Sheep & Goat Research Journal
Volume 29, 2014 - December

Performance by Yearling Katahdin Ewes Grazing Toxic Tall Fescue Using Either Continuous or Rotational Grazing Schemes in Late Spring Through Summer

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Summary

Rotational grazing has increased in popularity; however, this management practice has not been evaluated thoroughly with Katahdin hair sheep. Our objective was to evaluate the effects of continuous or rotational grazing on performance by yearling Katahdin ewes grazing endophyte-infected, tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh; E+] in late spring through summer. Over two consecutive years, a total of 50 yearling Katahdin ewes were stratified by BW and BCS and allocated randomly to one of five, 0.4-ha E+ pastures on May 5, 2011 and May 7, 2012. Treatments consisted of: 1) continuous (Cont) or 2) 4-cell rotation (4R). Basal cover and forage quality and quantity did not differ ($P \geq 0.19$) between treatments. A sampling date effect ($P \leq 0.01$) was detected for forage quality and quantity. Grazing d, beginning, end of breeding, and end of the grazing period BW, FAMACHA scores, ADG, total gain, number of lambs/ewe exposed, and lamb birth weight did not differ ($P \geq 0.12$) between treatments. Ewe BW and BCS change during the breeding season did not differ ($P \geq 0.17$) between treatments. Beginning breeding BCS tended ($P = 0.10$) to be greater for Cont compared with 4R, but end BCS did not differ ($P = 0.45$) between treatments. Pregnancy rates and frequency of multiple births were greater ($P \leq 0.04$) from 4R compared with Cont. Therefore, utilizing a 4-cell, rotational-grazing system for yearling Katahdin ewes grazing E+ in late spring through summer may improve pregnancy rates and multiple births. However, further studies are warranted.

Key words: Continuous Grazing, Forage Quality and Quantity, Performance, Tall Fescue, Yearling Katahdin Ewes

Introduction

In recent years, rotational grazing has increased in popularity as a livestock- and forage-management practice. Rotational grazing is a process in which large pastures are subdivided into smaller individual paddocks with livestock being rotated through the smaller paddocks; whereas with continuous grazing the livestock remain on the same pasture for the duration of the grazing period (Sharrow and Krueger, 1979). Benefits associated with rotational grazing include: better forage utilization and less forage waste (Sharrow and Krueger, 1979; Ball et al., 2007), better forage production and persistence (Sharrow, 1983; Popp et al., 1997), and ultimately greater carrying capacity (Bertelsen et al., 1993). Although rotational grazing has been reported to decrease individual animal gains (Hafley, 1996; Popp et al., 1997), the increase in stocking rates associated with rotational grazing potentially improves returns for producers. However, limited research is available evaluating rotational grazing with small ruminants, especially Katahdin hair sheep. Therefore, our objective was to evaluate the effects of continuous or rotational grazing schemes on performance by yearling Katahdin ewes grazing endophyte-infected, tall fescue [*Lolium arundinaceum* (Schreb.) Darbysh; E+] pastures through late spring and summer.

Materials and Methods

Pasture and treatments

This study was conducted at the Lincoln University Carver Farm located in Jefferson City, Mo. All animals were treated according to the recommendations of *The Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (Consortium, 1988). Over two consecutive years, a total of 50 yearling Katahdin ewes (53 kg ± 0.68 kg initial BW; 3.3 ± 0.09 initial BCS) was stratified by BW and BCS, and allocated randomly to one of five, 0.4-ha pastures on May 5, 2011 and May 7, 2012 at a stocking rate of 12 ewes/ha. Pastures consisting predominately of E+ were utilized and allocated randomly in each year to one of two grazing treatments: 1) continuous grazing (Cont; five replications total; two replications in year 1 (10 yearling ewes); three replications in year 2 (15 yearling ewes) or 2) 4-cell rotational grazing (4R; five replications total; three replications in year 1 (15 yearling ewes); two replications in year 2 (10 yearling ewes). Animals assigned to Cont were allowed to graze the entire pasture area for the duration of the project. Each 4R pasture was subdivided into 4 equally sized (0.1-ha) cells by an electric fence, and animals were rotated among cells as to not restrict intake (<1000 kg/ha) by visual evaluation. Initially, ewes were rotated every four d, and as the grazing season extended into July and August, ewes were rotated every one to two d.

Each spring, 56 kg/ha of ammonium nitrate (34-0-0) was applied to all pastures. Phosphorus, potassium, and lime were applied annually to meet soil test requirements, as outlined by the University of Missouri Cooperative Extension Service (Buchholz, 2004). All pastures were clipped at the end of May to an approximate 20-cm stubble height to maintain available forage quality.

Animal management

At initiation of the study (14 d prior to the breeding season), a Controlled Internal Drug Releasing Device (CIDR®; Pfizer Inc., New York, N.Y.) was inserted intra-vaginally into each ewe. Fourteen d after CIDR® insertion (Year 1: May 19, 2011; Year 2: May 21, 2012), each ewe received 400 IU of PG 600 (Intervet Inc., Millsboro, Del.) and each CIDR® was removed. Ewes were then placed back in their respective pastures for a 40-d breeding season with one ram/replication/year that had passed a breeding soundness exam. Rams were rotated annually across groups to remove sire effects (Table 1.). Also, the number of ewes that were bred within each treatment and year are reported in Table 1. In year 2, after completion of the breeding season, each ram passed a second breeding soundness exam to ensure that each ram was a viable breeder for the duration of the breeding season. Two weeks prior to lambing, ewes were vaccinated against *Clostridium perfringens types C and D* and *Tetanus Toxoid* (Bar-vac© CD/T; Boehringer Ingelheim, Inc., St. Joseph, Mo.).

All ewes had *ad libitum* access to water, sheep mineral (ADM Alliance Nutrition, Inc., Quincy, Ill.), and a 3 × 4-m shade shelter (Portable Livestock Shelters, Seymour, Mo.) was available in each pasture. Water, mineral, and shade shelters were moved at the same time animals were rotated. Ewes were weighed and BCS (1-5 scale; 1 = healthy; 5 = obese; Russel et al., 1969) were determined at the start and end of the breeding season, and at the end of the grazing period. Ewe FAMACHA© scores (1-5 scale; 1 = healthy; 5 =

Table 1. Allocation of rams and the number of ewes bred by treatment and year.

			Ewes bred[a]	
Ram	Year	Treatment[b]	Pregnant	Open
A	1	4R	5	0
B	1	4R	5	0
C	1	Cont	3	2
D	1	4R	4	1
E	1	Cont	3	2
B	2	Cont	2	3
A	2	Cont	1	4
E	2	4R	4	1
D	2	Cont	4	1
C	2	4R	2	3

[a] Ewes bred = number of ewes that were bred by each ram within treatment and year.
[b] Cont = Continuous; 4R = 4-cell rotation.

severely anemic; Bath et al., 2001), which are indicators of parasite burden and anemia, were assigned at the beginning and end of the breeding season, and at the end of the grazing period. Each year, following the end of the grazing period, ewes were commingled and rotationally grazed on E+ pastures. During lambing (Year 1: October 10, 2011; Year 2: October 16, 2012), ewes remained on E+ pastures, and number of lambs and birth weights were recorded. Also, each lamb was ear tagged for identification.

Sample collection and analyses

On October 21, 2011 and October 16, 2012, pastures were evaluated for forage-species frequency and basal cover by a modified, step-point procedure (Owensby, 1973) in 49 locations/ha. Each month for the duration of the project, pastures were evaluated for quantity and quality of available forage. Available forage was estimated at 29 locations/ha using a rising disk meter (Bransby et al., 1977) by walking in a zig-zag pattern. Calibration samples were taken on each sampling date in five locations by clipping forage directly under the disk meter (0.25 m^2) to a 2.5-cm stubble height with hand shears. These samples were placed in brown paper bags, placed in a drying oven at 50°C, and dried to a constant weight under forced air. Dry sample weights were converted to kg/ha by multiplying dry weights by 40. These converted weights were then regressed against disk meter heights to determine calibration equations. Forage quality samples of E+ only were taken at the time of disk meter readings with 15 samples collected/ha on each sampling date. Samples for forage quality analyses were placed in plastic zip-lock bags and put in a cooler to stop transpiration until being frozen at -80°C. Samples were lyophilized using a Labconco FreeZone® Stoppering Tray Dryer (Labconco Corporation, Kansas City, Mo.). Following lyophilization, samples were placed back into freezer storage until analysis at a later date.

Forage quality samples were ground using a Wiley mill grinder (Arthur H. Thomas, Philadelphia, Penn.) to pass through a 1-mm screen. Ground E+ samples were analyzed for in vitro dry matter digestibility (IVDMD) using the batch culture method outlined by the Ankom Technology Corporation (Fairport, N.Y.). Samples were analyzed for total N using the rapid-combustion method (AOAC, 1998, Official Method 990.03; Elementar Americas Inc., Mt. Laurel, N.J.). Total N values were multiplied by 6.25 to estimate CP. Total ergot alkaloids concentrations were analyzed using the ELISA procedure outlined by Adcock et al. (1997).

Statistical analyses

Forage measurement. Percent basal cover, species composition frequency, and forage quantity and quality were analyzed using the PROC MIXED procedures for repeated measures of ANOVA (SAS Inst., Inc., Cary, N.C.); pasture was considered the experimental unit. The repeated measurement for available forage and forage quality was sampling date. The error term for treatment effects was pasture(treatment) and year was considered a random effect. Interactions between sampling date and treatment were included in the original model; however, if no interactions were detected ($P \geq 0.10$) they were removed from the model and only the main effects were reported. All data are reported as least squares means.

Animal measurements. Performance measurements and number of lambs born/ewe exposed were analyzed using PROC MIXED, and pasture or group of animals was considered the experimental unit. The error term was pasture(treatment) and year was considered a random effect. Ewe pregnancy rates are reported as a percentage that lambed of the total number of ewes exposed, and along with frequency of multiple births were analyzed using the Chi-square procedure of SAS (Version 9.3, SAS Inst. Inc., Cary, N.C.). Frequency of multiple births considered ewes that had two or more lambs within the lambing season. Sex of lamb and associated interactions were included in the model for lamb birth weight, but were removed from the model if they did not interact with main effects. Differences referred to as tendencies are those having a *P*-value between 0.05 and 0.10. All data are reported as least squares means.

Results and Discussion

Monthly rainfall data for 2011 and 2012 during the grazing period (May through August) are shown in Table 2. Monthly rainfall averages were inconsistent over the grazing season and except for May and June in year 1, were lower than the 30-year average.

Basal cover and species composition frequency

Basal cover did not differ ($P = 0.40$) between treatments, which agrees with Popp et al., (1997) who grazed steers on alfalfa-grass pastures using either continuous or rotational grazing treatments with light (1.1 steers/ha) or heavy (2.2 steers/ha) stocking rates. Endophyte-infected tall fescue was the dominant forage representing 73.1 percent and 74.3 percent from Cont and 4R, respectively, but did not differ ($P = 0.89$) between treatments (Table 3). Percentage of cool-season perennial contamination that included orchardgrass (Dactylis glomerata L.) did not differ ($P = 0.11$) in 4R compared with Cont and represented only a minimal percentage of the total forage composition (≤ 4.3 percent). Cool-season-perennial contamination was not found in year 2 of the study, which could be a result of the drought conditions that occurred at the study

Table 2. Precipitation (mm) in Jefferson City, MO during the grazing period (May-August) over 2 years.

	Year[a]		
Mo	2011	2012	Average[b]
May	170	46	137
June	170	41	125
July	50	69	114
August	84	25	105

[a] Mo rainfall average for 2011 and 2012 (DNR, 2013).
[b] Mo rainfall averages from 1981-2010 (NOAA, 2013).

Table 3. Basal cover and species composition from endophyte-infected tall fescue pastures grazed using either continuous (Cont) or 4-cell rotational (4R) grazing schemes by yearling Katahdin ewes.

	Treatment			
Item	Cont	4R	SEM[a]	*P*-value
Basal cover, %	21	25	11.2	0.40
Species composition, % of plant species[b]				
Fescue, %	73	74	6.1	0.89
Cool-season perennials, %[c]	4	0	2.8	0.11
Warm-season annuals, %[d]	12	9	6.5	0.68
Broadleaf weeds, %	11	16	6.6	0.37

[a] SEM = Pooled standard error of the mean.
[b] Cool-season annuals and warm-season perennials were not detected.
[c] Includes orchardgrass (*Dactylis glomerata* L.).
[d] Includes crabgrass (*Digitaria sanguinalis* (L.) Scop) and knotroot foxtail [*Setaria geniculata* (Lam.) Beauv.].

site. Pastures were contaminated with warm-season annuals, such as crabgrass (*Digitaria sanguinalis* (L.) Scop) and knotroot foxtail [Setaria geniculata (Lam.) Beauv.], and broadleaf weeds that represented 9.4 percent to 16.4 percent of the total forage composition; however, they did not differ ($P \geq 0.37$) across treatments. Cool-season annuals and warm-season perennials were not detected in any treatment pastures across both years.

Available forage, forage quality, and total ergot alkaloid concentrations

Available forage and forage quality measurements are shown in Table 4. Sampling date × treatment interactions were not detected ($P \geq 0.10$). Therefore, these data were pooled across sampling date and year. Available forage, IVDMD, CP, and total ergot alkaloid concentrations did not differ ($P \geq 0.19$) between treatments. Heitschmidt et al. (1987) reported that continuous grazing of cattle resulted in a 50 percent increase in available forage during the grazing season from January through May in year 2 of their study compared with cattle rotationally grazing, which disagrees with our present study. Although the authors of that study reported an increase in standing forage, they concluded this to be a result of more dormant forage in the continuous grazed treatment, which subsequently resulted in a decrease in forage quality. In the present study, a sampling date effect was detected ($P \leq 0.01$) for all forage quantity and quality measurements (Table 5). Available forage was greater ($P \leq 0.05$) from August compared with all other months, but available forage did not differ ($P \geq 0.34$) among May, June, and July. This increase in available forage during August may be due to stem elongation associated with advancing forage maturity. In vitro dry-matter digestibility was greater ($P \leq 0.01$) in May compared with June, July, and August; however, June, July, and August did not differ ($P \geq 0.10$). Crude protein was greater ($P \leq 0.05$) in May compared with all other months, but June and August did not differ ($P = 0.35$) and were greater ($P \leq 0.04$) by one or two percentage units, respectively, compared with July. The decrease in IVDMD and CP over the summer grazing months agrees with others, who reported a decrease in E+ forage quality over time (Caldwell et al., 2011; Looper et al., 2010). July and August had greater ($P \leq 0.04$) total ergot alkaloid concentrations compared with May and June, although May and June did not differ ($P = 0.63$). The lower concentration of total ergot alkaloids in May is in contrast with work reported by Rogers et al. (2011). Concentrations of total ergot alkaloids normally follow a pattern of higher concentrations during the spring growing season and then decrease during the summer months, but concentrations increase again in the autumn months (Rogers et al., 2011). Although individual ergot alkaloids were not measured in

Table 4. Effects of continuous (Cont) or 4-cell rotational (4R) grazing schemes by yearling Katahdin ewes on forage quantity and quality (DM basis).

	Treatment			
Item	Cont	4R	SEM[a]	*P*-value
Available forage, kg/ha	3430	3605	157.5	0.45
IVDMD, %	58	59	6.3	0.53
CP, %	11	12	1.3	0.19
Total ergot alkaloids, μg/kg	208	219	108.1	0.72

[a] SEM = Pooled standard error of the mean.

Table 5. Sampling date effects on available forage and forage quality over 2 years from continuous or 4-cell rotational grazing schemes.

	Month				
Item	May	June	July	August	SEM[a]
Available forage, kg/ha	3259[c]	3396[c]	3316[c]	4100[b]	144.1
IVDMD, %	70[b]	58[c]	54[c]	54[c]	6.4
CP, %	14[b]	11[c]	9[d]	10[c]	1.3
Total ergot alkaloids, μg/kg	134c	154[c]	313[b]	253[b]	110.4

[a] SEM = Pooled standard error of the mean.
[b-d] Means in a row without common superscripts differ ($P \leq 0.05$).

the present study, concentrations of ergovaline may have impacted total ergot alkaloid concentrations. Ergovaline is reported (Bacon et al., 1986) as the dominating ergot alkaloid found in E+ and follows a pattern in which concentrations are low in the spring when forage is vegetative, and increase throughout the summer months as E+ matures (Rogers et al., 2011). Total ergot alkaloid concentrations were low in the spring months, thus ergovaline concentrations may have been lower at that time and increased as the plant matured during the summer months.

Grazing days and animal performance

Grazing days did not differ ($P = 0.24$) for 4R compared with Cont (Table 6), which disagrees with Popp et al. (1997), who reported an increase in grazing days for pastures grazed using a rotational grazing scheme with cattle. Ewe BW at the beginning and end of the breeding season, and BW change during the breeding season and at the end of the study did not differ ($P \geq 0.57$) between treatments. This agrees with previous work (Sharrow and Krueger, 1979) that reported no difference in ewe BW when utilizing rotational compared with continuous grazing with Romney ewes and their lambs year round; ewe BW ranged from 47 kg to 55 kg for both treatments. Body condition scores at breeding (two weeks after initiation of study) tended ($P = 0.10$) to be greater from Cont compared with 4R. However, ewe BCS change during the breeding season, at the end of the breeding season, and at the end of the grazing period did not differ($P \geq 0.17$) between treatments. Beginning and end of the breeding season and end of the grazing period FAMACHA© scores did not differ ($P \geq 0.12$) between treatments. Because average FAMACHA© scores ranged from 1.0 to 1.3 in this study, parasite infestation did not seem to negatively impact animal performance between treatments (Table 6). Additionally, ADG and total gain did not differ ($P \geq 0.19$) from 4R compared with Cont.

Table 6. Performance measurements and grazing days by yearling Katahdin ewes grazing endophyte-infected tall fescue pastures using either a continuous (Cont) or 4-cell, rotational (4R) grazing scheme.

Item	Treatment			
	Cont	4R	SEM[a]	*P*-value
Grazing d, d/ha	181	227	41.0	0.24
Ewe BW, kg				
At breeding	54	54	2.6	0.66
End of breeding	57	57	3.2	0.83
End of grazing	60	60	4.6	0.66
Ewe BW change, kg				
During breeding	3	3	0.8	0.57
BCS[b]				
At breeding	3.5	3.1	0.37	0.10
End of breeding	3.3	3.2	0.24	0.44
End of grazing	3.1	3.2	0.10	0.45
BCS change				
During breeding	-0.16	0.04	0.136	0.17
FAMACHA© score[c]				
At breeding	1.3	1.1	0.14	0.17
End of breeding	1.2	1.0	0.06	0.12
End of grazing	1.2	1.2	0.10	0.79
ADG, kg	0.07	0.07	0.015	0.48
Total gain, kg	6	7	2.0	0.19
Pregnancy rate, %[d]	52	80	-	0.03
Number of lambs/ewe exposed	0.8	1.6	0.31	0.11
Frequency of multiple births, %[d]	28	56	-	0.04
Lamb birth weight, kg	3	3	0.3	0.42

[a] SEM = Pooled standard error of the mean.
[b] 1 to 5 scale; 1 = healthy; 5 = obese (Russel et al., 1969).
[c] 1 to 5 scale; 1 = healthy; 5 = severely anemic (Bath et al., 2001).
[d] Analyzed using Chi-square procedure of SAS.

Pregnancy rates from 4R were 28 percentage points higher ($P = 0.03$) compared with Cont, as seen in Tables 1 and 6. Overall, pregnancy rates in this study were greater than those reported by Burke (2005), who observed a 42-percent, overall pregnancy rate from 1- to 2-year-old Katahdin ewes grazing E+ during the spring-breeding season (April to May). It should be pointed out also that pregnancy rate was greater in year 1 (80 percent) than in year 2 (52 percent). Number of lambs born/ewe exposed did not differ ($P = 0.11$) between treatments (0.8 vs. 1.6 from Cont and 4R, respectively), which agrees with Sharrow and Krueger (1979) who reported no difference in number of lambs born alive/ewe exposed in Romney sheep using either continuous- or rotational-grazing schemes. Frequency of multiple births was 28 percentage units greater ($P = 0.04$) from 4R compared with Cont. No treatment × sex interactions or sex effects were detected ($P \geq 0.23$) for lamb birth weight. Lamb birth weight did not differ ($P = 0.42$) from 4R compared with Cont, which agrees with previous work reported on continuously or rotationally grazed sheep (Sharrow and Krueger, 1979).

Conclusions

Implementing a 4-cell, rotational-grazing system with Katahdin hair sheep at a stocking rate of 12 ewes/ha may not influence basal cover, forage quantity or quality, or animal gains and BCS. The 4-cell rotational grazing system appeared to increase pregnancy rates and multiple births over continuous grazing under the condition of grazing toxic tall fescue. Such an increase should increase the number of lambs available for sale, and thereby, increase potential profits for producers. However, the authors caution that in this study only 50 yearling ewes were used over a 2-year period; thus, further research would be needed to confirm that effect.

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