

The association between hunting and the feeding and vigilance times of American bison in North Dakota and Montana

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SUMMARY

Bison being a keystone species makes understanding the impact that hunting can have on their behavior vital to their ecological recovery. Prior studies have explored the effects of hunting on reproductive behavior and stress levels in ungulates; however, the effects of hunting on feeding and vigilance of American bison (*Bison bison*) have not yet been explored. We hypothesized that feeding times of bison in the hunted populations would be significantly shorter than that of bison in the non-hunted population and vigilance times would be significantly longer than that of bison in the non-hunted population. We utilized focal animal sampling while observing videos of bison from two hunted populations and one non-hunted population, and the feeding and vigilance times of individual bison were recorded. Notably, we found significant differences in feeding and vigilance times of bison in the hunted and non-hunted populations. However, these differences did not support our original hypothesis; bison in hunted populations spent more time feeding and less time vigilant than bison in the non-hunted population. The results of our study differed from previous investigations of ungulates, however, as noted in prior elk studies, the hunted bison may have fed more and were less vigilant because they encountered periods of safety within the observed times. Future studies investigating the association between hunting and bison behaviors could use populations of bison that are hunted more frequently, which may provide different results.

INTRODUCTION

Hunting is a common activity in the United States but can have serious consequences for the hunted populations (1). Understanding the effects of hunting on wildlife behavior is pertinent to making educated management decisions, such as setting hunting regulations to protect species that are essential to a properly functioning ecosystem. Previous studies illustrated that hunting by predators, including humans, affects prey behavior, which in turn influences the prey's overall health and the stability of the population (2-5).

The stability of a population, including its size and birth rate, is an indicator for the risk of inbreeding and the population's ability to adapt to environmental change (6). Several studies have previously investigated the effects that hunting can have on aspects of feeding habits, vigilance, moving, and resting of various species. However, the influence of hunting on feeding and vigilance behaviors of American bison (*Bison bison*) has not been documented.

American bison were a source of food, tools, clothing, and trade for Native North Americans for centuries (7). Once Europeans settled in North America, the increased demand for bison products resulted in excessive hunting, which, in conjunction with exotic disease and habitat loss, led to the near extinction of the species (7). In 1890, there were merely 600 bison remaining when American and Canadian ranchers sought to protect them. They urged their governments to create areas where the population could be confined and bison numbers could grow and stabilize (7). The relatively small and protected population of bison has grown into the hundreds of thousands of bison that now live on Native American reservations, ranches, farms, and in national parks across North America and Canada. Hunting on reservations and ranches is often regulated, and bison on farms are raised for commercial meat production (5). To maintain the existing population of bison and recognize their historical importance, the National Bison Legacy Act was signed in 2016, making bison the first national mammal of the United States. To improve the long-term sustainability of the American bison, studies related to these confined bison are essential.

The health of American bison has economic and ecosystem prominence. Hunting is a widespread activity in the United States and hunters pay to hunt "trophy" animals. However, bison behavior may be affected by hunting events that can negatively impact their wellbeing. If bison are not in the best of health, they will no longer be "trophy" animals and hunters may not want to pay to hunt these animals. Native American reservations that allow restricted hunting often rely on hunters as a source of revenue to support their reservations; without hunters, they may lose money and would no longer be able to protect bison populations (8). More importantly, bison are a keystone species within their prairie ecosystems, meaning they play a central ecological role in their environments

(9). If bison behavior is negatively impacted by hunting, the trophic food chain of the ecosystem may be altered, which would affect the biodiversity of the ecosystem. Although the present study focuses on bison in confined locations where they did not interact with their natural habitats, the questions and conclusions discussed can be applied to wild populations of bison, which interact with their natural ecosystems, that are also hunted by humans.

Lima and Dill explored the effects of predation on the feeding behavior of prey such as birds, mice, and aquatic animals and discovered that animals make foraging decisions such as when and where to feed, what to eat, and how to handle food based on the risk of predation (3). For example, nocturnal animals reduce foraging during a full moon to avoid predators (3). Similarly, Anderson found that small mammals feed in areas that have maximum ground coverage (10). Ferguson *et al* reported that caribou preferentially feed in areas with low food availability over areas with high food availability, where they could be easily hunted by wolves (11). Although these studies focused on the effects that hunting by natural predators have on prey, hunting by humans can cause similar, if not greater, effects (2, 4). Impala (*Aepyceros melampus*), greater kudu (*Tragelaphus strepsiceros*) and sable antelope (*Hippotragus niger*) frequent waterholes at night rather than in daylight to avoid human hunters (12). Additionally, Santos *et al* found that secretion of cortisol, a hormone that responds to stress, by red deer (*Cervus elaphus*) was higher when the animals were hunted by humans than by natural predators, indicating that hunting by humans has a greater impact on the animals' stress levels (4).

Ciuti *et al* showed that elk became more vigilant due to human disturbances, such as motorized vehicles and hunting, which caused a decrease in their foraging time (2). Vigilance is the act of being alert, especially to avoid harm. Likewise, Berger *et al* found that pronghorn antelope (*Antilocapra Americana*) experienced increased vigilance due to human disturbances such as hunting, motorized vehicles, and recreational activities (13). Vigilance takes time and energy away from fitness enhancing activities such as feeding, grooming, resting, and mating and is often caused by the risk of predation; a greater risk of predation often leads to increased vigilance (5, 14). Hunter and Skinner studied vigilance in African ungulates (hooved mammals) and found that impala and wildebeest experienced increased vigilance behavior when exposed to predation by African cats (14). Similarly, Laundre *et al* discovered that bison and elk in Yellowstone National Park exhibited increased vigilance when wolves were reintroduced to the community (15). This vigilance was at the expense of foraging and was correlated with increased movements by the animals (15). The surviving animals of a hunted population may experience increased stress, which can lead to changes in their natural behavior that ultimately affect the stability and number of individuals of a population. If a population can no longer adapt to change, they may be threatened by extinction. This can apply to any

hunted population, even those in protected and regulated areas. An important and underreported aspect of hunting by humans is how hunting influences American bison, the largest land mammal and ungulate in North America.

In our study, we explored the question, how does hunting by humans alter the feeding and vigilance time of American bison. We hypothesized that the feeding times of bison in the hunted populations would be significantly shorter than that of bison in the non-hunted population and vigilance times would be significantly longer than that of bison in the non-hunted population. To investigate bison feeding and vigilance times associated with hunting, we analyzed videos of bison herds recorded from two hunted locations in North Dakota and one non-hunted location in Montana.

RESULTS

Understanding the behavioral effects hunting can have on bison impacts the bison population and the species in their ecosystem. The hunted populations were from Standing Rock Indian Reservation and the non-hunted population was from Snowcrest Ranch. Videos recorded from each location were analyzed and the time spent feeding and vigilant by individual bison was documented and these results were analyzed.

After observing bison for approximately 100 hours, the total times spent feeding and spent vigilant for each bison were recorded during a five-minute observation period. The percentages of times spent feeding and spent vigilant, during the total time observed (within the five-minute videos), were calculated for each individual bison (**Appendix A, Tables A1-3**). Kolmogorov-Smirnov (K-S) tests for normality indicated that neither the feeding nor vigilance data (including hunted and non-hunted populations) were normally distributed ($p=0.006$ and $p=0.004$, respectively). A Mann-Whitney U test indicated that there was a statistically significant difference in both the percentage of time feeding and vigilant between the hunted and non-hunted populations (**Table 1**). Since the data was not normally distributed, the medians were a better representation of the data than the means.

Median feeding time was longer in the hunted populations compared to the non-hunted population, with the medians being 0.74 and 0.25 respectively (**Figure 1**). Additionally, the

Table 1. Results from Mann-Whitney U Test for feeding times and vigilance times between hunted and non-hunted populations.

Behavior	U-value	p-value*
Feeding	816	0.0096
Vigilance	731.5	0.0014

NOTE: * = significant $p<0.05$ These values were found using an online calculator for a Mann-Whitney U test and the data used were the times spent feeding and vigilant for each bison from the hunted populations and the non-hunted population. The values from each population were compared in the test.

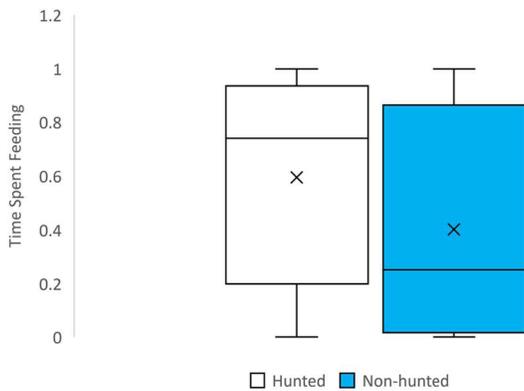


Figure 1. Box and whisker plot for feeding times of hunted and non-hunted bison. The top and bottom whiskers represent the maximum and minimum values, respectively. The X represents the mean of each data set (47 bison in the hunted and 50 bison in the non-hunted).

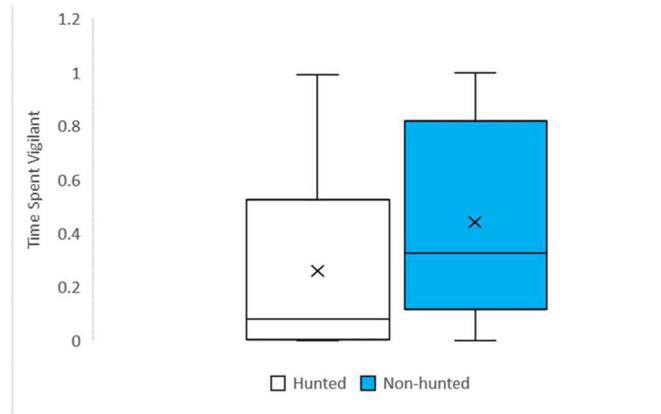


Figure 2. Box and whisker plot for vigilance times of hunted and non-hunted bison. The top and bottom whiskers represent the maximum and minimum values, respectively. The X represents the mean of each data set (47 bison in the hunted and 50 bison in the non-hunted).

median vigilance time was longer in the non-hunted population compared to the hunted populations since the medians were 0.36 and 0.08 respectively (Figure 2).

Kolmogorov-Smirnov (K-S) tests were also conducted for the feeding and vigilance data of the two hunted populations (West Pasture and North Pasture) and indicated that both sets of data were not normally distributed ($p=0.049$ and $p<0.001$, respectively). The Mann-Whitney U test conducted for the feeding times indicated no significant difference, while the test for the vigilance times indicated that the data from the two hunted populations was significantly different (Table 2).

DISCUSSION

To determine the effects hunting by humans can have on the feeding and vigilance times of bison, videos were recorded from populations of hunted and non-hunted bison and were analyzed. Our results demonstrated that although there was a significant difference in the feeding and vigilance times of bison from Standing Rock Indian Reservation (hunted) and Snowcrest Ranch (non-hunted), the hunted populations did not feed for less time and were not more vigilant than the non-hunted population, as we hypothesized. In fact, the

bison on Standing Rock spent more time feeding than the bison at Snowcrest Ranch (Figure 1). Additionally, the bison on Standing Rock spent less time vigilant than the bison on Snowcrest Ranch (Figure 2). Therefore, our hypothesis that feeding times of bison in the hunted populations would be significantly shorter than that of bison in the non-hunted population and that vigilance times would be significantly longer than that of bison in the non-hunted population was not supported by the data.

It is important to consider that there were many bison that were resting during the videos taken from Snowcrest Ranch and none during the videos from Standing Rock Indian Reservation. This may be indicative of the bison being more relaxed and at ease, although the time of day could also be a factor in this. Additionally, Creel *et al* found that hunted populations of elk spent more time feeding and less time vigilant within short periods of time where they felt safe (16). Within these periods, the elk fed as quickly and as much as they could because they did not know how long they would be safe from predators (16). Since the bison on Standing Rock in this investigation had similar behavior to the elk in Creel *et al* during the five-minute observation periods, they may have felt safe during those times, leading to them feeding more and being less vigilant than the non-hunted population of bison. There may be temporal variation of risk, meaning the animals had periods of time where there was no imminent threat, which caused the elk and bison in the hunted populations to feed quickly in times of safety (16).

The results of this study could also be due to a critical hunting frequency that needs to be met for bison behavior to be impacted that was not met at the locations in this study. West and North Pastures at Standing Rock Indian Reservation were hunted relatively infrequently (only hunted two days/year and four months/per year, respectively). It is possible that the amount of time that the bison were hunted did not negatively impact their behaviors. Ciuti *et al* reported

Table 2. Results from Mann-Whitney U Test for feeding times and vigilance times between hunted populations (West Pasture and North Pasture).

Behavior	U-value	p-value*
Feeding	203	0.1527
Vigilance	154.5	0.0135

NOTE: * = significant $p<0.05$ These values were found using an online calculator for a Mann-Whitney U test and the data used were the times spent feeding and vigilant for each bison from the hunted populations in Standing Rock Indian Reservation, West Pasture and North Pasture. The values from each population were compared in the test.

that hunting by humans and recreational activities resulted in changes in elk feeding behavior, but the areas studied were visited year-round and were hunted for approximately six months, as compared to the two days of hunting and four months of hunting at the locations in this study (2). The elk in Ciuti *et al* were exposed to hunting and human activities more frequently than the bison hunted at Standing Rock Indian Reservation (2). The difference in vigilance behavior between the two hunted populations (Table 2), may be correlated to the difference in the time the populations were hunted.

The bison in this study were viewed for a relatively short length of time (approximately five min/bison); therefore, the data collected may not portray the bison's true feeding behavior. Feeding and vigilance behaviors are more challenging to consistently observe than other types of behavior. Therefore, for future bison behavioral studies, collecting data directly in the field for a longer period may give a clearer understanding of the relationship between hunting and the feeding and vigilance behaviors of bison.

Uncontrolled or unrecorded variables in this investigation, such as temperature and weather, could have a stronger effect on feeding times than hunting does. For example, Pedersen *et al* found that temperature affected the resting times but not the feeding times of European bison (*Bison b. bonasus*) (17). Recording environmental variables, such as temperature and weather, during observation periods could lead to a greater understanding of the range of effects these variables could have on bison behaviors. Similarly, the quality of the habitat may affect the lengths of time spent feeding by animals. The hunted locations in North Dakota have woodland terrains while the non-hunted location in Montana is grassland (18, 19). The bison at Standing Rock Indian Reservation may have fed for more time because there was more forage available to them.

If collecting data directly in the field proves difficult, alternatives include using drones, which would record bison herds from above. This would make the area covered in each video wider, allowing the bison to be better observed without going out of frame. Additionally, the definition of vigilance has varied among different researchers, and the definition of vigilance in this study may have provided less accurate results than other definitions of vigilance (13-15, 20). It would be beneficial for future studies to investigate the different outcomes for one definition of vigilance versus another to establish if following certain definitions alters the recorded lengths of time spent vigilant by animals.

Understanding the importance of hunting on bison behavior will help wildlife managers maintain robust, sustainable populations of bison. The management of bison populations is a prominent component of maintaining not only the populations, but also the ecosystems they inhabit. Bison are a keystone species within their prairie ecosystems, meaning bison populations affect every other aspect of their ecosystems, such as the growth of grasses, the number of other herbivores and the number of predators in the area (9). If bison numbers plummet, their ecosystems' biodiversity



Figure 3. Locations of Bison Populations a) Standing Rock Indian Reservation b) Snowcrest Ranch. Standing Rock Indian Reservation in North Dakota is home to the hunted populations of bison (West Pasture and North Pasture). Snowcrest Ranch, in Montana, is where the non-hunted population of bison lives.

and processes will be jeopardized. It is important to not only manage hunting of confined populations of bison but wild populations as well. The results of this investigation can be applied and utilized in maintaining wild populations of bison for those populations and their ecosystems to prosper.

METHODS

Study area

Bison were observed in two confined locations (Figure 3). The first location was Standing Rock Indian Reservation in North Dakota, a reservation owned by the Standing Rock Sioux Tribe (45.7503° N, 101.2004° W) (Figure 3A). There were two pastures recorded at this reservation: West Pasture, which is hunted two days/year, and North Pasture, which is hunted four months/year. The second location was Snowcrest Ranch in Montana, where hunting is not permitted (45.4561° N, 112.1958° W) (Figure 3B). The ranch is home to diverse wildlife and is owned by Turner Enterprises, Inc. There were 47 bison observed at Standing Rock Indian Reservation (20 from West Pasture and 27 from North Pasture) and 50 bison at Snowcrest Ranch.

Bison behavioral observations

The videos of bison were recorded during July and August of 2020, outside of the hunting season. These videos were recorded by the same person using an HD1080P digital recorder shot at 400 ISO. The videos were recorded for 10 minutes between 9 am and 3 pm. Once the videos from each area were downloaded, the videographer emailed them to the student researcher. The videos were then downloaded onto the student researcher's personal computer and named according to the order that they were received. The feeding and vigilance behaviors of each bison were observed in the videos received. The feeding behavior was defined as when a bison was standing or walking slowly with its head angled towards the ground (Figure 4). The vigilance behavior was defined as a bison standing with its head lifted away from the ground and paying attention to its surroundings, with or

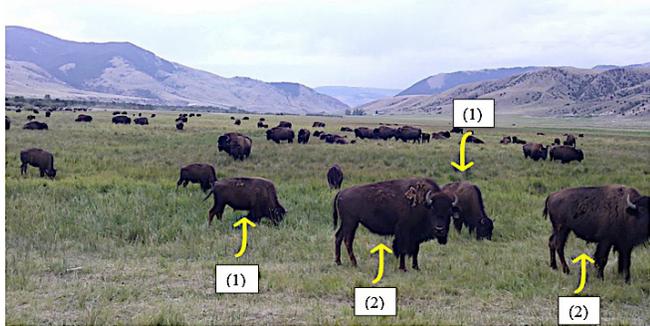


Figure 4. Image taken from a video of the Snowcrest Ranch non-hunted population. The (1) indicates bison that are feeding and (2) shows bison that are vigilant.

without scanning the environment (**Figure 4**) (2, 14). Factors such as sex and age could not be documented by the student researcher since the videos did not clearly depict the physical traits or age-related behaviors of each bison.

Individual feeding and vigilance times were recorded using focal animal sampling, in which a single animal is chosen and observed for the entire observation period (22). Following this method, one bison was chosen and observed for a sample period of approximately 5 minutes or until they were no longer visible. During the video observation period, the total lengths of time that each individual bison spent with its head angled towards the ground (feeding) and standing with its head lifted away from the ground at shoulder-level (vigilant) were recorded (**Figure 4**). The total time that each bison was observed was also documented, and the total time spent feeding and vigilant by each bison was calculated. Since observation periods varied, the percentages of time spent feeding and time spent vigilant within the total time observed were calculated for each bison. The observed bison did not always spend the whole time feeding or vigilant; they were also resting, walking, and drinking within the observation time. These behaviors were not recorded, meaning the feeding and vigilance times combined do not always equal the total time observed.

Data analysis

Kolmogorov-Smirnov (K-S) tests were performed using an online software on socscistatistics.com and indicated that neither feeding nor vigilance times were normally distributed. Therefore, Mann-Whitney U tests performed on socscistatistics.com were utilized to determine if there were differences in feeding and vigilance times in the hunted versus non-hunted populations. K-S tests were also conducted for the feeding and vigilance times of the two hunted populations (West Pasture and North Pasture) and indicated the data sets were not normally distributed, allowing Mann-Whitney U tests to be conducted to show if there were differences in the feeding and vigilance data between the two hunted populations.

Ethics statement

The student researcher had no contact with the animals studied and only utilized the videos of the bison. These videos were received from a videographer who recorded bison that were accustomed to human visitation, and the videos were recorded a distance away from the bison. At Standing Rock Indian Reservation, the bison were recorded from approximately 183-274 meters away, and at Snowcrest Ranch, the bison were recorded from approximately 5-183 meters away. The videographer did not interact with the bison in any way and the bison were not manipulated by any physical means. This study was purely observational, and the environment of the bison was not altered. Additionally, the methods did not involve restricted habitat or interference with other species and followed institutional (Hofstra University IACUC # 13/14-5) and national guidelines for the care and use of nonhuman animals. The videographer had permission from authorities at all locations to record the bison.

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Table A1. Total time spent feeding, total time spent vigilant and total time observed per bison in videos from Standing Rock Indian Reservation: West Pasture, North Dakota (hunted 2 days/year) 2020.

Standing Rock Indian Reservation- West Pasture				
Bison #	Video #	Total Time Spent Feeding	Total Time Spent Vigilant	Total Time Observed
1	8	4:56 min	0 min	5:00 min
2	8	0:39 secs	2:18 min	4:06 min
3	8	0:41 secs	2:22 min	5:00 min
4	8	4:16 min	0 min	5:00 min
5	8	4:47 min	0:08 secs	5:00 min
6	9	0 min	4:24 min	5:00 min
7	9	4:23 min	0:24 secs	5:00 min
8	9	0:59 secs	3:29 min	5:00 min
9	9	2:43 min	3:05 min	5:00 min
10	9	5:00 min	0 min	5:00 min
11	9	0:45 secs	3:05 min	4:36 min
12	9	1:27 min	3:23 min	5:00 min
13	9	0:34 secs	3:25 min	5:00 min
14	10	4:24 min	37 secs	5:00 min
15	10	1:03 min	3:44 min	5:00 min
16	10	2:54 min	0:06 secs	5:00 min
17	10	4:53 min	0:05 secs	5:00 min
18	10	2:21 min	2:40 min	5:00 min
19	10	0 min	4:58 min	5:00 min
20	10	1:07 min	3:56 min	5:00 min

APPENDIX A

Table A2.Total time spent feeding, total time spent vigilant and total time observed per bison in the videos from Standing Rock Indian Reservation: North Pasture, North Dakota (hunted, 4 months/year) 2020.

Standing Rock Indian Reservation- North Pasture				
Bison #	Video #	Total Time Spent Feeding	Total Time Spent Vigilant	Total Time Observed
1	11	1:54 min	1:43 min	3:42 min
2	11	0 min	3:18 min	3:47 min
3	14	3:59 min	0:17 secs	5:00 min
4	14	3:40 min	1:75 min	4:58 min
5	14	4:31 min	0:27 secs	5:00 min
6	14	4:28 min	0:10 secs	5:00 min
7	14	0:08 secs	0:32 secs	5:00 min
8	14	3:57 min	0:26 secs	5:00 min
9	14	2:10 min	2:38 min	5:00 min
10	15	2:41 min	0:23 secs	5:00 min
11	15	4:52 min	0 min	5:00 min
12	15	5:00 min	0 min	5:00 min
13	15	4:46 min	0:14 secs	5:00 min
14	15	4:41 min	0:18 secs	5:00 min
15	15	3:42 min	0:14 secs	5:00 min
16	15	1:00 min	2:30 min	5:00 min
17	15	4:44 min	0 min	5:00 min
18	15	5:00 min	0 min	5:00 min
19	15	0:09 secs	0:47 secs	5:00 min
20	17	2:43 min	0:39 secs	5:00 min
21	17	4:28 min	0:24 secs	5:00 min
22	17	4:17 min	0:07 secs	5:00 min
23	17	4:35 min	0 min	5:00 min
24	17	0:17 min	0:01 sec	5:00 min
25	17	4:44 min	0 min	5:00 min
26	17	3:59 min	0 min	4:49 min
27	17	4:47 min	0 min	5:00 min

Table A3.Total time spent feeding, total time spent vigilant and total time observed per bison in the videos from Snowcrest Ranch, Montana (non-hunted) 2020.

Snowcrest Ranch				
Bison #	Video #	Total Time Spent Feeding	Total Time Spent Vigilant	Total Time Observed
1	12	4:11 min	0:40 secs	5:00 min
2	12	0 min	5:00 min	5:00 min
3	12	0 min	4:54 min	5:00 min
4	12	0:18 secs	4:24 min	5:00 min
5	12	0 min	5:00 min	5:00 min
6	12	0:18 secs	1:54 min	5:00 min
7	12	0:36 secs	1:36 min	5:00 min
8	19	0:03 secs	3:44 min	5:00 min
9	19	0:05 secs	4:56 min	5:00 min
10	19	0 min	5:00 min	5:00 min
11	19	0 min	5:00 min	5:00 min
12	19	0:12 secs	3:17 min	5:00 min
13	19	0:46 secs	4:13 min	5:00 min
14	20	1:16 min	1:19 min	5:00 min
15	20	1:14 min	3:02 min	5:00 min
16	20	3:35 min	0:53 secs	5:00 min
17	20	0 min	4:02 min	5:00 min
18	20	2:34 min	0:51 secs	5:00 min
19	20	4:19 min	0:06 secs	5:00 min
20	20	4:39 min	0:16 secs	5:00 min
21	20	0:04 secs	2:06 min	5:00 min
22	20	0 min	5:00 min	5:00 min
23	20	4:43 min	0:10 secs	5:00 min
24	20	0:39 secs	0:46 secs	4:37 min
25	20	4:32 min	0:26 secs	5:00 min

Table A3 (continued)

Snowcrest Ranch				
Bison #	Video #	Total Time Spent Feeding	Total Time Spent Vigilant	Total Time Observed
26	20	4:36 min	0:11 secs	5:00 min
27	20	1:28 min	2:22 min	5:00 min
28	21	4:21 min	0:40 secs	5:00 min
29	21	4:42 min	0:10 secs	5:00 min
30	21	0 min	5:00 min	5:00 min
31	21	0:28 secs	3:47 min	5:00 min
32	21	0 min	4:52 min	5:00 min
33	21	4:23 min	0:34 secs	5:00 min
34	21	0 min	4:45 min	5:00 min
35	21	0:21 secs	4:03 min	5:00 min
36	21	1:15 min	2:54 min	5:00 min
37	21	1:35 min	2:41 min	5:00 min
38	22	4:48 min	0:13 secs	5:00 min
39	22	3:19 min	1:14 min	5:00 min
40	22	1:07 min	1:48 min	5:00 min
41	22	0:45 secs	1:05 min	5:00 min
42	22	2:11 min	2:42 min	5:00 min
43	22	4:01 min	0:50 secs	5:00 min
44	22	3:39 min	0:58 secs	5:00 min
45	27	5:00 min	0 min	5:00 min
46	27	4:19 min	0:36 secs	5:00 min
47	27	4:44 min	0:07 secs	5:00 min
48	27	2:09 min	1:40 min	5:00 min
49	27	2:17 min	0:10 secs	5:00 min
50	27	4:53 min	0:04 secs	5:00 min