SHEEP PERFORMANCE, GRAZING BEHAVIOR, AND BODY TEMPERATURES IN SILVOPASTURE SYSTEMS

Gabriel Pent & John H. Fike[1]

Silvopasture systems integrate trees with forages for grazing livestock. In some comparisons with open pasture systems, animal gains have been similar or better in silvopastures despite lower forage yield. The objective of this study was to determine whether changes in forage nutritive value or changes in lamb behavior during summer might compensate for lower forage productivity in honeylocust and black walnut silvopasture systems. Tree species had variable effects on forage characteristics and animal behavior, but lamb weight gains were similar across all treatments. Forages in the honeylocust silvopasture systems were more productive and nutritious than forages in the open pasture systems. Forages were least productive and nutritious in the black walnut silvopasture systems. However, greater shading in walnut systems kept the lambs cooler throughout the day. Lambs in silvopasture systems spent more time lying down and distributed grazing events throughout the day. Lambs in the open pastures spent more time standing and concentrated their grazing events into evening hours. Interestingly, although parasites kept lamb weight gains low across treatments, lambs in the open pastures had higher fecal egg counts and lower weight gains.

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Abstract

Silvopasture systems integrate trees for timber or fodder with forages for grazing ruminants. Reports of forage and animal productivity from these systems have been variable. In some cases, animal gains are similar or better despite lower forage yield. We explored the relationship between grazing system, body temperature, grazing behavior, and animal performance in this study. Black walnut (*Juglans nigra*) and honeylocust (*Gleditsia triacanthos*) based silvopasture systems were compared with open pastures in a randomized complete block design (r = 3). Pastures were rotationally stocked with six or seven lambs depending on forage availability. All sheep were weighed and fecal samples from a subset of the lambs were taken every four weeks. Body temperatures and grazing behavior measures were recorded within a replicate within a week, and these measures were taken sequentially within three experimental periods. Ewe lambs (n=3) within each experimental unit were equipped with a vaginal temperature sensor and a wideband audio recording device to detect prehension events. Time lapse cameras documented sheep behavior every 60 seconds. Forage availability measurements taken with a rising plate meter indicated no difference between the honeylocust silvopasture (4400 ± 70 lbs/acre) and the open pasture (4300 ± 70 lbs/acre; P = 0.9916), though forage availability in the black walnut silvopastures (3100 ± 70 lbs/acre) was lower than that within the other treatments (P < 0.0001). Animal gains were highest in the honeylocust silvopastures (27.8 ± 2.12 lbs/period), and were significantly different from the gains of the open pastures (20.8 ± 2.20 lbs/period; P = 0.0254) and the gains of the black walnut silvopastures (18.7 ± 2.22 lbs/period; P = 0.0046), though no difference was found between the latter two systems (P = 0.5173). Observations indicate that sheep in silvopastures had extended foraging periods and, in some cases, lower body temperatures.

Introduction: Silvopasture management entails the intentional integration of livestock, forages, and trees in a single system. Previous research has shown that tree species have differential effects on pasture composition; forage yield and nutritive value responses can be positive or negative depending on tree age, stand density, and slope position, among other factors (Buergler et al., 2005; Buergler et al., 2006). While deciduous silvopastures may differ from open pastures in terms of forage characteristics, these responses do not necessarily track differences in animal performance (Peri et al., 2001; Lehmkuhler et al., 2003; Kallenbach et al., 2006).

Recent research (Fannon-Osborne, 2012) with lambs grazing in walnut- and honeylocust-based silvopasture systems suggests animal performance is comparable to

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that from lambs grazing open pastures, even when forage yield is reduced. However, the mechanisms behind these responses have not been clearly defined. Some data suggest that increased forage nutritive value compensates for lower forage mass in silvopastures (e.g. Kallenbach et al., 2006), but lower soluble carbohydrates (Buergler et al., 2006) and only moderate, variable responses in terms of fiber digestibility (Fannon-Osborne, 2012) challenge this idea. Altered animal behaviors – such as grazing time, standing, and lying – and consequences to energy expenditure may thus be more important drivers of the similar animal gains observed between open and silvopasture systems.

Animal behavior in silvopasture has received limited study. Heat load may change activities and intensify stresses experienced by animals in open pastures, thus increasing time and energy spent in behaviors to stabilize body temperature. Ambient temperatures are lower and less variable in silvopasture systems; thus, animals may experience more time with conditions suitable for grazing and increase dry matter intake (DMI) (Mitloehner & Laube, 2003). Distinguishing between reduced energy needed for maintenance vs. greater opportunity for grazing in pasture systems is challenged by the limited tools for monitoring grazing animals, and current methods involve time-intensive observations.

The purpose of this project was to integrate information on forage quantity and quality with spatial and temporal information on grazing behavior and body temperatures to understand the effects of silvopasture dynamics on animal performance.

Materials and Methods: The 12-week grazing study was performed at the Whitethorne Agroforestry Demonstration Center at Virginia Tech's Kentland Farm (Blacksburg, VA). Trees for the silvopasture treatments were planted in 1995 and thinned to a final density in 2012 (about 25 stems per acre). Black walnut (*Juglans nigra*) and honeylocust (*Gleditsia triacanthos*) trees were used to create two silvopasture systems treatments for comparison with open pastures. Each system is 0.67 acres, replicated three times in a randomized complete block design. Pastures and silvopastures were divided into eight subpaddocks for rotational stocking management. The honeylocust silvopasture and open pasture systems were stocked with 7 lambs while the black walnut silvopasture was stocked with 6 lambs. Lambs were weighed with a portable scale for two consecutive days at initiation and conclusion of the study and once each period. Fecal samples from three lambs within each experimental unit were taken at each weigh date to assess for *Haemonchus contortus* infection rates. FAMACHA scores from every lamb were taken every two weeks after the first period and any lamb scoring a 4 or higher after the first period or a 3 and higher after the second period was dewormed with levamisole.

Forage mass was estimated using a rising plate meter before and after every rotation interval; a regression curve was made by double-sampling at every other measurement interval. Samples for nutritive value estimates were collected by hand plucking forage at every other measurement interval. Nutritive value measures were determined by near infrared spectrometry. Vegetation composition was determined every period using a six-class Daubenmeyer approach.

Three sheep in each experimental unit within a block were fitted with a Roland R-05 recorder (Roland Corporation, Los Angeles), which recorded WAV files at a 16 bit resolution and 48 kHz sampling rate, and a Sennheiser ME-2 lavalier microphone (Sennheiser Electronic Corporation, Germany). The devices remained on nine animals for one day before being transferred to sheep in another block the following week for three consecutive weeks of measures in each period. After post processing to remove low frequency noise, prehension events were detected by SIGNAL and GRASS software (Engineering Design, Berkeley). Software parameters were calibrated by determining bite events from the synchronized video and audio files.

Ewe vaginal temperatures were measured by implanting a DST micro-T temperature logger (Star-Oddi, Iceland) into a blank controlled internal drug release device (Zoetis, Florham Park, NJ). The three sheep fitted with the acoustic devices were also equipped with the vaginal temperature loggers for three days in a week.

Moultrie D-500 trail cameras (EBSCO Industries, Inc., Birmingham, AL) were set to visually encompass the entire subpaddock containing the sheep with recorders, capturing images every 60 seconds. Before sampling, the sheep of interest were marked with pink, orange, or blue paint. The photos were processed sequentially by recording the behavior (standing up, lying down, grazing) and shade utilization (in the shade, in direct sunlight) of each sheep by minute.

PROC MIXED in SAS (SAS Institute, Inc., Cary), using a repeated measures model with unstructured variance, was used to conduct an ANOVA of treatment effect on average daily gains (ADG) and fecal egg counts (FEC) of the lambs and total animal gain from each experimental unit. PROC MIXED was used to conduct an ANOVA of treatment effect on forage mass predictions from the rising plate meter and total digestible nutrients (TDN) of orchardgrass (*Dactylis glomerata*) and mixed grass nutritive value samples for each experimental unit.

Results and Discussion: Lambs in the honeylocust silvopastures gained more than lambs in the open pastures ($P = 0.0206$); ADG of lambs in the black walnut silvopastures did not differ from the ADG of lambs in the open pastures or silvopastures ($P \geq 0.25$) (Table 1). Significant treatment by period interaction effects on ADG ($P=0.0191$) likely reflects increasing *H. contortus* loads over time.

Due to the lower stocking rate of the black walnut silvopastures, it is more informative to evaluate animal gains by system rather than by individual animal performance. The gain per experimental unit of the honeylocust silvopastures was significantly higher than that of the open pastures ($P = 0.0254$) and the black walnut silvopastures ($P = 0.0046$). Despite lower stocking rates, gain per experimental unit of the black walnut silvopastures was not significantly different from the gain per experimental unit of the open pastures ($P = 0.5173$).

FAMACHA scores were taken every other week beginning after the first period to determine which lambs should be treated with levamisole. However, lamb anemia due to

H. contortus infection depressed weight gains throughout the study. No treatment effects on FEC were observed, although FEC were numerically lowest in black walnut silvopastures (Table 1).

Throughout the season, forage availability was consistently lowest in the black walnut silvopastures ($P < 0.0001$; Table 1). As a result, the stocking rate of the black walnut silvopastures was kept one animal lower (~55-65 lbs) per experimental unit. No difference was found in forage availability between the honeylocust silvopastures and the open pastures ($P = 0.8709$).

TDN levels in orchardgrass did not differ among the open pasture and silvopasture treatments ($P = 0.6910$; Table 1). However, the TDN of the mixed sward was lower ($P = 0.0055$) in black walnut silvopastures compared with honeylocust silvopastures due to the increased presence of nimblewill (*Muhlenbergia schreberi*) in the walnut system. TDN levels of mixed swards in open pastures did not differ ($P = 0.2919$) from those within the black walnut silvopastures but tended ($P = 0.0721$) to be lower from those within the honeylocust silvopastures.

Ewes in the open pastures had the largest diurnal change in temperatures, with large temperature gains between early morning and late evening and rapid decline late in the day. Body temperatures of the open pasture ewes tracked more closely with the temperature humidity index (THI), presumably because of greater exposure to ambient conditions without tree modulation effects. Unexpectedly, the ewes in the honeylocust silvopasture treatment had the highest peak body temperatures in July and August.

The data to document ewe behavior for this paper were gathered from time lapse photos recorded in August. Ewes in open pastures spent more time standing up than lying down (Table 2). This behavior may reflect efforts to dissipate heat by exposing higher proportions of body surface area to wind. Ewes in the open pasture were able to access to shade around 16:30 as shade from bordering trees covered the experimental unit.

Out of the 28 prehension events counted manually from the video files in a given segment of time, 26 were also detected automatically by GRASS. Using the parameters from this calibration, the acoustic grazing data were analyzed for one date (August 4, 2015) and one ewe per treatment within that date. Grazing time as determined by manual classification of the time-lapse images correlated well with prehension occurrences. The time-lapse images and the acoustic results indicate that the ewe in the open pasture system spent more time grazing with a higher bite rate than ewes in the other systems.

These data indicate that although tree species have variable effects on forage productivity and nutritive value in deciduous silvopastures, animal performance can be equal or better than that in traditional open pasture systems. The environment in silvopastures moderates animal behavior and body temperature, potentially improving animal health and well-being. In turn, adding trees to pastures offers opportunity to increase the overall productivity of the land base.

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Table 1: Performance parameters by treatment.

Treatment	Black walnut silvopasture	Honeylocust silvopasture	Open pasture
Average daily gain (lbs/day)	0.12 ± 0.012	0.14 ± 0.011	0.10 ± 0.011
Gain per experimental unit (lbs/period)	18.7 ± 2.22	27.8 ± 2.12	20.8 ± 2.20
Fecal egg count (eggs/g)	3700 ± 738	4140 ± 728	4600 ± 728
Forage availability (lbs/acre)	3100 ± 70	4400 ± 70	4300 ± 70
Total digestible nutrients in orchardgrass sward (%)	66 ± 0.72	67 ± 0.72	66 ± 0.72
Total digestible nutrients in mixed grass sward (%)	67 ± 0.70	70 ± 0.70	68% ± 0.70

Table 2: Behavioral characteristics of ewes by treatment.

Activity	Black walnut silvopasture	Honeylocust silvopasture	Open pasture
Standing (% of total)	7	5	33
Lying down (% of total)	34	44	6
Grazing (% of total)	59	51	61
Shade utilization (% of total)	99	95	34