Winter performance of North American *Bos grunniens* offered hay harvested from different forage species

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Abstract
Bos grunniens or the domesticated yak was brought to North America in the late 1800's and early 1900's. In Asia, yaks have been observed to lose 25% or more of their body weight over the winter in the high mountain altitudes. Little research has been conducted with the domesticated yak and their nutritional needs. Maintaining positive weight change during the winter is expected to improve the profitability and viability of yak production systems in North America. An on-farm study was conducted near Wellington, KY, USA to investigate the winter performance of yaks and hay type. Four outdoor grass lots approximate 0.32 hectares in size were utilized for growing yaks through the winter. Three hay types were offered to yaks and included alfalfa (*Medicago sativa*), a mixture of orchardgrass (*Dactylis glomerata*) and red clover (*Trifolium pratense*), or a mixture of common pasture cool-season grasses (Year 1) or orchardgrass (Year 2). Hay disappearance and weight change were monitored. Hay disappearance was found to be similar across the hay types when expressed as a percentage of body weight but was numerically greatest for alfalfa. Weight change was similar for alfalfa and orchardgrass-red clover mixture in both years with alfalfa having greater weight gain than the grass hay fed. Average daily gain was greatest for alfalfa and similar to the orchardgrass-red clover mixture in Year 1. In Year 2, orchardgrass-red clover mixture and orchardgrass had similar ADG. Yaks respond positively to higher forage quality in hay during the winter-feeding period.

Introduction
Bos grunniens or the domesticated yak taxonomically is a member of the Bovidae family and *Bos* genus. The domesticated yak is found primarily in the alpine meadows and steppe of the Qinghai-Tibetan Plateau and surrounding areas. The primary domesticated yak range includes the mountainous regions of central Asia, Mongolia, Russia and extends west to include the mountain ranges in Kazakhstan, Kyrgyzstan, Tajikistan, Afghanistan, Pakistan, Kashmir, Nepal, Bhutan, and India (Leslie et al., 2009; Rhode et al., 2007; Wiener et al., 2003). An estimated 14 million domesticated yaks are believed to graze in these regions (Rhode et al., 2007). The North American domesticated yak population is unknown, but there may be an estimated 3,000 to 5,000 animals. Due to their limited numbers, little research has been conducted on nutritional requirements, performance, health and other management aspects. This has resulted in cattle being utilized as a reference for animal husbandry recommendations. Lack of information has led to misinformation being shared by the community of yak owners in some instances. The intake of yaks was one potential item that was misrepresented with an intake of only 1% of body weight being shared. Cattle have dry matter intakes of 1.5-3% depending on the diet. Misinformation related to expected forage intake could have a detrimental impact on animal performance and more concerning the animal's well-being. Therefore, this study was conducted to collect on-farm information related to forage intake of growing yaks as well as gain insight on the performance of yaks during the winter-feeding period.

Methods
Research protocols were approved by the University of Kentucky IACUC. Four grass traps approximately 0.5 ha in size were constructed on the Zhi-ba Shing-ga Yak farm (37°56'00.5 N 83°29'36.6 W). Grass traps were grazed short prior to the start of the study.

Year 1

Three forage types were evaluated and included alfalfa, orchardgrass-red clover and a cool-season forage mixture representative of common pasture forages in the region. Three forage treatments were assigned to one of four pens over three periods providing four replications for each forage. Treatments were fed for a period of 44 days. The study was initiated on 11/29/2020 and terminated on 4/13/2021.

Animals utilized included two female and 3 male yaks with an average age of 181 days at the start of the study which were assigned to the same grass trap representing younger yaks. Five female yaks with an average age of 582 days were managed together in a second grass trap. Ten male yaks averaging 510 days of age at the

start of the study were assigned to the remaining two grass traps. Animals were weighed at the initiation of the study and at the end of each period. Yaks were vaccinated for clostridial diseases (Ultrabac-8, Zoetis, Inc., Kalamazoo, MI) and bovine respiratory diseases (Triangle 10 HB, Boehringer Ingelheim Animal Health USA, Inc., Duluth, GA) as well as given an injectable mineral supplement (MultiMin 90, MultiMin USA, Inc., Fort Collins, CO) and treated for internal parasites. Five animals were treated for coccidiosis approximately 85 days after the initiation of the study as a result of positive fecal tests.

Forage type was assigned to grass traps with hay offered ad libitum. Large square bales of hay were purchased. Bales were weighed prior to feeding with the remaining portion of bales weighed to calculate hay offered. A visual estimate of waste was utilized to determine hay disappearance. Forage samples were collected at the beginning of the study and sent to a commercial laboratory for analyses. Hay disappearance was corrected to a dry matter basis based on forage test results. The average body weight for the feeding period was utilized to calculate hay disappearance expressed as a percent of body weight.

Year 2

The overall trial design was similar to Year 1 with small modifications. Again, three forage types were evaluated which included alfalfa, orchardgrass-red clover and orchardgrass. Three forage treatments were assigned to one of four pens over three periods providing four replications for each forage. The trial ran from 12/9/2021 through 4/14/2022 and periods were 42 days in length.

Sixteen yaks were utilized to evaluate hay disappearance and winter performance. Three heifers and one bull calf were assigned to each of two grass traps with an average age of 226 days. A third grass trap contained four bull calves having an average age of 213 days. The fourth grass trap contained three heifers and one bull where the average age was 535 days. Animals were weighed at the initiation of the study and at the end of each period. Yaks were vaccinated for clostridial diseases (Ultrabac-8, Zoetis, Inc., Kalamazoo, MI) and bovine respiratory diseases (Triangle 10 HB, Boehringer Ingelheim Animal Health USA, Inc., Duluth, GA) as well as given a 4-gram copper oxide bolus and treated for internal parasites (Dectomax, Zoetis, Inc., Kalamazoo, MI).

Forage type was assigned to grass traps with hay offered ad libitum. Large square bales of hay were purchased. Bales were weighed prior to feeding with the remaining portion of bales weighed to calculate hay offered. Hay waste was collected, weighed and subtracted from the quantity of hay offered to determine hay disappearance. Forage samples were collected at the beginning of the study and sent to a commercial laboratory for analyses. Hay disappearance was corrected to a dry matter basis based on forage test results. The average body weight for the feeding period was utilized to calculate hay disappearance expressed as a percent of body weight.

Data were analyzed using Proc Mixed (SAS 9.4, SAS Institute Inc., Cary, NC) where the grass trap was considered the experimental unit. Variables of interest were main effects in the model with grass trap set as a random variable and period handled as a repeated measure. Least-squared means were separated using Tukey with $P<0.10$.

Results and Discussion

Forage nutrient composition is reported in Table 1. In Year 1, the alfalfa and orchardgrass-red clover were quite similar in nutrient content and calculated energy density while the mixed grass hay was lower in crude protein while being similar in calculated energy. For Year 2, the orchardgrass hay had lower crude protein than the alfalfa and orchardgrass-red clover hay and lower calculated energy. The orchardgrass-red clover hay is assumed to have been harvested at a more mature stage or had less red clover than in Year 1 based on the higher cell wall content and lower crude protein.

Table 1. Forage nutrient content for hays offered to growing yaks.

Item	Alfalfa	Orchardgrass-red clover	Mixed Grass
Year 1			
Dry Matter, %	88.8	86.8	86.6
Crude Protein, %	17.6	17.0	10.8

NDF, %	43.9	48.2	54.9
ADF, %	33.0	35.1	38.7
Net energy Maint., mcal/kg	1.23	1.39	1.25
Net energy Gain, mcal/kg	0.66	0.81	0.68
	Alfalfa	Orchardgrass-red clover	Orchardgrass
Year 2			
Dry matter, %	93.4	93.4	88.1
Crude Protein, %	17.6	12.3	10.4
NDF, %	45.0	53.6	54.1
ADF, %	39.1	44.1	45.1
Net energy Maint., mcal/kg	1.34	1.25	1.01
Net energy Gain, mcal/kg	0.77	0.68	0.46

Growing yak gain was found to differ by hay type. In Year 1, alfalfa hay supported greater period weight gain and average daily gain ($P<0.10$) than mixed grass hay. Due to the high degree of variability, orchardgrass-red clover was similar in performance to both forage types though numerically the weight change was more like alfalfa being positive. Part of this variability may be due to the yaks which were found to have significant coccidia levels which would reduce nutrient absorption and induce gut inflammatory response leading to reduced performance.

Year 2 animal performance yielded similar results with alfalfa supporting greater weigh gain and average daily gain ($P<0.10$) compared to orchardgrass hay. Orchardgrass-red clover hay weight gain did not differ from either alfalfa or orchardgrass being intermediate. Calculated average daily gain was found to be similar ($P>0.10$) to orchardgrass and less than alfalfa. When comparing animal performance to the previous year, it is noted animals had lower daily gains numerically than Year 1. This may partially be attributed to younger animals in Year 2, colder temperatures and partially due to slightly lower hay quality, except for alfalfa. Daily gains for yaks vary based on dietary nutrient supply. The gains observed in this work are in agreement with previously reported gains for yaks consuming a forage-based diet (Xue et al., 2007). Hay disappearance when expressed as a percent of body weight on a dry matter basis did not differ ($P>0.1$) among hay types during either year ranging between 2.2% and 2.7%. Yaks offered oat hay were found to have voluntary intakes near 1.9% of body weight (Wang et al., 2011). The findings in the current study as well as previous research suggests that yaks have daily intakes greater than 1% of body weight.

Table 2. Winter performance of growing yaks offered different hay types during the winter.

Item	Alfalfa	Orchardgrass-Red Clover	Grass	SEM	P-value
Year 1					
Weight change, kg	10.0^{a}	$8.4^{a,b}$	-5.0^{b}	3.5	<0.10
ADG, kg/d	0.23^{a}	$0.19^{a,b}$	-0.11^{b}	0.18	<0.10
Hay DM disappearance, % BW	2.69	2.29	2.24	0.19	0.26
Year 2					
Weight change, kg	7.4^{a}	$4.9^{b,c}$	4.4^{c}	0.6	<0.10
ADG, kg/d	0.17^{a}	0.12^{b}	0.10^{b}	0.01	0.05
Hay DM disappearance, % BW	2.52	2.28	2.30	0.24	0.75

^{a,b,c} Least-squared means within a row with unlike superscripts differ significantly $P<0.10$.

Due to the limited number of available growing yaks, animals differing in both age and sex were used. This may contribute to some of the differences when comparing across years and forage types. Additionally, as this was an on-farm study conducted outdoors in grass traps, the animals were subjected to variation in climate conditions. As the animals entered the last period, pasture forages were beginning to grow as well and variability in spring forage availability may have slightly affected the outcome of the last period contributing to variability in performance. Lastly, there may have been cover-over effects from the previous hay type offered. Given the lower rate of gain shortening the length of the feeding periods was deemed unacceptable to assess animal performance. This combined with the limited time available due to pasture green-up, no washout period was used, and one should not rule out the possibility of carry-effects. These are some of the challenges inherent with on-farm field trials.

Conclusions and/or Implications

Alfalfa forage provided the greatest winter performance for growing yaks. Depending on the quality of orchardgrass-red clover hay, this combination is expected to support similar winter gains as alfalfa when the protein and calculated energy content is similar. Given the length of time required to reach harvest weights, 3-4 years, maintaining positive weight gain during the winter is essential to improve production efficiency and profitability of yak systems for meat production in North America. Additionally, hay disappearance was observed to be similar to reported values for beef cattle and much higher than the 1% of body weight commonly mentioned in the media. This information adds to the limited information available regarding yak production in North American and will be useful to yak producers for developing winter feeding programs for growing yaks.

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