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Effect of Aggregation at a Winter Feeding Station on Intestinal Parasite Load in Elk (Cervus canadensis)

Morgan Jaromilla Hughes
Utah State University

Effect of Aggregation at a Winter Feeding Station on Intestinal Parasite Load in Elk (*Cervus canadensis*)

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Morgan Jaromilla Hughes

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Effect of Aggregation at a Winter Feeding Station on Intestinal Parasite Load in Elk (*Cervus canadensis*)

Honors Undergraduate Thesis

Morgan Hughes

Mentor: Dr. Johan du Toit
Department of Wildland Resources, Utah State University

Abstract

Winter feeding stations are used throughout the western US to reduce elk depredation of crops and haystacks on private lands. Many of the unintended effects of such artificial congregation remain unexamined, but generally, across species, locally increased host densities result in increased parasite loads. This adds physiological stress to individual animals and in game species such as elk it could reduce their value to sportsmen. Through laboratory analyses of fresh samples, we recorded nematode egg densities in elk feces collected during two periods (early and late) in the supplementary feeding season. Mean nematode egg density remained fairly constant in fecal samples over these periods but the proportion of infected elk was significantly higher in the later stage of the feeding season. Results confirm that nematode loads carried by individual elk in this population during the study period were below the level at which clinical symptoms of morbidity would be expected. However, at the population level, the increased prevalence of nematode infection from early to late stages of supplementary feeding implies that the feeding station does facilitate parasite transmission.

Acknowledgements

I would like to thank Dr. Johan du Toit for his guidance and encouragement throughout the process. In addition, Brad Hunt and the Utah Division of Wildlife Resources are thanked for their flexibility in allowing access to the feeding station. I appreciate the Utah Veterinary Diagnostics Lab and Dr.Thomas Baldwin for allowing me the use of their lab. I could not have done this without the support of the S.J. and Jessie E. Quinney College of Natural Resources, the USU Honors Program, and the USU Office of Research and Graduate Studies. Finally, thank you to my parents and friends for their inspiration and assistance, particularly Erin Butikofer and Raul Lira-Rodriguez.

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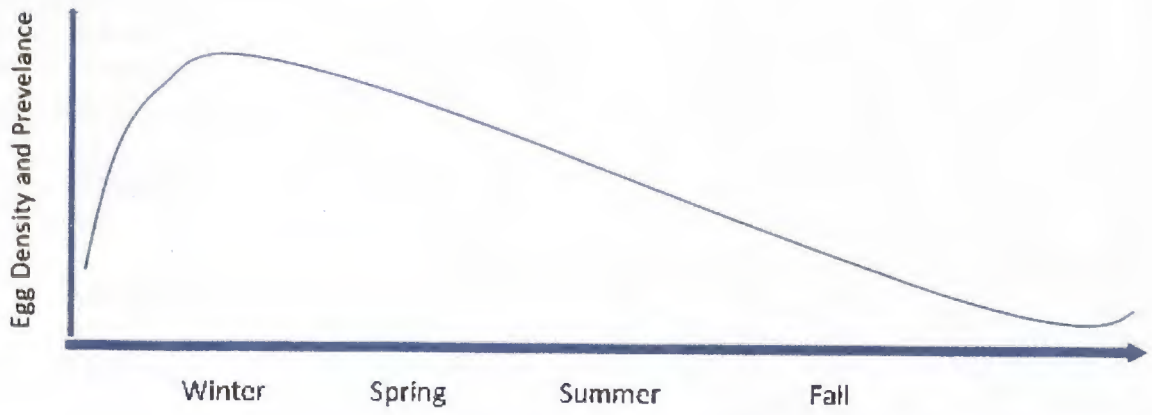

Figure 3. Hypothetical seasonal variation in both nematode egg count per fecal sample (individual level) and prevalence of nematode infection across all elk fecal samples (population level). For both variables, the peak is in late winter following increased propagule pressure at the feeding station. The decline during the summer is due to immune response (individual level) and herd mixing (population level).

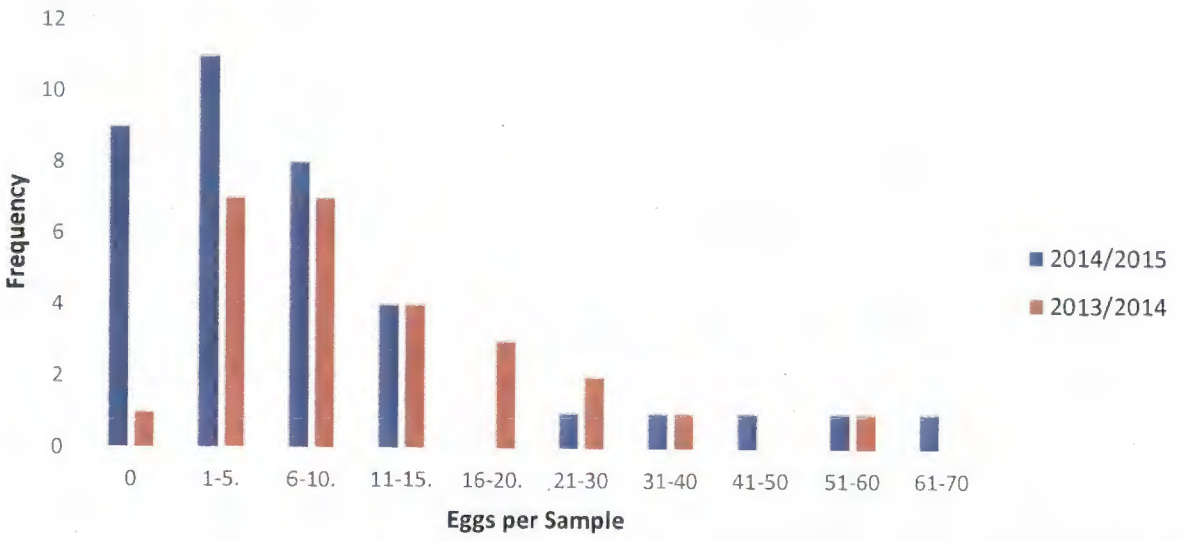

Figure 4. Distribution of nematode egg densities (frequency of eggs per gram of fecal sample) during the two sampling periods: in 2014/15 sampling was early in the feeding season; in 2013/14 it was at the end.

	Mean eggs/g	standard deviation	Percent not shedding	Sample size
2013/ 2014	12.2	12.0	3.85	26
2014/ 2015	10.2	15.2	24.3	37

Table 1. Summary of nematode egg shedding in winter-fed elk, as determined from fecal egg counts. The significant result ($P< 0.05$) was the much lower prevalence of endoparasite infection in the early-season 2014/15 sample (24.3% of elk not shedding nematode eggs) compared to the late-season 2013/14 sample (only 3.85% not shedding).

Introduction

Across the western US, more than 31,000 wild elk (*Cervus canadensis*) are fed annually at winter feeding grounds at a cost of more than $1.6 million. This management action reduces winter mortality while increasing animal density on the range near feeding sites. Although disease transmission is a complex issue, the effect of density-dependence on parasite abundance and diversity is well known and well documented (Dietz, 1988; Arneberg, 1998). Across mammalian taxa, host density is strongly correlated with parasite prevalence (Dietz,1988). In wild, unaltered communities unaffected by malnutrition, parasites remain endemic at a low density and with little effect on individual health (Choquette, 1956). An individual's immune system responds to infection through an increase in the number of lymphocytes in the mucosa of the abomasum, a decrease in the percentage of T cells and an increase in the percentage of B and gamma delta cells (Gasberre, 1997). These responses can be substantially costly for the host with sloughing epithelial cells representing a loss of 20-125 g protein and up to 10% of blood volume per day (Coop, 1999). The immune system has varying levels of success often requiring a novel immune response over multiple years for complete eradication of a parasite species from an individual's intestinal tract (Gasberre, 1997). After a short period, there is often a reduction in parasite egg output in the feces following an immune response thereby decreasing infectivity of the host (Gasberre, 1997). However, higher densities of intestinal parasites have been encountered in farmed ungulates (Mikolon, 1994; Hoberg, 2008).These nematode infections reduce feed intake by altering gastrointestinal motility and digesta flow while reducing protein,

mineral and electrolyte absorption (Holmes, 1989; Houtert, 1996). At clinical levels, blood loss can lead to anemia and weight loss (Hoberg, 2001). In domestic sheep, anthelmintics are applied when fecal egg densities reach 600-700 eggs/g (Ahmad, 2010). Application at this level prevents the rise to clinical levels and can be viewed as a threshold point which signals that immune response may not be sufficient to maintain low densities of parasites.

Negative effects of high intestinal parasite densities have been demonstrated through lower growth rates in red deer (*Cervus elaphus*) and similar results could be expected with elk (Hoskin, 1999). There is a shortage of literature examining elk parasite relationships as most parasite literature and experiments are focused on domestic sheep. Nevertheless, we assume the mechanisms of parasite-host interaction can be generalized across ruminant species. There are 17 known groups of nematode strongyle parasites that infect elk. The majority of these species have direct lifecycles with pre-patent periods ranging from 2 weeks in *Nematodirus* sp., to 6 weeks in *Oesophagostomum venulosum* (Hoberg, 2001). Seasonal shedding patterns vary across the groups with the majority of patterns unexamined in the literature. Of those patterns known, *Ostertagia* species tend to shed during warm months while *Marshallagia marshalli* increases or maintains egg shedding rates throughout the winter season (Carlsson, 2012). There is a distinct lack of literature documenting the nematode species present in elk in the intermountain West. This restricts the ability of managers to understand the appropriate management actions and concerns for disease in these animals. Although I was unable to determine the species of nematodes present, I was able to determine if egg shedding and disease transfer occur during the winter season when the animals are most heavily managed.

Research Questions

1. Do elk at Hardware Ranch in northern Utah shed nematode eggs in winter, and if so does nematode egg shedding (at the level of individual elk) change over the season?
2. Based on egg shedding values, are elk at Hardware Ranch experiencing clinical levels of nematode infection?
3. What is the average nematode fecal egg count in a herd of apparently healthy elk?
4. Is there a change in the proportion of animals (at the elk population level) shedding nematode eggs over the winter feeding season?

Methods

a. Field Sites

Hardware Ranch is located in the Blacksmith-Fork Canyon east of Hyrum in northeastern Utah (Figures 1 and 2). A winter supplemental feeding program run by the Utah Division of Wildlife Resources (UDWR) maintains 600 elk on 3.2kg of hay/elk/day at an annual cost of $45,000 to $75,000. This meadow is surrounded by a mosaic of private ranches and national forest land. The presence of winter forage on historical summering grounds results in altered migration routes, behavior, and nutrition of the animals. The animals are fed hay each morning and utilize the range later in the day resulting in degraded range condition surrounding the feeding station. Motivations behind the feeding include allowing a higher elk population size, a more stable population, fewer land conflicts and educational outreach/research opportunities. The typical feeding season runs from December through March depending on snow fall. During this

time, the UDWR traps 30 cows and a number of juveniles in holding pens for brucellosis testing.

b. Data Collection

The 2013/2014 and 2014/2015 seasons were unusually warm resulting in short feeding periods and insufficient trapping time to reach the normal testing opportunity of 30 cows twice over the season. For example, in the 2014/2015 season, feeding only occurred from December 19th to February 1st with elk densities on the ranch much lower than average at the ends of this period. As a result, I was only able to collect samples during one period in each feeding season. On February 12th, 2014, 26 fecal samples were collected directly from cow and juvenile elk in squeeze chutes. This was determined to be "late season" because it was more than six weeks after feeding began. Based on the life cycle range of the majority of nematode species affecting elk, those parasites ingested at the beginning of the season would be shedding eggs by this date. On January 7th and 16th of 2015, a total of 37 samples were collected from the meadow. This was determined to be "early season" because it was less than 4 weeks after feeding began. Based on the latency period range of the majority of nematode species affecting elk, those parasites ingested at the beginning of the season would not be shedding eggs by this date. For the 2015 samples, a scoop was used to collect fecal matter on the ground from the feeding wagon. The samples were then visually inspected to ensure that they were not frozen before being bagged. All samples were stored in laboratory fridges before processing which occurred within 6 days of collection. For processing, 1g of feces was broken into a

suspension of 15ml water. This was strained into a centrifuge tube and centrifuged in free-swinging buckets for 10 minutes at 1500 RPM. The sample was then decanted and filled with zinc sulfate flotation solution (100ml water, 371 g zinc sulfate) until a meniscus formed. A cover slide was placed in contact with this solution and centrifuged again. The cover slip was then examined on a slide at 200-400x zoom and all eggs observed were tallied. This resulted in the eggs/g density estimate of shed nematode eggs. Any number of eggs in a sample was considered to indicate an infected individual.

c. Data Analysis

Microsoft Excel software was used to organize the data and an egg density frequency graph was constructed with increments of 5 eggs/g (Figure 4). The data analysis add-in was then used to determine equal variances in mean eggs/g (P=0.111) using an F-test for two sample variance. I then performed a T-test for equal variance which returned sample means and standard deviations for the two sample periods to answer the first research question (Table 1). This add-in was again used to perform a Fisher's exact test to determine the significance of apparent differences in the proportion of non-shedding individuals. This test was used rather than a Pearson's Chi-square test due to the small sample size preventing our samples from meeting the Chi-square assumptions. Logical tests were used to sort the data into the shedding (n>0) and not shedding (n=0) categories (Table 2) before the software was used to perform the test to answer the fourth research question. After determining that there was no significant difference between the sampling periods for egg density or variation, the densities

were combined to determine the average nematode fecal egg count for the herd across the sampling periods to answer the third research question.

Results

High variation in egg density per sample prevented the detection of any consistent pattern of change across samples (P=0.291). This indicates that there is no detectable change in nematode egg shedding density over the season (Question 1).All samples were well below the levels that would be expected from clinical infections and within the range that indicates that the immune response is likely sufficient to control parasite densities (Question 2). All samples were within 0-69 eggs/g with the majority of samples below 20 eggs/g(Figure 4). The average nematode egg density across all fecal samples was 11.0 eggs/g with a standard deviation of 13.9 (Question 3). There was a significant change (P= 0.037) across sampling periods in the percentage of shedding individuals (Question 4), with more elk shedding late in the season (96.2%) compared to early (75.7%)(Table1).

Discussion

Overall, our data do not indicate a clinical level of infection. In deer, 20,000-25,000 larvae are required for clinical symptoms to be prevalent which would be expected to correlate with much higher egg shedding (Levine, 1980). This is impossible to confirm from egg densities alone due to unknown seasonal variation in shedding (Martin, 2000). The use of necropsy could confirm these results by calibrating shedding rates with infection densities for this population and season. Despite the lack of clinical infection, the presence of winter egg shedding and the

increased proportion of infected individuals means that disease should be considered in the management of feeding stations. Due to limitations brought on by a short winter during the study period, it is impossible to conclusively distinguish between year to year variation and variation caused by the feeding station in this study. Even at sub-clinical levels, the increased prevalence of shedding individuals at the end of the season could indicate an increased physiological strain on the elk (Coop, 1999). Animals who would have remained uninfected without this artificial congregation must now dedicate immune response and nutrition to minimizing their parasite load. The strong response of the immune system to parasite infections diminishes the host's ability to response to subsequent stressors (Gasbarre, 1997). Previous studies have found that infected cattle had increased levels of stress-related hormones which reduce weight gain and production. In addition, subclinical infection in ewes can reduce nitrogen uptake by 24-39% (Coop, 1999). Ewes, for example, experience periparturient relaxation (PPR) in immunity where their body sacrifices immune response for increased juvenile health just prior to delivery (Houdijk, 2000). The host is making resource allocation trade-offs between maintenance, reproduction and immune response. Any additional immune response solicited by a sub-clinical parasite infection can reduce birth weight, soft tissue deposition, skeletal growth and lactation periods (Coop, 1999).

The extremely high prevalence of nematode infection (>95% in late winter) at the feeding ground could indicate that elk do not have sufficient immune mechanisms to eradicate infections of some species of parasite (Roberts, 1999) This would mean that animals infected at the feeding station could remain infected indefinitely. Rare, dispersed and low intensity infections in deer and other ruminates indicate that parasite-related disease has likely not been a regulating factor for elk populations in the past (Hoberg, 2001). As a result, we cannot draw strict conclusions or

comparisons based on studies from domestic animals. Although many of the mechanisms are similar, it is possible that sylvatic hosts have lower threshold levels of exposure for subclinical signs to cause population-level changes (Hoberg, 2001). Mean egg densities this low are rare in domestic species and indicate the importance of having species-specific data for healthy baseline infection rates and intensities. If samples from wild populations are collected with average egg densities significantly higher than 11 eggs/g, there might be cause for concern despite the fact that these values are lower than those expected from domestic animals. This could indicate that nutritional or environmental stress is limiting the herd's immune response.

Nutrition plays an important role in nematode and host population dynamics (Hoberg, 2001). Parasites and other diseases have long been implicated as a method of density-dependent population control (Hoberg, 2001). When combined with malnutrition and lack of food availability, lowered immune system responses allow parasite load to increase, further increasing malnutrition (Hober, 2001). As range condition around Hardware Ranch has decreased due to the high utilization, it is likely that parasites would exacerbate the effects of a lean season (Elk Herd Unit Management Plans, 2012). Nutrition also presents an opportunity for adaptive management. It has been successfully shown in many species that increased protein during key periods allows the infected individuals to maintain or eradicate their infection (Houdijk, 2000). Further studies should be done to examine the use of protein supplements in reducing disease in wild ungulates whose ecology has been altered by land development or management actions.

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Author Bio

Morgan Hughes arrived at Utah State University in the fall of the 2012 following her graduation from high school in central Virginia. Before her arrival she completed two programs with the Student Conservation Association in Yosemite National park and Saw-tooth National Forest, where she performed restoration and maintenance work. Morgan also completed an internship with the Virginia Institute of Marine Science and a veterinary technician program. Since arriving at Utah State University she worked as a seasonal technician for the United States Forest Service and as an intern for the Division of Wildlife Resources. During her school years she worked various jobs including editing books on zoonotic diseases and harvesting quinoa for a PhD student's dissertation. Morgan has presented her research at scientific conferences in two oral and three poster presentations at international, regional and state levels. During her final year at Utah State University she was Wildland Resources coordinator in the QCNR student council, vice president of the Wildlife Society, and secretary of the Society for Range Management's student chapters. She has been involved in these clubs since her freshman year and has helped organize dozens of events and conferences. One of these events was the 2015 annual International Society of Range Management meeting in Sacramento, California, where she obtained the highest score in the Undergraduate Range Management exam. She is the Utah State Valedictorian for 2015. Following her graduation she will be leaving for her Peace Corp. program where she will be working as an environmental consultant in Peru. Following this program, she hopes to perform graduate research on disease dynamics of bat populations.