Diet Preference and Parasites of Grey Wolves in Riding Mountain National Park of Canada

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A thesis submitted to
the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

Master of Environment

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BY

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MASTER OF ENVIRONMENT

ABSTRACT

Diet Preference

I studied the diet preference of grey wolf (*Canis lupus*) in Riding Mountain National Park (RMNP) of Canada using faecal samples collected from fall 2001 to summer of 2003. Of 369 faeces analyzed and 413 food items identified, elk, (wapiti) *(Cervus elaphus)* represented 53.93% of wolf diet, followed by: beaver *(Castor canadensis)* 18.70%; moose *(Alces alces)* 14.09%; white-tailed deer *(Odocoileus virginianus*) 10.03% and hare 3.25%. In all seasons, elk are the most commonly occurring prey species. Beaver, moose, and white-tailed deer show varying degrees of importance, depending on the season.

Parasites

Three hundred and twenty faecal samples were collected from where free-ranging wolves (*Canis lupus*) traveled in Riding Mountain National Park of Canada (RMNP), between September 2001 and March 2003 and examined for gastrointestinal parasites and Canine Parvovirus (CPV). Most samples (228/320) contained at least 1 parasite. Parasites identified on faecal examinations included *Alaria* sp. (31/320), *Capillaria* sp. (6/320), *Coccidia* sp. (10/320), *Cryptosporidium* sp. (1/320), *Demodex* sp. (1/320), *Giardia* sp. cysts (70/320), *Moniezia* sp. (3/320), *Sarcocysts* sp. (120/320,*)* *Taeniid* sp. (108/320), *Toxascaris* sp. (3/320), *Toxocara* sp. (1/320), *Trichuris* sp., (11/320).

The presence of Canine parvovirus (CPV) was assessed by performing analysis on 106 scats from representative regions of RMNP. All samples were negative for CPV.

Prevalence of parasites was consistent across the park landscape, with no significant geographic differences. Slight spatial and temporal trends, when present, can be attributed to collection regime artefacts.

ACKNOWLEDGEMENTS

Parks Canada, Manitoba Conservation, Manitoba Agriculture and Food, and The Canadian Parks and Wilderness Society funded this project. Other contributors include the Riding Mountain Biosphere Reserve, Friends of Riding Mountain, and the Manitoba Big Game Trophy Association.

My academic supervisor Dr. Baydack, along with the other committee members, Dr. Riewe, Dr. Paquet, and Mr. Bergeson supported this research, both with advice and with encouragement. Dr. Paquet and Mr. Bergeson were especially helpful with all aspect of the project. I would also like to thank Dr. Walker for his enthusiastic statistical mind.

Of course, thanks goes out to family and friends (too many to mention) who helped along the long road to getting this finished.

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General Information

1.1 Introduction

In Canadian National Parks the "maintenance of ecological integrity through the protection of natural resources shall be the first priority" (National Parks Act 1989). This concept of ecological integrity has been instilled into Canadian National Park management by legislation. The concept of ecological integrity, as defined by Woodley (1993) is:

> *"Ecological integrity is defined as a state of ecosystem development that is optimized for its geographic location. For parks and protected areas, this optimal state has been referred to by such terms as natural, naturally evolving, pristine and untouched. It implies that ecosystem structures and functions are unimpaired by human-caused stresses, that native species are present at viable population levels and, within successional limits, which the system is likely to persist. Ecosystems with integrity do not exhibit the trends associated with stressed ecosystems. Parks and protected areas are part of larger ecosystems and determinations of integrity in national parks must consider these larger ecosystems."*

To help address the requirement of maintaining ecological integrity, Canada's National Parks are developing an ecosystem-based approach to management (Department of Canadian Heritage 1994, Riding Mountain National Park Round Table 1996), with Riding Mountain National Park (RMNP), developing an Ecosystem Conservation Plan in 1997 (Ecosystem Conservation Plan Team 1997). The Ecosystem Conservation Plan compliments Canadian park policy in stating that management decisions must be based upon research and science (Department of Canadian Heritage 1994). The purpose of the Ecosystem Conservation Plan is to "protect, restore and monitor...natural heritage within the Park to ensure ecological integrity" (Ecosystem Conservation Plan Team 1997). The Plan set objectives for ecosystem management and protection, which includes establishing and implementing species inventories and monitoring programs (Ecosystem Conservation Plan Team 1997). Riding Mountain National Park must also be managed in a context that is broader than its political boundaries (Riding Mountain National Park Round Table 1996). Because ecosystems do not abruptly end at the Park's jurisdictional boundaries, information sharing, cooperation, and partnerships with other individuals and organizations are vital to effective ecosystem management (Haufler et al. 1996).

The identification and monitoring of ecological integrity is a primary goal of the Ecosystem Conservation Plan (Ecosystem Conservation Plan Team 1997). Ecological integrity may be analyzed in a variety of ways, including consideration for species viability (Woodley 1993). Wolves (*Canis lupus*) were chosen as 1 species to help identify and monitor ecological integrity of RMNP. They are a keystone species closely linked to the regional ungulate populations and as such, exhibit strong links to the integrity of the ecosystem food web.

1.2 North America Wolf Populations

Human development and other activities have led to the extirpation of grey wolves (*Canis lupus*) throughout most of North America (Mech 1995, Clark et al. 1996). Historic wolf ranges have been reduced to about half since European settlement (Figure 1) (Harrington and Paquet 1982). Continued disturbance and habitat exploitation and alteration threaten the long-term survival of wolf populations and other large carnivore populations (Hummel and Pettigrew 1991, Paquet and Hackman 1995, Clark et al. 1996).

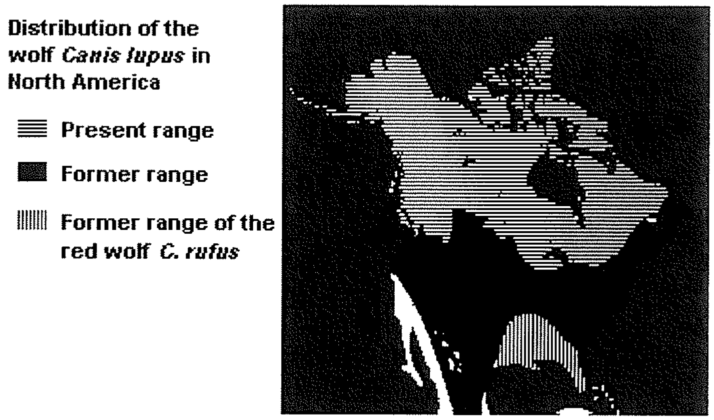

Figure 1. North American Wolf Range (Rutter, R.J., and D.H. Pimlott 1968)

1.3 Riding Mountain National Park Regional Situation

Habitat patches, ostensibly islands, have restricted movement of large carnivores such as wolves and are of particular concern to wildlife managers (Newmark 1995, Woodruffe and Ginsberg 1998). Much of the land surrounding RMNP has been modified by human activity, primarily through agricultural use. With its irregular shape and small size, RMNP is, in fact, "an island of wilderness in a sea of agriculture." Stressors such as roads, general hunting, and trapping that are present will influence the long-term viability of wolves in the RMNP regional ecosystem.

1.4 RMNP Regional Wolf Population

For many years, RMNP has been undertaking annual wolf population estimates, based on ground tracking and aerial surveys. Monitoring surveys conducted in the park between 1995-1997 revealed a decrease in wolves (Figure 2), to an estimated wolf population of 30-50 animals (Goulet 1997, Parks Canada 1997). In recent years, it has rebounded to an RMNP population of about 80 in 12 packs (T. Hoggins, Park Warden, pers. comm. 2007).

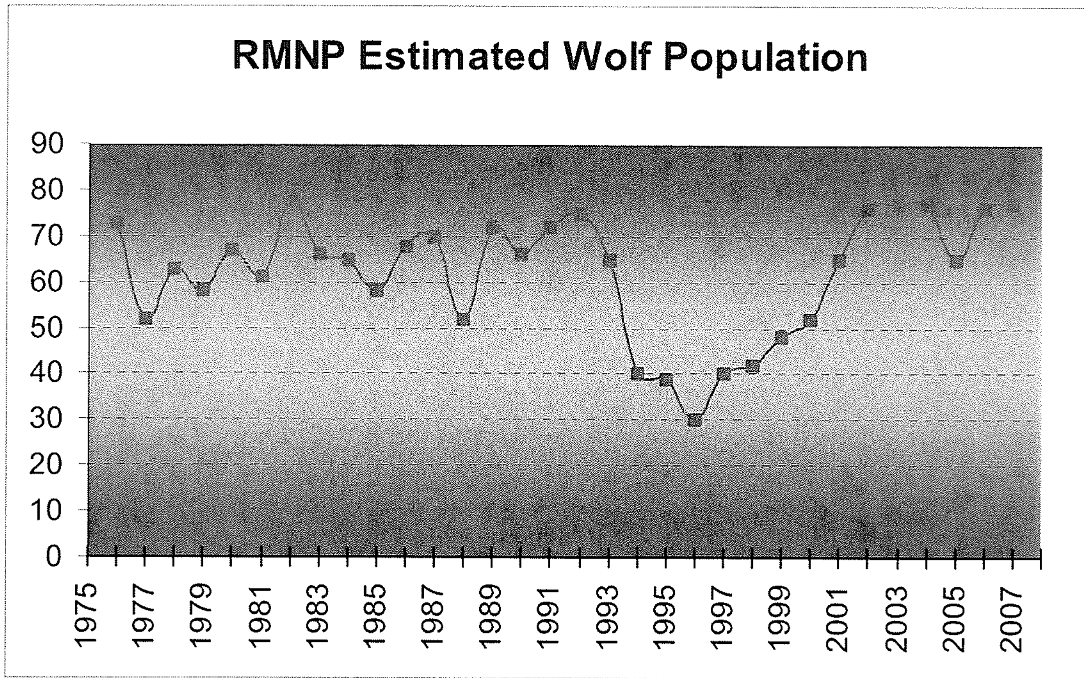

Figure 2. Estimated Number of Wolves in RMNP over time (Parks Canada 2007).

Wolf population or individual health in and around RMNP is dependent on both natural- (e.g. disease, inter-specific competition, prey availability and environmental conditions) and human induced (e.g. hunting, roads) factors. Verification of the exact causes of regional wolf population fluctuations is lacking (Goulet 1997); however, it is known that natural change will occur amid changes in food supply (Parks Canada 1997). Aerial surveys indicate that prey populations have been relatively abundant since 1976 (Figure 3) and are capable of supporting as many as 100 wolves (Parks Canada 1997). It has therefore been suggested that some other factors must be limiting the wolf population. Based on available information, the main contributing factors resulting in reducing wolf populations includes a combination of disease, habitat fragmentation and high human-caused mortality (Goulet 1997, Parks Canada 1997).

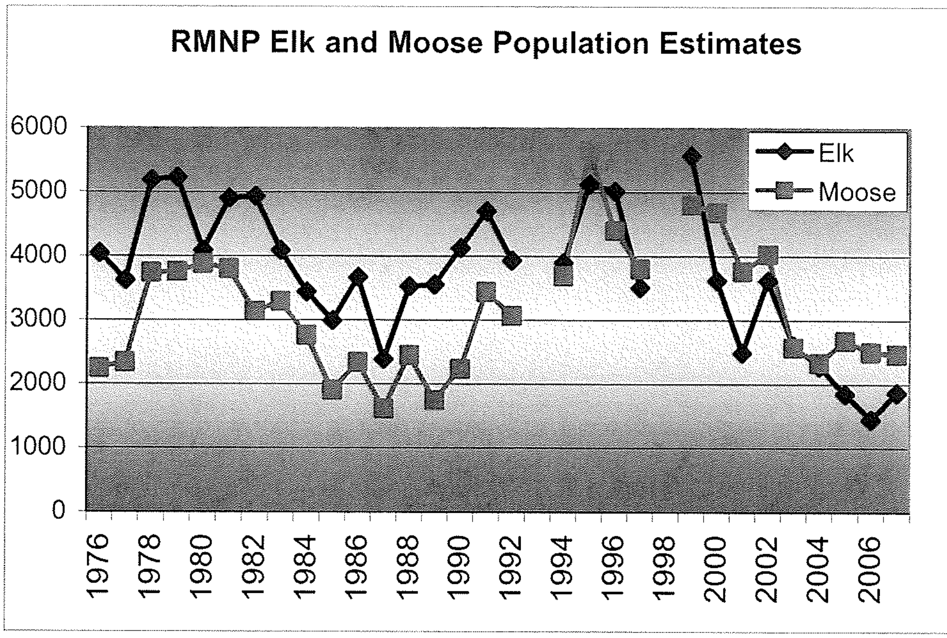

Figure 3. Estimated Number of large ungulates in RMNP over time (Parks Canada 2007).

1.5 Wolf Diet

Elk (*Cervus elaphus*) are the main prey species for wolves in RMNP, whereas alternative prey includes moose (*Alces alces*), white-tailed deer (*Odocoileus virginianus*), beaver (*Castor canadensis*) and snowshoe hares (*Lepus americanus*) (Carbyn 1983). Recent management actions to reduce the elk population in and around RMNP may be having deleterious effects on the regional wolf population. Wolf reliance on a reduced elk herd may reveal densities and distribution changes and an altered diet preference (Fuller and Sievert 2001, Carbone and Gittleman 2002), thus influencing population viability of these large carnivores (Fuller and Sievert 2001).

Prey availability changes can indirectly change behaviour contributing to observed changes in carnivore densities (Fuller and Sievert 2001). For example, wolf pack territory size was negatively correlated with white-tailed deer (*Odocoileus virginianus*) density in Wisconsin (Wydeven et al. 1995).

1.6 Wolf Macro- and Micro- parasites

Traditionally, parasites have been viewed as inconsequential to ecosystem functions. "However there is increasing evidence that parasite-mediated effects could be significant. they shape host population dynamics, alter interspecific competition, influence energy flow and appear to be important drivers of biodiversity" (Hudson et al. 2006). A rich and diverse configuration of parasites may be considered part of a healthy system. A description of the assorted parasites present in wolf scat in RMNP is provided in Chapter 3.

1.7 Study objectives

Analysis of wolf diet was completed in 1979 (Carbyn 1983) and 1984 (Meleshko 1986.) Given the proposed management pressures on the RMNP elk population for *M. bovis* issues, wolf scat analysis was completed to gauge changes from past studies and to provide an assessment of current wolf diet preference prior to elk management changes. In addition, an analysis of macro and micro parasites present in wolf scat was completed to provide baseline data.

In chapter 2, I complete a descriptive analysis of prey selection by wolves in RMNP using wolf scat.

In chapter 3, I complete a descriptive analysis of macro- and micro-parasites present in wolf scat from RMNP.

All permits and proper authorities were given from the relevant parties to conduct this research in Riding Mountain National Park. Documents such as animal care committee permits and ecological impact statements were approved.

1.8 Conservation Needs

Links between ecosystem characteristics, including prey availability and use and parasite density and diversity provide important baseline information. These relationships provide insight into ecosystem structure and function and contribute to the increased awareness of ecosystems for which better conservation and management decisions can be made (Clark et al. 2001).

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Chapter 2

Diet Assessment of Grey Wolves in Riding Mountain National Park Regional Ecosystem

2.1 Introduction

Ungulates are the main prey of wolves throughout North America. In Riding Mountain National Park (RMNP), elk (*Cervus elaphus*) have been identified as the primary ungulate prey species of wolves (*Canis lupus*) (Carbyn 1974, Carbyn 1983, Meleshko 1986, Paquet 1989, Paquet 1992, Carbyn et al. 1993). Wolves are known to consume alternate prey when readily available, abundant, or when primary prey numbers are low (Kohira and Rexstad 1997). Beaver (*Castor canadensis*), moose (*Alces alces*), and white-tailed deer (*Odocoileus virginianus* (WTD) have been identified as secondary prey in the RMNP area (Carbyn 1974, Carbyn 1983, Meleshko 1986, Paquet 1989). Rodents and lagomorphs, black bear (*Ursus americanus*), and spawning fishes are known to constitute a significant proportion of wolf diet in some regions of North America (Darimont and Paquet 2000, Darimont and Reimchen 2002).

Dietary analysis using scat is a non-invasive technique for gaining insight into predator-prey relationships (Ciucci et al. 1996) and enables accurate determination of food habits when intrusive methods are impractical (Carbyn 1974, Theberge et al. 1978). I assessed the diet of grey wolves in RMNP, faecal samples collected from September 2001 to July of 2003.

Typically, a wolf's diet comprises the most vulnerable ungulates, which include the unhealthy, the old, and calves of the species (Boyd et al. 1994). *M. bovis* is present in the elk and WTD populations of RMNP regional ecosystem. The presence of this disease may be influencing the diet selection by wolves focusing on *M. bovis* infected animals as prey. Accordingly, scat was analyzed for the presence of the *M. bovis* using PCR technology and bacterial culture. Over the long term, wolves in the RMNP ecoregion possibly will aid in the reduction or eradication of this disease.

The objectives of this study are: (*i*) to identify prey species consumed by wolves through faecal analysis; (*ii*) to compare prey species composition with past research from RMNP; (*iii*) to compare biomass of each species consumed with results from Prince Albert National Park (PANP); (iv) to measure the incidence of *M. bovis* bacteria in scats to determine if wolves are concentrating on infected ungulates.

2.2 Study Area

2.2.1 Riding Mountain National Park - Historical Setting

Approximately 12,000 years ago, glaciers began disappearing from the southwestern regions of Manitoba, including the RMNP area (Pettipas 1970, Colwill and Jamieson 1972, Buchner et al. 1983, Ecosystem Conservation Plan Team 1997). Twelve thousand to 10,000 years before present (BP), RMNP was colonized by white spruce (*Picea glauca*) forest (Ecosystem Conservation Plan Team 1997). Ten thousand to 3,000 years BP, an expansion of grassland occurred within the region (Buchner et al. 1983, Colwill and Jamieson 1972,). For about 2,500 to 3,000 years BP, the RMNP area was dominated by aspen (*Populus tremuloides*) parkland, mixed conifer, and mixed deciduous forest, which eventually evolved into a mixed wood ecosystem (Colwill and Jamieson 1972, Reeves 1970).

A long human history has influenced the development of RMNP's ecosystems (Ecosystem Conservation Plan Team 1997). Aboriginal people have inhabited the RMNP area for at least 6000 years (Buchner et al. 1983, Riding Mountain National Park Round Table 1996) and have practiced hunting, gathering, trapping, and burning to survive (Ecosystem Conservation Plan Team 1997). Assiniboine and Cree people became involved in the commercial fur trade in the RMNP area in the 1600s. The earliest Europeans, who arrived in the mid-18th century, were fur traders (Ecosystem Conservation Plan Team 1997). During this time, several species of wildlife were exploited for furs and food. Several were extirpated from the RMNP region including beaver and bison (*Bison bison*) (Ecosystem Conservation Plan Team 1997).

Agricultural settlement began in the 1880s and by 1920, the region was largely settled and a supportive infrastructure was being developed (Warkentin 1967, Colwill and Jamieson 1972, Jamieson 1974). In the RMNP area, timber harvesting, to support the building of farms and towns, was extensive "to the extent that no undisturbed stands remain" (Ecosystem Conservation Plan Team 1997). The Riding Mountain Forest Reserve was established in 1895 to protect the timber resources, although some timber harvesting continued within the reserve boundaries, along with reforestation, haying, and grazing. These activities continued until about 1970 (Ecosystem Conservation Plan Team 1997).

The RMNP area was formally established as a National Park in 1930, and opened officially in 1933. At present, the town of Wasagaming is a tourist resort and a network of trails and campsites are scattered throughout the Park. Most of the area surrounding the RMNP has been converted into agricultural land. The Ecosystem Conservation Plan

Team (1997) stated that this long human history has "significantly influenced the development of the Riding Mountain's regional ecosystem as it exists today."

2.2.2 Riding Mountain National Park - Present Situation

Riding Mountain National Park (Figure 4) encompasses 297,600 ha in western Manitoba. The Park includes the confluence of 3 varied landscapes including the Manitoba Lowlands, the Saskatchewan Plain, and the Manitoba Escarpment (Riding Mountain National Park Round Table 1996).

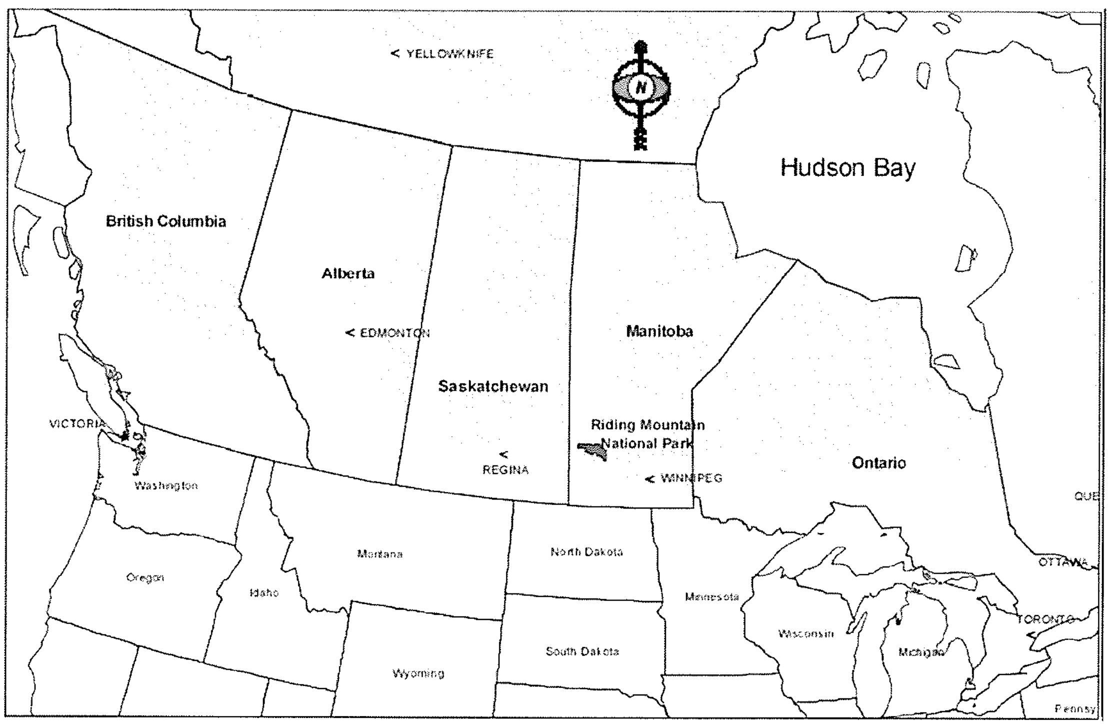


Figure 4. Riding Mountain National Park regional setting

These landscapes support grasslands, eastern deciduous forest, boreal forest, and mixed-wood forest ecotones (Riding Mountain National Park Round Table 1996). The vegetation has been classified using a variety of methods (Bailey 1968, Rowe 1972, Wang 1995). Rowe (1972) described most of the Park as boreal mixed wood, although he categorized a small section in the southwestern area of RMNP as the Aspen-Oak Section. Grasses and forbs dominate the vegetation cover on areas interspersed throughout the Park, mainly in the western regions. Trembling aspen, balsam poplar (*Populus balsamifera*), white birch (*Betula papyrifera*), white spruce (*Picea glauca*), and balsam fir (*Abies balsamea*) characterize the mixed wood Section (Wang 1995) and occupy imperfectly to well-drained areas. In drier areas, jackpine (*Pinus banksiana*) and white spruce (*Picea glauca*) predominate, and black spruce (*Picea mariana*) and tamarack (*Larix laricina*) characterize the wetter and marshy areas. On the edge of the Manitoba Escarpment, the Aspen-Oak Section is mainly characterized by balsam poplar in the moister areas. Bur oak (*Quercus macrocarpa*) is often found along rivers, in areas with shallow dry soils, or on south or west-facing slopes. Alluvial soils are populated by white elm (*Ulmus americana*), green ash (*Fraxinus pennsylvanica*), and Manitoba maple (*Acer negundo*). Consequently, the Park's biota is diverse.

The Park exists as a wilderness area in an agriculturally dominated ecoregion (Figure 5).

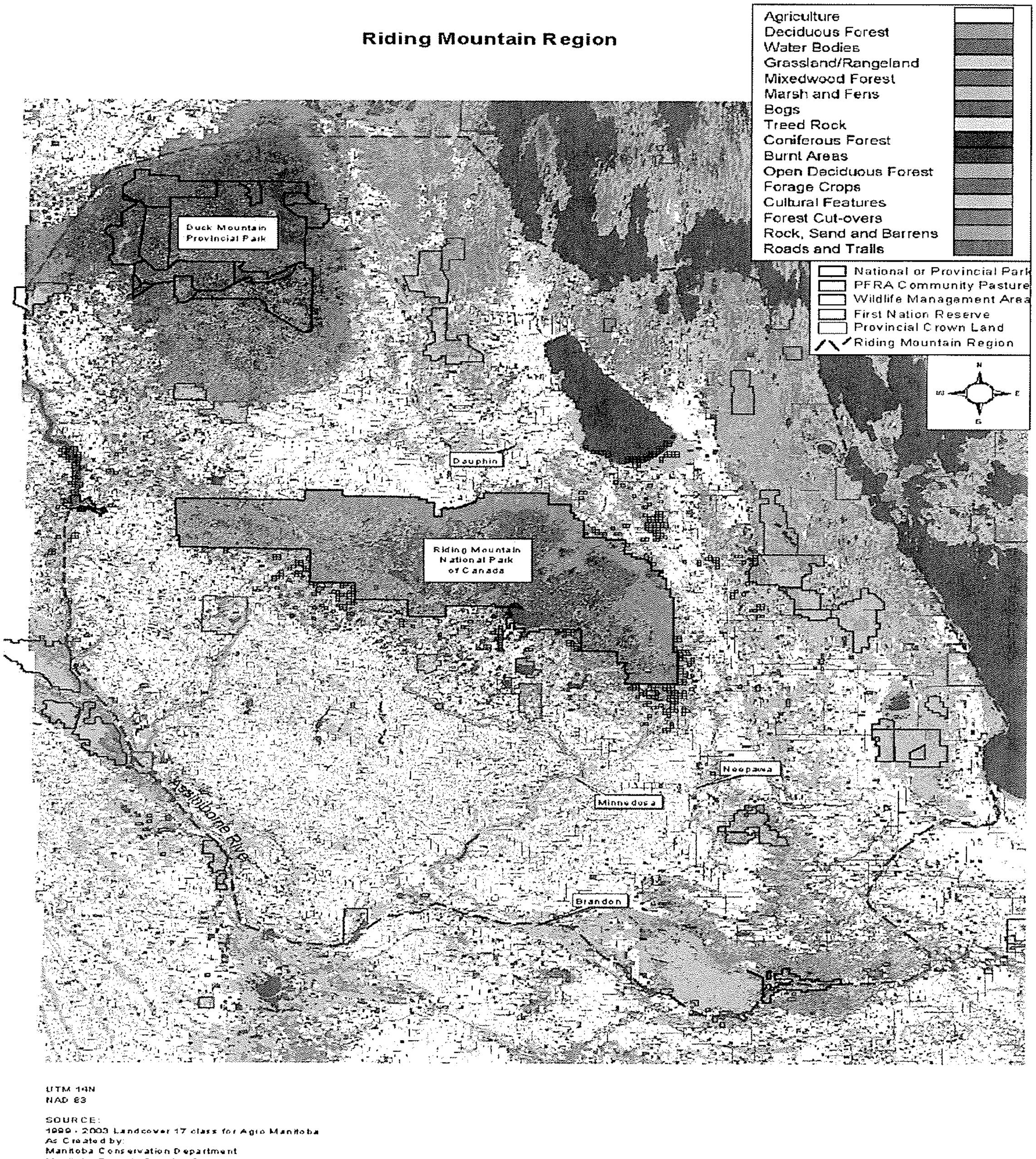


Figure 5. Riding Mountain National Park Regional Ecosystem, Manitoba

2.2.3 Riding Mountain National Park – Faunal Description

The wildlife of RMNP is varied and has been the subject of many investigations since the late 1930s. Early investigations provided the first indication of the great diversity of wildlife species present in the Park, reflecting the parallel diversity of habitat types. Up to 233 species of birds, 64 species of mammals, 6 species of amphibians, 4 species of reptiles, 27 species of fish, 13 species of skippers and 69 species of butterflies as well as numerous invertebrate species are known or expected to occur in the park. A near complete natural food chain is present in RMNP from the top carnivores through ungulate and small mammal herbivores to scavengers and the invertebrates and bacterial agents of decomposition and nutrient recycling. That RMNP is situated in a "sea of agriculture" adds to its inherent value of representing habitat types that no longer exist in much of south-central Manitoba, the Southern Boreal Plains and Plateaux.

2.3 Methods - Field and Laboratory Procedures

Three hundred sixty nine (369) wolf faeces were collected on the trail network of RMNP, between September 2001 and July 2003. Faeces were collected in plastic bags, dated, and their locations recorded using a GPS. All samples were stored frozen before analysis. Only faecal samples with a diameter of greater than 2.5 centimetres or those of definite wolf origin were used in this study.

Laboratory procedures followed Ciucci et al. (1996). Frozen samples were autoclaved at 90° C for 24 hrs to kill potentially harmful *Echinococcus granulosus* and *E. multilocularis* (hydatid tapeworms). Faeces were then immersed in water for 48 hrs, and thoroughly washed in a sieve (mesh size 1.0 mm) to separate microscopic and macroscopic materials. Sample elements were then air-dried on labelled paper plates. Gloves and dust masks were worn during all steps to decrease risk of pathogen exposure.

Dried components were spread on a white 11 x 17 sheet of paper and visually examined to identify prey remains. Species were identified by course examination of guard hairs. Guard hairs from inconclusive samples were examined using a dissection microscope and compared with sample photos from Moore et al. (1974) and Kennedy and Carbyn (1981). Scale patterns from guard hairs were transferred onto microscope slides when faecal samples either lacked sufficient number of guard hair or hair was of uncertain origin (n = ~5).

Bones were not used for identification purposes, except when hair was not present. Plant material was noted but not identified.

2.4 Data analysis

Qualitative analysis of prey remains in wolf scat is affected by digestibility and detectability of the source prey item (Kohira and Rexstad 1997). Wolf diet is determined using 2 analytical methods: occurrence/faeces and biomass consumption.

2.4.1 Occurrence/Faeces

Frequency of occurrence of each prey species in each scat (- OF) was calculated by taking the total occurrence of a prey item divided by the total number of scats (Pederson & Tuckfield 1983, Reichel 1991). Seasonal differences, both 4-season (spring/summer/fall/winter) and 2-season (summer/winter), in prey selection were then calculated and ANOVA was used to test differences between seasonal prey exploitation.

2.4.2 Biomass Consumption

Misinterpretation often occurs when analyzing diet habits in carnivores. Smaller prey items produce more scat per unit weight then do large prey species, leading to an overestimation of the importance of smaller prey species in the final diet analysis. (Floyd et al. 1978, Weaver 1993). To compensate for this bias, Weaver (1993) derived the following equation from controlled feeding trials of captive wolves:

$$Y = 0.439 + 0.008x$$

Where Y = kg of a prey species consumed per field collectible scat and x = average weight of that species. Average prey weights were taken from Banfield (1974). Solving for Y gave an estimation of biomass consumed per scat for each prey species. Multiplying Y by the number of scats found to contain a particular prey species gave the relative weights of each prey species consumed. These values were then used to calculate the percent biomass contribution of each of the different prey species to the RMNP wolf diets and represent a more biologically meaningful evaluation of diet (Ciucci et al. 1996, Biswas and Sankar 2002). Biomass estimates excluded non-mammalian prey.

2.5 Results and Discussion

2.5.1 Four-Season Analysis (OF)

This portion of the analyses defines the seasons as follows: Spring - (April 1-June 30); Summer - (July 1-Sept 31); Fall - (Oct 1-Dec 31); Winter - (Jan 1-March 31)

Elk are the prey of choice for wolves in RMNP. Of 369 faecal samples examined, elk were the most commonly occurring prey species (%OF; 53.93%). Occurrence of elk was consistent throughout all 4 seasons. This was followed by: beaver (18.7%); moose

(14.09%); white-tailed deer (WTD) (10.03%); and snowshoe hare (3.25%); (see Table 2.1 and Figure 2.3).

All other prey species show large variations in seasonal occurrence. Beaver occurs most in scat for the summer (35.14%) and spring (28.95%) seasons. Moose is prevalent in fall periods (23.73%) and hare during the spring (13.16%). WTD are more vulnerable to predation in the winter (16.67%): (see Table 1 and Figure 6).

Table 1. Relative occurrence (%OF) of food items identified in 369 wolf faeces for each season. Scats collected in RMNP from September 2001 to August 2003.

	Beaver	**%**	**Hare**	**%**	**Moose**	**%**	**WTD**	**%**	**Elk**	**%**	**Total**
Winter	20	10.1%	1	0.5%	30	15.2%	33	16.7%	114	57.6%	198
Fall	12	20.3%	1	1.7%	14	23.7%	1	1.7%	31	52.5%	59
Spring	11	28.9%	5	13.2%	1	2.6%	0	0%	21	55.3%	38
Summer	26	35.1%	5	6.8%	7	9.5%	3	4.1%	33	44.6%	74
Mean		18.7%		3.3%		14.1%		10.0%		53.9%	

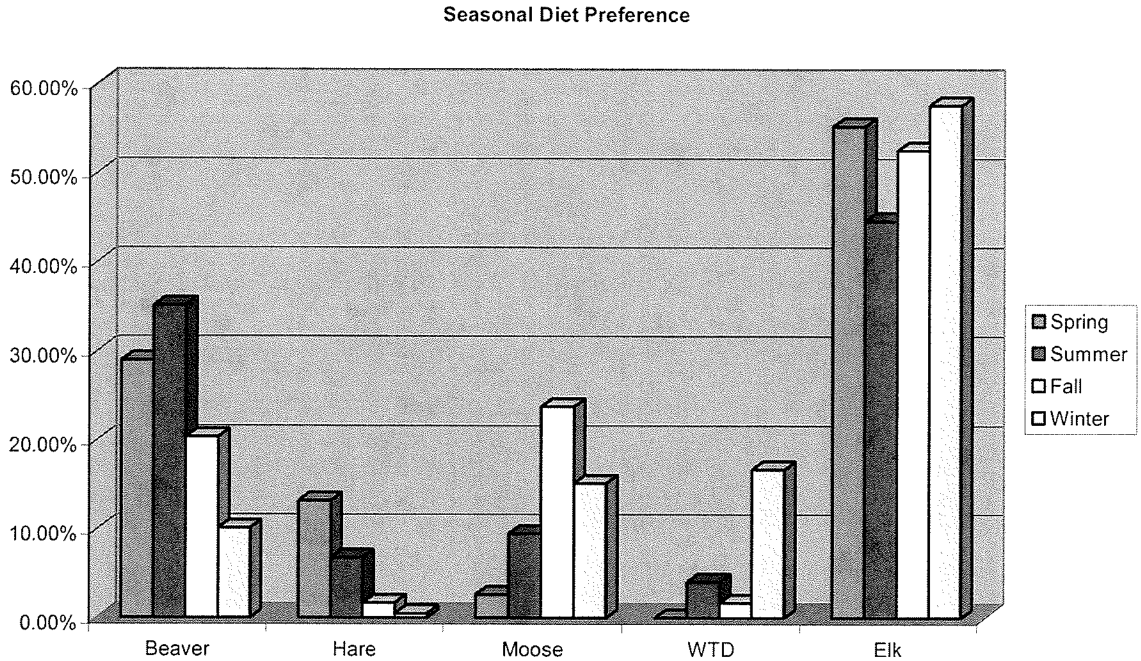


Figure 6. Relative occurrence (%) of food items identified in 369 wolf faeces for each season. Scats collected in RMNP from fall 2001 to summer 2003

2.5.2 Two-season analyses (OF)

When data are grouped into winter (Oct. 1 – Mar 31) and summer seasons, the importance of elk in the wolf diet is more evident. Elk constitute more than half (56.42%) of the winter diet and are almost as frequent in summer. The remainder (mean = 14.25% for all 3) of the diet is largely the product of moose, WTD, and beaver. Hare are less frequently consumed in winter (Tables 2 and Figure 7)

Summer diets show elk as being most important at 48.21%. Beaver consumption is almost triple in summer months from that in winter (33.04% from 12.45%). Moose and hare occur at about 8% and WTD drops below 3% for summer consumptions rates.

Table 2. Relative occurrence (%) of food items identified in 369 wolf faeces lumped by summer and winter seasons. Scats were collected in RMNP from fall 2001 to summer 2003.

	Beaver	Hare	Moose	WTD	Elk
Winter = 100%	12.5%	0.8%	17.1%	13.2%	56.4%
Summer = 100%	33.0%	8.9%	7.1%	2.7%	48.2%

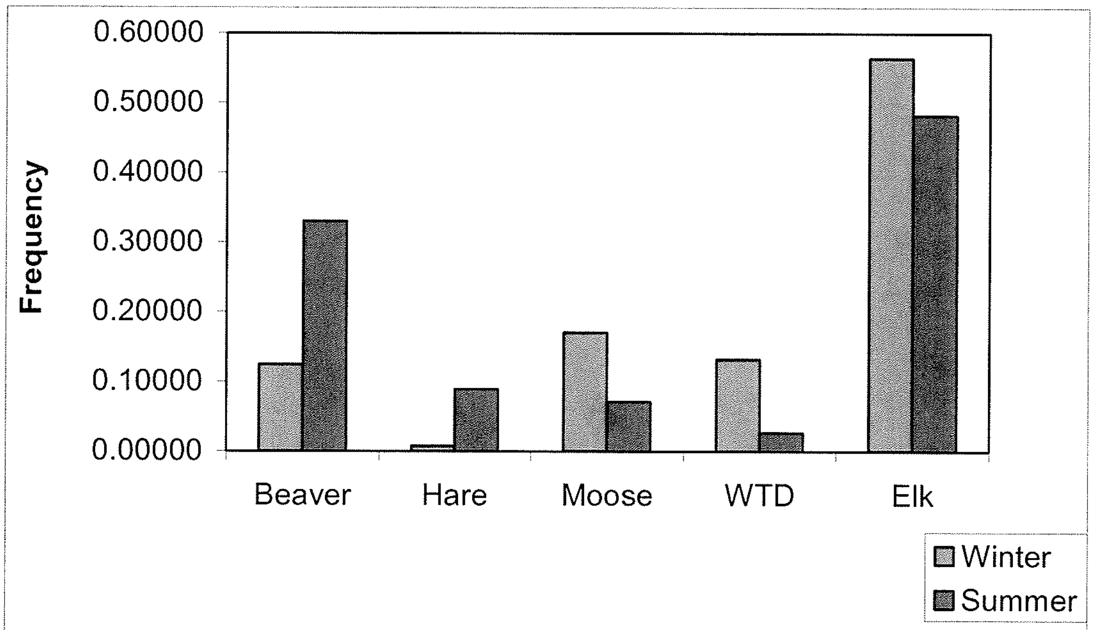
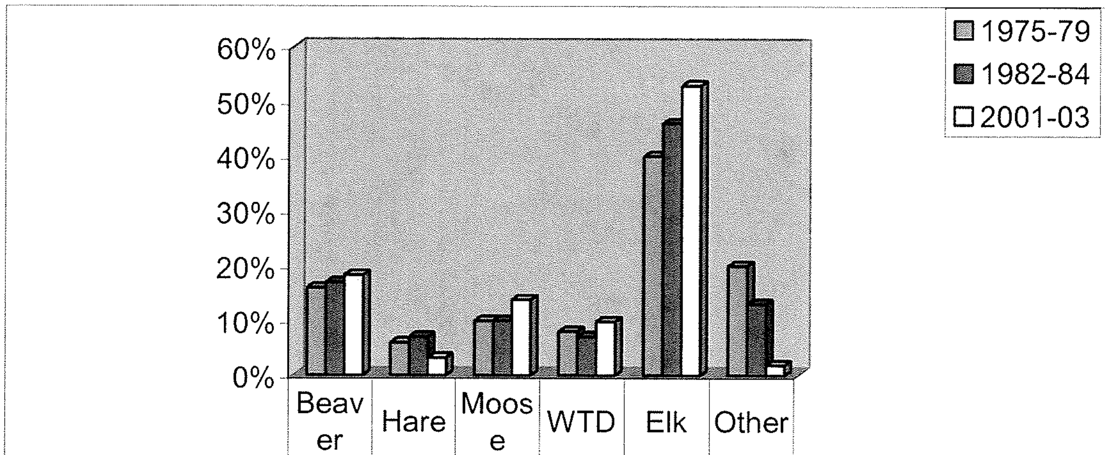


Figure 7. Relative occurrence of food items identified in 369 wolf faeces divided into summer (100%) and winter (100%) seasons. Scats collected in RMNP from fall 2001 to summer 2003.

2.5.3 Comparison with Other Studies

Scat/diet analysis studies by Carbyn (1983), and Meleshko (1986) showed similar results overall. However, my results suggest the use of elk as a year round resource for wolves has increased (Figure 8). The use of beaver, moose, and WTD does not appear to have changed. The major difference is in the "Other" category for identification. The present study has very few unknowns, (i.e. birds, porcupine, etc.) in comparison with the 2 previous studies. This may be due to a reduced sample size or temporal difference in collection regimes. In my study most scat were collected in winter when decomposition of scat was not an issue. In comparison, a large portion of scat analyzed by Carbyn (1983) and Meleshko (1986) was collected in summer and fall.



	Beaver	Hare	Moose	WTD	Elk	Other
1975-79	16%	6%	10%	8%	40%	20%
1982-84	17%	7%	10%	7%	46%	13%
2001-03	18%	3%	14%	10%	53%	2%

Figure 8. Comparison of data from previous studies and present research. Scats collected in RMNP from fall 2001 to summer 2003.

2.5.4 Biomass Contribution

Weaver's (1993) equation of relative biomass contribution (BC) of prey gives a clearer assessment of diet than results obtained from frequency of occurrence (OF). The importance of elk is increased from 53.93% (OF) to 67.11% (BC). Moose contributed nearly 23% (BC) compared with the OF calculation of 14% of available biomass to wolf diet. White-tailed deer and beaver contributed only 4% and 5% BC, respectively, compared with 10% and 18% OF. Smaller mammals such as snowshoe hare showed a biomass contribution of <1% (Table 2.5).

The biomass contribution results from RMNP compared with PANP (Urton, 2005) show a difference in prey usage. Although elk remain the main prey item in both regions (67% in RMNP vs. 56% in PANP), WTD seemed to be relied upon much more heavily in PANP (4% in RMNP vs. 24% in PANP), but there is no statistical difference (Gtest, $G=0.009$, $p=0.999$, $df=4$) (Table 3).

Table 3. Results of *OF and BC* in prey selection of 369 wolf faeces. Scats collected in RMNP from fall 2001 to summer 2003.

	Ave Wt (Kg)	RMNP Total	RMNP %	RMNP % biomass	PANP Total	PANP %	PANP % biomass
Beaver	23	69	18.70%	5.32%	18	4.77%	1.89%
Elk	286	199	53.93%	67.11%	125	33.16%	57.59%
Hare	1.5	12	3.25%	0.67%	1	0.27%	0.08%
Moose	390	52	14.09%	22.89%	27	7.16%	16.23%
WTD	55	37	10.02%	4.02%	163	43.24%	24.21%

2.5.5 PCR Analysis of Scat for *M. bovis*

The presence of *M. bovis* in the elk and WTD herds of the RMNP ecosystem has implications for the wolf population and eradication of the disease in ungulates. Wolves often select for unhealthy, old, and young prey (Paquet 1989, Boyd et al. 1994). In theory, wolves might succumb to diseases contracted from animals they have killed and consumed. This may have been the case for the 2 8-month old wolves found dead in 1978 that died of *M. bovis*.

The apparent appetite of wolves for elk might facilitate the reduction or eradication of *M. bovis* in elk and WTD, particularly if wolves select disproportionately for diseased animals. If maintenance of the disease in ungulates is density dependent, then killing by wolves of animals in the high-density areas could improve conditions for disease eradication by limiting growth of the population.

The *M. bovis* bacteria were tested for in 308-winter scat using the polymerase chain reaction test (Figure 9). No scats were found to have the *M. bovis* bacteria present. The lack of any findings of the *M. bovis* bacteria does not necessarily disprove the hypothesis, as a critical mass of about 1,500 *M. bovis* bacteria is needed in the scat to be detected. In addition, the fragility of the organism may play a role in the lack of detection (Greg Appleyard, Parasitologist, pers. comm.) Wolves may be selecting *M. bovis* infected animals, although detection through scat analysis of this occurring may be extremely difficult.

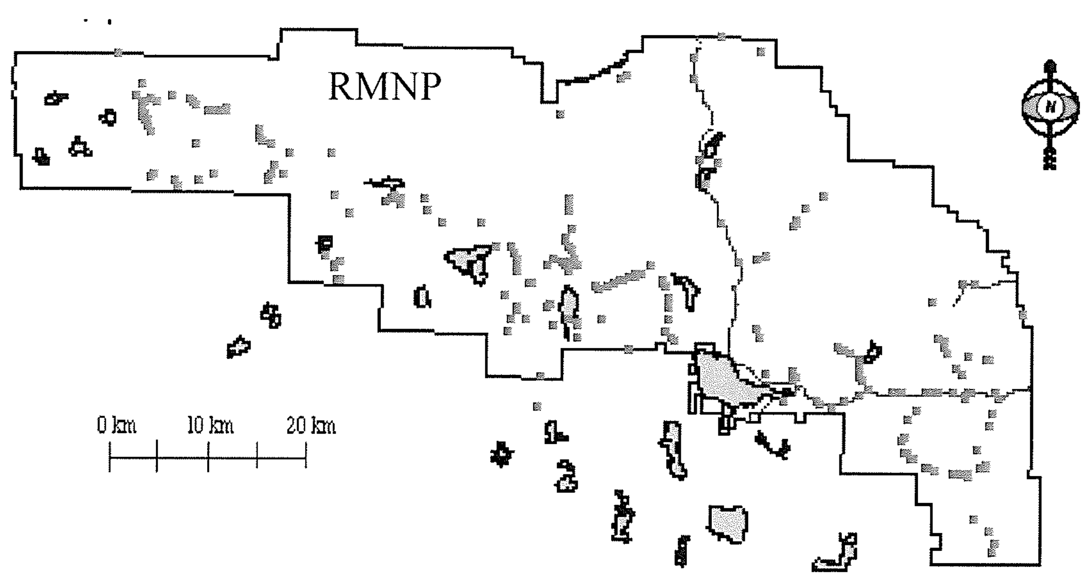


Figure 9. Distribution of scat tested for *M. bovis*. Scats collected in RMNP from fall 2001 to summer 2003.

2.6 Prey consumed

The number of individual animals consumed per species can be calculated using the formulas presented by Weaver (1993). It is generally agreed that each wolf needs from 1.5 to 3 kg of food per day, depending on the time of year, to maintain health. Using 2.2 kg as the mean for required sustenance and given that there are about 80 wolves in RMNP we can conclude Table 4. These numbers are only a general estimate and will vary depending on the number of wolves and the prey abundance within RMNP.

Table 4. Number of individual species consumed by wolves per year in RMNP.

	Ave Wt (Kg)	RMNP % biomass	#of individuals
Beaver	23	5.32%	148.6
Elk	286	67.11%	150.7
Hare	1.5	0.67%	286.9
Moose	390	22.89%	37.7
WTD	55	4.02%	47.0
			670.9

2.7 Conclusion

Elk are the primary prey of grey wolves in RMNP. These results concur with previous studies that have examined foraging ecology of wolves in RMNP (Carbyn 1980, Carbyn 1983, Meleshko 1986, Paquet 1992). However, secondary prey species constitute a considerable proportion of prey consumed. Seasonally, moose, WTD and beavers, each make up a large portion of wolves' diet. The seasonal shifts in prey usage are probably due to greater vulnerability/availability of the species during certain times of the year. Beavers are more active in spring and summer, snowshoe hare may be slow to moult to summer colours in spring, and snow depths affect WTD mobility in winter.

As in previous studies, a component of the wolf diet in RMNP may not be adequately accounted for in this study. Small foods items such as frogs, fish, and mice may not be detected due to their small mass and quick and complete digestive qualities. The lack of such prey items in scat may be due to the temporal and spatial scale by which scat collections occurred. About 70% of the faecal collection occurred during fall and winter, which could have excluded important seasonal hatches, spawns, and calving periods.

Livestock, primarily cattle, occur in great numbers around the study area. Livestock depredation by wolves is well documented throughout the world (Pullianien 1965, Fritts and Mech 1981, Gunson 1983, Tompa 1983, Vos 2000). No evidence of hair from cattle was found in 369 wolf scats, although it should be pointed out that none of the scat collected where found outside of RMNP boundaries. If livestock depredation does occur, it is so infrequent that this type of analysis could not detect it. Ungulate species probably provide an adequate natural prey base promoting a disinterest in livestock (Vos 2000). In addition, forays on to agricultural land may present too great a risk as wolves often have negative encounters with humans (Mazzioli et al 2002).

This and past studies show that a substantial portion (>50%) of the RMNP wolf's diet is elk. Ecosystem modification, such as prescribed burns and herd reduction (hunting and cull) will influence prey populations, which in turn affect populations of predators. Often, management decisions about a single species (i.e. elk herd reduction) do not take into account the repercussions for other species in the ecosystem. The reduction of the elk population in the RMNP herd, to aid in the eradication of *M. bovis* from the ecosystem, may have dire affects on the park's wolf population and the dynamics of the ecosystem.

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Chapter 3.0

Macro- and Micro- Parasites of Grey Wolves (*Canis lupus*) in Riding Mountain National Park

3.1 Introduction

Disease monitoring is an important aspect of a multidisciplinary approach to the conservation of uncommon species, such as wolves, as the introduction of existing or new diseases could have devastating consequences to an isolated population (Grenfell and Gulland 1995, Marathe et al. 2002, Moreno and Alvar 2002). The wolves (*Canis lupus*) of RMNP are thought to be a genetically discreet population (Wilson et al. 2000, Arndt, Geneticist, pers. comm. 2002) with approximately 80 individuals (T. Hoggins, Park Warden, pers. comm. 2007). Trapping/hunting, habitat loss just beyond the boundary RMNP, and disease transmission from other wildlife species such as elk (*Cervus elaphus*) and coyote (*Canis latrans*) are potential threats to the persistence of this genetically isolated wolf population (Carbyn 1980). Transmission of disease to wolves is likely through ingestion of infected prey, interaction with other predators or water (Moreno and Alvar 2002, Bruning-Fann et al. 2001).

As part of the ongoing RMNP monitoring program, wolf faecal samples were collected from trails in Riding Mountain National Park of Canada, and sent to the University of Saskatoon, College of Veterinary Medicine, Clinical Parasitology Laboratory, for examination for macro- and micro parasites. The objectives of this study were; to identify parasites and parasite products in the wolf faeces; to establish a baseline for the prevalence of macro- and micro-parasites in wolves of RMNP; and to compare the prevalence of these parasites across the RMNP landscape. Descriptive and spatial analyses of the findings are presented in this thesis chapter.

3.2 Materials and Methods

From September 2001 to March 2003, 320 faecal samples were collected from wild grey wolves in RMNP, Manitoba, Canada (Appendix 1 & Figure 10). The park covers 3000 km^2 and is located at the transition of 3 major vegetation communities; boreal mixed-wood forest, prairie grassland, and forest-prairie overlap. Scat samples were collected year round during routine warden patrols and on deliberate gathering excursions. Only samples with a diameter of greater than 2.5 centimetres and those of definite wolf origin were used.

The samples were stored at -20°C until sub-samples were taken and sent to the University of Saskatoon, College of Veterinary Medicine, Clinical Parasitology Laboratory.

Before handling of wolf scat for parasitological and CPV examination, samples were placed in a freezer at –80°C for 3 day to kill *Echinococcus granulosus* eggs. Samples were then stored at –20°C until final examination.

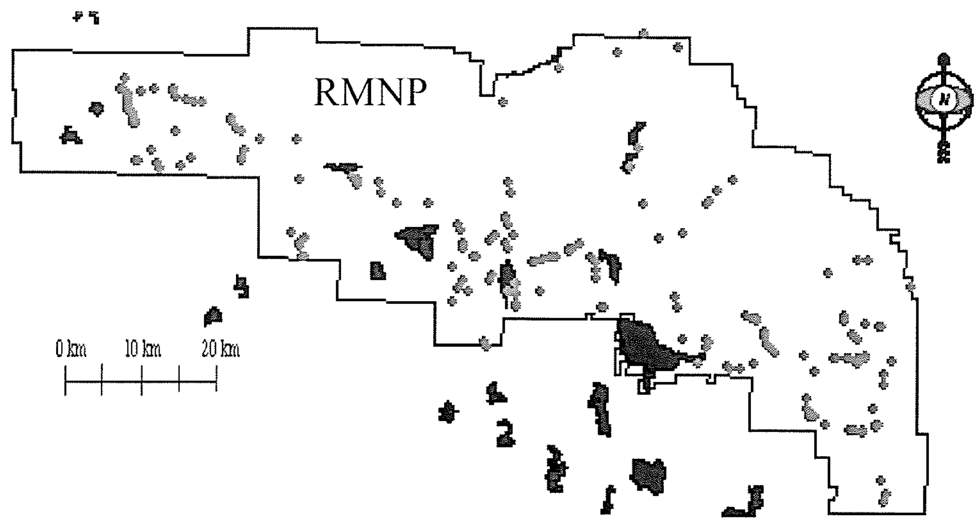

Figure 10. Distribution of wolf faecal samples analyzed for parasites from RMNP collected Sept. 2001 to March 2003.

3.2.1 Parasitologic Examination

After a 1-hour thaw, sub-samples of 4 grams were placed into a labelled paper cup. Forty ml of H_2O was added and mixed with the scat using a tongue depressor. The mixture was then filtered through 50-wt cheesecloth into a second labelled cup. Five ml of the 10% aliquot was placed into labelled test tubes. Eight ml of water were added to the test tubes and then centrifuged at 1500 rpm for 10 minute as a washing step. The supernatant was poured off and the sediment resuspended in the Sheather's flotation solution (Appendix 2) and mixed. The tubes were filled until a slightly convex meniscus appeared and a cover slip applied. The tubes were centrifuged again at 1500 rpm for 10 minutes. Following that, the cover slips were removed and placed on microscope slide for examination of parasitic stages and results recorded. All parasitologic analysis was completed by the same person to ensure consistency throughout data collection. (B. Wagner, Parasitologist, pers. comm. 2003)

3.2.2 *Giardia* and *Cryptosporidium*

All faecal samples were microscopically examined for Giardia and Cryptosporidium cysts and oocysts using the Cyst-a-Glo^{TM} Kit Fluorecein-labeled, for Simultaneous Direct Immunofluorescence Detection. (B. Wagner, pers. comm. 2003)

3.2.3 CPV

Sub-samples from 106 faeces were inoculated into a 12.5-cm^2 tissue culture flask of CRFK (Crandall's feline kidney) cells grown in Dulbecco's Modified Eagle medium (DMEM) with 5% gamma irradiated foetal bovine serum and incubated at 37 degrees for 5 days. The monolayers were scraped off and a cytospin preparation of the cell suspension was made on a glass slide. The cells prep was examined for the presence of CPV-2 infected cells by FAT (fluorescent antibody technique) using a monoclonal antibody raised against CPV-2 that recognizes CPV-2 and feline panleukopenia virus. (K. West, Virologist, pers. comm. 2003)

Statistical analyses performed were summary statistics and the Mantel test with both unaltered and natural logged data sets. $P <= 0.05$ was considered significant.

3.3 Results

Flotation examination revealed 1 parasite in 228 (71.3%) of 320 samples. Seventy-nine (24.7%) had 2 species of parasite, 22 (6.9%) had 3, and 2 (>1%) scats were infected with 4 and 5 parasite species each (Figure 11). The detailed data for parasites in the 320-scat samples are shown in Appendix 3. Sarcocysts and Taeniids were found most frequently in the samples, occurring in 120/320 (37.5%) and 108/320 (33.80%), respectively. Of special concern is the percentage of scat found with Giardia (21.9%).

The initial source of *Giardia* and down stream uses of waterways may have implications to the health of other wildlife and humans (Chilvers et al. 1998).

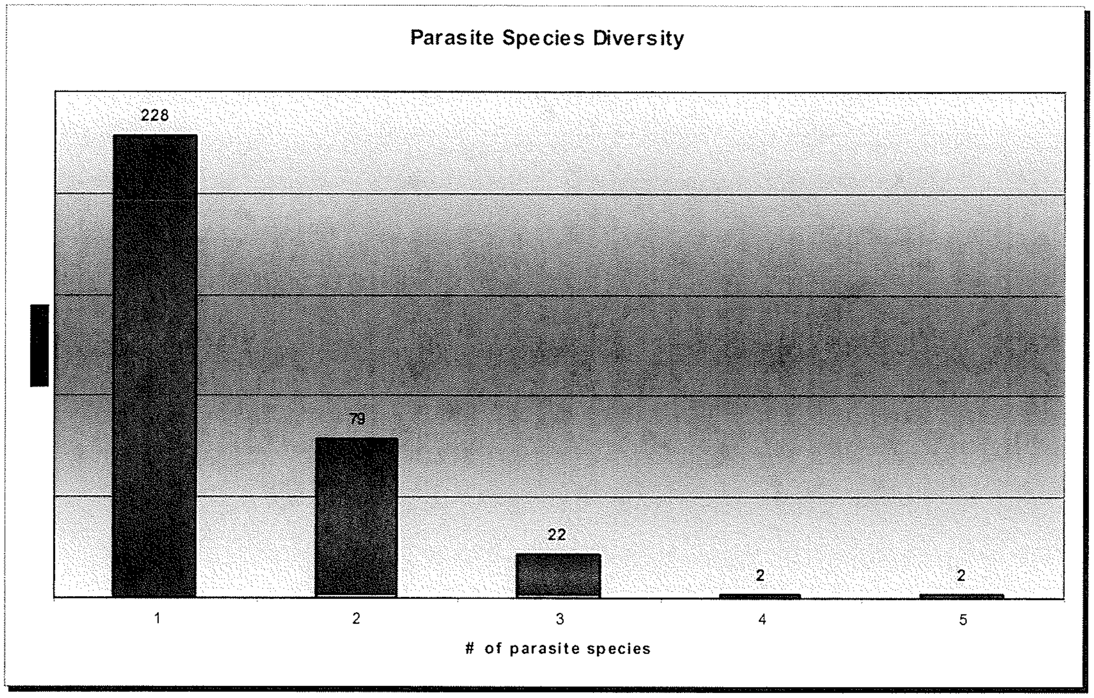

Figure 11. Scat Parasite Species Diversity - shows number of parasite species found in each scat.

The percent (%) prevalence is defined as the proportion of samples showing the presence of parasites. Mean intensities in positive samples were calculated ignoring the negative samples (Table 4, Figure 12 and 13).

Table 5. The % occurrence and mean number for each parasite in wolf (*Canis lupus*) scat from Riding Mountain National Park. Faecal samples were collected from September 2001 to March 2003.

Parasite (n=320)	Occurrences	% Prevalence	Sum of Parasite	Mean Intensities
Alaria	31	9.70%	378	12.19
Capillaria	6	1.90%	8099	1349.83
Coccidia	10	3.10%	825	82.50
Cryptosporidium	1	0.30%	800	800.00
Demodex	1	0.30%	1	1.00
Giardia	70	21.90%	25181	359.73
Moniezia	3	0.90%	262	87.33
Sarcocysts	120	37.50%	550765	4589.71
Taeniid	108	33.80%	86650	802.31
Toxascaris	3	0.90%	274	91.33
Toxocara	1	0.30%	7	7.00
Trichuris	11	3.40%	171	15.55

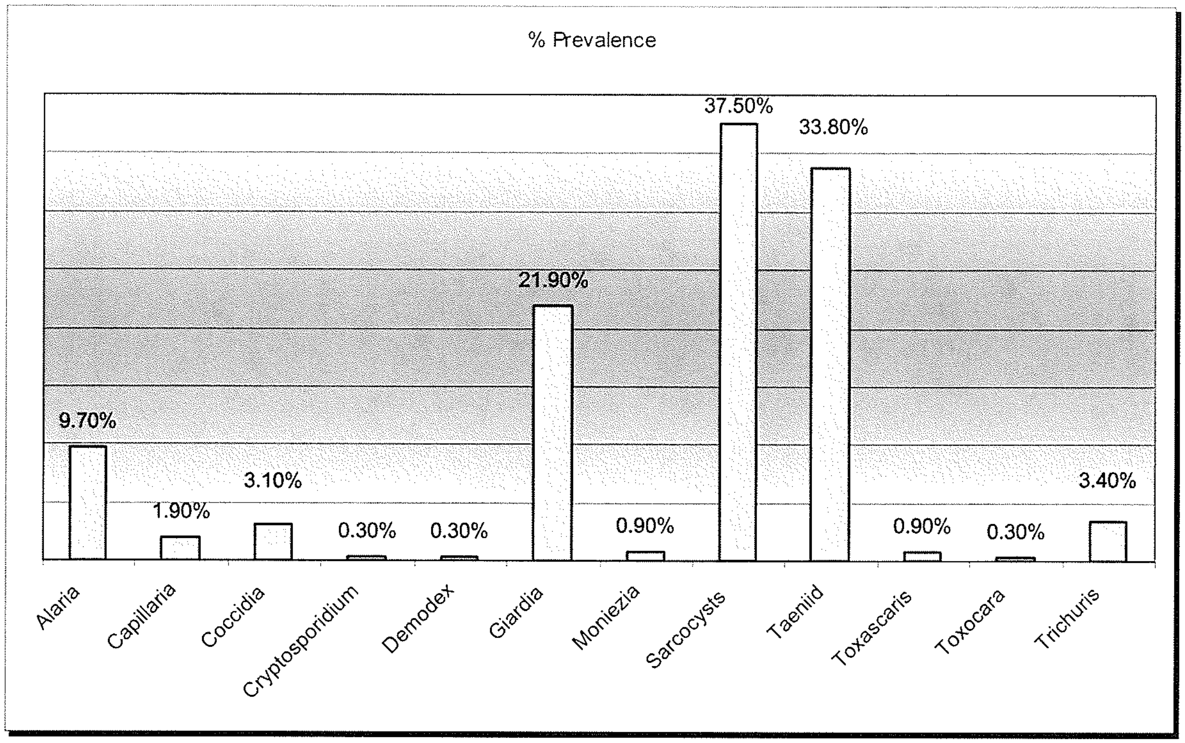

Figure 12. Proportion of scat samples showing the presence of parasite species.

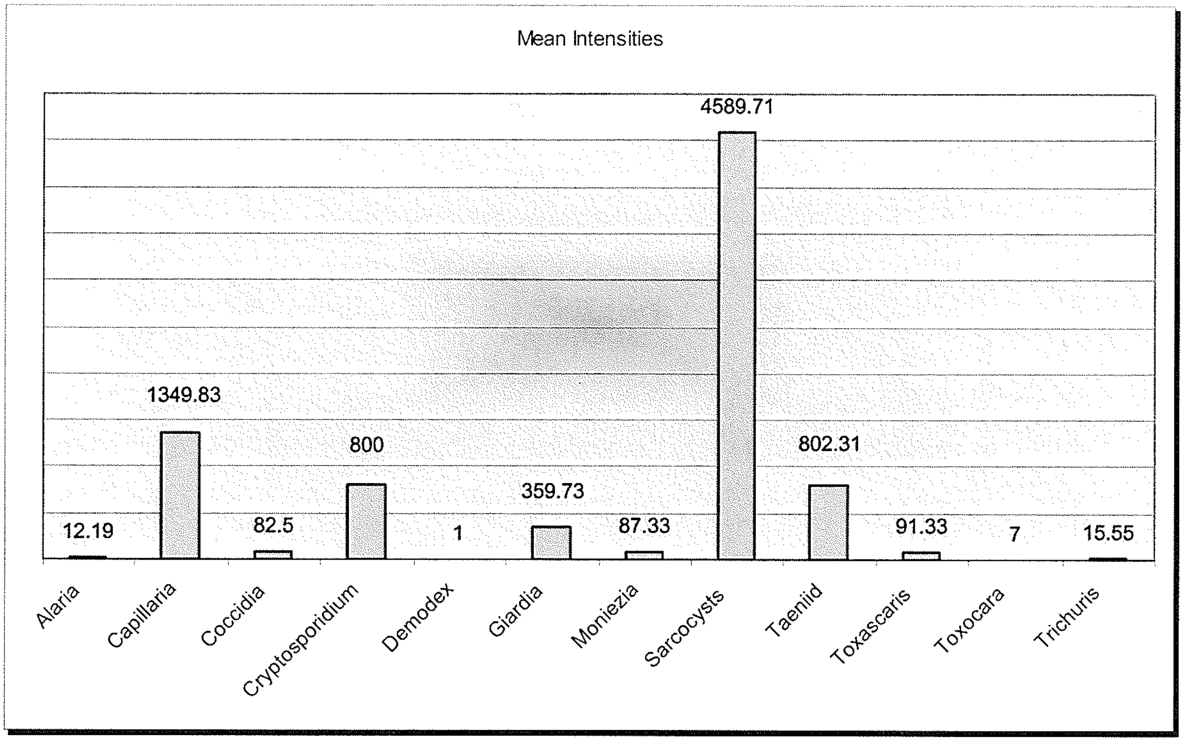

Figure 13. Mean number of parasite species in scat samples collected. (n=320)

The mean densities for all the samples were calculated separately (Table 5).

Table 6. Summary statistics of parasites in all (n=320) wolf scat from Riding Mountain National Park of Canada. Faecal samples were collected from September 2001 to March 2003.

Parasite (n=320)	Mean Density	Standard Error	St. Dev.
Alaria	1.2	0.3	6.2
Capillaria	25.3	20.2	360.5
Coccidia	2.6	1.2	21.8
Cryptosporidium	2.5	2.5	44.7
Demodex	0.003	0.003	0.1
Giardia	78.7	14.9	267.6
Moniezia	0.87	0.6	9.96
Sarcocysts	1721.1	286.4	5123.26
Taeniid	270.8	118.1	2112.16
Toxascaris	0.9	0.6	10.86
Toxocara	0.02	0.02	0.4
Trichuris	0.5	0.4	6.5

The Mantel analyses with permutation test reveals that distributions of parasites present in wolf scat are even across RMNP, i.e. no "hot spots" of parasite prevalence occur in any particular region of the park. The slight trend from northwest to southeast can be attributed to the collection regime of scat according to the Mantel analyses. Any trend toward seasonality in parasitic presences can also be attributed to scat collection bias in winter months.

3.4 Brief description & spatial distribution of parasites found in wolf scat from RMNP.

3.4.1 *Alaria* sp. (Indirect infection to definitive host (e.g. wolf) - up to 4 intermediate hosts)

This parasite is of interest because of its complex life cycle in which a canid species acts as the definitive host. The adult worms infect the small intestine of a canid where eggs are laid and pass out with the host faeces. After hatch, the larval stage locates and penetrates an aquatic snail. The sporocyst stage develops in the snail over a period of about 1-year, when they escape from the snail, swim to the surface of the water, and seek out another intermediate host, such as a tadpole. When they contact the tadpole and penetrate, they form a mesocercaria, the infective stage for the next host. This stage remains infective during the period in which the tadpole metamorphosis to the frog (Bush et al. 2001).

The transmission from tadpole to canid is quite unlikely, but if eaten by a third intermediate host such as a muskrat the mesocercaria burrow into the host tissue and remain as infective mesocercaria. The muskrat, when eaten by the definitive host (canids) releases the mesocercaria, which penetrate the gut wall entering the coelum and move to the diaphragm and lungs where they transform into a diplostomulum metacercaria. The metacercaria migrate up the trachea, are swallowed, and mature in the small intestine, after about 1-month. The mature worms are very pathogenic often killing the host (Bush et al. 2001). (Figure14.1)

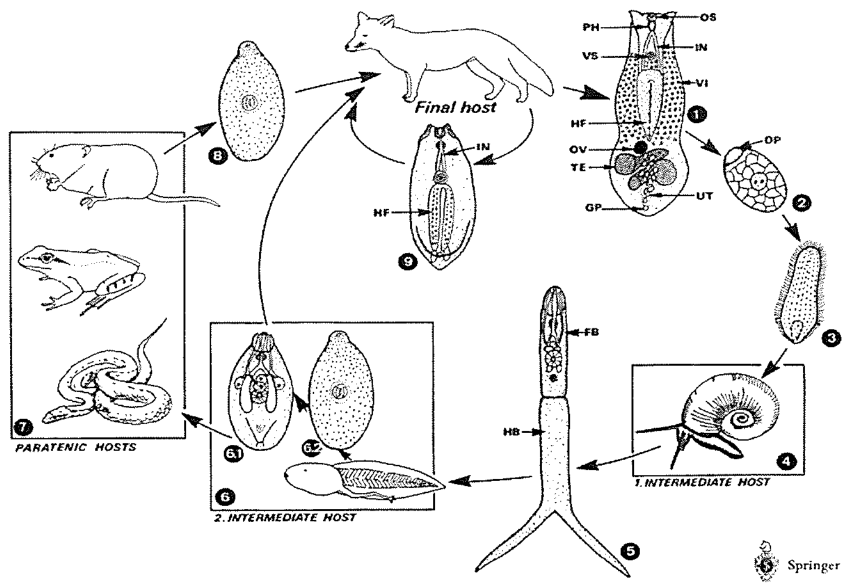

Figure 14.1. *Alaria* Lifecycle
http://parasitology.informatik.uni-wuerzburg.de/login/b/me14248.png.php

The distribution of wolf scat containing Alaria is consistent with the distribution of scat collection. There is no real concentration or focal point for this parasite in the park. The distribution is shown in Figure 14.2.

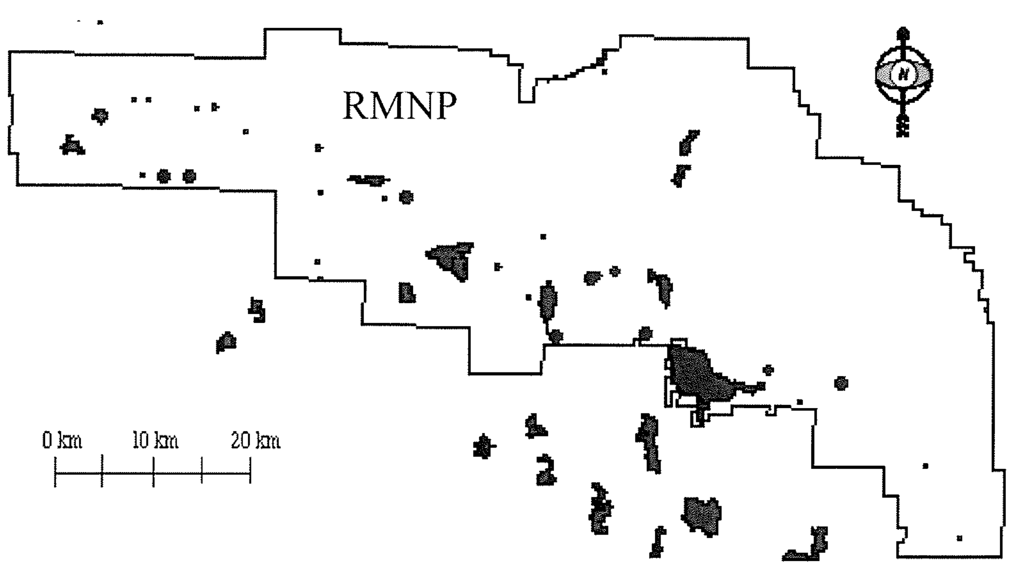

Figure 14.2. *Alaria* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.2 *Capillaria* (Accidental in wolf through prey)

This parasite is found primarily in rodents, although it has been reported in canines and humans. The adult female produces eggs, but few of these eggs are passed in the host's faeces. Eggs are passed on when a predator (wolf in this case) eats the infected host. The eggs are then released from the rodent's tissue and passed in the predator's faeces. Once returned to the soil, the eggs are ingested by the next host (rodent) and hatch in the small intestine. The larvae enter the blood stream and are transported to the liver. Once in the liver the juveniles grow into sexually mature adults (Bush et al. 2001) (Figure 15.1.)

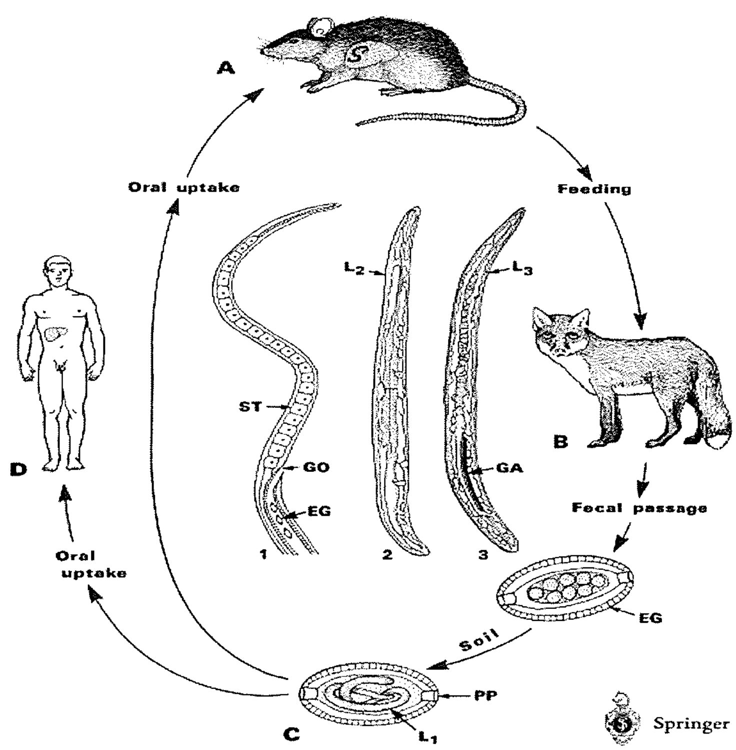

Figure 15.1. *Capillaria* Lifecycle
http://parasitology.informatik.uni-wuerzburg.de/login/frame.php

The distribution of wolf scat containing *Capillaria* may be focused around the Audy Lake region of the park. The distribution is shown in Figure 15.2.

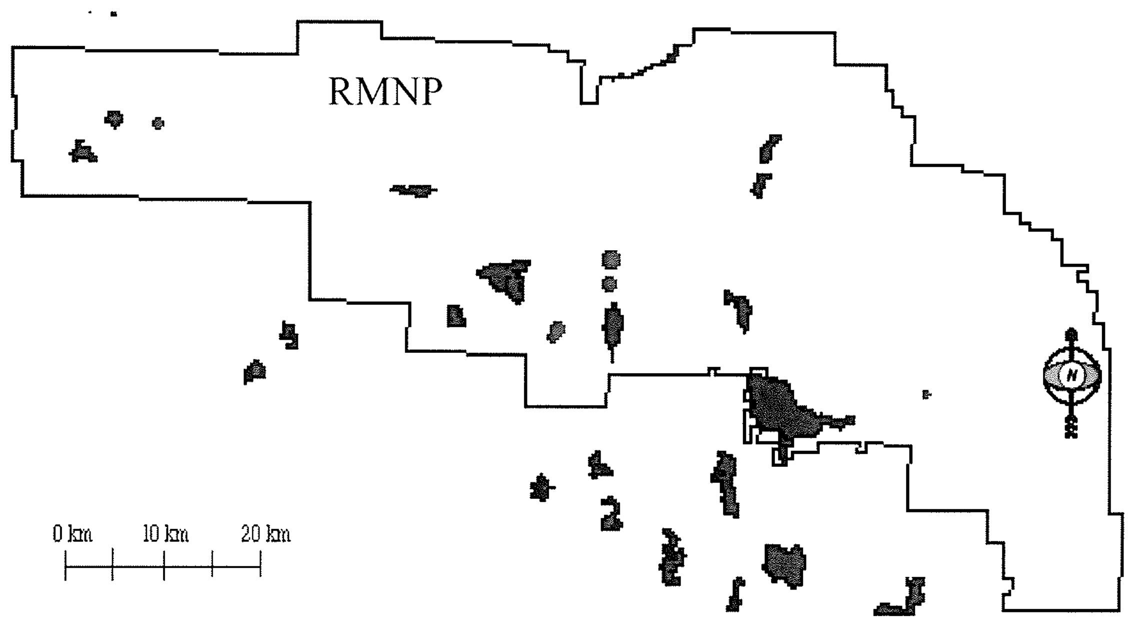

Figure 15.2. *Capillaria* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.2 *Coccidia* – Eimeria spp. (likely species for RMNP scat samples) (Accidental in wolf through prey)

A host is infected when it ingests infected faeces from another host or preys on infected rodents. The parasite reproduces in the gut and it is passed in the host's faeces. Typically, when eggs are passed in the faeces, they are not infective until several days (or weeks, depending on the species) outside of the host's body. The eggs complete development, becoming infective to the next host (Bush et al. 2001). The distribution of scat infected with Coccidia is shown in Figure 16.

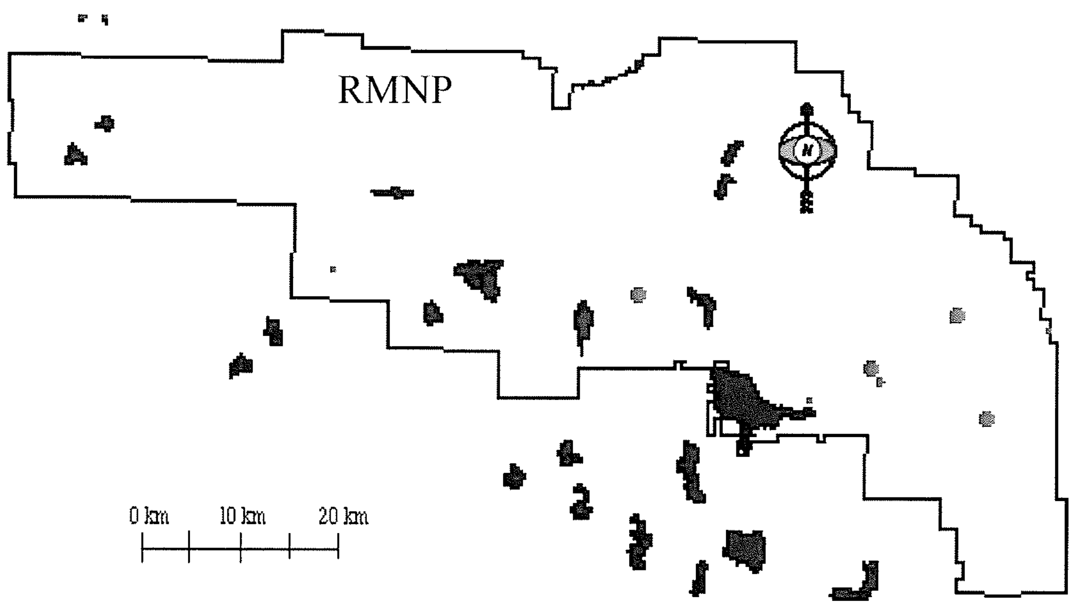

Figure 16. *Coccidia* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.4 ***Cryptosporidium*** is an accidental infector of wolves through water. It lives in the small intestine and is passed in the faeces. The contamination of drinking water with *Cryptosporidium* from agricultural "run-off" (i.e. drainage from pastures) can cause severe diarrhea in both animals and human. Death may occur in immunosuppressed individuals (Deng et al. 2000; Fayer et al. 2001; Buckley and Warnken 2003; Medica and Sukhdeo 2001).

The life cycle of most *Cryptosporidium* species is completed within the gastrointestinal tract (primarily the small intestine) of the host, with developmental stages being associated with the luminal surface of the mucosal epithelial cells (Figure 17.1).

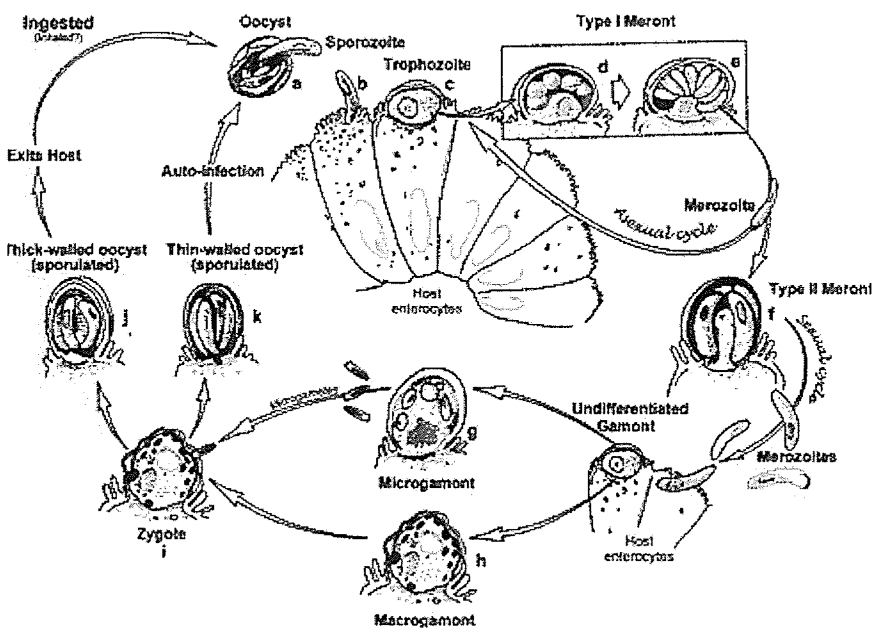

Figure 17.1. *Cryptosporidium* Lifecycle.
http://www.cryptosporidium.it/index.php?id=0102

The single occurrence wolf scat containing Cryptosporidium is shown in Figure 17.2.

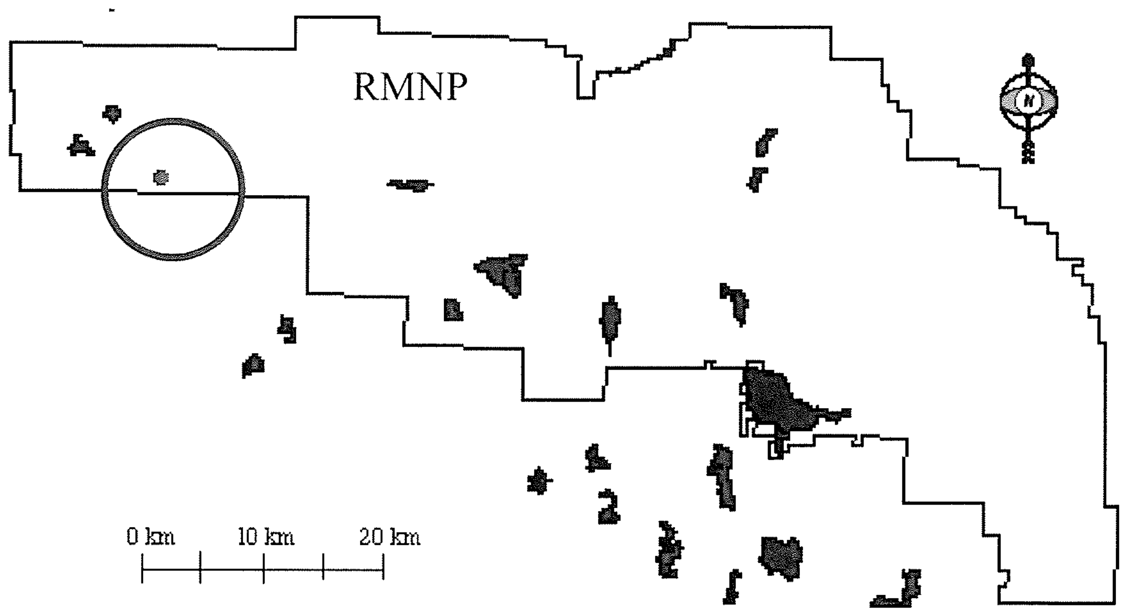

Figure 17.2. *Cryptosporidium* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.5 *Demodex* spp. (Follicle mites) (Accidental ingestion by wolf through grooming or prey infection)

Follicle mites infect many species of mammals and are host specific. Canids are infected with *D. canis* (the dog follicle mite), which can cause red mange or canine demodectic mange. This mite can cause severe skin problems in infected canids, including significant loss of hair and skin rashes (Bush et al. 2001) (Figure 18.1).

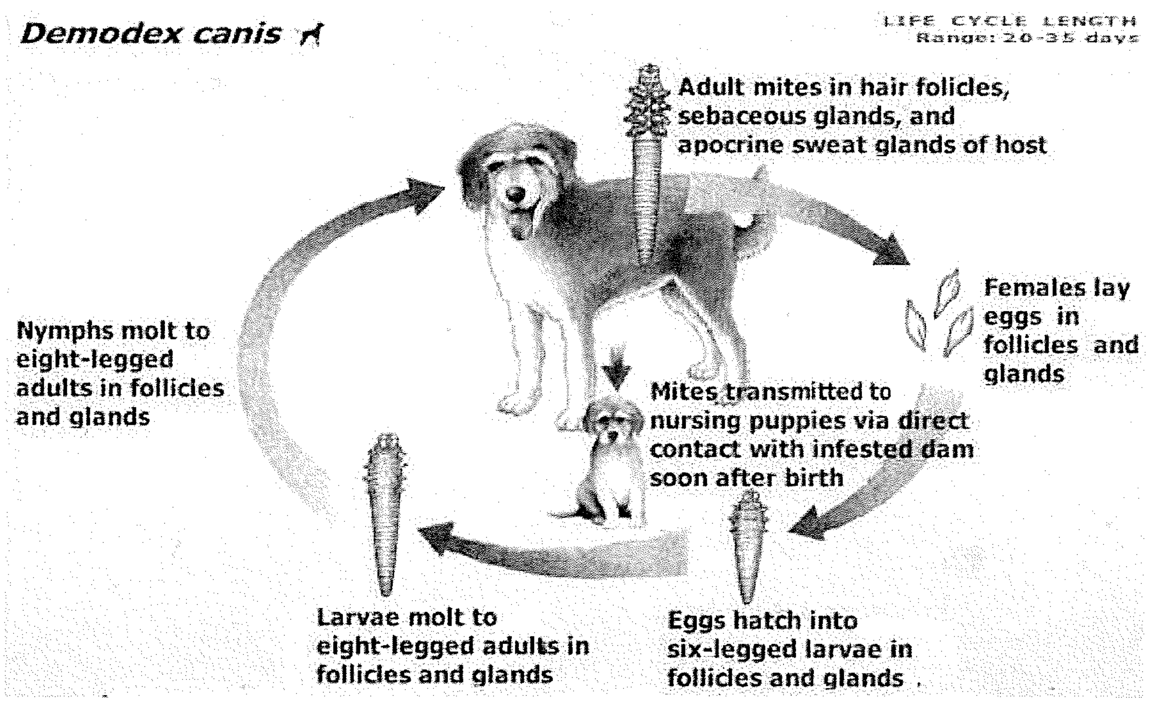

Figure 18.1. *Demodex* Life Cycle
http://www.cvm.okstate.edu/instruction/mm_curr/parasitology/1DemoLife.htm

The single occurrence wolf scat containing Demodex is shown in Figure 19.2.

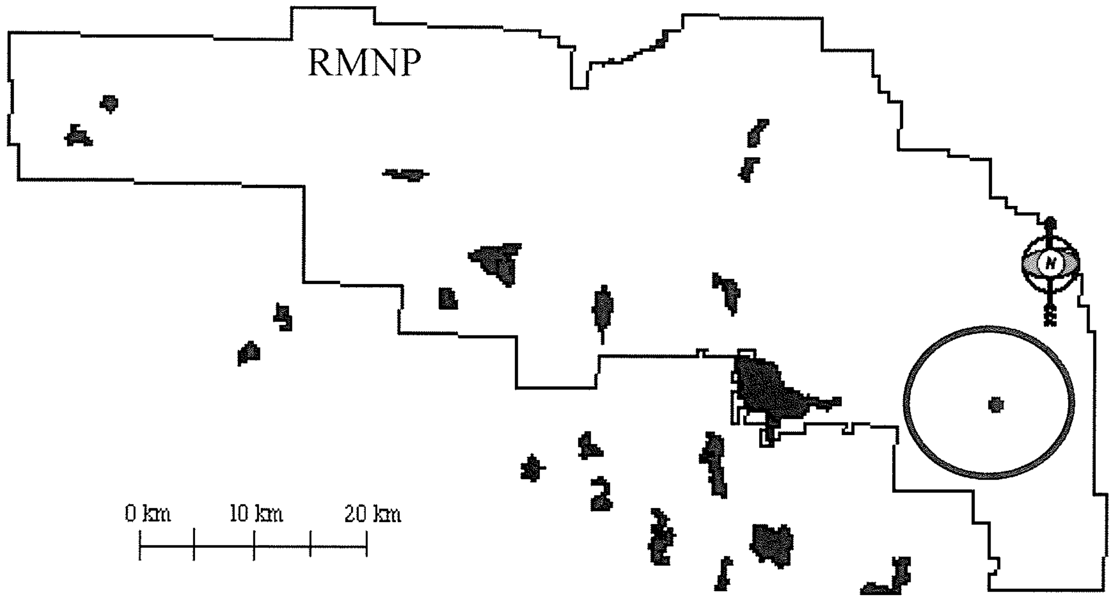

Figure 18.2. *Demodex* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.6 *Giardia* (Accidental infection of wolf through water)

Giardia spp. lives in the small intestine of the host. Cysts are very hearty, and pass in the faeces of an infected host. Ingesting infected food or water infects the next host. *Giardia* adheres to the lining of the small intestine, and may cause no symptoms or very to severe, chronic diarrhea (in heavy infections). *Giardia* infects animals, particularly beavers, and wolves may contract giardiasis from drinking stream water or consuming beavers. Some authorities believe that wildlife infections result from streams contaminated with human faeces (Buckley and Warnken 2003).

Giardia is found in wolf scat throughout RMNP (Figure 19).

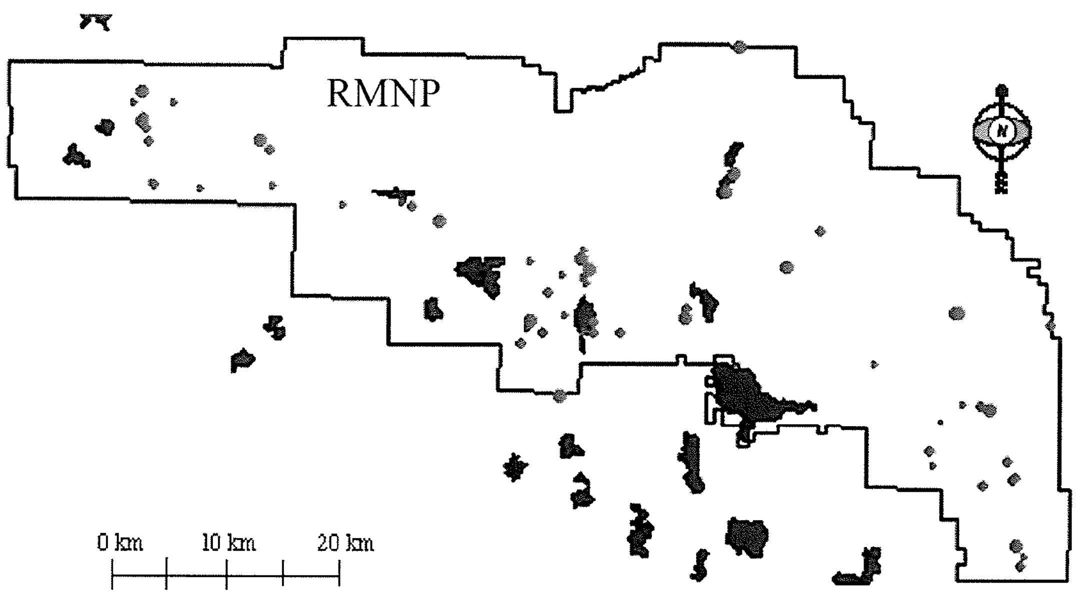

Figure 19. *Giardia* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.7 *Moniezia* spp. (Accidental in wolf through prey - up to 2 hosts)

Moniezia spp. adults are tapeworms found in the intestines of sheep and cattle. Eggs pass in the faeces and are soil mites. The soil mites harbour the parasite until the definitive host, sheep, cattle or elk eats the infected mite. Canids contract the parasite through ingestion of the ungulate host carriers (Bush et al. 2001) (Figure 20.1).

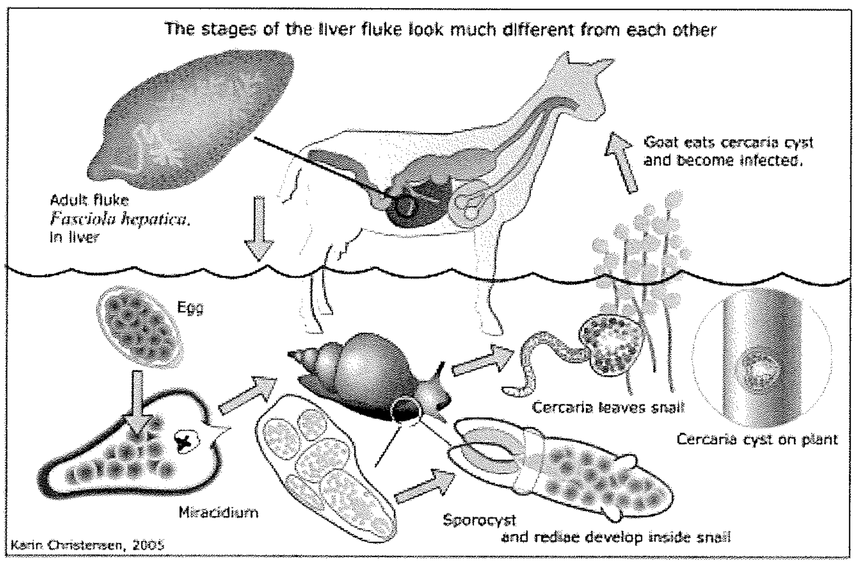

Figure 20.1. *Moniezia* life cycle
http://www.imagecyte.com/parasites.html

The occurrence of *Moniezia* seems to be centered in the Whirlpool Lake Area of RMNP (Figure 20.2)

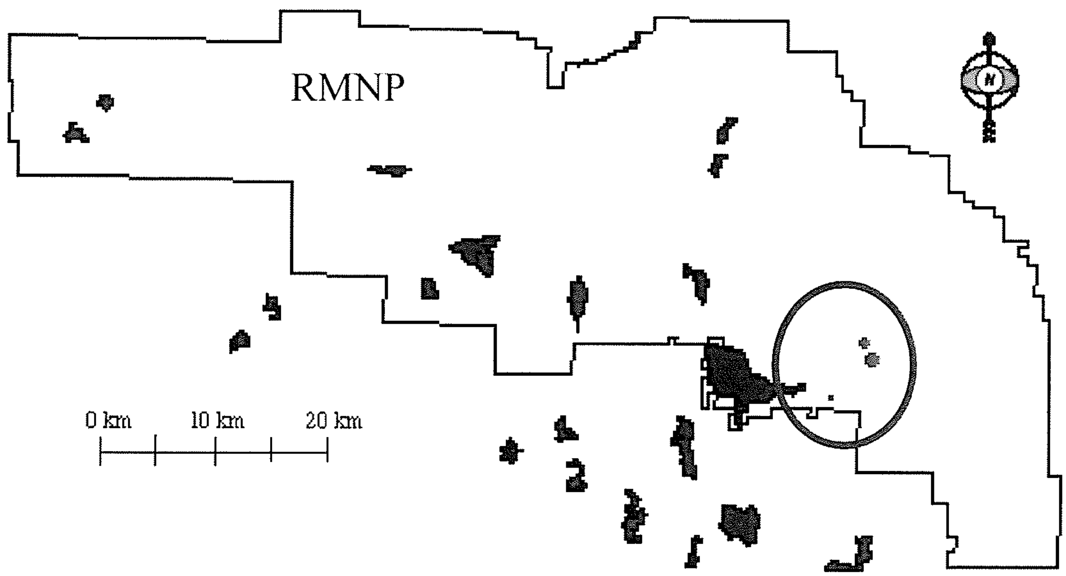

Figure 20.2. *Moniezia* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.8 *Sarcocystis* spp. (Indirect infection to definitive host (e.g. wolf) - 2 intermediate hosts)

There are a number of species of *Sarcocystis*, all of which need 2 hosts to carry on the life cycles. In most instances, the intermediate host is a hoofed animal (elk), and many species of canids will be the definitive host. The definitive host is infected when it ingests tissues (meat or prey) containing sarcocysts. In the definitive host (wolf), the parasites infect the small intestine and eventually pass in the faeces. The intermediate hosts will inadvertently ingest the parasite, left by the wolf faeces, while grazing and complete the cycle within this intermediate host (Bush et al. 2001) (Figure 21.1).

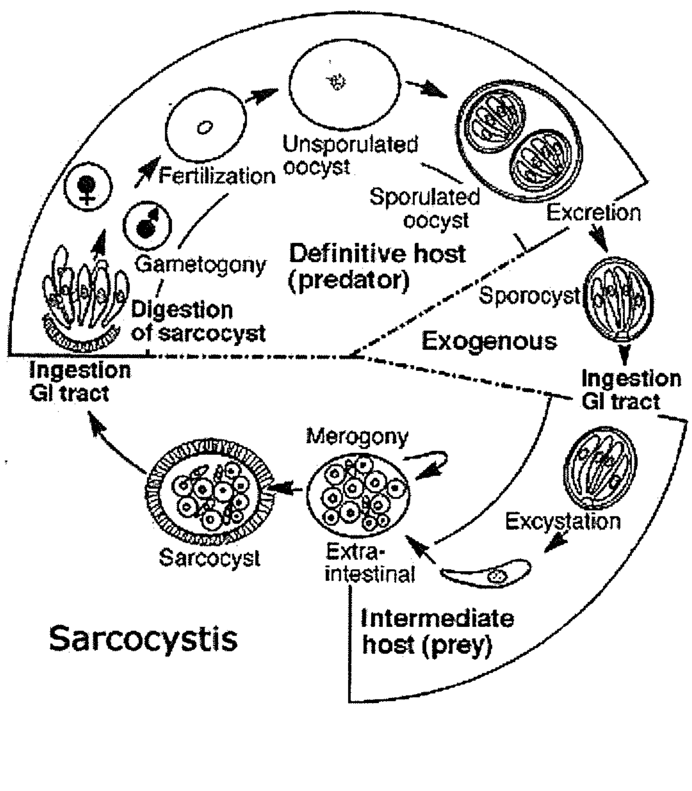

Figure 21.1. *Sarcocystis* spp. Life Cycle
http://www.michigan.gov/dnr/0,1607,7-153-10370_12150_12220-27272--,00.html

Sarcocystis spp. seems to be ubiquitous throughout RMNP, as shown in Figure 21.2.

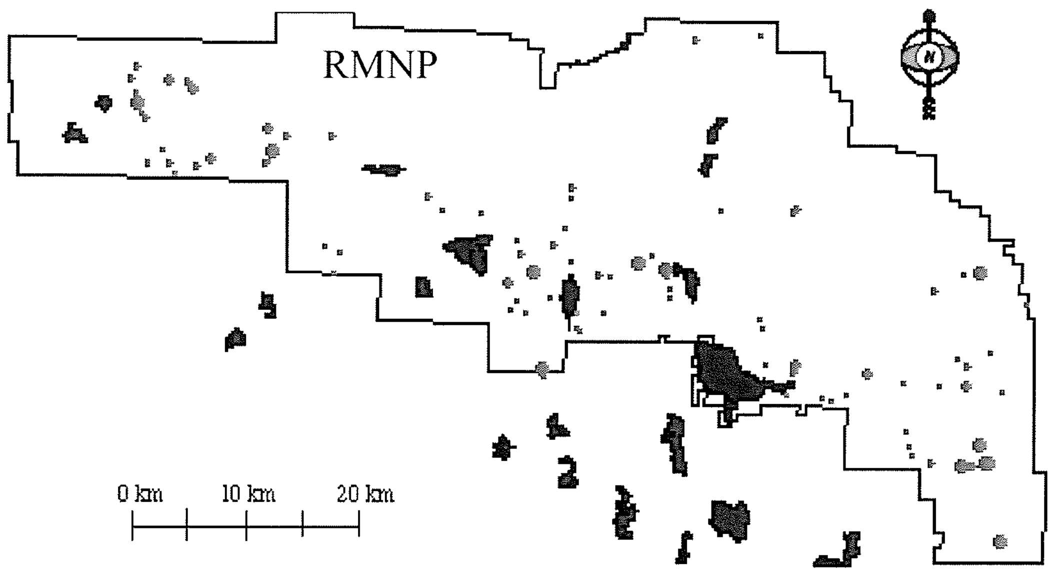

Figure 21.2. *Sarcocysts* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.9 *Taenia* spp. (Indirect infection to definitive host (e.g. wolf) - 2 intermediate hosts)

All species of *Taenia* have similar life cycles. The adult tapeworm lives in the definitive host's small intestine. Proglottids, which contain eggs, break off the posterior end of the tapeworm, and these proglottids are either passed intact in the host's faeces or they dissolve in the host's intestine and eggs are passed in the faeces. The intermediate host is infected when it ingests the eggs, and a cysticercus develops in the intermediate host. The definitive host is infected when it eats an intermediate host infected with the parasite (McNeill et al. 1984; Shimalov and Shimalov 2000) (Figure 22.1).

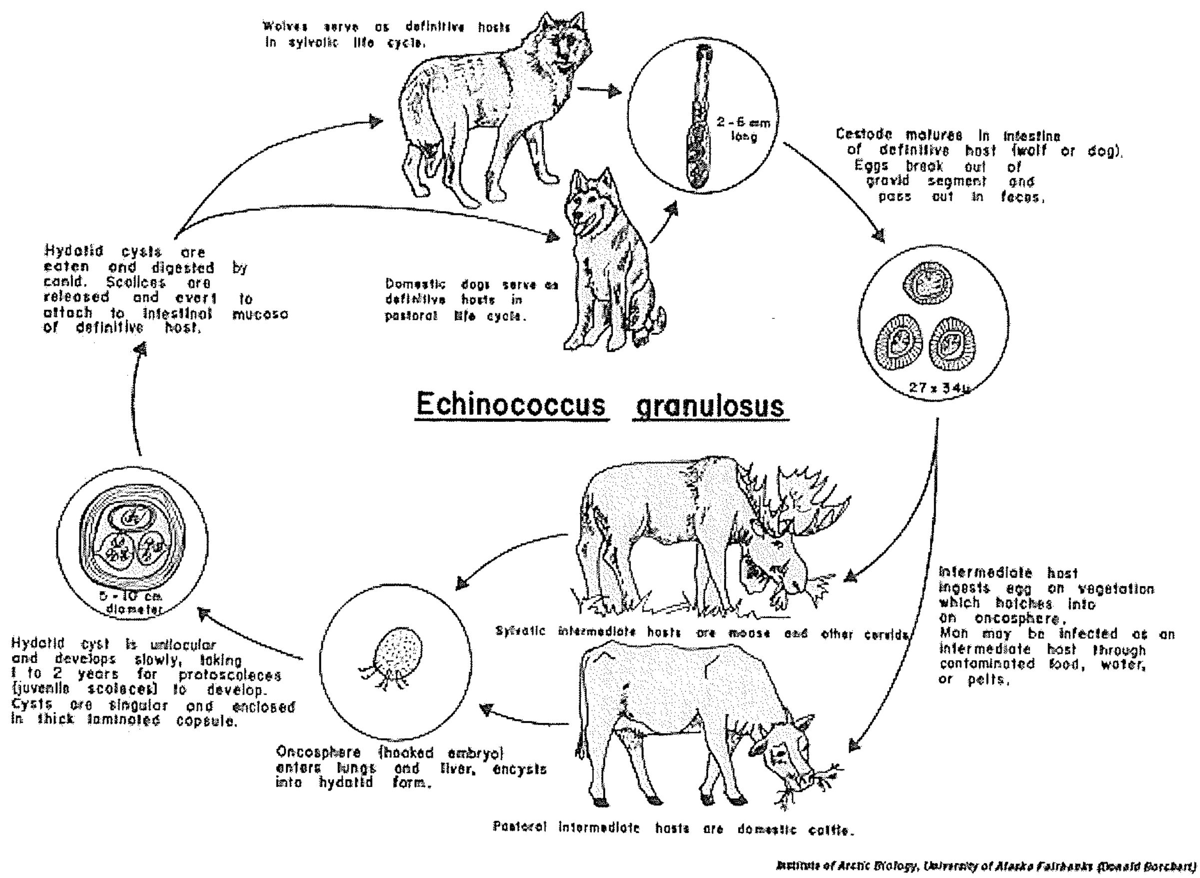

Figure 22.1. *Taenia* spp. Life Cycle.
http://www.michigan.gov/images/echinococcustransmission_124098_7.jpg

Taenia spp. also seems to be ubiquitous throughout RMNP, as shown in Figure 22.2.

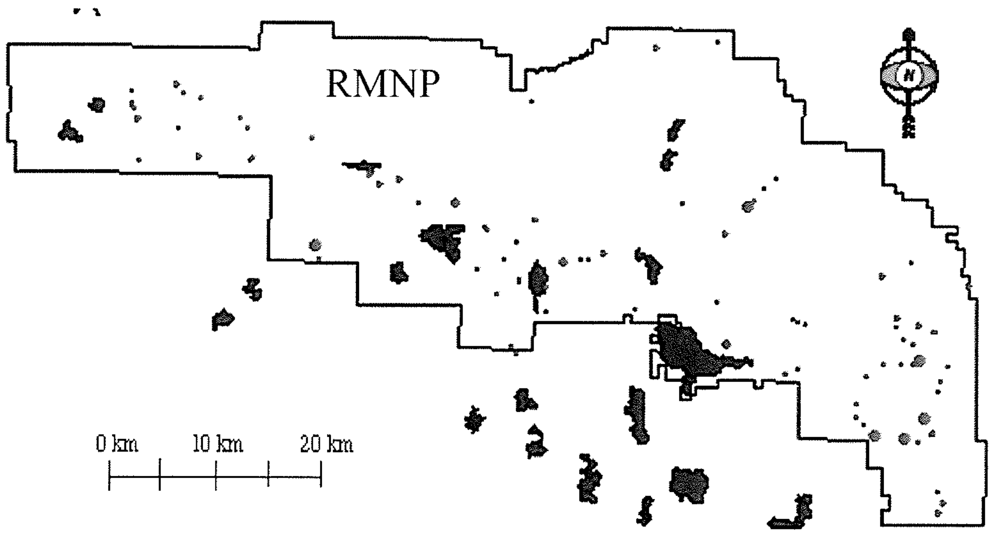

Figure 22.2. *Taeniid* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.10 *Toxocara* and *Toxascaris* spp. (intestinal roundworm) (Accidental in wolf through prey)

The life cycle of Toxocara and Toxascaris, a common roundworm of canids, are very similar. If an animal, such as a rodent, eats infective eggs of these parasites, larvae will develop in this animal. If a canid then eats this animal, the canid is infected. The eggs of these parasites are extremely resistant to adverse environmental conditions, and once an area is contaminated with eggs, it is very difficult to sanitize the area (Bush et al. 2001) (Figure 23.1).

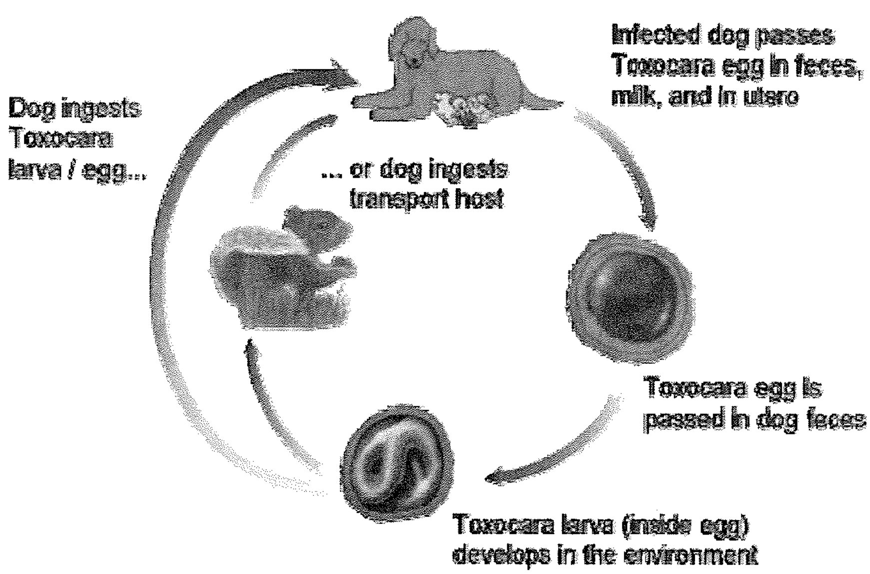

Figure 23.1 Roundworm Life Cycle
http://marvistavet.com/html/body_roundworms_in_canids.html

The few occurrences of roundworm are situated in the Ministic Lake area of RMNP (Figure 23.2).

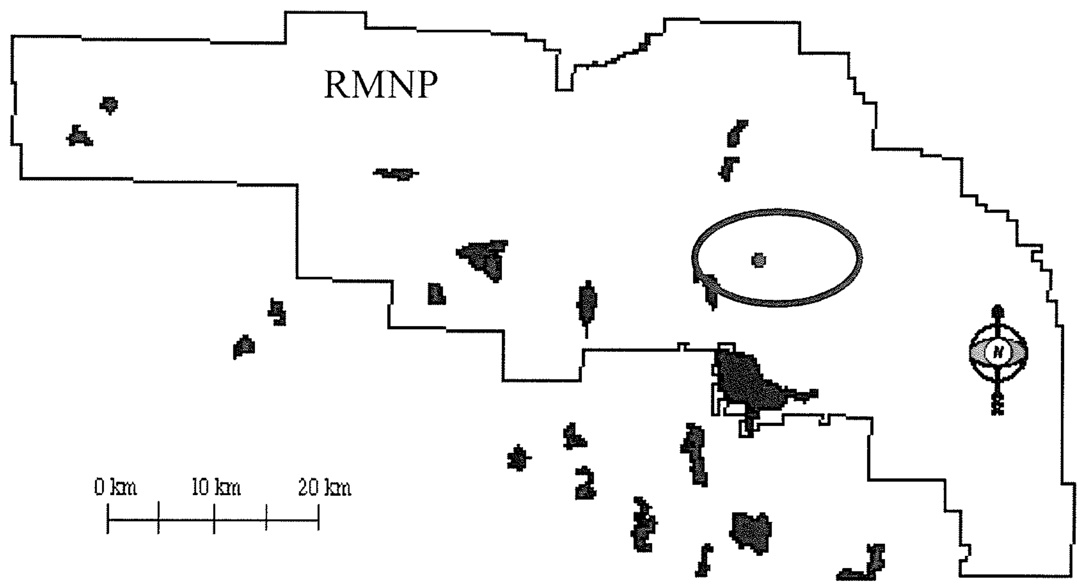

Figure 23.2. *Toxocara* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

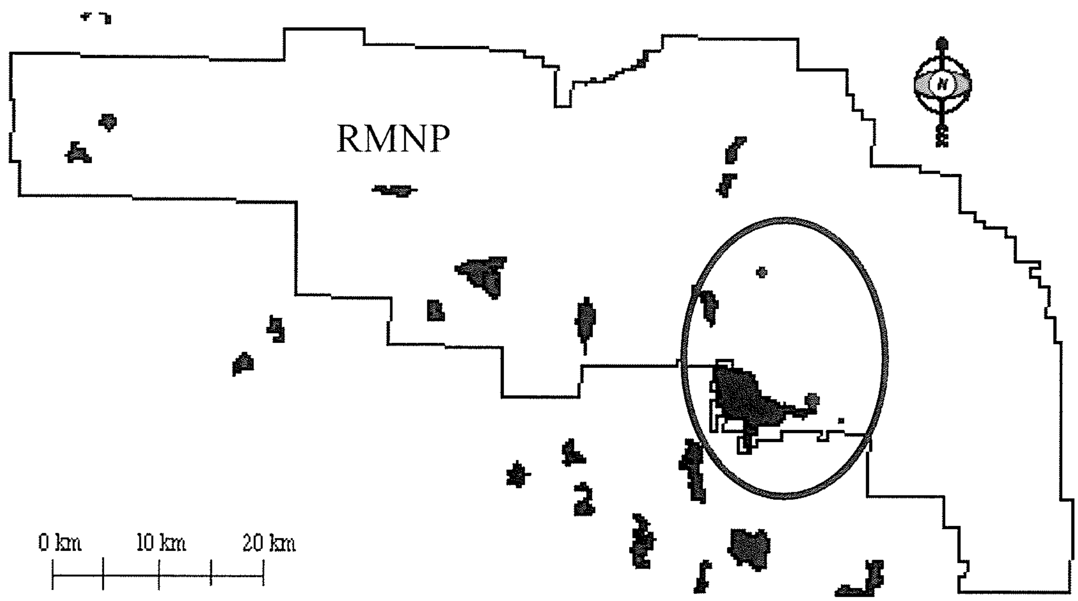

Figure 23.3. *Toxascaris* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.11 *Trichuris* spp. (Whipworms) (direct lifecycle in wolf)

Approximately 60 species of whipworms infect mammals. The adult, canine whipworm, *T. vulpis*, lives in the host's large intestine. Eggs are passed in the host's faeces, and are eaten by the appropriate host to hatch in the small intestine. Most infections of whipworms cause no problems but because the worms live a long time and can reinfect constantly, heavy worm burdens can develop. Symptoms of whipworm infection can include diarrhea, dysentery, and anaemia (Pozio et al. 2001; Bush et al. 2001) (Figure 24.1).

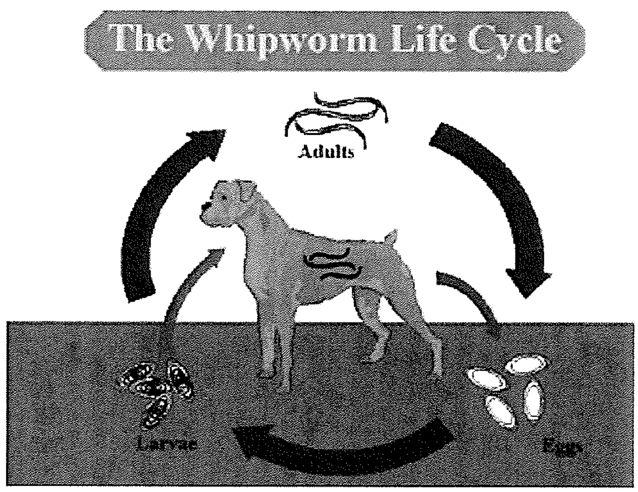

Figure 24.1 General *Trichuris* spp. Life Cycle

The *Trichuris* spp. is found in wolf scat sporadically throughout RMNP (Figure 24.2).

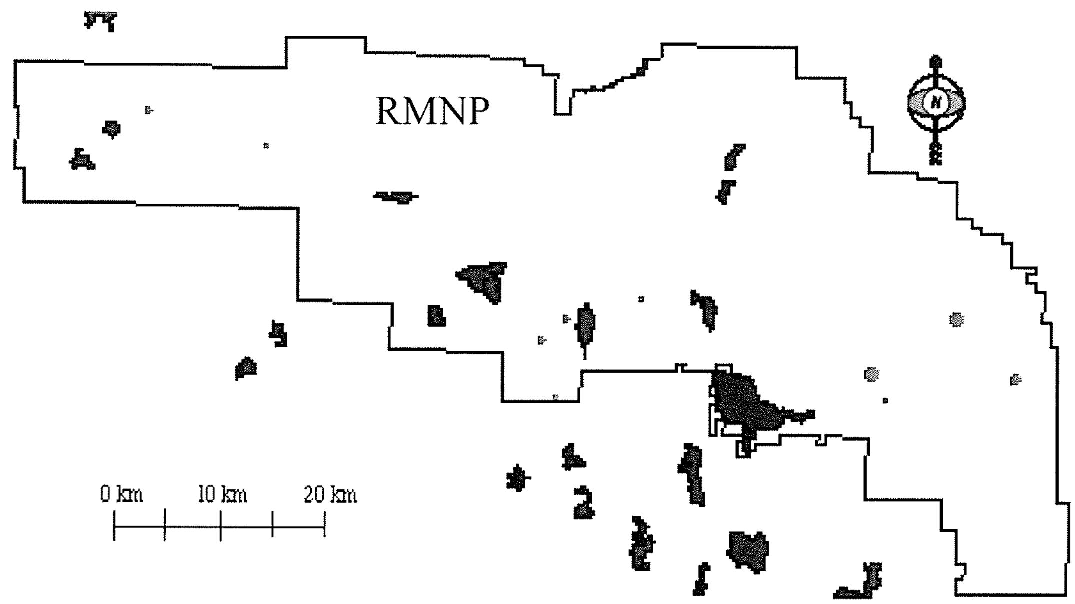

Figure 24.2. *Trichuris* distribution from RMNP faecal samples collected Sept. 2001 - March 2003.

3.4.12 Canine parvovirus (CPV) (direct lifecycle in wolf)

CPV is a relatively new disease, first appearing in the mid-1970s and now ubiquitous throughout the world. The disease is highly contagious and spreads rapidly in canids. Infection is through the oral/nasal route when contaminated faeces are contacted. The virus reproduces in lymph nodes and the upper respiratory system. One to 5 days after infection the virus enters the bloodstream where it travels to the small intestine and attacks the intestinal epithelial cells resulting in diarrhea. The small intestine may be damaged so much that normal gut fauna (bacteria) may gain access to the bloodstream resulting in secondary bacterial infection. Fecal shedding of the virus begins 3 or 4 days after the animal is exposed (before the onset of clinical signs). One week after recovery viral shedding ends. The virus remains infectious in the environment for over 6 months.

Figure 25 shows the distribution of wolf scat tested for CPV in RMNP, all were negative.

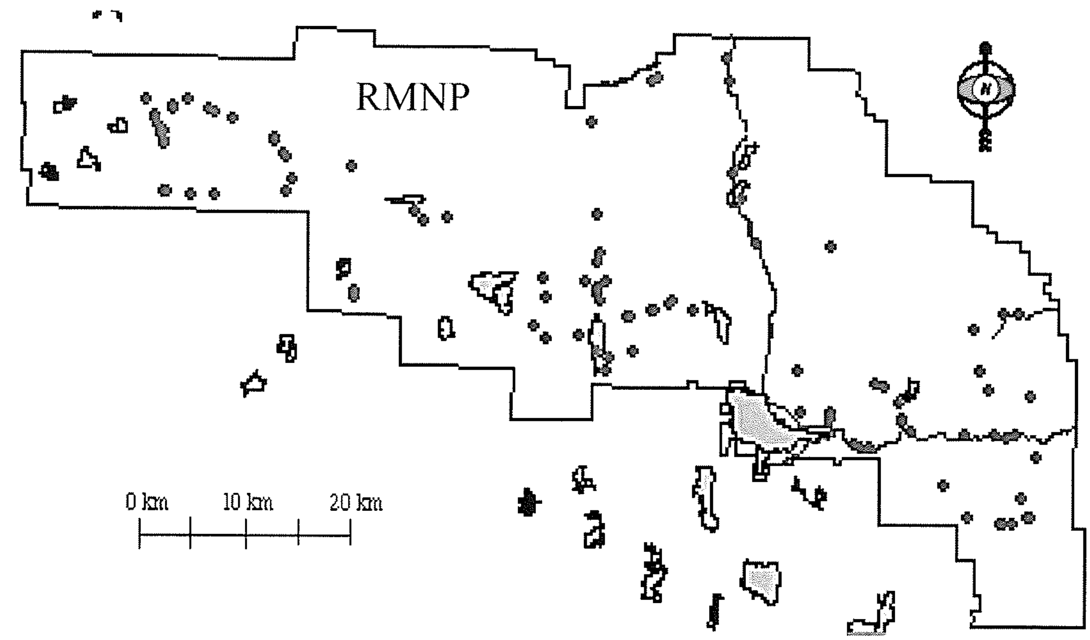

Figure 25. Distribution of 106 faecal samples collected (Sept. 2001 - March 2003) and tested for CPV. All were negative for CPV.

3.5 Discussion

The investigation of some 320 scat samples, collected from September 2001 - March 2003, in RMNP, detected 12 intestinal parasite species. Other published results of intestinal parasite species richness are in the range of 5 in a Quebec study to 24 in Byelorussia (McNeill et al. 1984, Shimalov and Shimalov 2000, Segovia et al. 2003). Although the overall prevalence of parasites in wolf scat from RMNP is at 95% (n=320), a Poland study showed a prevalence rate of 63.5% (n=52) (Kloch et al. 2005). The prevalence rate in RMNP is more comparable to wolf autopsy data from parts of Europe at 100% (Guberti et al. 1993) and 96% (Segovia et al. 2001). Therefore, this study has probably given a realistic examination of overall prevalence rates of parasite load in RMNP wolves.

The maximum parasite species diversity was 5 in 2 scat (Figure 11). This is comparable to reports from other studies in North America and Europe (Choquette et al. 1973, Kloch 2005). Exact identities of species were not determined, but as in other studies, *Taeniids* were 1 of the more abundant parasites found at 33.8% prevalence (Figure 12 and 13). In Kloch et al. (2005) *Taeniids* had a prevalence of almost 40% in Poland. The presence of certain species of *Taeniids* is believed to increase with host age and may suppress host immune response (Behnke et al. 1999, Guberti et al. 1993).

Another prevalent parasite in RMNP wolf scat is the *Sarcocysts*. It was found to be present in 37.5% of the wolf scat examined (Figure 12 and 13). This is a single celled organism found throughout the world and is most certainly present in the prey species of RMNP wolves (P. Rousseau, Park Warden, pers. comm. 2005). The rate of infection is probably not surprising and future research may prove this the norm.

Giardia spp. is found at a 22% prevalence rate in RMNP wolf scat (Figure 12 and 13). Because these parasites are commonly found in young animals, this may suggest a large proportion of young wolves in the park. The role of wildlife in the spread of this parasite may have management implications for backcountry users of RMNP. Further study will determine if this distribution is an anomaly or if this parasite is indeed a threat to human users of the park.

The 9 other parasite species detected in this study were at less than 10% prevalence (Figure 12 and 13). Species like *Alaria, Trichuris*, and *Coccidia* are considered satellite species by Segovia et al. (2003). As a group, they are abundant, but individually they are limited in numbers. Their presence may be an indication of a healthy intestinal community for wolves in RMNP and therefore an indication of a healthy functioning regional ecosystem (Hudson et al. 2006, Keesing et al. 2006). The data tabulated for these and the other parasites can act as a baseline for comparison when further research can be completed. Slight spatial and temporal trends, when present, can be attributed to collection regime artefacts.

Canine parvovirus is a disease of concern for any small, isolated population of wildlife (Mech and Goyal 1993). Although recent cases have not been reported in the RMNP wolves, it is known that CPV antibody are present in blood serum taken from recently collared animals (Vik Stronen, UNB Research Student, pers. comm. 2006). This disease is not necessarily a concern for older animals as they are shown to become immune once exposed. Pups are much more susceptible upon infection and are more prone to death (Johnson et al. 1994).

3.6 Conclusions

Wolves have a rich and diverse parasite species community. These results leave no doubt about the need to include parasites and diseases in any comprehensive study of wolf ecology. Because the frequency of locating fresh scats is usually high in most of the wolf areas, parasite compositions in scats can be useful in monitoring wolf health, particularly in areas where wolf sightings are rare. Besides a number of questions regarding individual health, pack demographics, prey choice, territorial behaviour, movement patterns, and reproductive success in relation to parasite loads can be worth investigating (Hudson et al. 2006).

Parasites have complex interactions with their hosts and the environment. Various factors including spatial location, season, host characteristics (behaviour, genetics, natural and acquired immunity), as well as the life cycles of the various parasites, determine the level of infection on the host. Before this study, the presence and prevalence of gastrointestinal parasites in wolves, found through scat analysis, has not been documented in RMNP. These data will be used as baseline information for comparative analysis for further investigations.

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Chapter 4.0

Summary, Conclusions and Recommendations

4.1 Summary and Conclusions

The focus of this thesis were to quantitatively assess the dependence of wolves on the faunal components of the RMNP ecosystem by way of measuring relative consumption of prey species and to gather baseline information on the macro- and micro-parasites present in the wolves through scat analysis.

A basic component of wolves continued existence in an area is the distribution and abundance of prey (Carbyn 1980). In Chapter 2, I showed that wolves use a wide variety of prey, suggestive of a wolf's generalist nature. In RMNP, wolves are inextricably linked to the elk population. Indeed, elk, in biomass, comprise a full 2/3 of a wolf's diet and are clearly important for sustaining this wolf population. This reliance on elk is a mainstay of human conflict with this large carnivore (Boitani 2003, Callaghan 2002, Kyle and Strobeck 2002). As management actions change the number of elk in this region, wolves may become susceptible or deemed responsible for reduced recreational activities.

In Chapter 3, my research provided important baseline data and insight into the vulnerability of the RMNP wolf population to potential disease within the environment. The data provides background for possible concerns about diseases entering a population that may be genetically fragmented (Mech and Boitani 2003, Wilson et al 2000, Woodruffe and Ginsberg 1998)

The investigative techniques used in this work may also contribute to the development research methods that reduce needs for invasive research. These techniques may lead to conclusions about what affect management actions are having on animal populations and may determine overall health of any given population.

4.2 Recommendations

Management of the wolf population in RMNP should focus on factors both internal and external to the RMNP boundaries. Management of prey species is a key factor wildlife managers can control. Management action may include habitat enhancement, restoration, and ungulate monitoring and hunting season success. Other factors are also important to the whole concept of species protection.

For RMNP, external factors play critical roles in wolf conservation. Involvement of stakeholders in wildlife considerations should extend beyond political boundaries of the Park. Teamwork is vital to the management of any large-scale species. Riding Mountain National Park would benefit from participating in open dialogue with various stakeholders about the wolf research occurring in RMNP and asking for their input. Interested parties may include Manitoba Department of Natural Resources, Duck Mountain Provincial Park, trappers, landowners, First Nations groups, various environmental groups, surrounding school groups, the Riding Mountain Biosphere Reserve, universities, and other researchers. Working with these individuals and groups would create better understanding of RMNP wolf population trends, habitat requirements, and usage, and benefits of a persistent wolf population.

4.3 Specific Recommendations

4.3.1 Reassess Wolf Diet Through Scat Analysis.

The data detailed for this thesis was collected in 2002 and 2003. This is before elk management regimes had any marked effect on the RMNP elk populations. The RMNP elk population is currently at lower levels compared to previous years. The importance of elk, as the primary prey species, should be recalculated. A shift from higher relative elk populations to higher relative moose populations.

4.3.2 Reassess Wolf Parasites Through Scat Analysis.

The baseline data collected for this thesis was collected in 2002 and 2003. A sampling regime of every 5-10 years is recommended to capture drastic changes in parasite prevalence in the local wolf population. After a determination is made concerning wolf diet in association with prey population variability, it would be of interest to verify if the parasite diversity and abundance has changed, as well.

4.3.3 Monitor Wolf Population Trends.

As with most wildlife species, it is impossible to determine a complete count for a specific population (Newmark 1995). Consequently, it is recommended that the annual snow-tracking monitoring program be continued. The framework for the annual monitoring is already established. This method, with slight modifications taking into account the decrease in park personnel and reduced coverage is recommended for future monitoring.

Continuous monitoring of the wolf population within RMNP will help determine whether populations in RMNP are increasing or decreasing in relation to elk population changes. With annual monitoring data trends, managers can determine if further investigation is needed into disease, human presence, or other stresses that may affect wolves.

4.3.4 Monitor wolf habitat usage of the areas between RMNP and other wildlife refugia, (e.g. Duck Mountain Provincial Park and the Interlake region.)

Recent habitat initiatives by the Nature Conservancy of Canada and the Parkland Habitat Project may improve movement opportunities for wolves. A recent study by Aidnell (U of M research student, pers. comm., 2007) determined the extent that wolves use the travel corridors that exist outside RMNP's boundaries. She found no evidence of any such movement. Maintaining and perhaps restoring travel corridors between RMNP and Duck Mountain Provincial Park, as well as between RMNP and the Interlake region is very important in the preservation of many species, not just wolves. Because disease susceptibility increases with genetic depletion, maintaining genetic interchange through habitat corridors may be essential for a healthy and viable population in the end.

Conversely, increased movement between these areas may increase the likelihood of disease transmission to other areas and may dilute the genetic uniqueness of RMNP wolves.

4.3.5 Ensure that there is stakeholder involvement when monitoring wolf population trends.

Riding Mountain National Park managers, alone, cannot achieve ecological integrity of the RMNP region. Present partnerships can be improved, and new ones should be established to take into account the ecoregion have which comprises RMNP. For instance, provincial park officials from Duck Mountain Provincial Park, Manitoba Natural Resources, landowners, and Louisiana Pacific Forestry Company are examples of the groups needed to help maintain and potentially reconstruct the travel habitat that links RMNP to other wildlife sources. Involving the public or other interest groups in monitoring the wolf population is another way of obtaining support and interest in Park management. Other groups such as First Nations, outfitters, Manitoba schools and conservation groups need to understand the importance of managing for large carnivores. RMNP managers already understand the importance of teamwork and stakeholder involvement by the recent approaches taken with the Management Plan for RMNP, building on these successes is important.

4.3.6 Watch for new and emerging wildlife diseases.

Monitor local veterinarian clinics for new and emerging domestic animal diseases that may affect the local wolf population. Heartworm, Lyme disease, West Nile virus, Blastomycosis and Leishmaniasis are some that may be included in the surveillance regime.

4.3.7 Determine the genetic uniqueness of RMNP wolves.

Are the wolves of RMNP unique? Are RMNP wolves in danger of the genetic inbreeding? Is increased movement to and from other areas going to be a dilemma to contend with in the RMNP area? These are all questions to be answer with genetic studies being conducted at present.

4.3.8 Movement study location intensity.

Monitoring wolf movement to and from RMNP would be greatly improved with the use of Argos enabled GPS collars. Large movement and greater location intensity would be very valuable in the determination of wolf dispersal from RMNP.

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Appendices

Appendix 1. Locations of all wolf (*Canis lupus*) scat from Riding Mountain National Park of Canada (UTM NAD 83, Zone 14). Faecal samples were collected from September 2001 to April 2003.

Sample	Easting	Northing	Date
RM001	413076	5621400	13-Oct-01
RM002	422661	5624122	13-Oct-01
RM003	422410	5625190	13-Oct-01
RM004	417400	5625960	02-Dec-01
RM005	450720	5613700	29-Nov-01
RM006	450950	5613846	30-Nov-01
RM007	415120	5625212	24-Nov-01
RM008	435883	5615600	03-Dec-01
RM009	413152	5619647	30-Nov-01
RM010	438725	5612590	03-Dec-01
RM011	367697	5645773	17-Nov-01
RM012	366960	5645534	17-Nov-01
RM013	368348	5645667	17-Nov-01
RM014	366834	5645083	17-Nov-01
RM015	372908	5636880	04-Dec-01
RM016	372908	5636880	04-Dec-01
RM017	370506	5636286	02-Dec-01
RM018	372905	5636880	04-Dec-01
RM019	372905	5636880	04-Dec-01
RM020	374275	5637628	04-Dec-01
RM021	453651	5625552	04-Dec-01
RM022	453651	5625552	04-Dec-01
RM023	454646	5613821	11-Jan-02
RM024	447342	5613924	11-Jan-02
RM025	443922	5614140	11-Jan-02
RM026	412500	5628000	01-Sep-01
RM027	419300	5626350	01-Sep-01
RM028	419300	5626450	01-Sep-01
RM029	419300	5626550	01-Sep-01
RM030	419300	5626650	01-Sep-01
RM031	367780	5637333	04-Jan-02
RM032	380445	5637612	10-Jan-02
RM033	380186	5637190	10-Jan-02
RM034	380186	5637390	10-Jan-02
RM035	379065	5642186	04-Jan-02
RM036	379065	5642286	04-Jan-02
RM037	379065	5642386	04-Jan-02
RM038	379065	5642486	04-Jan-02
RM039	379065	5642586	04-Jan-02
RM040	379065	5642686	04-Jan-02
RM041	422631	5623215	11-Jan-02
RM042	423026	5619867	11-Jan-02
RM043	419760	5626695	11-Jan-02
RM044	418452	5626253	11-Jan-02
RM045	417915	5625982	11-Jan-02
RM046	417719	5625951	11-Jan-02
RM047	416215	5625379	11-Jan-02
RM048	415263	5625154	11-Jan-02
RM049	414939	5625311	11-Jan-02
RM050	419300	5626450	01-Sep-01
RM051	432927	5628718	08-Feb-02
RM052	435647	5632149	08-Feb-02
RM053	436024	5632456	08-Feb-02
RM054	411780	5630351	07-Feb-02
RM055	411810	5630521	07-Feb-02
RM056	412241	5633639	07-Feb-02
RM057	412023	5634720	07-Feb-02
RM058	411300	5644360	07-Feb-02
RM059	447776	5607407	07-Feb-02
RM060	447923	5607229	07-Feb-02
RM061	387349	5627345	31-Jan-02
RM062	436127	5632639	02-Feb-02
RM063	432094	5628358	02-Feb-02
RM064	455447	5607561	06-Feb-02
RM065	438808	5635320	06-Feb-02
RM066	454444	5604586	08-Feb-02
RM067	454420	5604939	08-Feb-02
RM068	448170	5606509	08-Feb-02
RM069	450061	5605479	08-Feb-02
RM070	453079	5604973	08-Feb-02
RM071	450045	5605502	08-Feb-02
RM072	448642	5606615	08-Feb-02
RM073	372660	5645173	05-Feb-02
RM074	372600	5645173	05-Feb-02
RM075	372660	5645173	05-Feb-02
RM076	367470	5643320	06-Feb-02
RM077	367470	5643420	06-Feb-02
RM078	372395	5640942	05-Feb-02
RM079	367564	5642087	06-Feb-02
RM080	367564	5642187	06-Feb-02
RM081	367564	5642287	06-Feb-02
RM082	367664	5642287	06-Feb-02
RM083	366856	5644257	05-Feb-02
RM084	366838	5643830	05-Feb-02
RM085	367564	5642087	06-Feb-02
RM086	367470	5643320	06-Feb-02
RM092	432881	5615752	15-Feb-02
RM093	432311	5619841	15-Feb-02
RM094	432877	5615919	15-Feb-02

RM096	431973	5620790	15-Feb-02
RM097	432287	5619952	15-Feb-02
RM098	432280	5619939	15-Feb-02
RM099	450956	5605236	14-Feb-02
RM100	453179	5604971	14-Feb-02
RM101	450080	5605546	14-Feb-02
RM102	453143	5604971	14-Feb-02
RM103	449986	5605563	14-Feb-02
RM104	397164	5633656	14-Feb-02
RM105	453502	5604968	14-Feb-02
RM106	453614	5604967	14-Feb-02
RM107	452797	5604970	14-Feb-02
RM108	460012	5622390	14-Feb-02
RM110	456190	5617411	14-Feb-02
RM111	450409	5623764	15-Feb-02
RM112	394343	5634519	14-Feb-02
RM113	450409	5623764	15-Feb-02
RM114	434933	5612786	12-Feb-02
RM115	450409	5623864	15-Feb-02
RM116	397164	5633656	14-Feb-02
RM117	394153	5634998	14-Feb-02
RM118	396678	5634903	14-Feb-02
RM119	398775	5632390	14-Feb-02
RM120	386377	5628784	14-Feb-02
RM121	379703	5641238	13-Feb-02
RM122	393383	5635103	13-Feb-02
RM123	450409	5623764	15-Feb-02
RM124	393447	5635477	13-Feb-02
RM125	457688	5613270	19-Feb-02
RM126	372206	5645647	13-Feb-02
RM127	456371	5617331	19-Feb-02
RM128	372206	5645647	13-Feb-02
RM129	371989	5646032	13-Feb-02

RM130	374643	5644525	13-Feb-02
RM131	371989	5646032	13-Feb-02
RM132	381772	5637705	14-Feb-02
RM133	372206	5645647	13-Feb-02
RM134	428074	5652789	11-Feb-02
RM135	435883	5646220	15-Feb-02
RM136	429677	5646054	15-Feb-02
RM137	435684	5614975	22-Feb-02
RM138	409650	5614900	04-Feb-02
RM139	437150	5634031	16-Feb-02
RM140	409161	5615506	14-Feb-02
RM141	435815	5616005	22-Feb-02
RM142	413040	5621143	25-Feb-02
RM143	413026	5622618	25-Feb-02
RM144	412963	5619954	25-Feb-02
RM145	409951	5623119	03-Mar-02
RM146	409876	5627725	03-Mar-02
RM147	410026	5623562	03-Mar-02
RM148	410026	5623562	03-Mar-02
RM149	410578	5621140	03-Mar-02
RM150	425114	5650502	08-Mar-02
RM151	442850	5615600	13-Mar-02
RM152	375594	5644757	25-Feb-02
RM153	426614	5636800	09-Mar-02
RM154	427762	5638850	09-Mar-02
RM155	426611	5636865	09-Mar-02
RM156	418132	5648692	01-Mar-02
RM157	457325	5597278	04-Apr-02
RM158	373765	5644668	25-Feb-02
RM159	417579	5648307	01-Mar-02
RM160	457332	5597243	04-Apr-02
RM161	427584	5638918	09-Mar-02
RM162	410560	5628450	17-Mar-02

RM163	454984	5599914	04-Apr-02
RM164	456515	5598778	04-Apr-02
RM165	370188	5637056	02-Apr-02
RM166	426620	5636849	09-Mar-02
RM167	370188	5637056	02-Apr-02
RM168	425837	5639121	14-Apr-02
RM169	425931	5639685	14-Apr-02
RM170	453859	5613070	10-Apr-02
RM171	453902	5613540	10-Apr-02
RM172	453906	5613561	10-Apr-02
RM173	447578	5608805	22-May-02
RM174	447600	5608805	22-May-02
RM175	438413	5612676	23-Apr-02
RM176	451315	5613756	31-May-02
RM177	411903	5627530	14-Jun-02
RM178	457282	5613656	19-Jun-02
RM179	452739	5613700	17-Jun-02
RM180	412011	5628138	14-Jun-02
RM181	412204	5626957	14-Jun-02
RM182	438767	5612539	17-Jun-02
RM183	449722	5613666	17-Jun-02
RM184	448674	5612043	08-Jul-02
RM185	447952	5610950	21-Jul-02
RM186	454760	5613856	17-Jul-02
RM187	442665	5617343	22-Jul-02
RM188	441850	5618230	22-Jul-02
RM189	440466	5618865	22-Jul-02
RM190	441112	5618442	22-Jul-02
RM191	452744	5613716	25-Jun-02
RM192	448686	5612058	25-Jun-02
RM193	415488	5625100	26-Jun-02
RM194	442739	5613453	08-Jul-02
RM195	452588	5613690	25-Jun-02

RM196	452587	5613686	25-Jun-02
RM197	422516	5620450	20-Jul-02
RM198	388723	5633475	27-Jul-02
RM199	412047	5629772	23-Jul-02
RM200	412400	5631600	23-Jul-02
RM201	405555	5620500	16-Aug-02
RM202	453847	5615824	11-Aug-02
RM203	411778	5627700	15-Aug-02
RM204	454516	5613876	01-Aug-02
RM205	412200	5626900	15-Aug-02
RM206	412178	5626920	15-Aug-02
RM207	406800	5623078	16-Aug-02
RM208	411584	5628100	15-Aug-02
RM209	411836	5630700	23-Jul-02
RM210	412400	5631650	23-Jul-02
RM211	412238	5628150	13-Aug-02
RM212	412028	5635160	23-Jul-02
RM213	406050	5621930	16-Aug-02
RM214	406600	5622918	16-Aug-02
RM215	406600	5622918	16-Aug-02
RM216	412047	5629772	23-Jul-02
RM217	366671	5644484	25-Aug-02
RM218	367350	5642750	25-Aug-02
RM219	367412	5643102	25-Aug-02
RM220	412309	5628136	19-Aug-02
RM221	366823	5644760	25-Aug-02
RM222	366830	5644890	25-Aug-02
RM223	404590	5629800	19-Aug-02
RM224	430044	5627900	02-Sep-02
RM225	428200	5632441	02-Sep-02
RM226	412856	5627650	19-Aug-02
RM227	366830	5644871	25-Aug-02
RM228	366666	5644530	25-Aug-02

RM229	404500	5629800	19-Aug-02
RM230	367035	5643716	25-Aug-02
RM231	425252	5648225	02-Sep-02
RM232	406712	5628500	19-Aug-02
RM233	367011	5643722	05-Sep-02
RM234	367011	5643722	05-Sep-02
RM235	366827	5644450	05-Sep-02
RM236	412421	5629462	05-Sep-02
RM237	412770	5628481	05-Sep-02
RM238	422774	5621878	04-Sep-02
RM239	422218	5625573	04-Sep-02
RM240	435890	5615445	12-Sep-02
RM241	423371	5619573	09-Sep-02
RM242	446350	5613922	11-Sep-02
RM243	443000	5615281	13-Sep-02
RM244	442800	5616900	13-Sep-02
RM245	442752	5616262	24-Sep-02
RM246	441348	5618310	24-Sep-02
RM247	441079	5618580	24-Sep-02
RM248	441549	5618277	24-Sep-02
RM249	452026	5618114	04-Oct-02
RM250	454505	5617920	04-Oct-02
RM251	447274	5608510	17-Oct-02
RM252	368387	5645677	04-Oct-02
RM253	387853	5625850	22-Oct-02
RM254	387500	5625850	22-Oct-02
RM255	438336	5612728	25-Oct-02
RM256	365877	5646244	03-Nov-02
RM257	366609	5647515	03-Nov-02
RM258	365977	5646244	03-Nov-02
RM259	366659	5647515	03-Nov-02
RM260	369982	5646215	27-Nov-02
RM261	369982	5646215	27-Nov-02

RM262	367975	5637538	13-Nov-02
RM263	369982	5646215	27-Nov-02
RM264	367975	5637538	13-Nov-02
RM265	375702	5644481	27-Nov-02
RM266	367975	5637538	13-Nov-02
RM267	455103	5625705	08-Nov-02
RM268	450259	5613624	15-Nov-02
RM269	367975	5637538	13-Nov-02
RM270	380760	5638542	13-Nov-02
RM271	369527	5638820	14-Nov-02
RM272	432116	5651130	17-Dec-02
RM273	380227	5640841	17-Dec-02
RM274	379355	5641514	17-Nov-02
RM275	380227	5640841	17-Nov-02
RM276	380760	5638542	17-Nov-02
RM277	456300	5625700	20-Nov-02
RM278	441182	5612933	22-Nov-02
RM279	412100	5621800	11-Nov-02
RM280	367633	5641986	13-Dec-02
RM281	382373	5639927	13-Dec-02
RM282	435850	5615670	13-Jan-03
RM283	451958	5618752	27-Dec-02
RM284	452987	5616604	27-Dec-02
RM285	451126	5619952	27-Dec-02
RM286	451726	5619425	27-Dec-02
RM287	456676	5610400	27-Dec-02
RM288	456842	5611680	27-Dec-02
RM289	412938	5620150	23-Apr-02
RM290	364146	5650814	31-Jan-03
RM291	405450	5624450	06-Feb-03
RM292	406070	5629687	06-Feb-03
RM293	435990	5615445	13-Feb-03
RM301	439820	5612360	12-Feb-03

RM303	407570	5621660	12-Feb-03
RM304	415700	5621660	12-Feb-03
RM305	387800	5628000	16-Feb-03
RM306	407570	5621660	12-Feb-03
RM307	387200	5627700	31-Jan-03
RM308	387250	5635300	16-Feb-03
RM309	387800	5628000	31-Jan-03
RM310	442816	5616790	27-Feb-03
RM311	387000	5640004	16-Feb-03
RM312	456713	5596249	18-Feb-03
RM313	387000	5640000	16-Feb-03
RM314	387000	5640000	16-Feb-03
RM315	392700	5634850	16-Feb-03
RM316	443194	5615047	27-Feb-03
RM317	406714	5626936	01-Mar-03
RM318	407857	5625823	19-Feb-03
RM319	406754	5627025	19-Feb-03
RM320	406759	5627587	19-Feb-03
RM321	408270	5625809	19-Feb-03
RM322	456076	5605700	19-Feb-03
RM323	420612	5627663	22-Feb-03
RM324	402753	5632259	22-Feb-03
RM325	406492	5629101	22-Feb-03
RM326	406492	5629101	22-Feb-03
RM327	455905	5605442	19-Feb-03
RM328	456170	5605758	19-Feb-03
RM329	456013	5605520	19-Feb-03
RM330	456119	5605731	19-Feb-03
RM331	456228	5605786	19-Feb-03
RM332	455963	5605470	19-Feb-03
RM333	455963	5605470	19-Feb-03
RM334	456193	5605761	19-Feb-03
RM335	456145	5605750	19-Feb-03

RM336	455851	5605425	19-Feb-03
RM337	456229	5605784	19-Feb-03
RM338	418471	5618500	21-Feb-03
RM339	416939	5625819	21-Feb-03
RM340	421927	5625900	21-Feb-03
RM341	364700	5637800	13-Mar-03
RM342	367221	5643647	25-Mar-03
RM343	369700	5637800	13-Mar-03
RM344	369700	5637800	13-Mar-03
RM345	367221	5643647	25-Mar-03
RM346	367221	5643647	25-Mar-03
RM347	410860	5638504	26-Mar-03
RM348	411252	5646011	26-Mar-03
RM349	411984	5635235	26-Mar-03
RM350	378747	5635889	01-Apr-03
RM351	431301	5623539	17-Feb-03
RM352	412084	5634540	01-Feb-03
RM353	412563	5632306	26-Mar-03
RM354	369700	5637800	13-Mar-03
RM355	413130	5621400	01-Sep-03
RM356	456227	5605785	19-Feb-03
RM357	419500	5618600	02-Feb-03
RM358	399129	5625195	10-Mar-03
RM359	409533	5649218	10-Mar-03
RM360	400291	5651599	10-Mar-03
RM361	448826	5612752	05-Mar-03
RM362	448194	5605528	05-Mar-03
RM363	447569	5609379	05-Mar-03
RM364	448216	5606068	05-Mar-03
RM365	447321	5608104	05-Mar-03
RM366	447507	5610445	05-Mar-03
RM367	364129	5650814	31-Jan-03
RM368	369496	5652024	31-Jan-03

RM369	365424	5650777	31-Jan-03
RM370	363812	5650820	31-Jan-03
RM371	363779	5650827	31-Jan-03
RM372	447387	5608027	05-Mar-03
RM373	367550	5651382	23-Jan-03
RM374	374094	5680073	03-Mar-03
RM375	374113	5679381	03-Mar-03
RM376	369361	5650679	02-Mar-03
RM377	377740	5649466	18-Apr-03
RM378	377741	5649528	18-Apr-03
RM379	394310	5634567	15-Apr-03
RM380	378067	5647450	15-Apr-03
RM381	401888	5632026	15-Apr-03
RM382	396990	5634551	15-Apr-03
RM383	400996	5632232	15-Apr-03
RM384	408220	5630530	15-Apr-03
RM385	413105	5619721	15-Apr-03
RM386	404567	5629750	15-Apr-03
RM387	411265	5646191	26-Mar-03
RM401	386886	5642848	31-Mar-03
RM402	387324	5641967	30-Mar-03
RM403	387025	5645459	29-Mar-03

Appendix 2

Sheather's Flotation Solution (Specific Gravity 1.26)

39.66ml Formaldehyde

3000g white sugar

2436ml-distilled water

4000ml Sheather's Flotation Solution

Appendix 3. Raw data of parasites in wolf (*Canis lupus*) scat from Riding Mountain National Park of Canada. Faecal samples were collected from September 2001 to March 2003.

Sample #	Date	Toxocara	Capillaria	Toxascaris	Strongyloides	Taeniid	Dipylidium	Diphyllobothrium	Alaria	Metorchis	Coccidia	Sarcocysts	Trichuris	Giardia	Cryptosporidium	Demodex	Moniezia
RM001	13-Oct-01	0	0	0	0	0	0	0	0	0	0	76	0	200	0	0	0
RM002	13-Oct-01	0	0	0	0	0	0	0	0	0	0	480	0	200	0	0	0
RM003	13-Oct-01	0	0	0	0	0	0	0	0	0	0	240	0	0	0	0	0
RM004	02-Dec-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM005	29-Nov-01	0	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0
RM006	30-Nov-01	0	0	0	0	0	0	0	0	0	0	75	0	30	0	0	0
RM007	24-Nov-01	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
RM008	03-Dec-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM009	30-Nov-01	0	0	0	0	5	0	0	41	0	0	480	0	0	0	0	0
RM010	03-Dec-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM011	17-Nov-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM012	17-Nov-01	0	0	0	0	11	0	0	1	0	0	0	2	0	0	0	0
RM013	17-Nov-01	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
RM014	17-Nov-01	0	0	0	0	0	0	0	0	0	0	85	0	0	0	0	0
RM015	04-Dec-01	0	0	0	0	0	0	0	0	0	0	5175	0	0	0	0	0
RM016	04-Dec-01	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0
RM017	02-Dec-01	0	0	0	0	0	0	0	0	0	0	450	0	0	0	0	0
RM018	04-Dec-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM019	04-Dec-01	0	0	0	0	0	0	0	0	0	0	200	0	30	0	0	0
RM020	04-Dec-01	0	0	0	0	189	0	0	0	0	0	9450	0	0	0	0	0
RM021	04-Dec-01	0	0	0	0	20	0	0	0	0	0	170	0	0	0	0	0
RM022	04-Dec-01	0	0	0	0	0	0	0	0	0	0	210	0	0	0	0	0
RM023	11-Jan-02	0	0	0	0	1850	0	0	0	0	0	0	0	0	0	0	0
RM024	11-Jan-02	0	0	0	0	0	0	0	0	0	0	54	0	0	0	0	0
RM025	11-Jan-02	0	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0
RM026	01-Sep-01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM027	01-Sep-01	0	0	0	0	5	0	0	0	0	0	7200	0	0	0	0	0
RM028	01-Sep-01	0	0	0	0	178	0	0	3	0	0	16200	0	0	0	0	0
RM029	01-Sep-01	0	0	0	0	75	0	0	0	0	0	95	0	0	0	0	0
RM030	01-Sep-01	0	0	0	0	90	0	0	0	0	0	9675	0	0	0	0	0
RM031	04-Jan-02	0	0	0	0	69	0	0	1	0	0	126	0	0	0	0	0

Sample #	Date	Toxocara	Capillaria	Toxascaris	Strongyloides	Taeniid	Dipylidium	Diphyllobothrium	Alaria	Metorchis	Coccidia	Sarcocysts	Trichuris	Giardia	Cryptosporidium	Demodex	Moniezia
RM032	10-Jan-02	0	0	0	0	11	0	0	0	0	0	170	0	0	0	0	0
RM033	10-Jan-02	0	0	0	0	112	0	0	0	0	0	4950	0	30	0	0	0
RM034	10-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM035	04-Jan-02	0	0	0	0	11	0	0	2	0	0	0	1	200	0	0	0
RM036	04-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM037	04-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM038	04-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	1500	0	0	0
RM039	04-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM040	04-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM041	11-Jan-02	0	0	0	0	0	0	0	0	0	0	175	0	800	0	0	0
RM042	11-Jan-02	0	0	0	0	29	0	0	48	0	0	0	0	0	0	0	0
RM043	11-Jan-02	0	0	0	0	0	0	0	0	0	0	91	0	0	0	0	0
RM044	11-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM045	11-Jan-02	0	0	0	0	0	0	0	0	0	265	0	1	0	0	0	0
RM046	11-Jan-02	0	0	0	0	48	0	0	9	0	0	0	0	0	0	0	0
RM047	11-Jan-02	0	0	0	0	0	0	0	0	0	0	180	0	0	0	0	0
RM048	11-Jan-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM049	11-Jan-02	0	0	0	0	780	0	0	0	0	0	5175	0	0	0	0	0
RM050	01-Sep-01	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0
RM051	08-Feb-02	0	0	0	0	124	0	0	0	0	0	0	0	800	0	0	0
RM052	08-Feb-02	0	0	0	0	20250	0	0	0	0	0	6000	0	0	0	0	0
RM053	08-Feb-02	0	0	0	0	0	0	0	0	0	0	5000	0	0	0	0	0
RM054	07-Feb-02	0	0	0	0	47	0	0	2	0	0	0	0	0	0	0	0
RM055	07-Feb-02	0	0	0	0	88	0	0	0	0	0	96	0	30	0	0	0
RM056	07-Feb-02	0	0	0	0	0	0	0	0	0	0	27	0	0	0	0	0
RM057	07-Feb-02	0	0	0	0	0	0	0	0	0	0	5040	0	0	0	0	0
RM058	07-Feb-02	0	0	0	0	77	0	0	0	0	0	0	0	0	0	0	0
RM059	07-Feb-02	0	0	0	0	2	0	0	0	0	0	2200	0	0	0	0	0
RM060	07-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM061	31-Jan-02	0	0	0	0	26000	0	0	0	0	0	0	0	0	0	0	0
RM062	02-Feb-02	0	0	0	0	7	0	0	0	0	0	0	0	200	0	0	0
RM063	02-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM064	06-Feb-02	0	0	0	0	13500	0	0	0	0	0	29000	0	200	0	0	0
RM065	06-Feb-02	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Sample #	Date	Toxocara	Capillaria	Toxascaris	Strongyloides	Taenid	Dipylidium	Diphyllobothrium	Alaria	Metorchis	Coccidia	Sarcocysts	Trichuris	Giardia	Cryptosporidium	Demodex	Moniezia
RM066	08-Feb-02	0	0	0	0	7	0	0	0	0	0	0	0	0	0	0	0
RM067	08-Feb-02	0	0	0	0	0	0	0	0	0	0	3375	0	0	0	0	0
RM068	08-Feb-02	0	0	0	0	0	0	0	0	0	0	175	0	0	0	0	0
RM069	08-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM070	08-Feb-02	0	0	0	0	2250	0	0	0	0	0	2700	0	200	0	0	0
RM071	08-Feb-02	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0	0
RM072	08-Feb-02	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
RM073	05-Feb-02	0	0	0	0	0	0	0	0	0	0	12500	0	0	0	0	0
RM074	05-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM075	05-Feb-02	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
RM076	06-Feb-02	0	0	0	0	17	0	0	0	0	0	0	0	0	0	0	0
RM077	06-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM078	05-Feb-02	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
RM079	06-Feb-02	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0
RM080	06-Feb-02	0	0	0	0	0	0	0	0	0	0	5730	0	0	0	0	0
RM081	06-Feb-02	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
RM082	06-Feb-02	0	0	0	0	29	0	0	0	0	0	1650	0	0	0	0	0
RM083	05-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM084	05-Feb-02	0	0	0	0	26	0	0	0	0	0	44000	0	0	0	0	0
RM085	06-Feb-02	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
RM086	06-Feb-02	0	86	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM092	15-Feb-02	0	0	0	0	667	0	0	0	0	0	0	0	0	0	0	0
RM093	15-Feb-02	0	0	0	0	0	0	0	0	0	0	2300	0	0	0	0	0
RM094	15-Feb-02	0	0	0	0	5	0	0	0	0	0	675	0	0	0	0	0
RM096	15-Feb-02	0	0	0	0	67	0	0	0	0	0	375	0	0	0	0	0
RM097	15-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM098	15-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM099	14-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM100	14-Feb-02	0	0	0	0	108	0	0	0	0	0	11	0	0	0	0	0
RM101	14-Feb-02	0	0	0	0	0	0	0	0	0	0	6000	0	0	0	0	0
RM102	14-Feb-02	0	0	0	0	905	0	0	0	0	0	17000	0	0	0	0	0
RM103	14-Feb-02	0	0	0	0	12825	0	0	0	0	0	6000	0	0	0	0	0
RM104	14-Feb-02	0	0	0	0	0	0	0	0	0	0	3000	0	0	0	0	0
RM105	14-Feb-02	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0

RM106	14-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM107	14-Feb-02	0	0	0	0	1412	0	0	0	0	0	985	0	0	0	0	0
RM108	14-Feb-02	0	0	0	0	131	0	0	4	0	1	30	0	200	0	0	0
RM110	14-Feb-02	0	0	0	0	2	0	0	0	0	0	1530	1	0	0	0	0
RM111	15-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0
RM112	14-Feb-02	0	0	0	0	140	0	0	2	0	0	0	0	0	0	0	0
RM113	15-Feb-02	0	0	0	0	367	0	0	0	0	130	125	43	30	0	0	0
RM114	12-Feb-02	0	0	0	0	0	0	0	0	0	0	245	0	0	0	0	0
RM115	15-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0
RM116	14-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0
RM117	14-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0
RM118	14-Feb-02	0	0	0	0	176	0	0	43	0	0	0	0	0	0	0	0
RM119	14-Feb-02	0	0	0	0	9	0	0	0	0	0	40	0	0	0	0	0
RM120	14-Feb-02	0	0	0	0	0	0	0	0	0	1	185	0	0	0	0	0
RM121	13-Feb-02	0	0	0	0	12	0	0	0	0	0	0	0	200	0	0	0
RM122	13-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM123	15-Feb-02	0	0	0	0	3	0	0	0	0	59	2750	0	1500	0	0	0
RM124	13-Feb-02	0	0	0	0	162	0	0	0	0	0	0	0	30	0	0	0
RM125	19-Feb-02	0	0	0	0	19	0	0	0	0	0	900	0	0	0	0	0
RM126	13-Feb-02	0	0	0	0	0	0	0	0	0	0	1850	0	0	0	0	0
RM127	19-Feb-02	0	0	0	0	10	0	0	0	0	0	0	8	0	0	0	0
RM128	13-Feb-02	0	0	0	0	0	0	0	0	0	0	185	0	0	0	0	0
RM129	13-Feb-02	0	0	0	0	0	0	0	0	0	0	645	0	0	0	0	0
RM130	13-Feb-02	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
RM131	13-Feb-02	0	0	0	0	216	0	0	0	0	0	3250	0	0	0	0	0
RM132	14-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM133	13-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM134	11-Feb-02	0	0	0	0	57	0	0	0	0	0	0	0	1500	0	0	0
RM137	22-Feb-02	0	0	5	0	0	0	0	0	0	2	2700	0	0	0	0	0
RM138	04-Feb-02	0	0	0	0	13	0	0	0	0	0	270	0	1500	0	0	0
RM139	16-Feb-02	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0
RM140	14-Feb-02	0	0	0	0	18	0	0	0	0	0	33450	1	0	0	0	0
RM141	22-Feb-02	0	0	0	0	0	0	0	0	0	0	13500	0	0	0	0	0
RM142	25-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM143	25-Feb-02	0	0	0	0	41	0	0	0	0	0	0	0	200	0	0	0

RM144	25-Feb-02	0	0	0	0	0	0	0	0	0	0	380	0	0	0	0	0
RM145	03-Mar-02	0	0	0	0	2	0	0	0	0	0	150	0	0	0	0	0
RM146	03-Mar-02	0	0	0	0	3	0	0	0	0	0	0	0	30	0	0	0
RM147	03-Mar-02	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
RM148	03-Mar-02	0	0	0	0	18	0	0	2	0	0	0	0	30	0	0	0
RM149	03-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM150	08-Mar-02	0	0	0	0	241	0	0	0	0	0	4950	0	0	0	0	0
RM151	13-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM152	25-Feb-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM153	09-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM154	09-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM155	09-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0
RM156	01-Mar-02	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
RM157	04-Apr-02	0	0	0	0	180	0	0	2	0	0	0	0	30	0	0	0
RM158	25-Feb-02	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
RM159	01-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM160	04-Apr-02	0	0	0	0	0	0	0	0	0	0	17550	0	0	0	0	0
RM161	09-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0
RM162	17-Mar-02	0	0	0	0	0	0	0	0	0	0	3825	0	0	0	0	0
RM163	04-Apr-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM164	04-Apr-02	0	0	0	0	11	0	0	0	0	0	0	0	800	0	0	0
RM165	02-Apr-02	0	0	0	0	0	0	0	0	0	0	235	0	0	0	0	0
RM166	09-Mar-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM167	02-Apr-02	0	0	0	0	0	0	0	25	0	0	4400	0	0	0	0	0
RM168	14-Apr-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM169	14-Apr-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM170	10-Apr-02	0	0	0	0	0	0	0	0	0	220	0	0	200	0	0	0
RM171	10-Apr-02	0	0	0	0	2	0	0	0	0	0	0	0	1500	0	0	0
RM172	10-Apr-02	0	0	0	0	9	0	0	0	0	0	8775	0	0	0	0	0
RM173	22-May-02	0	0	0	0	0	0	0	0	0	0	75	0	0	0	0	0
RM174	22-May-02	0	0	0	0	80	0	0	0	0	0	0	0	200	0	0	0
RM175	23-Apr-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM176	31-May-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
RM177	14-Jun-02	0	1386	0	0	0	0	0	0	0	0	0	0	30	0	0	0

RM178	19-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM179	17-Jun-02	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
RM180	14-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM181	14-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM182	17-Jun-02	0	0	0	0	0	0	0	0	0	0	640	0	0	0	0	0
RM183	17-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM184	08-Jul-02	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0
RM185	21-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM186	17-Jul-02	0	0	0	0	385	0	0	0	0	0	0	0	0	0	0	0
RM187	22-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM188	22-Jul-02	0	0	0	0	6	0	0	0	0	0	0	0	30	0	0	0
RM189	22-Jul-02	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
RM190	22-Jul-02	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0
RM192	25-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
RM193	26-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM194	08-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM195	25-Jun-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM196	25-Jun-02	0	0	0	0	5	0	0	0	0	0	0	0	200	0	0	0
RM197	20-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM198	27-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM200	23-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM201	16-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0
RM202	11-Aug-02	0	0	0	0	19	0	0	0	0	0	3375	0	0	0	0	0
RM203	15-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM204	01-Aug-02	0	0	0	0	171	0	0	0	0	0	0	0	0	0	0	0
RM205	15-Aug-02	0	0	0	0	0	0	0	0	0	0	53	0	0	0	0	0
RM206	15-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM207	16-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM208	15-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM209	23-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM210	23-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM211	13-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM212	23-Jul-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM213	16-Aug-02	0	86	0	0	0	0	0	0	0	0	450	0	30	0	0	0
RM214	16-Aug-02	0	0	0	0	0	0	0	0	0	0	740	0	1500	0	0	0

RM215	16-Aug-02	0	215	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM216	23-Jul-02	0	6300	0	0	0	0	0	0	0	0	0	0	1500	0	0	0
RM218	25-Aug-02	0	0	0	0	0	0	0	0	0	0	75	0	0	0	0	0
RM219	25-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM220	19-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM221	25-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM222	25-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM223	19-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM224	02-Sep-02	7	0	109	0	0	0	0	0	0	0	0	0	0	0	0	0
RM225	02-Sep-02	0	0	0	0	14	0	0	0	0	0	61	0	0	0	0	0
RM226	19-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM227	25-Aug-02	0	0	0	0	0	0	0	0	0	0	125	0	30	0	0	0
RM228	25-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0
RM229	19-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM230	25-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0
RM231	02-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM232	19-Aug-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM233	05-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM234	05-Sep-02	0	0	0	0	5	0	0	0	0	0	54	0	0	0	0	0
RM235	05-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	1500	0	0	0
RM236	05-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM237	05-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	800	0	0	0
RM238	04-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM239	04-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM240	12-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM241	09-Sep-02	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
RM242	11-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM243	13-Sep-02	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
RM244	13-Sep-02	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0	140
RM245	24-Sep-02	0	26	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM246	24-Sep-02	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0
RM247	24-Sep-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM248	24-Sep-02	0	0	0	0	0	0	0	0	0	119	0	108	0	0	0	110
RM249	04-Oct-02	0	0	0	0	23	0	0	0	0	0	0	0	0	0	0	0
RM250	04-Oct-02	0	0	0	0	248	0	0	0	0	0	0	0	0	0	0	0

RM251	17-Oct-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM252	04-Oct-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM253	22-Oct-02	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
RM254	22-Oct-02	0	0	0	0	0	0	0	2	0	0	3	0	0	0	0	0
RM255	25-Oct-02	0	0	160	0	0	0	0	0	0	0	0	0	0	0	0	12
RM256	03-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM257	03-Nov-02	0	0	0	0	0	0	0	0	0	0	480	0	0	0	0	0
RM258	03-Nov-02	0	0	0	0	0	0	0	0	0	0	6300	0	0	0	0	0
RM259	03-Nov-02	0	0	0	0	0	0	0	0	0	0	4320	0	800	0	0	0
RM260	27-Nov-02	0	0	0	0	0	0	0	0	0	0	270	0	0	0	0	0
RM261	27-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM262	13-Nov-02	0	0	0	0	0	0	0	0	0	0	2400	0	0	0	0	0
RM263	27-Nov-02	0	0	0	0	0	0	0	0	0	0	12600	0	30	0	0	0
RM264	13-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM265	27-Nov-02	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
RM266	13-Nov-02	0	0	0	0	0	0	0	0	0	0	140	0	30	0	0	0
RM267	08-Nov-02	0	0	0	0	0	0	0	0	0	0	19665	0	0	0	0	0
RM268	15-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM269	13-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	200	800	0	0
RM270	13-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM271	14-Nov-02	0	0	0	0	0	0	0	0	0	0	210	0	0	0	0	0
RM272	17-Dec-02	0	0	0	0	3	0	0	0	0	0	275	0	0	0	0	0
RM273	17-Dec-02	0	0	0	0	0	0	0	0	0	0	10800	0	0	0	0	0
RM274	17-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM275	17-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM276	17-Nov-02	0	0	0	0	0	0	0	0	0	0	17550	0	0	0	0	0
RM277	20-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM278	22-Nov-02	0	0	0	0	48	0	0	0	0	0	740	0	0	0	0	0
RM279	11-Nov-02	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM280	13-Dec-02	0	0	0	0	4	0	0	0	0	0	4950	0	200	0	0	0
RM281	13-Dec-02	0	0	0	0	0	0	0	0	0	0	5000	0	0	0	0	0
RM282	13-Jan-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM283	27-Dec-02	0	0	0	0	237	0	0	0	0	0	0	0	0	0	0	0
RM284	27-Dec-02	0	0	0	0	65	0	0	0	0	0	160	0	0	0	0	0
RM285	27-Dec-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RM286	27-Dec-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM287	27-Dec-02	0	0	0	0	61	0	0	0	0	0	0	0	0	0	0	0
RM288	27-Dec-02	0	0	0	0	81	0	0	0	0	0	0	0	0	0	0	0
RM289	23-Apr-02	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM290	31-Jan-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM291	06-Feb-03	0	0	0	0	5	0	0	0	0	0	12600	0	0	0	0	0
RM292	06-Feb-03	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
RM293	13-Feb-03	0	0	0	0	0	0	0	22	0	0	0	0	0	0	0	0
RM301	12-Feb-03	0	0	0	0	2	0	0	3	0	0	320	0	0	0	0	0
RM302	27-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM303	12-Feb-03	0	0	0	0	0	0	0	0	0	0	0	3	200	0	0	0
RM304	12-Feb-03	0	0	0	0	0	0	0	0	0	0	280	0	200	0	0	0
RM305	16-Feb-03	0	0	0	0	0	0	0	0	0	0	150	0	0	0	0	0
RM306	12-Feb-03	0	0	0	0	19	0	0	0	0	0	640	0	0	0	0	0
RM307	31-Jan-03	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
RM308	16-Feb-03	0	0	0	0	0	0	0	2	0	0	0	0	30	0	0	0
RM309	31-Jan-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM310	27-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM311	16-Feb-03	0	0	0	0	0	0	0	0	0	0	90	0	0	0	0	0
RM312	18-Feb-03	0	0	0	0	120	0	0	0	0	0	0	0	200	0	0	0
RM313	16-Feb-03	0	0	0	0	0	0	0	0	0	0	165	0	0	0	0	0
RM314	16-Feb-03	0	0	0	0	62	0	0	7	0	0	7200	0	0	0	0	0
RM315	16-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM316	27-Feb-03	0	0	0	0	0	0	0	0	0	0	11700	0	0	0	0	0
RM317	01-Mar-03	0	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0
RM318	19-Feb-03	0	0	0	0	0	0	0	0	0	0	510	0	0	0	0	0
RM319	19-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM320	19-Feb-03	0	0	0	0	0	0	0	0	0	0	7200	0	0	0	0	0
RM321	19-Feb-03	0	0	0	0	44	0	0	0	0	0	28800	0	200	0	0	0
RM322	19-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	0
RM323	22-Feb-03	0	0	0	0	0	0	0	0	0	0	410	0	0	0	0	0
RM324	22-Feb-03	0	0	0	0	718	0	0	0	0	0	270	0	0	0	0	0
RM325	22-Feb-03	0	0	0	0	73	0	0	0	0	0	420	0	30	0	0	0
RM326	22-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	30	0	0	0
RM327	19-Feb-03	0	0	0	0	68	0	0	0	0	0	0	0	0	0	0	0

RM329	19-Feb-03	0	0	0	0	74	0	0	0	0	0	0	0	0	0	0	0
RM330	19-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM331	19-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM332	19-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM333	19-Feb-03	0	0	0	0	0	0	0	0	0	0	17100	0	0	0	0	0
RM334	19-Feb-03	0	0	0	0	96	0	0	0	0	0	3825	0	200	0	0	0
RM335	19-Feb-03	0	0	0	0	0	0	0	0	0	0	4275	0	30	0	0	0
RM336	19-Feb-03	0	0	0	0	4	0	0	0	0	0	22950	0	0	0	0	0
RM337	19-Feb-03	0	0	0	0	0	0	0	0	0	0	6300	0	200	0	0	0
RM338	21-Feb-03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RM339	21-Feb-03	0	0	0	0	22	0	0	56	0	0	0	0	0	0	0	0
RM340	21-Feb-03	0	0	0	0	0	0	0	0	0	0	17100	0	0	0	0	0
Sum of Para		7	8099	274	0	86650	0	0	378	0	825	550765	171	25181	800	1	262
Count of Para		1	6	3	0	108	0	0	31	0	10	120	11	70	1	1	3