HABITAT USE AND ABUNDANCE OF THE COMMON GARTER SNAKE, *THAMNOPHIS SIRTALIS*, AT THE NORTHERN LIMIT OF ITS RANGE IN MANITOBA

BY

JONATHAN P. WIENS

A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

MASTER OF SCIENCE

Department of Environment and Geography

University of Manitoba

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THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

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ABSTRACT

The common garter snake (*Thamnophis sirtalis*) is a wide-ranging species that reaches the northern limit of its range in central Manitoba. Although *Thamnophis sirtalis* (and especially the subspecies *parietalis)* has been the subject of intense biological research, there are large gaps of knowledge regarding the ecology of this species in extreme northern latitudes. A recently discovered northern hibernaculum in the boreal forest region near Jenpeg, Manitoba, provided an ideal opportunity for comparing the ecology and biology of this species with geographically distant populations. The climate at Jenpeg is sub-arctic continental and consists of cold winters, and cool short summers. The area lies on the Canadian Shield, and is characterized by surface outcrops of granitic bedrock. Garter snakes were found colonizing artificial habitat features for winter habitat including dikes and rock quarries. Research on the ecology of this species was conducted from May 2005 to May 2007. Snakes emerged in late April and early May. Activity at the den lasted approximately two weeks before snakes dispersed for the summer. Mark-recapture results from 2005 indicate that this population is small (~79 individuals ± 10.6) and exhibits a wide variation in adult sizes (350-1340 mm total length). Radio telemetry and funnel trapping have shown that summer habitat use is concentrated around wetlands, with wood frogs (*Lithobates sylvatica*) constituting the most common food source (56%). Many snakes dispersed over distances exceeding two kilometres, despite the apparent abundance of prey species near the den site. Analysis of colour patterns revealed substantial variation in the skin folds between the lateral scales. The majority of snakes expressed no red colouration on the lateral scales (45%), while some individuals expressed rare examples of bright red colouration (erythristism) (6%) and dark colouration (melanism) (1%). Traditional local knowledge gathered from aboriginal hunters, fishers and trappers outlined the long-term presence of garter snakes in the region, and

provided local distribution data for the species. Aboriginal peoples stated that the overall population density of snakes in the region was low, and provided additional support for the findings of large variation in body sizes and colour. It is hypothesized that relative reproductive isolation and a prolonged overwintering period are factors contributing to the uniqueness of this northern population. Information from this study will benefit our understanding of garter snake biology and provide valuable information to assist the conservation efforts of wildlife and landscape managers in the region.

ACKNOWLEDGEMENTS

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INTRODUCTION

1.1 COMMON GARTER SNAKE ECOLOGY

1.1.1 DESCRIPTION

Common garter snakes (*Thamnophis sirtalis*) are a long and slender snake species (Figure 1.1). They express a wide array of dorsal colour patterns in various parts of their range, which has allowed for the recognition of eleven geographically defined subspecies (Rossman et al. 1996). Dorsal rows reach a maximum of 19 rows, with a lateral stripe usually found on the second and third scale row. Adult females attain sexual maturity at 504 mm snout-vent length, while males have attained sexual maturity at 387 mm (Fitch 1965). Females can grow larger than males and can attain a maximum total length of 1372 mm (Froom 1972). Mating typically occurs in spring, immediately after emergence from a communal hibernaculum. Fall mating has also been recorded. Young are born live (ovoviviparous), in a litter generally ranging in size from of 10-15. Neonate snout vent lengths (SVL) range from 154.4 mm in Manitoba to 201.3 mm in British Columbia (Rossman et al. 1996). Female reproduction varies annually from 23.5% to 88.0% (Whittier and Crews 1990), with evidence that females in northern latitudes do not reproduce annually (Larsen et al.1993). Survival rates are highly variable for this species, with survival largely dependent on predation pressure, food availability, and overwintering conditions (Rossman et al. 1996).

Common garter snakes are able to withstand very cold temperatures. Body temperatures as low at 0.5°C have been recorded in Wood Buffalo National Park, Alberta (Larsen and Gregory 1988). This tolerance of cold temperatures may help explain the ability of this species to survive northern latitudes (Preston 1982).

In the northern part of their range, the common garter snake commonly overwinters in communal dens. The population sizes of these hibernacula vary, but in the Interlake of Manitoba can often reach population sizes of thousands of individuals. These sites have been well documented by many researchers (Gregory 1974, 1977; Gregory and Stewart 1975) and provide valuable locations for zoological research.

1.1.2 TAXONOMY

Thirty species of garter snakes have been identified in the literature with the common garter snake (*Thamnophis sirtalis*), being the best studied (Rossman et al. 1996). The common garter snake has the most variable dorsal colour pattern of all species within its genus and, as a result, has a long and varied taxonomic history, with the recognition of numerous subspecies (Rossman et al. 1996). A large number of researchers have evaluated geographically consistent morphological forms (Cope 1900, Ruthven 1908, Fitch 1941) and eleven subspecies continue to be generally recognized based on colour (Rossman et al. 1996). Manitoba falls within the range of the red-sided garter snake (*Thamnophis sirtalis parietalis*), which is generally identified by red colouration on the dorsolateral area. Eastern garter snakes (*Thamnophis sirtalis sirtalis*) are known to interbreed with red-sided garter snakes in south-eastern Manitoba (Preston 1982), and may interbreed across northern Manitoba and north-western Ontario. However, based on recent genetic studies, the validity of *Thamnophis sirtalis* subspecies has been questioned, and its continued use is now uncertain. (Rye 2000, Janzen et al. 2002).

1.1.3 DISTRIBUTION

1.1.3.1 NORTH AMERICA

Garter snakes (*Thamnophis sp.)* are the most widespread and abundant snakes in North America (Rossman et al. 1996). Their extensive range stretches from northern Canada to the southern tip of Mexico. The common garter snake occurs across much of the United States and southern Canada (Figure 1.2). It is noticeably absent from a large portion on the American southwest, and the Canadian prairies. Common garter snakes are known to exist in high alpine environments in areas such as Banff National Park, AB. A northern disjunct population occurs in the region around Wood Buffalo National Park in northern Alberta and the Northwest Territories. The factors limiting the distribution of this species in Canada, has only received attention from one other study (Larsen 1986). The distribution and population dynamics of the common garter snake in northern Ontario and Quebec has not been studied. The relative abundance of this species makes it an ideal model for understanding how reptiles survive in northern latitudes. Endangered reptile species such as the Northern Prairie Skink (*Eumeces septentrionalis*) or Eastern Massasauga Rattlesnake (*Sistrurus catenatus*) are difficult to study at the northern edge of their range, so basic biogeographical information from other northern reptile species can help aid in the understanding of their basic biology.

1.1.3.2 MANITOBA

In Manitoba, the common garter snake is found across the southern portion of the province. It is common to abundant everywhere except in the south-western Manitoba, where it becomes rare, and the Western Plains Garter Snake *(Thamnophis radix haydeni)* is more prevalent. To the North, the distribution of the common garter snake is poorly known, but it is found discontinuously from Flin Flon in the west, to Gods Lake in the east (Preston 1982).

Unconfirmed reports also exist of garter snake sightings in the lower stretches of the Churchill River near the community of Churchill (Shelford and Twomey 1941, P. Harms pers. comm.). Common garter snakes could have started invading Manitoba as far back as 10,000 years ago. The retreat of the last Pleistocene glacier allowed squamate reptiles to colonize northern environments as quickly as the glacier receded. As recently as 9,900 years ago Michigan had its complete reptile fauna (Holman 2000). During the climatic optimum that occurred 8,000 years ago, common garter snakes may have reached their northern limit in Manitoba. Distribution of common garter snakes in Manitoba since then may be a response to available habitat and conditions.

1.2 RESEARCH BACKGROUND AND OBJECTIVES

1.2.1 ORGANIZATION OF THE THESIS

This thesis is organized in a series of six journal-article style chapters. It is tied together with three common chapters, including an introduction, study area description, and conclusion with management recommendations. A literature review of each topic is imbedded in the introduction of each chapter.

1.2.2 CONTEXT

Extreme latitudes and climates create survival challenges for all life forms. Some of the most vulnerable organisms are ectotherms, which must rely on external energy sources for body heat. Life history traits of many species are known to vary over their geographic ranges, and studies from extreme locations provide valuable insight into survival and reproductive strategies.

Although *Thamnophis sirtalis* (and especially the subspecies *parietalis)* has been the subject of intense biological research, there are large gaps of knowledge regarding the ecology of this species at the northern limit of its range. Many studies have been published from southern Manitoba, including the large hibernacula sites near Narcisse and Inwood, but there is no information from near the known northern limit of distribution for the species. Some researchers have suggested that concentrated research of these atypically large aggregations might be biasing our understanding of *Thamnophis* biology (Shine et al. 2001). Therefore, it is important to expand our research efforts into other regions where wildlife conservation is a concern and basic ecological questions remain unanswered.

This study examines the ecology of a population of garter snakes near Jenpeg, Manitoba (54°30 N, 98°03 W). Information from this study will benefit the conservation efforts of landscape and wildlife managers, including Manitoba Conservation and Manitoba Hydro. Five major questions are directed to understanding the issues surrounding these newly documented snake dens. These questions function as research objectives for this study.

1.2.3 OBJECTIVES

The goal of this study is to determine the habitat use and abundance of common garter snakes near the known limit of their range in Manitoba. Specifically, the objectives were to:

1. Collect basic life-history information on growth, foraging ecology, and colouration of common garter snakes in northern Manitoba:
2. Determine the population size of a northern denning site over multiple seasons;
3. Determine habitat use, dispersal directions, migration distances, and identify important landscape features;
4. Consult with local peoples, including First Nations, on their traditional and local knowledge of common garter snakes in the region;
5. Develop management recommendations for common garter snakes in northern Manitoba.

1.2.4 CONTRIBUTION TO SCIENCE

This study will address three important questions contributing to the understanding of common garter snakes ecology:

1.2.4.1 HABITAT USAGE

What types of habitat are used by common garter snakes in Manitoba? Current information indicates that wetlands with high abundance of prey items represent ideal habitat for common garter snakes in Manitoba. This study will verify these findings and identify specific habitat features used in extreme latitudes. It will also attempt to learn about movement patterns and the proximity between summer and winter habitat.

1.2.4.2 LIFE-HISTORY CHARACTERISTICS

This study will provide baseline information on life-history characteristics and habitat use over two active seasons. These findings will allow for comparisons with geographically distant populations and provide information on limiting factors in northern latitudes.

1.2.4.3 MANAGEMENT

This research will help determine how garter snakes survive in extreme latitudes in Manitoba, and provide information for wildlife management planning. Landscape managers such as Manitoba Hydro and Manitoba Conservation will be better prepared to preserve and conserve other hibernacula that may be discovered in northern Manitoba. Garter snakes may also serve as important representative species for interpretation in northern Provincial and National parks.

REFERENCES

Carpenter, C.C. 1954. The presence and variation of lateral red coloration in a population of common garter snakes (*Thamnophis sirtalis sirtalis*). Herpetologica 10:89.

Charland, M.B., and Gregory, P.T. 1995. Movements and habitat use in gravid and nongravid female garter snakes (Colubridae: *Thamnophis*). Journal of Zoology 236(4):543-561.

Cope, E.D. 1900. The crocodilians, lizards and snakes of North America. Annual Report of the United States National Museum for 1898:153-1270.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. Scientific Papers: Natural History Museum: The University of Kansas 15:493-564.

Fitch, H.S. 1941. Geographic variation in garter snakes of the species *Thamnophis sirtalis* in the Pacific Coast region of North America. American Midland Naturalist 26:570-592.

Fitch, H.S. 2001. Further study of the garter snake, *Thamnophis sirtalis*, in Northeastern Kansas. University of Kansas Publications, Museum of Natural History 19:1-6.

Froom, B. 1972. The Snakes of Canada. McClelland and Stewart, Toronto.

Gregory, P.T. 1974. Patterns of spring emergence of the red-sided garter snake *(Thamnophis sirtalis parietalis)* in the Interlake region of Manitoba. Canadian Journal of Zoology 52:1063-1069.

Gregory, P.T., and Stewart, K.W. 1975. Long-distance dispersal and feeding strategy of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in the Interlake of Manitoba. Canadian Journal of Zoology 53:238-245.

Gregory, P.T. 1977. Life-history parameters of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in an extreme environment, the Interlake Region of Manitoba. National Museum of Canada, Publications in Zoology 13:1-44.

Gregory, P.T. 1984a. Habitat, diet, and composition of assemblages of garter snakes (*Thamnophis*) at eight sites on Vancouver Island. Canadian Journal of Zoology 62:2013-2022.

Gregory, P.T. 1984b. Communal denning in snakes. *In* Vertebrate Ecology and Systematics: A Tribute to Henry S. Fitch. *Edited by* R.A. Seigel, L.E. Hunt, J.L. Knight, L. Malaret and N.L. Zuschlag. University of Kansas Publications, Museum of Natural History. Special Publication. 10:57-75.

Harms, P. 2004. Personal Communication. Churchilll Northern Studies Centre Research Staff Member.

Holman, J.A. 2000. Fossil snakes of North America: Origins, Evolution, Distribution, Paleoecology. Indiana University Press. Bloomington. 357 pp.

Janzen, F.J., Krenz, J.G., Haselkorn, T.S., Brodie Jr., E.D., and Brodie III, E.D. 2002. Molecular phylogeography of common garter snakes (*Thamnophis sirtalis*) in western North America: implications for regional historical forces. Molecular Ecology 11:1739-1751.

Kephart, D.G., and Arnold, S.J. 1982. Garter Snake Diets in a Fluctuating Environment: A Seven-Year Study. Ecology 63(5):1232-1236.

Larsen, K.W. 1986. Ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Unpubl. M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Larsen, K.W., and Gregory, P.T. 1988. Amphibians and reptiles in the Northwest Territories. *In* The natural history of Canada's north: current research. *Edited by* C. Kobelka, and E. Stephens. Occasional Paper no. 3, Prince of Wales Northern Heritage Centre, Yellowknife. Northwest Territories. pp. 31–51.

Preston, W. 1982. The Amphibians and Reptiles of Manitoba. Manitoba Museum of Man and Nature. Manitoba. 128 pp.

Rossman, D.A., Ford, N.B., and Seigel, R.A. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press. Norman, Oklahoma.

Ruthven, A.G. 1908. Variations and genetic relationships of the garter-snakes. Bulletin of the United States National Museum 61:1-201.

Rye, L.A. 2000. Analysis of areas of intergradation between described subspecies of the common garter snake, *Thamnophis sirtalis*, in Canada. Ph.D. Thesis, University of Guelph.

Shelford, V.E., and Twomey, A.C. 1941. Tundra animal communities in the vicinity of Churchill, Manitoba. Ecology 22(1):47-69.

Shine, R., Elphik, M.J., Harlow, P.S., Moore, I.T., LeMaster, M.P., and Mason, R.T. 2001. Movements, mating, and dispersal of red-sided gartersnakes (*Thamnophis sirtalis parietalis*) from a communal den in Manitoba. Copeia 2000(1):82-91.

Whittier, J.M., and Crews, D. 1990. Body mass and reproduction in female red-sided garter snakes (*Thamnophis sirtalis parietalis*). Herpetologica 46:219-226.

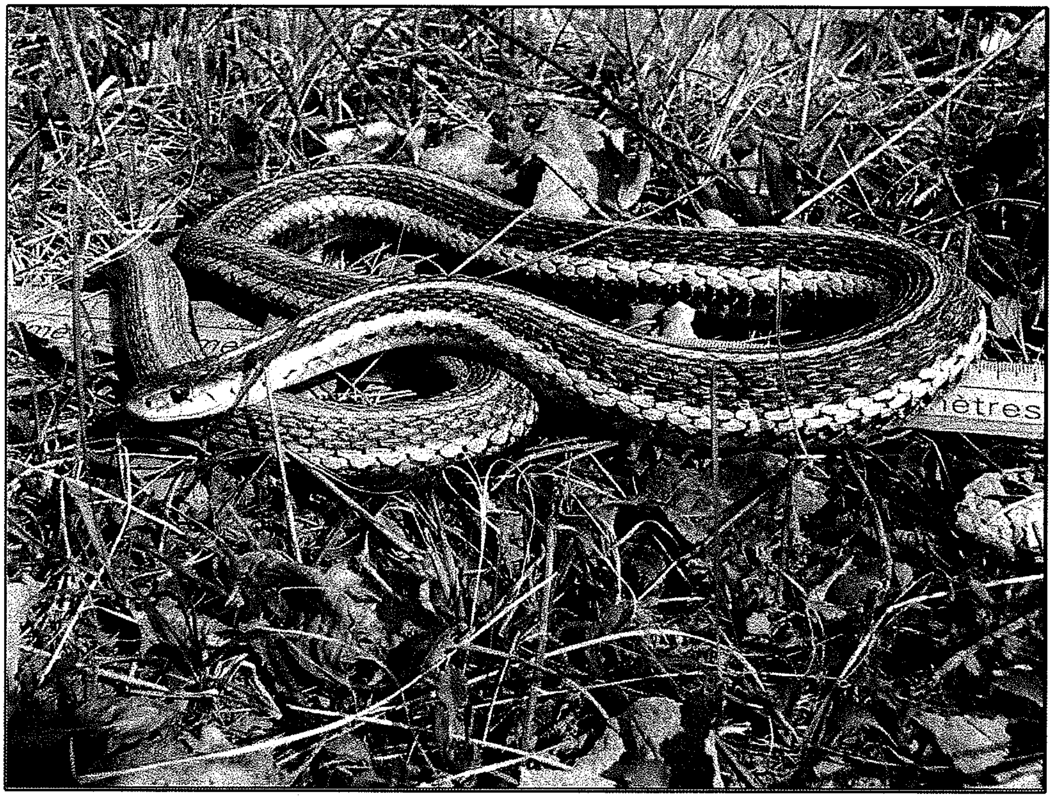


Figure 1.1 Large female common garter snake (*Thamnophis sirtalis*) from Kiskitto Lake, Manitoba.

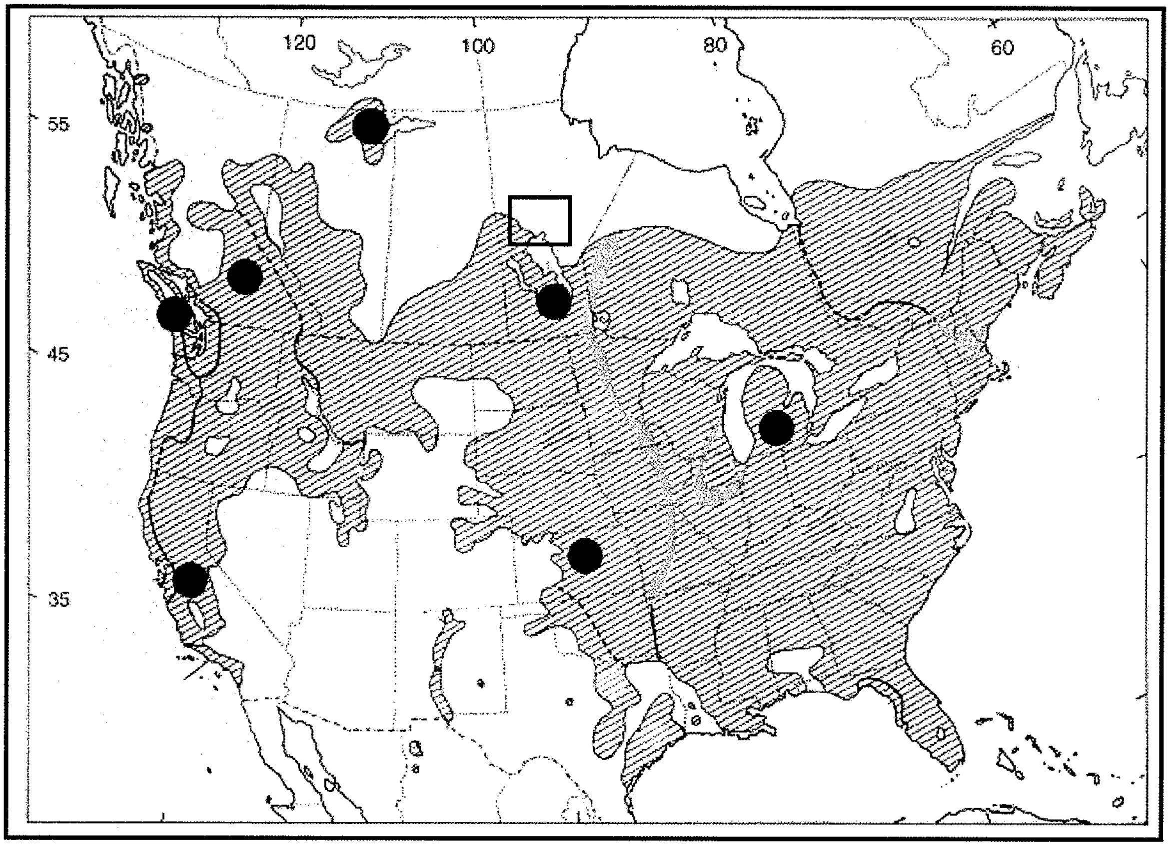


Figure 1.2 Range map of *Thamnophis sirtalis* (adapted from Rossman et al. 1996). Dark circles designate areas where the ecology of *Thamnophis sirtalis* has been studied. Vancouver Island, British Columbia – Gregory 1984; mainland British Columbia – Charland and Gregory 1995, Gregory 1984; northern Alberta – Larsen, 1986; southern Manitoba – Gregory 1977; Michigan – Carpenter 1952; northern California – Kephart 1982; Kansas – Fitch 1965, 2001. The range of the red-sided garter snake (*Thamnophis sirtalis parietalis*) extends from the grey line between Manitoba and Ontario to the dashed line near the Alberta and British Columbia border.

CHAPTER 2

THE STUDY AREA

2.1 GENERAL

The common garter snake has a widespread distribution across North America. This study focused on a newly discovered population in the most northern known portion of their range in Manitoba, Canada. Kiskitto Lake is located in north-central Manitoba, approximately fifty-five kilometres north of Lake Winnipeg (Figure 2.1). It is accessible by an unimproved road from Jenpeg, MB, approximately forty kilometres northeast of the den. Nearby communities include Pimicikamak Cree Nation (Cross Lake) and Norway House Cree Nation (Figure 2.1). This den site was originally discovered in 2002 by a group of Manitoba Hydro employees. In order to control vegetation growth, they were conducting a controlled burn on the dam in early May, when they happened across a series of mating balls on the south portion of the dam. This area was avoided during the course of the burn, and the snakes' activities were later reported to Manitoba Conservation, and officials at the University of Manitoba. This den site was the only known hibernaculum in north-central Manitoba.

During the course of this study, other common garter snake hibernacula and populations were found in the central portion of the province (Norway House, Cross Lake) and the north-western portion of the province (The Pas, and Cranberry Portage). Snakes from these locations, and southern locations, were examined for comparative purposes.

2.2 CLIMATE

Manitoba contains a gradient of climates and biomes. A total of eight species of reptiles occur in the southern portion of the province. To the north, the diversity of reptiles rapidly declines to only one species, the common garter snake. The factors restricting the range of the common garter snake are unknown, but are likely related to climate, length of the growing season, and the availability of denning sites.

The region around Jenpeg/Kiskitto Lake is characterized by a continental, subarctic climate. The winter season is long and cold, while the summer is short and mild. Within the worldwide climate classification system (Koeppen system), this region is classified as Dfc, and so is recognized for its severe winters, lack of dry season, and cool summers (Aguado and Burt 2001). Table 2.1 summarizes the long-term "active season" temperature statistics for locations where *Thamnophis sirtalis* has been studied. Figure 2.3 compares the mean monthly temperatures of these sites over the entire year. The temperatures at Jenpeg are generally colder than most sites, with the exception of Fort Smith N.W.T.. Fort Smith and Jenpeg share very similar temperature patterns, characterized by strong warming trends in April, a cool summer, and subzero temperatures again in October. Most of the other sites experience warmer temperatures throughout the year, with less variability (Table 2.1).

Figure 2.4 compares the twenty-year mean monthly temperature at Jenpeg with the mean monthly temperature during the two years of this study. The summer and fall months generally matched the normal trend, but during the emergence season (April), temperatures were significantly warmer during both years. As outlined by Larsen (1986), the cooler temperatures in northern sites decrease the "quality" of the active season and create additional pressures on survival. This study described life-history trends in northern sites to create a better understanding of how exothermic reptiles survive in these extremes.

2.3 GEOLOGICAL AND BIOTIC CHARACTERISTICS

The Jenpeg region is classified as boreal forest, and is part of the Hayes River Upland ecoregion (MCFB 2003). The area lies on Canadian Shield and is dominated by surface outcrops of granitic bedrock with broad areas of gnessic and volcanic bedrock. The topography varies from level to undulating and rolling. The area is an overlay of lacustrine clay, with discontinuous areas of fine-textured moraine till (Beke et al. 1973). This region closely borders the mid-boreal lowlands to the south and west. This area is covered by karst topography, a geologic formation of irregular limestone deposits with sinks, underground streams, and caverns. The covering forest is dominated by black spruce (*Picea mariana*) and tamarack (*Larix laricina*) in the lowlands, and jack pine (*Pinus banksiana*), white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), and paper birch (*Betula papyrifera*) in the uplands (MCFB 2003). The region contains many lakes, which are part of the Nelson River watershed. Permafrost occurs occasionally in peat accumulations and in local mineral deposits (Beke et al. 1973).

Unlike most areas in which the common garter snake has been studied, (Larsen 1986, Gregory 1977, Fitch 1965, Carpenter 1952) the Jenpeg region is not comprised of limestone, with karst features. Snakes in this region still have to find locations where they can access underground cavities to survive the winter, however. The adaptability of this species is demonstrated by how quickly nearby populations colonized the Kiskitto Lake dam and the associated nearby rock quarry. These artificial structures were constructed by Manitoba Hydro in the 1970's and have since become important areas for common garter snake overwintering. The Kiskitto Lake dam is approximately 600 meters long and reaches a maximum height of 15 meters. The rock fill used in the construction of the dam has created an ideal location for snakes to access a frost-free area near the water table. The Kiskitto Lake den consists of a single, inconspicuous opening, which descends through the top layer of substrate into a series of cavities between large loose rock fill. In addition, a second denning site was located in 2007 at a nearby quarry where fill materials were originally removed for the construction of the Kiskitto Lake dam. The blasting and upheaval associated with quarrying created cracks and fissures in the bedrock where overwintering snakes have also been identified. The local fauna diversity in this region includes all the typical representatives of the northern boreal forest, including a large host of predator and prey species (Bowers et al. 2004, Peterson and Peterson 2002).

REFERENCES

Aguado, E., and Burt, J.E. 2001. Understanding Weather and Climate 2nd Edition. Prentice-Hall, Inc. Upper Saddle River, New Jersey.

Beke, G.J., Veldhuis, H., and Thie, J. 1973. Bio-physical Land Inventory. Churchill-Nelson Rivers Study Area. Canada-Manitoba Soil Survey.

Bowers, N., Bowers R., and Kaufman, K. 2004. Mammals of North America. Houghton Mifflin Company. New York, New York.

Carpenter, C.C. 1952. Comparative ecology of the common garter (*Thamnophis s. sirtalis*) and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecological Monographs 22:235-258.

Environment Canada, National Climate Data and Information Archive. 2007. Website: http://www.climate.weatheroffice.ec.gc.ca/climateData/canada_e.html. Accessed June 2007.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. University of Kansas Publications, Museum of Natural History. 15:493-564.

Gregory, P.T. 1977. Life-history parameters of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in an extreme environment, the Interlake Region of Manitoba. National Museum of Canada, Publications in Zoology 13:1-44.

Kephart, D.G., and Arnold, S.J. 1982. Garter Snake Diets in a Fluctuating Environment: A Seven-Year Study. Ecology 63(5):1232-1236.

Larsen, K.W. 1986. Ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Unpubl. M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Manitoba Conservation Forestry Branch. 2003. Manitoba's Ecoregions. Website: http://www.gov.mb.ca/conservation/forestry/forest-education/general.html Accessed: June 2007.

National Oceanic and Atmospheric Administration Satellite Information Service. 2007. National Environmental, Satellite, Data Information Service. U.S. Statewide Analysis. Website: http://www.ncdc.noaa.gov/oa/climate/research/cag3/state.html. Accessed June 2007.

Peterson, R.T., and Peterson, V.M. 2002. Birds of Eastern and Central North America Fifth Edition. Houghton Mifflin Company. New York, New York.

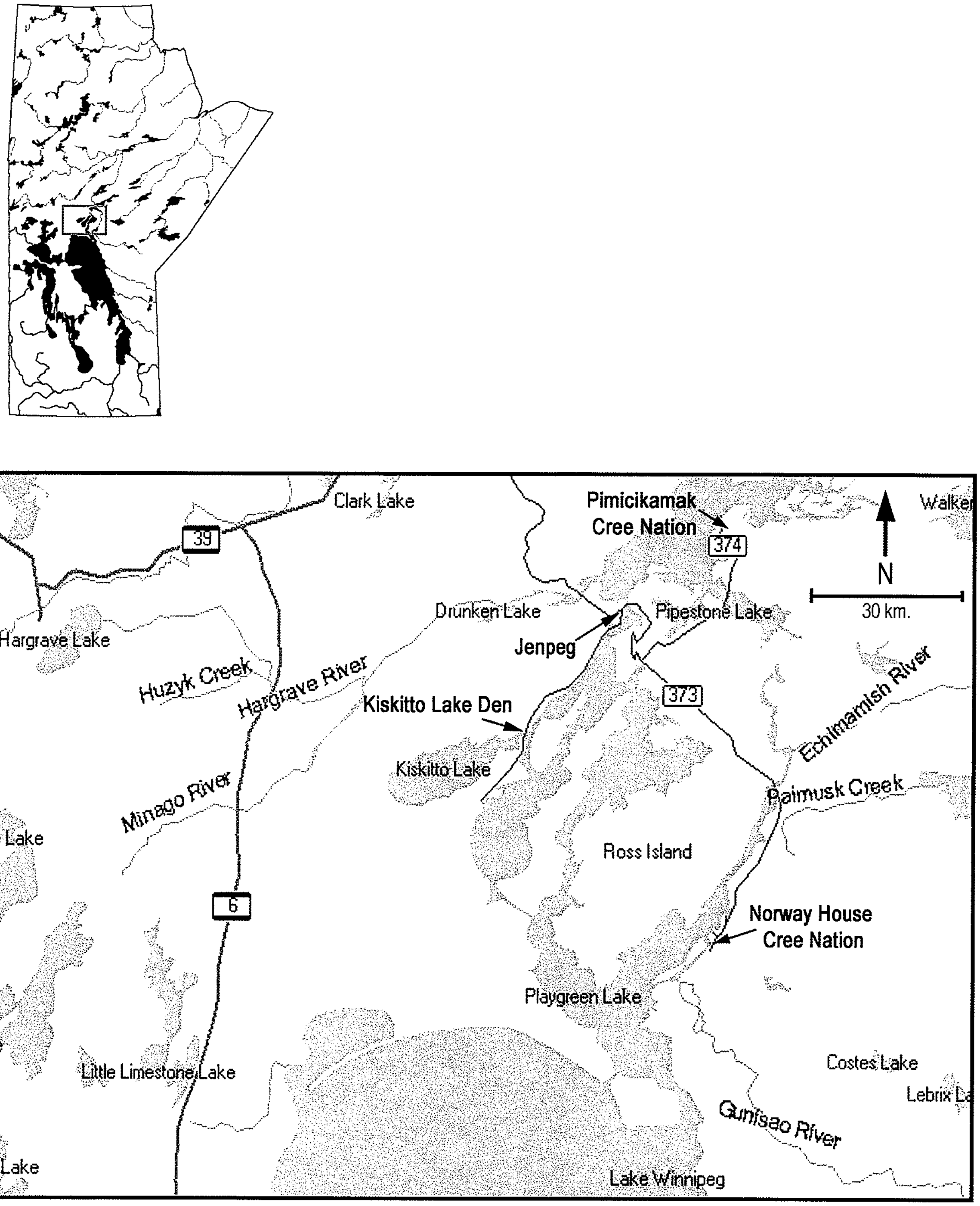


Figure 2.1 Map of north-central Manitoba showing the Kiskitto Lake den and surrounding communities (Inset courtesy Dave Walker).

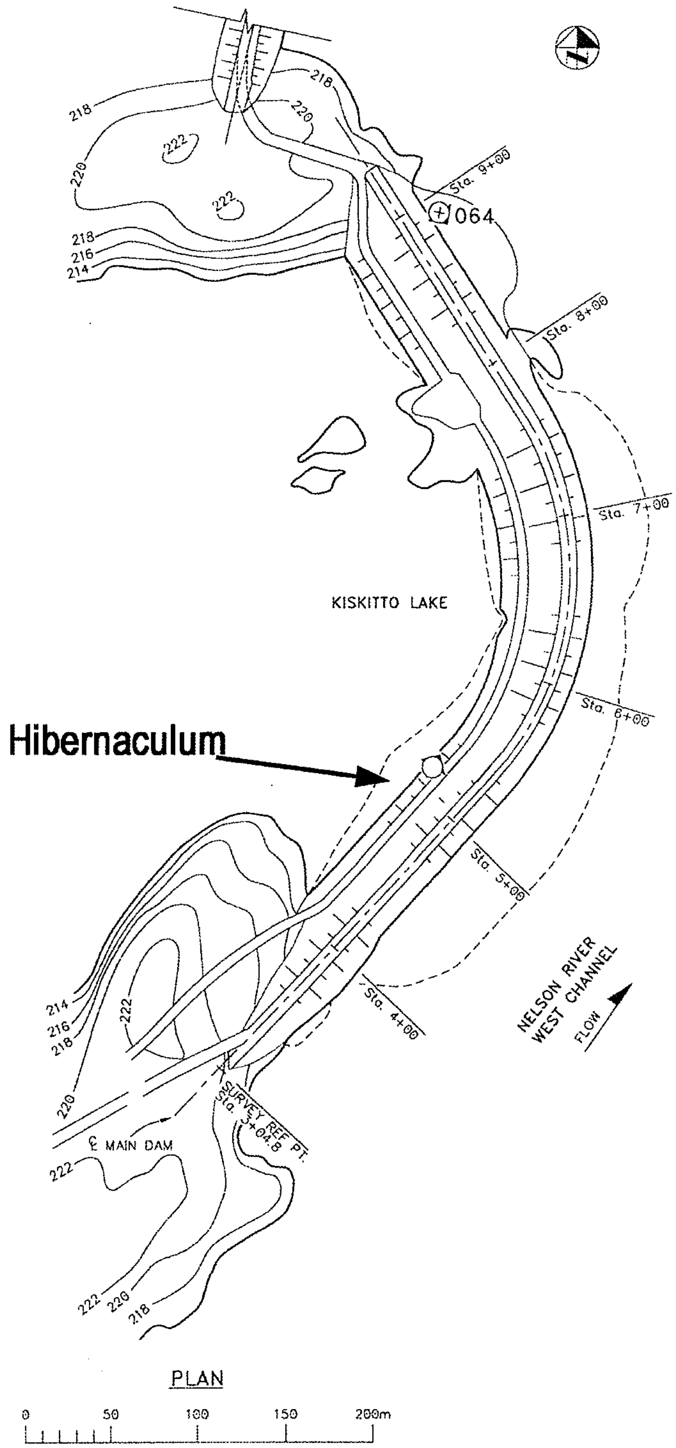


Figure 2.2 Diagram of the Kiskitto Lake dam (completed in 1978) and location of the Kiskitto Lake garter snake den (Courtesy Manitoba Hydro).

Table 2-1 Long-term temperature statistics (May-September) for locations where the ecology of *Thamnophis sirtalis* has been studied.

mean=mean daily temperature in Celsius, S.D.=standard deviation, C.V.=coefficient of variation ((S.D./mean)x100), frost free days=mean number of days where the temperature is greater than zero degrees Celsius. Source (Environment Canada, National Climate Data and Information Archive, 2007, for Canadian sites and National Oceanic and Atmospheric Administration, 2007, for American sites).

Location	mean	S.D.	C.V.	frost-free days
Vernon, Okanogan Valley (British Columbia)	16.7	1.6	9.6	241.3
Williams Lake (Chilcotin, British Columbia)	12.7	1.5	11.8	177.4
Winnipeg (Manitoba)	15.9	1.8	11.3	171.0
Fort Smith (N.W.T.)	12.4	1.6	13.1	140.5
Jenpeg (Manitoba)	13.5	1.9	13.8	156.0
Kansas	22.4	1.6	7.0	N/A
Michigan	17.0	1.4	8.4	N/A
California	21.3	1.2	5.4	N/A

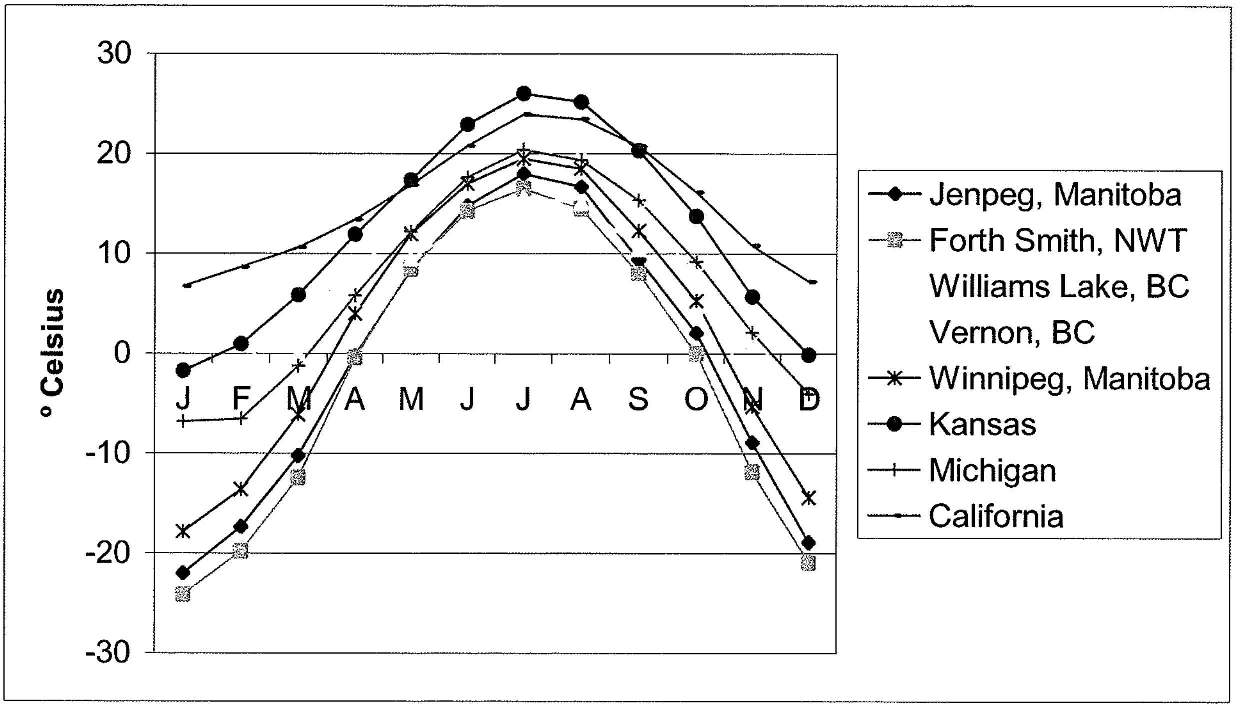


Figure 2.3 Comparison of mean monthly temperatures of sites where the ecology of *Thamnophis sirtalis* has been studied. (Source: Environment Canada, National Climate Data and Information Archive, 2007, for Canadian sites, and National Oceanic and Atmospheric Administration, 2007, for American sites).

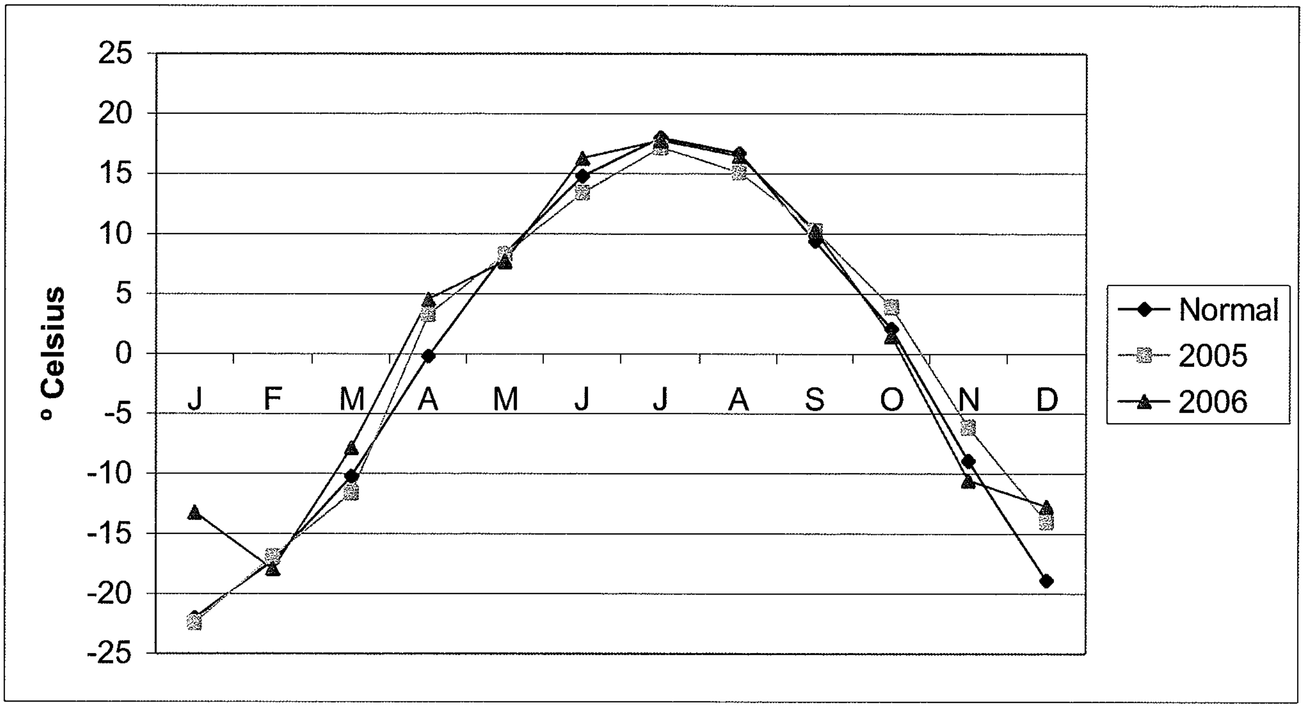


Figure 2.4 Mean monthly temperature for Jenpeg during each year of the study. Also shown is the 20-year normal for the region (Source: Environment Canada, National Climate Data and Information Archive, 2007).

CHAPTER 3

POPULATION DYNAMICS AND STRUCTURE OF THE COMMON GARTER SNAKE AT THE NORTHERN LIMIT OF ITS RANGE IN MANITOBA

ABSTRACT

Mark-recapture experiments in the field can reveal valuable information about population size, structure and dynamics. This knowledge can be important when evaluating a species population dynamics in different parts of its range, and determining strategies conservation and management planning. In this study, I evaluated a common garter snake (*Thamnophis sirtalis*) hibernaculum in northern Manitoba from the spring of 2005 to the fall of 2006. Overall, the population size was small, with approximately 79 (± 10.6) individuals using the hibernacula in 2005. The population declined in 2006, without any obvious cause. Individuals originally captured in 2005 comprised the majority of the large individuals captured in 2006. The sex ratio was not significantly different from 1:1. This northern population contained some of the largest common garter snakes ever recorded. Similar to other studies of common garter snakes in North America, snakes from the small size classes were not captured at the den site. It appears that even in the most northern populations neonates and immature snakes overwinter in areas outside of the adult denning site.

3.1 INTRODUCTION

Information on population structure can provide valuable data on the population dynamics, and provide insight into a species life history strategy (Parker and Plummer 1987). The common garter snake (*Thamnophis sirtalis*) overwinters in large communal hibernacula in the northern part of its range (Gregory and Stewart 1975). Individuals express a high rate of fidelity to their hibernacula and tend to return year after year. These populations are typically comprised of a 1:1 sex ratio, and therefore make excellent candidates for studies on population structure and dynamics. Information derived from this study can help contribute to our knowledge of a species' distribution and abundance, which is critical for the conservation and management planning (Waye 1999).

The purpose of this study was to evaluate, by mark-recapture in the field, the population dynamics and structure of a common garter snake population in northern Manitoba, and compare it to other populations that have been studied in other parts of its range. This population is suspected to be small, and to be at least partially isolated from the nearby populations.

3.2 METHODS

The Kiskitto Lake den was completely encircled with thirty meters of ninety-centimetre galvanized hardware cloth (WW 8 mesh .017 – available at Scott Screen and Co.). The hardware cloth was supported with ¼ inch rebar cut to ninety centimetres lengths. Ten wooden funnel traps (20cm x 20cm x 60cm) were placed along the perimeter of the fencing to intercept any snakes leaving or entering the denning site. The traps were checked daily and fencing repairs were made regularly to minimize the probability of any snakes escaping. With the exception of small problems caused by high winds, the fencing and trap system was very effective. The ventral scale clipping technique as described by Brown and Parker (1976) was used to mark all snakes in this study. At most, three small sections of skin (2 mm x 2 mm) were removed along a series from the snakes ventral side. Snakes were not overtly harmed by this technique and were observed in mating behaviour in as little as 30 seconds after release. Most clippings were still faintly visible 24 months after release.

Lincoln-Peterson estimates (Bower and Zar 1984) with the Bailey's correction technique (Bailey 1951) were used to estimate the population size of the Kiskitto Lake den. Male and female snakes were marked in autumn before hibernation. The proportion of marked to unmarked snakes recaptured the following spring provided an estimate of the population size. Lincoln-Peterson estimates are only appropriate where there is no recruitment between sampling periods, and each snakes has the same probability of overwinter survival.

Jolly-Seber estimates provide a more complex analysis (Seber 1982) and offer estimates of population size, survivorship, and recruitment within an open population. This model has been successfully applied in northern garter snake studies and requires a minimum of three sampling seasons. How the assumptions of this model apply to a northern population of common garter snakes is reviewed in Gregory (1977) and Larsen and Gregory (1989). The major assumptions are as follows:

1. Dispersal of marked snakes is complete between sampling periods.
2. The mark applied to each snake was permanent and did not affect survivability or catchability.
3. Every marked snake has the same probability of being captured at a given sampling period.

Although the rate of den fidelity was not examined in this study, there is little evidence to assume that it differs much from studies in southern Manitoba, where Gregory (1977) found that 96% of adult snakes returned to the den site they used the previous winter. Smaller snakes tend to be more susceptible to mortality than large snakes; therefore, it is unsafe to assume that survival rates between adult and immature garter snakes are equal (Bronikowski and Arnold 1999). To minimize survivorship bias, analysis of population size and structure was limited to adult snakes (<400 mm)(Rossman et al. 1996).

The Jolly-Seber model was applied to both male and female snakes of the Kiskitto Lake population. The population estimates were very similar to the results of Lincoln-Peterson estimates, which is to be expected since they are based on comparable mathematical principles.

Spring and autumn samples were used to compare the ratio of males to females within the population. In most studies of the common garter snake, spring samples are often heavily biased towards males because of their courting behaviour during the mating season (Gregory 1974, Larsen 1989, Shine et al. 2001). Data were expressed as the proportion of males in the population using standard error estimates as outlined by Gregory (1977)(Cochran 1963). Chi square goodness of fit was used to test against a theoretical 1:1 sex ratio (Zar 1999).

3.3 RESULTS

Table 3.1 shows the results of the Lincoln-Peterson and Jolly-Seber population estimates. The short duration of this study allowed only a brief description of population dynamics. Both models portray a similar representation of the Kiskitto Lake den population size (including standard errors). The total population size experienced a decline in the autumn of, however the accompanying standard errors for (Nt) are relatively small.

Body size distributions for both male and female snakes in 2005 and 2006 are shown in Figures 3.1 and 3.2. The sample sizes are very small, but it is obvious that mature male snakes fell between 400 mm to 650 mm SVL. Female snakes were substantially longer, with the majority falling between 450 mm and 1100 mm SVL. Only two neonates and two juveniles were ever captured at the denning site. The neonate snakes were most likely born at the denning site the previous fall. Gravid females were only rarely encountered near the den site during the parturition season. Overlayed on the histograms in Figures 3.1 and 3.2 are the proportions of snakes encountered at the hibernaculum during the first sampling period. Snakes first caught in 2005 represented a decreased proportion of the total population in 2006. Of the twenty-one males marked in the spring on 2005, four were recaptured in the spring of 2006. Female snakes showed a similar trend. Of the thirty-one snakes captured at the den in the spring of 2005, five were recaptured in the spring of 2006. In both sexes, recaptured snakes were represented in the longest size classes.

The ratio of male to female snakes was very similar in all sampling periods years, likely supported by the unbiased sampling approach afforded by fencing and traps. The proportions of males at the den were 0.432 (S.E. 0.0115), 0.422 (S.E. 0.0012), 0.377 (S.E. 0.008) 0.370 (S.E. 0.0185) for the spring and autumn of 2005, and 2006 respectively. Only in the spring of 2006 was the sex ratio close to being significantly different from 1:1 (chi square=3.69, df=1, $0.10>P>0.05$).

Of the 117 individual snakes captured at the den site, 29 (25%) were recaptured elsewhere during the summer months. This demonstrates that the other 75% likely overwintered at other nearby hibernacula.

3.4 DISCUSSION

The population of common garter snakes at the Kiskitto Lake den was small. Although the data suggests that the population experienced a decline in the autumn of 2006, the overall results lend support to the conclusion that the Kiskitto Lake den is a small, stable population.

There is no explanation for why the population size may have declined during the course of this study. No snakes were found with a major illness or disease. It is possible that my presence at the den site may have contributed to a decline, but this is unlikely since I did not directly contribute to the death of any snakes. In addition, there is little evidence to suggest that the large presence of visitors at the Narcisse Interpretive dens has contributed to any population decline in those areas. Other possibilities include a possible food decline in 2006, or an increase in predation pressure. Both of these variables are difficult to measure however because this site was only studied for two seasons, and formal estimates of prey and predators were not taken. The snake recruitment and survivorship observed at this site is not unlike the population size fluctuation reported in other studies of Manitoba common garter snakes (Gregory 1977).

The completion of the Kiskitto Lake dam in 1978 marks the earliest point at which garter snakes may have begun using this specific site. This study is the first to describe a very small population of common garter snakes in Manitoba. It stands in contrast to the large snake populations in Manitoba's Interlake region as described by numerous authors (Aleksiuk and Stewart 1971, Aleksiuk 1976, Gregory 1974, Gregory 1977, Shine et al. 2001). Although Manitoba is renowned for having the largest aggregations of garter snakes in North America, the population size of the Kiskitto Lake population may be more representative of a small *Thamnophis sirtalis* hibernaculum and provide a valuable contrast for comparisons of life-histories characteristics and reproductive strategies.

The size frequency histograms for males and females presented in Figures 3.1 and 3.2 are not easy to interpret, and comparable to those reported for common garter snakes from other parts of North America (Larsen 1989, Gregory 1977, Fitch 1965, Carpenter 1952). Snakes originally captured in the spring of 2005 represent the largest snakes captured in 2006. The available sample size was too small to test for differences in survivability of various size classes, but other researchers have not found significant differences between adults. The presence of only a few neonates and juveniles is analogous to other studies (Larsen 1986, Gregory 1984). Females typically give birth to their young during the summer, while they are away from the denning site. Young snakes overwinter in unknown locations for their first and possibly second winter before eventually migrating to a communal adult denning site. Some researchers have found immature garter snakes in ant mounds (Criddle 1937), but other suitable sites may also exist. Larsen and Hare (1992) briefly summarized the current knowledge on overwintering capabilities of immature garter snakes. In this study, immature snakes were occasionally found on beaver lodges, which may also serve as appropriate overwintering sites. As listed by Larsen (1986), there are several factors explaining the paucity of immature snakes at communal denning sites in northern latitudes:

1. Gravid females may remain at summer feeding grounds until parturition, because they may be more susceptible to predation if they make long distances migrations while supporting offspring.
2. Immature snakes may be able to find small, suitable overwintering sites locally and therefore do not need to migrate to communal dens. They would also than benefit from feeding later into the autumn and earlier in the spring.
3. Suitable hibernacula sites may be limiting for the relative large size of adult snakes, therefore they hibernate communally because those are the only spots available.
4. Enhanced reproductive benefits may occur from the close arrangement of males and females in the spring mating season.

The sex ratio for adult male and female snakes was similar in all four sampling periods. Female snakes were always found in higher percentages, but not significantly. This contrasts with other studies of common garter snakes in northern latitudes (Gregory 1977, Larsen 1989) where the spring sex ratio is significantly skewed towards male snakes. The small size of the Kiskitto Lake population, and the use of fencing, helped eliminate behavioural differences incurred by mating activity.

The total population size of common garter snakes in the study site is difficult to calculate. The only reliable population estimates were equated from the Kiskitto Lake hibernaculum. The observation that 25% of the snakes captured in the nearby summer habitat overwintered at the Kiskitto Lake den suggests that this den site is a substantial refuge for a portion of the total population in this region.

REFERENCES

Aleksiuk, M. 1976. Reptilian hibernation: evidence of adaptive strategies in *Thamnophis sirtalis parietalis*. Copeia 1:170-178.

Aleksiuk, M., and Stewart, K.W. 1971. Seasonal changes in the body composition of the garter snake (*Thamnophis sirtalis parietalis*) at northern latitudes. Ecology 52(3):485-490.

Bailey, N.T.J. 1952. Improvements in the interpretation of recapture data. Journal of Animal Ecology 21:120-127.

Bronikowski, A.M., and Arnold, S.J. 1999. The evolutionary ecology of life history variation in the garter snake, *Thamnophis elegans*. Ecology 80:2314–2325.

Brown, W.S., and Parker, W.S. 1976. A ventral scale clipping system for permanently marking snakes (Reptilia, Serpentes). Journal of Herpetology 10:247-249.

Bower, J.E., and Zar, H.Z. 1984. Field and Laboratory Methods for General Ecology. 2nd Edition. WCB Publishers. Dubuque, Iowa.

Carpenter, C.C. 1952. Comparative ecology of the common garter (*Thamnophis s. sirtalis*) and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecological Monographs 22:235-258.

Cochran, W.G. 1963. Sampling Techniques. 2nd Edition. John Wiley & Sons, Inc. New York.

Criddle, S. 1937. Snakes from an Ant Hill. Copeia 1937(2):142.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. University of Kansas Publications, Museum of Natural History. 15:493-564.

Gregory, P.T. 1974. Patterns of spring emergence of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in the Interlake region of Manitoba. Canadian Journal of Zoology 52:1063-1069.

Gregory, P.T. 1977. Life-history parameters of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in an extreme environment, the Interlake Region of Manitoba. National Museum of Canada, Publications in Zoology 13:1-44.

Gregory, P.T. 1984. Habitat, diet, and composition of assemblages of garter snakes (*Thamnophis*) at eight sites on Vancouver Island. Canadian Journal of Zoology 62:2013-2022.

Larsen, K.W. 1986. Ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Unpublished M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Larsen, K.W., and Gregory, P.T. 1989. Population size and survivorship of the common garter snake (*Thamnophis sirtalis*), near the northern limit of its distribution. Holarctic Ecology 12:81-86.

Larsen, K.W., and Hare, J.F. 1992. Criddle's Riddle: Where do young garter snakes hibernate? Herpetological Review 23(2):39-40.

Parker, W.S., and Plummer, M.V. 1987. Population Ecology. *In* Snakes-Ecology and Evolutionary Biology *Edited by* Seigel, R.A., J.T. Collins, S.S. Novak. MacMillan, New York. pp. 253-301.

Rossman, D.A., Ford, N.B., and Seigel, R.A. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press. Norman, Oklahoma.

Shine, R., Elphik, M.J., Harlow, P.S., Moore, I.T., LeMaster, M.P., and Mason, R.T. 2001. Movements, mating, and dispersal of red-sided gartersnakes (*Thamnophis sirtalis parietalis*) from a communal den in Manitoba. Copeia 2000(1):82-91.

Waye, H. 1999. Size and age structure of a population of Western Terrestrial Garter Snakes (*Thamnophis elegans*). Copeia 1999(3): 819-823.

Table 3-1 Estimates of the adult common garter snake (*Thamnophis sirtalis*) population at the Kiskitto Lake Den. N = population size, Ø = survivorship, ß = recruitment.

			Peterson estimate		Jolly estimate					
		period	N_t	S.E. (N_t)	N_t	S.E. (N_t)	Ø	S.E. (Ø)	ß	S.E. (ß)
males	Fall	2005	38.1	6.2	65.7	39.4	1.132	0.403	-21.8	19.2
	Spring	2006			52.5	30.1	0.102	0.051	7.6	2.3
	Fall	2006	14.3	2.1	13.0	2.9				
females	Fall	2005	41.1	4.0	54.0	14.1	1.012	0.164	-1.8	8.1
	Spring	2006			52.9	8.9	0.302	0.062	5.6	2.4
	Fall	2006	24.0	3.3	20.7	2.2				

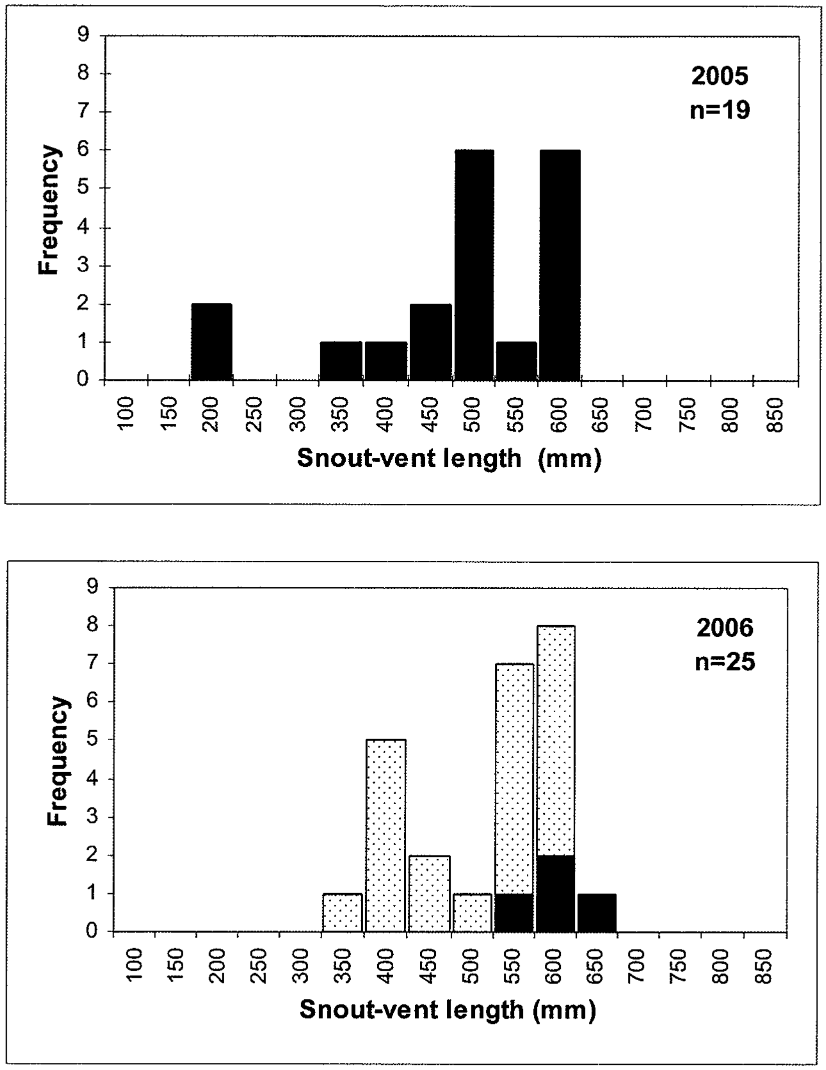


Figure 3.1 Population structure of male *Thamnophis sirtalis* captured in the spring at the Kiskitto Lake Den. Snakes are grouped into 50 mm SVL intervals. Superimposed on the 2006 histogram are snakes first captured in 2005.

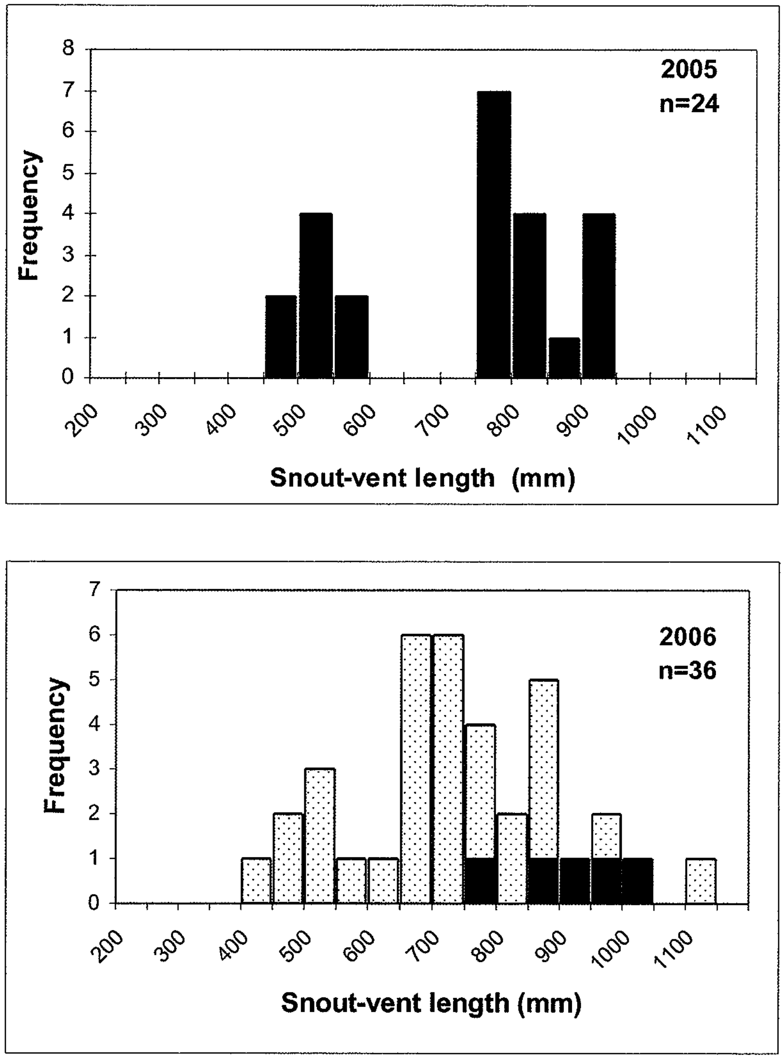


Figure 3.2 Population structure of female *Thamnophis sirtalis* captured in the spring at the Kiskitto Lake Den. Snakes are grouped into 50 mm SVL intervals. Superimposed on the 2006 histogram are snakes first captured in 2005.

CHAPTER 4

HABITAT USE AND MOVEMENTS OF THE COMMON GARTER SNAKE IN NORTHERN MANITOBA

ABSTRACT

Common garter snakes (*Thamnophis sirtalis*) exhibit wide variation in movement patterns across their geographic range. Movement patterns are closely linked to resource acquisition and partitioning. I examined the habitat use and movements of common garter snakes at the northern limit of their range in Manitoba. Radiotelemetry and funnel traps were used to determine movements of snakes from spring through fall. One radio tracked female travelled a maximum distance of 1.4 km from the den and moved on 79% of summer days. Three of five radio tracked snakes died from predation during this study, reinforcing that predation pressure may play a significant role in habitat use and movement. Funnel trapping revealed that snake movements were focused around pond and wetland areas. Snakes were captured as far away as 5.0 km from the den site, despite the apparent abundance of available habitat and food around the den site. Snakes were commonly seen basking on beaver lodges and other beaver structures. Through temperature and light profiling, it was identified that beaver lodges provide ideal garter snake habitat. This suggests that a commensal relationship might exist between these two species.

4.1 INTRODUCTION

Animal movements are intrinsically linked to their requirements for resources within their surroundings (Charland and Gregory 1995). In general, habitat use has been broadly defined as "the relationship between the spatial distribution of an organism and specific environmental habitats" (Reinert 1993). The habitat use of ectothermic animals deserves particular attention in extreme latitudes, where low-sunlight energy places additional pressures on resource acquisition. Previous studies of the habitat use and movements of common garter snakes have provided valuable insight into the physiological costs and benefits of animal movement (Charland and Gregory 1995, Fitch 1965, Fitch 2001, Larsen 1987, Shine et al. 2001). The requirement of further work on this topic has been identified due to the plastic nature of common garter snakes (*Thamnophis sirtalis*) in different geographic locations (Larsen 1987, Shine et al. 2001). Therefore, the purpose of this study is to investigate the habitat use and movements of common garter snakes in the extreme conditions of northern Manitoba.

In the northern part of the common garter snake's range, suitable hibernacula play a critical role in overwintering. Individual snakes have been known to migrate up to 17.7 km from their overwintering hibernacula (Gregory and Stewart 1975). This movement obviously comes at quite an energetic cost to an animal, especially when considering its restricted "active season". Therefore, to best understand the ecology of this species, it is important to understand the landscape features surrounding any hibernacula.

On his study sites in Kansas, Fitch (1965) described common garter snakes as being capable of occupying any mesic habitat. But like most species, snake habitat use is not random (Reinert 1993). Snakes make use of an assortment of habitats during different times of the day, or year (Law and Dickman 1998). This spatial pattern of habitat use has been refined down to three important factors in garter snakes.

1. Canopy Cover
2. Thermal Sites

3. Prey Availability (Rossman et al. 1996)

Habitat selection (the cause or mechanism responsible for habitat use) in snakes has been described on a four-stage gradient from macrohabitat to microhabitat (Reinert 1993):

1. Internal physiological factors (digestive state, reproductive condition, ecdysis)
2. Structural habitat cues (canopy structure, substrate structure)
3. External environmental factors (chemical or thermal gradients)
4. Proximal chemical or climatic cues (prey odours, temperatures, conspecific pheromones)

This description is valuable because it accounts for the different ways that snakes use a landscape based on a wide range of possible internal and external conditions. Sympatric and allopatric situations, including the presence of predation, competition, or other mechanisms are all accounted for in this model. Increasing our understanding of snake habitat selection is difficult to achieve, but is becoming increasingly important in conservation planning (Reinert 1993).

The hibernaculum is a specialized form of habitat used by common garter snakes in northern regions for up to six months of the year. Each hibernaculum must to possess certain characteristics, such as consistent above freezing temperatures, and elevation above the water table (Nuttall et al. 2002). Larsen (1986) researched the overwintering thermal gradients of hibernacula of northern Alberta. His results showed that snakes hibernated approximately 1.9 meters below the surface. They were also observed to reposition during the winter, likely in response to changing thermal gradients. It is still unclear however how snakes are able to positively identify suitable overwintering habitats (LeMaster et al. 2001, Larsen 1986).

Common garter snake habitat use is highly correlated with the habitat of their prey species. In most study sites, wetland areas have the highest densities of available prey species and are therefore highly attractive to snakes. In southern locations, common garter snakes are usually subjected to interspecific competition with other snake species, which may force them into less suitable habitat (Fitch 1965). In the North, no such competition exists and cold tolerance is likely a more important factor.

The common garter snake prefers mesic habitats (Fitch 1965) and interacts with other wildlife species that use the same habitat, including beavers (*Castor canadensis*). The impoundments that beavers create provide appropriate habitat for their shelters (lodges), as well as habitat for a large number of other wildlife species, including common garter snakes. In the 2005 field season, snakes were often found on, or near, beaver lodges. Occasionally snakes could also be observed moving in and out of beaver lodges through small holes. In this experiment I tested whether beaver lodges, a relatively small landscape feature, actually provided an additional "optimal microhabitat" for snakes. There are at least four reasons to believe this may be the case:

1. Lodges provide good camouflage. The wooden sticks and grass on the surface of the lodge closely match the shape and form of a common garter snake.
2. Lodges provide opportunities for thermoregulation. Lodges are generally elevated from the surrounding area are created out of a dark substrate, and therefore absorb much of the available sunlight.
3. Lodges provide opportunities for quick escape. Snakes can often escape into the lodge itself, or quickly use available cover to move into surrounding vegetation or water.

4. Lodges provided close access to food sources. The common garter snakes main prey species (frogs, toads, aquatic invertebrates) are most abundant around wetlands.

4.2 METHODS

Mark Recapture

General information on the habitat use and movements of common garter snakes was obtained from a literature review and preliminary field exploration in 2005. The majority of field data on the habitat use and movements on snakes in the Jenpeg region was acquired through the recapture of marked individuals. Snakes were recaptured using two methods: 1) by hand while conducting surveys of nearby habitats on foot; 2) in strategically placed funnel traps. Two long lines of drift fencing with funnel traps were erected across suspected migration routes within the study site. In addition to this sampling, pairs of funnel traps with drift fencing were placed near beaver lodges and wetlands at twelve locations around the study site.

Radiotelemetry

To obtain detailed information on individual movements, five snakes were outfitted with surgically implanted radio transmitters. Radio telemetry allowed the researcher to follow the movements and habitat use of an individual snake over a period of four months. Although this methodology allowed for consistent data collection from the same individual, it did present many challenges. Only large female snakes were suitable for this experiment as the transmitter package was quite large (Holohill Systems Ltd. Model SB-2 5g (19x9.5)(l x diameter) (mm)) and would therefore adversely affect the movements, behaviour, and survivorship of smaller individuals. The snakes chosen for this radio telemetry study were all captured at the Kiskitto Lake den soon after emergence in the spring of 2006. They were quickly transported to the Assiniboine Park Zoo hospital in Winnipeg (via aircraft), where they were held for observation before surgery (Webb and Shine 1997). Common garter snakes used for implantation were heavier than 200 gm, therefore ensuring a body mass to transmitter ratio greater then (0.05:1). For details on the surgery procedures, please refer to Appendix 1.

Upon release at the Kiskitto Lake den, the snakes were tracked on foot with a hand held collapsible antenna and a portable receiver (HR2000 Osprey, H.A.B.I.T. Research LTD). In order to minimize disturbances, every attempt was made to observe snakes from a distance. Whenever possible, the position of each snake was determined once every day. If an individual snake was observed to be actively moving, its position was obtained numerous times per day. Exact locations of snakes were recorded with a GPS unit (Garmin 76S, Garmin 60CSx).

As outlined by Larsen (1986), there are multiple challenges in tracking two or more migratory garter snakes. Some of these include: 1) the poor signal range of the transmitters once snakes move into heavily vegetated or uneven terrain, 2) the long distances snakes can travel in short periods of time, 3) the ability of snakes to traverse large bodies of water, 4) the inaccessibility of remote road-less areas. All of these challenges were experienced in this study. Every reasonable attempt was made to track all five snakes despite these known obstacles.

Beaver Lodge Counts

To investigate the relationship between common garter snakes and beavers (*Castor canadensis*), twelve beaver lodge sites were identified within the study area. Two wooden funnel traps (20cm x 20cm x 58cm) were stationed at each beaver lodge sampling location. Trap A was stationed directly beside the beaver lodge. Trap B was stationed near open water at a randomly determined distance from Trap A (minimum 20 m, average 29 m). To assist in capturing snakes, 1.5 meters of galvanized fencing was positioned at 45 degree angles from the four corners of the funnel trap (Figure 4.1). Traps were inspected once a day. Ambient temperature, surface soil temperature, and any captured animals were noted. All snakes were marked and processed using the same procedures as snakes captured at the denning site. A paired t-test was used to test for differences in capture rates between the two traps. A value of $p \leq 0.05$ was considered significant

To obtain a better understanding of the environmental conditions around beaver lodges, temperature and sunlight patterns (recorded as lumens) were recorded at three sampling locations using Hobo Data Loggers©. An experiment logger was positioned directly on the surface of a beaver lodge, and a control logger was positioned at a randomly determined (terrestrial) location near the lodge (minimum 30 meters from lodge). Daily temperature and light readings were taken at 10-minute intervals from 8:00 until 18:00 to identify differences in environmental conditions. A chi-square test with $p \leq 0.05$ was considered significant.

To augment my visual survey, a miniature video camera (Rigid/Kaufmann Diagnostic Equipment) was used to explore small crevices and openings in three beaver lodges on which snakes were frequently observed to bask. Images were recorded onto a VHS tape and later examined for evidence of common garter snakes inside the lodge.

4.3 RESULTS

Spring Emergence

In the earliest phase of spring emergence, male snakes would surface in the morning and bask in the immediate vicinity of the den opening. As spring progressed, males became increasingly active, and began continuously searching for females in the surrounding area. The initial behaviour of all snakes at first emergence involved slowing raising their head out of the den opening and then waiting five to ten minutes before completely exposing their entire body (Figure 4.2). Any sign of a threat (i.e. avian predator, human, wind gust) would cause the snake to quickly retreat into the shelter of the den. The den site at Kiskitto Lake was limited to only one opening, making all snakes particularly vulnerable to a waiting predator.

Mating generally occurred in the immediate vicinity of the denning site. Male snakes would court an emerging female vigorously before she had an opportunity to move more than a few meters from the den site. Occasionally mating was observed in a nearby treed area (< ten meters). It appeared that female snakes preferred to spend their first hours post-emergence in this sheltered area. Male snakes remained in the vicinity of the den for a week or more. Most males found overnight shelter in nearby leaf litter, old stacks of wood, or rock piles, but occasionally some would retreat to the den. Female snakes only spent a minimum amount of time (~1 day) around the den before starting their spring migration. She/male behaviour (as described by Mason and Crews 1985) was also observed on two occasions in 2006.

Migratory Movements

Of the 117 individual snakes captured at the den site, 29 (25%) were recaptured elsewhere during the summer months. Snakes from the Kiskitto Lake den disperse in a range of directions, and do not migrate to any particular region (Figure 4.3). Most recaptures were made south of the den site; however, there may have been a bias in the number of snake recoveries to the north because the rugged terrain caused difficulty in trapping. It is also possible that some snakes traversed the large water bodies to the east and west of the den and spent the summer in remote, inaccessible regions. The largest numbers of recovered snakes (10) were captured in funnel traps along a narrow strip of land, two kilometres south of the den site. This location was fenced from the shoreline of Kiskitto Lake to Kiskittogisu Lake (Nelson River) to ensure that snakes passing through this natural funnel would be forced into one of a series of traps. The most distant recoveries of snakes originally marked at the Kiskitto Lake den were actually two males captured 5.0 kilometres south of the den on August 8, 2006 and August 19, 2006, respectively.

The return migration of snakes to the hibernacula encompassed a period of approximately two months. In 2005, the earliest snake returned on July 8. This non-gravid female remained in the vicinity of the den site for the remainder of the active season. The latest snake to return was on September 19. In 2006, the earliest snake returned on August 11, and the last snake returned on September 26. The peak of return activity typically occurred in late August. Throughout this sampling period, many snakes were captured in the field that did not arrive at the Kiskitto Lake den. It can only be presumed that they were returning to one or more other hibernaculum sites that have not yet been located.

The majority of these snakes were captured in a long line of drift fencing with funnel traps that were positioned along a suspected migration route (Figure 4.3, south of the den (10)). The remainder of the snakes were captured by hand, or in small funnel trap stations distributed around the wetlands within the study site.

Radiotelemetry

Table 4.1 summarizes the tracking results from five radio-fitted females. Two measures of movement rate are presented, overall movement rate (OMR) and actual movement rate (AMR) (Charland and Gregory 1995). OMR is the total distance moved by a snake over the total number of days sampled. AMR is the total distance moved by a snake over the number of days on which movement was actually observed. These two measures were needed because of my inability to track snakes every day, and the fact that snakes often spend long periods of time in one location. Activity ranges were calculated as complex polygons. Only snake #1 was tracked for an adequate period of time to provide long-term information on habitat use and movements. The movements of four females are illustrated in Figure 4.4. Snakes #2 and #4 quickly dispersed after their release. Both snakes travelled on a direct continuous route away from the den site, and were not found again until their return to the den site in late summer. Snake #3 remained near the den site after her release. Her lack of movement and overall poor condition, prompted me to return her to the veterinarian for an examination. After the examination, she was released at the den site, and quickly travelled in a north-westerly direction, but was intercepted and killed by a predator. Snake #5 appeared content to stay near the den site for the first few days after her release. She was observed occasionally moving along the shoreline, and often found in a stack of old wood near the den overnight. For an unknown reason, she was discovered mostly eaten six days after her release. It is unknown as to whether her death resulted from an unknown effect of the surgery, or whether she was caught off guard by a predator.

Snake #1 provided continuous tracking data until autumn. Her initial movements were restricted to a small area around the den site. After three days, she moved 750 meters from the hibernaculum to a site containing a thirty five year old, over-grown concrete building pad. This location was on a rocky shoreline of Kiskittogisu Lake, and was surrounded by patchy stands of tall grass (mainly *Philaris arundinacea*) and willows (*Salix spp.).* Snake # 1 moved on 79% of days monitored. Specifically, she spent 29 of 58 tracking days within a (1.2 km^2) area around the overgrown building pad. Once I became familiar with the area, her daily movements became quite predictable. During the morning, she would usually bask on an open surface in an eastfacing location. Her movements after this initial warm-up period varied, but often included foraging excursions along the edge of the lake. During these times, she would move slowly through the grass and woody debris, while frequently stopping to raise her head. She continually flicked her tongue and explored surrounding crevices. Overcast, cold and rainy weather often forced her to spend the entire day under cover. During these times, I repeatedly tracked her signal to the old building pad, where she appeared to be seeking refuge in a narrow crevice. During long periods of inclement weather, she would spend several days under this building pad, without any apparent movement. In contrast, hot and sunny weather often found her aboveground, concealed in the shade of willows or tall grass. Her death by predation in mid-September came as a surprise, as her movements and general appearance matched that of a healthy snake.

Beaver Lodge Counts

Trapping was conducted for a total of seventy days between June and September 2006. In total, 142 snakes were captured. There was no significant difference in the number of snakes caught at the beaver lodges sites compared to the control sites (x^2=0.028, df=1, p>0.25) (Table 4.2). There was also no significant difference in the average soil temperatures between the beaver lodge sites and the control sites (Table 4.2). However, a significant difference was observed in the surface temperature and light regimes at two of the three environmental sampling locations (Table 4.3). The loggers on beaver lodge sites recorded significantly higher temperatures and sunlight intensity than those at nearby control sites. Sampling location #3 did not reveal any significant differences, partially because it experienced recurrent technical difficulties and therefore acquired only nine days of comparative data.

No evidence of snake activity was observed in any of the beaver lodges that were explored with the miniature video camera. All three lodges appeared to be actively used by beavers, and were inspected during the daylight hours. However, the disturbance associated with positioning the camera may have prevented getting any candid footage of snakes in a lodge (although beavers were observed). During the course of this exploration, many small crevices were identified in the structure of the lodges. These small openings could easily accommodate a snake with direct access to the interior. Snake skin sheds were also frequently observed on the exterior of beaver lodges entangled in the logs.

4.4 DISCUSSION

Movements and habitat use are two interrelated points of study. The factors that affect an animal's habitat use also affects its movements, and vice versa (Charland and Gregory 1995). The habitat around the Kiskitto Lake den site is not homogeneous and is utilized by snakes in a non-random way. The trends and patterns observed in this study are best examined with combined information on both the movements and habitat use.

Snakes utilizing the Kiskitto Lake den dispersed in many directions after spring emergence. Snakes had many opportunities to move in directions largely inaccessible to humans but not snakes. The majority of recaptured snakes were found south of the den site, where favourable landscape features assisted in field trapping. Snakes may have been travelling south to arrive at a series of large marsh complexes (five km south of the den). This suggestion is difficult to support however, because just as Larsen (1987) and Gregory and Stewart (1975) found, snakes continued to disperse even after they reached areas of high prey density (frogs). Gregory and Stewart (1975) speculated that long distance movements by *Thamnophis sirtalis* might be the result of resource partitioning between all individuals. This explanation however, does not appear to apply to the region around Kiskitto Lake, where food sources appear to be abundant and snake populations are relatively low. The majority of snakes caught at the most distant trapping sites were male. This may indicate that males have higher movement rates and less site fidelity than females, which makes sense considering that females are required to transport developing offspring. This sexual difference in movement rates has also been reported in Kansas (Fitch 2001).

The seasonal movements of *Thamnophis sirtalis* have been described in Michigan by Carpenter (1952) and in Kansas by Fitch (1965, 2001). Both researchers report seasonal movements of less than 1.2 km, considerably less than described by studies in northern climates (17.7 km one-way Gregory and Stewart 1975, and 18.0 km round-trip Larsen 1987). Studies of garter snake orientation have shown that geomagnetism can be used for complex navigation. Garter snakes appear to follow a specific bearing, which allows them to follow a long distance loop formation back to a primary shelter (Smith 2002). The shoreline movements of snakes in this study may be a sampling artefact, but may also demonstrate that snakes use this feature to enhance movement. The "funneling effect" of the Kiskitto Lake dam may also describe why snakes colonized this site so quickly after its construction.

The radiotelemetry results from this study are limited, but do show that not all individuals travel long distances during spring dispersal. Snake #1 utilized a nearby rocky shoreline with close access to shrub vegetation and an old building foundation. Her movements were mainly restricted to daily foraging expeditions with no long-distance movements. Gregory and Charland (1995) found gravid females to be far more sedentary than non-gravid individuals. Snake #1 appeared to be non-gravid and subsequently had a high rate a movement and a large active area

($1.2\ km^2$). Despite these trends, the short duration of this study and limited number of experimental animals utilized means that extreme caution should be used when interpreting data (Shine 1987).

The influence of predators may also affect habitat use and movements of common garter snakes. Although only one adult common garter snake was ever overtly seen being eaten by a predator (mature eagle – August 2006), three of the five radiotracked snakes died due to predation. Based on the highly disfigured condition of their carcasses they were most likely predated on by avian or small mammalian predators. Although every precaution was taken, the stress and discomfort caused by the transmitter may have resulted in a higher rate of mortality in these snakes. A small proportion of the population were noted to have body scars and tail breakage, a clear indication of predation attempts (Placyk and Burghardt 2005). Although predation pressure may be an important factor in snake movements and habitat use, it is difficult to characterize without a controlled situation. Charland and Gregory (1995) found that snakes selected sites with high availability of cover. This behaviour may serve as an anti-predator mechanism (Greene 1988).

The relationship between beavers and common garter snakes is poorly understood. Beavers are known to alter the landscape and create habitat for wetland species (Naiman et al. 1986). Snakes were caught in similar proportions at beaver lodge traps and control traps. No significant difference in capture rate was detected at any sampling station. The data suggest that snakes do occupy habitat around beaver lodges, but not preferentially to other shoreline sites. These results then provide support for at least two possible conclusions:

1) Human observational bias. It may be that during my initial field survey, snakes appeared to be more abundant on beaver lodges because they were

more visible to a human observer, while snakes occupying other nearby areas were not.

2) It may be that snakes range widely but tend to stay near (and spend a majority of their time near) favoured beaver lodges. This type of activity may therefore be represented in the capture rates of both the experimental and control traps (average distance between traps was only 29 meters). A greater distance between traps (>100 meters) may have provided a different capture rate. Over the course of the field season, some individual snakes were repeatedly captured in both the beaver lodge traps and control traps, suggesting that their activity was concentrated in a fairly restricted area.

The difference in the environmental conditions between beaver lodge sites and control sites demonstrates a clear trend. Beaver lodge sites have both higher temperatures and light regimes than surrounding areas. Although not directly supported by the number of snake captures, these warmer areas may provide valuable basking locations for common garter snakes, especially at the northern limit of their range where average daytime temperatures are lower than in southern locations.

The lack of direct evidence of common garter snakes in beaver lodges does not preclude the compelling visual evidence that lodges are occasionally used as a refuge. Common garter snakes are opportunists and are renowned for their plasticity (Rossman et al. 1996). The advantages acquired from utilizing these pre-existing habitat structures are intuitive. Given that this behaviour does not provide any apparent benefits to beavers, this relationship may serve as an ecological example of commensalism. Further research may reveal if beaver lodges even serve as overwintering refugia for common garter snakes. According to anecdotal reports, garter snakes have been found during the winter in beaver lodges excavated in the Mackenzie River basin, NWT (Charles Jonkel 2006 personal communication.). Very little is known about the over-wintering strategies of neonate garter snakes (*but see* Larsen and Hare 1988), and it seems possible that beaver lodges could offer a protective hibernacula. Before this study, no research had been conducted on the relationship between beavers and common garter snakes, and I believe this experiment should serve as a starting point for more thorough, investigative work.

REFERENCES

Carpenter, C.C. 1952. Comparative ecology of the common garter (*Thamnophis s. sirtalis*) and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecological Monographs 22:235-258.

Charland, M.B., and Gregory, P.T. 1995. Movements and habitat use in gravid and nongravid female garter snakes (Colubridae: *Thamnophis*). Journal of Zoology 236(4):543-561.

Fitch, H.S. 2001. Further study of the garter snake, *Thamnophis sirtalis*, in Northeastern Kansas. Scientific Papers: Natural History Museum: The University of Kansas 19:1-6.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. Scientific Papers: Natural History Museum: The University of Kansas 15:493-564.

Greene, H.W. 1988. Antipredator mechanisms. *In* Biology of Reptilia *Edited by* Gans, C. and R.B. Huey, R. Alan. Liss Inc. New York 16:1-152.

Gregory, P.T., and Stewart, K.W. 1975. Long-distance dispersal and feeding strategy of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in the Interlake of Manitoba. Canadian Journal of Zoology 53:238-245.

Jonkel, C. 2006. Personal communication. Retired Canadian Wildlife Service Scientist.

Larsen, K.W. 1986. Ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Unpubl. M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Larsen, K.W. 1987. Movements and behaviour of migratory garter snakes, *Thamnophis sirtalis*. Canadian Journal of Zoology 65:2241-2247.

Larsen, K.W., and Hare, J.F. 1992. Criddle's Riddle: Where do young garter snakes hibernate? Herpetological Review 23(2):39-40.

Law, B.S., and Dickman, C.R. 1998. The habitat mosaics by terrestrial vertebrate fauna: implications for conservation and management. Biodiversity and Conservation 7(3):323-333.

LeMaster, M.P., Moore, I.T., and Mason, R.T. 2001. Conspecific trailing behaviour of red-sided garter snakes, *Thamnophis sirtalis parietalis*, in the natural environment. Animal Behaviour 61(4):827-833.

Mason, R.T., and Crews, D., 1985. Female mimicry in garter snakes. Nature 316:59–60.

Naimern, R.J., Melillo, J.M., and Hobbie, J.E. 1986. Ecosystem alteration of boreal forest streams by beaver (*Castor canadensis*). Ecology 67(5):1254-1269.

Nuttall, D., Zonneveld, R., and Lussier, R. 2002. The design of an artificial snake den: red-sided garter snakes (*Thamnophis sirtalis parietalis*) in the Interlake Region of Manitoba. Department of Landscape Architecture. University of Manitoba. Winnipeg, Manitoba.

Placyk, J.S., and Burghardt, G.M. 2005. Geographic variation in the frequency of scarring and tail stubs in eastern gartersnakes (*Thamnophis s. sirtalis*) from Michigan, USA. Amphibia-Reptilia 26:353-358.

Reinert, H.K. 1993. Habitat selection in snakes. *In* Snakes-Ecology and Behavior *Edited by* R.A. Seigel and J.T. Collins. 1993. McGraw-Hill Inc. New York. pp. 201-233.

Rossman, D.A., Ford, N.B., and Seigel, R.A. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press. Norman, Oklahoma.

Shine, R., Elphik, M.J., Harlow, P.S., Moore, I.T., LeMaster, M.P., and Mason, R.T. 2001. Movements, mating, and dispersal of red-sided gartersnakes (*Thamnophis sirtalis parietalis*) from a communal den in Manitoba. Copeia 2000(1):82-91.

Smith, D.E. 2002. Geomagnetic sensitivity and orientation in eastern garter snakes (*Thamnophis sirtalis*). Unpubl. PhD dissertation. University of Rhode Island.

Webb, J.K., and Shine, R. 1997. Out on limb: Conservation implications of tree-hollow use by a threatened snake species (*Hypolocephalus bungaroides*: Serpentes, Elapidae). Biological Conservation 81:(21-33).

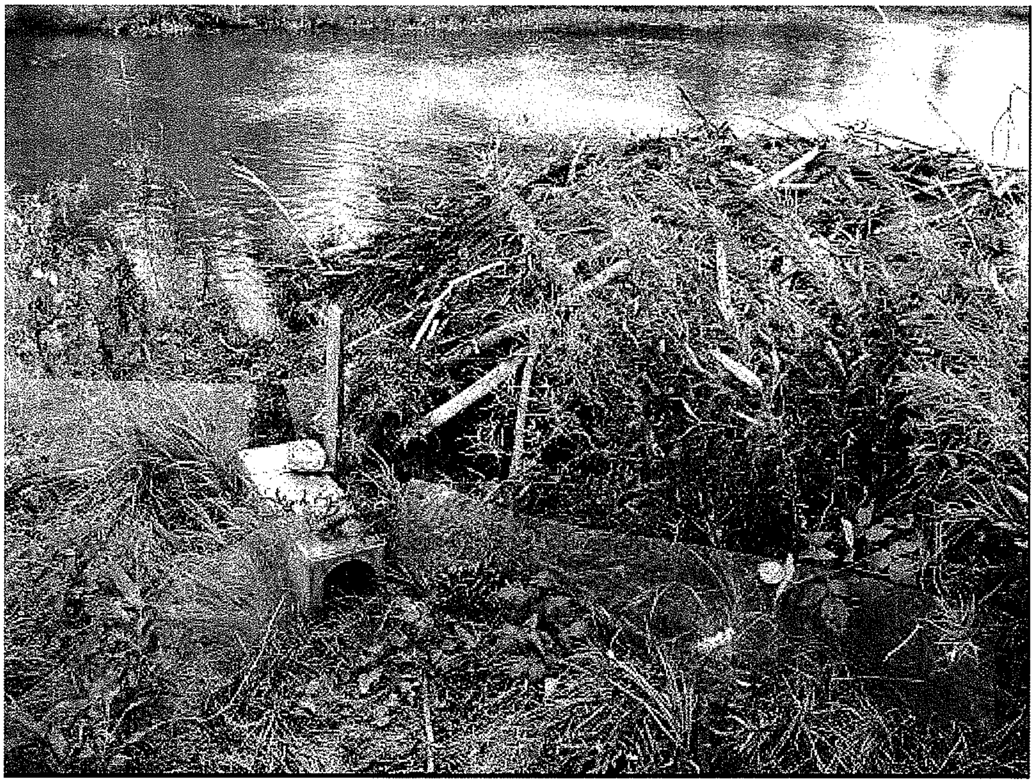


Figure 4.1 Funnel trap with galvanized steel fencing used to intercept common garter snakes (*T. sirtalis*).

Figure 4.2 A snake cautiously emerging from the single opening of the Kiskitto Lake Den.

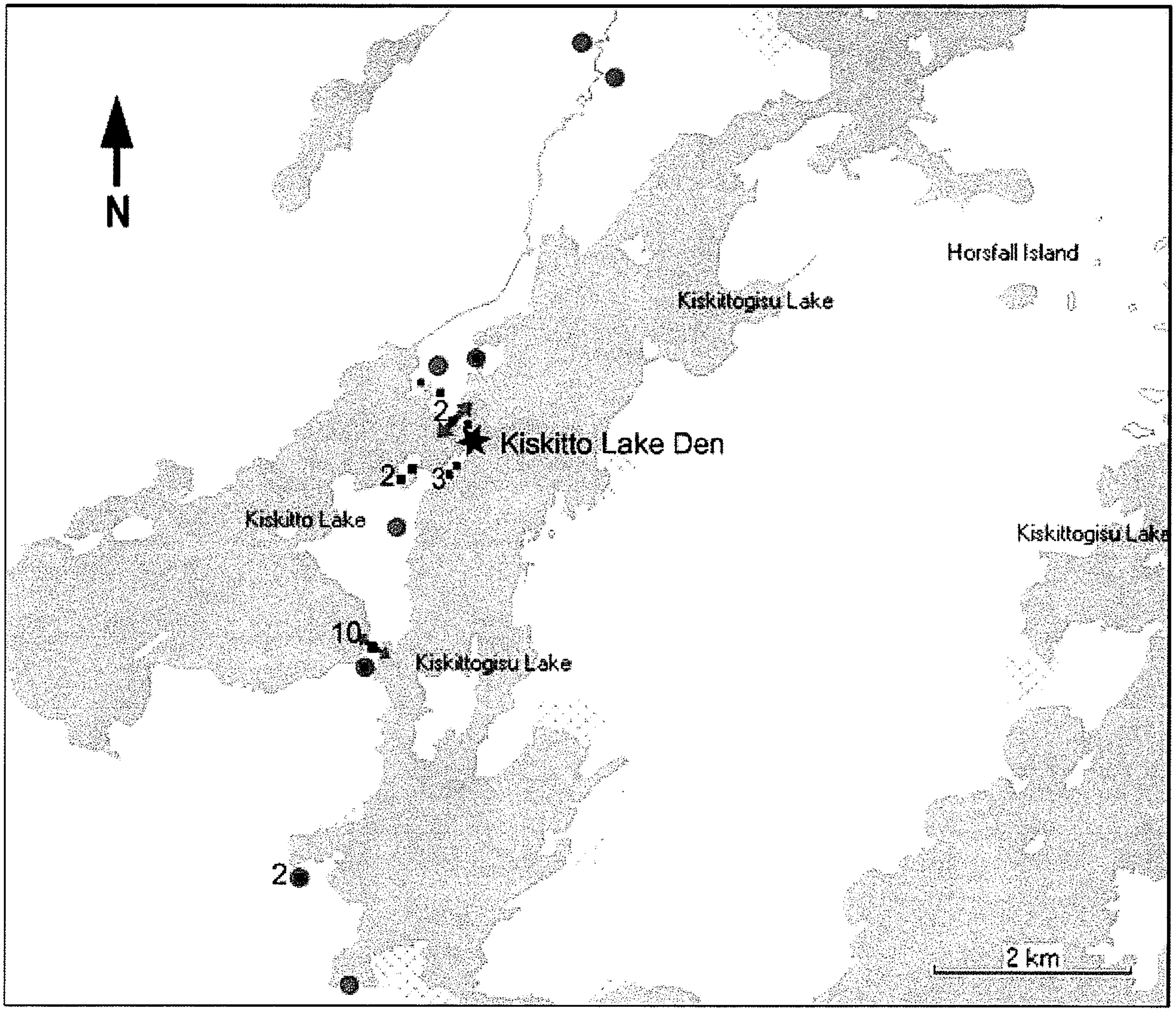
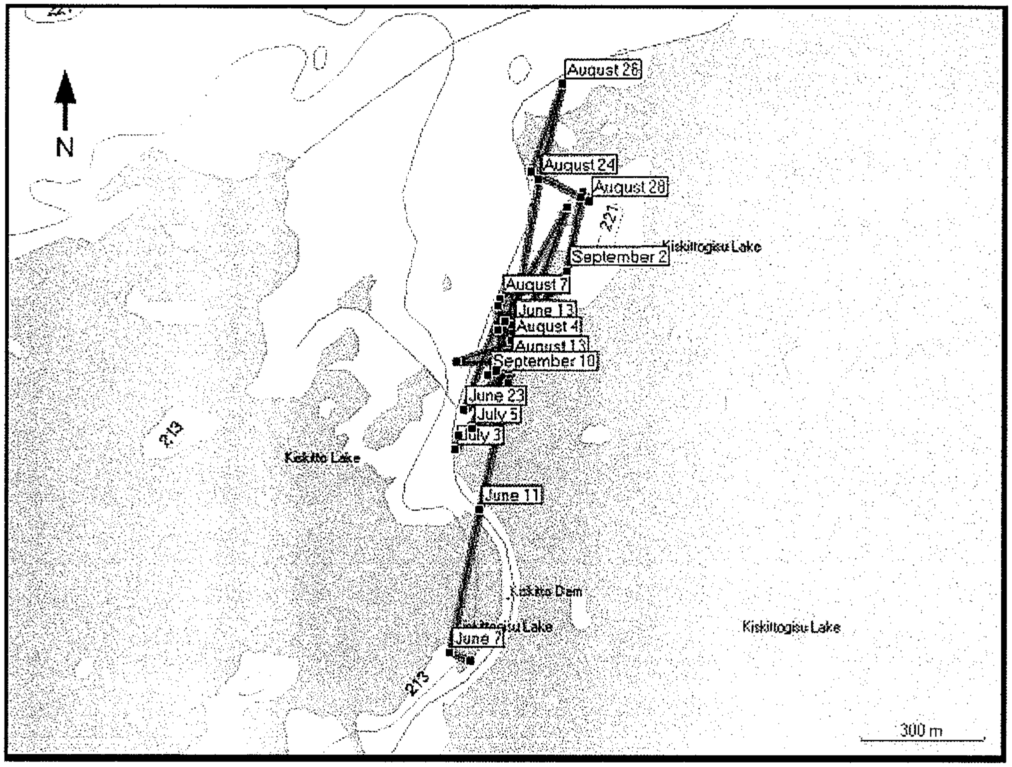


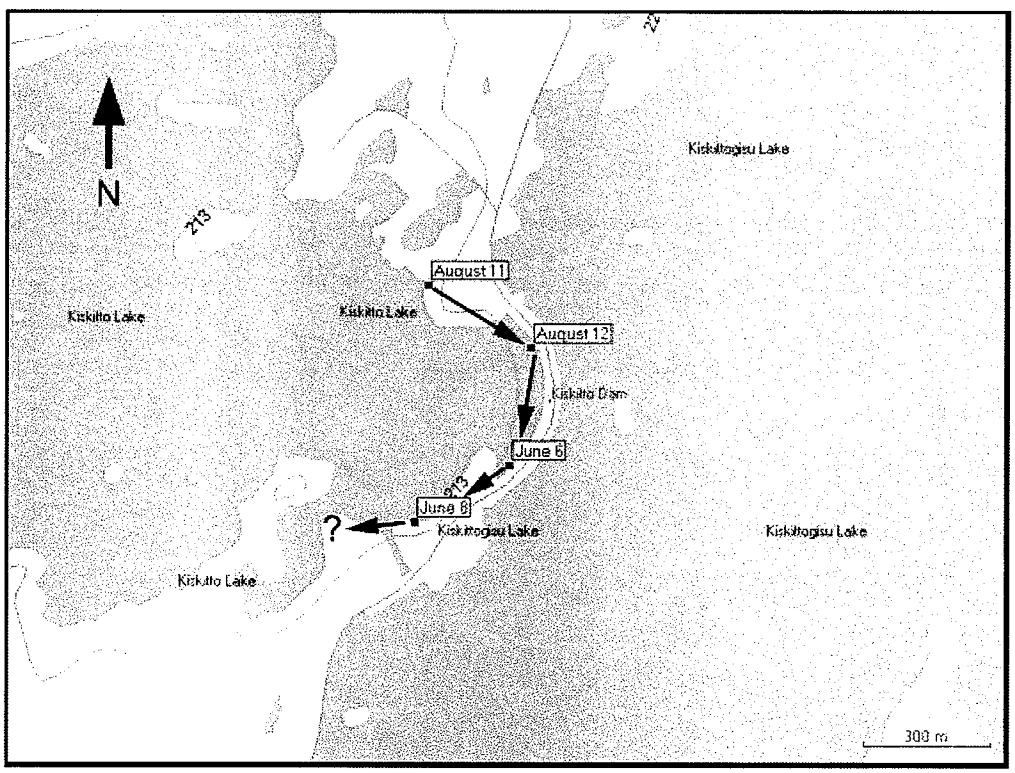
Figure 4.3 Map of the study area around Kiskitto Lake, demonstrating where snakes were recaptured in relation to the Kiskitto Lake Den site. Red dots represent trapping locations, black dots represent recapture locations (with an adjacent number if more than one recapture was made) and red arrows represent long lines of drift fencing and traps extending from Kiskitto Lake to Kiskittogisu Lake.

Table 4-1 Data on the movements of five female common garter snakes (*Thamnophis sirtalis*) from Jenpeg, Manitoba.

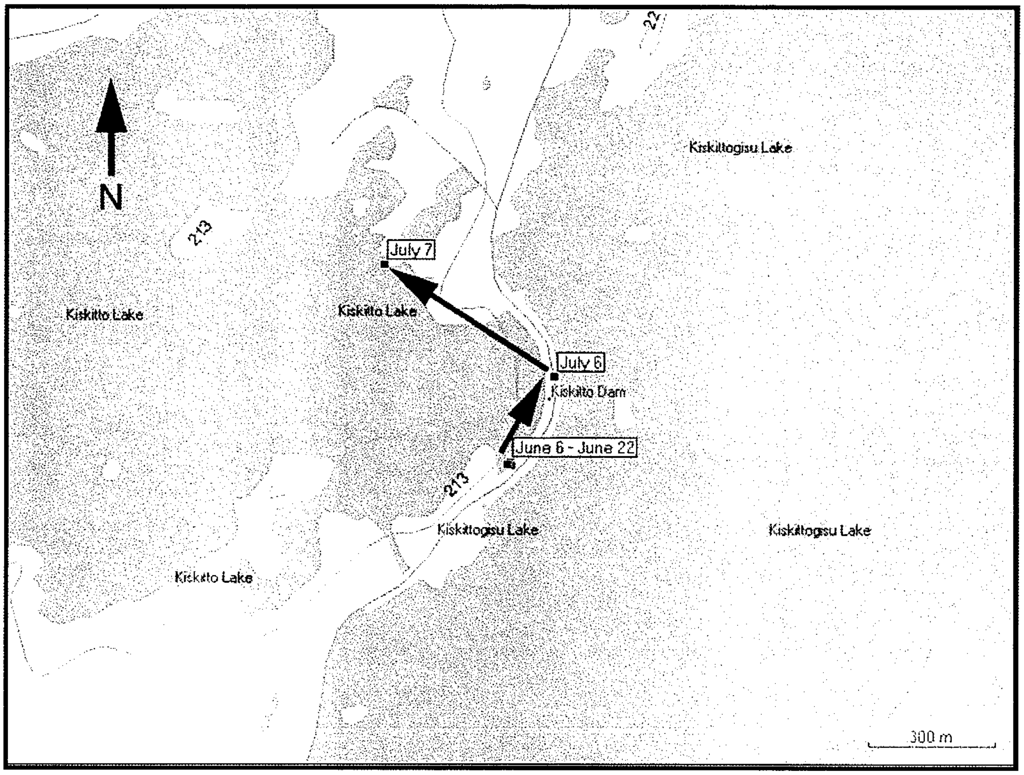
	Number of days tracked	Tracked daily movement (total) (m)	Overall Movement Rate/day (m)	Actual Movement Rate/day (m)	Percentage of days spent moving	Furthest distance tracked from den (m)	Activity range (km^2)	Survival
Snake #1 570	101	5710	93±122	119±126	79%	1432	1.2	Death by small mammal?
Snake #2 640	5	845	211±141	282±13	26% (N/A)	480	N/A	Yes
Snake #3 609	19	756	121±40	213±151	100%(N/A)	575	N/A	Death by small mammal?
Snake #4 509	2	1035	518±204	518±204	100%(N/A)	671	N/A	Yes
Snake #5 490	5	9	1.5±4	9	20% (N/A)	9	N/A	Death by small mammal or birds



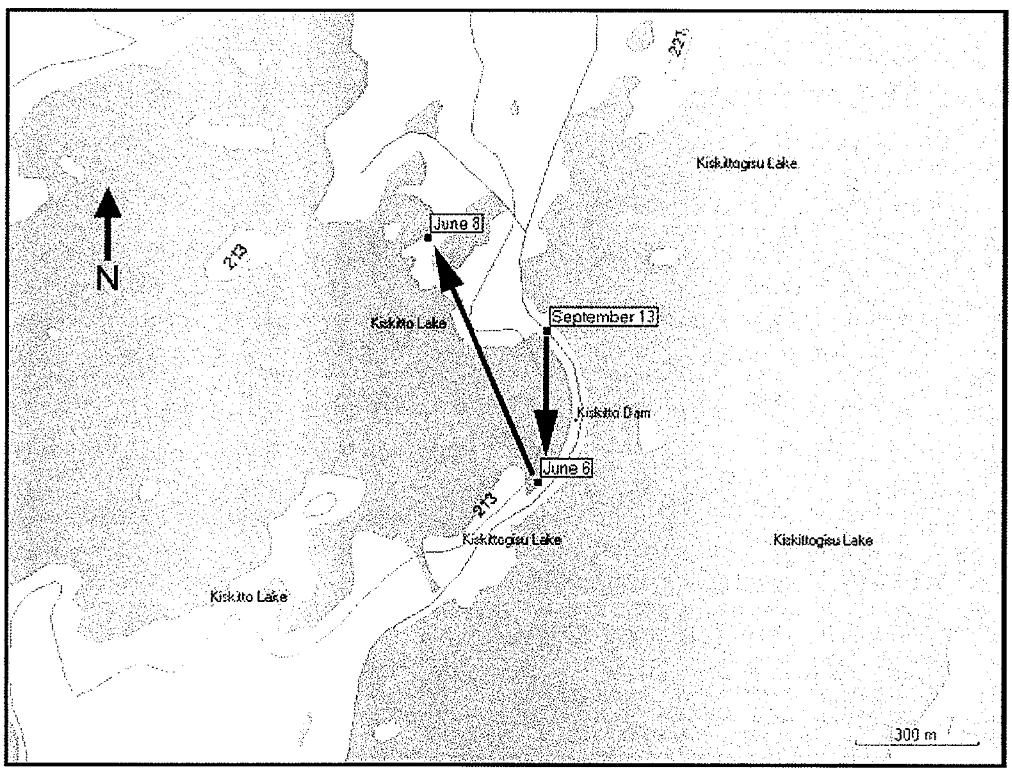
a) Snake #1



b) Snake #2



c) Snake #3



d) Snake #4

Figure 4.4 Movements of four snakes tracked with radiotelemetry around the Kiskitto Lake Den.

Table 4-2 Frequency of snake captures and average soil temperatures at twelve funnel trap sampling stations located in wetland areas associated with beaver (*Castor canadensis*) activity. Trap A was stationed directly beside the beaver lodge. Trap B was stationed near open water at a randomly determined distance from Trap A (minimum 20 m, average 29 m).

Station	Trap A	Trap B	Average Temp °C	SD	DF	Test Statistic	P-Value
1	18		17.0	3.5	54	-0.11	>0.25
		11	17.1	3.7			
2	9		16.8	4.1	70	1.46	>0.05
		11	15.8	3.6			
3	18		16.5	4.1	66	0.73	>0.25
		19	16.0	4.1			
4	4		15.6	3.0	66	1.49	>0.05
		0	14.8	3.0			
5	2		15.4	3.3	65	0.73	>0.20
		1	15.0	3.2			
6	4		16.4	4.3	59	-0.07	>0.25
		5	16.5	4.7			
7	6		15.2	3.2	53	-0.71	>0.20
		10	15.7	3.5			
8	4		15.7	3.9	56	0.90	>0.15
		2	15.0	3.7			
9	5		14.0	3.4	52	-0.08	>0.20
		4	14.0	3.0			
10	1		14.3	3.0	47	0.01	>0.25
		0	14.3	2.6			
11	0		15.9	3.9	45	0.27	>0.25
		1	15.7	4.1			
12	1		16.1	2.0	23	0.87	>0.25
		6	15.6	2.1			
Total	72	70					

Table 4-3 Comparisons of environmental conditions between beaver lodges (Trap A) and a nearby terrestrial control location (Trap B) (minimum 30 meters from lodge) using a paired t-test. Data were recorded daily at 10 minute intervals from 08:00 to 20:00. Site #3 suffered technical difficulties and only received nine days of data.

Source		Average Surface Temperature °C	SD	DF	Test Statistic	P-Value	Average Light Intensity (Lux)	SD	DF	Test Statistic	P-Value
Site #1	Trap A (days=78)	22.87	6.85	77	6.96	<0.05	49552	26489	77	14.02	<0.05
	Trap B	16.57	4.11				7048	3906			
Site #2	Trap A (days=79)	29.95	9.19	78	9.30	<0.05	78196	36775	78	15.50	<0.05
	Trap B	18.94	5.11				13116	6308			
Site #3	Trap A (days=9)	13.68	5.38	8	1.55	>0.05	20998	7348	8	-0.75	>0.05
	Trap B	18.68	8.03				26012	18534			

CHAPTER 5

GROWTH ANALYSIS OF THE COMMON GARTER SNAKE FROM THE NORTHERN LIMIT OF ITS RANGE IN MANITOBA

ABSTRACT

Growth rates of animals are often a reflection of the quality of their environment. Snakes are influenced by thermal dynamics, prey availability, and predation pressure. I studied the common garter snake (*Thamnophis sirtalis*) in northern Manitoba from May 2005 through September 2006 to determine their annual life-cycle and growth rates. I measured snout-vent length (SVL), total length, and mass of snakes and recorded sex, approximate age class, and body condition. Thirty-one individuals (14 male, 17 female) were recaptured after complete active seasons. It was found that female adult snakes from Jenpeg grow less during an active season than snakes from Inwood, MB and Kansas, but slightly more than snakes from Wood Buffalo, Alberta. Male snakes from Jenpeg also grow less in an active season than snakes from Kansas, but faster than snakes from Inwood, MB and Wood Buffalo, Alberta. Northern Manitoba also possessed many examples of extreme gigantism, including some of the longest common garter snakes ever recorded. These findings indicate that northern Manitoba has suitable habitat for common garter snake populations, but does pose some challenges when compared to southern locations. The longer length of the hibernating period in northern climates may select for larger snakes, and may be driving the expression of gigantism.

5.1 INTRODUCTION

Growth rates in reptiles are controlled by a number of factors including habitat quality, food availability, and predation pressure (Gibbons 1967, Sinervo and Adolph 1989, Placyk and Burghardt 2005). Within a species, the factors responsible for varying growth rates across a wide geographic range can indicate how well it is adapted to certain environments. Common garter snakes (*Thamnophis sirtalis*) are the most wide-ranging reptile in North America, and may potentially provide a good model for understanding how growth rates are controlled by various circumstances. Conditions such as hibernation period, seasonal anorexia, and competition can affect outcomes such as growth, gigantism and sexual dimorphism (O'Donnell et al. 2004, Shine 1993, Aleksiuk and Stewart 1977).

The purpose of this research was to determine morphological condition (snout-vent length and mass) of common garter snakes in northern Manitoba and to compare these findings to other populations in Manitoba and elsewhere.

5.2 METHODS

Weight to length relationships were plotted for both male and female snakes. Linear regression analysis was conducted by using log-to-log transformations. Zar's (1999) methodology (at a rejection level of alpha=0.05) was used to test for differences between slopes and intercepts.

Growth rates were determined by examining length increases in recaptured snakes. As noted by Larsen (1986), length is a more reliable representation of growth than weight. Recent meals, hydration levels, and reproductive condition can cause short-term variation in weight. Growth measurements were only used from snakes recaptured after a complete active season.

The total mass snakes' lost over the wintering period was used to evaluate the energy requirements and physical stress of hibernation. Snakes were caught and weighed before hibernation, and then recaptured and weighed soon after emergence.

Juvenile and neonate snakes were rarely recaptured. This limitation is also described by Larsen (1986) and Gregory (1977). It is unsafe to assume that growth rates of immature snakes are equivalent to adults (Rossman et al. 1996); therefore, growth analysis was confined to adults using Walford plots (Ricker 1975). Based on the results of Fitch (1965), female snakes were considered sexually mature at 504 mm, and male snakes were considered sexually mature at 387 mm. The length of a snake in autumn (SVL t+1) was plotted as a function of its length in the spring (SVL t). The predicted asymptotic size was derived from the intersection of (SVLt)=(SVLt+1). Zar's method (1999) (rejection level alpha=0.05) was used to compare slopes and intercepts between locations and sexes.

5.3 RESULTS

The best-fit equations describing the exponential weight-length relationships of all the snakes captured near Jenpeg (Figure 5.1) were (LOG WT)= 2.7081(LOG SVL)-5.6838 (r^2=.975) for males (n=194) and (LOG WT) = 2.9467(LOG SVL) – 6.2603 (r^2=.9745) for females (n=233), where LOG = natural log, WT = weight (grams), and SVL (mm). Significant differences existed between the slopes (t=2.5618, df=423, $P<0.01$), and therefore further analysis of intercepts was not necessary (Zar 1999).

The small total sample size of recaptured males (n=14) and females (n=17) did not allow for a comparison of growth rates between years. Therefore recapture data from 2005 and 2006 were pooled. The best-fit equations for these relationships were SVL (t+1)=0.5513 SVL+421.4

for females, and SVL (t+1)=0.499 SVL + 324.15 for males (Figure 5.2). Significant differences existed between the slopes of males and females ($t=3.53225$, $df=27$, $P<0.001$).

Twenty-four snakes were weighed directly before hibernation and then again soon after emergence. On average, snakes lost, 8.0% (s.d. 8.0%) of their mass.

Examples of extremely fast growth rates include a young non-gravid female originally weighing 5 grams (260 mm SVL) on June 23, 2006, that subsequently measured 47 grams (465 mm SVL) on August 4, 2006. A second example is of young female originally weighing 25 grams (460 mm SVL) on May 17, which subsequently measured 117 grams (680 mm SVL) on August 30. The largest specimen captured was a 1060 mm SVL (1340 mm total length, 435 grams) female captured on May 5, 2006 at the Kiskitto Lake den. This snake is the second largest common garter snake ever recorded, the largest being captured in Ontario (Froom 1972).

5.4 DISCUSSION

The ideal technique for measuring growth rates is to make multiple recaptures of individual snakes over extended periods of time. This method is more accurate than evaluating changes in overall population size and structure (Rossman et al. 1996). Gregory (1977) and Larsen (1986) both point out the difficulty in comparing growth rates of *Thamnophis sirtalis* from different parts of their range. Snakes from northern populations (i.e. Jenpeg, Inwood, Wood Buffalo) overwinter in communal dens and have clearly defined active seasons, which allow for comparable growth stages. Southern populations of *Thamnophis sirtalis* have less defined growing periods, so data extrapolations are required for comparisons with northern populations. Larsen (1986) emphasized that short-term studies provide only a brief snapshot of the growth rates within a population. Any comparisons across time and space need to be interpreted with a certain degree of scepticism. Table 5.1 compares the results of Walford plots (based on several years of growth) for snakes from Jenpeg, Inwood, and Wood Buffalo National Park, to snakes from Kansas. This table was originally produced in Larsen (1986) and now includes a fourth layer of information. Larsen notes that data from Kansas are likely not as accurate due to the extrapolations required to predict one-season intervals. Nonetheless, Figure 5.3 does show that female adult snakes from Jenpeg will grow less during an active season than snakes from Inwood and Kansas, but slightly more than snakes from Wood Buffalo. Male snakes from Jenpeg will also grow less in an active season than snakes from Kansas, but faster than snakes from Inwood and Wood Buffalo. The predicted asymptotic size and mean size of female snakes from Jenpeg are significantly higher than any other population. Male snakes, however, are comparable to other populations.

Snakes are expected to lose weight during the hibernation period. Stored energy and water are slowly used to maintain basic bodily functions during the winter months. Aleksiuk and Stewart (1971) identified that seasonal aphagia and low winter temperatures are the most important factors causing seasonal changes in body condition. Snakes emerging from the Kiskitto Lake den only lost an average of 8% of their body weight (8% s.d.) over the 2005 and 2006 hibernating period. Some snakes even appeared to maintain their weight. Of course, this calculation does not account for the rate of over-wintering mortality. Gregory (1977) found that between a third and one half of the snakes at Inwood dens could die over the hibernating period.

The Jenpeg region contains some of the largest common garter snakes ever recorded in North America. Three individuals were captured that exceeded the longest recorded red-sided garter snake (*Thamnophis sirtalis parietalis* -124.1 cm total length) published in Conant and Collins (1991). The tail tip of one large female (102.0 cm SVL – 127.5 cm total length) was analyzed by Heather Waye (Waye 1996) to determine her approximate age. Although the evidence was not conclusive, it appeared that this individual was approximately 10 to 12 years old. The largest recorded common garter snake (*Thamnophis sirtalis*) is noted in Froom (1972). Its apparent length was 54 inches (137.1 cm) and was found in southern Ontario.

Common garter snakes from the Jenpeg population grow longer, on average than common garter snake populations further south. This trend is appears to conform to Bergmann's Rule, which states that closely related endothermic animals tend to be larger in colder environments than those in warmer environments (Mayr 1956). Larsen (1986) also observed giant common garter snakes in northern Alberta, and considered the following as contributing factors:

1. Adults may live, on average, longer in the North.
2. A basking reptile might accrue a thermoregulatory advantage by being larger. (Despite the fact that Bergmann's rule is meant to apply to endotherms).
3. Larger females may be able to produce more or larger offspring, and hence have a reproductive advantage over smaller females. This may be more pronounced in northern population than southern ones.

However, none of these explanations derive much supporting evidence from Larsen's data or mine. Comparisons of Walford plots do not demonstrate that northern populations of garter snakes are capable of growing faster or living longer. There is also little direct evidence that large snakes have a thermoregulatory advantage in a cold northern climate over smaller snakes. Although the reproductive characteristics of Jenpeg snakes were not studied, Larsen et al. (1993) found that snakes from Wood Buffalo had fewer but larger offspring than snakes from southern Manitoba. Fitch (2001) suggests that sexual size dimorphism in *Thamnophis sirtalis* is maintained by diet, where females have developed larger heads, which allow them to feed on larger mammalian prey items to help support developing offspring. Dietary data from Jenpeg and Wood Buffalo does not support this theory in relation to body size gigantism. Only one mouse (*Peromyscus maniculatus*) was palpated from a snake from Wood Buffalo and only one small unidentifiable mouse was palpated from a snake from Jenpeg. Female snakes from Jenpeg rely on invertebrates, fish, and amphibians of various sizes (see chapter on Foraging Ecology).

Ashton (2001a) found that most squamate reptiles attain smaller sizes at high latitudes (60:82). Evidently, *Thamnophis sirtalis* does not follow this trend. He outlined three additional explanations for latitudinal variation in body size for squamate reptiles.

1. Fasting endurance - Larger snakes are better able to survive prolonged periods of food shortage, which occur at higher frequencies in more seasonal and northern climates.
2. Competition - Intense competition results in smaller body sizes, therefore individuals living at higher latitudes benefit from reduced competition.
3. Maintenance of preferred body temperature – Smaller snakes have an increased surface area to volume ratio and therefore absorb heat more rapidly. The greater heat retention capacity of a larger snake would result in the ability to remain active for a greater portion of the day.

A fourth possible explanation may be the lack of predation pressure on extremely northern snakes. As outlined by Placyk and Burghart (2005), snakes living in areas with higher predator abundances tend to have a higher rate of injuries. The list of potential predators (and presumably density of predators) would be presumably be lower in Jenpeg, than for example, Inwood, Manitoba. Since snakes in extremely northern climates have a lower population density across the landscape, they may not be a specific target species for the local predator fauna, and may therefore live longer. The lower density of roads and vehicles in the region around Jenpeg may also mean a lower rate of mortality. Differential predation mortality based on snake size may also play a factor. Once snakes exceed a critical size they become less accessible to predation. These questions require further research and analysis.

The validity of Bergmann's rule (Bergmann 1847) has been extensively debated since its description (*for review see* Angilletta and Sears 2004). Despite many unresolved questions, this rule is still regarded as the best explanation for intraspecific geographic variation in body size for mammals and birds (Ashton 2001a). Some authors have shown that its application extends beyond endotherms, into ectotherms including animals, plants, protists and bacteria (Atkinson 1994, Atkinson and Sibley 1997). These studies show how slower juvenile development in cold limiting environments tends to result in a larger adult body size. Some authors have even argued that larger adult size in cold temperatures (high elevations and latitudes) is a simple result of developmental processes where cells grow larger at lower temperatures (Van Voorhies 1996). Ashton (2000) reviewed the application of Bergmann's rule to squamate reptiles in North America and found that they generally follow the inverse of Bergmann's rule (latitude 60:82, temperature 36:52). In a recent study, Olalla-Tárraga et al. (2006) found that European snakes tended to be smaller at northern latitudes, whereas lizards became larger. Data from North America, however, did not provide any clear latitudinal trends for snakes or lizards. In a detailed case study, Ashton (2001b), reviewed the body size patterns within phylogenetic clades of the wide-ranging Western rattlesnake (*Crotalus viridis*). By using multiple regression analysis, he considered physical and climate variables, including latitude, elevation, precipitation, actual evapotranspiration, wet bulb temperature, and mean annual temperature. His results provided contrasting evidence for the application of Bergmann's rule to squamate reptiles. *C. oreganus* tended to be smaller in seasonal environments with cooler temperatures, whereas *C. viridis* tended to be larger in cooler, seasonal environments. These divergent life-history outcomes between closely related species highlight the plasticity of body size variation in reptiles, and the difficulty in making broad generalizations. Ashton (2001b) did suggest that there may be greater selective advantage for large snakes in northern populations of *C. viridis* because they have substantially longer hibernating periods than northern populations of *C. oreganus*. It is well known that larger snakes have a higher survival rate than smaller snakes during extended periods of hibernation (Gregory 1982). Based on current knowledge, it is clear that the factors contributing to the large body sizes in northern populations of *Thamnophis sirtalis* are complex. Further research is required to test which specific physical or climactic variables might explain northern gigantism in *Thamnophis sirtalis*.

REFERENCES

Ashton, K.G. 2001a. Bergmann's rule and tetrapod vertebrates, with special emphasis on body size variation of the western rattlesnake. Ph.D. Dissertation, University of Colorado, Boulder.

Aleksiuk, A., Stewart, K. 1971. Seasonal changes in the body composition of the Garter Snake (*Thamnophis sirtalis parietalis*) at Northern Latitudes. Ecology 52:485-490.

Ashton, K.G. 2001b. Body size variation among mainland populations of the western rattlesnakes (*Crotalus viridus*). Evolution 52:2523-2533.

Angilletta, M., and Sears, M. 2004. Evolution of thermal reaction norms for growth rate and body size in ectotherms: an introduction to the symposium. Integrative and Comparative Biology 44:401-402.

Atkinson, D. 1994. Temperature and organism size – a biological law for ectotherms? Advances in Ecological Research 25:1–58.

Atkinson, D., and Sibly, R.M. 1997. Why are organisms usually bigger in colder environments? Making sense of a life history puzzle. Trends in Ecology and Evolution 12:235–239.

Bergmann, C. 1847. Über die Verhältnisse der wärmeökonomie der Thiere zu ihrer Grösse. Gottinger Studien 3:595–708.

Conant, R., and Collins, J. 1991. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Houghton Mifflin, Boston, Massachusetts, U.S.A.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. University of Kansas Publications, Museum of Natural History. 15:493-564.

Fitch, H.S. 2001. Further study of the garter snake, *Thamnophis sirtalis*, in Northeastern Kansas. University of Kansas Publications, Museum of Natural History. 19:1-6.

Froom, B. 1972. The Snakes of Canada. McClelland and Stewart, Toronto, Ontario, Canada.

Gibbons, J.W. 1967. Population dynamics and ecology of the painted turtle, *Chrysemys picta*. Ph.D. Thesis. Michigan State University.

Gregory, P.T. 1982. Reptilian hibernation. *In* Biology of the Reptilia *Edited by* C. Gans, and F.H. Pough. Academic Press, New York 13:53-154.

Gregory, P.T. 1977. Life-history parameters of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in an extreme environment, the Interlake Region of Manitoba. National Museum of Canada, Publications in Zoology 13:1-44.

Larsen, K.W. 1986. Ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Unpubl. M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Larsen, K., Gregory, P., and Antoniak, R. 1993. Reproductive ecology of the common garter snake *Thamnophis sirtalis* at the northern limit of its range. American Midland Naturalist 129:336-345.

Mayr, E. 1956. Geographical character gradients and climatic adaptation. Evolution 10:105–108.

O'Donnell, R.P., Shine, R., and Mason, R.T. 2004. Seasonal anorexia in the male red-sided garter snake, *Thamnophis sirtalis parietalis.* Behavioral Ecology and Sociobiology 56(5):413-419.

Olalla-Tárragal, M.Á., Rodriguez, M.Á., and Hawkins, B.A. 2006. Broad-scale patterns of body size in squamate reptiles of Europe and North America. Journal of Biogeography 33:781–793.

Placyk, J., and Burghardt, G. 2005. Geographic variation in the frequency of scarring and tail stubs in eastern garter snakes (*Thamnophis s. sirtalis*). Amphibia-Reptilia 26:353-358.

Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada. 191.

Rossman, D.A., Ford, N.B., and Seigel, R.A. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press. Norman, Oklahoma.

Sinervo, B., and Adolph, S.C. 1989. Thermal sensitivity of growth rate in hatchling *Sceloporus* lizards: environmental, behavioral and genetic aspects. Oecologia 78:411-419.

Shine, R. 1993. Sexual Dimorphism in Snakes. *In* Snakes - Ecology and Behavior. *Edited by* R.A. Seigel and J.T. Collins. McGraw Hill Inc, New York. pp. 49-78.

Voorhies, W. Van. 1996. Bergmann size clines: A simple explanation for their occurrence in ectotherms. Evolution 50:1259-1264.

Waye, H.L. 1996. Age determination of individual garter snakes (*Thamnophis* spp.) using skeletochronology. Unpublished M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Zar, J. 1999. Biostatistical Analysis, 4th Edition. Prentice Hall. Upper Saddle River, New Jersey.

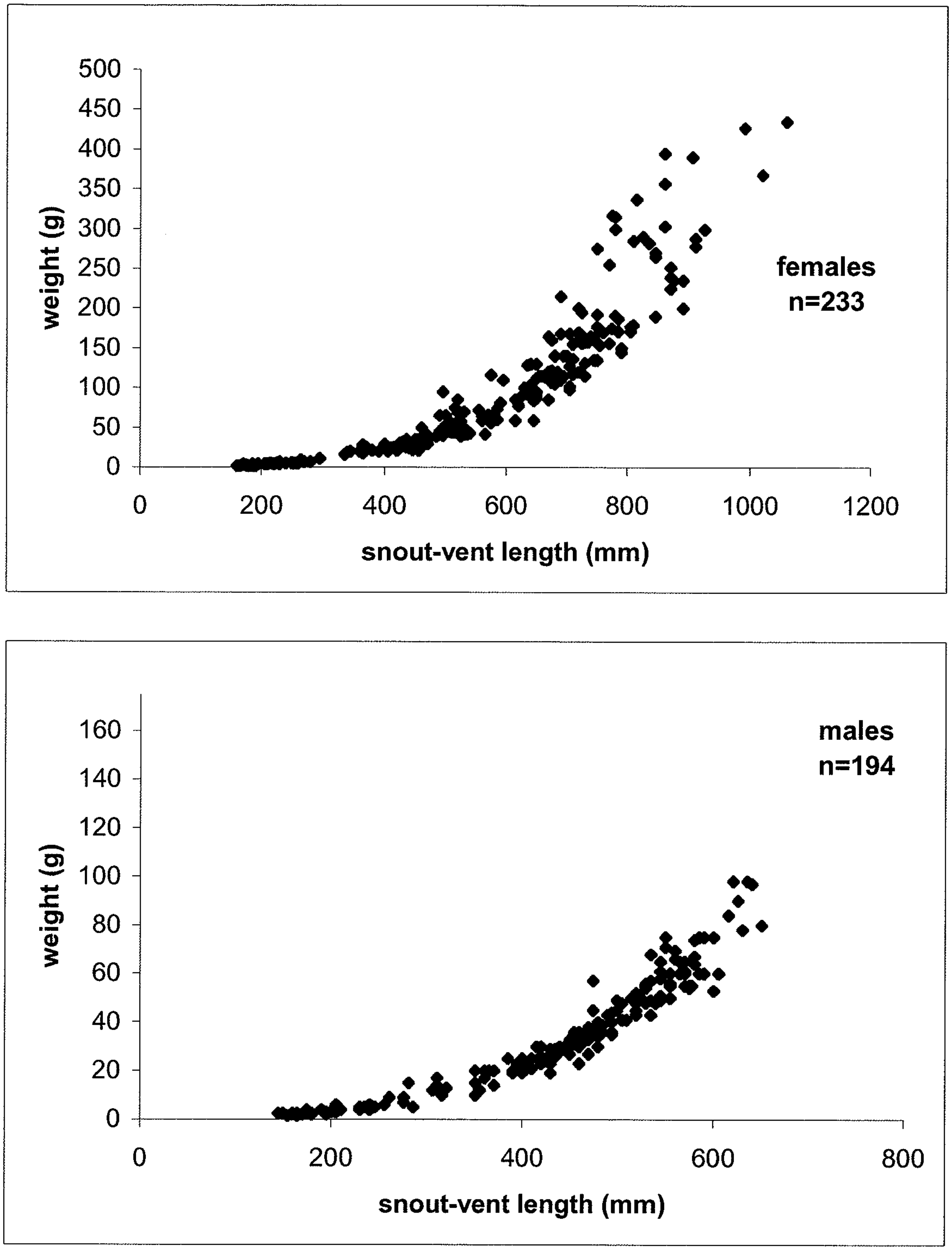
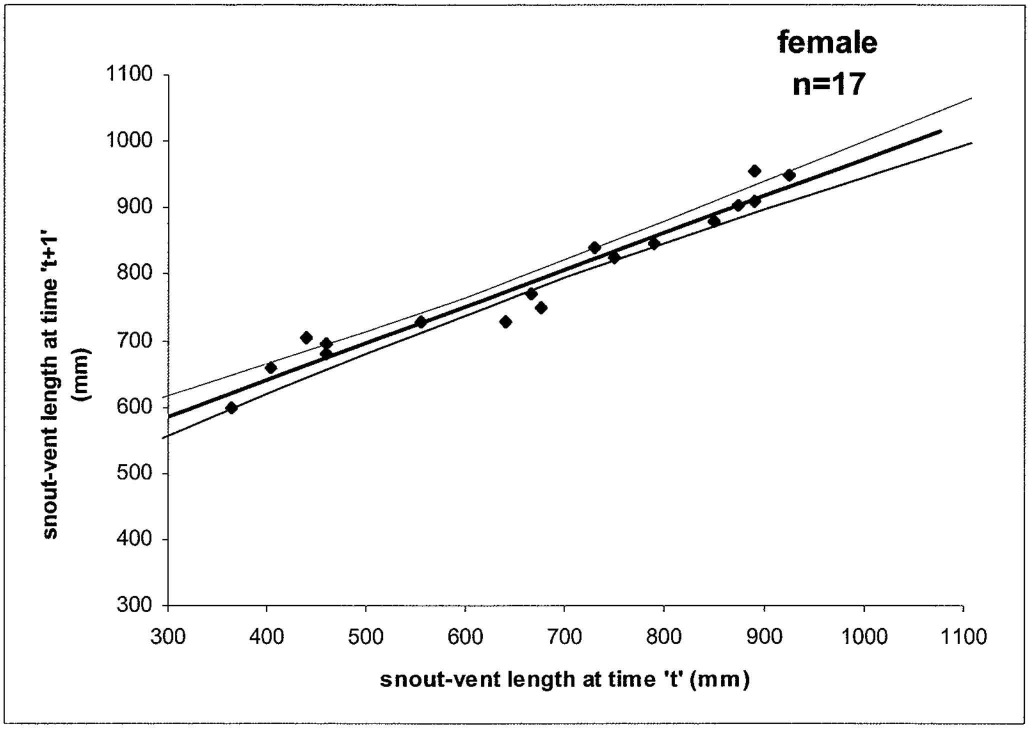


Figure 5.1 Weight-length relationships for female and male *Thamnophis sirtalis* from Jenpeg.



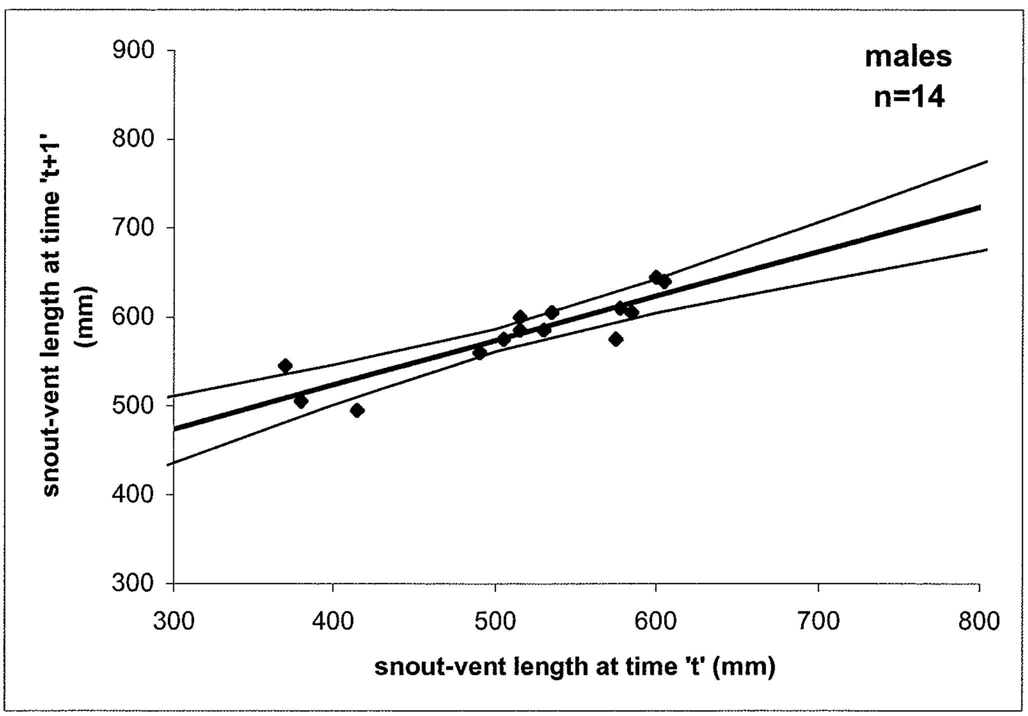


Figure 5.2 Walford plots for *Thamnophis sirtalis* from Jenpeg. Narrow lines represent 95% confidence limits.

Table 5-1 Summary of Walford plots for four populations of *Thamnophis sirtalis.*

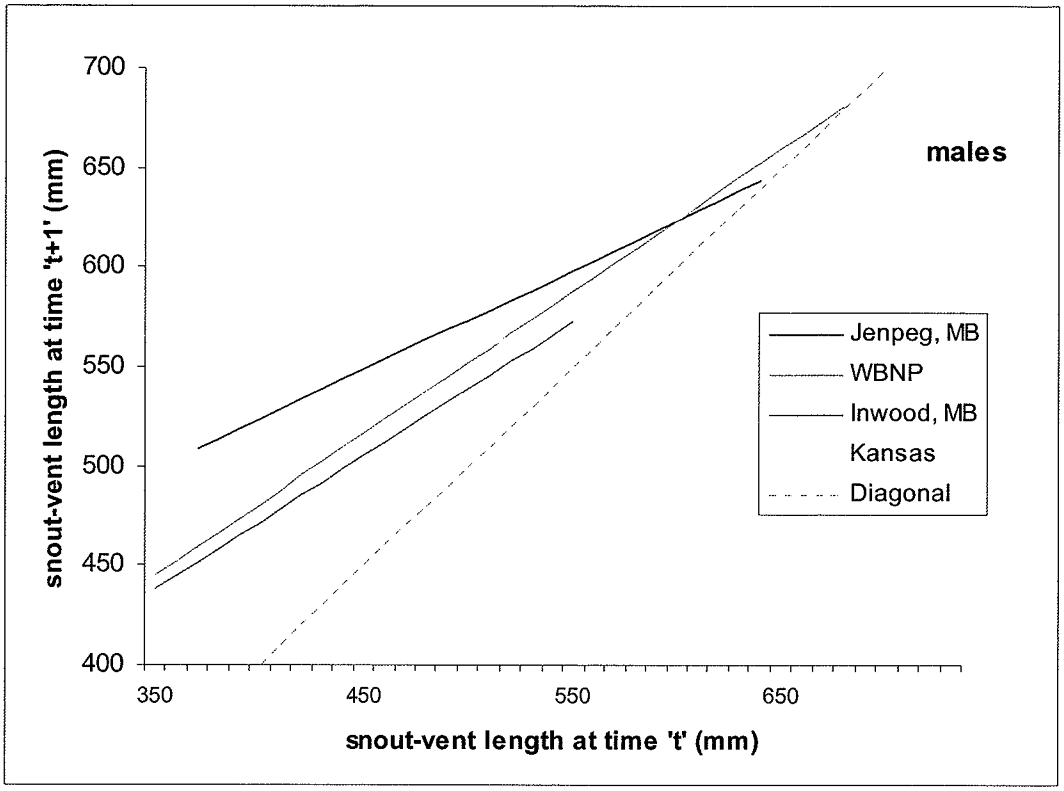
RC= regression coefficient, I=intercept, PAS=predicted asymptotic size, MS=mean size of 10 largest individuals reported in study, r^2=coefficient of determination, and n=size of sample used to generate Walford plot.

	Location	n	RC	I	PAS	MS	r^2
Males	Kansas*	27	0.392	360.77	593	579	0.16
	Inwood, MB**	368	0.672	203.13	619	672	0.72
	Wood Buffalo, AB	188	0.715	194.88	684	715	0.83
	Jenpeg, MB	14	0.499	324.15	647	622	0.7819
Females	Kansas*	46	0.459	473.08	874	895***	0.24
	Inwood, MB**	18	0.53	335.25	713	789	0.62
	Wood Buffalo, AB	21	0.603	331.22	833	913	0.67
	Jenpeg	17	0.5513	421.44	939	938	0.947

*Fitch, unpublished (from Larsen 1986)

**Gregory, unpublished (from Larsen 1986)

***extracted from Fitch (1965) and Fitch (unpublished) (from Larsen 1986)



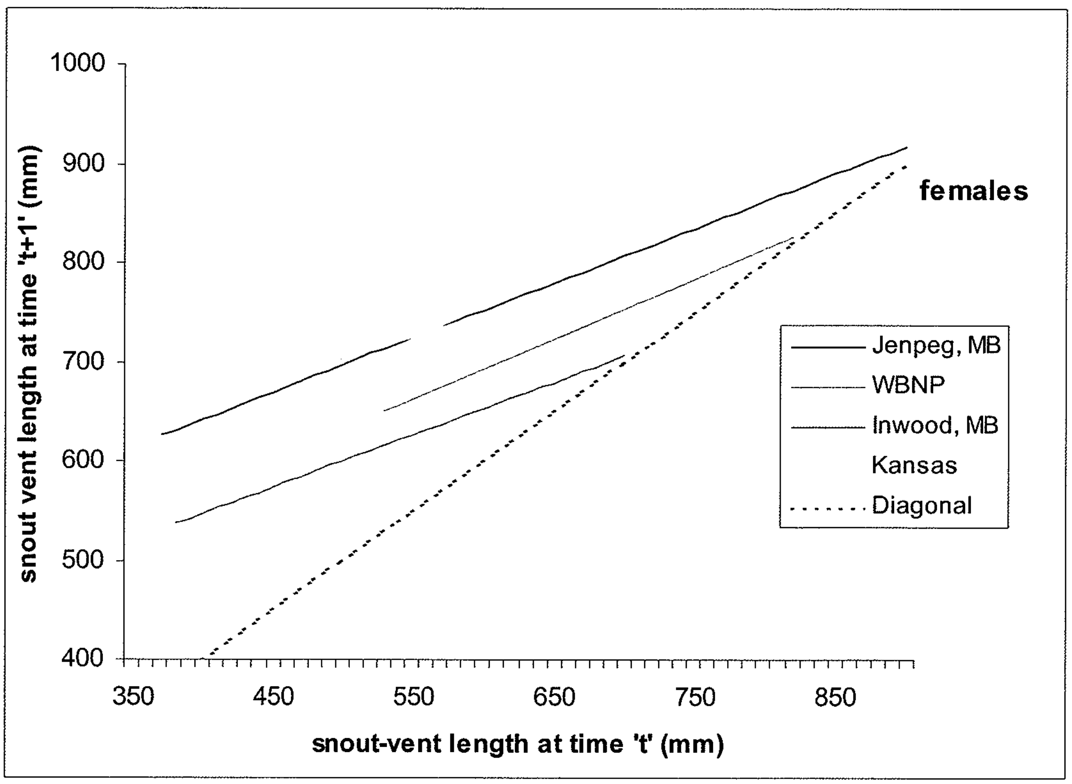


Figure 5.3 Comparison of Walford plots for female and male populations of *Thamnophis sirtalis* at Jenpeg, MB; Kansas, Inwood MB; and Wood Buffalo National Park, AB.

CHAPTER 6

FORAGING ECOLOGY OF THE COMMON GARTER SNAKE IN NORTHERN MANITOBA

ABSTRACT

The study of diet is vital in understanding the fundamental ecology of a snake species. Evaluating this life-history characteristic can provide valuable insights into how populations differ across wide geographic ranges. Common garter snakes (*Thamnophis sirtalis*) make excellent candidates for studies on foraging ecology, because they are highly abundant and can be sampled with minimal harm to the individual. In this study, I palpated the stomachs of 299 common garter snakes from northern Manitoba from the spring of 2005 to the fall of 2006. Of the snakes sampled, 18% contained food items. This figure is similar to other studies across North America. A total of nine categories of prey items were found, with the wood frog (*Lithobates sylvaticus*) being the most common. Mice and earthworms made up only a small portion of food items sampled, which contrasted with studies from southern locations. Large snakes generally ate larger prey items including American toads (*Anaxyrus americanus*) and Leopard frogs (*Lithobates pipiens*). It appeared that food availability was not a limiting factor in the survival of common garter snakes in northern Manitoba.

6.1 INTRODUCTION

The diet of any species is important in understanding its place in the trophic hierarchy (Mushinsky 1987). Studies of diet are often difficult to conduct however because they must be conducted in natural setting, and over long periods of time. It is also vital to minimize disturbance of the natural behaviour of the species of interest. Common garter snakes are valuable in the study of snake foraging ecology because they are highly abundant, harmless, can be studied over their entire active period (in northern latitudes), and can have their stomach palped without any harm (Fitch 1987). By understanding what food sources snakes prey on, it is possible to better understand their fundamental ecology.

6.2 METHODS

Dietary information was obtained through gentle stomach palping of snakes captured in summer and fall. Stomach contents were gently massaged into the oral cavity with the thumb of one hand, while the other hand secured the posterior portion of the snake. Snakes were caught either by hand, or with the aid of drift fencing and funnel traps. Snakes were occasionally palpated in spring, if they displayed obvious signs of stomach contents. Whenever possible, prey items were kept in the oral cavity and palpated back into the stomach after identification. When this was not possible, prey items were identified, weighed and photographed.

6.3 RESULTS

Between June 1 and September 6, 2005 and 2006, 299 snakes were captured. A total of 54 (18%) contained food items in their stomach. The earliest record of a prey item in a snake was a wood frog *(Lithobates sylvaticus)* in a male snake (625 mm SVL) captured at a hibernaculum on April 28, 2007. The latest record was of a small wood frog (<1g) in a neonate female on September 11, 2006. Despite the proximity of the den to food sources, no snakes contained stomach contents upon return to the den in the fall.

Prey items were identified and categorized to species. Prey items that were not easily recognizable to species were identified into broad categories (anuran, fish) and listed as “unidentified”. Wood frogs (*Lithobates sylvaticus*) were the most frequently documented prey item followed by (*Anaxyrus americanus*)(Figure 6.1). Other prey items included leeches, chorus frogs (*Pseudacris maculata*), leopard frogs (*Lithobates pipiens)*, earthworms, and one unidentifiable mouse. No snakes were observed feeding in the field. Most snakes contained only one prey item although five individuals contained multiple prey items (Table 6.1).

Of the twenty-one gravid females sampled, only one contained prey. This individual was captured on June 16, in the early stages of gestation. Five leeches (~five grams) were palpated from her stomach. Although gravid females were not found to contain prey items in the latter stages of gestation, one individual captured on August 9 (soon after parturition) contained an 8.0 gram leopard frog. This coincided closely with the start of the leopard frog migration in early August (personal observation)(Preston 1982).

August 12 was the earliest recorded date of a neonate garter snake containing a prey item. This individual contained a newly metamorphosed wood frog. Nine (of forty one) neonates snakes produced stomach contents in their first summer. A wide variety of prey items were palpated including wood frogs, chorus frogs, American toads, and earthworms. One male neonate, weighing only five grams, regurgitated a two-gram boreal chorus frog.

American toads, leopard frogs, and small mammals provided the best opportunity for a large meal. One large female snake (mass 220 grams) produced a partially digested American toad weighing over 51 grams. The average mass of most prey items was 3.9 grams. Presumably, some mass will have been lost to digestion before I was able to palpate each meal.

The differences in food habits between males and females, and adults and young are shown in Table 6.2. The only occurrence of a mammalian prey item was in the diet of a large female. In contrast, the one example of an earthworm in a diet was from a neonate. Boreal chorus frogs were also only preyed on by young snakes. Wood frogs were clearly a vital food source for all snakes, regardless of size or sex.

Wetlands were abundant in this study region. Wood frogs, boreal chorus frogs, spring peepers, American toads, and leopard frogs could be heard calling throughout the spring. Although no formal estimates of prey abundance were obtained, wood frogs appeared to be the most abundant. They were seen commonly around the margins of ponds, lakes, rivers, and ditches. Newly metamorphed frogs were abundant in mid summer and provided an important food source.

Although chorus frogs and spring peepers were commonly heard throughout the spring, only one spring peeper was ever seen. Their cryptic nature, small size, and nocturnal behaviour made them difficult to locate. Although the spring peeper is apparently at the north-western edge of its range near Jenpeg, it was commonly heard calling from most water bodies. On the evening of May 5, 2006, a chorus of spring peepers was heard calling from the shores of Lake Athapapuskow (UTM14 0344139 6051584). This finding constitutes a north-western range expansion for this species.

American toads began calling in May and were frequently encountered around ponds and sandy shores of the Nelson River. Metamorphosing toads were abundant in July, but surprisingly were not included in the diet of sampled snakes. Leopard frogs were not encountered in the study area until the beginning August, when they became increasingly abundant. Large adults and younger frogs aggregated along the shorelines of large water bodies, presumably in advance of the fall hibernation.

Earthworms are not native to northern Manitoba, and were not encountered in the field. However, a sole record of their existence was provided from the stomach of a neonate snake in the summer of 2006. The abundance and distribution of earthworms in this region is unknown.

6.4 DISCUSSION

The feeding habits of *Thamnophis sirtalis* have been studied at numerous locations across North America. The diets of snakes in this population did not differ greatly from other locations. Most studies, however found a higher percentage of prey items in snake stomachs (26%, Carpenter, 1952; 37%, Gregory and Stewart, 1975; 25%, Kephart 1982; 44%, Gregory, 1978; 26%, Larsen, 1986). It is difficult to understand why Jenpeg snakes may have a lower frequency of prey items in their stomach. However, the high capture rate of gravid females and neonates in the traps may have biased the sample toward snakes that fed infrequently or not at all. This rate of sampling also creates some biases in that snakes caught in traps possess a lower probability of having food in their stomaches than snakes caught by hand in the field. Since the snakes diet comprises of soft bodied prey items, food may have been partially or completely digested before I was able to palp them.

The general absence of food in the stomachs of snakes in late summer and fall (return migration) is consistent with studies from southern Manitoba (Gregory and Stewart 1975) and northern Alberta (Larsen 1986). Although food sources were readily available at nearby marshes and lakeshores, snakes seemed preoccupied with return travel and occasional mating behaviour.

The diets of snakes from the Jenpeg region are similar to the diets of snakes from other regions. The composition of snake diets from Jenpeg region was similar to investigations of other *Thamnophis sirtalis* populations. Amphibians were the primary prey source recorded by Fitch (1965), Fitch (2003), Gregory and Stewart (1975), Kephart (1982), and Gregory (1984). All of the other prey items recorded in this study (earthworms, leeches, mice, fish) have been documented elsewhere (Rossman et al. 1996). Earthworms are often a significant source of food for southern populations (Carpenter 1952, Fouquette 1954), but as noted by Larsen (1986), they are not critical for the successful establishment of a population, as has been suggested by other authors (Fitch 1965). The rarity of earthworms in the study, suggests that they are taken opportunistically, if at all, by young snakes, and are not critical for survival or growth. Young birds and eggs were available in the study site but were not represented in snake diets.

The abundance of prey items in this study site was not measured. Based on informal call and foot surveys it appeared that wood frogs and American toads were abundant around the edges of most ponds and rivers. Although prey appeared abundant, the availability of prey cannot be objectively compared to other regions where populations of garter snake have been studied.

Neonates in this study were born in late July and early August. This parturition date is significantly earlier than recorded by Larsen (1986) in northern Alberta. The favourable growing seasons of 2005 and 2006 may have contributed to the health and fecundity of gravid females. An early parturition date may have also offered an advantage to newborn snakes by providing them the opportunity to feed on newly metamorphosed wood frogs, and boreal chorus frogs. Evidence of neonates capturing frogs as large as two grams, demonstrates their ability to swallow large prey items. In fact, one nine gram neonate captured August 23 2006, had tripled its weight in less than four weeks.

The differences in food habits between males and females, and young and adult snakes are consistent with the finding that (generally) larger snakes eat larger prey items (Arnold 1993 *in* Seigel and Collins (1993)). Fitch (2001) demonstrated that large snakes (predominantly females) from his study site in Kansas were more likely than small snakes to feed on large prey items (frogs, toads, and mice). Data from this study site is generally in agreement with the trend that the lower size limit of prey increases with snake size. In other words, large snakes did not consume the small prey items selected by small snakes. Although there appeared to be an abundance of small mammals in this study site (personal observation), they did not provide an important food source, even for the giant snakes within this population. This finding is similar to work conducted by Larsen (1986) in northern Alberta, where only one mouse was recorded from a sample of sixty-five snakes (26% contained food). One possible explanation for the paucity of mammals in the diet of Jenpeg snakes could be that the relative ease in catching abundant, low-risk amphibians outweighs any benefit of attacking a high risk prey such as a mammal.

REFERENCES

Arnold, S.J. 1993. Foraging Theory and Prey-Size-Predator-Size Relations in Snakes. *In* Snakes-Ecology and Behavior. *Edited by* R.A. Seigel and J.T. Collins. McGraw-Hill Inc., New York. pp. 87-115.

Carpenter, C.C. 1952. Comparative ecology of the common garter (*Thamnophis s. sirtalis*) and Butler's garter snake (*Thamnophis butleri*) in mixed populations. Ecological Monographs 22:235-258.

Fitch, H.S. 1987. Collecting and Life-History Techniques. *In* Snakes-Ecology and Evolutionary Biology *Edited by* R.A. Seigel, J.T. Collins, S.S. Novak. MacMillan, New York. pp 143-165.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. University of Kansas Publications, Museum of Natural History. 15:493-564.

Fitch, H.S. 2001. Further study of the garter snake, *Thamnophis sirtalis*, in Northeastern Kansas. Scientific Papers: Natural History Museum: The University of Kansas 19:1-6.

Fouquette, M.J., Jr. 1954. Food competition among four sympatric species of garter snakes, genus *Thamnophis*. Texas Journal of Science 5:172–188.

Gregory, P.T., and Stewart, K.W. 1975. Long-distance dispersal and feeding strategy of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in the Interlake of Manitoba. Canadian Journal of Zoology 53:238-245.

Gregory, P.T. 1978. Feeding habits and diet overlap of three species of garter snakes (*Thamnophis*) on Vancouver Island. Canadian Journal of Zoology 56:1967-1974.

Gregory, P.T. 1984. Habitat, diet, and composition of assemblages of garter snakes (*Thamnophis*) at eight sites on Vancouver Island. Canadian Journal of Zoology 62:2013-2022.

Kephart, D.G., and Arnold, S.J. 1982. Garter Snake Diets in a Fluctuating Environment: A Seven-Year Study. Ecology 63:1232-1236.

Larsen, K.W. 1986. Ecology of the common garter snake, *Thamnophis sirtalis*, at the northern limit of its range. Unpubl. M.Sc. Thesis, University of Victoria. Victoria, British Columbia.

Mushinsky, H.R. 1987. Foraging Ecology. *In* Snakes-Ecology and Evolutionary Biology *Edited by* Seigel, R.A., J.T. Collins, S.S. Novak. MacMillan, New York. pp. 302-334.

Preston, W. 1982. The Amphibians and Reptiles of Manitoba. Manitoba Museum of Man and Nature. Manitoba. 128 pp.

Rossman, D.A., Ford, N.B., and Seigel, R.A. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press. Norman, Oklahoma.

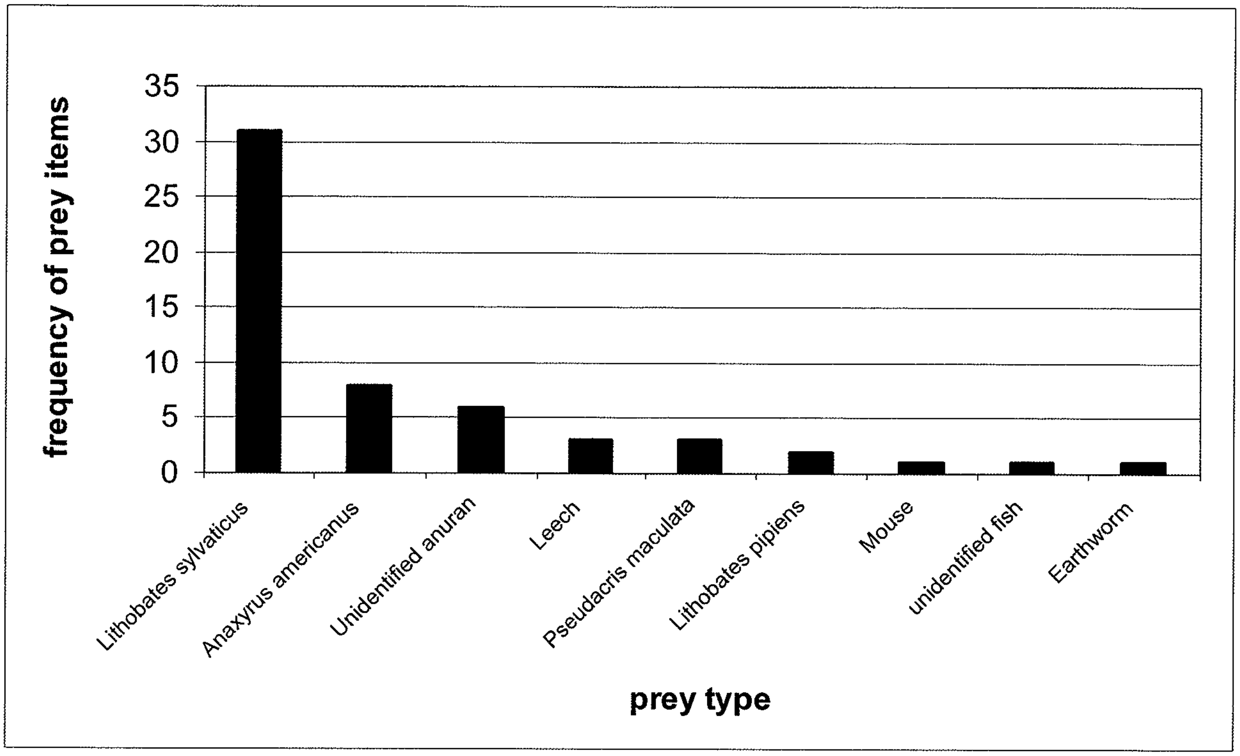


Figure 6.1 Frequency of prey items found in *Thamnophis sirtalis* near Jenpeg (n=54).

Table 6-1 Occurrences of a common garter snake (*Thamnophis sirtalis*) containing more than one individual of a particular prey type.

	Number of prey items		
Type of prey	2	3	5
Leeches			X
Lithobates sylvaticus		X	
Earthworms		X	
Anaxyrus americanus	X		

* plus one snake with a wood frog and unidentified fish.

Table 6-2 Prey eaten by common garter snakes (*Thamnophis sirtalis*) at Jenpeg and sizes of snake predators. In columns of SVL, the first line is the observed range and the second line is the mean ± SE. Measurements in mm.

Kind of Prey	N	SVL of male predator	N	SVL of female predator
Earthworm	-	-	1	190
				-
Mouse	-	-	1	910
				-
Lithobates sylvaticus	11	280-495	20	170-755
		370.5 ± 106.1		500.3 ± 165.6
Anaxyrus americanus	3	205-455	5	230-925
		350.0 ± 129.7		664 ± 264.9
Leech	-	-	2	210-785
		-		497.5 + 406.6
Lithobates pipiens	1	500	1	750
		-		-
Pseudacris maculata	2	260-275	1	240
		267.5 ± 10.6		-
Unidentified anuran	3	315-450	4	400-810
		395.0 ± 70.9		601.3 ± 199.3

CHAPTER 7

COLOURATION PATTERNS OF THE COMMON GARTER SNAKE IN MANITOBA

ABSTRACT

This study reports on the variation and frequency of colour morphs within Manitoba populations of the common garter snake (*Thamnophis sirtalis*). Five distinct colour morphs (three of which are operating on a continuum) are identified and described. Sampling at six denning sites around the province has revealed substantial variation in interscale red pigmentation within discrete populations. In the most northern population (Jenpeg at 54°30 N, 98°03 W) and an island population (George Island, Lake Winnipeg, at 52° 49 N 97° 37 W), all five colour morphs were expressed. The northernmost population also exhibited sexual colour dimorphism, with female snakes expressing significantly more red than males. In contrast, the two central and western populations showed very little variation, with only two of the most similar colour morphs expressed. This study also reports on the existence of erythristic snakes in Manitoba. This bright red colour morph was found in three separate locations around Lake Winnipeg. Melanistic snakes are also reported from three new locations in the province, all widely disjunct from previously identified sites exhibiting melanism found around Lake Winnipegosis (Mason et al. 1991). The evolutionary underpinnings of these phenomena are yet to be fully understood.

7.1 INTRODUCTION

The common garter snake (*Thamnophis sirtalis*) has the most variable dorsal colour pattern of all species within its genus and, as a result, has a long and varied taxonomic history, with the recognition of numerous subspecies (Rossman et al. 1996). The body of work on geographically consistent forms is significant (Cope 1900, Ruthven 1908, Fitch 1941) and eleven subspecies continue to be generally recognized based on colour (Rossman et al. 1996, Janzen et al. 2002).

Colour variation in discrete populations of *Thamnophis sirtalis* has been documented in several parts of its range. Melanistic populations in Ontario have been studied extensively (King 1988, Bittner et al. 2002, Bittner and King 2003). In Kansas red-sided garter snakes (*T. s. parietalis*), Fitch (1965, 2001) documented variation in the amount of red in interscale fold, from all red to no red, surprising variation for a character used to define the subspecies. In a lesser-known work, Carpenter (1954) found similar variation in Michigan populations of eastern garter snake (*T. s. sirtalis*), with almost 60% of the individuals exhibiting at least some red interscale colour. Bleakney (1959) reported that individuals from around Montreal in southern Quebec and near Abitibi and James Bay in north-eastern Ontario have orange or red lateral and dorsal stripes. Blais (1997) described extreme erythrism in a small percentage of individuals in scattered populations of southern Quebec and adjacent upstate New York where lateral stripes, vertebral stripe on the neck, ventral scales, and labial scales were bright red. This intrapopulation variation has received only cursory attention in most accounts (e.g. Cook 1984) or none at all (Rossman et al. 1996).

Manitoba is home to perhaps the largest populations of *Thamnophis sirtalis,* in Canada. In Manitoba's Interlake region, these snakes have been studied for over thirty years (Gregory 1974, 1977; Gregory and Stewart 1975) and access to large sample sizes has allowed an extensive range of biological research to be conducted (e.g. Mason and Crews 1985, Mason et al. 1989, Shine et al. 2001). Despite the fact that colour is a trait easily recorded in the field, its contribution to understanding the evolutionary process has only recently received any scientific interest in Manitoba, in part because very little variation has been documented in the most studied populations. Shine et al. (2004) recorded differences in the proportion of red skin between populations at separate dens in the Interlake region, but variation among individuals at each den site was very low. On islands in Lake Winnipegosis (western Manitoba), a significant number of individuals are either melanistic or lack red or yellow pigmentation on dorsal or lateral stripes (Mason et al. 1991, personal observation). Although little more is known about these Manitoba populations, reproductive isolation has been implicated as a cause for the melanism.

Extreme colour variation was found among and within discrete populations of Manitoban common garter snakes. Proportions of red and non-red individuals varied significantly among sites. Within sites, all examined populations exhibited at least some variation in the amount of red found in interscale folds, and on the lateral stripes, but two populations exhibited a unique and extreme array of variation from no red to bright red, and even melanistic forms. Phenotypic colour evolution in garter snakes is believed to be influenced by selection and drift (Lande 1976). As a result, analysing the phenotypes of distinct populations can offer a good model for advancing our understanding of evolutionary biology (Bittner and King 2003). This study documents and describes the colour morphology of the common garter snake, *Thamnophis sirtalis*, at six locations across Manitoba in anticipation of more detailed evolutionary investigation.

7.2 *METHODS*

Data collection was conducted in 2005 and 2006 in Manitoba, Canada. Berens River, on the eastern shore of Lake Winnipeg at 52° 21' 47.78" N 97° 01' 32.14" W; Clearwater, about 140 km WNW of Lake Winnipeg at 53° 57' 57.90" N 100° 59 01.30" W; George Island, in Lake Winnipeg's north basin about 15 km from the eastern shore at 52° 49' 6.6" N 97° 37' 11.1"W; Inwood, 50° 30' 23" N 97° 29' 44" W; Jenpeg, about 55 km north of Lake Winnipeg at 54° 27' 49.1" N 98° 06' 54.8" W; Big Sandy Island, in Lake Winnipeg's north basin about 30 km from the nearest shore, at 52° 57' 50.85" N 97° 58' 10.28" W.

Snakes were captured by hand during brief sampling expeditions, except at Jenpeg where funnel traps were used for two seasons. Immature snakes were excluded from this analysis to eliminate the influence of ontogenetic change in colour morphology (Fitch 2001, personal observation). At Jenpeg, recaptured snakes were excluded to ensure independent sampling (marked by ventral scale clipping - Brown and Parker 1976); recaptures at other sites were avoided by retaining all captured snakes at the field camp during the sampling period.

Adult snakes were examined for traits that have previously been used to describe colour morphology (Carpenter 1954, Rossman et al. 1996). These included examining the colour pattern of the vertebral stripe, ventral scales, head and chin, lateral stripe, and the interscales on the dorsolateral area (at a point approximately 10 cm posterior from the head). All features were examined for their extent of pigmentation (Figure 7.1). After preliminary analysis, it was decided that only the lateral stripe and interscale colour pattern were relevant for this analysis. Colour pattern was scored on a five-category scale: 0 – no red; 1 – some red as discrete flecks on lateral interscale skin; 2 – significant/prominent red on lateral interscale skin, sometimes extending onto lateral stripe scales; 3 – erythristic morph, high red expression, with red lateral interscales and fully red lateral stripes, and a variably red or orange face, venter and dorsal stripe; 4 – melanistic morph defined as dark colouration with no yellow or red, and with muted, bluish striping (Figures 7.2, 7.3). Category 2 most closely matches the taxonomic description of *Thamnophis sirtalis parietalis* as outlined by Rossman et al. (1996). At Jenpeg, Inwood, and Clearwater, snakes were scored for colour pattern by the author. Data from snakes at George Island, Big Sandy Island, and Berens River was contributed by Randy Mooi (Manitoba Museum) and Gary Casper (Wisconsin Museum) following corroboration on scoring techniques. Colour morphs were documented and photographed at each location.

Pearson $\chi2$ tests were used to test for differences in colour morphs between sexes at each site. When no differences in morph frequency were found, sexes were pooled and $\chi2$ was used to determine whether morph frequencies were independent of site.

7.3 RESULTS

Report of Erythristic and Melanistic Colour Morphs

This study reported on the existence of two atypical colour morphs of the common garter snake in Manitoba. Erythristic snakes (Figure 7.2) were found at three sites around the province. Melanistic snakes (Figure 7.3) were also found at new locations. The individuals expressing these rare colour morphs appear strikingly different from the typical common garter snake (Figure 7.4). Even within these extreme colour morphs, individuals can display a variation in the intensity of their respective red or black colour.

Spatial Variation in Colour Morphs

A total of 547 adult snakes were sampled during the two years of this study. Table 7.1 provides a comparison of the proportion of various colour morphs from six Manitoba populations. Figure 7.5 outlines the geographic locations of the sampling sites.

All populations exhibited at least some variation in the amount of red expressed on lateral interscale skin. Long-term sampling at Jenpeg generated the largest sample size and the widest variation in colour morphs. The majority of snakes from Jenpeg expressed no red colouration (46%) and appeared very similar to the eastern garter snake (*Thamnophis s. sirtalis*). *T.s.parietalis* and *T.s.sirtalis* are known to interbreed in a wide zone across south-eastern Manitoba (Rossman et al. 1996). Although the relevancy of *Thamnophis sirtalis* subspecies has recently come into question (Rye 2000, Janzen et al. 2002), this new information indicates that the zone of intergradation may extend into the north-central portion of Manitoba. Inwood and Clearwater populations expressed the same proportion and variation in red colouration, but both populations were significantly different when tested against Jenpeg. Sampling at George Island, Big Sandy Island and Berens River produced only small sample sizes not testable with $\chi 2$ analysis although the available data did provide valuable insights. Big Sandy Island had only three categories expressed, but this location is represented by an extremely small sample and showed remarkable variation given the number of snakes scored, including some individuals with no red pigment. George Island, Berens River, and Jenpeg all had examples of the erythristic morph at levels of from 5-10% of the population. In addition, George Island and Jenpeg also had melanistic individuals, although in very low numbers, making these populations exceptional in having the full range of recognized variation for the species in Manitoba. Jenpeg is further exceptional in having almost half of its population expressing no red pigment.

Sexual Dimorphism

The sample sizes at Jenpeg, Inwood, and Clearwater were large enough to test for differences in colour morph proportions between sexes. Only the Jenpeg population had a significant difference between males and females (x^2=24.17, df=3, P<0.0025). Females expressed significantly more red than males. The sexes were pooled for the populations from Clearwater and Inwood. A significant difference was not detected in colour morph frequencies between those two populations.

Male and female snakes from Jenpeg were tested against snakes from Clearwater and Inwood. Both sexes of Jenpeg snakes expressed significantly less red than Clearwater snakes (male: x^2=119, df=3, P<0.0005, female: x^2=152, df=3, P<0.0005) and Inwood snakes (male: x^2=169, df=3, P<0.0005, female: x^2=209, df=3, P<0.0005).

7.4 DISCUSSION

This study has described five common garter snake colour morphs and provided proportion frequencies for six discrete locations in Manitoba. This research builds on the only preceding publication on common garter snake colouration in Manitoba (Mason et al. 1991). Analyses presented here indicate that: 1) three common garter snake populations around Lake Winnipeg express erythristic and melanistic colour morphs; 2) colour morph frequencies can be significantly different between populations; 3) a significant percentage of snakes residing to the east and north of Lake Winnipeg do not express any red colouration; 4) sexual colour dimorphism with higher red expression in females occurs in some populations.

This study documents the reports on the occurrence of erythristic common garter snakes in Manitoba. This colour morph has been briefly mentioned in the scientific literature (Bleakney

1959) and received minimal exposure in popular media (Blais 1997) for Ontario, Quebec and New York. Its existence in Manitoba has been recognized by First Nations from Norway House Cree Nation and by local herpetologists (W. Preston, pers. comm. 2006), but has not been reported in the literature. The factors contributing to the evolution of this colour morph are unknown, but as with melanism, may be related to gene flow, random genetic drift, and natural selection (King 2003). A fourth possible explanation relates to diet (Bechtel 1995), but this is unlikely based on the occurrence of erythristic neonates at Jenpeg and Berens River. It is currently unknown whether erythrism is related to melanism, or whether it is inherited as a Mendelian trait. Unlike melanism, no studies have been conducted on the underlying physiology of erythrism (i.e. xanthophores, iridophores). There are also no data on selective mechanisms that might favour erythristic snakes. It seems improbable that any thermal advantage could be accrued or that this colouration could serve as a form of camouflage, as has been suggested for melanism (Bittner et al. 2002). However, Don Hart (1975) found that the colour and heat absorption rate of common garter snakes explained some of the habitat niche differences between that species and the plains garter snake (*Thamnophis radix*). A bright red colouration may serve as a aposematic antipredator mechanism, a function described in some cases of avian predation (Gotmark 1994). Fitch (2001) proposed a link between red colour and aggressive behaviour, although this was in regards to sexual dimorphism of colour frequency – it would seem unlikely that a selective advantage for colour and behaviour in females would not also be an advantage for males. Another possibility is that erythrisitic colouration is correlated (or paired) with a second trait that is not recognizable to researchers; the unrecognized trait would provide an evolutionary benefit while erythrism itself is of no significant value. This has been shown to exist within *Thamnophis ordinoides* in regards to colouration and antipredator displays (Brodie 1992).

Gene flow and random drift provide likely explanations for colour variation. Predation avoidance and heat absorption are considered to be the most likely factors in the maintenance of the "typical" common garter snake colour morph (King 1988). Northern populations of common garter snakes are known to return to traditional denning sites year after year (Gregory 1977, Shine and Mason 2004), with mating often taking place at the den site upon emergence in spring. Such behaviour could, in effect, produce island-like population genetic structure. In mainland populations recruitment of offspring from parents of other den sites likely allows a certain rate of gene swapping, however some populations in this study are truly island populations 20-30 km from the mainland, undoubtedly limiting gene exchange. Populations on less isolated islands in Lake Erie suggest that random genetic drift can influence colour pattern frequencies (Bittner and King 2003). Clearly, further investigation is required to test these hypotheses as explanations for erythrism.

Melanistic garter snakes have been documented at numerous locations around the Great Lakes (Lake Ontario, Lake Michigan, Lake Erie) (King 1988, 2003) and have served as good subjects for studies on garter snake colour variation. Until recently, descriptions of melanism in Manitoba have been restricted to regions around Lake Winnipegosis (Mason et al. 1991). This study reports melanism in populations at Jenpeg and George Island, as well as a third site at Grand Rapids (R. Costello, pers. com., amateur herpetologist, Grand Rapids, MB), confirming that melanism exists across a wide region of Manitoba. Mason et al. (1991) suggested reproductive isolation to explain melanism at Lake Winnipegosis, though studies of gene flow and selection should be undertaken.

Analyses presented here indicate that morph frequencies can differ significantly between populations of the same subspecies. The range of colour variation (from erythrism to melanism) described for two sites in Manitoba, Jenpeg and George Island, has not been previously reported for any single and discrete population of common garter snake anywhere across its range. Other populations, like Clearwater and Inwood, showed strikingly low levels of variation (Table 7.1). Differences in morph frequency were not apparent between Clearwater and Inwood populations, but were significantly different for all populations tested against Jenpeg. Populations from Jenpeg, Clearwater, and Inwood are all separated by considerable distances (>200 kilometres). The underlying cause of spatial variation (or similarity) in morph frequencies is unclear, but is likely the result of a host of factors including gene flow, genetic drift, and selection. Gene flow has been shown to maintain polymorphisms by contributing genetic information that may not be selected for locally. For example, populations of garter snakes on the islands of Lake Erie may be prevented from becoming completely melanistic because of genetic mixing with typical coloured garter snakes from the mainland. (Bittner and King 2003). The rate of gene flow between Manitoba garter snake populations is not known. Studies of garter snakes from Lake Erie show that water barriers and long distances do not impede high rates of gene flow (King 1988, Lawson and King 1996), but that nonetheless natural selection does act on colour pattern (Bittner and King 2003). Detailed phylogeographic work by Janzen et al. (2002) further shows that local evolutionary forces play a significant role in shaping morphological variation. Manitoba populations of *T. s. parietalis* seem to support this contention because of the varied frequencies and occurrences of colour morphs from one locality to another. Michigan populations of *T. s. sirtalis* also exhibit significant differences in colour morph frequencies even between relatively proximate localities (Carpenter 1954). Reports of erythristic and less redpigmented morphs of *T. s. sirtalis* in eastern Ontario (Bleakney 1959) and western Quebec (Blais 1997) also imply that local factors are driving colouration in these snakes.

Small populations are at increased risk of inbreeding depression (Madsen et al. 1996) and the affects of random genetic drift (Bittner and King 2003, King 1988). The small population size at Jenpeg, George Island may be coupled with a low rate of gene flow, which is resulting in a wider rate of morph frequencies than is observed at larger and more southern populations. This hypothesis requires detailed genetic analysis.

The role of selection in adaptive evolution (including colour morphology) is a valuable area of study. Selective pressure on squamate colour is believed to relate to two factors: 1. substrate colour and, 2. differing thermal environments (Rosenblum et al. 2004). Diurnal snakes are typically under selection from visual predators and so are pressured to match the surrounding substrate colour. In some populations, snakes are thought to be under thermal selection. In these situations, individuals with dark colouration may be better equipped to absorb solar energy and therefore have a higher rate of survival and reproduction (Bittner et al. 2002). Shine et al. (2000) described that only when harassed or provoked did common garter snakes flatten their body to display their bright red lateral patches. He noted that overlapping scales normally hide these blotches, and that the evolution of this colouration suggests, "that antipredator displays may have been a target of significant selection in this species" (p. 240).

The existence of sexual colour dimorphism in Jenpeg is notable. Fitch (2001) described a similar occurrence in *T. s. parietalis* from Kansas. He suggested that females have evolved a higher expression of red than males because they are larger, and more likely to show an aggressive display when provoked. He noted that males are more apt to take flight and are therefore better served by a less colourful appearance. The snake population from Jenpeg may be operating under this selective regime, but there is no evidence that populations from other parts of Manitoba express any significant gender-based colour differences. The Inwood and Clearwater populations each had 100% red expression and exhibited no sexual dimorphism. Shine et al. (2004) also reports essentially identical red coloration of males and females at Inwood, as well as no gender colour differences at two other sites, The Narrows and Vogar, in southern Manitoba. One would expect that these populations would share similar selection for antipredator responses. Addressing this evolutionary question requires larger sample sizes and further testing of selective pressures.

REFERENCES

Bechtel, H.B. 1995. Reptile and Amphibian Variants: Colors, Patterns, and Scales. Krieger Publishing Company, Malabar, Florida, U.S.A.

Benton, M.J. 1980. Geographic variation in the garter snakes (*Thamnophis sirtalis*) of the north-central United States, a multivariate study. Zoological Journal of the Linnean Society 68: 307-323.

Bittner, T.D. and King, R.B. 2003. Gene flow and melanism in garter snakes revisited: a comparison of molecular markers and island vs. coalescent models. Biological Journal of the Linnean Society 79:389–399.

Bittner, T.D., King, R.B., and Kerfin, J.M. 2002. Effects of body size and melanism on the thermal biology of garter snakes (*Thamnophis sirtalis*). Copeia 2002 (2):477-482.

Blais, P. 1997. Flame garters: a variation on an old theme. The Vivarium 9(6):10-29.

Bleakney, S. 1959. *Thamnophis sirtalis sirtalis* (Linnaeus) in eastern Canada, a redescription of *T. s. pallidula* Allen. Copeia 1959:52-56.

Brodie III, E.D. 1992. Correlational selection for color pattern and antipredator behavior in the garter snake *Thamnophis ordinoides*. Evolution 46(5):1284-1298.

Brown, W.S. and W.S. Parker. 1976. A ventral scale clipping system for permanently marking snakes (Reptilia, Serpentes). Journal of Herpetology 10:247-249.

Carpenter, C.C. 1954. The presence and variation of lateral red coloration in a population of common garter snakes (*Thamnophis sirtalis sirtalis*). Herpetologica 10:89-91.

Cook, F.R. 1984. Introduction to Canadian Amphibians and Reptiles. National Museum of Canada Natural History Paper.

Cope, E.D. 1900. The crocodilians, lizards and snakes of North America. Annual Report of the United States National Museum for 1898:153-1270.

Costello, R. 2006. Resident amateur herpetologist Grand Rapids, MB. Personal communication.

Fitch, H.S. 1941. Geographic variation in garter snakes of the species *Thamnophis sirtalis* in the Pacific Coast region of North America. American Midland Naturalist 26: 570-592.

Fitch, H.S. 1965. An ecological study of the garter snake, *Thamnophis sirtalis*. University of Kansas Publications, Museum of Natural History. 15:493-564.

Fitch, H.S. 2001. Further study of the garter snake, *Thamnophis sirtalis*, in Northeastern Kansas. University of Kansas Publications, Museum of Natural History. 19:1-6.

Gotmark, F. 1994. Does a novel bright colour patch increase or decrease predation? Red wings reduce predation risk in European blackbirds. Proceedings: Biological Sciences 256(1345): 83-87.

Gregory, P.T. 1974. Patterns of spring emergence of the red-sided garter snake *(Thamnophis sirtalis parietalis)* in the Interlake region of Manitoba. Canadian Journal of Zoology 52:1063-1069.

Gregory, P.T. and Stewart, K.W. 1975. Long-distance dispersal and feeding strategy of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in the Interlake of Manitoba. Canadian Journal of Zoology 53:238-245.

Gregory, P.T. 1977. Life-history parameters of the red-sided garter snake (*Thamnophis sirtalis parietalis*) in an extreme environment, the Interlake Region of Manitoba. National Museum of Canada, Publications in Zoology 13:1-44.

Janzen, F.J., Krenz, J.G., Haselkorn, T.S., Brodie Jr., E.D., and Brodie III, E.D. 2002. Molecular phylogeography of common garter snakes (*Thamnophis sirtalis*) in western North America: implications for regional historical forces. Molecular Ecology 11:1739-1751.

King, R.B. 1988. Polymorphic populations of the garter snake *Thamnophis sirtalis* near Lake Erie. Herpetologica 44:451–458.

King, R.B. 2003. Mendilian inheritance of melanism in the garter snake *Thamnophis sirtalis*. Herpetologica 59(4):484-489.

Lande, R. 1976. Natural selection and random genetic drift in phenotypic evolution. Evolution 30:314-334.

Lawson, R. and King, R.B. 1996. Gene flow and melanism in Lake Erie garter snake populations. Biological Journal of Linnean Society 59:1–19.

Madsen, T., Stille, B., and Shine, R. 1996. Inbreeding depression in an isolated population of adders *Vipera berus*. Biological Conservation 75:113–118.

Mason, R.T. and Crews, D. 1985. Female mimicry in garter snakes. Nature 316(6023):59-60.

Mason, R.T., Fales, H.M., Jones, T.H., Pannell, L.K., Chinn, J.W., and Crews, D. 1989. Sex pheromones in snakes. Science 245:290-293.

Mason, R.T., MacMillan, S., Whittier, J.M., Krohmer, R.W., and Koonz, W.H. 1991. *Thamnophis sirtalis parietalis* (red-sided garter snake) Population morph variation. Herpetological Review 22:61.

Preston, W. 2006. Retired curator of zoology. Manitoba Museum. Personal Communication.

Rosenblum, E.B., Hoekstra, H.E., and Nachman, M.W. 2004. Adaptive colour variation and the evolution of the *MC1R* gene. Evolution 58(8):1794-1808.

Rossman, D.A., Ford, N.B., and Seigel, R.A. 1996. The Garter Snakes: Evolution and Ecology. University of Oklahoma Press. Norman, Oklahoma.

Ruthven, A.G. 1908. Variations and genetic relationships of the garter-snakes. Bulletin of the United States National Museum 61:1-201.

Rye, L.A. 2000. Analysis of areas of intergradation between described subspecies of the common garter snake, *Thamnophis sirtalis*, in Canada. Ph.D. Thesis, University of Guelph.

Shine, R., Elphick, M.J., Harlow, P.S., Moore I.T., LeMaster, M.P., and Mason, R.T. 2001. Movements, mating, and dispersal of red-sided gartersnakes (*Thamnophis sirtalis parietalis*) from a communal den in Manitoba. Copeia 2001(1):82-91.

Shine, R., Olsson, M.M., LeMaster, M.P., Moore, I.T., and Mason, R.T. 2000. Effects of sex, body size, temperature, and location on the antipredator tactics of free-ranging gartersnakes (*Thamnophis sirtalis*, Colubridae). Behavioral Ecology 11(3):239-245.

Shine, R., and Mason, R.T. 2004. Patterns of mortality in a cold-climate population of garter snakes (*Thamnophis sirtalis parietalis*). Biological Conservation 120:201-210.

Shine, R., Phillips, B., Waye, H., LeMaster, M., and Mason, R.T. 2004. Species-isolating mechanisms in a mating system with male mate choice (garter snakes, Thamnophis spp.). Canadian Journal of Zoology 82:1091–1098.

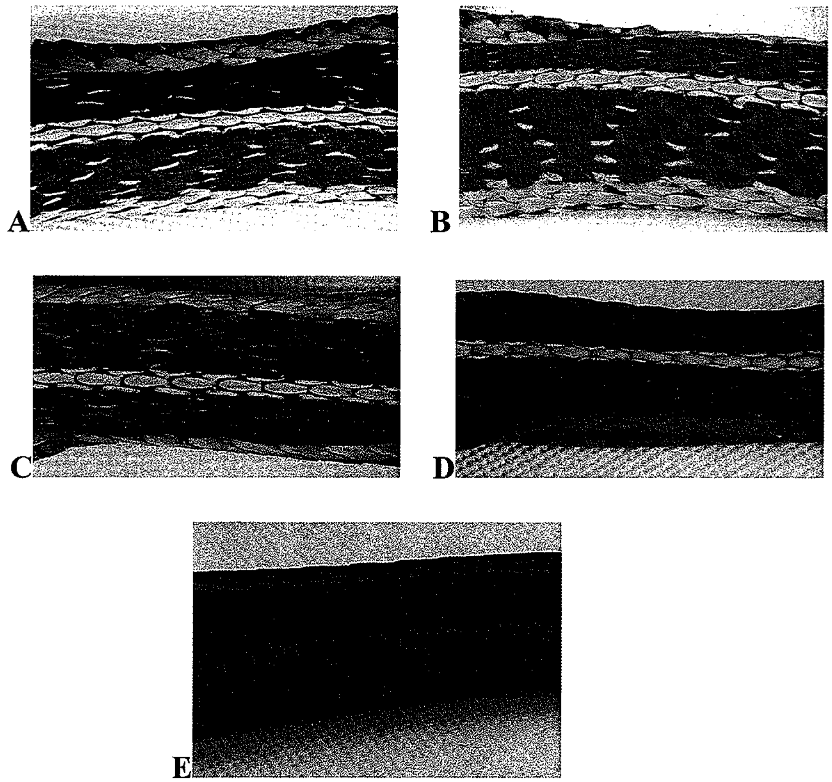


Figure 7.1 Colour variation in common garter snakes (*Thamnophis sirtalis*) from Jenpeg, Manitoba demonstrating the scoring system. A – **no red (score 0);** B – **some red, as flecks, on interscale skin (score 1);** C – **significant red on interscale skin extending onto lateral stripe scales (score 2);** D – **Erythristic or extreme red form (score 3);** E – **Melanistic form (score 4). Photos by J. Wiens.**

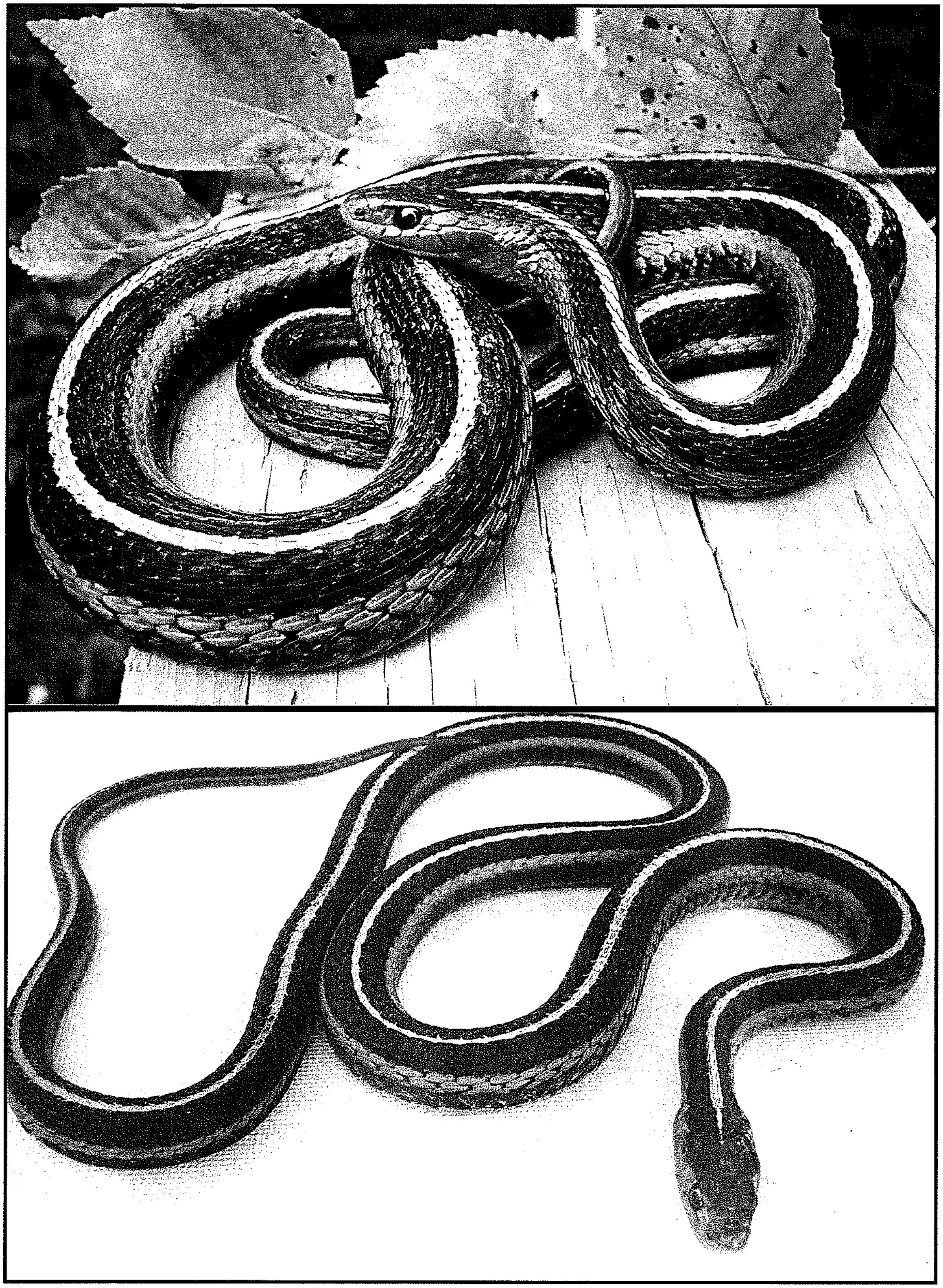


Figure 7.2 Representatives of the erythistatic colour morph of the common garter snake (*Thamnophis sirtalis*) from Kiskitto Lake, Manitoba.

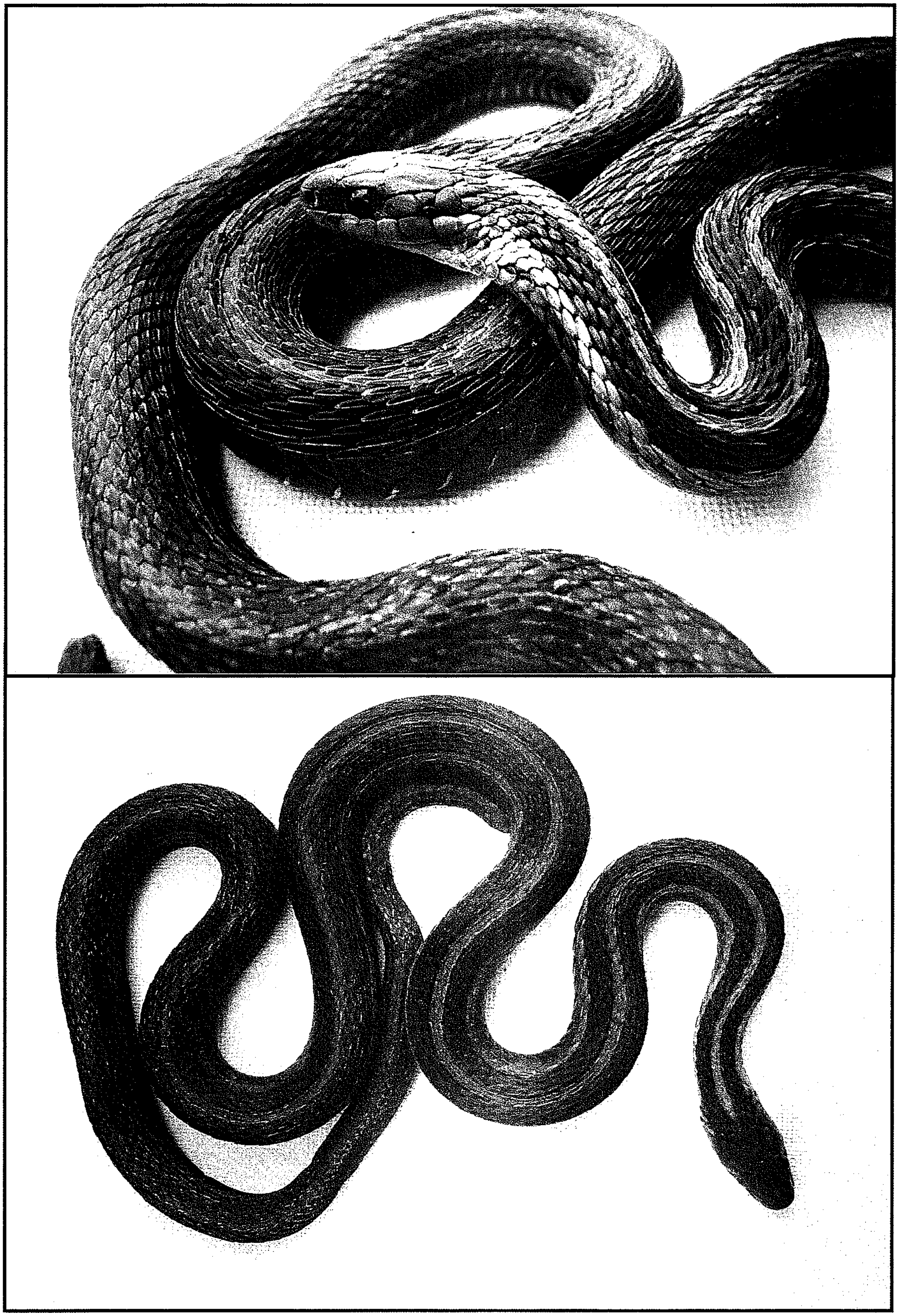


Figure 7.3 Representatives of the melanistic colour morph of the common garter snake (*Thamnophis sirtalis*) from Kiskitto Lake, Manitoba.

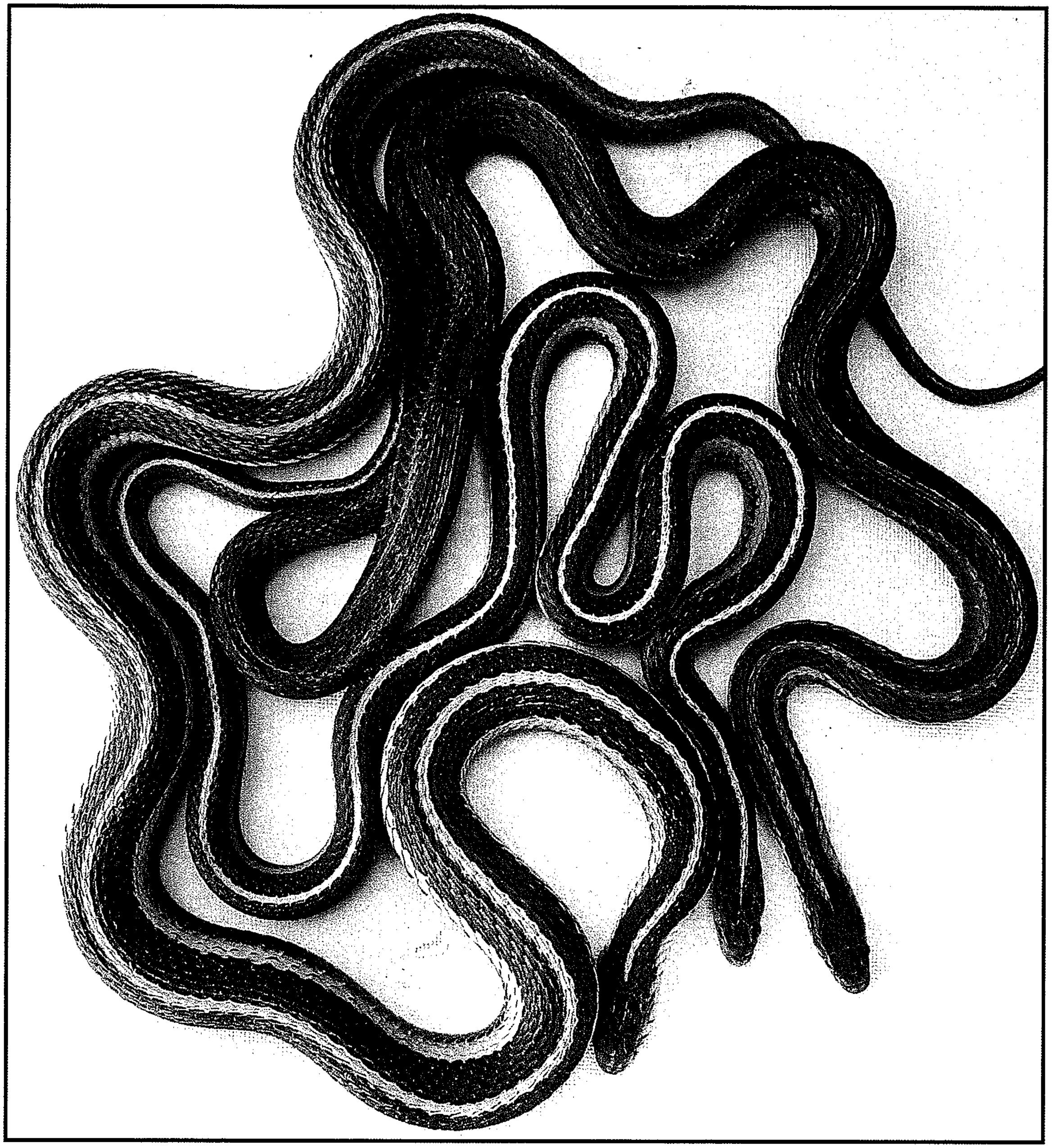


Figure 7.4 Comparison of the dorsal view of three colour morphs of the common garter snakes (*Thamnophis sirtalis*) from Kiskitto Lake. Left: typical (colour score 1); Middle: erythristic; Right: melanistic.

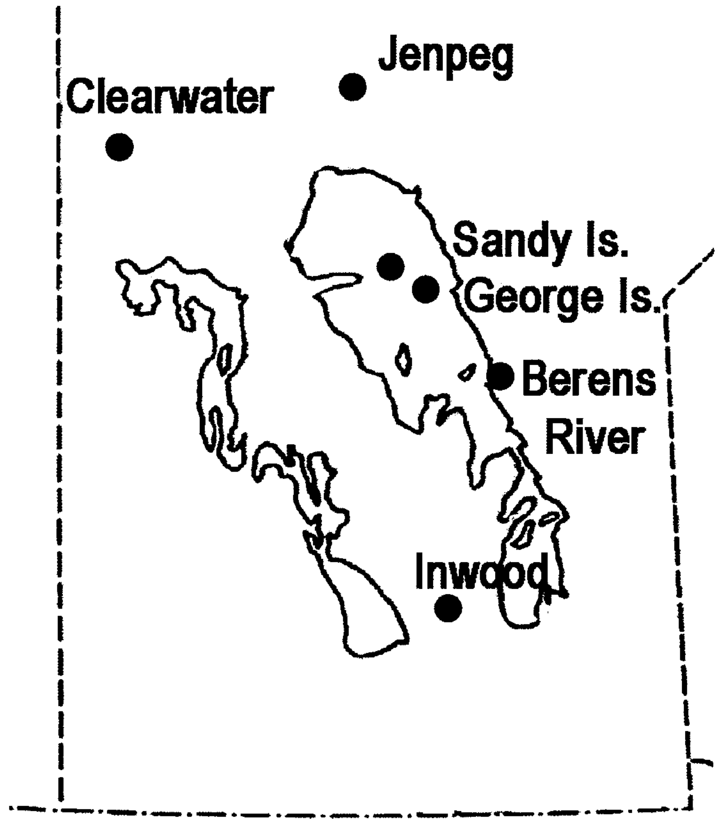


Figure 7.5 Common garter snake (*Thamnophis sirtalis*) sampling locations in Manitoba.

Table 7.1: Colour morphs proportions for six Manitoba populations of the common garter snake (*Thamnophis sirtalis*). Totals for George Is., Big Sandy Is. and Berens River exceed combined male and female counts as snakes of unknown gender were included.
Colour scores are: 0 – no red; 1 – discrete and minimal red flecks on lateral interscale skin; 2 – prominent and significant red on lateral interscale skin, sometimes with some red on lateral stripes; 3 – erythristic, with red lateral interscale spots, red lateral lines, red labial and ventral scales, and red or orange dorsal stripe anteriorly; 4 – melanistic, no red or yellow and bluish, muted lateral and dorsal stripes.

	Jenpeg			Inwood			Clearwater			George Island				Big Sandy Island				Berens River			
Colour Score	Male (n=130)	Female (n=186)	Total (n=316) %	Male (n=95)	Female (n=6)	Total (n=101) %	Male (n=45)	Female (n=15)	Total (n=60) %	Male (n=10)	Female (n=16)	Unknown (n=4)	Total (n=30) %	Male (n=4)	Female (n=3)	Unknown (n=1)	Total (n=8) %	Male (n=8)	Female (n=20)	Unknown (n=4)	Total (n=32 %
0	79	66	45.9	0	0	0	0	0	0	0	2	0	6.7	2	0	0	25	1	4	1	18.8
1	31	93	39.2	3	0	3	1	1	3.3	0	2	1	10	1	1	0	25	5	6	0	34.4
2	12	15	8.5	92	6	97	44	14	96.7	9	12	1	73.3	1	2	1	50	2	8	2	37.4
3	7	11	5.7	0	0	0	0	0	0	1	0	1	6.7	0	0	0	0	0	2	1	9.4
4	1	1	0.6	0	0	0	0	0	0	0	0	1	3.3	0	0	0	0	0	0	0	0

CHAPTER 8

INCLUDING TRADITIONAL AND LOCAL KNOWLEDGE IN A SMALL-SCALE WILDLIFE STUDY

ABSTRACT

Working with people from Cree communities in northern Manitoba has allowed me to integrate traditional and local knowledge with scientific research. The inclusion of traditional knowledge in research has helped to assert the validity and importance of local knowledge systems and provided a more holistic perspective to wildlife research. There can be many challenges when starting a research project in a northern aboriginal community, but the benefits gained in knowledge and friendship are invaluable. I learned that common garter snakes (*Thamnophis sirtalis*) have always been a part of the local wildlife fauna and that large body sizes and unique colour patterns are common.

8.1 INTRODUCTION

Traditional and local ecological knowledge has gained increased acceptance in the fields of wildlife research and natural resource management (Gilligan et al. 2006). However, successfully integrating expert-based science and experienced-based knowledge is challenging, and has not yet been widely reported (Brook et al. 2006). In some cases, legislation mandates the inclusion of traditional ecological knowledge in management decisions (Usher 2000), but increasingly managers are seeking this knowledge, in addition to scientific knowledge. In large part, this is due to the increased realization that experience based knowledge can be equal, and usually complimentary, to the results of classic scientific query (Gagnon and Berteaux 2006).

Given this enlightenment within the research community, a growing number of scientists are challenged with the prospect of including local and traditional knowledge within their work, while simultaneously being respectful of local customs, traditions, worldviews, and knowledge transfer practices (Piquemal 2003). Researchers quickly learn that obtaining experienced based knowledge is rigorous and involves more than simple surveys or brief interviews. Experienced based knowledge only truly becomes valuable after personal relationships are developed, often outside of specific "data collection meetings" (Gallagher 2003). Researchers also need to be mindful of the ethics surrounding the collection of local and traditional knowledge and ensure meaningful collaboration is conducted on how the information will be used (Piquemal 2003, Wenzel 1997). The intent here is to describe how novice researchers, with limited training and Northern experience, can include the perspectives of aboriginal peoples in wildlife research.

Aboriginal perspectives are rarely included within the study of herpetology. Publications generally focus on the traditional questions concerning biology, systematics, physiology, and ecology. When I developed an interest in studying the ecology of the common garter snake (*Thamnophis sirtalis*) in northern Manitoba (near Pimicikamak Cree Nation and Norway House Cree Nation), I knew I wanted to include the perspectives of local people, despite few examples of such work in the published literature. My greatest challenge was that I did not have any contacts within the local communities. My only acquaintance was one person from a nearby Manitoba Hydro generating station, where I was setting up my research camp. University level research had not been conducted in this region for over fifteen years, so I could not rely on any other academics to introduce me to local people. I will highlight the positive outcomes of my work in hopes that other researchers can benefit from my experiences.

8.2 METHODS

The First Field Season

In my first field season, I struggled to make connections in the nearby communities. My camp was located at Jenpeg, a Manitoba Hydro generating station only thirty-five kilometres from Kiskitto Lake, home to one of the most northern garter snake dens in Manitoba. Manitoba Hydro had agreed to sponsor my study and allowed me to stay near the station and use their facilities. The Cree communities of Pimicikamak (Cross Lake) and Norway House were 1 hour and 1.5 hours drive away (respectively). Despite the distance, I called, wrote letters, and visited the Band offices of each community on multiple occasions. My goal was to conduct semi-directive interviews (Huntington 1998) with knowledgeable local people including elders, hunters, trappers, and fishers. Essentially, I was interested in speaking to anybody who had experience out on the land. My objective was to include the perspectives of the local people in my wildlife research, in hopes that the project would be more holistic and have a broader time scale. I also did not want to work in relative isolation, as my research would extend over four months each summer. Before leaving Winnipeg, I read all the available published literature about the communities, and sought advice from the University of Manitoba Aboriginal Elder. The community of Norway House was accommodating and interested in my work. On three occasions in 2005, a large fishing boat took me to remote clean-up sites, where workers had been encountering snakes. Although the information I gained was limited, I did develop good friendships and acquired a better appreciation of snake distribution and density in the region.

I was also interested in working with the community of Pimicikamak Cree Nation (PCN)(Cross Lake). Unfortunately, PCN was dealing with many political issues and concerns in 2005. The band office did not express any interest in getting involved with a wildlife research project. Despite this, I worked hard at trying to meet people in the community and build up friendships. I befriended a local commercial fisherman from Wabowden (Figure 8.1), but the local hunters and trappers from PCN, expressed very little interest in my presence. Initially, I was concerned that connection to Manitoba Hydro, and my white southern background, might alienate me from the community, but I soon found out that personal relationships are worth much more than affiliations and skin colour. My most positive experience came when I was made aware that volunteers were needed for the construction of a new church. Although my construction experience was limited, I spent two Saturdays cleaning up the work site and installing a new roof. This activity provided me with my first contacts in the community. Unfortunately, my 14-week field season was nearly complete and the few people I had met were not particularly interested in reptiles. Although I had some successes in 2005, I was frustrated in my attempts to connect and learn from the local people.

The Second Field Season

Once I evaluated the challenges I faced in my first field season, I developed a strategy to meet my objectives during my second field season. My main problem was that I was spreading my research efforts to thin, and I did not yet have a contact person, or a liaison, in either PCN or Norway House. That all changed when I developed a friendship with Mr. Tom Scott, the local newspaper editor in PCN. He developed an interest in my study and soon published a story about my work in his monthly newspaper. He visited me occasionally at my study site, and we soon we became good friends. He shared with me his experiences as a newspaper editor, University of Manitoba Native Studies graduate and Northern Flood Agreement Liaison and provided a wealth of information about his community. Soon after meeting Tom, I was invited to give a presentation at the Career Day event at the local high school. This provided me exposure to hundreds of students, and their teachers. Not soon after, my research was featured in the national news media, and my local name politely became known as "the snake guy". After the publication of the local newspaper article, the high school presentation, and the national media exposure, I was often recognized within the community at local restaurants, grocery stores, and gas stations. It became easy to talk to people, and soon I found myself in extended conversations with people who were previously strangers. My next step in becoming engaged in the community was hiring a field assistant. The rugged nature of my fieldwork, including heavy lifting and canoeing, made hiring a field assistant necessary. After some initial struggles in finding an appropriate candidate, I hired the nephew of Pierre Ross, the head trapper of the registered trap line around Kiskitto Lake. This arrangement worked out well. I was able to provide employment to a local young person, and I was able to develop a close friendship with the extended family of the head trapper. I soon found myself invited to their cabin for tea, bannock and many traditional meals. I met most of Pierre's family, and soon found myself accompanying them on trips "out on the land". I developed strong friendships with the head trapper and his brothers, mainly because of our mutual interest in wildlife, especially moose, wolves, waterfowl, and bears.

I also continued to engage myself in the broader Pimicikamak community. Over the spring and summer, I gave presentations to small school groups, and volunteered at community events, such as the Canada Day Festivities, and the Annual Volunteer Fire Fighter's Fundraiser. I attended all the community events that were advertised on the local radio station, even if I knew none of my new friends would be attending. I was often the only white southerner attending traditional elders gatherings at historic sacred sites. I got a few strange looks, but most people were very welcoming, offering me fresh tea, expressing interest in my work, and providing perspectives on their culture and land. I quickly met knowledgeable Elders and developed lasting relationships with them. A great deal of what I learned from my new friends related to reptiles, but much of it did not. I was promptly given Cree language lessons, and soon learned the words and enunciation of over thirty wildlife species. Most people admitted that they did not have much knowledge of garter snakes, some even stated that they disliked them, but everybody was quick to share whatever information they had and to direct me to people who did.

8.3 RESULTS

In general, there was a wide range in pre-existing knowledge regarding the ecology of garter snakes. Many Elders, trappers, hunters, and fisherman had very little interest in snakes and did not have very much information to offer, others however held a great interest in reptiles and it quickly became obvious that these people had amassed extensive knowledge over their lifetime. It was these people that agreed to participate in this study.

Although many people shared with me stories of their snake encounters, I formally interviewed twelve people to obtain focused and thorough knowledge of garter snakes in this region. The people I interviewed were from the three nearby communities (Wabowden, Pimicikamak, Norway House). All were recognized in their communities for being excellent hunters, trappers, fisherman, berry-collectors, or Elders.

The interviews and ensuing discussions provided me with very valuable information regarding the historical and present prevalence of snakes in the region. I found no real disagreement in the information reported from community members and the information I found through my scientific sampling. Snakes have always been a part of the local wildlife fauna. People relayed stories with me of snake sightings even when they were young children. People who travelled to Kiskitto Lake as far back as the 1950's recall encountering snakes around that area. Snake sightings have never been unusual or rare in this region. The majority of people hypothesized that they are now seeing more snakes now than in the past, but they cautioned that this may be the result of more roadways and travel, and hence a greater potential for encounters. Most snake encounters were made in late spring, summer, and early fall. People most commonly saw snakes when they were out driving, fishing, or berry picking. People frequently told me of sightings of large snakes. Their rough descriptions of the length and circumference of these snakes closely matched the proportions I had measured during my fieldwork. A few people also shared with me observations of red coloured snakes. Their descriptions of these individuals closely matched the red coloured snakes I was finding (with a about 8% frequency) in the Kiskitto Lake population.

During the course of these interviews, I was also able to confirm the existence (or non existence) of snake populations in other regions of northern Manitoba. Common garter snakes are known to occur east of Jenpeg, to at least the communities of Oxford House and Island Lake (including Walker Lake and Carrot River). Snakes are known to occur to the north, to at least Sipewesk Lake and Wabowden. No snakes are reported from Thompson, but to the north-west snakes are known to occur from Wekusko Lake to Flin Flon.

Throughout the interview process I was always receptive to stories or tales of wildlife in Cree aboriginal folklore. Although I was told of tales of bear, moose, and geese, snakes were never featured in these stories. It was stated that snakes played an essential role in the local environment, but did not play a significant role in historical legends.

8.4 SUMMARY

I can summarize my experience by providing the following advice for novice researchers preparing for a research project that includes gathering traditional and local knowledge.

1. Remember to secure the appropriate research licenses and ethics approvals. Be prepared to provide appropriate gifts/honourariums for participants in your study.
2. Find a contact person or community liaison as soon as possible. Conduct a literature review for recent research work in the region and contact the authors. The next step is to contact the local government and natural resource office. Remember that personal relationships are key. A phone call is worth more than a letter, and a personal visit is even better.
3. Hire a local research assistant. Most research requires technical assistance, but if you can find someone locally, you will gain the advantage of an existing network of contacts. He or she can also serve as a translator for conducting interviews and explaining community events.
4. Spend extended periods of time in the local community. Your acceptance in the community will be directly related to how long you stay there.
5. Attend as many social gatherings as you can. You may find yourself bogged down with research work and writing, but the best way to learn from local people is to meet them at local events. It may be very intimidating to arrive solo at an elders gathering or pow-wow, but it can be the best way to meet knowledgeable people and develop an appreciation of their culture and practices.
6. Make an attempt to learn the local language. Community members and Elders will have a greater respect for you if make the effort to use their native words. Learning a few

common phrases also serves as a great "ice-breaker" and can lead to extended conversations.

7. Find opportunities to present yourself, and your work, to the community. The local newspaper and radio station is a great medium to broadcast your research, but you need to ensure that your message is easy to understand and relevant. Presentations at local schools (particularly science classes) provide a platform that can eventually spread news of your work to all parts of the community.
8. Treat your interviewee as you would a close friend. Conducting research with local people can be daunting, but if you treat everyone as you would a close friend, you will find your work far more rewarding and successful. I have continued relationships with many of the people I met during my study. I expect to maintain those friendships for years to come.

REFERENCES

Brook, R., M'Lot, M., and McLachlan, S. 2006. Pitfalls to avoid when Linking Traditional and Scientific Knowledge. *In* Climate Change: Linking Traditional and Scientific Knowledge. *Edited by* J. Oakes and R. Riewe. Aboriginal Issues Press. Winnipeg. pp. 13-20.

Gagnon, C.A., and Berteaux, D. Integrating Traditional and Scientific Knowledge: Management of Canada's National Parks. *In* Climate Change: Linking Traditional and Scientific Knowledge. *Edited by* J. Oakes and R. Riewe. Aboriginal Issues Press, Winnipeg. pp. 209-222.

Gallagher, C. 2003. "Quit thinking like a scientist!". *In* Native Voices in Research. *Edited by* J. Oakes, R. Riewe, K. Wilde, A. Edmunds, and A. Dubois, Aboriginal Issues Press, Winnipeg. pp. 183-190.

Gilligan, J., Clifford-Pena, J., Edye-Rowntree, J., Johansson, K., Gislason, R., Green, T., Arnold, G., Heath, J., and Brook, R. The value of integrating traditional, local, and scientific knowledge. *In* Climate Change: Linking Traditional and Scientific Knowledge. *Edited by* J. Oakes and R. Riewe. Aboriginal Issues Press, Winnipeg. pp. 3-12.

Huntington, H. 1998. Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51(3):237-242.

Piquemal, N. 2003. Redefining ethics in research. *In* Native Voices in Research. *Edited by* *Edited by* J. Oakes, R. Riewe, K. Wilde, A. Edmunds, and A. Dubois, Aboriginal Issues Press, Winnipeg. pp. 199-210.

Usher, P. 2000. Traditional ecological knowledge in environmental assessment and management. Arctic 53(2):183-193.

Wenzel, G. 1999. Traditional ecological knowledge and Inuit: Reflections on TEK research and ethics. Arctic 52(2):113–124.

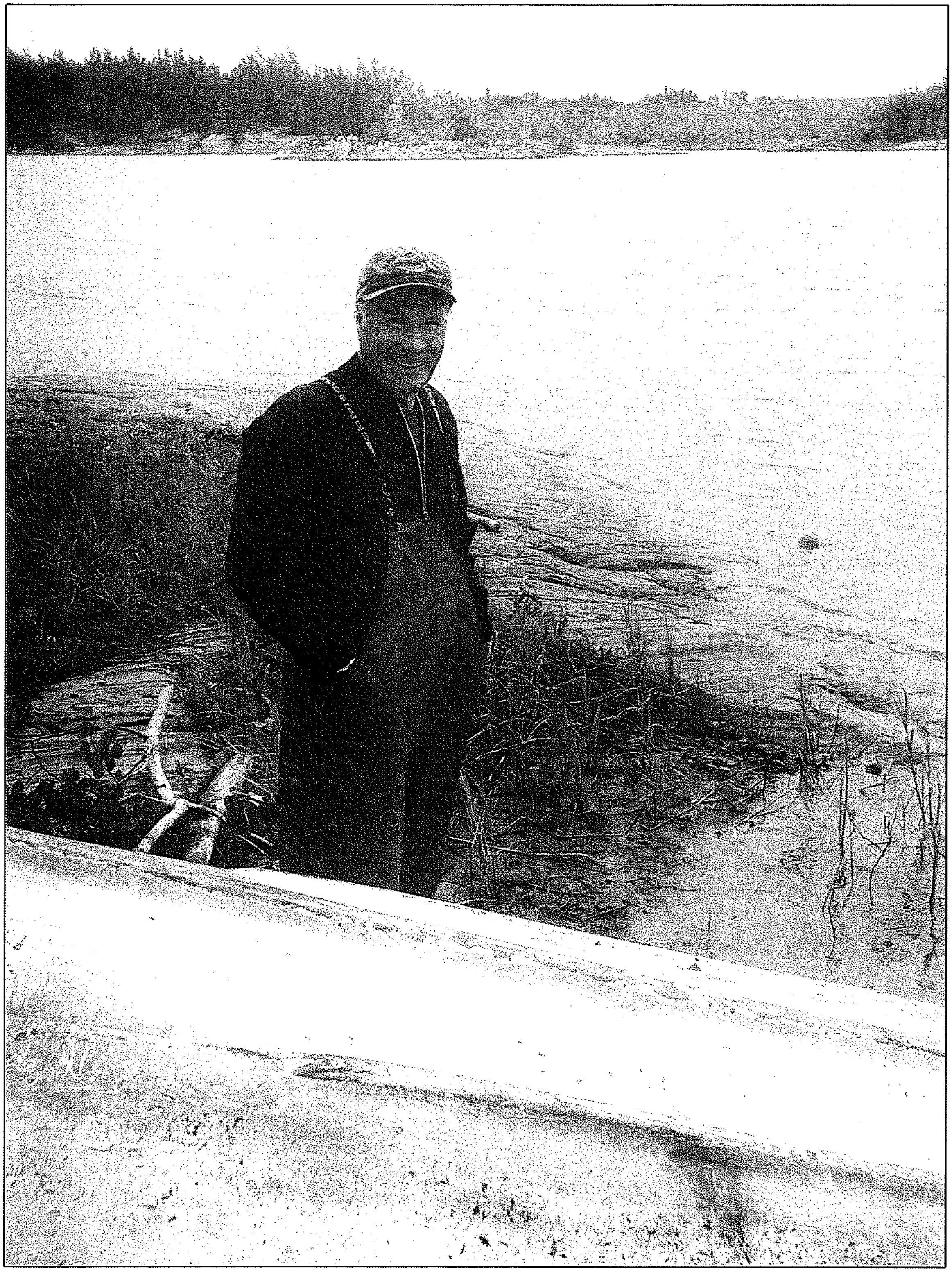


Figure 8.1 Picture of a fisherman from Wabowden who has commercially fished Kiskitto Lake since 1957.

CHAPTER 9

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS FOR THE COMMON GARTER SNAKE IN NORTHERN MANITOBA

This study builds on the large preceding body of research on the ecology of common garter snakes in North America. Garter snakes in northern Manitoba survive in an extreme climate, comparable to the conditions of northern Alberta (Larsen 1986). Some of the factors that have been implicated as limiting the northern distribution of snakes in that region, such as reduced annual growth rates, are seen here. The abundance of wetlands in much of central Manitoba indicates that snakes are not limited by food supply, or the requirement to make long migrations between summer feeding grounds and hibernacula. The most likely limiting factor preventing snakes from colonizing higher latitudes in Manitoba is not known, but is likely controlled by availability of denning sites to survive the long, cold winters.

Common garter snakes from north central Manitoba differed in two dramatic ways from populations elsewhere in North America: snakes tend to grow to much larger sizes, and display a wider array of colour morphs. These characteristics are likely expressed because of a host of climatic and genetic circumstances this population is required to tolerate at the edge of their range.

Information on the distribution of snakes in central Manitoba was significantly supported by the inclusion of traditional and local knowledge. Snakes are known to exist along a vague line from Oxford House in the east, to Flin Flon in the west. Knowledge from aboriginal people helped broaden the scope of this work, and provided a perspective not commonly targeted in wildlife research.

In order to help conserve and preserve the common garter snake population at Kiskitto Lake (near Jenpeg), I have developed six recommendations for Manitoba Hydro and or Manitoba Conservation. These recommendations can hopefully be integrated into current dike and road management plans without major overhaul of existing practices.

1. Prevent the obstruction of the common garter snake denning site on the south portion of the Kiskitto Lake dam (see Figure 2.2). There is only one opening to this den site and it is located in a small drainage channel. It is imperative that this den site be preserved to protect the unique population of snakes that overwinter at this site, including some of the largest common garter snakes ever recorded. This unique site may also be of interest to other snake researchers who may wish to collect data on from this population in future research.
2. Avoidance of Kiskitto dam maintenance operations (heavy machinery and trucks) between the periods of April 15th to May 15th. This four-week period is critical for garter snake spring emergence and mating.
3. In order to commemorate and recognize the value of the Kiskitto Lake dam, I recommend that a plaque or interpretive sign be erected on the dam to remind visitors and workers of the unique value this site holds for wildlife conservation. The sign should be visible from the road, but not in such a way that visitors would know the exact site of the den opening (to prevent vandalism). An appropriate sign could be manufactured for approximately $500-$800 (possibly less). Text may include:

   "Kiskitto Lake Dam – Completed in 1978

   Habitat for the largest red-sided garter snake (*Thamnophis sirtalis parietalis*) ever recorded."

4. Continued use of herbicide applications to control vegetation growth on the dike is acceptable. Research conducted by the California Fish and Game Department has demonstrated that common garter snakes are not acutely affected by commonly used herbicides and surfactants (Hoseau et al. 2004).
5. Spring or fall burning can also continue to be used as a management tool to control vegetation and weeds. However, I would recommend a forty-meter buffer around the den site during spring burns.
6. In general, the use of large granitic boulders in dam creation and maintenance has created garter snake habitat. The continued use of these materials will create positive habitat for garter snakes especially at the northern edge of its range where overwintering sites are limited.

In order to continue this work, further research should be conducted to investigate the genetic composition of northern Manitoba snakes in comparison to neighbouring populations. This work would help identify if the observed life-history characteristics of northern snakes are genetically precoded or the result of environmental adaptability (or both).

REFERENCES

Hosea, R.C., Bjurstrom, K.Z., and Littrell, E.E. Acute oral and dermal toxicity of aquatic herbicides and a surfactant to garter snakes. California Department of Fish and Game. Administrative Report 2004-1. February 23, 2004.

APPENDIX 1.

SURGERY PROCEDURES

Common garter snakes used for implantation were heavier than 200 gm, therefore ensuring a body mass to transmitter ratio greater then (0.05:1). Surgery was conducted by Dr. Gordon Glover and Janice Berger at the Assiniboine Park Zoo hospital. Anaesthesia was induced using 5% isoflorane with the snake under manual restraint using an anaesthetic mask. After induction, the snake was maintained on 2-3% isoflorane after intubation using an intravenous catheter of appropriate size (18 gauge). Positive pressure ventilation at a rate of approximately two per minute was used throughout the surgical period. Upon completion of surgery the snake was maintained on 100% O_2 until the first signs of movement when the intratracheal tube was withdrawn and recovery completed under observation in a terrarium. Metacam was used for post operative analgesia. Sterile surgical techniques were maintained throughout the surgical procedure. The surgical protocol generally followed that described by Webb and Shine (1997). An incision 1.5 cm in length (just long enough to enable passage of the implant) was made along the long axis of the snake on the left side just ventral to the ribs at the level of tip of the liver. A 5/0 monocryl suture was tied around the implant and the ends left long. The antenna was passed through the incision and led caudally in the coelomic cavity using a long, blunt alligator forcep. The antenna end of the transmitter was inserted caudally through the incision retaining the long ends of the suture attached to the transmitter. Traction was applied to the sutures attached to the transmitter pulling it cranially until it is anterior to the incision. The suture is then passed through the intercostal muscles, around a rib securing the transmitter in the body cavity. The coelomic cavity and overlying muscle were closed using a single line of interrupted 4/0 Monocryl suture. Vetbond skin adhesive was used to close the skin. The snakes were held for five -seven days post surgery and observed for any adverse signs before being returned to Kiskitto Lake den for release. The same anaesthesia and surgery procedures were conducted during the recovery of the transmitter at the end of the study.

REFERENCES

Webb, J.K., and Shine, R. 1997. Out on limb: Conservation implications of tree-hollow use by a threatened snake species (*Hypolocephalus bungaroides*: Serpentes, Elapidae). Biological Conservation 81:(21-33).