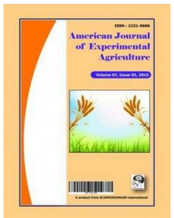

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# Forage Intake and Wastage by Ewes in Pea/Hay Barley Swath Grazing and Bale Feeding Systems

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***Authors' contributions***

*This work was carried out in collaboration between all authors. Authors EEN, RWK, MKP and PGH designed the study and wrote the protocol. Authors EEN, DLR and PGH were responsible for all sampling. Authors EEN, PGH and JGPB wrote the first draft of the manuscript. Authors ECG, JGPB, MKP, AWL, PGH and RWK reviewed the experimental design and all drafts of the manuscript. Authors EEN, PGH and DLR managed the analyses of the study. Authors EEN, PGH and DLR performed the statistical analysis. All authors read and approved the final manuscript.*

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## ABSTRACT

Harvested feed costs, particularly during the winter, are traditionally the highest input associated with a ruminant livestock operation. Although swath grazing has been practiced for over 100 years and literature exists for cattle use of swath grazing, no published results are available on use of swath grazing by sheep. Sixty mature, white-faced ewes were used in a completely randomized design repeated 2 years to evaluate whether feeding method (swath grazed or fed as baled hay in confinement) of intercropped field pea (*Pisum sativum* L.) and spring barley (*Hordeum vulgare* L.) forage affected ewe ADG (average daily gain), forage DMI (dry matter intake), and wastage. The study was conducted at Ft. Ellis Research Station in Bozeman, MT during the summers of 2010 and 2011. Each year, 30 ewes were allocated to 3 confinement pens (10 ewes/pen) and 30 ewes were

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allocated to 3 grazing plots (10 ewes/plot). Ewes had ad libitum access to forage and water. Individual ewe forage DMI was estimated using chromic oxide ($Cr_2O_3$) as a marker for estimating fecal output. Measures of fecal output were combined with measures of forage indigestibility to determine DMI for each ewe. Forage wastage was calculated by sampling and weighing initial available forage, and subtracting final available forage and DMI. Forage DMI ($P \geq 0.13$), ewe ADG ($P \geq 0.40$), and forage percent wastage ($P > 0.28$) did not differ for swathed versus baled pea/hay barley forage during either year. These results suggest that a swathed feeding system can function as a viable alternative to a traditional baled feeding system for pea/hay barley forage in commercial sheep operations.

*Keywords: Bales; forage intake; range ewes; swath grazing; wastage.*

## 1. INTRODUCTION

Winter feeding costs are some of the highest inputs associated with livestock production [1]. Costs of traditional baled feeding systems include harvesting and baling hay, maintaining machinery, moving, stacking, and feeding bales, and removing wastage and manure [2]. To reduce winter feed and production costs, feeding strategies can be employed to extend the standard grazing season [3]. Swath grazing is the process of cutting forage and leaving it in windrows or raking it into swaths for livestock to graze at a later date [4]. As more of the burden of harvest is transferred to livestock, swath grazing reduces labor, time, and costs associated with baled forages. The quality of forage tends to be lower in swaths compared to bales because exposure to precipitation and other environmental conditions can degrade its nutritive value [2,3]. However, swathed forage may still be a viable feeding alternative for livestock operations if lower costs offset nutritive limitations [5].

Although swath grazing is widely used in the Northern U.S. and Canadian Prairie Provinces, present research is limited to cattle and has shown variable results with regard to intake, BW (body weight), and wastage [2,3,5]. In this study, we evaluate ewe ADG, forage DMI and wastage for pea/hay barley forage fed in a swathed versus baled feeding system.

## 2. MATERIALS AND METHODS

### 2.1 Ewe Management and Treatments

Activities involving live animals were approved by the Agricultural Animal Care and Use Committee at Montana State University (Protocol #2009-AA04). This experiment was a completely randomized design repeated over 2 years, which evaluated feeding method of intercropped field pea (*Pisum sativum* L.) and spring forage barley (*Hordeum vulgare* L.); as 1) swath grazing pea/barley forage or 2) baled pea/barley hay fed in confinement on forage DMI, and wastage. The same experimental protocol was used as described in Ragen et al. [6]. Each year, 60 non-pregnant, non-lactating, mature western white-faced ewes were selected, and an initial shrunk BW was obtained after a 16-h removal from food and water.

Ewes were randomly assigned to either a swath grazing treatment (SWATH, $n$ = 30), or a confinement, bale-fed treatment (BALE, $n$ = 30). For SWATH, forage was defined as: 1) the swath and 2) standing forage including post-harvest stubble and regrowth. For BALE, forage was defined as baled forage fed in an outdoor pen. There were 3 replications for SWATH (3 plots, 10 ewes/plot) and 3 replications for BALE (3 pens, 10 ewes/pen). Stocking rates of 10 ewes per plot were based on measures of initial available forage determined before harvest [3] and on NRC [7] projected DMI levels for mature non-lactating ewes (75.0 – 81.5 kg) adjusted for ad libitum access to forage. Forage that fell within ten 0.1 $m^2$ ring-samples collected at random throughout each plot was clipped to ground level. The mean aggregated 1.0-$m^2$ weight of forage was then multiplied by the plot area to estimate total initial forage available per plot. Our stocking protocol assumed 75-80% consumption of initial available forage over the span of 7 d (with no less than 15-20% forage refusal) for SWATH. Ewes in BALE were fed an amount of hay sufficient to ensure no less than 10% daily forage refusal.

### 2.2 Study Site and Forages

Research was conducted at the Fort Ellis Experiment Station of Montana State University located 10 km east of Bozeman, MT (elevation 1,520 m). Average annual precipitation was 460 mm, with average annual minimum and maximum temperatures of -0.4℃ and 12.9℃, respectively [8]. During the study, August through October of 2010 had an average temperature of 15℃ and average precipitation of 50 mm. August through October of 2011 had an average temperature of 14℃ and average precipitation of 30 mm.

The study used 12 distinct forage plots (6 for 2010 and 6 for 2011), with each plot measuring 15.2 m × 91.4 m. The pea/hay barley forage was planted mid-May in 2010 and 2011, and allowed to enter the soft dough stage before being harvested in mid-August. Pea forage was planted at a rate of 112.2 kg/ha and barley at 50.4 kg/ha in a zero tillage system using a John Deere 7320 tractor (John Deere, Moline, IL) and a Great Plains 610 drill (Great Plains Ag, Salina, KS). A commercial *rhizobium* inoculant was applied to pea seed at a rate of 3.58 ml/kg during seeding.

Pea/hay barley forage was harvested using a self-propelled model 8830 Case International swather (Case IH, Grand Island, NE) equipped with a conditioner. Each year, we randomly selected 3 plots for the SWATH treatment, and 3 plots for the BALE treatment. For the SWATH treatment, cut forage in each plot was raked into a single swath measuring 0.6 × 1.0 × 46 m. The swath was allowed to dry and cure without any further handling. For the BALE treatment, forage harvested in the remaining 3 plots was baled using a model 4590 Hesston small square baler (AGCO, Duluth, Georgia) as soon as the DM (dry matter) concentration reached approximately 18% (based on a hay moisture meter; Delmhorst, Ventura, CA). Bales measured approximately 36 × 46 × 91 cm and were immediately stored on raised, wooden pallets in a covered, three-sided building on-site.

Samples of the swaths (three random 10-cm profile sections of an ungrazed swath per plot were composited), and bales (core samples of 6 random bales were composited) were taken. Forage analyses were conducted as described by Ragen et al. [6]. Descriptive forage composition values are presented in Table 1 (taken after curing/baling; August 11, 2010; August 22, 2011). Within both years, little difference was observed between initial or final forage quality measures of SWATH and BALE samples (data not shown).

In 2010, forage regrowth occurred in SWATH plots. In 2011, glyphosate was applied before harvest to all plots to control the growth of Canadian thistle (*Cirsium arvense*). This application resulted in no post-harvest regrowth available to ewes in the SWATH treatment of 2011. Because of this, standing forage was omitted and only swathed and baled forage composition was provided.

### 2.3 Intake

Each SWATH plot was divided into 2 sections of 697 $m^2$. One section was used for a 7-d adaption period and the other for a 7-d data collection period. Each 465-$m^2$ drylot pen for BALE ewes contained a combination hay rack/grain trough measuring 3.0 × 0.6 × 1.0 m. All ewes were permitted ad libitum access to water as well as salt mixed (Sheep Range Mineral, CHS, Inc., Sioux Falls, SD).

Individual ewe forage DMI was estimated using measures of fecal output and indigestibility as described by Ragen et al. [6] 2015. Dosing and fecal sample collection occurred once per day at 1000 h to minimize interference with documented grazing rhythms of sheep [9]. Ewe forage DMI was averaged for each plot or pen, and plot or pen was used as the experimental unit.

**Table 1. Composition of forage consumed by ewes in pea/hay barley swath grazing and confinement (baled forage) feeding systems for 2 years (DM basis)**

| Year | Item | Forage type | |
|---|---|---|---|
| | | Swath | Baled |
| 2010 | CP, % | 11.3 | 10.5 |
| | NDF, % | 55.0 | 50.8 |
| | ADF, % | 29.5 | 28.7 |
| 2011 | CP, % | 7.3 | 7.1 |
| | NDF, % | 50.6 | 48.7 |
| | ADF, % | 27.1 | 26.6 |

*Where CP= crude protein, NDF= neutral detergent fiber, and ADF= acid detergent fiber*

## 2.4 Forage Wastage

Wastage was determined during the 7-d collection period. In both SWATH and BALE treatments, initial and final forage availability was determined to calculate DM wastage as $W = F_i - F_f - I$, where W is wastage, $F_i$ is initial available forage, $F_f$ is final available forage, and I represents intake over the 7-d collection period. Both $F_i$ and $F_f$ included swathed forage, stubble and any regrowth. To estimate initial forage availability of SWATH treatments prior to stocking, 3 random 1-m sections of swath (approximately 6%) were collected. These sections were weighed in a wire sling and then replaced using methods similar to Volesky et al. [3]. The average weights of the 3 samples were multiplied by swath length to estimate total swath weight for each plot. Any post-harvest regrowth and crop residue biomass were included in the analysis of wastage. Standing forage was sampled using the ring-sampling method described previously to estimate standing forage and added to the total estimated swath weight to derive the initial available forage per plot. Final available forage was collected in the same manner and was defined as refused and edible (unsoiled, untrampled) forage. To estimate initial available forage for BALE treatments, all bales were weighed before feeding each day. Final edible forage available for BALE treatments was estimated by weighing refused forage left in each combination hay feeder at the end of the 7-d data collection period.

## 2.5 Statistical Analysis

This study was a completely randomized design with each SWATH or BALE enclosure as the experimental unit. Data were analyzed within year due to experimental differences between 2010 and 2011 (use of glyphosate in 2011). PROC GLM of SAS (SAS Institute Inc. Cary, NC) was used to evaluate within-year treatment differences in initial BW, ewe ADG, forage DMI, and wastage. Means were separated using the LSD procedure when a significant F value was found ($P \leq 0.10$).

# 3. RESULTS AND DISCUSSION

## 3.1 Forage DMI and Ewe Performance

Proper nutrients and intake are critical in winter feeding systems for animal performance [10]. Ewe DMI, measured as kg per day, and percentage of BW, did not differ ($P \geq 0.13$) between SWATH or BALE in 2010 or 2011 (Table 2), averaging 2.2 kg and 3.3% BW in 2010, and 2.2 kg and 3.5% BW in 2011, respectively. Ewe ADG also did not differ ($P \geq 0.40$) between treatments in 2010 or 2011 (Table 2). However, our measurement of ADG occurred over a relatively short time period, and may not be indicative of results on a longer term application. Volesky et al. [3] attributed differences in animal performance to availability of high quality regrowth that occurred post-harvest. This could explain the relatively lower ADG we observed by ewes in 2011 when there was no post-harvest regrowth available.

## 3.2 Forage Wastage

Wastage can represent a costly aspect of feeding systems in both expense of feed lost as well as labor for removal of soiled feed [5]. Generally, wastage varies depending on storage method, feeder type, feed amount, and whether or not a time-restriction is imposed during feeding [11,12]. No difference ($P \geq 0.28$) was seen between SWATH or BALE for wastage expressed as a percent of initial available forage in either 2010 or 2011 (Table 2). Pea/hay barley forage wastage averaged 25.8% in 2010, and 13.8% in 2011.

Prior research on swath grazing has established that wastage is primarily dependent upon stocking rates and grazing management [3]. It has generally been observed that if cattle are allowed unlimited access to swaths, they waste some of the forage by lying on it, urinating and defecating on it, and destroying the continuity of the swaths [5]. Thus, it is widely recommended that an electric fence be used to limit cow access to swaths and a 2-wk grazing window has been proposed [5,13]. We observed no difference in wastage between feeding systems for either year, despite allowing ewes access to the entire swathed area and the use of stocking rates to ensure 10-20% forage refusals.

Previous research suggests that although forage quality of baled forage may provide an advantage in nutrients when compared to both swath and standing forage, swathed forage can result in adequate calf gains throughout the fall and winter [2,3]. In our study, observation of nutrient concentrations indicated general weathering effects for both swathed and baled forage.

**Table 2. Dry matter intake, initial BW, ADG and forage wastage for ewes in pea/hay barley forage swath grazing and confinement (baled forage) feeding systems for 2 years**

| Year | Item | Feeding system | | SEM[3] | *P*-value |
|---|---|---|---|---|---|
| | | GRAZE[1] | BALE[2] | | |
| 2010 | Initial BW, kg | 66.3 | 64.7 | 1.25 | 0.43 |
| | ADG, kg | 0.21 | 0.24 | 0.027 | 0.40 |
| | DMI, $kg \cdot ewe^{-1} \cdot d^{-1}$ | 1.8 | 2.6 | 0.31 | 0.15 |
| | DMI, % BW | 2.7 | 3.9 | 0.49 | 0.16 |
| | Wastage, %[4] | 31.9 | 19.7 | 7.51 | 0.28 |
| 2011 | Initial BW, kg | 63.1 | 60.8 | 1.07 | 0.19 |
| | ADG, kg | 0.10 | 0.12 | 0.028 | 0.66 |
| | DMI, $kg \cdot ewe^{-1} \cdot d^{-1}$ | 2.5 | 2.0 | 0.19 | 0.13 |
| | DMI, % BW | 3.9 | 3.2 | 0.32 | 0.20 |
| | Wastage, %[4] | 17.44 | 10.22 | 7.51 | 0.52 |

*[1] Ewes grazed pea/ hay barley swaths and standing forage.*
*[2] Ewes fed pea/hay barley hay in confinement.*
*[3] n = 3,*
*[4] Wastage, % = [(initial forage availability – ending forage availability – total DMI) / beginning forage availability)] x 100*

## 4. CONCLUSION

Our research expands on previous research for cattle and suggests that swath grazing pea/barley forage may have utility in sheep production. Although our results show that nutrient composition tended to be lower in the swathed pea/barley forage, wastage and animal performance were similar between swathed and bale-fed pea/barley treatments, and suggests that a swathed pea/forage feeding system could function as a viable alternative to a traditional baled feeding system in arid climates.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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