

EFFECT OF SWATH GRAZING ON FORAGE INTAKE AND WASTAGE BY EWES

by

Erin Elizabeth Nix

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Dr. Patrick G. Hatfield

Approved for the Department of Animal and Range Sciences

Dr. Glenn Duff

Approved for The Graduate School

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ABSTRACT

Sixty non-pregnant and non-lactating mature white faced ewes (Targhee 65.4 ± 5.84 kg BW in 2010 and Rambouillet 61.9 ± 6.28 kg BW in 2011) were used in a 2-yr study to evaluate intake, forage wastage, and nutrient composition of a pea/barley forage fed either as baled hay in confinement (CONFINEMENT) or swathed and left to graze (GRAZE). Forage DMI was estimated using IVDMD and chromic oxide as an external marker for estimating fecal output. Forage wastage was estimated by sampling and weighing the initial swath, standing, and baled forage, and weighing the forage again after a 7-d collection period, and subtracting the estimated forage DMI. Samples of baled, swathed, and any standing forage were collected in August and October and analyzed for DM, OM, CP, NDF, ADF, and in situ dry matter digestibility (ISDMD). There was no treatment by year interaction ($P = 0.56$) for BW change and no difference ($P = 0.33$) between treatments. There was a treatment by year interaction ($P = 0.04$) for DMI. In 2010, DMI was greater ($P = 0.06$) by CONFINEMENT ewes compared to GRAZE ewes (2.4 vs 1.7 kg•ewe⁻¹•d⁻¹); however, in 2011, DMI did not differ ($P = 0.25$) between treatments. There was no treatment by year interaction ($P > 0.22$) for forage wastage either as a percent of beginning available forage or as kilograms of wastage. Although percentage wastage did not differ between treatments ($P = 0.23$), kilograms of wastage was greater ($P = 0.03$) for GRAZE than CONFINEMENT. For both years in the swathed forage, ISDMD and OM decreased while NDF and ADF increased. In 2010 CP increased, but in 2011 it remained the same. For both years in the baled forage, CP decreased while ISDMD and NDF increased. In 2010, ADF decreased and OM increased, but in 2011 ADF increased and OM decreased. Although nutrient content was lower in the swath, wastage and animal performance did not differ between the treatments. This research provides a sound biological basis for an economic assessment of using swath grazing in commercial sheep operations.

CHAPTER 1

INTRODUCTION

Swath grazing is a feeding strategy used as an alternative to baling and feeding the forage to livestock. Swath grazing reduces the labor, time, and costs associated with harvesting forages (Surber et al., 2001). However, animal performance with swath grazing has been variable with no difference in BCS and weight gain between swath grazing and bale feeding (Munson et al., 1999), greater ADG and BCS for swath grazing (Volesky et al., 2002; Nayigiugu et al., 2007), and a decline in ADG, depending on year and grazing conditions (Karn et al., 2005; Nayigiugu et al., 2007). Another concern for swath grazing is forage wastage as Volesky et al. (2002) reported that waste by calves on a bale treatment was 12.5%, whereas wastage by calves on the swath grazing treatment was 29%. A third concern with swath grazing is forage quality. Forage quality with swath grazing was lower compared to bales due to weathering effects (Munson et al., 1999; Volesky et al., 2002; Nayigihugu et al., 2007). Swath grazing has only been compared to other feeding strategies in 4 peer-reviewed articles and all of these articles used cattle. Most information on swath grazing comes from the popular press. There is only 1 peer reviewed article measuring intake and forage wastage for swath grazing compared to baled feeding. Therefore, the objective of this study was to evaluate ewe BW change, DMI, forage wastage, and nutrient composition of a pea/barley forage either swath grazed or baled and fed in confinement.

CHAPTER 2

LITERATURE REVIEW

History and Practice of Swath Grazing: A Popular Press Review

Swath grazing is a feeding strategy used as an alternative to baling and feeding the forage to livestock. The forage is cut and raked in swaths (windrows) for livestock to graze later in the summer, fall, or even through the winter. Swath grazing has only been compared to other feeding strategies in 4 peer-reviewed articles and all of these articles used cattle. Most literature on swath grazing comes from popular press.

Swath grazing practices can be traced back to popular press articles as early as Day (1959) and Davenport (1960). In a review by Day (1959), several research centers reported positive results when swathed hay was fed to weaned lambs and flushing ewes. These results included high lambing percentages as well as a 0.5 kg increase in gain by weaned lambs consuming swathed forage compared to dry grass pasture, and 1.8 kg increase in gain of weaned lambs consuming swathed forage compared to subterranean clover residue forage. In contrast, another research center (Day, 1959) grazed 4 groups of weaned lambs on swathed hay, alfalfa, dry grass pasture residue, or clover pasture residue for 63 d and reported that the group maintained on alfalfa gained 2.3 kg more per lamb over the duration of the study than weaned lambs who grazed the swathed treatment. This researcher also discussed several options to make swath grazing more successful as a feeding strategy including making large swaths instead of small ones, raking the forage in one direction, and compacting the swaths to shed water and resist weather damage.

Davenport (1960) reviewed pasture research in Australia and discussed the benefits of mowing excess spring pasture to be grazed as swaths in the summer as a way to keep the summer forage in its current state of quality if grazing later. Since lignin increases and forage quality decreases as plants mature, forage quality is maintained for summer grazing by mowing the forage when the quality is greatest. Swath grazing is used widely as an alternative to bale feeding in the fall and winter today, but Davenport (1960) suggested in this early study that only the excess standing forage should be cut for summer grazing. At many different experiment sites using sheep to graze the different forage types, Davenport (1960) reported that protein was generally 3% higher in the mown, swathed forage than in the standing forage and that the sheep maintained BW better than those grazing the standing forage. Davenport (1960) reported an average gain of 2.3 kg to 7.7 kg more per sheep on the swath treatment compared to the standing forage treatment over 3 to 5 months across the different study sites. He also reported an average of 1.1 kg to 2.5 kg more wool per acre for sheep on the swath treatment. On a different study site, standing, swath, and baled forage were all compared. The swath treatment resulted in 3.6 kg less BW in sheep and 0.8 kg less wool per acre compared to the baled treatment, but both these treatments yielded 4.5 kg more wool per acre compared to the sheep grazing the standing forage.

Swath grazing research appeared in peer reviewed articles in 1989 with Dougherty et al. evaluating the effects of ingestive behavior of cattle grazing standing alfalfa, cattle grazing alfalfa that was immediately mown and swathed, and cattle grazing wilted alfalfa that was mown the previous day and left in a swath. They utilized 12 cows

grazing the 3 treatments and recorded observations of individual grazing time and bite counts, estimated average DMI from the amount of forage available before and after grazing, and any remaining forage was separated into leaf and stem percentages. They reported that cows grazing the wilted swath had greater forage intakes due to a greater amount of forage consumed per bite compared to the freshly mown swath (Dougherty et al., 1989). However, cows grazing standing alfalfa had greater forage intakes and selected a higher quality diet than cows on either the freshly mown or the wilted swath treatments.

By the mid 1990's, the Western Forage Beef Group at the Lacombe Research Centre in Canada pushed swath grazing into popularity by promoting it to producers as a way to lower winter feed costs. Because of this, the number of beef producers using swath grazing reached 2000 in 2006 (Gregson, 2008), although a location for these producers was not specified though they were most likely throughout Canada.

Another promoter of swath grazing was The Year Round Grazing Project, funded by the Livestock and Forage Group of Agriculture Research and Extension Council of Alberta (ARECA; Havens et al., 2006). The Year Round Grazing Project was made up of a group of 5 cattle producers who applied a variety of grazing systems year round, including swath grazing, in order to reduce costs associated with feeding in their cow/calf operations. For the swath grazing systems, they estimated costs ranging from \$0.40 to \$1.15 • cow⁻¹ • d⁻¹. The prices they reported varied with location, if and how water was provided, and any additional labor involved. The producers concluded that swath grazing could be a viable alternative to feeding baled forage at the lower price point. Because of the variation in costs, only the right situation based on location, labor,

and other costs to achieve the lower price point would be able to benefit from swath grazing.

Popular press articles were written by others who also practiced swath grazing in effort to lower winter feed and production costs. Gregson (2008) claimed that costs could be cut as much as 47% with swath grazing compared to traditional winter feeding methods, although details on how this number was calculated were not specified. Brummer and Haugen (1997) estimated that costs could be cut by 75% by eliminating the process of baling forage. Surber et al. (2001) reviewed research performed in Canada and estimated a 60 to 75% savings with swath grazing when barley was the primary forage fed to cows, but calculations were not provided. Gerrish (2007) reported that swath grazing could save \$25 to \$40 per ton compared to making silage or baling forage; however, once again, no details were provided on how this savings was calculated. Thomson (1999) reported a cost of \$9 per ton of forage for swath grazing compared to \$45 per ton for feeding bales after measuring the costs associated with swathing, fencing, baling, stacking, feeding, and labor. The costs associated with swath grazing in both years of a 2-yr study were about \$269 per ha whereas the drylot costs, where hay was fed, were \$369 per ha in the first year and \$403 per ha in the second. Planting, land rent, combining, baling, and any other associated costs to each treatment were added to determine the cost (Kelln, 2010). Backgrounding calves on swathed forage barley in the winter reduced the cost of gain (production cost per unit of meat produced) by 60.5% compared to a drylot system where the calves were fed a grass-legume hay (Kumar, 2010). These costs in both treatments were calculated from feed costs, bedding,

machinery upkeep, manure removal, fence building, and any other associated labor costs for each treatment. The Grazing and Pasture Technology Program provided information comprised of many different projects to extend the grazing season as well as manage and improve seeded forages and native rangeland for the purpose of demonstration and to gather data in order to aid producers. One of these projects by Springer (2001) reported a 40 to 50% reduction in feed costs with swath grazing compared to bale feeding. They included costs associated with seeding, swathing, baling, hauling, feeding, fencing, and waste in their calculations. Another project in the Grazing and Pasture Technology Program, by Klein et al. (2001) collected forage samples which were analyzed for nutrient composition and recorded plot yields associated with swath grazing and baling. Using the Feed Value Calculator from Saskatchewan Agriculture and Food (Doig, 2008), they determined that even though forage quality decreased in the swaths, swath grazing was still more economical than feeding bales.

On the other hand, there are some disadvantages to swath grazing. Forage could be wasted and not utilized by livestock having too much access to the swaths (Dietz, 2005; Rinehart, 2009). Swaths exposed to poor environmental conditions could lose nutritive quality (Rinehart, 2009). Swath grazing seemed to work best when snow covered the swaths as it protected the forage and maintained a moisture content equivalent to that observed in baled hay (Brummer, 2002). In contrast, snow crusting has been a disadvantage to swath grazing when cows had difficulty breaking the snow to access the swaths (Brummer, 2002). In a thesis by Kelln (2010) cows grazing swathed barley lost 8 kg over the course of the 21-d study during the first year, whereas the cows

fed barley hay in the drylot gained 23.4 kg. This difference was due to the cows on the swath treatment eating less based on estimated intake calculations from forage weighed before and after the feeding period. Things that could have affected the lower intake were weather and forage quality. However, for the first year of the study, the cost for swath grazing was $\$0.92 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$ but the costs associated with the feedlot baled treatment were $\$1.19 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$. For the second year the costs for swath grazing were $\$0.63 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$, but $\$1.42 \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$ for the feedlot treatment. With the lower cost of the swath treatment, Kelln concluded that swath grazing is a viable grazing alternative even during winter months.

Due to these disadvantages and variation in costs of swath grazing depending on labor involved, many producers who have used swath grazing suggest common general techniques to make swath grazing a viable option. Although no numbers were provided, the tips from these producers suggest that forage wastage can be reduced by either moving a temporary fence to allow limited access to swaths rather than allowing cows unlimited access (Dietz, 2005; Rinehart, 2009). A higher stocking rate for the area could also be used (Davenport, 1960). Additionally, making large swaths and raking the forage in one direction may help maintain forage quality (Day, 1959; Surber et al., 2001). Forage should be cut at the soft dough stage in grain directly before freezing weather to keep it cold and dry (Surber et al., 2001; AAFRD, 2004; Dietz, 2005). Bedding and manure areas should also be managed by providing portable windbreaks (AAFRD, 2004).

Animal Performance

Animal performance is an important factor with any feeding strategy. Peer reviewed research results are inconsistent on how swath grazing affects animal performance. Munson et al. (1999) reported no difference in BCS or BW change for cows grazing millet in swaths or fed baled millet. They divided the land into strips with half the strips harvested and left as swaths and the other half baled and stacked at the end of the strip. Sixty gestating cows were divided among the treatments and replications, and the study was conducted from November through January. Both treatments restricted the cows to $13.2 \text{ kg} \cdot \text{cow}^{-1} \cdot \text{d}^{-1}$ of DMI by moving a fence in the swath pastures or feeding a specific amount of hay. Likewise, Volesky et al. (2002) reported no difference in BW gain in the second year of their 2-yr study. They used 48 steer calves grazing swaths or fed bales of a meadow hay forage. They also reported greater intake by calves on the swath treatment in the second year; however, based on analysis of steer gains, they hypothesized that there was an over-estimation of intake for that year. Both treatment groups of calves were allowed ad libitum access to the forage. The bale-fed calves were fed in dry-lot pens, and in the swath treatment, an electric fence was moved to allow 0.5 ha to calves every 10 to 14 d. Intake was measured using an intraruminal continuous release device containing chromium. Feces were collected once a day in the morning for 6 d from the 18 dosed calves.

In the first year of this study (Volesky et al., 2002), calves grazing the swaths gained an average of 10 kg more per calf than the calves which were fed baled forage over the duration of the study, even though the intakes for both treatments were the same

for this year. They attributed this difference to high quality regrowth in the swath grazed pens that the calves were allowed to graze. Likewise, Nayigihugu et al. (2007) reported that cows grazing swathed forage had greater ADG and BCS than those fed the baled forage in the first year of their 2 yr study. All treatment cows had ad libitum access to forage and the bale treatment was fed in pastures. They attributed the differences to the cows grazing more regrowth in the swath treatment (230 kg) compared to grazing less regrowth in the baled treatment (6 kg) although both had access to the regrowth in the pastures. In addition, cows were fed once per day in the baled treatment compared to continual grazing in the swath treatment, even if the amount of forage available was the same. In the second year of the study by Nayigiugu et al. (2007), cattle on the swath treatment had a lesser ADG compared to cattle on the baled treatment. In this second year there was a crusting of the snow over the swaths and the cows had trouble gaining access to the forage.

Karn et al. (2005) also reported varied results in animal performance when comparing 3 winter feeding systems. The winter feeding treatments consisted of swathed western wheatgrass, a medium-quality mixed grass hay fed in dry-lot as a control, and a 3-crop rotationally grazed treatment (RGSC) consisting of swathed oat/pea, triticale residues, and swathed corn. After averaging the results across the 3-yr study, ADG was lower in the swathed western wheatgrass treatment compared to cows on the swathed corn rotation of the RGSC treatment, but greater compared to cows grazing the swathed oat/pea and triticale residues of the RGSC treatment. Average daily gain did not differ between RGSC and drylot cows in the first 2 yr of the study, but was lower by RGSC

cows in the third year. When there was a loss of weight in the cows, the authors noted ice on the swaths and temperatures below normal. Cows on the RGSC treatment were also supplemented daily on an as-needed basis with the harvested dry-rolled oat/pea and triticale grain from the study plots.

Forage Wastage with Swath Grazing and Bale or Confinement Feeding

Forage wastage is an expense both in terms of lost feed and the cost of removing this wastage from the pen (Karn et al., 2005). There are few reports comparing forage wastage of swath grazing to bale feeding. Munson et al. (1999) quantified wastage using visual estimations and concluded that there was more wastage throughout the trial with bale feeding than the swath grazing treatment. In contrast, Voleskey et al. (2002) reported that calves consuming baled forages wasted less forage than calves grazing swaths (12.5 vs. 29%). They measured forage wastage in the swath treatment by laying a section of the swath on a piece of plywood and weighing it before and after grazing. For the bale treatment, they weighed the hay prior to feeding and weighed the refused forage in and around the feeder at the end of the 30-d study period. Forage wastage could be reduced with swath grazing by allowing cattle to only graze certain portions of the swath at a time and making sure they finished consuming that portion before allowing access to new forage (Munson et al., 1999; McCartney et al., 2008).

More literature has focused on managing forage wastage of livestock fed in confinement than of swath grazing. Wastage due to bale feeding can vary depending on amount fed and frequency of feeding. In a study to see if hay waste and manure

production could be reduced without compromising cow performance, Miller et al. (2007) allowed cows either ad libitum access to the hay or time-restricted access to the hay. They found that the more time the cows had access to the hay, the more hay was wasted. Martinson et al. (2012) evaluated forage wastage and BW gain of horses fed hay in 9 different types of round bale feeders and on the ground. They reported that there was no difference in BW gain among any of the treatments. All feeders reduced the wastage (feeder wastage ranging from 5 to 33%) compared to hay fed on the ground (57% wastage). More hay wastage resulted from open feeders compared to the feeders with a restricted access. Buskirk et al. (2003) evaluated 4 different types of feeders, cow behavior, and the wastage associated with each type of feeder. With a cradle or trailer type feeder, the wastage of hay ranged from 11.4 to 14.6%; however, ring and cone-type feeders set on a concrete surface only resulted in wastage of 3.5 to 6.1%. Landblom et al. (2007) took a different approach and analyzed wastage of hay from round bales rolled out on the ground, shredded and fed on the ground, or fed in a cone-shaped round-bale feeder. These researchers reported that hay offered in the cone feeder resulted in the least amount of waste, but wastage also varied with the type of hay and bale density. A dense alfalfa-grass hay mix in the feeder had 4.3 to 5 times less wastage than the rolled out bale or shredded bale treatments; however, when the strings were cut on a bale, leaving the hay loose in the feeder, wastage was the same as the shredded bale treatment fed on the ground. Blasi et al. (1993) measured forage wastage of wheat hay or a hybrid sudan hay forage that was shredded and fed in bunks, shredded and fed on the ground, and of large round bales that were unrolled and fed on the ground. They reported greater wastage of

the wheat hay bales that were unrolled and fed on the ground compared to when it was shredded and fed in bunks. The percentages of wastage of the wheat and hybrid sudan hay were 22 to 23%, respectively, when each was unrolled and fed on the ground, or 8 and 11%, respectively, when fed in a bunk, and 13% and 16%, respectively, when shredded and fed on the ground. Lechtenberg et al. (1974) reported that 23 to 39% more hay was needed to feed cows when they were fed on the ground compared to feeding hay in a rack. Cows that were fed in a rack wasted 3.7% of the hay fed compared to an additional 32.1% hay needed to feed the cows without a rack. In a study using horses, McMillan et al. (2009) reported that when hay rings were used to feed hay there was less wastage than when hay was fed without the rings on the ground. Horses fed hay in a feeder also wasted less hay than when they were fed on the ground. In a literature review, Broce et al. (2005) noted that 25 to 30% of hay was wasted when it was fed on the ground. Ball et al. (1998) stated that wastage varies depending upon the effort made to reduce it. They concluded that wastage of 3 to 6% would be acceptable in feeding programs, but that the large amount of labor required to achieve this may not be cost effective.

Forage Quality of Swath Grazing and Confinement Feeding

Forage quality is another aspect of a feeding strategy to consider. In a 2-yr study, Nayigihugu et al. (2007) fed pregnant heifers bales or allowed them to graze swaths from the same forage which was comprised of native grasses and ‘Garrison’ creeping foxtail. Bales and a section of swath that was fenced off were sampled from September (2000) or

October (2001) through January. Standing forage samples were collected from the baled and swath areas from November through January that had regrown after the forage was cut in July (2000) or August (2001). Acid detergent fiber was greater in the swath treatment compared to the bales for both years. In the first year, NDF in both forages decreased from September through November and increased in January, but in the second year it increased throughout all months for both forages and NDF was also greater in the swath forage. In the first year, IVDMD did not differ over time or between the 2 treatments, but in the second year it declined over time in both treatments. Crude protein did not differ over time in both years; however, in the second year it was greater for swath compared to baled forage. The fiber to cell soluble ratio increased due to weathering effects in the swath. Nayigihugu et al. (2007) stored the uncovered bales outside. Forage quality in the swath decreased more than in the bale treatments due to greater exposure to the weather as forage in bales is tighter packed and may be able to shed moisture better.

Munson et al. (1999) harvested millet, half of which was left in swaths and the other half baled. Bales were stored at the end of the strip from which they were swathed and forage samples were collected every 2 wk from the bales and from a section of swath that was protected from grazing. Acid detergent fiber remained the same over sampling times in bales, but increased over time in swaths. Neutral detergent fiber increased over time in both treatments, but the increase was greater in the swath treatment. In both treatments, CP and cell solubles decreased over time, but decreased at a greater rate in the

swaths. Total digestible nutrients decreased in the swaths, but was stable over time in the bales.

Volesky et al. (2002) used 3 pastures of wet meadow forage comprised of cool-season grass species for a 2-yr study evaluating swath grazing and bale-feeding. These researchers cut the forage in early to mid-September, raked it into swaths, and baled alternate swaths. Forage samples from the swath and bale were collected by hand every month for the duration of the study. Acid detergent fiber was similar between swathed and baled forage in September, but was greater for swath forage than baled forage from November through February. Baled and swathed treatments had similar CP contents which did not differ for either forage from September through February. The 2 treatments had similar NDF contents in September, but the swath treatment had greater NDF than baled forage from November through February.

These studies showed that ADF was greater and increased more rapidly in the swath treatments compared to the baled treatments. While NDF increased in both treatments in all 3 studies, NDF increased in the swath treatment more rapidly. Crude protein remained constant over time in 2 studies (Volesky et al., 2002; Nayigihugu et al., 2007), but decreased in the swaths of Munson et al. (1999). These studies showed that generally the forage quality of swaths is lower than that of baled forage due to weathering effects.

Summary

Swath grazing is a feeding strategy used as an alternative to baling and feeding the forage to livestock. Cattle have been shown to have the same ADG and BCS on swath grazing compared to bale feeding, but performance may depend upon the quality of the regrowth available to swath grazing cattle or to any ice or snow covering the swaths which may limit intake. Forage wastage is an expense both in terms of lost feed and cost of removal. The 1 study where forage wastage was directly measured in swath grazing, there was twice as much wastage in the swath grazing compared to bale feeding. Using a feeder reduced the amount of forage wasted; however, wastage due to bale feeding varies with feeder type, amount fed, and frequency of feeding. Generally the forage quality of swaths was lower than that of baled forage due to weathering effects.

CHAPTER 3

MATERIALS AND METHODS

Objective and Hypothesis

The objective of this study was to evaluate ewe BW change, DMI, forage wastage, and nutrient composition of a pea/barley forage either swath grazed or baled and fed in confinement. The hypothesis was that ewe BW change, forage DMI, forage wastage, and nutrient composition would differ by ewes swath grazing or confinement-fed pea/barley forage.

Ewe Selection and Management

Activities involving live animals were approved by the Institutional Animal Care and Use Committee at Montana State University (2009-AA04). This 2-yr study used 60 non-pregnant and non-lactating mature white faced ewes (Targhee 65.4 ± 5.84 kg BW in 2010 and Rambouillet 61.9 ± 6.28 kg BW in 2011). The Targhee ewes in 2010 were from the Bair Ranch near Martinsdale, MT. The Rambouillet ewes in 2011 were from Red Bluff Research Ranch near Norris in Madison County, MT. A shrunk BW of the ewes was taken before and after the study by holding ewes off feed and water for 16 h before weighing. All sheep were paint branded after arriving at the study site.

In 2010, ewes were weighed on September 25 before being placed in their treatment areas at the study site. They were weighed again on October 23 after being removed from the study area for 16 h. In 2010 the ewes were part of an additional

flushing study where they grazed or were fed additional pea/barley forage a week prior to the adaptation period and a week after data was collected. In 2011, ewes were weighed immediately prior to the adaptation week on September 6 and again on September 20 after the data collection week. In both years, all ewes had ad libitum access to forage, water, and a salt/mineral supplement during the study. To achieve a proper stocking rate, an estimate of forage available was determined. Before forage was swathed or cut and baled from the plots, 10 randomly located 0.1 m² quadrates were placed per plot and forage was clipped at ground level and weighed from each ring. The total 1 m² weight was multiplied by the total plot area. Estimations of intake based on NRC (2007) recommendations as well as a perceived percentage of forage refused were subtracted from the estimated forage availability. This was used as a guideline to determine that 10 ewes were needed per paddock for a proper stocking rate.

Study Site

Research was conducted from mid-September through mid-October in 2010 and 2011 at Montana State University's Fort Ellis Experiment Station, 10 km east of Bozeman, MT at an elevation of 1,520 m. The average annual precipitation (at the nearest weather station to Fort Ellis which is on the MSU campus in Bozeman) is 46.99 cm. The average annual maximum and minimum temperatures are 12.89°C and -0.4°C, respectively, with the average maximum temperature of 27.39°C occurring in July and the average minimum temperature of -11.11°C occurring in January (WRCC, 2008).

The pea/barley forage used in the grazing and feeding treatments was grown on 6 different plots per year at the study site. The plots were managed using a 3-yr crop rotation sequence comprised of spring wheat, pea/barley forage, or summer fallow. Each rotation was represented each year with 3 replicates. The pea/barley forage was planted with a John Deere 7320 tractor and a Great Plains 610 seeder. The Hays barley was planted at a rate of 20.4 kg/acre. The Arvika pea was planted at a rate of 45.4 kg/acre. An inoculant was also applied at seeding at a rate of 81.33 ml/22.7 kg of seed. The mix was planted May 18, 2010 and May 16, 2011 with a no-till drill.

Treatments

Using only the pea/barley forage part of the 3-yr rotation cropping system, treatments were: 1) sheep grazed pea/barley forage swaths in paddocks (GRAZE) or 2) sheep were fed mechanically harvested and baled pea/barley forage in confinement (CONFINEMENT). In the GRAZE treatment, 3 paddocks that measured 91 x 15 m were divided into 2 equal sections measuring 697 m² each. One section was used for adaptation and the second section was used for the data collection period. In the CONFINEMENT treatment, there were 3 confinement pens measuring 465 m² each. Each pen contained a combination hay rack with grain-trough sheep feeder measuring 3.0 m x 0.6 m x 1 m (Figure 1). Ewes were allowed a 7-d adaptation period to become accustomed to their surroundings and treatments. The adaptation period was from October 2 to October 8, 2010 and September 6 to September 12, 2011. In both treatments, there was a 7-d data collection period in which samples were collected to

determine forage availability, wastage, and intake. The data collection period lasted from October 9 to October 15, 2010 and September 13 to September 19, 2011. Facilities for handling ewes in the CONFINEMENT treatment were available near the pens. Handling facilities for the ewes in the GRAZE treatment were set up in the first adaptation section of the paddock using a variety of panels and T-fence posts.



Figure 1. A combination hay rack with grain trough measuring 3.0 m x 0.6 m x 1 m used to feed the pea/barley forage in the CONFINEMENT treatment.

Intake

Individual forage intake by ewes for both treatments was estimated using the following equation:

$$I = F/1-D$$

where I is forage intake, F is fecal output, and D is forage digestibility (all on a DM basis). The equation for fecal output is as follows:

$$F = c/f$$

where F is fecal output, c is g of chromium dosed to each ewe per day, and f is the concentration of chromium in the feces expressed in g of chromium per g of feces (all on a DM basis). Fecal output was determined using methods similar to Hatfield et al. (1991) by dosing the ewes with 2 g of chromic oxide in gelatin capsules once per d at 1000 h using a plastic balling gun. Ewes were dosed for 7 d to establish equilibrium and then dosed for an additional 7 d during which fecal grab samples were collected similar to the method described by Hatfield et al. (1991). Fecal grab samples were collected daily at 1000 h during the 7-d data collection period.

Forage digestibility is 1 minus indigestibility. Forage indigestibility was estimated using the in vitro technique from a modified Tilley and Terry (1963) method. Samples of forage (0.2500 g) were weighed in triplicate into test tubes. Twenty mL of a pre-heated buffer solution was added to the samples which were then incubated at 39°C for 20 min. Rumen fluid was collected from 2 ruminally-cannulated cows, combined, and strained through 16 layers of cheese cloth. Five milliliters of rumen fluid were then added to test tubes and the tubes were sealed with rubber stoppers. Needles were placed

through the rubber stoppers to allow the escape of gases. Test tubes were incubated at 39°C for 48 h. Test tubes were swirled at 2, 4, 20, 28 and 44 h. After 48 h, tubes were cold-shocked in an ice bath for 20 min. Liquid was filtered from the test tubes and particulate was collected on pre-weighed filter papers and allowed to dry in a 100°C oven for 48 h. The dry filter papers were then weighed. The filter paper weights were subtracted from the combined filter paper/forage particulate weight to yield indigestible forage weight.

Fecal samples were dried at 60°C, composited by sheep, ground through a 1-mm screen and analyzed for chromium concentration. One gram of the ground sample was placed in a 45-mL silica basin and dried at 100°C for a DM content. A 1-g sample was also ashed at 600°C for 1.5 h. After cooling, 3 mL of phosphoric acid-manganese sulfate solution and 4 mL of potassium bromate solution were added to the basins. The mixture was digested on a hot plate for 7 min until effervescence ceased. It was then diluted and washed completely. Twenty-five milliliters of calcium chloride solution was added and the mixture was saved for analysis of chromium content by atomic absorption spectrometry (Williams et al., 1962).

Forage Wastage

Forage wastage for both treatments was calculated as follows:

$$W = B - E - I$$

where W is wastage, B is the available forage at the beginning of the data collection week, E is the edible forage still available to the ewes at the end of the data collection

week, and I is intake during the whole week (all values expressed on a DM basis).

Beginning and ending available forage was measured using methods similar to Volesky et. al. (2002). For the beginning available forage in the swath, three 1-m sections of the swath were weighed with a wire mesh sling and hanging scale in the second section of the paddock. The sections were then returned to the swath and the 3 recorded weights were averaged and multiplied by the length of the swath in order to determine total swath weight. After the data collection period, three 1-m sections of remaining, edible swath (not trampled or soiled) were weighed with a wire mesh sling and hanging scale, averaged, and multiplied by the length of the remaining swath in order to estimate ending available forage. Available standing forage at the beginning of the data collection period was determined by clipping and weighing all forage inside ten 0.1-m² rings that were randomly placed throughout the paddock. This 1-m² weight of forage was multiplied by the area of the paddock. After the data collection period, samples from ten 0.1-m² rings were again randomly placed throughout the paddock, but only edible forage (not trampled or soiled) inside the ring was clipped and weighed, and this weight was multiplied by the area of the paddock in order to determine total standing forage weight.

In the CONFINEMENT treatment, all bales were weighed prior to feeding. Sheep were fed on a daily basis an amount of hay sufficient to ensure a level of refusal indicative of ad libitum consumption (not less than 10%). The refused forage left in the feeder was weighed once at the end of the data collection period.

Forage Analysis

A section of un-grazed swath was fenced off in each paddock for sampling. Bales were core sampled and samples were also collected by clipping standing forage. In 2010, samples were collected from swaths, standing forage, and bale cores on August 11 (after baling) and October 7 (prior to the data collection period). In 2011, samples were collected only from swaths and bale cores on August 22 and October 27 and a sample was also collected on September 23, but only analyzed for ISDMD.

All forage samples were dried at 60°C and ground in a Wiley mill through a 1-mm screen. Two 1-g samples of the 1-mm forage were weighed, dried at 100°C for 24 h, and reweighed to determine DM content. All forage samples were analyzed for N (AOAC, 2000) using a LECO machine (LECO Corp., St. Joseph, MI), and NDF and ADF (Van Soest et al., 1991) as modified for use in an Ankom 200 fiber analyzer. Two 1-g samples of the 1-mm ground forage were weighed and placed in a muffle oven at 500°C for 15 h to determine ash weights for calculation of OM content. Dry matter disappearance was determined using in situ techniques as described by Bowman and Firkins (1993). Forage samples (3 g) were placed in pre-weighed nylon Ankom bags and sealed with a bag sealer. The bags were placed in a lingerie bag and incubated for 48 h in cannulated cows consuming the pea/barley forage or a diet similar in nutrient content. After removal, the bags were rinsed in cold water until the runoff was clear. They were then dried at 60°C for 48 h and weighed.

Statistical Analysis

The study was a completely randomized design with pen or paddock as the experimental unit. Each treatment had 3 replications with 10 ewes/pen or paddock. Data were analyzed using PROC GLM of SAS (SAS Institutional Inc. Cary, NC). The statistical model included the effects of year, treatment, and year x treatment for ewe BW, DMI, and forage wastage and only the effect of treatment for nutrient composition. Means were separated using the LSD procedure when a significant F value was found ($P \leq 0.10$).

CHAPTER 4

RESULTS AND DISCUSSION

BW Change

There was no treatment by year interaction ($P \geq 0.47$) for beginning and ending BW and no difference ($P \geq 0.13$) between treatments (Table 1). The average beginning BW of the ewes was greater ($P = 0.02$) in 2010 (65.51 kg) compared to 2011 (61.95 kg). The average ending BW of the ewes was greater ($P < 0.01$) in 2010 (71.59 kg) compared to 2011 (63.54 kg). There was no treatment by year interaction ($P = 0.56$) for BW change and no difference ($P = 0.33$) between treatments. Ewe BW change was greater ($P < 0.01$) for ewes in 2010 (6.08 kg) than 2011 (1.6 kg), probably due to the difference in time the ewes were on study (4 wk in 2010 and 2 wk in 2011). These results are similar to Volesky et al. (2002) who reported no difference in BW change of calves in the second year of a 2-yr study comparing swath grazing to baled forage. In contrast to these and our results, calves gained 10 kg in 2 months (Volesky et al., 2002) and cows had greater ADG in 42 d (Nayigihugu et al., 2007) on swath treatments compared to baled treatments in 1 yr of these 2-yr studies. Both authors attributed this increased gain to cattle's access to high quality regrowth in the swathed treatment. Differences between their results and ours could be due to differences in animal species or because both these studies lasted over a month, whereas ewes in our study grazed or were fed ≤ 4 wk. Also in contrast to our results, Karn et al. (2005) and Nayigihugu et al. (2007) reported that cows had lower ADG on the swath treatment compared to the baled or feedlot treatment; however, these

studies were conducted in the winter and ADG decreased when the swaths were covered with ice and temperatures were below normal (approximately -10°C and lower).

Intake

There was a treatment by year interaction ($P \leq 0.06$) for DMI ($\text{kg}\cdot\text{ewe}^{-1}\cdot\text{d}^{-1}$ and % BW; Table 1). In 2010, both measures of DMI were greater ($P < 0.08$) by CONFINEMENT ewes compared to GRAZE ewes (2.4 vs 1.7 $\text{kg}\cdot\text{ewe}^{-1}\cdot\text{d}^{-1}$ and 3.54 vs 2.45%, respectively); however, in 2011, DMI did not differ ($P > 0.24$) between treatments. Only Volesky et al. (2002) estimated intake using chromium as an external marker and reported no differences in intake by cattle grazing swaths or fed bales in the first year and greater intake by cattle grazing swaths compared to bales the second year. In the second year they also reported no difference in ADG between treatments and after analyzing steer gains, determined that there was an overestimation of intake for that year. The overestimation of intake in the second year and the use of a continuous release chromium bolus could attribute to the different results between Volesky and the current research. Results of other studies comparing swath grazing to confinement or bale feeding did not measure intake directly. Intake due to ewe breed could also have had an effect. In a study comparing sheep breed on effects of growth and carcass traits, lambs sired by Targhee rams had a larger ADG and intake compared to lambs sired by Rambouillet rams (Sakul et al., 1993). All lambs from this study were from Targhee ewes. The Rambouillet ewes could also be a smaller, hardier breed compared to the Targhee ewes, able to survive easier off the lower forage quality, with lower CP and

ISDMD, in 2011. Although not using Rambouillet sheep, a study by Hatfield et al., (1999) showed a difference in sheep breed as physiological status and breed played a more important role in GH and blood urea nitrogen than did energy intake for Targhee and Suffolk ewes. There are many things that could have affected the year by treatment interaction. In addition to different ewe breeds, there was a different average ewe BW and size between the two breeds. Many articles have looked at size differences on intake and many equations have been used to calculate growing, lactating, or gestating animals as summarized in NRC, 2007. The visual condition of the forage may have contributed to the year effect as the forage in 2011 appeared similar to straw after it was sprayed with glyphosate. Management differences of the two breeds could have also been a factor as the Rambouillet ewes for the Red Bluff Research Ranch are also used to range management and not accustomed to smaller pens and paddocks. If this was a potential factor, the 7 d adaptation period may not have been adequate in this specific situation. The management of the Targhee ewes and their familiarity to pens was not known.

Table 1. Least squares means, SE, and *P*-values for beginning BW, ending BW, BW change, total DMI, DMI (kg•ewe⁻¹•d⁻¹), and DMI (% BW) for ewes with ad libitum access to pea/barley forage either fed as a baled hay in confinement or swathed and left to graze in 0.2 ha paddocks

Item	2010		2011		SE	<i>P</i> -value		
	Confinement	Graze	Confinement	Graze		Treatment	Yr	Treatment x Yr
Beginning BW, kg ¹	64.73 ^{b,c}	66.29 ^c	60.76 ^a	63.14 ^{a,b}	1.16	0.13	0.02	0.73
Ending BW, kg ²	71.30 ^b	71.88 ^b	62.48 ^a	64.60 ^a	1.02	0.23	< 0.01	0.47
BW change, kg	6.57 ^b	5.58 ^b	1.73 ^a	1.47 ^a	0.59	0.33	< 0.01	0.56
Total DMI, kg ³	166.36 ^b	117.56 ^a	108.10 ^a	135.19 ^{a,b}	15.55	0.51	0.23	0.04
DMI, kg•ewe ⁻¹ •d ⁻¹	2.38 ^b	1.68 ^a	1.54 ^a	1.93 ^{a,b}	0.22	0.51	0.23	0.04
DMI, %	3.54 ^b	2.45 ^a	2.52 ^a	3.05 ^{a,b}	0.36	0.46	0.59	0.06

^{a-c}Within a row, means without a common superscript differ (*P* < 0.10)

¹Beginning BW was taken when ewes arrived at study site after a 16 hr shrink September 25, 2010 and September 6, 2011

²Ending BW was taken 16 hr after sheep were removed from food and water on October 23, 2010 and September 20, 2011

³Total amount of forage consumed during the 7 d collection period for all ewes

Forage Wastage

There was no treatment by year interaction ($P = 0.12$) for beginning forage availability (kg), but there was a difference between treatments ($P < 0.01$) and years ($P < 0.01$; Table 2). Beginning forage availability was greater in 2010 (624.45 kg) compared to 2011 (308.62). In 2010, regrowth was available to the ewes to graze along with the swath. In 2011 glyphosate was applied to all plots due to growth of Canadian thistle. This was to facilitate transitioning into the next research project. This resulted in no regrowth by the time the collection period commenced and could explain differences in forage availability between years. Beginning forage availability was less in CONFINEMENT ($P < 0.01$) (369.29 kg) compared to GRAZE (563.78 kg). There was a treatment by year interaction ($P < 0.01$) for ending forage availability (kg). In 2010, the amount of forage available at the end of the study period was greater ($P < 0.01$) for GRAZE (138.95 kg) compared to CONFINEMENT (246.30 kg), but there was no difference ($P = 0.41$) in ending forage availability between treatments in 2011. There was no treatment by year interaction ($P > 0.23$) for forage wastage expressed as either kilograms or as a percent of beginning available forage (Table 2). Kilograms of forage wastage was greater ($P = 0.03$) in GRAZE compared to CONFINEMENT (157.55 versus 64.93 kg) and was greater ($P = 0.01$) in 2010 compared to 2011 (174.14 versus 48.34 kg). However, when wastage was calculated as a percent of beginning available forage, there was no difference between treatments ($P = 0.23$) or year ($P = 0.15$). Voleskey et al. (2002) reported that calves consuming baled forages wasted less forage than calves grazing swaths (12.5 vs. 29%). These authors limited cattle's access to swaths in an attempt to reduce wastage and calves

fed bales had access to hay in a circular ring-type feeder. In contrast, Munson et al. (1999) concluded that wastage was greater in the baled treatment compared to the swath treatment, but wastage was estimated visually and not directly measured, although there appeared to be more wastage when more forage was available to the cows.

Nutrient Composition

CP

Nutrient composition was different between the years from the glyphosate application in 2011 therefore statistics were run within year. In 2010, there was no difference ($P = 0.24$) for beginning CP content among the forage treatments, but there was a treatment difference ($P \leq 0.01$) for ending CP content and change in CP content (Table 3). The CP in the swathed forage increased (1.65%), remained relatively constant in the baled forage (-0.15%), and decreased in the standing forage (-1.71%). In 2011, there was a difference ($P < 0.08$) in beginning and ending CP between treatments with baled forage being greater than swathed forage (6.93% vs 5.30% for beginning CP, and 6.57% vs 5.30% for ending CP). There was no difference ($P = 0.52$) in CP change between treatments in 2011. Volesky et al. (2002) reported that CP did not differ between swath or bales from September through February. Likewise, Nayigihugu et al. (2007) reported that CP did not differ over time in both years, but in the second year CP was greater for swaths compared to baled forage when bales were stored uncovered and outside. Munson et al. (1999) reported that CP decreased over time in both the swath and bales. They also stored bales uncovered and outside.

ISDMD

There was no difference ($P > 0.32$) for beginning ISDMD, ending ISDMD, and change in ISDMD among the treatments in 2010 (Table 3). In 2011, there was no difference ($P = 0.28$) in beginning ISDMD between the treatments, but there was a difference ($P < 0.01$) in ending ISDMD between swathed and baled forage (29.77 vs. 43.73%, respectively) and for change in ISDMD ($P = 0.04$). The ISDMD decreased in the swathed forage (-7.03%) and increased in the baled forage (3.63%). The data was analyzed statistically to find differences between the forage types on each sample date. As the data was not analyzed statistically to find change between the 2 sample dates, it is not known if this change was significant, or if it is the small variation of change with sampling, but statistically remained the same between the 2 sampling dates. Nayigihugu et al. (2007) reported that for the first year IVDMD did not differ over time or between the swath and baled treatments, but in the second year it declined over time in both treatments.

Table 2. Least squares means, SE, and *P*-values of beginning forage availability, ending forage availability, forage wastage, and wastage as a percentage of beginning forage available for ewes with ad libitum access to pea/barley forage either fed as a baled hay in confinement or swathed and left to graze in 0.2 ha paddocks

Item	2010		2011		SE	<i>P</i> -value		
	Confinement	Graze	Confinement	Graze		Treatment	Year	Treatment x Year
Beginning forage, kg ¹	246.30 ^c	378.15 ^d	122.99 ^a	185.63 ^b	19.84	< 0.01	< 0.01	0.12
Ending forage, kg ²	27.44 ^b	138.95 ^c	2.46 ^a	14.53 ^{a,b}	9.80	< 0.01	< 0.01	< 0.01
Wastage, kg ³	52.50 ^a	121.64 ^b	12.43 ^a	35.91 ^a	17.41	0.03	0.01	0.23
Wastage, % ⁴	19.71 ^{a,b}	31.96 ^b	10.22 ^a	17.44 ^{a,b}	7.51	0.23	0.15	0.75

^{a-d}Within a row, means without a common superscript differ (*P* < 0.10)

¹DM forage available to ewes at beginning of study period October 2, 2010 and September 6, 2011

²DM forage available to ewes at end of study period October 8, 2010 and September 12, 2011

³Wastage = beginning forage availability – ending forage availability – total DMI

⁴Percent wastage = (wastage / beginning forage availability) * 100

Table 3. Least squares means, SE, and *P*-values of beginning CP, ending CP, CP change, beginning in situ dry matter disappearance (ISDMD), ending ISDMD, ISDMD change, beginning NDF, ending NDF, NDF change, beginning ADF, ending ADF, ADF change, beginning OM, ending OM, and OM change for swath, standing forage (stubble and regrowth), and baled pea/barley forage

Item	2010			SE	<i>P</i> -value	2011			<i>P</i> -value
	Swath	Standing	Bale		Treatment	Swath	Bale	SE	Treatment
Beginning CP, % ¹	10.80	10.00	11.83	0.68	0.24	5.30 ^a	6.93 ^b	0.47	0.07
Ending CP, % ²	12.43 ^b	8.3 ^a	11.67 ^b	0.58	0.01	5.30 ^a	6.57 ^b	0.32	0.05
CP change, %	1.65 ^c	-1.71 ^a	-0.15 ^b	0.28	< 0.01	0.01	-0.35	0.36	0.52
Beginning ISDMD, % ¹	72.70	62.97	62.00	5.15	0.33	36.80	40.10	1.85	0.28
Ending ISDMD, % ³	69.00	65.17	67.40	2.40	0.56	29.77 ^a	43.73 ^b	1.62	< 0.01
ISDMD change, %	-3.70	2.17	5.40	5.24	0.50	-7.03 ^a	3.63 ^b	2.48	0.04
Beginning NDF, % ¹	50.40 ^b	57.47 ^c	43.53 ^a	1.67	< 0.01	60.57 ^b	50.37 ^a	2.07	0.03
Ending NDF, % ²	58.23 ^c	52.57 ^b	46.30 ^a	1.63	< 0.01	65.83 ^b	53.37 ^a	1.31	< 0.01
NDF change, %	7.87 ^c	-4.90 ^a	2.77 ^b	1.42	< 0.01	5.27	3.00	3.24	0.65
Beginning ADF, % ¹	26.53 ^a	34.33 ^b	25.20 ^a	0.77	< 0.01	34.47 ^b	26.53 ^a	1.48	0.02
Ending ADF, % ²	32.07 ^c	27.80 ^b	23.27 ^a	1.19	< 0.01	39.33 ^b	29.57 ^a	0.88	< 0.01
ADF change, %	5.47 ^c	-6.57 ^a	-1.97 ^b	1.14	< 0.01	4.83	3.00	1.97	0.55
Beginning OM, % ¹	91.27 ^b	85.10 ^a	89.53 ^b	0.93	0.01	92.03	90.80	0.46	0.13
Ending OM, % ²	84.47 ^a	91.73 ^b	92.10 ^b	0.75	< 0.01	85.33	88.97	1.32	0.12
OM change, %	-6.83 ^a	6.63 ^c	2.57 ^b	1.05	< 0.01	-6.70 ^a	-1.83 ^b	1.24	0.05

^{a-d}Within year and row, means without a common superscript differ (*P* < 0.10)

¹Sampled August 11, 2010 and August 22, 2011

²Sampled October 7, 2010 and October 27, 2011

³Sampled September 23, 2011

NDF

In 2010, there was a difference ($P < 0.01$) among the treatments for beginning NDF, ending NDF, and NDF change (Table 3). Beginning NDF was greatest in standing forage (57.47%), intermediate in the swathed forage (50.40%), and least in the baled forage (43.53%). Ending NDF was greatest in the swathed forage (58.23%), intermediate in standing forage (52.57%), and least in the baled forage (46.30%). The NDF content increased in the swathed forage (7.87%) and baled forage (2.77%), but decreased in the standing forage (-4.90%). This decrease in NDF for standing forage could be attributed to the regrowth over the months as the stubble from the cut forage grew into a vegetative state with greater cell soluble to fiber ratio. In 2011, there was a difference ($P < 0.04$) between the treatments for beginning NDF and ending NDF, but no difference ($P = 0.65$) between the treatments for change in NDF. The swathed forage had greater NDF than baled forage at the beginning and ending of the sample collection period (60.57% vs. 50.37% and 65.83% vs. 53.37%). The NDF in both forages increased (5.27 and 3.00% for the swath and bale, respectively). These results are similar to Nayigihugu et al. (2007) who reported an increase in NDF over the duration of the study for both the swath and bale treatments in both years with NDF also greater in the swathed forage than the baled forage the second year of the study. Likewise, Munson et al. (1999) reported NDF increased in both the swath and bale treatments over the course of the study and was also greater in the swath than the baled treatment. Volesky et al. (2002) also reported that the swath treatment had greater NDF than the baled forage from November through February, but the treatments had similar NDF content in September.

ADF

In 2010, there was a difference ($P < 0.01$) among the treatments for beginning ADF, ending ADF, and ADF change (Table 3). Beginning ADF of standing forage was greater ($P < 0.01$) compared to swathed and baled forages. Ending ADF was greatest in the swathed forage (32.07%), intermediate in standing forage (27.80%), and least in baled forage (23.27%). The ADF content increased in the swathed forage (5.47%), decreased slightly in the baled forage (-1.97%), and decreased the greatest amount in standing forage (-6.57%). This decrease in ADF for standing forage could also be attributed to regrowth over the months as the stubble from the cut forage grew into a vegetative state with greater cell soluble to fiber ratio. In 2011, there was a difference ($P < 0.03$) between the treatments for beginning ADF and ending ADF, but no difference ($P = 0.55$) between the treatments for ADF change. The swath had greater ($P < 0.05$) beginning and ending ADF content than bale (34.47% vs. 26.53% and 39.33% vs. 29.57%, respectively). The ADF content increased in both forages (4.83 and 3.00% for the swath and bale, respectively). The second year of our results were supported by Nayigihugu et al. (2007) who reported that ADF was greater in the swath treatment compared to the baled treatment in both years. The change in ADF in the first year of the current study where ADF in the swathed forage increased and ADF in the baled forage only decreased slightly was fairly similar to Munson et al. (1999) who reported that ADF remained the same across sampling times in bales, but increased over time in swaths. Likewise, Volesky et al. (2002) reported ADF was similar for swathed and baled forage in September, but was greater for swathed forage than baled forage in November through February.

OM

In 2010, there was a difference ($P < 0.02$) among the treatments for beginning OM, ending OM, and OM change (Table 3). Beginning OM was least ($P = 0.01$) in standing forage (85.10%) compared to the swathed and baled forage (89.53% and 91.27%, respectively). Ending OM was least ($P < 0.01$) in the swathed forage (84.47%) compared to standing and baled forage (97.73% and 92.10%, respectively). The OM increased in standing forage (6.63%) and the baled forage (2.57%), but decreased in swathed forage (-6.83%). In 2011, there was no difference ($P > 0.11$) between the treatments for beginning OM and ending OM (Table 3); however, there was a difference ($P = 0.05$) in OM change between the treatments. The OM in the swathed forage decreased more (-6.70%) than in the baled forage (-1.83%). The greater decrease of OM in the swathed forage in both years could potentially be attributed to the increasing dirt content on the swath as it lay on the ground exposed to the elements from August through October.

CHAPTER 5

CONCLUSION

Swath grazing is a feeding strategy used as an alternative to baling and feeding the forage to livestock. This study examined ewe BW change, DMI, forage wastage, and forage quality between swath grazing and confinement feeding of ewes. There was no difference in BW change between the 2 treatments. There was no difference in DMI between the 2 treatments. The average amount of forage wasted was greater for GRAZE than for CONFINEMENT, but wastage as a percentage of beginning forage availability was the same for both treatments. In 2010, standing forage reflected changes associated with regrowth as ISDMD and OM increased, and CP, NDF, and ADF decreased. Swathed forage reflected quality changes associated with weathering effects such as an increase in NDF and ADF and a decrease in OM; however, CP increased and ISDMD remained the same. Nutrient content in the baled forage remained relatively stable in regards to CP, increased in NDF, ISDMD, and OM, and decreased in ADF. Nutrient content in 2011 also reflects the weathering effects for swathed forage. The NDF and ADF content in swathed and baled forage increased. The OM content of swath had a greater decrease ($P = 0.05$) than baled forage. Although CP remained the same in both forages, ISDMD decreased in the swath forage and increased in the bale. Even though forage quality was lower in the swathed forage, wastage and animal performance did not differ between the two treatments. This research provides a sound biological basis for an economic assessment of using swath grazing in commercial sheep operations.

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