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STOCKERS FED SERICEA LESPEDEZA PELLETS SHOW REDUCED IMPACTS OF FESCUE TOXICOSIS

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Background

Tall fescue is a predominant pasture forage in Virginia grown on over 1 million acres of hay and pastureland. Despite having high forage productivity and good forage quality characteristics, the presence of endophytic fungus within the tall fescue plant, which produces toxic alkaloids, leads to various syndromes in livestock commonly known as fescue toxicosis. The toxins cause vasoconstriction (constriction of blood vessels), which reduces blood flow to the extremities and reduces animals' ability to dissipate body heat. This presents serious challenges and economic losses of nearly $2 billion annually to the beef industry in the U.S. (Kallenbach, 2015).

Several mitigation strategies have been attempted to minimize the negative effects of consuming endophyte-infected tall fescue in livestock. Renovating wild-type endophyte-infected tall fescue pastures to novel endophyte-infected tall fescue is often the best option to deal with fescue toxicosis as these cultivars have comparable nutritional quality as the endophyte-infected tall fescue but without any deleterious effect on livestock. However, pasture renovation with non-toxic tall fescue or other species of grass is usually expensive, costing $240/acre (Kallenbach, 2015), and likely not feasible in situations such as uncertain land leases and highly erodible land.

Pasture inclusion of condensed tannins-based forage species may be an effective strategy to reduce the effects of fescue toxicosis in livestock due to the possibility that tannins may bind various nitrogen-based compounds such as alkaloids (Okuda et al., 1982). Condensed tannins may help reduce the absorption of alkaloids through the gastrointestinal epithelia, thus reducing their toxic effects (Catanese et al., 2014). Stable complexes are formed as tannins bind with alkaloids (Okuda et al., 1982) and are excreted in the feces (Malinow et al., 1979). Sericea lespedeza is a warm-season perennial legume well adapted to the warm climatic conditions of the southern U.S (Hoveland et al., 1990).

Supplementing ground or pelleted forms of sericea lespedeza as a source of condensed tannins can be an effective strategy to deal with fescue toxicosis. Pelleting sericea lespedeza hay can also add value by increasing its flexibility for feeding, storage, and shipping. In this study, we tested the effect of sericea lespedeza pellets as a source of condensed tannins in reducing the severity of fescue toxicosis in steers.

Methods

This study was carried out for 12-weeks during the summers of 2020 and 2021.

In 2020, twelve fall-born Angus cross steers were divided into four different groups with 3 steers within each group and stocked in four different wild-type endophyte-infected tall fescue pastures. Steers in all pastures were supplemented with sericea lespedeza pellets (daily at 0.5% of BW), but pellets for steers in two pastures were treated with polyethylene glycol as a positive control. Polyethylene glycol within the control treatment inactivates the condensed tannins in the sericea lespedeza which helped us to differentiate tannins effects from diet effects.

In 2021, twelve fall-born Angus cross steers were stocked in a wild-type endophyte-infected tall fescue pasture. All steers were supplemented with sericea lespedeza pellets in a feed bunk equipped with Calan gates (daily at 0.5% of BW), but pellets for half (6) of the steers were treated with polyethylene glycol.

For both years, animal body weight was recorded once every 4-week interval and was used to calculate average daily gain. Hair retention scores of steers were recorded once every 4-week interval. Thermal images of the body extremities i.e., ear, front hoof, and tail tip were taken using an infrared thermal camera, and these images were processed to determine extremity surface temperature. The rectal temperature of the steers was also recorded. Hair and blood samples were collected and were used for the analysis of hair and blood cortisol levels as a stress measure. Urine and fecal samples were collected from steers for the analysis of urine and fecal total ergot alkaloid concentration.

Results

In our study, we found that the overall average daily gain was greater (P=0.0080) for steers supplemented with sericea lespedeza pellets in the second year compared to steers on the control treatment. Interestingly, the steers fed the sericea lespedeza pellets also had slicker hair coats (Figure 1) and lower levels of hair cortisol (indicating reduced stress) in the second year compared to the control steers. Ear skin temperature and tail surface temperature were greater ($P \leq 0.0373$) in steers supplemented with sericea lespedeza pellets during the first year compared to steers on the control treatment. Steers supplemented with sericea lespedeza pellets had cooler rectal temperatures (P=0.0299) during the second year compared to steers on control treatment. Hair cortisol, a measure of long-term stress, was greater (P=0.0367) in the steers supplemented with sericea lespedeza pellets than the control steers, while blood cortisol, usually considered an instantaneous measure of stress, was not significantly different between the steer groups.

Summary and Conclusions

This study indicated some changes in the physiological responses of animals in response to dietary supplements containing condensed tannins. Steers that grazed toxic endophyte-infected tall fescue pasture and supplemented with a diet containing condensed tannins in one year gained more weight and manifested cooler core body temperatures and lower hair cortisol levels compared to control group. Additional study is needed to better understand the potential benefits of condensed tannins in reducing the post-ingestive effects of fescue toxicosis.

Table 1: Average daily gain, extremity temperatures, rectal temperature, and cortisol measure of steers on wild-type endophyte-infected tall fescue supplemented with either sericea lespedeza pellets or control treatment

Variables	2020		2021	
	SEL[1]	Control[2]	SEL	Control
Average Daily Gain, lbs/day	1.45	1.38	1.47	0.81
Ear Skin Temperature, ºF	85.1	81.9	85.1	85.5
Hoof Surface Temperature, ºF	83.7	81.5	83.5	83.5
Tail Skin Temperature, ºF	83.7	80.8	82.2	81.5
Rectal Temperature, ºF	103.5	104.0	103.1	103.6
Blood Cortisol, ng ml^{-1}	8.0	11.4	6.8	8.5
Hair Cortisol, pg mg^{-1}	4.2	4.3	3.7	4.4

[1]SEL- Steers supplemented with sericea lespedeza pellets

[2]Control- Steers supplemented with sericea lespedeza pellets mixed with polyethylene glycol

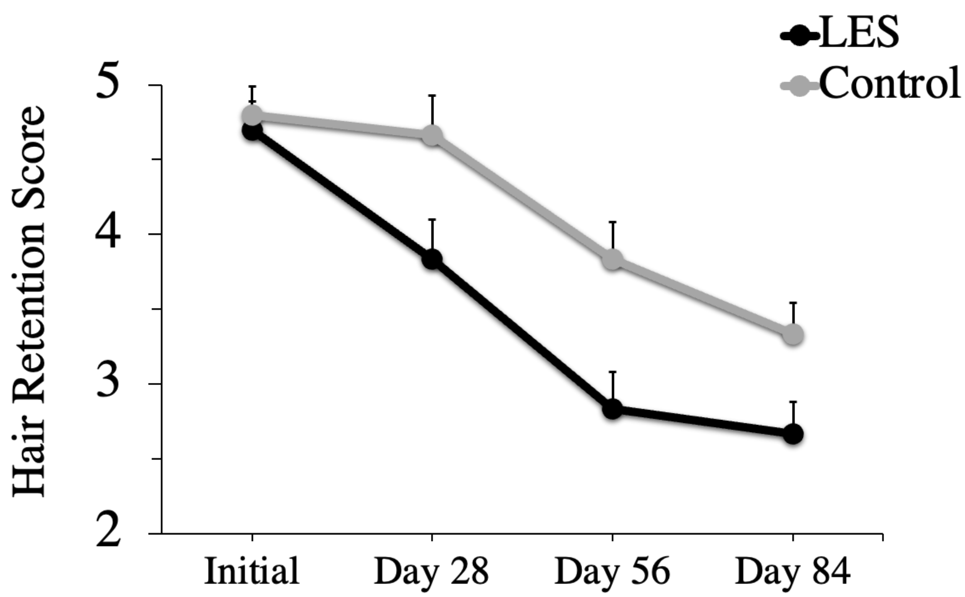

Figure 1: Hair retention score of steers on wild-type endophyte-infected tall fescue supplemented with either sericea lespedeza pellets or sericea lespedeza pellets with polyethylene glycol in 2021

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CREEP-GRAZING BRASSICA AND SMALL GRAIN FORAGES FOR FALL-BORN CALVES

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The Shenandoah Valley Agricultural Research and Extension Center (SVAREC) switched from a spring-calving herd to fall-calving six years ago. At that time, a growing body of research indicated increased profitability realized by fall- vs. spring-calving herds when reliant on tall fescue forage. The AREC herd made the switch to stay relevant to Virginia production systems as a number of herds were shifting to fall-calving.

Past work at SVAREC in a spring-calving system has indicated an increase in weaning weights when calves are provided continual access to alfalfa and endophyte-free tall fescue pasture through a creep-grazing technique. However, this system is not well-suited to fall-calving herds, where calves are on cows at a time when alfalfa has largely completed its growing cycle for the year.

Alternative forage species that may be well suited to creep grazing for fall-born calves are forage brassicas and small grains. These species can produce large amounts of very nutritious forage in only 45-60 days.

Through a project funded by the Virginia Cattle Industry board, we are utilizing existing native warm season grass pastures, which can provide forage to dry cows in the summertime, to overseed winter annual forages in late summer for creep-grazing by fall-born calves through the winter and spring. We are evaluating the production potential and profitability of such a system compared to traditional rotational stocking and continuous stocking with no creep-grazing option.

In the first year of the project, the planting for this project was slightly delayed due to external factors. In addition, in both years, deer grazing pressure significantly impacted the growth and timing of the available forage in the creep-grazing paddocks, which delayed the time that we were able to provide creep-grazing access to the calves in the appropriate treatments. However, we were able to achieve some promising results despite these limitations.

In the second year of the project, we changed the seed mixture and attempted to exclude deer with some additional fencing. The exclusion efforts were only minimally successful, but the forage mixture grew much more vigorously through the fall and spring months.

The four treatments that we included in this project included:

- System 1: continuously stocked, tall fescue-based pastures
- System 2: rotationally stocked, tall fescue-based pastures
- System 3: rotationally stocked, tall fescue-based pastures with one native warm season grass paddock which is overseeded with winter annual forages for calf creep-grazing
- System 4: rotationally stocked, tall fescue-based pastures with one paddock which is seeded with winter annual forages for calf creep-grazing and summer annuals for cow grazing

Each experimental unit (16 acres) was stocked with eight cows, and treatment systems 1, 3, and 4 were replicated three times while treatment system 2 was replicated twice in the first year and three times in year two. Treatment system 4 was sprayed with glyphosate (2 qt/ac + 0.5% surfactant) in October in 2020 and in September in 2021. Creep forage (variety-not-stated rye at 70 lb/ac and rape cv. 'Barsica' at 3 lb/ac) was established in the native grass and winter annual pastures between September 24 – October 5, 2020. The creep forage seed mixture in 2021 consisted of 50 lb/ac oats cv. 'Reeves,' 50 lb/ac triticale cv. 'Surge,' 3 lb/ac rape cv. 'Barsica,' and 15 lb/ac crimson clover cv. 'Dixie.' This mixture was planted in system 4 and in a single paddock in system 3 in 2022. Nitrogen fertilizer was spread on the native grass and winter annual pastures on October 1, 2020 (80 lb/ac) and September 14, 2021 (60 lb/ac). Calves were provided access to creep forage in the native grass and winter annual pastures on April 8 in 2021 and April 1 in 2022. Calves in the continuous stocking treatment occasionally would graze cool season perennial forage by slipping under the single strand of electric wire around the hay feeding area in these treatment pastures. Following weaning in both years, the cows grazed the creep paddock in treatment system 4 following weaning. A brown-midrib sorghum-sudangrass hybrid was then established and fertilized in these paddocks after the winter annual forage was sprayed.

Calves were weaned from dams on May 4 in 2021 and April 20 in 2022 using a fenceline weaning method. Calves in the native warm season grass and winter annual treatments were provided access to their creep-graze paddocks in addition to another cool season grass paddock. Calves in the rotational stocking and continuous stocking treatments were given access to cool season grass paddocks. Calves were removed from the paddocks 16 and 14 days later in 2020 and 2021, respectively, and re-weighed.

While calves were provided access to the creep-grazing paddocks, there was no difference (P=0.7616) in available forage mass between the native warm season grass paddocks (1840 ± 90 lb/ac) and the winter annual paddocks (1880 ± 90 lb/ac), but forage mass increased over time within a season (P=0.0163). There was significantly more forage (P=0.0264) in year two than in year one.

In year one, there was no difference in the percent of the sward as rye (41 ± 11%; P=0.5739), native warm season grasses (2 ± 2%; P=0.2254), clover (7 ± 6%; P=0.2153), winter annual weeds (28 ± 14%; P=0.2685), or bare ground (5 ± 1%; P=0.4226). There was significantly more (P=0.0438) cool season perennial grasses as percent cover in the native grass pastures (29 ± 2%) than in the winter annual forage pastures (13 ± 2%). Forage species composition was not analyzed in 2022, although annual forage germination and production in the single system 3 paddock that was planted was of little significance. The native grass paddocks consisted largely of cool season perennial forages by the winter of the second year.

In year one, forage crude protein was similar in the native grass and the winter annual forage pastures (16.5 ± 0.9%). In year 2, forage crude protein tended (P=0.0571) to be slightly higher in the winter annual forage pastures (21.0 ± 0.9%) than in the native grass pastures (17.7 ± 0.9%). Crude protein declined in both pastures over time in both seasons (<0.0001). Forage total digestible nutrients were similar (P=0.2338) in both treatment pastures (64.4 ± 0.7%), but tended (P=0.0841) to be greater in year one than in year two.

Calf weaning weights were adjusted to 205-day age adjusted weaning weights (AdjWW) using the American Angus Association dam age adjustment factors. For this analysis, we calculated 205-day age adjusted weaning weights using the weaning weight collected when calves were removed from weaning paddocks (around two weeks after removing from the dam). Results are reported as means across both years due to no treatment by year interaction.

The AdjWW of calves in the rotational stocking treatment (461 ± 9 lb) were significantly less (P≤0.0028) than the AdjWW of calves in the continuous stocking treatment (505 ± 8 lb), native grass treatment (515 lb ± 8 lb), and winter annual treatment (513 ± 8 lb). There was no significant difference in AdjWW of the calves in the latter three treatments.

With only one year's worth of hay feeding and production data, we are not able to finalize our economic analysis, but we can provide some preliminary figures. Using a partial budget analysis created from the costs incurred by implementing each treatment, we compared the relative profitability of the three treatments to the control treatment (rotational stocking).

Table 1: Relative profitability of creep-grazing treatments for fall-born calving systems using a partial budget analysis (all numbers reported as relative difference in dollars per cow-calf pair compared to rotational stocking treatment)

Treatment	***Continuous stocking***		***Native warm season and creep***		***Winter creep and summer annuals***	
	Year 1	*Year 2*	*Year 1*	*Year 2*	*Year 1*	*Year 2*
Variable costs for establishing winter annual forages	$0	$0	$80.67	$47.54	$96.42	$166.53
Variable costs for establishing summer annual forages	$0	$0	$0	$0	$164.23	$193.13
Net benefit of decreased hay feeding days	$0	$0	$25.03	$25.03	$50.05	$50.05
Net change in calf sales	$82.26	$26.73	$85.74	$16.09	$80.93	$17.61
Net annual profitability	$82.26	$26.73	$30.39	-$6.43	-$129.68	-$292.00

We used the VDACS 10-year average prices for steers and heifers by weight class to determine the change in gross returns to calf sales using AdjWW. With an assumed value of hay of $110/ton, we assumed that the continuous stocking treatment would be fed hay for the same amount of time as the rotational stocking treatment while the native grass and winter creep treatment would be fed hay for two less weeks and the winter and summer annual forages treatment would be fed hay for four less weeks.The significant cost of establishing the summer annuals eliminated the benefit of the increased AdjWW of the calves from that treatment, while providing creep forage in native grass pastures was slightly more profitable per cow than the control treatment in year one but not in year two (Table 1). Increasing costs of glyphosate and fertilizer in year two have further negated any improvements to weaning weight from the creep-grazing treatments. These data should be considered as preliminary, due to the assumptions noted above and the limitations of our study due to the wildlife damage to the creep-paddocks.

Even though we were only able to provide creep-forage to the calves for about 30 days prior to weaning, we still saw an improvement in AdjWW of around 53 lb compared to the rotational stocking treatment. However, the expense of seed and fertilizer eliminate any financial benefit to establishing annual forages for creep-grazing. We are hoping to continue this project one more year to determine the effect of yearly weather patterns on the project results, as well as to fully account for the costs and benefits associated with each grazing system.

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NATIVE WARM SEASON GRASS VARIETY TRIAL AND GRAZING EVALUATIONS

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Project background

While tall fescue (*Schedonorous arundinaceus*) is the predominant forage species in Virginia pasture systems, the species has limited productivity during the summer months. In addition, most of the tall fescue in Virginia is infected with an endophyte that produces ergot alkaloids. These alkaloids can be toxic to livestock and induce vasoconstriction in cattle, which reduces their ability to regulate their body temperature. As a result, many livestock in Virginia experience severe heat stress during the summer months, resulting in impaired productivity and welfare. These stressed livestock often seek relief from heat within sensitive woodlands, surface waters, and riparian areas; thus, toxic tall fescue is at least partially responsible for woodland degradation and water impairment.

Tall fescue also forms a dense sod, which is unconducive to travel by ground nesting birds, such as the bobwhite quail, a target species of the Working Lands for Wildlife (WLFW) partnership. The lack of appropriate habitat has been cited as largely responsible for the rapid decline in bobwhite quail numbers across the state.

Unlike cool-season grasses, which grow predominately in the spring and fall, warm-season grasses are most productive during summer months and have the potential to fill a large forage production gap in the southeastern US, known as the "summer slump." Native warm season grasses (NWSG) are well-adapted to this region's climate and soils, maintaining high productivity even in the summer months and with minimal inputs, in part because their roots can exploit water resources at greater depths than cool-season grasses. Their deep rooting potential also has value for carbon sequestration.

In addition to offering these production benefits and ecosystem services, NWSG have an important role to play in wildlife conservation. The robust, upright form and open space between plants in a NWSG stand provides the type of habitat required for foraging and nesting by bobwhite quail and other ground nesting birds. These grasses shelter small mammals and birds from predators, even after heavy snow events when left standing overwinter.

Native grasses can provide food for livestock and wildlife alike. Under proper management, NWSG provide highly nutritious forage and can persist in pastures indefinitely. Unfortunately, their adoption has been minimal. Lack of familiarity, historic challenges with establishment, and misperceptions and uncertainty surrounding nutritional quality and stand management largely account for farmer reluctance to adopt NWSG in Virginia. We intend to address these issues through demonstrations and outreach efforts; a central goal of this project involves disseminating documentation of producers' real-world conversion experiences.

Producers interested in converting some acres to NWSG in their operations face a lack of information about suitable species and varieties. There are numerous varieties of NWSG that could be utilized in Virginia, but their suitability to produce forage in different plant hardiness zones has received little attention. The timing and rates at which these grasses develop and mature has a significant impact on their utilization and nutritional quality. Understanding species and varietal differences in growing degree days to maturity would be helpful in selecting varieties for grazing systems for specific regions of the state.

The goal of this project, funded by the USDA Natural Resources Conservation Service, is to increase the number of forage-livestock producers that convert cool-season forage-based pastures to NWSG pastures in Virginia. Specifically, our objectives include:

- Demonstrate the conversion of tall fescue pastures to NWSG pastures.
- Determine the regional productivity and maturation rates of select NWSG species and varieties.
- Determine the forage characteristics and consequent performance of stocker cattle grazing on NWSG pastures during the summer months.

Objective 1: Case-studies

To date, two farmer experiences converting a tall fescue pasture into NWSG have been documented in case-study publications. For more information and to read about these case studies, search for "Converting pastures to native warm season grasses" at pubs.ext.vt.edu.

In the first publication (*Converting Pastures to Native Warm Season Grasses: Forage for Drought in Bedford County*), we document the experiences of Keith Tuck, who successfully established a field of switchgrass (*Panicum virgatum*) at his farm in Bedford County. Keith identified his reason for converting a 16-acre field to switchgrass: "We typically have a drought period sometime each summer, and I need some pasture acres that are planted to a forage that is better suited for summer production and can better withstand drought conditions and still provide some fresh forage for my grazing livestock."

In the second publication (*Converting pastures to native warm season grasses: Summer forage and wildlife habitat in Caroline County*), we document the experiences of Tim Tobin, a farmer in Caroline County, who established a field of Eastern gamagrass (*Tripsacum dactyloides*) and then a field of big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), and indiangrass (*Sorghastrum nutans*) the following year. Tim has made good use of the summer forage produced in these pastures in the first few years since establishment, and he has even heard a bobwhite quail call in the new native grass pastures.

Objective 2: Variety trial

A variety trial of 20 selected NWSG varieties was planted at five locations across Virginia in 2020 (Suffolk, Blackstone, Glade Spring, Raphine, and Middleburg) in a randomized complete block design with four replicates at each location. Four species (big bluestem, Eastern gamagrass, indiangrass, and switchgrass were included in the trial. Multiple sprays and tillage were utilized at each location prior to seeding the Eastern gamagrass with a push-type corn seeder and the other three species with a Carter cone seeder. Variety establishment was largely successful in the Tidewater, Southern Piedmont, and Shenandoah Valley regions, but was only partially successful in the Northern Piedmont and Southwest regions. Plot size was six feet by ten feet.

The plots at the Shenandoah Valley Agricultural Research and Extension Center (SVAREC) in Raphine were established on June 11, 2020. A soil sample indicated a pH of 5.7 and phosphorus and potassium levels of 22 ppm (low) and 60 ppm (very low), respectively. No soil amendments were added to the plots.

Plots at SVAREC were sprayed with 3 qt/ac Satellite herbicide, 1 qt/ac GlyStar Plus herbicide, and 0.5% CNI 80:20 surfactant on April 5, 2022. Plots were mechanically harvested once in 2021 (November 5) and once in 2022 (June 29), with another harvest planned for 2022. Subsamples were weighed, dried, and re-weighed to determine forage dry matter content. Row one was excluded from the analysis due to significant sedge pressure and poor native grass establishment in some of the plots within this replicate.

Plot yield was calculated as the product of the total plot fresh weight by the forage dry matter concentration. Forage dry matter yield by cultivar was compared within a species using PROC MIXED in SAS Studio, v. 94 (SAS Inst., Cary, NC). Differences were considered significant when $P \leq 0.05$ and as trends when $0.05 < P \leq 0.10$.

Yields by cultivar are reported in Table 1 and the plot map is shown in Figure 1.

Table 1: Native warm season grass variety trial results from the Shenandoah Valley AREC

Species[1]	**Cultivar**	**Yield (lb/acre)**		**2-year mean (lb/acre)**	
		2021	*2022*	*LSM*	*SE*
BB	Niagara	1160	4490	2180*	200
BB	Pawnee	1120	3750	1900*	200
BB	Kaw	400	4440	1780*	200
BB	KY Ecotype	430	3240	1370*	200
EG	Pete	1670	7740	3600*	490
EG	Highlander	1400	5960	2830*	490
EG	Iuka IV	1830	4340	2460*	490
IG	Osage	2140	5810	3150*	170
IG	Cheyenne	1770	4950	2650*	170
IG	KY Ecotype	1750	4840	2600*	170
IG	Holt	990	5800	2570*	170
IG	Rumsey	1200	5100	2430*	170
IG	NC Ecotype	1550	3170	1910*	170
IG	GA Ecotype	510	1290	720	170
SG	Performer	2190	8400	4100*	380
SG	Alamo	1570	8190	3710*	380
SG	BoMaster	1310	8420	3660*	380
SG	Shawnee	980	8390	3480*	380
SG	Cave-in-Rock	1330	7650	3400*	380
SG	Carthage	1050	6610	2890*	380

[1] BB: big bluestem (*Andropogon gerardii*); EG: Eastern gamagrass (*Tripsacum dactyloides*); IG: indiangrass (*Sorghastrum nutans*); SG: switchgrass (*Panicum virgatum*)

* Not significantly different from the highest numerical value in the column by species; presented despite significant (P=0.0054) replicate by treatment interaction and significant (P=0.0009) year by treatment interaction for the analysis of indiangrass yield.

Table 1: Native warm season grass variety trial plot plan

Row 4		Row 3		Row 2		Row 1	
KY Ecotype	**IG**	**NC Ecotype**	**IG**	**Iuka IV**	**EG**	**Alamo**	**SG**
Rumsey	**IG**	**KY Ecotype**	**IG**	**Osage**	**IG**	**BoMaster**	**SG**
Cheyenne	**IG**	**Pete**	**EG**	**Highlander**	**EG**	**KY Ecotype**	**BB**
Performer	**SG**	**Iuka IV**	**EG**	**Niagara**	**BB**	**Pete**	**EG**
Niagara	**BB**	**Highlander**	**EG**	**Holt**	**IG**	**Iuka IV**	**EG**
Cave-in-Rock	**SG**	**Cheyenne**	**IG**	**Carthage**	**SG**	**NC Ecotype**	**IG**
Alamo	**SG**	**Kaw**	**BB**	**Cave-in-Rock**	**SG**	**Cheyenne**	**IG**
Pawnee	**BB**	**Holt**	**IG**	**KY Ecotype**	**BB**	**Pawnee**	**BB**
Iuka IV	**EG**	**Carthage**	**SG**	**BoMaster**	**SG**	**KY Ecotype**	**IG**
Holt	**IG**	**Rumsey**	**IG**	**NC Ecotype**	**IG**	**Performer**	**SG**
KY Ecotype	**BB**	**Performer**	**SG**	**Pete**	**EG**	**Niagara**	**BB**
Shawnee	**SG**	**GA Ecotype**	**IG**	**Kaw**	**BB**	**Highlander**	**EG**
Carthage	**SG**	**Niagara**	**BB**	**Performer**	**SG**	**Cave-in-Rock**	**SG**
Kaw	**BB**	**Alamo**	**SG**	**KY Ecotype**	**IG**	**Holt**	**IG**
BoMaster	**SG**	**Osage**	**IG**	**GA Ecotype**	**IG**	**Rumsey**	**IG**
High-lander	**EG**	**Shawnee**	**SG**	**Pawnee**	**BB**	**Osage**	**IG**
Pete	**EG**	**BoMaster**	**SG**	**Cheyenne**	**IG**	**GA Ecotype**	**IG**
Osage	**IG**	**KY Ecotype**	**BB**	**Shawnee**	**SG**	**Kaw**	**BB**
GA Ecotype	**IG**	**Cave-in-Rock**	**SG**	**Alamo**	**SG**	**Shawnee**	**SG**
NC Ecotype	**IG**	**Pawnee**	**BB**	**Rumsey**	**IG**	**Carthage**	**SG**

Objective 3: Animal performance on native warm season grass pastures

A 15-acre field of tall fescue was selected for conversion to a three-way mixture of NWSG at the Southern Piedmont Agricultural Research and Extension Center (SPAREC). The field was selected in part due to a need for control of some broadleaf weeds (*Rubus* spp., *Rhus* spp., etc.).

A series of sprays and winter cover crop plantings were performed from October 25, 2018 through February 25, 2020. A mixture of big bluestem cv. 'Niagara' (5 lb/acre), indiangrass cv. 'GA ecotype' (3 lb/ac), and little bluestem cv. 'Camper' (2 lb/ac) was cross-planted on March 17-19, 2020 with a no-till drill along with some pelletized lime as a carrier for the fluffy seed. Plateau herbicide (4 oz/acre) was sprayed ten days later to control warm season annual grasses prior to germination. The field was sprayed again with Duracor (12 oz/acre) and Cimmaron Plus (0.125 oz/acre) for broadleaf weeds in July of 2020.

Steers from SVAREC were sent to SPAREC for a comparison of grazing performance on this NWSG pasture and novel-endophyte tall fescue pastures in 2021 (**Figure 2**). The steers were randomly allocated to the two forage types and rotated on a weekly basis through four paddocks. Steers were weighed every four weeks.

Figure 2: Steers grazing a mixture of big bluestem, indiangrass, and little bluestem at the Southern Piedmont Agricultural Research and Extension Center on June 11, 2021.

The trial commenced on June 11. The NWSG paddocks had about 3 tons of dry matter available per acre to the steers, which resulted in significant trampling (Figure 3). Regrowth was reduced due to this trampling throughout the rest of the summer on the NWSG paddocks.

Figure 3: Trampled forage left after steers finished grazing in a native grass paddock on July 6, 2021

Steer weight gains were similar for the steers on the NWSG pastures (1.2 lb/day) and novel-endophyte tall fescue pastures (1.3 lb/day) from the beginning of the test through the first week of September, 2021.

We are repeating the demonstration this year, and we were able to initiate grazing at an earlier date (May 11) while the NWSGs were in the vegetative stage to minimize forage trampling and improve animal performance. In the first two months of grazing, the steers on the NWSG pastures have gained 1.8 lb/day while the steers on the novel-endophyte tall fescue pastures gained 1.4 lb/day. (Note: this is a non-replicated demonstration trial.)

Acknowledgements

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BIODIVERSE FORAGE MIXTURES FOR BEES AND BEEF CATTLE

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Introduction

Native warm-season grasses (NWSG) can be used to supplement tall fescue during the summer in Virginia. Including wildflowers in NWSG plantings might help pollinators such as bees, which are declining globally. However, establishing and maintaining complex pastures can be challenging. We started three small plot experiments and one grazing experiment in 2021 at SVAREC to examine the aspects of establishment and maintenance of biodiverse stands. These ongoing experiments hope to maintain the forage supply provided by NWSGs, improve cattle weight gain relative to tall fescue, and increase floral resources for bees relative to current pasturelands.

Small Plot Experiments

Three small plot experiments were deployed in June 2021 to evaluate aspects of establishing native warm-season grasses (NWSG) and wildflowers (WF) for multifunctional forage mixtures. Previous research found that mixing NWSGs and WF seed together may result in overdominance by wildflowers. To explore other planting configurations, Experiment 1 involved planting NWSGs and wildflowers in different spatial arrangements (e.g., side by side vs mixed together) and at different times (e.g., summer vs fall planting of NWSG and WF components into a stand). Experiment 2 involved planting different ratios of NWSG and WF seed and then spraying glyphosate in late fall. Anecdotal evidence suggests that a late fall glyphosate application might balance the NWSG-WF composition in mixtures, as well as control cool-season weeds in these stands. Experiment 3 sought to overcome the weed competition seen initially in biodiverse stands through the use pollinator-friendly companion crops. These companions were selected for their short lifecycles, floral production, and speedy establishment to help suppress weeds while the desired plants establish. The companion crops were sown at two different seeding rates to optimize the establishment of the biodiverse mixture.

Forage and floral units were assessed in July 2021 (near the end of peak biomass), September 2021, May 2022, and June 2022 (peak biomass). Botanical composition was assessed on the forage samples using the modified Daubenmire method for % cover, as well as whole plot visual scans to observe rare species.

Stand counts were taken at the quadrat level in May 2022. These counts were compared among treatments and to two success criteria seen in the academic literature. The success criteria used were a 11 plants per m^2 threshold that came from prairie restoration and NWSG forage planting guidelines and a 20 plants per m^2 threshold that came from another prairie restoration benchmark for NWSG-wildflower plantings.

Results

Forage mass

- So far, no significant differences were seen among the different establishment strategies
- Weed competition was intense in the establishment year, even under drought conditions

Stand counts

- Stands were generally found to meet available targets for successful NWSG/WF establishment

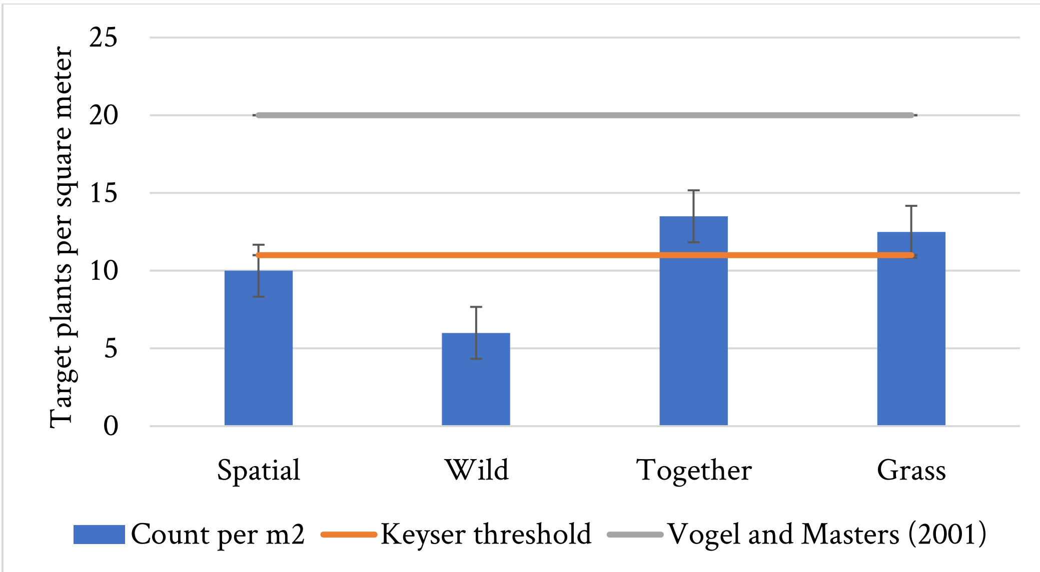

Figure 1. Experiment 1 stand counts by treatment compared to two literature targets. Spatial: NWSG and WF sown in separate strips in June 2021; Wild: WF sown in June 2021, NWSG sown into stand in November 2021; Together: NWSG and WF sown together in June 2021; Grass: NWSG sown in June 2021, WF sown into stand in November 2021.

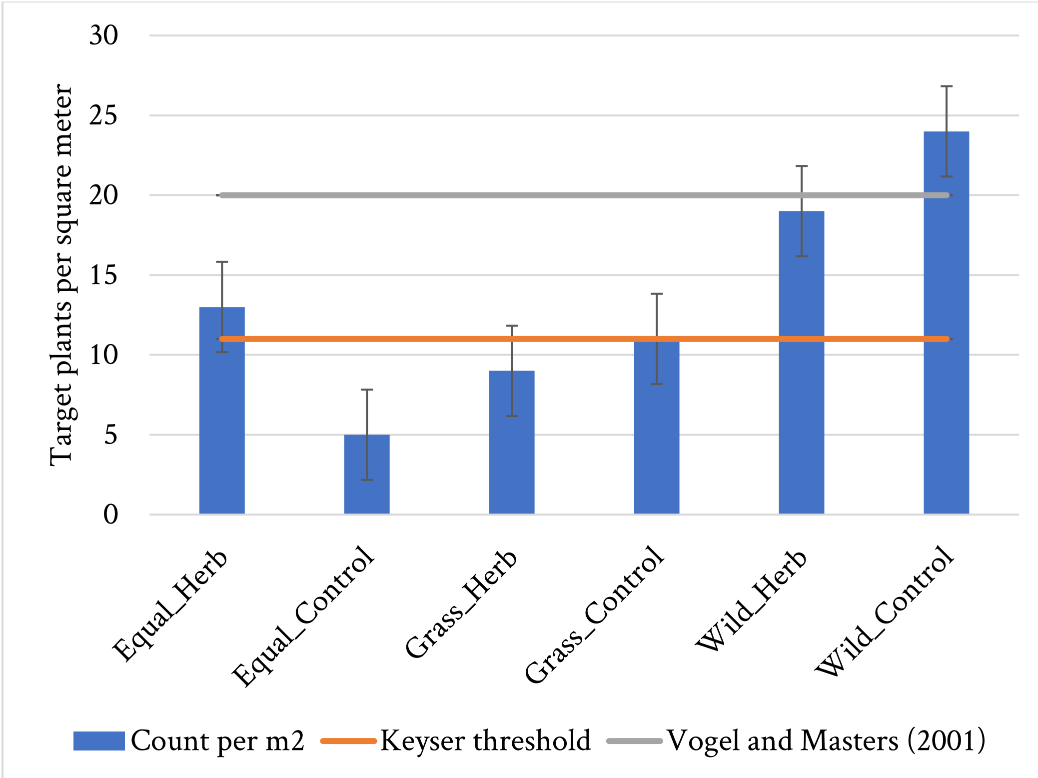

Figure 2. Experiment 2 stand counts by treatment compared to two literature targets. Equal: NWSG and WF sown on 1:1 pure live seed (PLS) basis; Grass: NWSG and WF sown on 4:1 PLS basis; Wild: NWSG and WF sown on 1:4 PLS basis; _Herb: area treated with glyphosate in November 2021; _Control: area left untreated

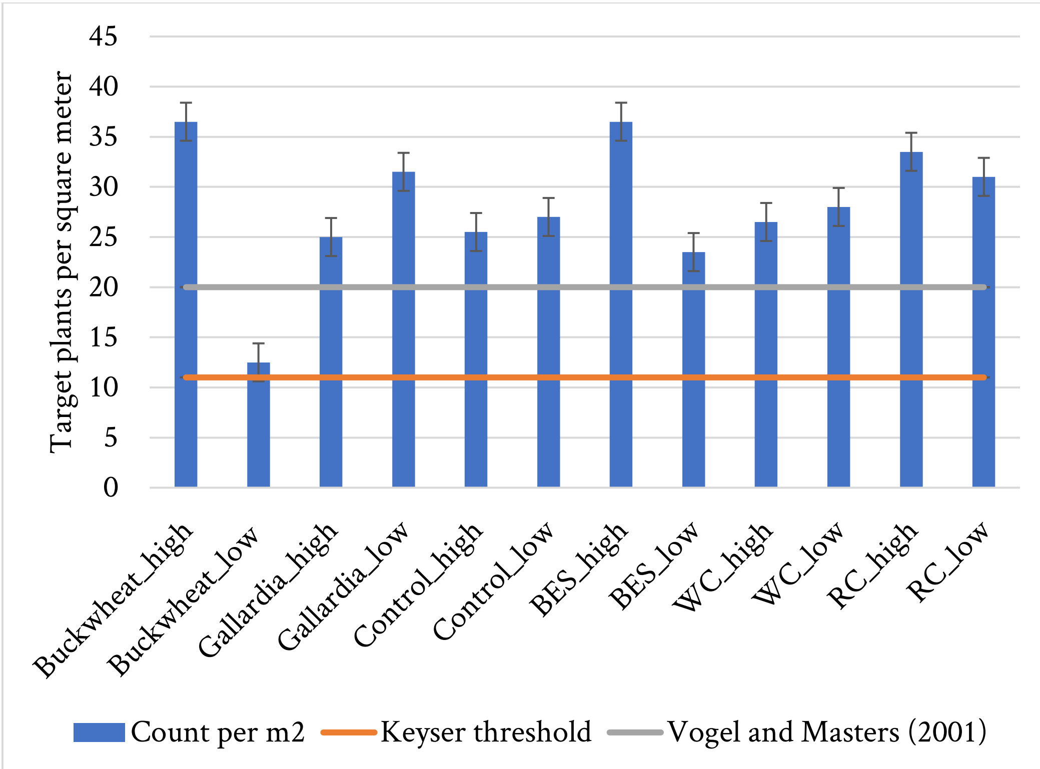

Figure 3. Experiment 3 stand counts by treatment compared to two literature targets. Buckwheat; BES: Black eyed Susan; Gallardia: Annual gallardia; Control: biodiverse mixture sown without a companion crop; WC: White clover; RC: Red clover; _High: Companion sown at a high seeding rate (3/4 of standard rate); _Low: Companion sown at a low seeding rate (1/4 of standard rate)

Botanical composition

- Wildflower stands were weedier than TF and NWSG stands
- Differences among establishment treatments might suggest optimal strategies to get native grass-wildflower mixtures to outcompete the weeds
- Main weeds were foxtail, crabgrass, and thistles

Floral units

- Lanceleaf corepsis, annual gallardia, black-eyed Susan, as well as maximilian sunflower were flowering in the fall of the establishment year
- More species were flowering by the second year (pale coneflower, purple coneflower, and Ohio spiderwort)

Small plot experiment conclusions

- Establishment might be a multiyear process rather than a single year
- Success criteria for biodiverse plantings might not match producer wisdom/NRCS eyeballing
- Treatments differences are not readily apparent in the first year of establishment

Grazing Experiment

Twelve, 2.5 acre (1 ha) plots were created from existing pastureland at SVAREC for the grazing experiment. The study site was sprayed in fall 2018 and again in spring 2019 with Roundup herbicide (2 qt/acre rate) to kill existing vegetation, which consisted of mostly tall fescue and sericea lespedeza. Three pasture treatments, replicated 4x, then were randomly assigned to the 12 plots. Treatments were: 1) pastures diversified with NWSG+WF, 2) pastures supplemented artificial shade, and 3) a control. For the diversified treatment plots, we designated a subplot representing 30% of the main plot area (0.75 ac./1.9 ha) that would be planted with NWSGs+WFs (Table 1). Diversified plots were planted with NWSG and WF mixtures in spring 2019. In fall 2019, endophyte-infected tall fescue was no-till seeded into the remaining area of the diversified plots and across all other treatment plots at a rate of 20 lb/ac using a Great Plains no-till seed drill. The artificial shade treatment was initiated in 2021 when cattle were first introduced to the experiment. The shade structures (10ft x 20ft x 10ft) were constructed of stabilized polyethylene knitted black shade cloth designed to block 80% UV radiation. Shade structures were placed near the center of each treatment plot and remained there until the end of the grazing season. Control treatments consisted of a monoculture of endophyte-infected tall fescue. Based on soil test, fertility levels and soil pH were considered adequate and not adjusted.

Tall fescue and the NWSG mix established well in 2020 but the WF mixture seeding was deemed a failure. The same WF mixture was replanted using a Great Plains no-till seed drill into the designated plot areas in November 2020. The second WF planting also was unsuccessful (no floral units were detected in 2021) necessitating a switch to a different WF pollinator mix which included red, white, crimson, and sweet clovers, as well as several wildflowers in the original mix.

Table 1. Original seed mixtures sown into the SVAREC grazing experiment in 2019.

Scientific name	Common name	Seeds sown/ft^2	Seeds/lb.	lb. sown/acre
		Native Warm-Season Grass Mix		
Andropogon gerardii	Big bluestem	15	165,000	4
Schizachyrium scoparium	Little bluestem	15	175,000	4
Sorghastrum nutans	Indiangrass	15	260,000	2
		Wildflower Mix		
Coreopsis lanceolata	Lanceleaf coreopsis	1	221,000	0.2
Linum perenne	Perennial blueflax	1	328,000	0.2
Tradescantia ohiensis	Ohio spiderwort	1	1,750,000	0.03
Rudbeckia hirta	Black-eyed susan	1	1,575,760	0.03
Echinacea purpurea	Purple coneflower	1	115,664	0.40
Agastache foeniculum	Anise hyssop	1	1,440,000	0.03
Ratibida pinnata	Grey-headed coneflower	1	427,500	0.10
Helianthus maximiliani	Maximilian sunflower	1	196,360	0.20
Solidago speciosa	Showy goldenrod	1	1,000,000	0.04

Angus-based commercial crossbred heifers were assigned to treatments in groups of four. These heifers were stocked to paddocks from May-late August 2021 when the forage became limiting. Another set of heifers were sent to the paddocks for set stocking in May 2022.

Heifers, as well as forage and floral units, were measured every 4-wk from the start of the experiment. Heifer weights were recorded, and average daily gain (ADG) was derived from these weights.

Results

Animal performance

- Average daily gain (ADG) was significantly improved when heifers had access to the NWSG portions of the wildflower-enhanced paddocks in July 2021.
- Season-long ADG was not significantly different, likely because the heifers were not able to use the NWSG area in late July and all treatments ran out of forage due to a summer drought in 2021.

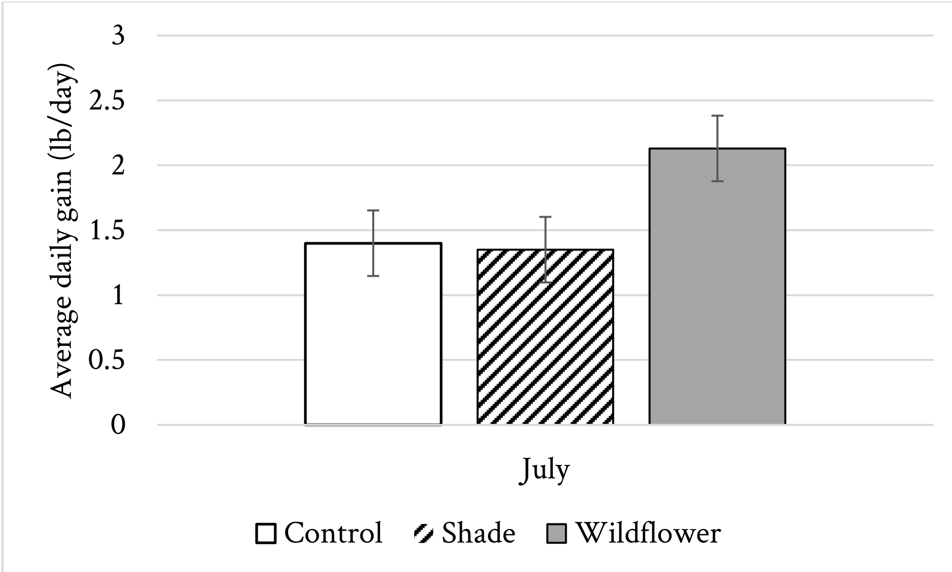

Figure 4. Average daily gain (lb/day) of heifers in July 2021.

Plant production

- NWSG provided additional summer herbage mass that benefitted animal performance in the paddocks diversified with NWSGs.
- Wildflowers struggled to establish and required additional replanting in April 2022 to include clovers.

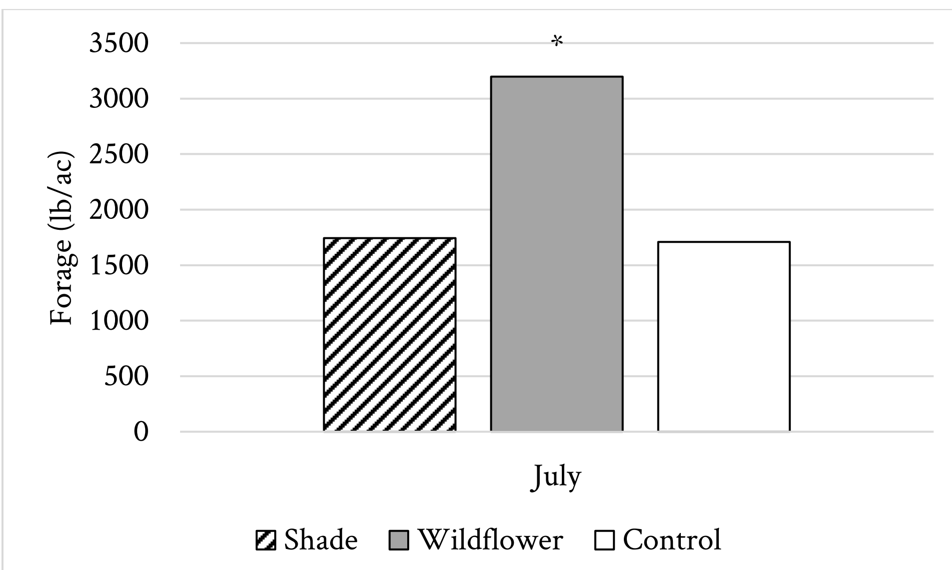

Figure 5. Forage mass (lb/ac) of paddocks on grazing experiment.). * denotes the significant difference of the wildflower-enhanced treatment from the shade and control treatments.

Grazing experiment conclusions

- Heifer development might be improved using biodiverse paddocks. Balancing forage supply and animal demand can be challenging.
- NWSGs can improve animal performance and allow some paddock area to be set aside for pollinator strips.

Future Work

- Small plots
    - Productivity and weed competition in years following establishment
    - Other weed control measures (such as pre-emergent herbicides)
    - Including other wildflower species in mixtures
- Grazing experiment
    - Intravaginal temperature measurements and analysis
    - Camera behavioral measurements and analysis
    - Shade efficacy measurement and analysis

FEMELSCHLAG & IMPROVING HARDWOOD REGENERATION

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Background

Virginia has a lot of wood standing around and most of it is in one of the many hardwood forest types. Sixty-two percent of the commonwealth's land base is forest (~16 million acres) and nearly eighty percent of this is hardwood forests. Depending on who is doing the lumping and splitting, we have at least four unique hardwood forest types with the largest by far being oak-hickory (*Quercus*-*Carya*). This, coupled with the fact that well over half of Virginia's forestland is owned by private woodland owners and farmers, suggests that what happens in privately-owned hardwood forests is important.

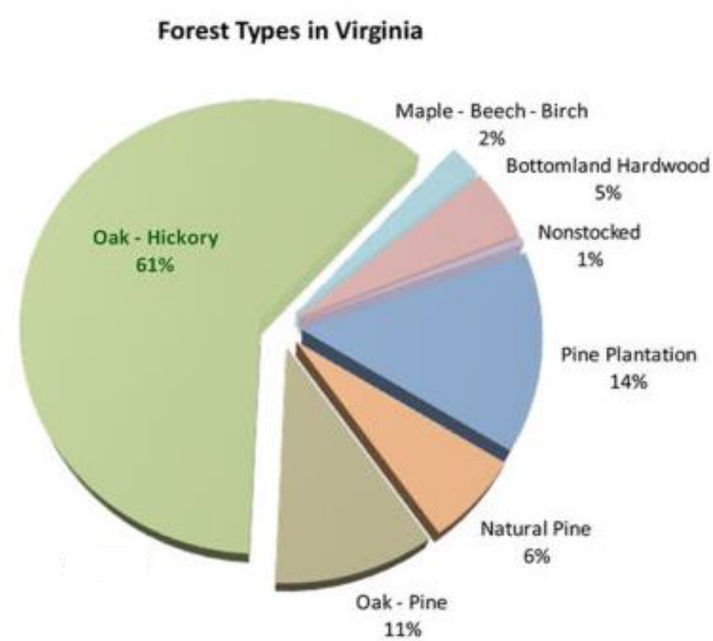

Figure 1: Major Virginia Forest Types
Source: USDA-FIA/VDOF

This resource and those who own it are intrinsically, economically and environmentally important. The intrinsic value of forestland is difficult to quantify. Various attempts have been made, however, and published dollar figures consistently dwarf the more easily measured economic importance. Forestry provides more than 107,000 jobs and contributes $21 billion annually to Virginia's economy and $9.3 billion in value added. Environmentally, the value of Virginia's forestland is also hard to measure considering the water filtration services provided, wildlife habitat and much more. The case is, therefore, easily made: Forests are valuable.

The notion that forests can take care of themselves is increasingly hard to support. Invasive species (plants, insects and diseases), overabundance of deer, lack of fire and other factors make a complex natural system even more complicated. These factors often require deliberate and informed management to mitigate their negative effects.

The "Oak Factor"

The mighty oak is somewhat of a "poster child" for the hardwood forest challenges. White oak (*Q. alba*), in particular, has captured the mind and heart of many as a key species for wildlife (sweeter acorns than oak in the red group), its necessity in the making of bourbon (and other wood-barrel-cured beverages) and its longevity. It's these attributes and the foundational ecological status of this species that makes the relative shortage of oak seedlings and saplings in many forests concerning. Where will our future oak trees come from?

At present, white oak is in 4^{th} place for volume of standing wood in Virginia and 8^{th} for number of trees. That means most of our white oak trees are large and old, and there are few "young-uns" (regeneration) coming in to replace them as they are harvested or die.

Oaks, of all the hardwood species, are usually the most challenging to regenerate. Oaks have several requirements for and several hindrances to successful regeneration. Acorns don't wait around on the forest floor for years for the right conditions to start growing like some other species seeds do. Either they grow, are eaten, or rot. If the light level, soil contact, and moisture aren't right, then they won't grow. If they start growing, deer like to eat their buds and twigs in the winter. It's not uncommon to find seedlings that are only a foot tall, but 5-6 years old due to repeated deer browsing. If there is too much light or the site is high quality and moist, then oak seedlings will be outcompeted by faster growing competitors like tulip-poplar (*Liriodendron tulipifera*) and red maple (*Acer rubrum*). Fire helped with this competition in the past through regular, low-intensity burns set by Native Americans, summer lightning storms, and early European settlers. More frequent canopy openings helped too by giving just the right amount of light for oaks, but not enough for the faster growing competitors. These were carried out by subsistence farmers for firewood, cooking, and construction. This list, though long, is still just a partial list of factors that favored oaks, and we can't repeat them. The result was the right levels and competition for successful oak regeneration. Perhaps we can do something else to get the same effect.

Femelschlag, a "new" Silvicultural Tool

Fortunately, we have the profession of forestry within which is a discipline called silviculture. Silviculture, literally "forest growing", is basically the deployment of art and science to regenerate a desirable stand of trees. Silviculture can look like anything from the harvesting of single trees to a clear-cut to controlling invasive plants in the understory (Figure 2). It's forward looking. What will the next stand be and what can we do now to better ensure a future stand that will be of value? Do we need to get more light on the ground for certain species? Is a thinning of the understory, over-story or some of both the best way to adjust light levels? What species and spacing should be left behind to better ensure establishment of desirable regeneration?

These are the kinds of questions foresters consider when deciding what silvicultural tool(s) to apply to a given stand. (A "stand" is a sufficiently uniform section of woods to be managed as a unit.) If the site is decent quality and tulip poplar is in and around the stand, a clear-cut may be the perfect tool to regenerate more tulip-poplar. Pretty easy.

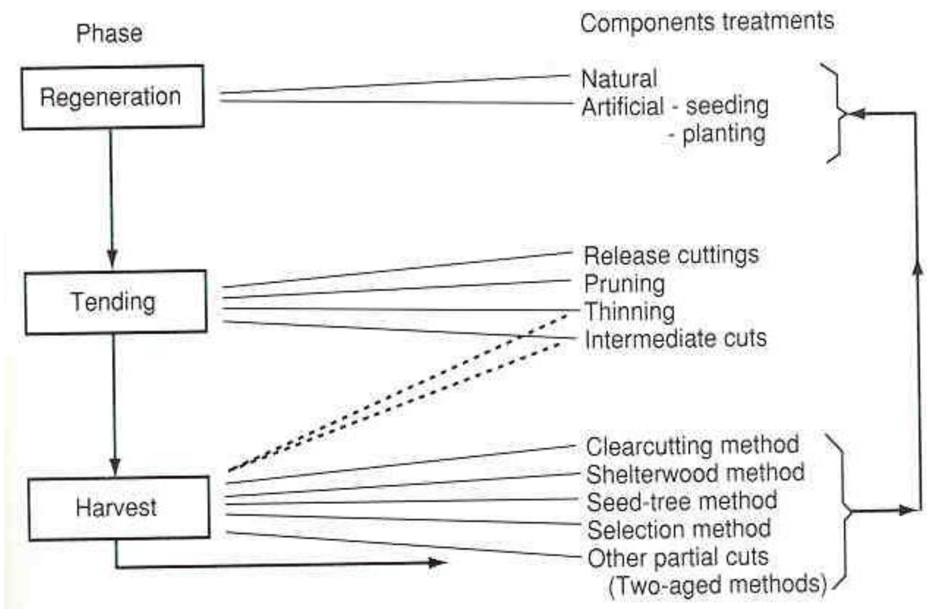

Figure 2: Three Phases of a Silvicultural System
Source: Nyland, 1996

Oak is not so easy. It can't compete against other species when full sun or full shade is in play. Most oaks are "semi-tolerant" of shade (meaning they will tolerate some shade) and if it's "just right" they will have a competitive edge. Furthermore, seed production is cyclical with most oak species having heavy/good acorn yields 1 out of every 4-10 years. Most of the time, we hope for the best and use silvicultural tools that give a window of time of 2-3 years where conditions for acorn germination and establishment will be optimal.

Expanding gap silviculture (or femelschlag) is a "new" tool to us foresters on this side of the pond. Germany is really where the forestry discipline was born and for some reason, not all silvicultural tools made their way to us when forestry was birthed in the U.S. in the late 1800s. In Germany, they call this expanding gap silvicultural tool "femelschlag".

In this system, a permanent road network is installed to conduct and connect a series of small group harvests made across the stand. A light "thinning from below" (removal of trees not tall enough to be part of the main forest canopy) may be conducted between these harvested gaps. This system creates a gradient of sunlight from full sun in the gaps to mostly shade between the gaps. The gap edges of partial sunlight may favor oak if other factors, such as an oak overstory and a moderate site quality are present. As sufficient oak regeneration grows around the edge of the gap, the initial openings are then "expanded" in subsequent entries (about every 5-10 years) to give the newly established oak saplings light to develop and thrive.

Virginia's First Femelschlag at McCormick Farm

Since the mid-1990s, expanding-gap silviculture has been applied and researched most intensively in the United States at the University of Maine. It has been slowly catching on elsewhere and in 2020 plans began to implement Virginia's first demonstration and research femelschalg at the Shenandoah Valley Ag Research and Extension Center. "Stand E" is the designation for management purposes as noted in Figure 3.

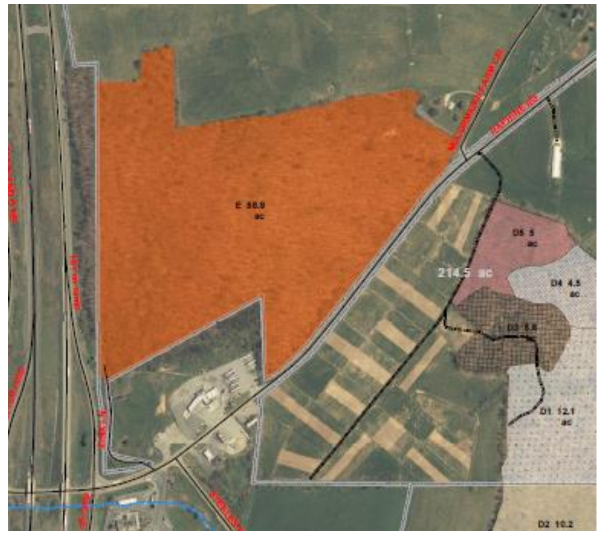

Figure 3: SVAREC Forest Stand E
Source: Bill Braford

Femelschlag project timeline, Stand E

- 2020: Forest inventory, gap layout, timber marked and invasive plant management
- 2021, Spring: Timber sold (competitive bid) with VDOF assistance
- 2021, Summer: Timber harvesting began
- 2021, December: Harvest and permanent road network completed
- 2022 (planned): Inventory regeneration, install demo deer exclosure
- 2024 or 2025 (planned): prescribed burn of half the stand

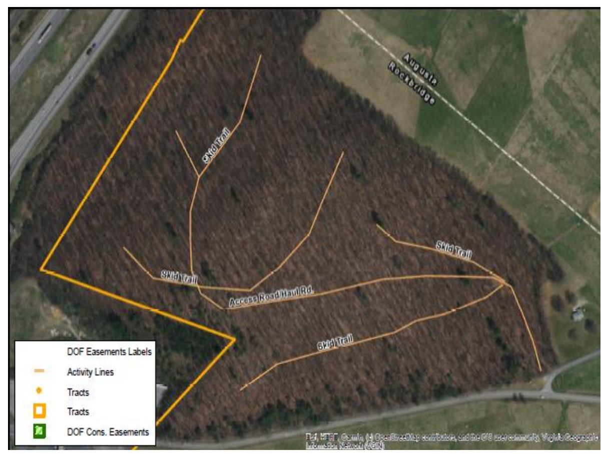

Figure 4: Road network (permanent & temporary)
Source: VDOF

Harvest results, Stand E

- ~50 acres
- Eight, 1-acre gaps with "inter-gap" thinning and permanent road
- Pulpwood: Approximately 430 tons
- Sawtimber: Approximately 99 MBF
- Together with ~19 acre thinned & ~18 acres clear-cut elsewhere on the farm (~85 acres total), timber sold for $57,678.00 or an average of ~$680/acre. Cost of sale = $13,676 (gravel, flagging, tree paint and VDOF administration)

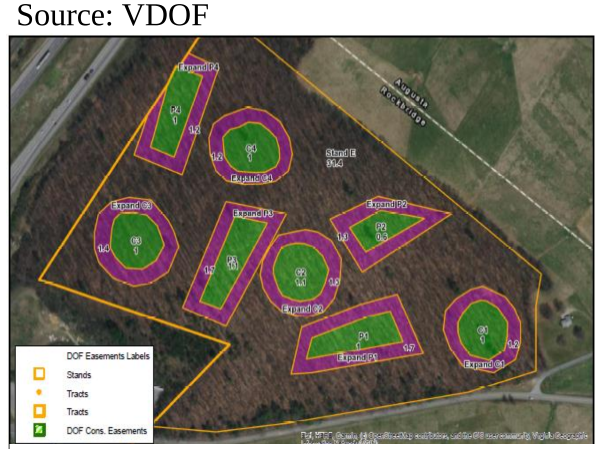

Figure 5: Initial harvest gaps and conceptual expansion zones
Source: VDOF

Figure 6: A video of the project to include harvesting action and more can be viewed at https://youtu.be/jSmi0S8oISo

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- Bill Braford: GIS & Mapping
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- Department of Forestry: Timber sale and harvest monitoring & mapping

UTILIZATION OF AN AUTOMATIC SCALE SYSTEM EQUIPPED WITH SOLAR PANELS TO DETERMINE BEEF CATTLE BODY WEIGHT

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Introduction

With the global population expected to reach 9.7 billion by 2050, our food production systems will need to exhibit remarkable improvements in productivity and resiliency to feed the human population. Feeding this growing population in a sustainable manner will require advances in productivity and efficiency of all agricultural systems. “Smart” agriculture is one promising technology that leverages advances in engineering, computer science, analytics, and life sciences to address productivity and efficiency challenges incurred in the agriculture sector.

Body weight is an essential measure in beef cattle production systems and it is used for diverse decision-making processes. Evolution of body weight is used to detect health and nutritional disorders associated with feed intake or feed quality, as well as a measure of growth rates and profitability of production systems. Accordingly, it is essential to measure body weight regularly and accurately. A precision livestock production system requires a routinely monitored body weight. However, the main problem of measuring body weight more frequently in grazing systems is the need to move the animals from pasture to the weighing facilities and back, which can be labor intense, and it also interferes with the animal environment and could cause heavy breathing, loss of grazing time, reduction in appetite and feed intake, which can negatively impact animal performance[1].

The possibility of having an automatic scale located in the pasture will allow for a reduction in labor intensity and the ability to measure and monitor body weight every day without the need of moving the animals. In addition, an automated system will ensure a more accurate body weight and growth rate estimation when compared to values obtained with a body weight measured between long time intervals.

Measuring body weight automatically and remotely in the pasture is feasible, reduces labor and animal space invasion and has great potential as a new tool to estimate water consumption, and changes of body weight in real time[2,3]. Virginia Tech is well-positioned to advance the field of “smart” agriculture because of the internal strengths in engineering, computer science, and agriculture and life sciences; the technology and agricultural industry presence in the state; and the access to agricultural research and extension centers that can serve as testbed research and demonstration areas. To capitalize on this opportunity, the Virginia Tech College of Agriculture and Life Sciences has launched a SmartFarm Innovation Network and the

Center for Advanced Innovation in Agriculture. Through these efforts, our research team was able to secure funding to purchase and test a system of automatic scales and performed a short-term study to evaluate and validate this system for grazing beef cattle.

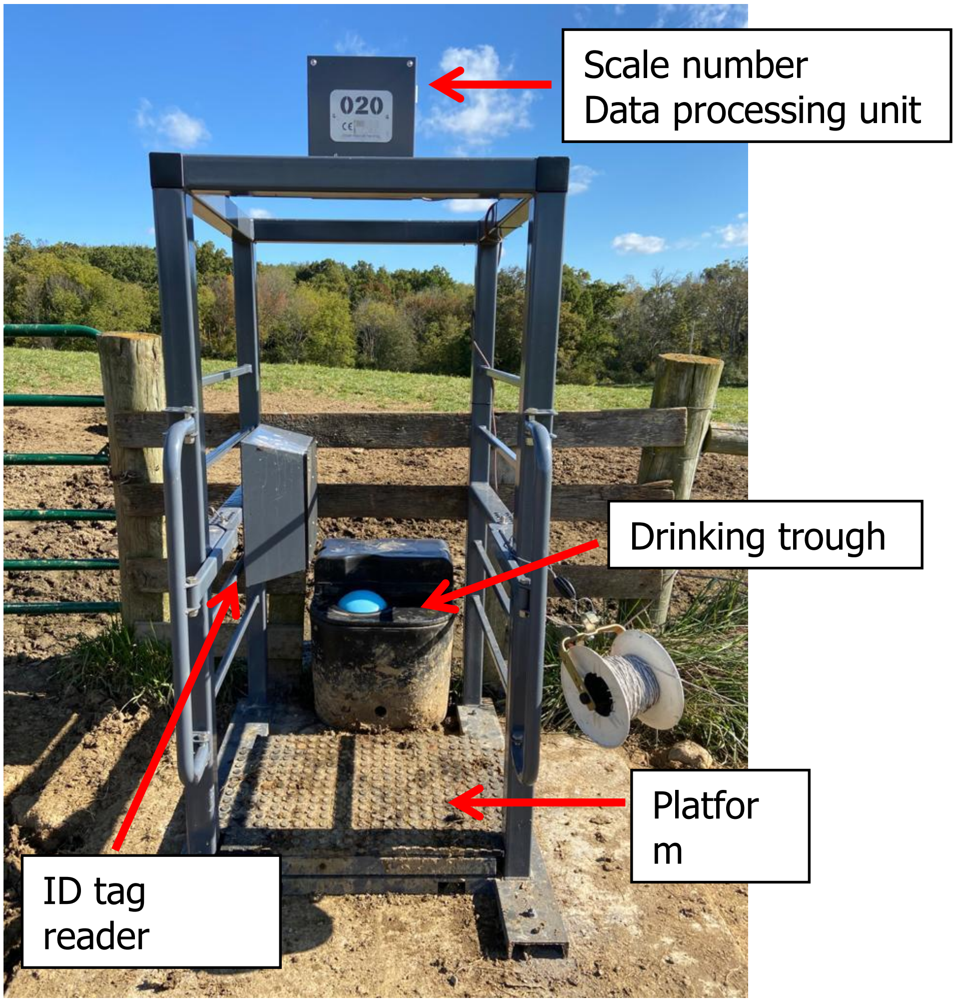

Figure 1: SmartScale installed on a concrete pad in front of the pre-existing water trough.

Objectives

Evaluate the functionality and accuracy of the body weight measured with the automatic scale located in the pasture in comparison with a conventional scale located at the cattle working facility.

Specific objectives:

1. Validation of the scale measurements of body weight registered daily with the automatic scale equipped with solar panels and located in the pasture with body weight measured in a 14-day interval with the conventional scale located at the cattle working facilities. Estimation of average daily gain, daily variation of body weight, evolution of body

weight and growth rate (as body weight regression over time) in the conventional and in the automatic weighing system will be performed.

2. Evaluate the automatic scale system performance, including technical issues, ability to remain powered, data transmission, and cyber security. Because the automatic scale will be working with solar panel and transmitting the measurements directly to a server via cellular network, it is essential to understand possible limitations or problems with the technology used.

Figure 2: Beef cow being weighed in the SmartScale while drinking water. Notice that only the front legs are on top of the load cells.

Methods

This experiment was conducted at the Shenandoah Valley Agricultural Research and Extension Center (SVAREC). Eight multiparous beef cows were weighed in a 14-day interval for a period of 57 days with a conventional scale attached to a restraining chute located in a cattle working facility. While the same beef cows had their body weight (BW) was measured daily with an automated scale (SmartScale; C-LOCK^{TM}) located in the pasture in front of the water trough. This wireless system registers BW every time the animal approaches the water trough and automatically transmit it to a server via cellular network. A correlation between weighing systems was evaluated through a linear regression (R Core Team, 2019).

Results

The SmartScale is represented in Figures 1 and 2 with details. Installation process was performed by the SVAREC farm crew without any issues and required the addition of concrete pads to provide a leveled and stable surface for installation.

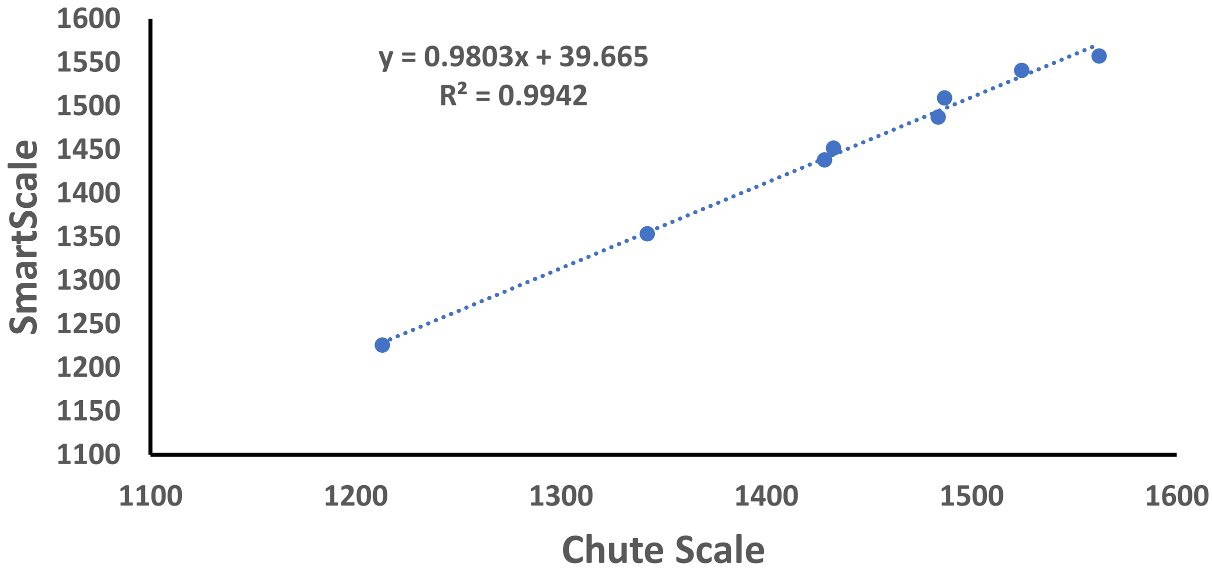

Figure 3: Correlation between body weight of beef cows measured using a conventional scale attached to a restraining chute and an automated scale system located in the pasture.

The adjusted R^2 value for the correlation was 0.99, determining an excellent linear relationship between BW values obtained by the conventional scale and BW values obtained by the automated scale (Figure 3). In addition, the automated scale registered the time of day, time spent in the scale, and number of daily visits. The probability to find an animal at the scale varies between 15% to 20% during daylight, decreasing under 9% during the night, with 2.5 ± 1.5 average number of visits per day, where animals spend in average 2.9 ± 1.8 minutes.

Summary

Advancements in technology will be essential for the agriculture sector to increase production and meet population needs while remaining sustainable. "Smart" technologies will play an important role on this process, but are dependent on multidisciplinary collaborations and extensive on-farm validation to ensure precision and functionality. The automated scale (SmartScale) system tested herein has the ability to measure beef cattle BW with great precision and has potential to be used as a complementary instrument to evaluate animal behavior in grazing systems.

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IMPACT OF IMPLANTING NURSING CALVES ON COW AND CALF PERFORMANCE

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Introduction

Implanting beef cattle is a prudent practice that can improve calf growth and performance as well as producer return on investment. Growth promoting implants are approved for all phases of beef cattle production (cow-calf, stocker, feedlot). Reviews of published literature find that the impact of implanting nursing calves improves calf average daily gain by +0.10 to +0.12 lbs a day over control calves with commercially available implants (Selk, G., 1997). However, surveys of cow-calf producers indicate only 37% of farms with 100+ cows implant their steer calves, while only 9% of producers with less than 100 cows implant their steer calves, (Vestal, et al., 2007). Another study found only 33% of cow-calf producers use growth promoting implants nationwide (Stewart, 2013). Though an expansive library of literature documents the benefit of implanting nursing calves on the average daily gain of the calf, there is limited data on the potential impacts on the dam of the implanted calf. The purpose of this study is to demonstrate the benefit of implanting nursing calves on average daily gain and weaning weight; and explore any impacts of implanting the calf on the calf's dam including body condition score, body weight and pregnancy status.

Methods

There are several brands of FDA approved implants for nursing calves. For this study, Synovex C® (100 mg progesterone/10 mg estradiol benzoate) was used (Zoetis, Kalamazoo, MI). Cattle used for the study included the 1st calf heifer and spare cow herd and their calves at Virginia Tech's Shenandoah Valley Agricultural Research and Extension Center (SVAREC). All implanting procedures were approved by the Virginia Tech Institutional Animal Care and Use Committee. All calves in the project were born between September 2 and November 29, 2021.

A total of 32 cow-calf pairs were included in the study, which was approximately half of the 1st calf heifer and spare cow herd (59). Initially, only steer calves and their dams were planned to be included. However, at the conclusion of the calving season, it was determined that later born heifers should be included in the study due to the greater number of heifers born in the calving season. Mature cows and 1st calf heifers were stratified by age and assigned randomly with their calves to either the control (n=17) or implant treatment (n=15). Calves were implanted at pre-breeding CIDR insert for the cow herd (12/7/21, day 0). Calf weights were recorded at implantation (day 0), pregnancy check (day 106), and weaning (day 133). Average calf age at implantation was 45 days and average age at weaning was 178 days. Cow body weight and body condition score was recorded at CIDR insert (day 0), and at pregnancy check (day 106). Calf ears were palpated at pregnancy check to insure proper implant placement.

Table 1 – Average cow weight (WT) and body condition score (BCS) and calf weight on Day 0 (12/7/2021).

Cow	Control	Synovex C	p Value
Avg Cow WT, lb	1242	1246	0.95
BCS	5.82	6.13	0.46
Calf	Control	Synovex C	p Value
Avg Calf WT lb	154	165	0.52

First calf heifers and the mature spare cow herd were managed on different pasture allotments from 12/7 (day 0) to 3/22/22 (day 105), when they were combined until weaning (day 178, 4/19/2022). Forage samples of stockpiled grass and hay were collected from 12/17 to 4/18 at regular two-week intervals (Table 2). Yields of stockpiled grass were also measured to estimate forage availability. Forage samples were sent to Cumberland Valley Analytical Services for nutrient analysis and averaged to estimate diet composition. Average forage availability was greater for first calf heifers (2381 lb/acre) than the spare herd (1956 lb/acre). Both herds were on hay for most of the period 1/17/2022 to 2/3/2022 during an extended period when frozen snow covered the ground. The spare herd was fed baleage beginning March 4. Both groups were fed baleage in addition to any remaining stockpile from 3/22 to 4/19.

Table 2. Nutrient density for forages collected (12/17/21-3/22/22).

1st Calf Heifers	**TDN%**	**CP%**
8 sample average (includes both stockpile and hay)	59.21	11.17
Spares	**TDN%**	**CP%**
8 Sample average (includes both stockpile and hay)	54.39	9.98

Results and Discussion

Cow body weight, BCS at preg check, and ADG (loss) from implant (day 0) to preg check (day 133) for cows is also included in Table 3. Weaning weights of calves and the average daily gain of calves is shown in Table 4. Data was analyzed using Microsoft Excel single factor Analysis of Variance (ANOVA).

Table 3. Cow body weight, body condition score, days pregnant at pregnancy check (3/23/2022).

	Control	Synovex C	p Value
Cow WT, lb	1137	1157	0.73
BCS	4.29	4.13	0.68
ADG, lb	-1.00	-0.79	0.43
Days Preg	73.53	77.67	0.73

Table 4. Average calf weaning weight, weight per day of age (WDA), and average daily gain (ADG) at weaning (4/19/2022).

	Control	Synovex C	p Value
Calf WT, lb	342	377	0.09
WDA, lb	1.06	1.21	0.07
ADG, lb	1.41	1.59	0.02

Implanted calf weaning weights averaged 35 lb greater than non-implanted control calves (P=0.09). Additionally, implanted calf WDA tended to be significantly greater (P=0.07) than control calves, while average daily gain for implanted calves exceeded the average daily gains of control calves (P=0.02). Calf weight by sex is shown in Figure 1. The end result for both steers and heifers was a 0.18 lb/day improvement in ADG. No significant differences were seen thus far in cow weights, body condition score, or days pregnant at pregnancy check.

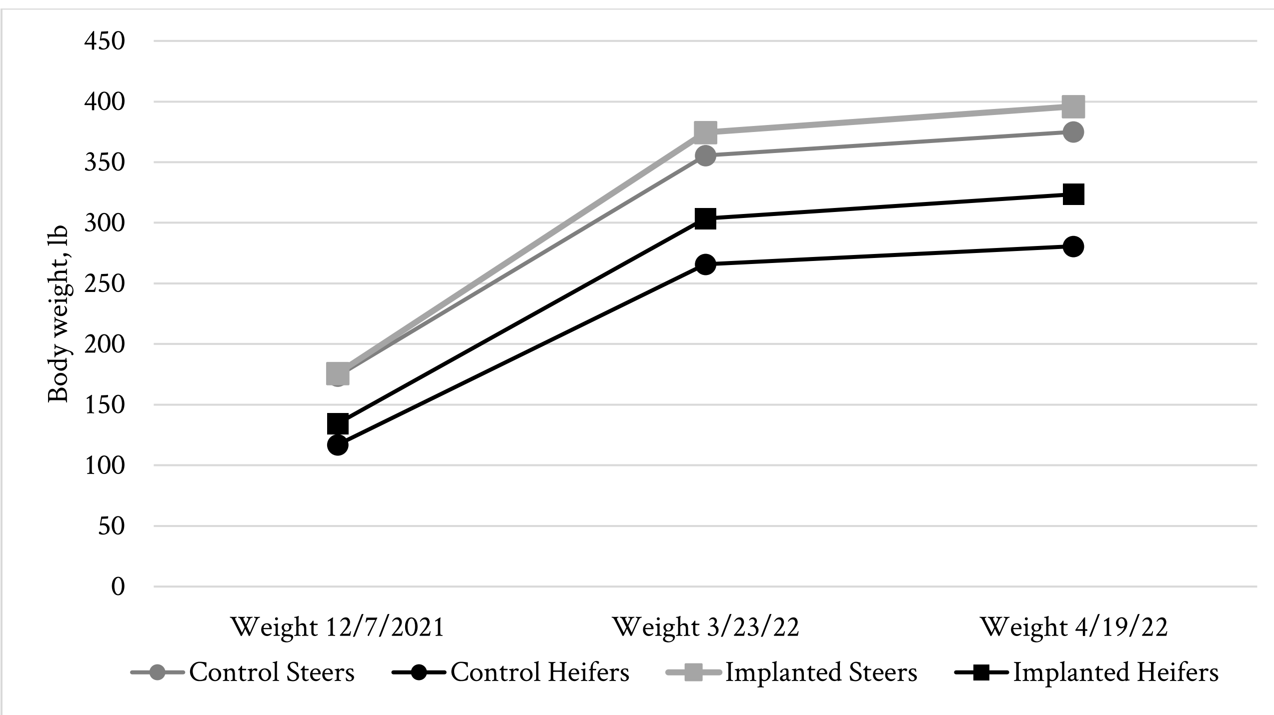

Figure 1. Calf weight by gender and implant status

Economics

Assuming implant costs at $1.35/head, labor at $0.80/head to implant plus $0.10/head for disinfectant and supplies, the total implant cost was calculated to be $2.25/head. Average prices for the weight range (377) and (342) for steers (377 lb = $1.71/lb; 342 lb = $1.83/lb) and heifers (377 lb = $1.48/lb; 342 lb = $1.44/lb) were pulled from the Virginia Weekly Cattle Auction Summary for the week of 4/17/2022-4/23/2022 (USDA-AMS/VDACS Market News Service). Using these assumptions, a return on investment was estimated for both steers and heifers using the following calculations.

Table 5. Predicted economic return for implanting calves prior to weaning

Weaning WT, lb	Treatment	Sex	Price/lb	Gross Return	Net Return
377	Synovex C	Steer	$1.71	$644.67	$18.81
342	Control	Steer	$1.83	$625.86	
Weaning WT, lb	Treatment	Sex	Price/lb	Gross Return	Net Return
377	Synovex C	Heifer	$1.48	$557.96	$65.48
342	Control	Heifer	$1.44	$492.48	

Naturally, these assumptions change with prices and weights, however, for calves designated to be sold at weaning in a non-natural market, implanting provides producers an increase in net return on investment by $18-65 for steer and heifer calves.

Conclusions and Continuing Work

The benefits of implanting nursing calves to calf productivity have been well established, and our results from a fall-calving herd in Virginia corroborate this body of work. With adequate nutrition supplied by medium-quality stockpiled forage, hay, and baleage, improvement to calf gains when implanted can be realized over non-implanted controls. A production system where cows are gathered for estrus synchronization and AI protocols offers an opportunity to implant calves at an average age of 65-45 days. We plan to repeat this study again this fall to increase cow and calf numbers involved in the study and account for any year over year variability in the results.

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ROTATIONAL BALE GRAZING: AN ALTERNATIVE WINTER HAY-FEEDING SYSTEM FOR BEEF COWS

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Background

Large round hay bales are often delivered to a sacrifice paddock regularly through the winter hay feeding period and placed in a hay ring for the cattle to feed on. These traditional winter hay feeding systems result in substantial daily labor, machinery use, fuel cost, uneven distribution of nutrients, soil compaction, and reduced forage production the subsequent year.

Figure 1: Sacrifice paddock at SVAREC after winter hay feeding

Beef producers in the Northern Great Plains and Canada are utilizing rotational bale grazing as an alternative winter hay feeding system. Rotational bale grazing involves placing round bales directly on the pasture before the winter hay feeding begins and when the weather is dry. The cattle are then provided access to the hay bales at a controlled rate using strip grazing, which involves moving a thin electric wire across the field as a new bale is needed.

This study was conducted to determine if beef producers can adopt rotational bale grazing as an alternative winter hay feeding system in the Southeastern region of the U.S., where increased winter precipitation and milder temperatures are present. Specifically, we evaluated the spatial distribution of nutrients and spring forage regeneration on a rotationally bale grazed system vs a sacrifice paddock system.

Site Preparation and Methods

Before beginning the hay feeding period at the Virginia Tech Shenandoah Valley AREC (SVAREC), we determined how many bales would be needed for 8 cow/calf pairs. With approximately 60 days of bale grazing and access to a new bale every 3 days, 20 bales for feeding each of the 6 groups were required. For the 5-paddock rotational bale grazing system, the 20 bales were preplaced equally across the paddocks before winter hay feeding began. Each paddock was ~2 acres, allowing placement of 4 bales in a 0.5-acre strip in each paddock. The cow/calf pairs in the sacrifice paddock system were brought a new bale every 3 days.

In October of 2021, we completed soil grid sampling on the 3 sacrifice paddocks and the 15, 2-acre tall fescue paddocks. The grids were created with ArcGIS software by dividing each paddock into 4, 0.5-acre strips as they would be for strip grazing. They were then divided in the opposite direction by 3 to create 12 grids per paddock, which can be seen in the example Figure 2 below. The grids were marked in the field using Emlid Reach View GIS Units. In each grid, 10, 0–4-inch soil cores were collected and combined giving us 12 soil samples per paddock.

Mehlich 1 soil nutrients were measured on each soil sample to give baseline nutrient measurements. In each rotational bale grazing paddock, round bales were placed in the middle of the grid with the lowest Mehlich 1 phosphorus in each 0.5-acre strip so that nutrients in manure and waste hay would be deposited where it is needed most.

On February 16th, 2022, 6 groups of 8 cow/calf pairs were allotted to either a sacrifice paddock or a 5-paddock rotational bale grazing system. Each treatment had 3 replications. The hay feeding period concluded on April 15th, 2022.

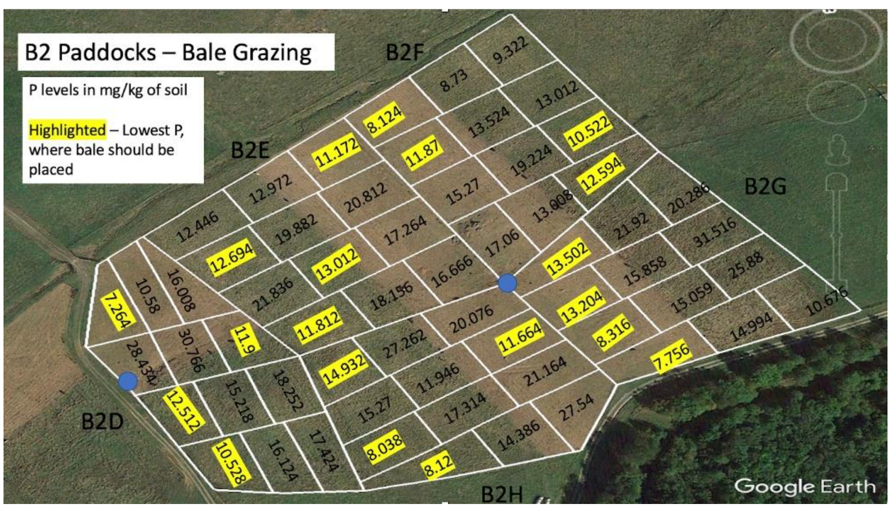

Figure 2: Rotational bale grazing paddocks with baseline Mehlich 1 phosphorous levels in mg/kg of soil, lowest phosphorous highlighted for bale placement

After winter hay feeding concluded, 3 drone flights were completed using an RGB sensor to evaluate forage regeneration. Simultaneously ground sampling was performed to measure forage spring recovery in each system. The first sensor flights took place on April 20th and 21st, 2022. Bale areas were then reseeded with a mixture of novel endophyte tall fescue, red clover, white clover, improved crabgrass, and annual lespedeza. The second sensor flight was completed on May 17th, 2022, and the third on June 6th, 2022. The images were post-processed using Pix4D software and point cloud was used to estimate biomass and generate 3D models of the forage biomass across each flight.

Figure 3: Recovering area where round hay bale was placed in a rotational bale grazing paddock following winter hay feeding

We will report the first year of data collected from this two-year study, focusing on impacts of rotational bale grazing versus using a sacrifice paddock on forage regeneration. In the following years, we will discuss the influence of rotational bale grazing on the spatial distribution of nutrients, forage spring recovery, and runoff using an artificial rainfall simulator. Soil grid sampling will be completed again in the fall of 2022 and also after winter hay feeding has concluded in 2023 to evaluate the influence of winter hay feeding systems on soil fertility and the spatial distribution of nutrients. Forage spring recovery will be evaluated again following rotational bale grazing in the second experimental year.

CLIPPING HEIFER HAIR COATS CAN BRIEFLY REDUCE FESCUE TOXICSOSIS SYMPTOMS

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Introduction

Quality heifer development is an important process at the Shenandoah Valley Agricultural Research and Extension Center (SVAREC). Fall-born replacement heifer candidates are artificially inseminated (AI) in December at 14-15 months of age. Our target for heifer weights is 780-840 pounds at this age for optimal success in breeding. Achieving this goal has been difficult, particularly through the summer, due to heat stress and the toxic endophyte-infected tall fescue forage base. For this project, we hypothesized that by clipping heifer hair coats after weaning, heifers would have improved weight gains and lower core body temperatures.

Materials and Design

Animal Management

Fall-born calves are weaned in late April and early May at the SVAREC through a fence line weaning process for two weeks. The heifers with the highest weaning weights are selected as replacement heifer candidates.

Thirty-six and 28 heifers were selected for this project in year one and two, respectively. Heifer hair coats were scored using the American Angus Association's Hair Shedding Scoring Guide (American Angus Association, N.D.). Scores on a scale of 1 to 5 are assigned to heifers, with a score of 1 indicating complete shedding of hair and a score of 5 indicating that no shedding has occurred. For this project, only heifers with a hair coat score of 4 or 5 were utilized.

The clipped treatment group was shorn using variable-speed shearing clippers with a set of Oster Cryotech blades (78511-126). Hair was sheared from the neck along the ribs to the pins, but not from under the belly or along the legs.

Heifer hair coats were scored again at the end of the study in both years to determine if any of the heifers in the control group had shed out on their own and to determine if any of the heifers from the clipped group had regrown their hair.

Pasture Management

Heifers were grouped in a single herd during the summer grazing season. The heifers spent the majority of the summer months in the Interstate I-81 pasture system (I-81) where they were rotated consecutively through paddocks 1A, 1B, 2A, 2B, 3A, 3B, 4A, and 4B (2.5 acres each) every three days, then through paddocks 5 and 6 (5 acres each) for seven days each before restarting the rotation. The heifers were moved in August to the Benson Farm pasture system (BF) where the project was concluded each year. The pasture rotation schedule at BF was two days in the barn lot paddock (3 acres), five days in paddocks 1 (9 acres) and 2 (8 acres) each, four days in paddock 3 (7 acres), five days in paddock 4 (7 acres), and seven days in paddock 5 (10 acres). A forage grab sample was collected when the heifers were rotated to a new pasture prior to or around entry. One split sample was analyzed with Near Infrared Spectroscopy (NIRS) by Cumberland Valley Analytical Services (Waynesboro, PA) for nutritive value, and another split sample was analyzed for total ergot alkaloids (TEA) through Enzyme Linked Immunoassay (ELISA) by Agrinostics, Ltd. (Watkinsville, GA).

Animal weight gain

All heifers were weighed twice over two days (once per day) at the beginning and end of the trial and once every 28 days throughout the duration of the trial. Heifers were weighed by running them through a chute system equipped with load bars. Double weights from the beginning and end of the study were averaged for a mean start and mean end weight. Average daily gain was calculated by subtracting the previous weight from the current weight and dividing the result by 28 days. Total seasonal average daily gain was calculated by subtracting the start weight from the end weight and dividing by the total number of days of the study each year. In 2020, the project began on June 4 and concluded on September 24. In 2021, the project began on June 22 and concluded on October 13.

Animal body temperatures

A blank controlled internal drug release (CIDR) device (Zoetis, Parsippany, NJ) was hollowed out to fit a cylindrical Star-Oddi DST micro-T temperature logger (Star-Oddi, Iceland). The temperature loggers were setup to log temperatures every ten minutes and were secured in the CIDRs with electrical tape. The CIDR and temperature loggers were inserted with an Eazi-Breed CIDR applicator and cattle lubricant using standard CIDR implant protocols. The CIDRs were inserted into six heifers randomly selected from each treatment group (12 total heifers). In year one, the devices were inserted into the heifers three different times throughout the summer for four days each. These sampling periods included: July 2 – July 6; July 31 – August 4; and August 27 – August 31. The selected data began at 9 am on the day of insertion and ended at 7 am on the day of removal. In year two, the CIDRs were inserted once for a five-day period (July 21- July 26) using the same timing schedule for the start and end times.

Statistics

Heifer average daily gains and vaginal temperatures were compared with a mixed effect analysis of variance test using PROC MIXED in SAS Studio, v. 94 (SAS Inst., Cary, NC). Average daily gains and vaginal temperatures were considered a repeated measures response variable using unstructured matrices for the weight gain analysis and compound symmetry structure for the temperature analysis with individual heifer as the subject. Least Squares Means (LSM) and standard errors (SE) were reported for each treatment by period combination and treatment by hour combination due to treatment by time interaction for the weight and temperature analyses, respectively. Differences were considered significant when $P \leq 0.05$ and as trends when $0.05 < P \leq 0.10$.

Results and Discussion

Animal Management

In the analysis of heifer hair coat scores, most of the heifers that were clipped regrew their hair coats and the control heifers retained their hair coats (Table 1).

Table 1: Counts of heifer at conclusion of the project within a hair coat score (HCS) category by treatment (control and clip) and starting hair coat score (4 and 5).

Year 1	**Control**		**Clip**	
	Start HCS			
End HCS	*4*	*5*	*4*	*5*
1	0	0	0	0
2	0	0	1	0
3	4	0	3	2
4	1	2	2	1
5	1	8	1	6
Year 2	**Control**		**Clip**	
	Start HCS			
End HCS	*4*	*5*	*4*	*5*
1	0	0	0	0
2	0	0	0	0
3	0	0	1	0
4	0	3	0	3
5	3	5	3	5

Heifers that were clipped regrew their coats through the summer. Other studies have indicated similar phenomena when cattle are stocked on toxic endophyte-infected tall fescue. The rough hair coats indicative of tall fescue toxicosis are made up of hair that is both retained from winter hair coats and additional hair that emerges during the summer, sometimes growing to excessive lengths (Aiken et al., 2011). Our study confirmed this pattern of excessive hair growth with similarity in hair coat scores between the two heifer treatments at the conclusion of the study. Despite the removal of hair from the clipped heifers in June, the hair grew back within several months.

Some of the heifers in this study with little hair shedding at the start of the study had shed out slightly by the end of the summer. Another study has reported little to no shedding for steers on toxic endophyte-infected tall fescue (McClanahan et al., 2008). Heifers grazing toxic endophyte-infected tall fescue with minimal hair shedding have lower body condition scores and reduced reproductive performance (Poole et al., 2019).

Pasture Management

Total ergot alkaloid levels in the forage largely exceeded 1000 ppb, except at two points in year one (Table 2). However, even these lower levels exceeded the threshold of total ergot alkaloid levels which are reported to induce symptoms of toxicosis in cattle. This threshold has been reported to be 60 ppb ergovaline, which is the dominant ergot alkaloid (85-97%) present in toxic endophyte-infected tall fescue (Liebe & White, 2018)

Based on forage nutritive value, our expected animal gains should have exceeded 1.5 lb/day (Miller, n.d.). With substantially lower animal weight gains realized than expected based on forage nutritive value (Table 3), it is likely that animal weight gains were suffering as a result of heifer consumption of the ergot alkaloids produced by the endophyte in the tall fescue forage.

Table 2: Forage nutritive value and total ergot alkaloids levels from grab samples by date and paddock (CP: crude protein; NDF: neutral detergent fiber; ADF: acid-detergent fiber; TDN: total digestible nutrients; TEA: total ergot alkaloids)

Date	Paddock	CP	NDF	ADF	TDN	TEA
June 16, 2020	I81 #1	14.6	58.1	35.5	59.8	1216
June 22, 2020	I81 #2	13.2	56.9	35.8	59.0	1333
June 29, 2020	I81 #3	14.2	61.5	36.0	59.7	1216
July 04, 2020	I81 #4	14.2	58.3	34.8	61.0	420
July 09, 2020	I81#5	17.8	55.6	32.2	61.9	585
July 17, 2020	I81 #6	15.2	56.1	35.1	59.9	1293
July 23, 2020	I81 #1	15.5	57.1	34.6	61.7	1583
July 29, 2020	I81 #2	17.0	54.3	31.2	63.1	1189

August 06, 2020	I81 #3	15.2	56.7	32.9	62.7	1007
August 13, 2020	I81 #4	19.2	56.8	32.9	61.7	1293
August 19, 2020	I81 #5	20.6	57.4	32.1	61.9	1182
August 25, 2020	I81 #6	18.9	49.5	27.9	64.9	1624
September 02, 2020	Benson #1	17.2	53.2	31.4	63.4	1695
September 09, 2020	Benson #2	16.1	52.4	30.8	62.7	1895
September 12, 2020	Benson #3	17.4	57.3	32.9	62.7	1637
September 17, 2020	Benson #4	18.8	40.9	35.4	55.0	1007
June 25, 2021	I81 #1A	12.0	61.2	34.5	61.1	1570
June 28, 2021	I81 #1B	10.0	64.1	36.5	60.4	1761
July 02, 2021	I81 #2B	8.9	67.6	39.2	59.0	1608
July 06, 2021	I81 #2A	10.2	64.7	36.9	59.7	1796
July 06, 2021	I81 #3A	10.7	59.6	33.7	61.5	1828
July 14, 2021	I81 #3B	8.8	66.3	38.1	59.1	1749
July 14, 2021	I81 #4A	11.6	64.9	36.6	59.7	1394
July 14, 2021	I81 #4B	10.9	64.8	37.2	59.3	1578
July 19, 2021	I81 #5	14.6	58.9	33.9	61.0	1771
July 28, 2021	I81 #6	10.1	63.3	37.3	59.1	1449
August 11, 2021	I81 #2	11.6	64.2	37.1	59.8	1904
August 11, 2021	I81 #3	13.9	61.7	35.2	60.3	1641
August 23, 2021	I81 #4	19.0	58.9	31.3	62.1	1772
September 03, 2021	I81 #5	17.4	58.0	31.9	62.0	1731
September 03, 2021	I81 #6	19.0	53.8	28.5	63.5	1945
September 20, 2021	Benson #1	17.6	58.4	32.5	61.5	1732
September 20, 2021	Benson #2	20.0	55.7	29.4	63.4	1805
September 24, 2021	Benson #3	18.3	54.5	29.4	63.6	1958

Animal weight gain

There was no treatment by year interaction for heifer average daily gains, but there was significant period by treatment interaction (P=0.0002). Average daily gains of the clipped heifers were greater than the average daily gains of the control heifers only in the first period of each year (Table 3). For the total seasonal average daily gains, there were no significant differences between the heifer treatments.

Table 3: Heifer average daily gain by period and season (LSM: Least Squares Means; SE: Standard Error)

Treatment	**Control**	**Clipped**	SE	P Value
Period	LSM ------- *lb/day* -------		-- *lb/day* --	
1	0.2	0.8	0.1	<0.0001
2	0.8	0.8	0.1	0.8975
3	0.7	0.5	0.2	0.5508
4	1.0	0.9	0.2	0.8468
Seasonal	0.6	0.7	0.1	0.1631

We saw a limited short-term benefit to weight gains after clipping the heifers. Other studies have indicated no impact of clipping steers on weight gains in the summer when grazing toxic endophyte-infected tall fescue (McClanahan et al., 2008). Clipped calves in Australia (forage type not reported) gained less than control calves in the winter, but gained 13% more than the control cattle in the summer (Turner, 1962).

Animal body temperatures

There was no treatment by year interaction for the analysis of heifer average internal temperatures, but there was significant hour by treatment interaction. Core temperatures of the clipped heifers were lower than the core temperatures of the control heifers from 7 am to noon and at 1 am, 5 am, 6 pm, and 10 pm (Table 4). Core temperatures of the clipped heifers tended to be lower than the core temperatures of the control heifers at 12 am, 2 am to 4 am, 6 am, 1 pm, 5 pm, 8 pm, 9 pm, and 11 pm.

Table 4: Heifer mean core temperature by hour (LSM: least squares means; SE: standard error)

	Control	**Clipped**		
	LSM		SE	P Value
Hour	----- *F*° -----		-- *F*° --	
0	102.9	102.5	0.1	0.0622
1	102.7	102.3	0.1	0.0367
2	102.6	102.3	0.1	0.0781
3	102.6	102.2	0.1	0.0555
4	102.6	102.2	0.1	0.0502
5	102.6	102.2	0.1	0.0237
6	102.2	101.8	0.1	0.0552
7	101.9	101.5	0.1	0.0168
8	102.2	101.7	0.1	0.0142
9	102.7	102.2	0.1	0.0036
10	102.9	102.5	0.1	0.0147
11	103.3	102.9	0.1	0.0193
12	103.6	103.3	0.1	0.0457
13	103.9	103.6	0.1	0.0754
14	104.0	103.8	0.1	0.2048
15	104.1	103.9	0.1	0.2706
16	104.1	103.9	0.1	0.3142
17	104.2	103.9	0.1	0.0904
18	104.0	103.6	0.1	0.0319
19	103.6	103.3	0.1	0.1648
20	103.2	102.9	0.1	0.0603
21	103.0	102.7	0.1	0.0666
22	103.1	102.7	0.1	0.0420
23	103.1	102.7	0.1	0.0614

Cattle fed toxic endophyte-infected tall fescue have higher rectal (core) temperatures than animals fed non-infected tall fescue (Eisemann et al., 2020). Another study (forage type not reported) reported significantly decreased respiration rate and skin and rectal temperatures, but no effect on sweating rate following clipping (Turner, 1962).

Conclusion

Clipping heifers resulted in a short-term benefit on weight gains when heifers were stocked on toxic endophyte-infected tall fescue pastures. However, clipping resulted in reduced core body temperatures throughout the summer months. Heat stress is a major issue for livestock producers, and clipping hair coats of cattle on tall fescue pastures may be a strategy to provide short-term relief for cattle.

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UPDATES ON ARTIFICIAL INSEMINATION PROTOCOLS FOR COWS AND IMPACTS OF CALVING SEASON ON COW-CALF PRODUCTIVITY

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Introduction

Advances in reproductive biotechnologies and enhanced understanding of the dynamics of the bovine estrous cycle have made possible the development of protocols to manipulate the estrous cycle and control ovulation using natural and/or artificially synthesized hormones. Utilization of estrus or ovulation synchronization and fixed-time artificial insemination (TAI) has facilitated the widespread utilization of artificial insemination (AI) and can greatly impact the economic viability of cow-calf systems by enhancing weaning weights and total pounds of calf weaned per cow exposed (Lamb & Mercadante, 2016). Implementation of TAI programs by beef producers, however, depends largely on 2 key factors:

1. Limited frequency of handling cattle; and

2. Elimination of detection of estrus by using TAI.

Currently only 7.3% of beef cow-calf operations in the United Sates use TAI as a reproductive management tool (NAHMS, 2017a); whereas 72.5% of all pregnancies in dairy females are the result of AI (NAHMS, 2017b). When queried as to their reluctance to use AI, more than 53% of operations cited labor concerns or complicated estrous synchronization protocols as primary reasons for not implementing this reproductive technology (NAHMS, 2017a). During the past decade, TAI protocols have been developed that eliminate detecting estrus and yield satisfactory pregnancy rates. Most of these TAI protocols depend largely on the use of exogenous progesterone (P4), gonadotropin-release hormone (GnRH) to induce ovulation, and luteolysis via administration of prostaglandin F2a (PGF) (Lamb & Mercadante, 2016). Pregnancy rates of TAI protocols range between 35 to 65% (Table 1), and are largely affected by body condition score and days post-partum at the time of AI (Stevenson et al., 2015).

Parity	Days postpartum	Body condition score	n	Pregnancy rate
Multiparous	> 72	> 5	2,154	51.7^{x}
	> 72	≤ 5	2,054	43.8^{y}
	≤ 72	> 5	1,056	44.2^{y}
	≤ 72	≤ 5	1,676	41.8^{y}
Primiparous	> 72	> 5	496	43.8^{x}
	> 72	≤ 5	623	43.5^{x}
	≤ 72	> 5	166	40.7^{xy}
	≤ 72	≤ 5	284	33.3^{y}

^{xy} Within parity, means without a common superscript differ ($P < 0.05$)

Table 1: Impact of cow body condition score (1-9 Scale) and days post-partum at the time of artificial insemination on pregnancy success. *Adapted from Stevenson et al., 2015*[4].

Current protocols for fixed-time artificial insemination

Extensive research has been done and is still being conducted by several research groups to enhance the understanding of physiologic processes involved in the estrous cycle and to enhance fertility and pregnancy success of TAI protocols. In an effort to combine expertise in reproductive physiology and estrous synchronization and encourage research cooperation across the United States, the Beef Reproduction Task Force (BRTF) was formed in 2002. The BRTF is a multistate team of reproductive physiology experts from universities across the United States. The objectives of the BRTF are to improve the understanding of the physiologic processes of the estrous cycle, the procedures available to synchronize estrus and ovulation, and the proper application of these systems to optimize the success of AI programs.

Every year the BRTF releases an updated chart of recommended estrous synchronization and TAI protocols that have been tested and are proven to be effective for beef cows and heifers, including different protocols for *Bos taurus* and *Bos indicus* cattle, and a newly released list of protocols specifically developed for sexed semen. These charts can be found at www.beefrepro.org under the "protocols" tab (Beef Reproduction Task Force, n.d.), and serve as a guideline for beef producers and industry leaders in the United States and across the world. We only recommend using protocols from that list, as those have been tested extensively across multiple years, different geographical locations, types of cattle and management systems, while showing consistent results.

Impacts of estrous synchronization on cow-calf productivity

Possible outcomes from the combined use of estrous synchronization and TAI include shortened calving season, increased calf uniformity, and earlier births during the calving season. Previous models have evaluated the economic benefits derived from estrous synchronization and TAI based on heavier weaned calves with a potential increased return of $25 to $40 per calf born from AI breeding for producers who decide to dedicate the time and effort required to successfully implement an AI protocol (Lamb & Mercadante, 2016). In an analysis that investigated the incorporation of TAI compared with natural mating in a cow/calf production setting, 84% of cows exposed to TAI subsequently weaned a calf compared with 78% of cows in the natural mating group. Calving distribution also differed, resulting in the mean calving day from initiation of the calving season to be 26.8 days for cows exposed to TAI and 31.3 days for cows exposed to natural mating. According to these data, not only are more calves weaned per cow exposed to estrous synchronization and TAI, but calves may be older at weaning and have had the opportunity to gain more weight.

This increase in weaning weight may have the greatest potential to offset the cost of estrous synchronization and TAI systems. Although the improvement in genetics is a significant and long-term improvement, many producers have a desire for an immediate recovery of costs. Such costs can be recovered with the increase in total pounds of calf produced. The increase in total pounds produced was due to cows producing more weaned calves, which tend to be older and heavier. It is clear that the benefits of estrous synchronization in combination with AI will continue to be realized and incorporated into beef production systems, with a subsequent improvement in efficiency of beef cattle operations.

Another advantage of establishing a TAI system, is the ability to reduce by half the number of natural service bulls in the operation. In a system using a natural service bull:cow ratio of 1:25, where all cows will be initially exposed to TAI and a 50% pregnancy rate will be achieved, then the natural service bulls will only have to breed half of the herd, only the cows that failed to become pregnant to TAI. A recent study from our group (Timlin et al., 2021) demonstrated that only a small portion of the observed variation (1–4% for bull to total number of cow ratio, 1–11% of variation for bull to open cow ratio) can be attributed to the bull:cow ratio. As seen in our data, bull:cow ratios remained similar to the 1:25 recommendation, yet after FTAI, the number of open cows that need servicing is reduced by half. Therefore, we recommend that a bull:cow ratio of at least 1:50 be used when implementing estrous synchronization and FTAI in combination with natural service.

In that scenario, beef operations can reduce significantly the costs of purchasing and maintaining bulls, without sacrificing natural service pregnancy rates. In addition, the ability to purchase fewer bulls creates an opportunity to purchase bulls of greater generic merit while still spending less money than when purchasing multiple bulls to maintain a bull:cow ratio of 1:25.

Summary

The use of TAI, among other reproductive technologies, is a great tool to improve selection pressure for increased fertility and genetic potential of the herd. Recent advances in TAI have provided protocols that require working cattle only three times, while resulting in satisfactory pregnancy rates. More importantly, economic analysis has shown that the costs of implementing TAI are outweighed by the potential gains that the system can generate. These include an increase in pregnancy rate, greater weaning weights and more pounds of calf weaned by cow exposed, as well as a reduction in costs associated with purchasing and maintaining natural service bulls.

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