

Diet choice and parasitism in *Bison bison* calves and bulls of the National Bison Range

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ABSTRACT

A routine summer analysis of bison parasite infection was coupled with an observation on the effects of parasitism on bison diet choice at the National Bison Range, Moiese, Montana. Bison were sampled at two locations: Saint Jon's creek and West Display. Fecal flotation and lungworm Baermann's tests were utilized for parasite analyses and microhistological analysis for diet monocot-dicot percentages. Diet and parasite comparisons were done exclusively on bulls and calves, due to difficulties in identifying cow feces. Statistical tests using one-way ANOVAs were used to determine effects of parasites and diet by age class, herd size, and location. Chi-square analyses were used to compare parasite incidence with age class, location, and herd size. A linear regression was used to compare nematode infection densities and monocot percentages. Nineteen of 33 bison examined had intestinal parasites. Monocots accounted for 76% of bull diet, while monocots accounted for 86% of calf diet: bulls and calves had similar diets. Bulls grazing in Saint Jon's Creek ate more monocots than bulls grazing West Display ($p=0.010$). Parasite incidence was similar for age class, location, and herd size. There appeared to be some effect of age class (bulls vs. calves) on diet ($p=0.1176$) and herd size on parasite density ($p=0.1791$). Calf diet did not respond significantly to parasite density ($p=0.3180$), nor did bison diet ($p=0.4432$). Finally, a relationship was observed between parasite density and diet for calves and bulls combined ($p=0.1861$).

Key Words: National Bison Range, nutrition, parasite, diet choice, *Bison bison*

INTRODUCTION

Herbivore health and fitness has often been associated with diet selection (Coop and Kyriazakis 1999). Animals want to maximize energy intake as well as obtain essential nutrients in order to fuel their bodies for growth, repair, and reproduction, (Belovsky 1986; Coop and Kryriazakis 1999). However, limited space, competition, and seasonal changes in food abundance and distribution place constraints on where food can be obtained. Herbivores face nutritional and physiological consequences for the foods they choose to eat, making foraging decisions complex.

A common cost of herbivory that has not been widely studied is gastrointestinal parasite acquisition. Trade-off theory has been used to describe foraging behavior when certain grazers are faced with the costs of parasitism and the benefits of increased nutrient intake (Hutchings *et al.* 2003). Nutrient rich areas also may happen to be parasite concentrated areas; feces not only deposit nutrients in the soil, producing relatively nutrient rich forage patches, but feces deposit parasites as well. Animals grazing these patches have access to greater nutrients, but also may be exposed to parasites. These costs and benefits may alter their foraging.

Avoiding Parasites

Herbivores have used foraging decisions to avoid and even lower parasite levels (Lozano 1998). For example, since herbivores cannot directly detect parasitic nematodes, the presence of feces serves as a clue of contamination (Cooper *et al.* 2000). When herbivores are faced with grazing feces contaminated and non-contaminated swards, they avoid the contaminated sward---a trend demonstrated by sheep and cows in agricultural systems (Bao *et al.* 1998; Hutchings *et al.* 1998; Cooper *et al.* 2000) and by sheep and reindeer in natural systems (van der Wal *et al.* 2000; Hutchings *et al.* 2002). Of course, as non-contaminated grazing area decreases, the chance of encountering feces and risking infection increases (Haynes and Williams 1993). If animals do have to graze contaminated areas, they may have to adapt behavioral strategies to reduce parasite intake (Hart 1990). For example, herbivores graze the upper portion of contaminated swards to avoid the parasites in the lower portion (Hutchings *et al.* 1998). Interestingly, the top of the sward happens to be the most nutritious part of the plant (Hutchings *et al.* 1999). It

may be difficult to say then whether animals graze the top of the sward to avoid parasites or to obtain more nutrients.

Avoidance of contaminated swards is stronger among parasitized grazers compared to non-parasitized grazers. Parasitized grazers almost entirely avoid contaminated swards, and graze only the top of contaminated swards (Hutchings *et al.* 1998). These animals may be responding to the costs of parasitism, damaged gastrointestinal tissue and an increased risk of mortality (Bown *et al.* 1991).

Fecal clues are not always a reliable way to determine contamination, because certain parasites remain after the feces have decomposed (Hutchings *et al.* 1998). For example, certain nematode eggs, for example, become migratory larvae only after several weeks (Familton and McAnulty 1997). Certain parasites directly released as infective migratory larvae may find ways to invade grazer's mouths. For instance, parasites like the cattle and bison nematode *Dictyocaulus viviparus* do not remain in the lower portion of the sward. Rather, they may migrate up grass blades, or they may attach to the *Pilobus* fungus common in cattle feces. The fungus releases spores, distributing the larvae as far as 10 feet away from the fecal pat (Haigh *et al.* 2002). Herbivores may not always successfully reduce parasitism by avoiding feces contaminated swards.

Nutrition and Parasites

Once parasitized, herbivores largely rely on their acquired immune system to combat infection (Hutchings *et al.* 2003). The acquired immune system appears in two phases: acquisition of immunity, in which an animal recognizes parasite invasion, and expression of immunity, in which the host's body launches a cellular and humoral response to infection (Hutchings *et al.* 2003). Allocation of nutrients in the host's body,

therefore, depends on what phase the animal is in. For example, growing animals that are naïve to parasites will prioritize immune acquisition to growth. In contrast, growing animals with prior experience to parasitism prioritize growth over the expression of immunity (Coop and Kyriazakis 1999). It has been observed that the effects of diet on acquisition of immunity are limited (Bown *et al.* 1991; Coop *et al.* 1995). However, diet does have a significant effect on the expression of immunity (Mansour *et al.* 1991; Coop *et al.* 1995; Houdijk *et al.* 2001).

Host intake of protein, in particular, can greatly effect the expression of acquired immunity in cattle, sheep, goats infected with gastrointestinal nematodes (Mansour *et al.* 1992; Coop *et al.* 1995; Singh *et al.* 1995). Several studies have shown that an increased supply of protein can reduce gastrointestinal worms in growing and pregnant sheep (Bown *et al.* 1991; Coop *et al.* 1995; Donaldson 1998; Kyriazakis and Houdijk 2006). Since growth and reproduction are prioritized over the expression of immunity (Coop and Kyriazakis 1999), growing animals and pregnant or lactating females need an extra nutrient rich diet to overcome disease. Most studies have been done on the effects of protein nutrition on resistance to gastrointestinal nematodes (Coop and Kyriazakis *et al.* 1999). This makes sense as energy nutrition (carbohydrates) has a small effect on immunity (Houdijk and Athanasiadou 2003) and many components of the immune system rely on protein materials (Coop and Holmes 1996).

There is a wide body of evidence that feeding behavior is affected by an animal's physiological state. Naturally grazing lambs, for example, select diets higher in protein in response to parasitism (Cosgrove and Niezen 2000). However, whether the change in diet was enough to greatly improve resistance to parasites is unknown (Hutchings *et al.*

2003). Improved parasite resistance was observed among parasitized sheep and goats when they selected more nutritious diets (Aumont et al. 1984; Kyriazakas 1994, 1996).

Kyriazakis and Houdijk (2006) use the term “immunonutrition” to describe the way in which nutrition may be used to improve resistance to parasites. Improved resistance means lower worm burdens and nematode egg counts. So far, aforementioned studies show that mothers and growing animals benefit most from protein supplemented diets and that ruminants in controlled feeding experiments selectively choose more nutrients in response to parasitism. However, little seems to be known about feeding response to parasitism among naturally grazing ruminants. In contrast to being hand fed, these ruminants freely graze an open area.

Interest in host nutrition and parasitism has developed in response to growing needs for controlling ruminant parasites (Coop and Kyriazakis 1999). Hopefully, better knowledge will reduce reliance on chemotherapy to treat infected animals in artificial as well as natural grazing systems.

The goals of this study are to measure diet and gastrointestinal parasite load from naturally grazing *Bison bison* and determine whether they are related. In order to observe effects of age on diet, calves and bulls are studied. Calves represent grazers that are still growing and still acquiring immunity while bulls are mature and have acquired immunity. Female cow diets are not studied for practical purposes: it is difficult to identify female fecal patties. In this case, females graze in large herds mixed with calves and a few young males and bulls. Large herds make it difficult to identify individuals when collecting fecal samples, because they are easily driven away before one can identify them. Bull herds, which are much smaller, do not present this problem. Finally,

while it may be difficult to identify individual calves in a large herd, calf feces are easily identified based on their relatively small size.

Bison graze primarily on monocots (grasses), but also on dicots (forbs and shrubs). Grasses are expected to dominate bison diets based on previous diet analyses. For example, monocots (grasses and sedges) accounted for 99% of bison diet on a ranch in Southern Utah (Vuren 1984). Monocots composed 98% of bison diets across all seasons in an Oklahoma study (Coppedge *et al.* 1998). Diet composition among bulls and cows at the National Bison Range had 97.8% grasses (Mooring *et al.* 2005). In addition to being more abundant on the landscape, monocots are generally require less energy to digest: however, dicots contain higher amounts of protein and gross energy than monocots (Golley 1961; unpublished work, Bison Range files).

Greater incidence infection is expected among calves, the age class most susceptible to parasites, especially during summer months (Berezowski 2001). Presumably, calves will be at a phase of acquiring immunity, which means their diets will be affected parasitism. Specifically, they may choose fewer monocots and more dicots in response to parasite loads. This makes sense, because dicots have more protein, and growing animals need extra protein to resist parasites. Bulls, on the other hand, have acquired immunity and will not be growing as rapidly (if at all) as calves. (Bulls continue growing until nine to ten years of age). Parasitism should not significantly affect the amount of monocots bulls are eating.

Parasites in this study are identified by the genus. The genus *Ostertagia* has been associated with bison disease Type II ostertagiosis, which has been linked to bison mortality (Haigh *et al.* 2002). At least 20,000 adults worms have to infect cattle

individuals in order for disease to develop: effects of infection include rapid weight loss, diarrhea, anemia, a dull coat, neutrophilia, hypoproteinemia, and death (Wade *et al.* 1979). Lungworms of the genus *Dictyocaulus* are also important parasites that have been isolated from bison in North America and Canada. Clinical signs of lungworm infection include a cough, increased respiratory rate, slight nasal discharge, increased heart rate, and mild fever (Berezowski 2001).

Data for studying diet selection and parasitism were collected from bison at the National Bison Range (NBR), in Moiese, Montana. While the project focused on the effect of parasitism on diet selection, another goal was to obtain a general survey of parasite infection among bison on the NBR. Routine fecal sampling has been implemented every summer at the NBR to monitor bison health. Fecal analysis was employed to determine abundance of gastrointestinal nematodes in bison and bison diet choices.

MATERIALS AND METHODS

Study Site

Plant distribution at the Bison range is as follows: monocots comprise 70% of the vegetation while dicots comprise 30% (Belovsky and Slade 1986). The NBR has a hot arid summer environment, producing very dry foliage for most of the summer; however, foliage was still green for the duration of the fieldwork.

Bison are managed on a rotational grazing system: rather than continuous concentrated grazing in one area, they change grazing areas at least three-times a year. For the duration of the project, in which field work was done at the end of June, female

cows were raising calves in large herds while males were generally grazing separately in small herds. The rutting season was just beginning as field work ended.

Field and Lab Work

There are 350 bison grazing the range in different sized herds: small, bull herds or large, mother-calf herds. Three different herds were examined: 1 small herd and 1 large herd near Saint Jon's creek in Alexander Basin and 1 small herd in the West Display area.

In order to obtain an adequate representation of the population, at least 30 samples were required for parasite analysis (Dr. Lee Jones, pers. comm.). Random samples (n=33) from fresh bison patties were collected from Alexander Basin and West Display. These included feces from 1 young male, 9 calves, 12 bulls, and 12 bison of unknown sex and age (Table 1). The calves and unknowns all came from the mother-calf herd. Bulls were identified as males ≥ 8 yrs and calves patties were identified by their relatively small size. It was not possible to identify individual female cow patties.

Table 1. Samples and locations.

	South John's Creek	West Display
*Bulls	6	4
Males (unknown age)	3	
Calves	9	
Unknowns (sex and age)	12	

*Including one male age 3-4

To test for parasites, 40 g of each sample (n=33) were sent to the Montana Department of Livestock (MDL) lab for fecal flotation and lungworm Baermann's tests.

Microhistological analysis of plant fragments was used to measure bison diet (Sparks and Malechek 1968). For this process, samples (n=18) from bulls and calves were oven dried (60°C) for 48 hours, then ground with a coffee grinder until uniformly fine. They were mounted on microscope slides, 5 slides per sample, with Hoyer's solution and analyzed under a compound microscope (125x). Relative monocot and dicot amounts were determined by reading 10 fields per slide and counting the presence of identifiable plant fragments. An electronic plant microhistological index was used as a reference (Dave Choate, unpubl data). Slide making and analysis was a time consuming process that limited the diet sample size to n=18. However, the sample size was divided equally between bulls and calves and considered adequate for a pilot study.

Statistics

Relative monocot-dicot abundance per sample was calculated by dividing the total number of monocots or dicots identified by the total number of plant fragments found in 50 fields. JMP IN 5.1 software was used for statistical analysis. Monocot percentages were compared by age class and by location using a one-way ANOVA test.

Lab results from MDL were used to calculate parasite incidence and density (number of individuals per gram of sample). Using the data for all individuals (n=33), parasite density were compared by field location where samples were gathered using a one-way ANOVA. A Chi-square analysis was used to compare parasite incidence with location and age class. Finally, a linear regression was used to see whether a relationship existed between monocot percentages and parasite density by location and age class (bulls and calves only).

RESULTS

Bison diets were dominated by grasses (Table 2). Overall, there appeared to be some effect of monocot percentages by age class bulls vs. calves ($F=2.7357$; $df=1, 16$; $p=0.1176$). Bulls grazing Saint John's area ate more monocots than bulls grazing West Display ($F=12.2174$; $df=1, 7$; $p=0.0101$).

Table 2. Percent monocot in bulls and calves (n=18).

	%Monocot
Bull	*86.390, **63.768 ***76
Calf	*85.832

* South John's area ** West Display ***Average

Nineteen of the 33 bison examined had intestinal parasites, and seven of the bison had lungworms of the genus *Dictyocaulus* (Table 2). The number of parasites per amount of sample (parasite density) for the lungworm Baermann's test (30 g) and the fecal flotation test (10 g) was very low. Average parasite density between bulls and calves was very low, 2.15 (Std Dev=3.53) and 5.65 (Std Dev=9.14) parasites per gram of feces, and not significantly different ($F=1.1346$; $df=1, 15$; $p=0.3036$). A large majority of the parasites came from the group of genera Cooperia, Trichostrongylus, and Ostergatia (Table 3). Parasite density analyses on the entire sample group (n=33) produced no significant results. However, herd size seemed to have an effect on the parasite density ($F=1.8893$; $df=1, 31$; $p=0.1791$). Location appeared to have no effect on parasite density ($F=0.9774$; $df=2, 30$; $p=0.3287$).

Parasite incidence was similar in bulls and calves ($\chi^2=0.798$; $p=0.6708$). Parasite incidence was also similar between bulls at Saint Jon's creek and Bulls at West Display ($\chi^2=0.090$; $p=0.7642$). Finally, parasites occurred equally in all herd sizes ($\chi^2=0.676$; $p=0.4110$).

Table 3. Fecal flotation and lungworm Baermann's test results (n=32).

Genus	No. Individual Parasites
Cooperia	2120
Trichostrongylus	
Ostergatia	
Nematodirus	20
Strongyloides	20
Dictyocaulidae (lungworm)	17
	Absent/Present
Moniezia	4
Thysanosome	

Linear regression was used to test for a relationship between monocot percentages and parasite density. Calf diet did not respond significantly to parasitism ($p=0.3180$), nor did bull diet ($p=0.4432$). The test did show that parasite density had some effect on monocot percentages for calves and bulls combined ($n=17$; $R^2=0.113501$; $p=0.1861$).

DISCUSSION

As expected, bison diets were dominated by grasses. However, the percentages were lower compared to the estimates above: 98% in Utah and 99% in Oklahoma. This was expected, because of limitations within the microhistological process, which focused on plant cell walls: only a few morphological characteristics were used to identify monocots from dicots. Consequently, plant estimates calculated for the study were viewed as relative rather than absolute indicators of the percent monocot-dicot eaten. Even so, it may be that bison were eating fewer monocots than expected because of the

relatively low number of monocots (70%) on the Range. This is a complicated argument, however, because samples were taken at only one point in time. It would have been useful to monitor diet over the summer to obtain averages on monocots and dicots consumed. A larger sample size would also have been useful: Mooring *et al.* (2005) used 200 fecal samples for diet analysis.

The significant difference in diet between bison in the Saint John's creek area vs. West Display may have been due in part to differences in plant distribution. There may have been significantly fewer monocots to graze on at West Display. However, dicots are more numerous than monocots in June (Gary Belovsky, pers. comm.). It would be interesting to investigate bison diets further to determine whether they truly eat relatively higher dicot amounts and what physiological effects result from a richer nutrient diet. While dicots contain more protein, they are often toxic and reduce digestibility (Iason 2004).

Overgrazing has historically been a problem on the NBR. It can change plant distribution dramatically, favoring more dicots to monocots (Jeffrey Ross, perso. comm.). If this has been the case on the bison range, bison may have fewer than desirable monocots to graze. They may have to make up for the difference by grazing more dicots. This is a problem for bison, because they have to be careful not to accumulate too many plant toxins. If dicots are more abundant but unpalatable, bison may graze less altogether.

The effect of herd size on parasite load may warrant further investigation. With a bigger sample size, it is likely large herds (ie mother-calf) would show greater rates of parasite infection. This was often the case for buffalo herds in Egypt (El-Magdoub *et al.*

1999). With larger herds, there is an increased chance of encountering feces and parasites. Calves and mothers grazing together may pass parasites to each other more easily than bulls, because they graze together in large groups. However, this may be difficult to determine unless the concentration of individuals in an area is known. Bison in large herds may be distributed in such a way to avoid feces or parasites. Nonetheless, calves were expected to have more parasites than bulls, because of their innocent immune systems, which would have been compromised by their relatively high growth rates.

It was difficult to find significant relationships between parasitism and diet, because of low parasite abundance and distribution, and because of few diet samples. The number of diet samples was limited by time constraints. Projects were conducted over a three week period: it would have been impossible to read slides for more than eighteen samples. The sample size was considered adequate for a pilot study.

Finally, it should be noted that animals that have acquired immunity may continue to be parasitized for the rest of their lives: an increase or decrease in protein intake should not reflect a response to parasitism. This makes it difficult to predict whether or not changes in diet affect parasite load among animals that have acquired immunity, such as bulls. If this were the case, then it would be inaccurate to compare bulls with calves. It may have been useful to focus on calf diet and to monitor the response to parasitism on individuals over a longer period of time.

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