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Sheep grazing efficiency and selectivity on Oregon hill pasture

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Abstract

Grazing trials were conducted during early and late spring of 1988 and 1989 to evaluate the impact of sheep grazing duration and stocking density on grazing efficiency and forage selectivity in tall fescue (*Festuca arundinacea* Schreb.)-subclover (*Trifolium subterranum* L.) hill pastures near Corvallis, Ore. Grazing treatments were 2, 6, and 10 days duration with corresponding stocking densities 380, 130, 78, and 1,390, 460, and 280 ewes/ha during early and late spring trials each year, respectively.

Grazing efficiency was generally greater (*P*<0.05) for the low density/longer duration (10-day) than for higher density/shorter duration (2-day) treatments. Greater grazing efficiency as duration increased largely reflected higher rates of intake rather than lower levels of non-consumptive forage destruction. Stocking density within a constant grazing duration (2 days) had little effect on grazing efficiency.

Within the 10 day grazing treatment, grazing efficiency was highest during the last 4 days and lowest during the first 2 days (*P*<0.05). Although short duration/high density grazing is considered to be non-selective, sheep were equally or more selective under very short duration/very high density compared to longer duration/lower density treatments in this study. These results suggest that the very short duration with very high stocking density was not an attractive management option since grazing efficiency was low and sheep were more selective

Key Words: short-duration grazing, grazing management, preference index, *Festuca arundinacea, Trifolium subterranium*

A common goal of grazing management is to increase livestock production per unit area of land while maintaining or improving the forage resource (Walker 1984). Production can be increased by increasing the amount of digestible forage produced and the efficiency by which forage is harvested. For a set amount of forage, a high proportion of plant energy and other nutrients will be channeled into the animal production cycle and grazing animal production will increase as efficiency of grazing increases (Vallentine, 1990). It has been suggested (Heitschmidt and Walker, 1983; Stoltz and Danckwerts 1990; Sharrow 1983) that increasing animal density while shortening grazing duration (i.e. rotational grazing) will result in more uniform grazing of pastures as livestock are forced to search all areas of the pasture for forage and to consume less favored plants to a greater extent. More uniform grazing. therefore, is often associated with increased efficiency of forage harvest and reduced dietary selectivity of livestock.

In western Oregon hill pastures, where sheep production is largely forage-based, introduction of more efficienct methods to produce forage and convert it into salable animal product could greatly increase productivity. Considerable information is known about how to produce forage, but much less is known about the factors that influence grazing efficiency and forage selectivity. The purpose of this study was to quantify the impacts of grazing duration and stocking density on grazing efficiency and dietary selectivity of sheep.

Materials and Methods

The study was conducted on the Oregon Agricultural Experimental Station Wilson tract (Latitude 44 N, longitude 123 W), approximately 5.5 kilometers northwest of Corvallis, Ore. The rolling hill pastures on the Wilson tract have approximately 9% west facing slope. Elevation is approximately 190 meters above sea level. Climate of the area is maritime, with rainy winters and warm, dry summers. Average annual precipitation is approximately 900 mm (NOAA 1988, 1989), about 80% of which falls as rain during October through March each year. Soil is a Philomath silty clay (Vertic Hyploxeroll; Soil Conservation Service 1975). The study pastures were composed of approximately 60% tall fescue (*Festuca arundinacea* Schreb.) and 20% subclover (*Trifolium subterraneum* L.) with 20% of perennial ryegrass (*Lolium perenne* L.), white clover (*Trifolium repens*), and other annual and perennial grasses by weight.

Grazing trials were conducted during early (April) and late (June) spring in 1988, and 1989. Dry ewes were randomly allocated each year for each trial to the experimental pastures from a flock maintained by the Animal Science Department, Oregon State University. The sheep were allowed to graze similar pastures, adjacent to the experimental pasture, 3 to 5 days prior to the start of each grazing trial.

Grazing duration treatments applied in each trial were 2, 6, and 10 days. Forage allowance and herd size were held constant within trials while changing grazing duration and stocking density by manipulating paddock size (Table 1). Paddock size was designed to supply a forage allowance of 2.5 kg dry matter/ewe/day with a 400 kg/ha residue in early trials and 800 kg/ha residue remaining after grazing in late trials. Levels of stocking density were higher in the late trials due to high initial forage standing crop. Stocking densities are designated in the text as high, medium, and low for the 2, 6, and, 10- day

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Table 1. Daily forage allowance, number of ewes per paddock, size of paddock, stocking density and stocking rate under three grazing durations during early and late trials of 1988 and 1989.

	Early			Late		
Grazing duration (days)	2	6	10	2	6	10
Daily forage allowance (kg DM/ewe/day)	2.5	2.5	2.5	2.5	2.5	2.5
Number of ewes/paddock	7	7	7	10	10	10
Paddock size (m)	23x8	23x24	23x40	9x8	9x24	9x40
Stock density (ewes/ha)	380	126	76	1390	463	278
Stocking rate (ewe days/ha)	760	756	760	2780	2778	2780

duration treatments, respectively. Treatments were replicated 4 times in a randomized complete block design.

Effects of stocking density within a constant duration were examined by comparing data collected during the initial 2 days of each grazing treatment. The 10-day duration treatment was divided into 3 stages during grazing to determine the pattern of intake within duration under a constant stocking density. These stages were the first 2 days (A), next 4 days (B) and the last 4 days (C).

Measurements

Forage mass before and after grazing was determined by harvesting all live herbage and litter within 12 randomly selected 0.1^2 rectangular quadrates to ground level in all paddocks. Twelve additional phytomass samples were clipped at the end of the first 2 and 6 days of grazing in 10-day paddocks. The forage samples were dried in an oven at 50°C for 48 hours and dry weights were recorded. Average daily forage intake (kg/ewe/day) was calculated as the difference between pre-grazing and post-grazing forage mass (green+litter) divided by the stocking rate (stocking density x duration). Post-grazing forage mass was adjusted for the amount of growth during each period using estimates of pasture growth derived from clipping 12 quadrants/block in adjacent ungrazed pasture at the beginning and the end of each trial period.

Four samples were selected randomly from the 12 samples clipped per paddock in each sampling date. These samples were hand-sorted into tall fescue, subclover, others (grasses and forbs), and litter (old and new). The average weight of each component in the 4 samples was recorded to estimate their percentages in pasture before and after grazing. The weight of each component in pasture was estimated by multiplying the percent of the forage component by the average weight obtained from the 12 samples. The dry weight of tall fescue, subclover and other species, collectively represent the green forage dry matter in pastures before and after grazing. Green forage dry matter after grazing, in each grazing event, was subtracted from green forage dry matter before grazing to estimate the amount of green forage disappearance (consumed and destroyed by sheep). Forage covered by manure along with that transferred from the green forage to litter categories (primarily by trampling) was considered destroyed. Grazing efficiency (GE) for the purpose of this study is defined as the ratio of green forage consumed by animals to the amount consumed plus that destroyed by the grazing animals (Stuth et al. 1981).

$$\text{Grazing Efficiency} = \frac{\text{Forage intake}}{\text{Forage disappearance}} \times 100$$

Sheep preference for tall fescue, subclover, and other species (as a group) were evaluated under different grazing duration treatments with a relative preference index (Van Dyne and Heady, 1965):

$$\text{Relative Preference Index} = \frac{\text{\% forage species in diet}}{\text{\% forage species in pasture}}$$

Confidence Intervals were constructed for Relative Preference Index to aid in their interpretation (Hobbs and Bowden, 1982). Index values were interpreted as follows: (1) Relative Preference Indexes whose lower limit of the 95% Confidence Interval exceeded 1.0 indicated preference, (2) Relative Preference Indexes whose upper limit of the 95% Confidence Interval was less than 1.0 indicated avoidance (3) Relative Preference Indexes whose 95% Confidence Interval included 1.0 indicated random selection.

During the early trial each year, the total number of tall fescue tillers and the percentage of them grazed were recorded for each of twenty 80 cm^2 randomly located quadrats at the end of the grazing period to estimate the evenness of grazing.

Statistical Analysis

Data for each trial were analyzed as a randomized complete block design with paddocks as replications. Means of significant (P<0.05) treatment differences, were separated using Student-Newman-Keul's procedure (Steel and Torrie, 1980).

Results and Discussion

A critical factor affecting animal production is the amount of forage dry matter produced and the efficiency with which dry matter is converted into salable animal products. For the purpose of this study, grazing efficiency is based on relating average daily intake (kg/ewe/day) to green forage disappearance (kg/ewe/day). Grazing efficiency was higher (P<0.05) under 10-day duration than 2-day duration treatments in the early trial of 1988 and early, and late trials of 1989 (Table 2). Grazing efficiency followed a similar numerical trend in the 1988 late trial, but differences lacked statistical signifi-

Table 2. Average daily intake (ADI), forage disappearance (DISAP), forage destroyed (DEST) and grazing efficiency (GE) by sheep under 3 levels of grazing duration during early spring (April-May) and late spring (June-July) in 1988 and 1989.

Duration (days)	Early				Late			
	ADI	*DISAP*	*DEST*	*GE*	*ADI*	*DISAP*	*DEST*	*GE*
1988	--- (kg/ewe/day) ---			(%)	-- -(kg/ewe/day) - --			(%)
2	0.63b	1.32c	0.69a	48b	0.76b	0.19c	0.43a	64a
6	1.37a	2.08b	0.71a	66a	1.19a	1.76b	0.57a	68a
10	1.83a	2.55a	0.72a	72a	1.39a	2.03a	0.64a	69a
SE	0.17	0.16	0.07	5	0.10	0.11	0.04	2
1989								
2	0.62c	1.03a	0.41a	60b	0.81b	1.09b	0.28a	74b
6	1.72b	2.32b	0.60a	74a	1.62a	1.96a	0.34a	83a
10	2.44a	3.10c	0.66a	79a	1.72a	2.00a	0.28a	86a
SE	0.23	0.26	0.05	3	0.13	0.12		2

Means within a column and year not sharing a common letter differ (P<.05, using Student-Newman-Keuls test). SE is standard error.

Table 3. Average daily intake (ADI), forage disappearance (DISAP), forage destroyed (DEST) and grazing efficiency (GE) by sheep under 3 levels of stocking densities in 2 days grazing during early spring (April-May) and late spring (June-July) in 1988-1989.

Density levels	Early ADI	Early DISAP	Early DEST	Early GE	Late ADI	Late DISAP	Late DEST	Late GE
1988	---(kg/ewe/day) ---			(%)	-- -(kg/ewe/day) - --			(%)
High	0.63b	1.32b	0.69b	48a	0.76a	1.19b	0.43b	64a
Medium	1.87a	3.14a	1.27a	59a	1.44a	1.94ab	0.50b	74a
Low	1.73a	3.59a	1.86a	48a	1.05a	2.64a	1.59a	40b
SE	0.20	0.34	0.18	3	0.18	0.23	0.17	6
1989								
High	0.62c	1.03c	0.41b	60a	0.81b	1.09b	0.28a	75a
Medium	1.45b	2.49b	1.04b	58a	1.84a	2.30a	0.46a	80a
Low	2.39a	4.23a	1.84a	57a	2.03a	2.48a	0.45a	82a
SE	0.27	0.46	0.21	2	0.18	0.20	0.03	2

Means within a column andyear not sharing common letter differ (P<.05, using Student-Newman-Keuls test). SE is standard error.

cance. Average daily forage disappearance in all trials was higher under the 10-day duration compared to the 2-day duration. Increased forage disappearance as grazing duration increased was also reported by Sheath (1983). The amount of forage destroyed by grazing animals was similar (P>0.05) under all grazing duration treatments. These results suggest that the lower grazing efficiency under 2-day duration compared to 10-day duration is largely due to lower average daily intake rather than to higher forage destruction.

The effect of stocking density within a constant grazing duration on grazing efficiency was estimated during the first 2 days in all grazing treatments. No differences in grazing efficiency (P>0.05) were detected during the early trial of 1988 and both trials of 1989 (Table 3). Average daily forage disappearance per animal in all trials increased (P<0.05) as stocking density decreased. Similar results were reported by other authors (Kothmann and Allison 1979 Stuth and Kirby 1981; Allison et al. 1982). The amount of forage destroyed by each ewe during the first 2 days of grazing was higher (P<0.05) under the low density treatment compared to other treatments during all trials of 1988 and the early trial of 1989 (Table 3). During the late trial of 1989, no difference was detected in forage destroyed between treatments (P>0.05), but numerically, the low density treatment had more forage destroyed than did the high density treatment. Similar grazing efficiencies under different densities of livestock during the initial 2 days of our trials reflects the high amount of forage destroyed under the low density treatment which offset the effect of

Table 4. Average daily intake (ADI), forage disappearance (DISAP), forage destroyed (DEST) and grazing efficiency (GE) by sheep under three stages of grazing duration within the 10-day duration during early spring (April-May) and late spring (June-July) in 1988 and 1989.

Stages[1]	Early ADI	Early DISAP	Early DEST	Early GE	Late ADI	Late DISAP	Late DEST	Late GE
1988	---(kg/ewe/day) ---			(%)	-- -(kg/ewe/day) - --			(%)
A	1.73a	3.46a	1.73a	50b	1.05a	2.52a	1.47a	42b
B	1.87a	2.22b	0.35b	84a	1.17a	1.89a	0.72b	62b
C	1.84a	2.44b	0.60b	75a	1.79a	2.02a	0.23b	89a
SE	0.11	0.20	0.20	5	0.17	0.13	0.18	7
1989								
A	2.39a	3.95a	1.56a	61b	2.03a	3.08a	1.05a	66b
B	2.96a	3.23a	0.27b	92a	1.92a	1.95b	0.03b	98a
C	1.96a	2.41b	0.45b	81a	1.38a	1.45b	0.07b	95a
SE	0.21	0.26	0.19	5	0.13	0.24	0.16	5

Means within a column and year not sharing a common letter differ (P<.05, using Student-Keuls test). SE is standard error.
[1]Stage within the 10-day duration is designated by A=first B=next 4 days; C=last 4 days.

Table 5. Percent of tillers grazed under 3 levels of grazing duration (days) by sheep during early spring (April-May) in 1988 and 1989.

Duration	Years 1988	2-years 1989	$\bar{x}$
Days	----------------- % -----------------		
2	78.0b	84.0b	81.0b
6	94.5a	95.8a	95.1a
10	95.3a	95.5a	95.3a
SE	2.7	2.0	

Means within a column not sharing a common letter differ (P<.05, using Student-Newman-Keul test). SE is standard error.

higher forage intake of that treatment. At high stocking density, most of the forage disappearance was eaten by the animal. In the late trial of 1988, the lower grazing efficiency under low density treatment was largely due to the increase in forage disappearance since average daily intake was similar under all stocking density treatments. Similar results were reported by Allison et al. (1982).

Within the 10-day treatment, grazing efficiency was lower (P<0.05) during the first 2 days compared to the next 4 days and last 4 days (Table 4). Rate of forage disappearance was highest (P<0.05) during the first 2 days. Higher forage disappearance during the early stages of grazing may be due to an initially high forage allowance (Allison and Kothmann 1979) or to establishment of trails, bedding areas and other habitual use areas by ewes. The decline in the amount of forage destroyed by grazing animals during the later stages of the 10-day duration may result from animals confining their activities to the habitual use areas selected during the early stages. This resulted in the highest grazing efficiency during the last 4 days.

Increased grazing efficiency may be achieved by applying more uniform frequency and intensity of grazing to the sward (Hinnat and Kothmann, 1986). Proportions of tillers grazed is an indication of the amount of forage removed, the evenness of grazing by livestock and their access to the plants. Percent of tillers grazing was higher (P<0.05) under the 10-day duration treatment than under the 2-day duration treatment (Table 5). This could reflect either more even distribution of grazing or the higher levels of forage intake as duration increased. More uniform utilization of pastures under longer grazing duration has been reported by Sheath (1983).

Grazing sheep are highly selective for green matter against dry (Arnold 1964; Thompson 1979; Guy and Watkin 1981) and for subclover over tall fescue in grass/clover mixtures (Bedell 1968). Sheep

Table 6. Relative preference index (RPI) with 95% confidence interval (95% CI) for tall fescue (Fear), subclover (Trsu) and others under 3 levels of grazing duration by sheep during early spring (April-May) and late spring (June-July) in 1988.

Forage species	Grazing druation (days) 2 RPI	95% CI	6 RPI	95% CI	10 RPI	95% CI	SE
Early Trial							
Fear	0.78a	(0.56-0.99)	0.88a	(0.66-1.09)	0.68a	(0.46-0.88)	0.06
Trsu	0.64a	(0.38-1.90)	1.47a	(1.21-1.73)	1.53a	(1.27-1.79)	0.06
Others	1.06a	(0.71-1.41)	1.02a	(0.67-1.37)	1.11a	(0.76-1.46)	0.08
Late trial							
Fear	0.86a	(0.72-1.00)	0.93a	(0.79-1.07	0.97a	(0.83-1.11)	0.03
Trsu	1.67a	(1.38-1.95)	1.36b	(1.07-1.64)	1.22b	(0.94-1.52)	0.08
Others	0.59a	(0.38-0.81)	0.83a	(0.61-1.04)	0.89a	(0.67-1.10)	0.07

Means within a row not sharing a common letter differ (P<0.05, using Student-Newman Keuls test). SE is standard error.

Table 7. **Relative preference index (RPI) with 95% confidence interval (95% CI) for tall fescue (Fear), subclover (Trsu) and others under 3 levels of grazing duration by sheep during early spring (April-May) and late spring (June-July) in 1989.**

Forage species	Grazing druation (days) 2		6		10		
			Early trial				
	RPI	*95% CI*	*RPI*	*95% CI*	*RPI*	*95% CI*	*SE*
Fear	0.67b	(0.47-0.87)	0.98a	(0.78-1.18)	1.08a	(0.88-1.28)	0.07
Trsu	1.61a	(1.27-1.95)	1.10b	(0.77-1.43)	0.91b	Others(0.58-1.24)	
0.12							
	1.25a	(0.96-1.54)	0.87ab	(0.58-1.16)	0.72b	(0.42-1.01)	0.11
			Late trial				
Fear	0.86b	(0.72-0.92	0.98a	(0.88-1.08)	1.02a	(0.92-1.12)	0.03
Trsu	1.75a	(1.42-2.07)	1.13b	(0.81-1.44)	1.15b	(0.83-1.47)	0.12
Other	1.29a	(1.02-1.56)	1.03a	(0.76-1.30)	0.87b	(0.60-1.14)	0.08

Means within a row not sharing a common letter differ ($P<0.05$, using Student-Newman Keuls test). SE is standard error.

in our 2-day duration treatments generally selected for subclover and against tall fescue (Tables 6 and 7). Selectivity for subclover was more pronounced in 2-day duration treatments than in 6 and 10-day duration during 3 out of our 4 trials. In the exception, early trial of 1988, subclover Relative Preference Indexes were also numerically higher for the 2-day compared to 10-day treatment, but differences lacked statistical significance. Tall fescue Relative Preference Indexes were lower on 2-day treatments compared to 6 and 10-day treatments in 1989. No treatment differences in tall fescue Relative Preference Indexes were evident in 1988.

Although it was reported that short duration high density is a non-selective grazing system (Savory and Parsons 1980), our results suggest that sheep under 2-day grazing with high density were selective. High forage consumption under the 10-day duration treatment produced effectively higher grazing pressure under this treatment. Forage selectivity has been reported to decline as grazing pressure increases (Walker 1984).

Management Implications

It is generally assumed that high animal density for short grazing periods reduces dietary selectivity by grazing animals (Savory and Parsons 1980; Sharrow 1983) and results in more even and efficient utilization of forage produced (Hinnat and Kothmann 1986). Data in our study suggested that under very short duration (2 days), sheep grazed selectively, and forage utilization was less efficient and relatively uneven. Increasing duration to 10 days reduced dietary selectivity, increased grazing efficiency, and increased evenness of forage utilization by sheep. Clearly, the 2- day duration treatments do not appear to be a very attractive management option when one considers probable reduced livestock performance and higher labor cost to move animals more often. Furthermore, there was little advantage evident to using 6 vs 10 day rotation duration. In some studies, under longer duration/lower density grazing, grazing efficiency increases as animals are grouped together and move more rapidly from pasture to pasture (Hinnat and Kothmann, 1986; Malecheck and Dwyer 1983). In other studies, under very short duration/high density grazing, forage intake and grazing efficiency increased as the duration increased and density reduced (Sheath 1983; White and Cosgrove 1990). If one accepts both sets of observations, then our 10-day treatment may represent a lower limit below which grazing efficiency declines duration is further shortened and density is increased.

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