

Rapid communication

Open Access

M. T. Springer, R. L. Atkinson*, L. Armit, and C. K. Nielsen

The utilization and apparent ruminal digestibility of dual-purpose food plots for wildlife and cattle grazing

DOI 10.1515/opag-2016-0017

Received November 23, 2016; accepted December 13, 2016

Abstract: The objective of this study was to examine cattle and deer utilization of nine different varieties of forage cereal grains. Yield and forage quality were also determined as well as apparent ruminal digestibility of select forage cereal grains. Cattle preferred annual ryegrass, followed by the oat varieties compared to wheat varieties. Deer preferred the wheat varieties and utilized the plots for the first nine weeks of the study but utilization decreased when cattle were introduced to the area. The annual cereal rye yielded the most tons per hectare followed by wheat varieties then the oat and other rye varieties. Apparent ruminal digestibility was determined through the use of fermenters that were randomly assigned to one of the following primary forage source: 1) fescue grass hay (GH); 2) ryegrass (RYE); 3) Buck Master Wheat (BMW); or 4) Buck Forage Oat (BFO). Dry matter digestibility was greater for RYE and BMW compared to GH and BFO. Neutral detergent fiber and CP digestibility were greater for RYE and BMW compared to GH and BFO. All varieties have the ability to extend grazing but more research needs to be done to determine best management practices for common use land areas.

Keywords: Cattle, Extended grazing, Forages, Oats, Rye, Wheat, White-tailed deer

1 Introduction

Winter annuals can be utilized to extend the grazing season decreasing overall production costs of cattle. Winter annual forages are suitable for beef cattle and forage quality is excellent [1]. The disadvantages of winter annual grazing are few and easily controlled with management [1]. Winter annuals such as wheat, rye, and oats are highly palatable and have been used extensively for years and if moderately grazed still produce a grain crop with minimal loss in yield. However, plant breeding has expanded to maintain the quality of these small grains while producing more forage yield for grazing purposes. Most of the new varieties are currently being tested in food plots for white-tailed deer (*Odocoileus virginianus*). Like cattle, deer are ruminants that have higher nutritional requirements, thus if these forage sources can be utilized for deer then they can also be utilized for cattle. However, differences in palatability do exist between cattle and deer.

Additionally, given the world's growing population and concomitant shrinking of natural areas, it is of utmost importance to provide habitats that can support both domesticated livestock and wildlife. Cereal grains are major components in the diets of deer when present on the landscape [2, 3, 4]. Competition for forage between cattle and deer has been documented in western rangeland, with deer using different areas or avoiding areas that either are currently being used or had been browsed heavily by cattle [5, 6, 7]. Given increasingly limited resources, deer may need to compete directly for resources with cattle in years of drought or other environmental extremes if the usage of cereal grains for cattle grazing is abundant. In addition, it is common for farmers to lease out hunting rights to their lands as added sources of income [8]. Understanding how both deer and cattle use food plots may therefore be important for farmers to maintain these lease agreements.

The objectives of this study were to qualitatively determine which new winter annual forage variety was

*Corresponding author: R. L. Atkinson, Depart. of Animal Science, Food & Nutrition, Southern Illinois University, Carbondale 62901, United States of America, E-mail: ratkinsn@siu.edu

M. T. Springer, Depart. of Forestry, University of Kentucky, United States of America

L. Armit, Depart. of Animal Science, Food & Nutrition, Southern Illinois University, Carbondale 62901, United States of America

C. K. Nielsen, Cooperative Wildlife Research Laboratory, Department of Forestry, Southern Illinois University, Carbondale 62901, United States of America

the most palatable among cattle; quantitatively determine deer palatability and cattle interactions when utilizing the same land area; examine yield and quality of forage; and determine apparent ruminal digestibility of preferred varieties.

2 Materials and Method

2.1 Yield and Quality

Eight forage varieties of small grains and annual ryegrass were utilized to determine yield and quality at test plots at Southern Illinois University, Carbondale, IL. The eight varieties were bred as a forage small grain and provided by Eagle Seed Company and annual ryegrass was utilized as the control because it is commonly used to extend grazing in southern Illinois. The varieties used for this study were: 1) Elbon rye; 2) ES Winter Keeper; 3) Buck Forage Oat; 4) Plot Spike Forage Oat; 5) Buck Master Wheat; 6) Range Master Wheat; 7) EK 102; 8) X55 Wheat; and 9) Ryegrass. Each variety was randomly planted in 3 replicates with plot sizes of 6.096 m x 1.2192 m (27 plots total). One day prior to planting 22.68 kg of DAP, K, and Ammonium Nitrate was applied. Varieties were planted the beginning of October 2012 at a rate of 45.36 kg per 0.40 hectare with exception of Buck Master Wheat which was planted at a rate of 68.03 kg per 0.40 hectare. Six months post-planting all plots were hand harvested 5 cm above ground and fresh-cut forage was weighed on a digital bench scale and a 2.72 kg subsample was obtained and immediately shipped to Analab (Division of Agri-King, INC, Fulton, IL) for dry matter (DM) and forage quality analysis. The relative feed quality was calculated as: $(DMI * TDN) / 1.23$; where $DMI = 120 / \%NDF$, DM and $TDN = 88.9 - (0.779 * \%ADF, DM)$. The remaining fresh-cut forage from the annual Rye grass, Buck Master Wheat, and Buck Forage Oats plots were immediately frozen for later use to determine apparent ruminal digestibility.

2.2 Palatability and Grazing Interactions

The same 9 varieties were randomly planted in 3 replicates with plot sizes of 60.96 m x 9.144 m (27 plots total) in October 2012 to be utilized for palatability and grazing interactions. One day prior to planting 45.36 kg per 0.40 hectare of DAP, K, and Ammonium Nitrate were applied. All varieties were planted at a rate of 45.36 kg per 0.40 hectare with the exception of Buck Master Wheat

which was planted at a rate of 68.03 kg per 0.40 hectare. The initiation of this portion of the study started in January 2013 (after 3 months of forage growth) and was terminated 10 weeks later in mid-March 2013. Although deer were allowed access to all 27 plots, estimates of deer use was estimated on 9 of the 27 plots with each variety being represented. Furthermore, deer had access to plots from the time of planting until the study was terminated but data was only recorded during the initiation of the study (mentioned above); while cattle only had access from week 9 to week 10 of the study. To estimate plot usage and cattle – deer interaction on these 9 plots, Cuddeback Attack passive infrared triggered cameras were placed 1 m off the ground. Cameras were programmed to take a picture every 5 minutes when triggered and all pictures included time and date of the capture event. Pictures were analyzed for frequency of use by species, duration and number of individuals located within the plot.

Cattle preference of forage variety was determined at the start of week 9 at which time they were released into the plots. The number of cattle in each plot ($n - 3/\text{variety}$) was recorded every 5 minutes during a 4 h observation period. Visual analysis of ground cover and manure deposits were utilized to further evaluate the forage variety use during a 3 d period which was conducted after the initial 4 h observation period.

2.3 Apparent ruminal digestibility

A dual-flow continuous culture apparatus [9] was used to determine apparent ruminal digestibility. The temperature of the fermenter contents was maintained at $38^{\circ}\text{C} \pm 1.0^{\circ}$ and the pH was recorded. The fermenter inoculum was obtained from two ruminally cannulated Angus heifers. Whole rumen contents were obtained and were strained under pressure through two layers of cheesecloth. Strained ruminal fluid from each cow was mixed and 1200 mL of mixed fluid was added to each fermenter along with 300 mL of pre-warmed buffer [10] with urea omitted, was used to inoculate the fermenter system.

The average fermenter volume was 1,654 mL and the liquid dilution rate was 0.10 h^{-1} using buffer [8] with urea omitted. The solids dilution rate was 0.055 h^{-1} , which produced a means solids retention time of 20 h. The pH and temperature was determined prior to each feeding and the fermenters were fed 3 times daily at 0700, 1300, and 1900.

Three of the selected varieties were thawed and dried in a 50°C oven (Precision Scientific Co., Chicago, IL).

Dried forage along with the hay were ground through a 2-mm screen in a Thomas Wiley Mill (Thomas-Scientific Philadelphia, PA) prior to mixing and feeding. A total of 80.5 g of each diet was fed to each fermenter daily. Fermenters were fed 26.83 g 3 times a day at 0700, 1300, and 1900 to prevent stirring problems. Fermenters were randomly assigned to one of the following treatments: 1) 559 (g/kg) fescue grass hay, 204 (g/kg) corn, 227 (g/kg) dried distillers grains and 9 (g/kg) Purdue heifer developer mineral (GH); 2) 788 (g/kg) ryegrass, 201 (g/kg) soyhulls and 11 (g/kg) Purdue heifer developer mineral (RYE); 3) 791 (g/kg) Buck Master Wheat, 198 (g/kg) soyhulls and 11 (g/kg) Purdue heifer developer mineral (BMW); or 4) 781 (g/kg) Buck Forage Oat, 100 (g/kg) soyhulls, 107 (g/kg) dried distillers grains and 11 (g/kg) Purdue heifer developer mineral (BFO). All diets were balanced to meet or exceed requirements for a developing heifer and to contain a minimum of 14.0% CP; however, after analyzing the diets the composition of CP in the rations averaged $12.88\% \pm 0.88 - 1.62\%$ CP (Table 1). The grass hay diet was selected as a negative control and was designed to mimic a typical diet used to develop heifers during the winter. Ryegrass was selected as a positive control and was the

control utilized in the yield, quality, and preference study. Buck Master Wheat was selected because this was one of the varieties that deer preferred while Buck Forage Oat was selected because it was one of the varieties that cattle preferred.

Each fermentation period was 10 days, with a 7 day adaptation period followed by 3 days for sampling. During sampling periods, effluent was continuously collected and held at 4 °C in a cold water bath to limit bacterial fermentation. Total effluent from each 24 hour within the 3 day sampling period was mixed, and a 1 L subsample was composited each day and stored at -20 °C, providing 3 L of total composited effluent. Effluent was later lyophilized (Virtis bench Top, Gardiner, NY) prior to analysis. A 450 gram subsample of effluent was processed for bacterial isolation [11], with saline omitted in the last step, and the microbes were analyzed for DM [12]. This allowed for the estimation of microbial DM outflow which was used to extrapolate gram of microbes DM per gram of effluent. Feed and ruminal contents were sent to Analab (Division of Agri-King, INC, Fulton, IL) to be analyzed for DM, Nitrogen content, neutral detergent fiber, and acid detergent fiber.

Table 1. Ingredients and analyzed composition of rations designed for developing heifers

| Item | TREATMENT DIETS ¹ | | | |
|-----------------------------------|------------------------------|-----|-----|-----|
| | GH | RYE | BMW | BFO |
| Ingredient, g/kg of DM | | | | |
| Grass hay | 559 | 0 | 0 | 0 |
| Ryegrass | 0 | 788 | 0 | 0 |
| Buck Master Wheat | 0 | 0 | 791 | 0 |
| Buck Forage Oats | 0 | 0 | 0 | 781 |
| Soyhulls | 0 | 201 | 198 | 100 |
| Corn | 204 | 0 | 0 | 0 |
| Dried distillers grains | 227 | 0 | 0 | 107 |
| Vit Premix ² | 9 | 11 | 11 | 11 |
| Chemical Composition, g/kg | | | | |
| DM | 908 | 919 | 928 | 916 |
| CP | 123 | 120 | 127 | 145 |
| NDF | 474 | 676 | 526 | 403 |
| ADF | 284 | 373 | 359 | 122 |

¹Treatment according to primary forage source: GH = grass hay; RYE = annual ryegrass; BMW = buck master wheat; BFO = buck forage oats

²Contained: 18.5 – 20.5% Ca, 4.8% P, 18.4 – 20.4% Salt, 1.1% Mg, 0.3% K, 760 ppm Cu, 9.5 ppm Se, 2,860 ppm Zn, 293,300 IU/lb Vit. A, 15,110 IU/lb Vit. D3, and 665 IU/lb Vit. E

2.4 Statistical Analysis

Forage yield data was analyzed using the MIXED procedure of SAS (SAS 9.3 Inst., Inc., Cary, NC) using a randomized complete block design. Plot was the experimental unit and the RANDOM statement included block. Comparisons of main effects were determined using least square means and Fisher's protected LSD ($P = 0.05$).

Deer count data from collected images were analyzed using Program R [13] and an alpha value < 0.05 was used as the threshold for significance for all deer related analysis. We used a repeated measures ANOVA to test for differences in deer usage between plots. We then used a post-hoc pairwise t-tests to test for the differences in the usage of individual plots. To test for the influence of cattle on deer use of the plots in general we used a repeated measures ANOVA with the weeks as the sample unit. We used a post-hoc pairwise t-tests to determine the differences in the deer usage of all plots by week. We focused on deer use of plots in week 10 when cattle were present relative to all other weeks the plots did not have cattle present.

All digestion data were analyzed using MIXED procedure of SAS (SAS 9.4 Inst., Inc., Cary, NC) using the model for a Latin square design. The model included treatment and period with animal specified in the RANDOM statement of SAS. Comparisons of main effects were determined using least square means and Fisher's protected LSD ($P = 0.05$) and tendency set at $P \leq 0.10$.

3 Results and Discussion

3.1 Yield and Quality

The annual Elbon rye yielded the greatest ($P = 0.001$) amount of forage per hectare followed by the three varieties of wheat compared to the control RYE (Figure 1). However, RYE yielded more forage compared to BFO and PSFO, oat varieties, but was similar to ESWK, an oat variety. It was expected that oats would yield less compared to wheat because the plots were harvested in spring when wheat is in peak forage production compared to oats. Conversely, in northern Arkansas, annual ryegrass yielded the most forage compared to small grains [1]. Southern Illinois is located within the transition zone, thus in the current study we had expected to observe similar results to those in northern Arkansas. It is possible that forage growth was hindered by the below average precipitation and a 6 degree above normal temperatures throughout winter. The summer of 2012 was a drought year in Illinois and by September 82% of the state still remained in some stage of drought. One sample from each plot was analyzed for forage quality and when examining the different varieties the wheat varieties had the greatest amount of protein at an average of 16% CP (Table 2). The control, RYE, had a similar CP of 15.9% compared to wheat varieties but greater CP compared to ER (13.4% CP). The average CP of

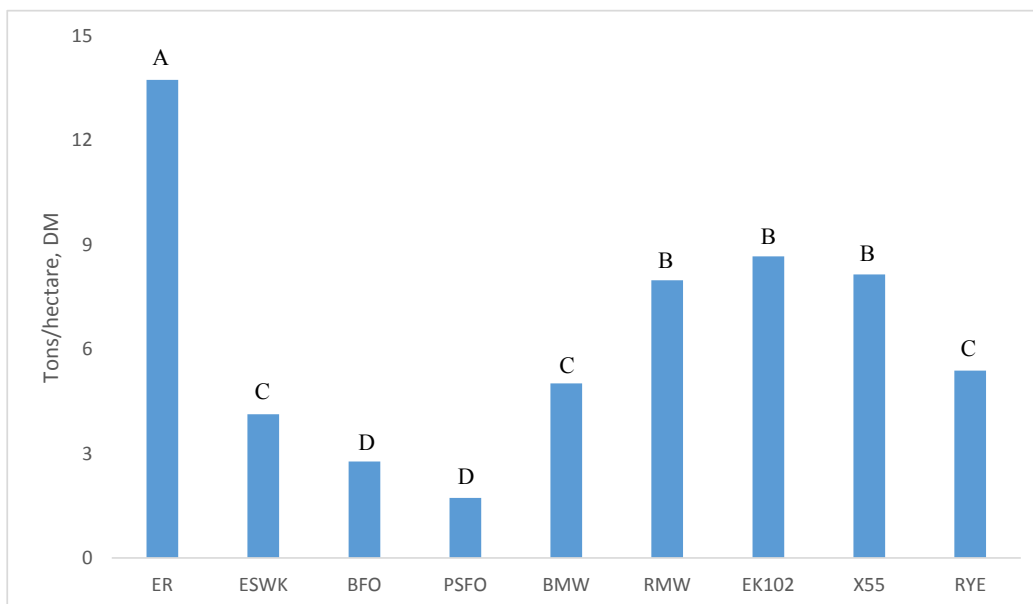


Figure 1. Forage plot yield of nine forage varieties ($P = 0.001$). ER = Elbon Rye (cereal rye); ESWK = ES Winter Keeper (oat variety); BFO = Buck Forage Oats; PSFO = Plot Spike Forage Oats; BMW = Buck Master Wheat; RMW = Range Master Wheat; EK102 = EK 102 (wheat variety); X55 = X 55 Wheat; RYE = Rye Grass (annual)

Table 2. Chemical composition of nine forage varieties

| Nutrient, %DM | VARIETY ¹ | | | | | | | | |
|---------------------------|----------------------|------|------|------|------|------|-------|------|------|
| | ER | ESWK | BFO | PSFO | BMW | RMW | EK102 | X55 | RYE |
| DM | 24.6 | 22.9 | 21.6 | 21.9 | 23.4 | 22.8 | 24.6 | 25.0 | 20.1 |
| Ash | 4.6 | 4.9 | 5.3 | 6.5 | 5.8 | 5.5 | 7.3 | 6.1 | 9.2 |
| Crude Protein | 13.4 | 12.8 | 12.3 | 12.9 | 15.8 | 15.2 | 15.5 | 17.7 | 15.9 |
| Soluble Protein | 47.7 | 49.6 | 42.6 | 50.4 | 39.7 | 36.0 | 35.4 | 33.9 | 31.9 |
| NDF | 53.1 | 40.7 | 34.9 | 34.2 | 38.2 | 41.7 | 40.9 | 42.6 | 40.1 |
| ADF | 31.8 | 25.9 | 23.2 | 19.6 | 24.7 | 23.0 | 26.7 | 25.9 | 25.4 |
| Fat | 3.45 | 2.42 | 2.19 | 2.18 | 2.41 | 2.49 | 2.5 | 2.42 | 2.44 |
| IVDMD | 68.9 | 75.1 | 79.0 | 80.4 | 78.4 | 76.7 | 77.7 | 77.2 | 80.8 |
| Calcium | 0.32 | 0.27 | 0.22 | 0.26 | 0.24 | 0.26 | 0.33 | 0.22 | 0.61 |
| Phosphorus | 0.34 | 0.26 | 0.24 | 0.26 | 0.30 | 0.30 | 0.30 | 0.36 | 0.39 |
| Magnesium | 0.12 | 0.09 | 0.08 | 0.08 | 0.07 | 0.08 | 0.09 | 0.08 | 0.13 |
| NE _M , Mcal/lb | 0.62 | 0.70 | 0.74 | 0.80 | 0.74 | 0.76 | 0.70 | 0.69 | 0.73 |
| NE _G , Mcal/lb | 0.36 | 0.43 | 0.47 | 0.52 | 0.47 | 0.49 | 0.44 | 0.42 | 0.46 |
| RFQ ² | 118 | 165 | 198 | 210 | 178 | 166 | 162 | 157 | 168 |

¹ ER = Elbon Rye (annual); ESWK = ES Winter Keeper; BFO = Buck Forage Oats; PSFO = Plot Spike Forage Oats; BMW = Buck Master Wheat; RMW = Range Master Wheat; EK102 = EK 102 (wheat variety); X55 = X 55 Wheat; RYE = Rye Grass (annual)

² RFQ = Relative Feed Quality; calculated as: $(DMI * TDN) / 1.23$; where $DMI = 120 / \%NDF, DM$ and $TDN = 88.9 - (0.779 * \%ADF, DM)$

the oat varieties were the lowest at 12.7% CP. The relative feed quality (RFQ) is also used as an indicator of how a forage will perform in an animal's diet. The oat varieties had a higher average RFQ of 191 compared to the wheat varieties of 165 and the cereal rye (ER) had a lower RFQ of 118 compared to the annual rye grass (RYE) at 168.

3.2 Palatability and Grazing Interactions

It was observed that within a 4 hour grazing period, cattle preferred the RYE and PSFO plots and were hesitant to graze ER and RMW plots. However, over a 3 day grazing period cattle more heavily grazed the ESWK, BFO, PSFO and RYE plots compared to all other plots. This observational data would suggest that cattle prefer annual ryegrass and forage oats over forage wheat and annual forage cereal rye. It should be noted that cereal rye, wheat, and oats are all widely used to extend grazing and any of these varieties could be used as such.

Pictures obtained allowed for the observation of differences in plot use by deer and cattle. Over a 10 week period, deer preferred the BMW, RMW, and X55 plots over PSFO, EK102, and RYE plots ($F_{8,72} = 4.57, P < 0.001$; Figure 2). Plot usage by deer also differed by week

($F_{9,72} = 3.30, P = 0.002$; Figure 3) with Week 10 having the fewest deer pictures and differing from all other weeks, except week 2. This study would suggest that because cattle preferred oat varieties and deer preferred wheat varieties, maximizing use of crops by both groups by planting a monoculture in one area would not be possible. Thus, planting a mixture of varieties may allow for utilization by both cattle and deer. Given the decreased usage of plots and the apparent avoidance of cattle, time when cattle removed from the area may be necessary to encourage increased deer usage. Although we were unable to test this, an alternative may be planting a large enough area to allow spatial segregation to occur between the deer and cattle. Competition for forage between cattle and deer has been documented in western rangeland, with deer using different areas or avoiding areas that had been browsed heavily by cattle [5, 6, 7]. Therefore, we had expected deer use to decrease as cattle were allowed access to the area to graze since spatially the area used was very small.

3.3 Apparent ruminal digestibility

Clippings from plots used for determination of yield and quality were persevered and at the conclusion of the

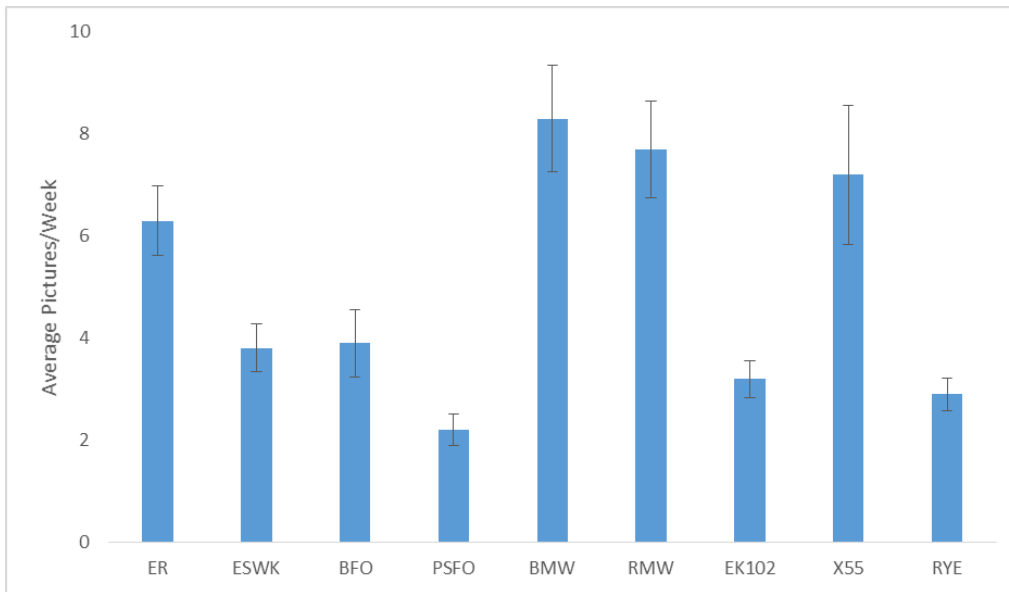


Figure 2. Deer use by plot, average number of deer pictures by week with standard error bars shown. ER = Elbon Rye (cereal rye); ESWK = ES Winter Keeper (oat variety); BFO = Buck Forage Oats; PSFO = Plot Spike Forage Oats; BMW = Buck Master Wheat; RMW = Range Master Wheat; EK102 = EK 102 (wheat variety); X55 = X 55 Wheat; RYE = Rye Grass (annual)

palatability and grazing interactions portions of the study, varieties were selected for determination of apparent ruminal digestibility. Grass hay (GH) was selected as a negative control, annual rye grass (RYE) as a positive control, Buck Master Wheat (BMW) due to deer preference, and Buck Forage Oat (BFO) due to cattle preference.

Dry matter digestibility was greater ($P = 0.005$) for RYE and BMW compared to GH and BFO (Table 3). Similar to DM digestibility both NDF and CP digestibility was greater ($P = 0.02$ and $P = 0.001$, respectively) for RYE and BMW compared to GH and BFO. This suggests that annual ryegrass and forage cereal wheat are more digestible compared to grass hay and forage cereal oats. The high NDF digestibility would suggest that forage maturation is different in the forage varieties of cereal grains compared

to the typical cereal grains. It is possible that because the end goal is not seed production then the forage maintains a more vegetative state longer, decreasing cellulose content.

4 Conclusions

More research is needed to determine cattle performance and economical returns from utilizing these cereal grains that were bred to produce forage rather than grain. Wildlife and cattle interactions were low and more research needs to be done to determine best management practices for common use land areas. Finally, because apparent ruminal digestibility is similar or greater than grass hay these forage-based cereal grains have the potential to

Table 3. Effects of forage oats and forage wheat on the apparent ruminal digestibility of rations designed for developing heifers

| | TREATMENT DIETS ¹ | | | | SEM | P-value |
|----------------------------|------------------------------|--------------------|--------------------|--------------------|------|---------|
| | GH | RYE | BMW | BFO | | |
| Digestibility, g/kg DM | | | | | | |
| DM | 316.8 ^b | 405.3 ^a | 399.7 ^a | 328.7 ^b | 1.28 | 0.0005 |
| DM, corrected for microbes | 614.1 ^b | 701.8 ^a | 684.9 ^a | 618.4 ^b | 0.68 | 0.0001 |
| NDF | 587.6 ^b | 758.2 ^a | 653.2 ^a | 616.1 ^b | 3.21 | 0.02 |
| CP | 421.7 ^b | 550.1 ^a | 537.2 ^a | 460.5 ^b | 1.73 | 0.001 |

¹Treatment according to primary forage source: GH = grass hay; RYE = annual ryegrass; BMW = buck master wheat; BFO = buck forage oats

extend grazing without adverse effects on digestion. However, further research is needed to determine which forage small grain would have the highest average daily gain, cost of gain, and net return before a single variety could be selected and promoted.

Acknowledgements: This research was supported by Eagle Seed Company and the SIU Undergraduate Research Rookies Program.

References

- [1] Jennings, J., Using cereal grain forages and mixtures with annual ryegrass for grazing, Accessed December 3, 2012. University of Arkansas Cooperative Extension
- [2] Korschgen, L. J., Foods of Missouri deer, with some management implications, *J. Wildlife Manag.*, 1962, 26, 164-172
- [3] Colligan, G. M., Bowman, J. L., Rogerson, J. E., and Vasilas, B. L., Factors affecting white-tailed deer browsing rates on early growth stages of soybean crops, *Human-Wildlife Interactions*, 2011, 5, 321-332
- [4] Springer, M.T., J. L. Bowman, and B. L. Vasilas, The effect of white-tailed deer browsing of wheat quality and yields in Delaware, *Wildlife Soc. Bull.*, 2013, 37, 155-161
- [5] Hansen, R. M. and Reid, L. D., Diet overlap of deer, elk, and cattle in southern Colorado, *J. Range Manag.*, 1975, 28, 43-47
- [6] Austin, D. D., Urness, P. J., and Fierro, L. C., Spring livestock grazing affects crested wheatgrass regrowth and winter use by mule deer, *J. Range Manag.*, 1983, 36, 589-593
- [7] Dohna H., D. E. Peck, B. K. Johnson, A. Reeves, and B. A. Schumaker, Wildlife-livestock interactions in a western rangeland setting: Quantifying disease-relevant contacts, *Prev. Vet. Med.*, 2014, 113, 447-456
- [8] Urbanek, R. E., M. F. Conlee III, C. K. Nielsen and E. M. Schaubert, Chapter 4: Impacts of outfitters on free access to white-tailed deer habitat, hunting opportunities, and local residents in Illinois, in O. P. Jenkins, editor. *Advances in Animal Science and Zoology*, Nova Publications, Hauppauge, New York, USA, 2016, Volume 9, p.123-148
- [9] Stern, M. D. and W. H. Hoover., The dual flow continuous culture system. In: *Continuous Culture Fermentors: Frustration or Fermentation?*, Workshop Handbook for NE ADSA-ASAS Regional Meeting, Chazy, NY, 1990
- [10] Weller, R. A., A. F. Pilgrim, Passage of protozoa and volatile fatty acids from the rumen of the sheep and from a continuous *in vitro* fermentation system, *Br. J. Nutr.*, 1974, 32, 341-351
- [11] Merchen, N. R. and L. D. Satter, Digestion of nitrogen by lambs fed alfalfa conserved as baled hay or low moisture silage, *J. Anim. Sci.*, 1983, 56, 943-951
- [12] AOAC, Official methods of analysis (15th ed.) Arlington, VA: Association of Official Analytical Chemists, 1990
- [13] Team, R. D. C., R: A language and environment free statistical computing, Vienna, Austria: R Foundation for statistical computing, 2010, Retrieved from <http://R-project.org>