growth to support continuous access to cool-season forage for grazing from late January through early May in each year of the demonstration project, illustrating the use of cool-season forages to fill part of the winter forage production shortfall in this region of the US.

Heifer growth and performance

Heifers experienced nutritional diet changes in the early part of the management season when heifers were received from consignors after having been weaned on conserved forage and concentrate-based drylot diets and transitioning to grazed cool-season forages on arrival to the research center. Cumulative ADG was observed to be lowest (P < 0.05) during the first 28 days of each year, except 2017 (Table 2). This period of lower heifer ADG in each year may be partially related to the transition time associated with a shift in diet composition. Fernando et al. (2010) reported that it takes two to three weeks for rumen microbes to transition to effectively digest a new diet. In most cases, heifers received a concentrate-based diet prior to arrival rather than coming from a high-quality, lush cool-season forage grazing-based system. Phillips et al. (2003) noted that Angus steers grazing wheat pasture only increased BW gain by 23.1 lb after 30-d of grazing following the transition onto pasture following a hay-based diet. In 2017, heifers did not experience a drop in ADG until after day 56 when forage was available for grazing. Although ADG lagged in the early transition phase of the demonstration project, this did not impact meeting the target animal body weight goal required pre-breeding.

Average daily gain change between weigh periods and across years is presented in Table 2. For ADG in every year except 2017, ADG increased (P < 0.05) from 28 d to 56 d on the project, which was most likely due to compensatory gain from acclimating to the transition onto grazing cool-season forages. In 2017, drought impacted the forage establishment time window, and heifers did not start grazing forages until after the second weigh period. Each year except 2016, where there was an extended spring with cooler than average temperatures, ADG decreased (P < 0.05) from d 81 to d 166 during the grazing season, most likely due to cool-season forages becoming overly mature and less nutritious. Mean ADG across years is similar (P > 0.05) for each year, with the exception of 2017.

Table 2. Mean average daily gain (lb/day) of beef heifers enrolled in the development program by year and across 28-d weigh periods.

Year	28-d	56-d	81-d	166-d	Mean
2016	1.07[a,e]	1.82[a,f]	2.00[a,f]	1.83[a,f]	1.69[a]
2017	1.67[b,e,f]	1.87[a,e]	1.56[b,f]	1.18[b,g]	1.58[a]
2018	0.79[a,e]	0.99[b,f]	1.71[a,b,g]	1.87[a,h]	1.34[b]
2019	1.10[a,e]	1.50[c,f]	1.07[c,g]	1.80[a,h]	1.69[a]

[a-d] Within a column, means differ (*P* < 0.05, SEM = 0.13, n = 4).
[e-h] Within a row, means differ (*P* < 0.05, SEM = 0.20, n = 4).

Regardless of year, all heifers reached a minimum of 60% of their projected mature weight based on frame score at the time of breeding. When heifers were weighed in mid-June, most heifers needed to continue to gain 0.29 to 0.99 lb/d until calving to reach 85% of their projected mature body weight at the time of calving. This rate of growth should be achievable with continued adequate forage availability on warm-season perennial pastures and fall growth of tall fescue (DeRouen, 1995; Poore et al., 2006).

Body weight gain between weigh periods and across years is presented in Table 3. For BW gain, heifers increased (*P* < 0.05) BW between each weigh period across all years. Mean BW gain during the grazing season was similar (*P* > 0.05) across years, except for 2018 in which mean BW gain was less (*P* < 0.05). In 2018, heifers gained more slowly through the 56-d weigh period but compensated with positive comparable gains to other years in the last two weigh periods.

Table 3. Body weight gain (lb) of beef heifers enrolled in the development program by year and across 28-d weigh periods.

Year	28-d	56-d	81-d	166-d	Mean
2016	28.82^{a,e}	106.6^{a,f}	180.6^{a,g}	286.0^{a,h}	140.4^{a}
2017	47.3^{a,e}	102.5^{a,f}	127.2^{b,g}	190.5^{b,h}	114.4^{b}
2018	19.8^{b,e}	54.1^{b,f}	137.3^{c,g}	228.6^{c,h}	110.0^{b}
2019	32.3^{a,e}	80.5^{c,f}	184.1^{a,g}	287.9^{a,h}	136.2^{a}

$^{a\text{-}d}$ Within a column, means differ ($P < 0.05$, SEM = 13.0, n = 4).
$^{e\text{-}h}$ Within a row, means differ ($P < 0.05$, SEM = 8.76, n = 4).

Frame score (1-9) change on heifers among year and across weigh periods is presented in Table 4. With frame score, the expectation is for the heifers to grow in height over time during the development phase across weigh periods. In all years except 2017, heifers frame score increased ($P < 0.05$) across weigh periods. The average frame score range was 5.0 to 6.3. The mean frame score was similar ($P > 0.05$) in 2016 and 2018, as well as 2017 and 2019.

Table 4. Frame scores (1-9) of beef heifers enrolled in the development program by year and across 28-d weigh periods.

Date	28-d	56-d	81-d	166-d	Mean
2016	5.6^{a,e}	5.8^{a,f}	6.0^{a,g}	6.0^{a,g}	5.9^{a}
2017	5.2^{b,f}	5.4^{b,e,f}	5.5^{b,e}	5.0^{b,g}	5.3^{b}
2018	5.7^{a,e}	5.8^{a,e}	5.9^{a,f}	6.3^{c,g}	5.9^{a}
2019	5.1^{b,e}	5.3^{b,f}	5.5^{b,f}	5.7^{d,g}	5.4^{b}

$^{a\text{-}d}$ Within a column, means differ ($P < 0.05$, SEM = 0.08, n = 4).
$^{e\text{-}h}$ Within a row, means differ ($P < 0.05$, SEM = 0.11, n = 4).

Reproduction

Reproductive tract score and hour bred (48-h, 60-h, 65-h, 72-h, 84-h post prostaglandin F2α injection) were not significant ($P > 0.05$) sources of variation for pregnancy outcome. However, method bred (estrus-detected vs. non-detected) tended ($P = 0.0921$) to improve conception rate to AI where 35% of heifers exhibiting behavioral estrus and 5% of heifers time-bred conceived to first service AI across years of the program. Across years, 40% of heifers conceived to first service AI, 42% conceived to clean-up bull, and 18% of heifers remained open after last pregnancy check. Overall mean conception across the 4 years was 78% total conception rate (2016 – 70%; 2017 – 82%; 2018 – 74%; 2019 – 84%).

Program costs and management

Table 5 contains the actual costs of the various aspects of developing heifers from weaning to breeding during each year of the demonstration project. In 2017, the heifers were fed hay and supplemental feed for the first 56 days of the program, which increased annual program costs. These feed costs also illustrate the greater carrying costs associated with extending periods of feeding hay and supplement compared with grazing-based management for growing heifers. Breeding costs included the cost of timed AI, lease of a clean-up bull and veterinarian costs for pregnancy checking the heifers.

Table 5. Annual program costs ($ per item category) on a per head basis for beef heifers enrolled in the development program.

Item	2016	2017	2018	2019
Forage[1]	$99.50	$68.34	$91.13	$89.89
Minerals	$21.08	$4.69	$4.69	$23.45
Feed	$0.00	$152.70	$0.00	$16.15
Health	$14.15	$12.05	$10.09	$13.77
Carcass Ultrasound	$14.42	$19.88	$19.88	$20.44
Breeding	$63.37	$67.04	$67.04	$63.26
Total Annual Program Costs Per Heifer	$212.52	$324.70	$192.83	$226.96

[1]Includes forage establishment costs for land preparation, seed costs, and fertility application each year.

Consignor survey results

Consignors in the program were surveyed, through a web-based survey platform (Qualtrics®, Provo, UT, 2021) (n = 12; 100% response rate), regarding their perceptions and applications of heifer management information following enrollment in the program. Survey results noted that 92% indicated participating in the program was strongly beneficial or may have been beneficial (8%) to their operation. Participants reported that animal performance data provided by the program was either extremely useful (66%), very useful (16%) or slightly to moderately useful (16%), which illustrates increased awareness and understanding of these metrics as part of the heifer development phase. Producer adoption of practices showcased as part of the heifer development program was high, with 84% indicating they had implemented various management practices after participating in the program. Of the management practices listed in the survey, consignors indicated they implemented one or more of the following (in order of most widely used to least): Bull selection and developing a defined breeding/calving season (13% for each category), herd health program, cool-season annual forages for developing heifers, reproductive management, pregnancy exams, replacement heifer evaluation/selection (12% for each category percent), implementing an animal identification system (10%). Producers could also report ‘other’ practices, which included purchasing weighing scales and implementing udder and foot scoring on their operation (4% percent).

Producers reported that their overall herd management level had increased because of participating in the program (80%), and 60% of the respondents indicated that this program led to new marketing methods for their cattle operation. Marketing methods utilized by the producers included direct sales (32%), group sales (27%), consignor-based bred heifer sales (23%), and retained ownership programs (18%). Eighty percent of consignors reported a return on the investment of consigning heifers to the program. These producers indicated the investment was realized through better maintenance of heifer body condition score (53%) breeding earlier in the season (47%), whereas 0% indicated return was associated with increased calf weaning weights. Survey participants were asked if calves from heifers developed through the program realized more income compared to previous years. Of the respondents, 70% indicated yes, 10% no, and 20% indicated maybe.

The program also served as a tool to continue engagement with stakeholders in subsequent Extension programs, with 90% of participants indicating they have participated in additional Extension meetings/programs after enrollment in this program. Performance data received (30% of respondents) from the project was the main factor influencing the decision to participate in the program, followed by not having the space to develop heifers on their own operation and opportunity for genetic enhancement through artificial insemination (20%), time and cost for daily feeding and observation as well as inability to plant winter annual forages, or 'other' indicating the consignor wanted to compare groups raised on the farm to groups sent to the development program (10%). These data demonstrate increased awareness, valuation, and application of beef heifer management practices following enrollment in the university-based consignment program.

Conclusions

Heifer development is one of the most important aspects of cattle production and the cow-calf sector. Critical attention to management of replacement heifers during development can have a sustained impact on long-term efficiency. Developing heifers on cool-season forages is an option that demonstrates steady growth and performance with minimized cost of gain. Utilizing a custom heifer development program can demonstrate best management practices related to nutrition, reproduction, and health management, while reducing the need for producers to maintain multiple herd sires, facilities and/or paddocks to develop heifers separate from the main herd. Developing herd management goals for selecting and replacing females with performance data collected in university-based heifer development programs enhances private-farm beef herd potential over time through increased awareness of technologies, application of management practices, and continued connection to Extension educational resources.

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