Mosquitoes in Winnipeg, Manitoba - Opinions, Alternatives, Education, and Opportunities

By

Julie K.J. Price Henderson

A Thesis
Submitted to the Faculty of Graduate Studies in Partial
fulfilment of the Requirements for the Degree of

Master of Natural Resources Management

Natural Resources Institute
University of Manitoba
Winnipeg, Manitoba

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MASTER OF NATURAL RESOURCES MANAGEMENT

A Mosquito in the Cabin

Although you bash her,
swat her, smash her,
and go to bed victorious,
happy and glorious
she will come winging
zooming and zinging,
wickedly singing
over your bed.

You slap the air
but she's in your hair
crackling with laughter.
You smack your head,
but she isn't dead –
she's on the rafter.

She's out for your blood –
yours, my friend,
and she will get it, in the end.
She brings it first to a boiling point,
then lets it steam.

With fee, fi, fo and contented fum
she sips it
while you dream.

Myra Stilborm, 1996.

Abstract

Mosquito control is a topic of interest both locally and globally. Problems created by mosquitoes are threefold and include the nuisance factor, disease transmission, and problems stemming from mosquito control efforts. For many years, Winnipeg citizens have debated the merits of the current local abatement program. To date, North America has not experienced the incidence of mosquito-borne pathogens to the extent of other regions, though the arrival of West Nile virus in 1999 to the continent has increased the focus of scientists and the general public on mosquito control issues. Integrated Pest Management (IPM) is the current method of choice for mosquito control.

This thesis contains the results of research, initiated in January of 2001, to address some specific issues surrounding mosquito control in Winnipeg, Manitoba. The objectives of this thesis research were fourfold: a) gather and analyze information from Winnipeg residents regarding their knowledge of mosquitoes and their control; b) identify non-toxic mosquito control methods and test them for effectiveness and viability in an urban setting; c) create an annotated bibliography of mosquito educational tools appropriate for middle-years school children; d) based on the findings make recommendations for improvement to the Winnipeg IPM mosquito abatement program.

The research was conducted through a literature review of key concepts, primary and secondary data review, semi-structured interviews, quantitative measurements and testing, participant feedback and participation. Data from Winnipeg residents were analyzed for themes and triangulated with literature review findings. Statistical evaluation was used to analyze non-toxic mosquito control product effectiveness. Recommendations for improvements to the Winnipeg program were formulated from information gathered from residents, product testing results, the annotated bibliography project outcomes, and from the literature review.

Following a review of candidate mosquito control or repellent products, the *Mosquito Magnet™* and *Mosquito & Gnat Repellent* were chosen for testing. Neither product was effective in reducing the number of mosquitoes collected in traps or the biting activity in the application area. There were correlations between the number of mosquitoes and environmental variables including; person effect, wind, temperature and cloud cover.

Surveying Winnipeg residents revealed a strong interest in mosquito issues and a high willingness to participate in this research. Education and communication on mosquito issues were identified as high priority, and as needing improvement. Awareness of mosquito biology was fairly high, though behaviour relating to that awareness was rather low. Participants expressed the need for information from credible sources.

The annotated bibliography project received high praise from those teachers and parents who participated. Educators were supplied with mosquito educational tools to review as they saw fit, and feedback was provided. The resulting annotated bibliography includes books, games, curricula, and more. It has garnered interest from educators and mosquito control experts both locally and throughout North America.

Results from the surveying and literature review aided in the identification of methods to improve the current Winnipeg IPM program. Recommendations focused heavily on education and communication, and included improved and expanded formal and informal education on mosquito issues. It is recommended that Winnipeg commit to investigating mosquito control alternatives and best application techniques of mosquito control products in the local scenario. Also, it is recommended that the program budget be re-allocated to reflect a greater commitment to components of IPM other than larviciding and adulticiding, such as education, surveillance, research, and public communication.

Acknowledgements

Firstly, it should be absolutely clear that this thesis would never have been conducted if not for the infinite number of individuals who created such annoyance, and caused enough illness, to make the project funding available. Thus, my first 'acknowledgement' must go to the mosquito, as without her familiar buzz and ambassador-like status in Winnipeg, I would likely have studied something else. However, there are many others to whom I must also pay tribute. If I have learned only one thing, it is that this project came to fruition with the help of many people.

Firstly, my wonderful advisor and committee guided me so skillfully and patiently through the process of conducting masters research. Dr. John Sinclair, my advisor, is the type who will let you learn and explore things on your own, so long as you are not running straight for some kind of figurative cliff (or literal I suppose, he does do a fair bit of research in the mountains). I found his approach to me, and the research, to be perfectly matched with my needs. His good advice and humour were appreciated, and I feel lucky indeed to have been able to work under him in this endeavour.

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Thank you to Rick Penner and Jen Peters, two of the original 'Wolseley protestors', who helped to create the public discussion regarding mosquito control, and had a hand in the project proposal. They helped to guide and shape the project in its infant stages, donated their yard to my use, introduced me to potential Wolseley participants, and were just generally helpful as a resource and sounding-board. I don't think this project would have ever got off the ground without them.

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There were so many others who helped out along the way. Dave Holder found and fixed the data collection equipment I needed. Ken Nowalski (Insect Control Branch) provided feedback on the survey questions, and was kind enough to read the entire thesis document and attend the thesis defence to represent Mr. Gadawski. Bill Elliot, President of the Fort Whyte Nature Centre, and all of the staff at Fort Whyte were very helpful in that they allowed the research to take place, facilitated setting up the experiment, and allowed my volunteers free access to experimental sites.

Then there are the people that made my experience in doing a graduate degree at the NRI such a great one. Profs, staff, and students are in this group. It was good fun, and the people I met are top notch. I especially appreciate all of the great and wandering conversations with Kenton, Gerald, and Serge, their equally fascinating partners Julie, Jen and Francine, and all of the road trips with so many willing participants. I don't think I can look at the shop in Pilot Mound or the fire pit at the lake in the same way. These people were both the foundation to the experience and the icing on the cake.

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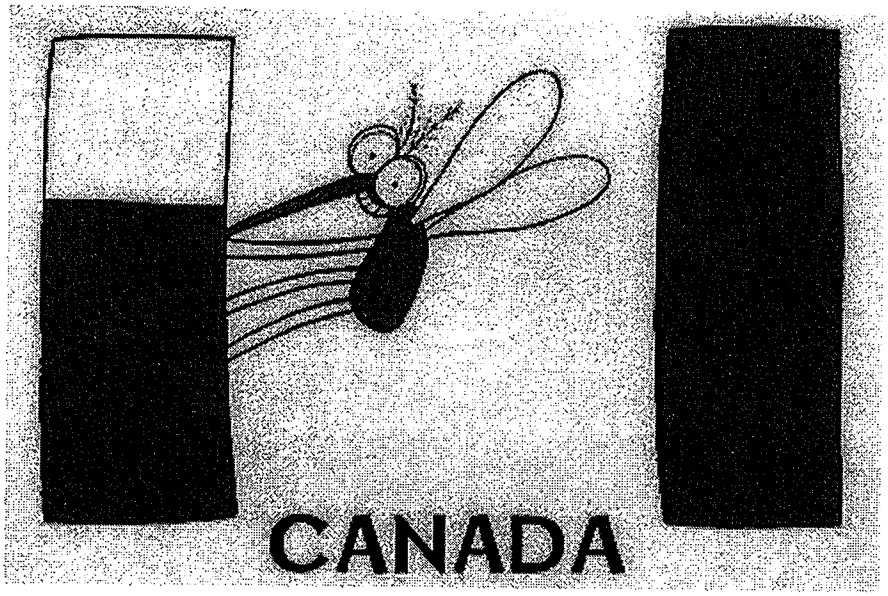
What is the most dangerous animal on earth? Is it a great white shark? Is it a king cobra? Is it a grizzly bear? Would you believe that it is a mosquito, that same backyard pest, that spoiler of outdoor fun, that whining nighttime menace. In fact, throughout the world, the mosquito is the cause of more death and misery than any other known animal. This makes this insect a natural subject for investigation. – *Frances J. Spray, The Mosquito Show, 2003.*

Chapter 1: Introduction



1.1 A Winnipeg Tale

Mosquitoes are a way of life, and a part of the Winnipeg culture.

We talk about mosquitoes in the spring, looking at the rain clouds and hypothesizing about the timing of their arrival. We gaze into the future, our unhappy anticipation juxtaposed against a certain smugness over our innate knowledge of, and bond with this insect. We feel that surely no other peoples on earth have the intimate relationship with mosquitoes that we do.

In the summer, heavy prairie rainstorms break from the sky, and the next day, brilliant prairie heat bakes the puddles. In the summer we curse the mosquito. We exclaim indignantly that summer is already *so short* in Manitoba, and it is *not fair* that it be made unpleasant by winged blood-suckers. We stand on the sidewalk with our neighbors, flailing and cursing, discussing the number of mosquitoes this year as compared to others. Dropping exclamations like, "This season is the worst ever!"

Then comes the fall. We breathe a collective sigh of relief - they are gone. We get a well-deserved respite from swatting and swearing, and we congratulate ourselves for having survived another season.

Finally comes the longest of Manitoba seasons, the winter. With winter inherently exists the reminiscing of happier, warmer, less-bundled-up times. Times when our bodies were bronzed by the sun and our cars did not need to be 'found' every morning under a blanket of snow. It is this time of year, in the cold darkness of winter, when every Manitoban feels that the mosquitoes were really not *that* bad (nothing compared to the frigid temperatures anyway). And we confess to our frozen steering wheel that we would take the hoarding mosquitoes over the snow and cold *any day*. And we dream of summer, and the return of the summer ambassadors, our hated friend, the mosquito.

1.2 The Mosquito

There are more than 3,000 species known, they inhabit virtually every corner of the globe, she feasts on reptiles, birds, mammals, and amphibians alike, and she transmits deadly pathogens that have shortened the lives of billions of her blood donors. With all of this, is it any wonder that the mosquito is one of, if not the most readily identifiable insect on the planet? The incessant whine of the blood-thirsty female mosquito means different things to different people, depending on where they are located geographically. From an annoying nuisance that plagues beaches and woodlands and makes outdoor fun a little less so, to a deadly insect that has sickened and killed more people though history than all other causes combined (Gubler, 1998). Even in these modern times, pathogens transmitted by mosquitoes kill millions of people every year (Spielman and D'Antonio, 2001).

With this kind of serious impact on the quality of human life, entomologists have searched to find ways of reducing and eliminating these pests for more than a century. Yet, with all of their diligence and study, absolute control of mosquitoes remains elusive (Spielman and D'Antonio, 2001). A more reasonable target for modern mosquito control is to minimize the impact that mosquitoes have upon human and animal comfort and quality of life. This vague, qualitative description of what a mosquito control program might accomplish, leaves a window of opportunity for the proclamation of program success. The City of Winnipeg is one of many mosquito control programs that have adopted this mandate (Gadawski, 2000). Some control districts, such as Harris County in Texas, risk failure by claiming the responsibility of 'preventing and controlling' mosquito-borne disease throughout the coverage area (Parsons, 2003). Regardless of the mandate, there are thousands of organized mosquito control programs across the world, spending millions on the common objective of reducing the number of mosquitoes that inhabit the face of this planet, specifically those that develop in their jurisdiction.

> ***It may be difficult to love the mosquito, but anyone who comes to know her well develops a deep appreciation.*** *– Spielman and D'Antonio, 2001.*

The basics of a mosquito life history are important for understanding how they can be controlled. Mosquitoes require standing water to develop. They have adapted to diverse aquatic habitats, including fresh water, salt water marshes, brackish water, or water in containers, old tires, or tree holes (Fradin, 1998). A mosquito passes through four successive stages in development, (egg, larva, pupa, and adult) the first three require water for their successful completion (Carpenter and LaCasse, 1974). Male mosquito mouth parts are not developed for sucking blood, only female mosquitoes take blood meals, and she may feed on successive occasions (Carpenter and LaCasse, 1974).

1.3 Pest Control: A History

The human desire to modify and manage the environment in order to render it more suited to our needs is not a new phenomenon. People have been blessed (or cursed) with the ability to alter the natural environment significantly, and have used this skill for many centuries. Pest control attempts date back almost as far as the human presence on earth. As agrarian societies developed, people endeavored to rear plants and animals in relatively controlled environments. Animals, plants, or insects that interfered with this process and competed with people for food were considered 'pests' (Hough, 1998). Early attempts at pest control included picking insects off plants, and with the development of more sophisticated societies came more advanced control attempts, such as the use of sulfur[1] and crop rotation (Hough, 1998). Though their effectiveness might be questioned, magic spells to ward off pest attack, excommunication of undesirable insects from the church, ritualistic practices, and live sacrifices to aid in pest control were prolific through ancient and medieval times (Hough, 1998).

The modern age of pest control began in the late nineteenth century. Human health, agricultural economy, development efforts, and human comfort, spurred the quest for effective insect control techniques. One well known motivating incident was the epic construction effort of the Panama Canal. During this project, malaria and other

[1] Homer described how Odysseus fumigated the hall, house, and the court with burning sulfur to control pests.

mosquito-borne pathogens devastated the workforce (LaFeber, 1978). The French portion of the canal project suffered a mosquito-related death toll of thirty per cent. During the American phase of the project, deaths were reduced to just two percent due to the success of mosquito control efforts of an army major and mosquito control specialist named William Crawford Gorgas (Speilman and D'Antonio, 2001). History books tell the tales of massive agricultural damages sustained from insect infestation. These infestations were another major motivating factor for the achievement of effective insect control. Finally, personal and animal comfort issues such as biting flies and ectoparasites have encouraged researchers to find insect control methods.

Chemicals were the first 'modern' tools employed for insect abatement. Arsenical compounds Paris Green and London Purple, were developed by Charles Riley in 1867, and originally used to keep unwanted human pilferers out of orchards and vineyards. The strategy was so effective that a number of children were not only stopped from stealing, but also killed in the process (Ordish, 1976). The creation of synthetic organic pesticides during the Second World War was the next major development in insect control. DDT, or Dichlorodiphenyltrichloroethane, was discovered to have insecticidal properties in 1939, following which it was quickly patented. Soon after, chemical compounds similar to DDT were recognized to have insecticidal properties (Spielman and D'Antonio, 2001).

The benefits of chemical use for mosquito control were immediate and obvious. Great progress was made in disease control. Deaths caused by malaria fell from 2.5 million per year in the 1940's to less than one million in the early 60's (Gabaldon, 1969). Other mosquito-borne diseases also declined. Due to this success, along with benefits realized in agricultural productivity, chemical use for insect control was highly praised and virtually uncontested for decades. The release of Rachel Carson's *Silent Spring* in 1962 "shook the world awake" to environmental and health problems caused by pesticides (Hynes, 1989). "It was around this time (the release of *Silent Spring*) that pesticides became a political matter" (van Emden and Peakall, 1996). During the same time period, evidence of insect resistance to chemicals was mounting. The first case of resistance to

pesticides was detected in 1914, and by 1990 nearly five hundred cases of resistance in insects and mites could be listed (Roush and Tabashinik, 1990).

A case study on the history of DDT use provides a framework for the evolution of global attitudes towards chemical use. Though DDT was first heralded as a chemical that would help eliminate disease and hunger, it became famous for its negative properties. It is persistent in the environment and has the capacity to bioaccumulate in the food chain. DDT dissolves in body fat and is stored in living tissue (Hough, 1998). DDT residues have been linked to a variety of human health disorders. Environmentally, the most obvious adverse effects of DDT were fish mortality and declining raptor populations (Hickey and Anderson, 1968; Porter, 1993; Davis, 1995; Mineau *et al.,* 1999). The Bald Eagle, which suffered dramatic declines in reproduction, became the poster child for the 'ban DDT' cause (van Emden and Peakall, 1996). Another problem is translocation from the original spray site, meaning that the chemical would re-volatilize and then settle in a distant area, making DDT contamination a global problem. DDT was outlawed nearly worldwide in 2000 under the terms of a United Nations Environmental Program Treaty. However, with no equally affordable and effective alternative available, DDT was not completely banned, and it still plays a vital role in malaria control in some developing countries (Spielman and D'Antonio, 2001).

These problems of environmental damage, human health impacts, bioaccumulation, and translocation, exemplified in the DDT case study, are not limited to DDT. Modern pesticides may exhibit one or more of these negative characteristics, though most governments no longer allow the use of chemicals with such extreme negative properties. Today, pesticides must undergo more rigorous testing procedures prior to registration, and generally they pose lesser environmental and health threats. However, many people feel that the testing of chemicals is still not rigorous enough. Testing is conducted under laboratory conditions, and chemicals are usually examined individually. According to a report published by the Maine Environmental Policy Institute in 2001,

> *"the reality of the complex interactions of chemicals in the environment, are, for the most part, not even studied. These interactions include the way the chemicals react in other species,*

> *to light, heat, biological systems, how one acts synergistically with another* in nature."

No chemical, regardless of the level of testing conducted, is completely benign, and there is always some level of risk assumed with chemical application (SCESD, 2000).

> ***The lack of scientific certainty should not be allowed to impede effective action to protect human health and the environment against actual or suspected harm caused by pesticides.*** *– SCESD, 2000*

1.4 Integrated Pest Management

Integrated Pest Management (IPM) is the current approach of choice for pest control specialists. IPM involves a judicious combination of nonpesticidal tactics with minimal pesticide use (Pimentel and Lehman, 1993). The wide spread adoption of IPM in mosquito control programs resulted in a shift from reliance on insecticides to programs that include surveillance, source reduction, larviciding and adulticiding, chemical and biological control, as well as public relations and education (Rose, 2001). Integrated mosquito management is based on "ecological, economical and social criteria and integrates multidisciplinary methodologies into pest management strategies that are practical and effective to protect public health and the environment and improve the quality of life" (Floore, 2003). IPM embraces public involvement and education as an integral component of a mosquito control program. Public pressure has forced mosquito control managers and researchers to continue to search for and develop abatement programs which are as economically viable, efficient, effective, and as environmentally sensitive as possible (Paparo-Stein, 1988; email communication, Andrew Gaffney, Entomology Technician, Calgary, Alberta, March 2001).

IPM has become an important mosquito management strategy as public opinion against wide-spread pesticide use increases. "Residents are increasingly concerned about pesticide spraying near their homes, schools, organic farms and other sensitive areas." (Beyond Pesticides, 2003). Dozens of Canadian communities have enacted by-laws to reduce or eliminate cosmetic pesticide use (Town of Hudson, 1991; Halifax Regional

Municipality, 2000; City of Toronto, 2003). These by-laws focus on 'non-essential' chemical use, and exemplify the desire to reduce pesticide use. IPM is holistic, using many control tools and addressing public concerns by reducing chemical use.

The make-up and balance of the components of an IPM mosquito control program should be designed to address the local needs and issues in the areas in which it is implemented. The presence of mosquito-borne pathogens is one of the strongest influences on the balance of program components (Conlon, 2002a; Palmisano, 2003). North America has historically had few mosquito pathogen issues relative to other parts of the world. However, North American mosquito control programs have targeted Western Equine Encephalitis, Eastern Equine Encephalitis, St. Louis Encephalitis, and instances of Yellow Fever. The 1999 arrival of West Nile virus (WNv) to North America has significantly changed the focus of mosquito control programs (Conlon, 2002b).

A shift in focus from the control of nuisance mosquitoes to the control of potentially pathogen-carrying mosquitoes has changed the role of chemical control as a component of mosquito control programs (New York State Department of Health, 2003; Gray, 2003). A Public Health Mosquito Management Strategy (Beyond Pesticides, 2002b) designed by public health officials, environmental health groups, and mosquito control specialists, outlines the balance of IPM program components depending on the local situation. The strategy states that without the presence of mosquito-born pathogens, monitoring, education, and environmentally sensitive prevention and control techniques should be the emphasized components of a mosquito control plan, and adulticiding nuisance mosquitoes should be avoided. In the presence of disease, spraying should be used only as a last resort, and in adherence to a number of safety guidelines.

In either scenario (disease or no disease) monitoring and public education are two fundamental components of mosquito control, from which other activities stem.

> *"Monitoring is an essential part of an effective mosquito management program. Tracking larval and adult population numbers, species types, and breeding locations provides invaluable information used to*

> *determine when, where and what kind of control measures might be needed."* (Beyond Pesticides, 2002b).

Monitoring mosquito species composition abundance will help to provide early assessment of disease hazard, as not all mosquito species are capable of carrying pathogens (Manitoba Health, 2003a). Sampling mosquito pools and sentinel birds for disease are additional methods of obtaining advanced warning of the presence of mosquito-borne pathogens, prior to human infection. Larviciding efforts can be targeted based on monitoring information. Larviciding reduces populations before they are perceived as problematic, and is targeted and well-defined control in comparison to adulticiding. Larviciding is a more efficient and effective method of controlling mosquitoes than adulticiding (Adams *et al.*, 2001; Colorado Mosquito Control, 2003).

Public education and awareness is the other pillar of an IPM program (Spielman and D'Antonio, 2001; Washington State Department of Ecology, 2003; Beyond Pesticides, 2002b). From public education and outreach efforts flow two important outcomes, source reduction (environmental) and personal protection (behavioural). An educated and aware population will be able to take the necessary steps to reduce pathogen transmission from mosquito to human by recognizing and reducing mosquito-breeding habitat on private property, and by personal protection. A well-educated public has the potential to reduce mosquito-breeding habitat more significantly than most mosquito control jurisdictions could hope to accomplish through source reduction alone (Miladin, 2003). Public education, in addition to reducing the number of mosquitoes in the environment and reducing the risk to the general public of contracting mosquito-borne diseases, can affect public attitude towards mosquitoes and mosquito control experts, increasing understanding of the situation and calming public fears (Nasci and Herrington, 1997; Williams, 2001).

1.5 The Winnipeg Mosquito Abatement Program

The Insect Control Branch (hereafter known as the Branch), a division of the Community Services Department of the City of Winnipeg, has carried out an organized mosquito

abatement program since 1927. The main aim of the program has been to reduce and control the number of nuisance mosquitoes in the Winnipeg area for the purpose of increasing the comfort of both humans and animals (Gadawski, 2001a). Winnipeg, being located on a flood plain, often experiences high numbers of mosquitoes when the weather conditions create good mosquito habitat (heavy rains followed by standing water). The intent of the abatement program is stated clearly in the *Annual Report on Mosquito Surveillance & Control in Winnipeg* of 1999.

> *"The Branch advocates management of mosquito populations, when and where necessary, by means of integrated programs designed to benefit or to have minimal adverse effects on people, wildlife and the environment. This integrated pest management policy recognizes that mosquito populations cannot be eliminated but can be suppressed to tolerable levels for the well-being of people, domestic animals and wildlife."* (Gadawski, 2001a)

In a minority of circumstances, the Winnipeg abatement program has been utilized as a method of reducing the spread of mosquito-borne pathogens. Until the summer of 2002, Western Equine Encephalitis (WEE) was the only mosquito disease to have touched Manitoba. WEE affects the central nervous system of humans and horses, and can be fatal. There have not been any cases of WEE infection confirmed in humans in Manitoba since 1983. West Nile Virus (WNV) was detected in birds, horses and mosquito pools in Manitoba in 2002, though there were no human cases confirmed. In 2003, the first human cases were identified in the province, with 141 cases (35 confirmed, 106 probable) and with WNv contributing to two deaths in the province (Manitoba Health, 2003a).

Winnipeg has a history of debate and conflict surrounding mosquito control methods. In the early 1970's there was a citizen movement calling for more environmentally sensitive abatement chemicals. In May of 1974, *Stein vs. the City of Winnipeg* sought to stop the City from spraying chemicals for mosquito abatement. In 2000, some Wolseley citizens organized with the goal of reducing chemical use for mosquito control in Winnipeg. About 240 private properties were registered to the de-listing program, rendering the entire district of Wolseley exempt from adulticiding efforts. In 2001 and 2002, citizens

repeated their actions and large sections of Wolseley and other neighborhoods in Winnipeg were exempt from the fogging. In 2002, following the provincial declaration of a 'health emergency', some city residents engaged in civil disobedience, and attempted to block fogging trucks from entering previously exempt areas. One protestor penned an article for the *Eco-journal*, summing protestor sentiments by writing, "We really need to halt this abuse of chemicals. The real Health Emergency that exists here is in our use and exposure to Malathion and other toxic chemicals." (Moroz, 2002).

During July of 2002, the first incidence of West Nile Virus (WNv) was detected in the Winnipeg area when it was confirmed in a dead crow. Following the confirmation of the arrival of the virus in that bird, the Provincial Minister of Health declared a 'health emergency' for the region. The City of Winnipeg declared their intent to treat the entire city with malathion via ULV ground application, using the city fogging trucks. The decision to treat the entire city meant de-listed properties would no longer be exempt.

Since the arrival of WNv to Manitoba, the issue of mosquito control has expanded from the regions of Brandon and Winnipeg, to a provincial issue. In April of 2003, the Government of Manitoba publicized an "aggressive $5.8 million strategy to address the threat of West Nile virus in Manitoba" (Manitoba Health, 2003). With this strategy, the City of Winnipeg will be partnering with the province of Manitoba and the Winnipeg Regional Health Authority. A portion of the funding ($3.6 million) will be allocated to a cost-shared mosquito control program of larviciding and/or adulticiding for areas outside of Winnipeg.

1.6 Purpose

The purpose of this project was to examine environmentally sensitive mosquito control options and to examine public opinion on mosquito control issues in Winnipeg, Manitoba. The goals of the project were to test the effectiveness of environmentally sensitive mosquito control products, to improve the access to information about mosquito educational tools for middle years educators, and to gather information from the public

and make recommendations for improvements to the Winnipeg Mosquito Abatement program.

1.7 Objectives

To achieve the above mentioned purpose and goals, the specific objectives of the study were:

1. To gather and analyze information from Winnipeg residents regarding their knowledge of mosquitoes and their control.

2. To identify non-toxic mosquito control methods and test them for effectiveness and viability in an urban setting.

3. To create an annotated bibliography of mosquito educational tools appropriate for middle years school children.

4. Based on the findings of the above objectives, to make recommendations on how to improve the Winnipeg IPM mosquito abatement program.

1.8 Methods

The research project consisted of a number of case studies that addressed the objectives. A mixture of quantitative and qualitative science was utilized. Case studies involving non-chemical controls, community level communication and education, and formal education were conducted. The particular methods for each of these case studies are detailed in Chapter 3.

Fieldwork was conducted over an eighteen-month period spanning from May of 2001 to October of 2002. The chosen area of study was the City of Winnipeg. The majority of quantitative product testing was conducted in the district of Wolseley, located in central Winnipeg, with some testing conducted at the Fort Whyte Nature Centre, located on the southwest edge of Winnipeg. Structured quantitative and qualitative feedback was gathered from volunteers participating in the product testing. Semi-structured interviews

were conducted with residents from three areas of the city and from riverfront property owners. The interviewees were selected randomly to represent an average cross section of Winnipeg citizens in education and community awareness. Mosquito educational tools were identified and whenever possible purchased. Educators from Laura Secord Middle School, located in Wolseley, and from John Gunn School, located in Transcona participated in contributing feedback regarding these educational tools.

1.9 Limits of the Study

The assessment of environmentally sensitive mosquito control products was limited to only two products currently available on the market. It was also limited to testing the effectiveness of single mosquito control products in urban and rural areas. No attempt was made to assess the effectiveness of these two products when utilized in confined areas with finite mosquito populations, or when these products are used in numbers greater than one (i.e., multiple machines or application greater than stated label directions). Time is a limitation, as products were assessed over the course of two mosquito seasons. Summer seasons often vary in the mosquito pressure and species of mosquitoes present, which could have bearing on the subsequent results. The study was focused specifically on the Winnipeg case study, and due to a wide range of variables that affect mosquito populations, the results may not be directly transferable to other mosquito abatement jurisdictions.

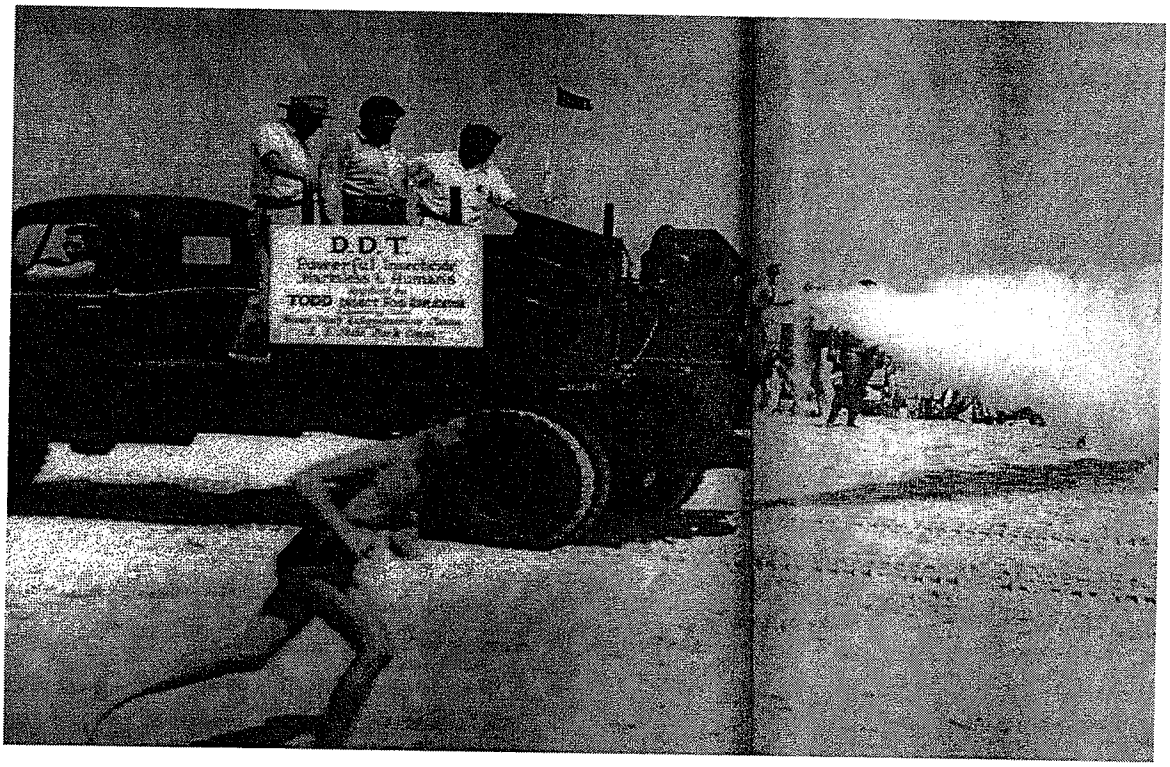
Additionally, the study component involving semi-structured interviews is limited to an analysis of the current level of knowledge and understanding that Winnipeg citizens hold regarding mosquito biology and the Winnipeg abatement program. The results of the interview data are dependent on those who agreed to participate, and therefore may be somewhat different than if a perfectly representative cross-section of citizens was selected and required to participate in the interviews.

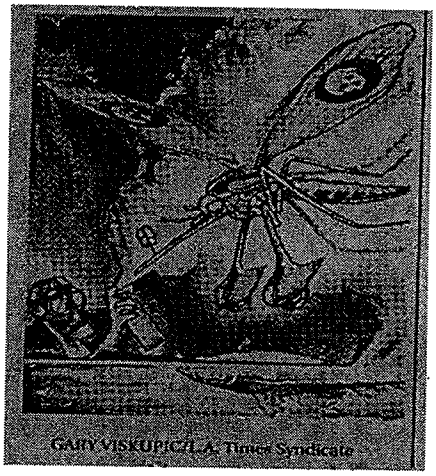
Finally, the annotated bibliography was limited to the educational tools that were available for purchase. The contents of the annotated bibliography are limited to the

feedback of the selected number of educators who agreed to participate in the study. The feedback contributed is likely based on current educational philosophies and current topical issues within the field of mosquitoes and mosquito control.

1.10 Organization

The thesis is organized into six chapters. Following the introduction, Chapter 2 is a review of related literature. Chapter 3 contains the methods used and the design of the experiments and the study. Chapter 4 includes the analysis and results of the product testing and Chapter 5 contains the surveying and annotated bibliography outcomes, and involves discussion of the results of these projects. The thesis culminates with Chapter 6, which is a re-cap of recommendations for current mosquito abatement program managers, recommendations for future research in the field and reflections on the project.





Chapter 2: Mosquito Control

2.1 Introduction

Concepts and discussions key to this project are introduced in this chapter. Jurisdictional mosquito abatement actions, discussions and rulings surrounding pesticide use and registration, educational programs and educational ideology regarding mosquitoes, and new and emerging approaches and challenges to mosquito control, specifically West Nile virus (WNv), are included. This chapter is an examination of the motivators for these key discussions, and provides context and clarity of the need for this project.

2.2 The Problem with Mosquitoes

Mosquitoes
By Bryan Paradise

Mosquitoes, Mosquitoes are a pain in the neck
They bite so hard that it hurts like heck.
Mosquitoes, mosquitoes, they are mean, nasty pests.
They go in the water and use it as a nest.
Mosquitoes, mosquitoes carry Yellow Fever,
Just imagine how sick it could make a beaver.

Mean Mosquitoes
By Georgia Akehurst

Annoying mosquitoes are
Nasty bugs that
Buzz around my head
And bite me really hard
Leaving itchy welts.
I hate Mosquitoes!

Bryan and Georgia were grade 6 students at Belvidere Elementary School, in Belvidere-Warren County, New Jersey when they wrote these poems in 2002. These poems highlight two of the three main problem issues linked to mosquitoes. These two issues (which will be discussed before the third) are disease and human health issues, and the annoyance factor caused by mosquitoes.

Mosquitoes can carry pathogenic organisms, and have killed more people through history than every war combined (Spielman and D'Antonio, 2001). They have played a major role in development, for example, in determining the progress of the building of the Panama Canal (LaFeber, 1978). They have influenced the winning and losing of wars, and the success of missionaries and those who would go out and conquer new territories.

> *When unable to defend herself by the sword,*
> *Rome could defend herself by means of the fever.*
>
> - The poet Godfrey of Viterbo, 1167

The poet was referring to the high incidence of malaria in Rome, the endemic local immunity, and the vulnerability that would-be invaders had to the disease.

Malaria, Yellow Fever, Dengue Hemorrhagic Fever, encephalitis[1], and other viruses[2] are transmitted by female mosquitoes. Although the World Health Organization, and many other local and global organizations have endeavored to reduce human illness resulting from mosquito-borne pathogens, they are still a significant threat too much of the world's population. Martens and Hall (2000) described the impact of malaria. Approximately 40% of the global population is at risk of contracting malaria (the world's most prevalent vector-borne disease) and there are 300-500 million infections every year, noting that approximately two million deaths are attributed to malaria annually, half of which are children under five. Resistance to drugs has plagued the war on malaria, as with many other mosquito-transmitted diseases. Though malaria is probably the most significant mosquito-related human health-threat on the planet, the numerous other mosquito-born diseases add up to a millions of maladies and fatalities every year. These immense health impacts are an important reason to conduct effective mosquito control.

The second problem associated with mosquitoes is the nuisance factor. No one welcomes the whine of an approaching mosquito, even if mosquito-related diseases are not endemic in the area. Mosquitoes can cause discomfort for people and animals alike. Not only do mosquitoes make summer months less enjoyable (unbearable to some), but also they can interfere with tourism and cause local economic damage (Goddard, 2002). This negative reaction caused by the blood-sucking activities of mosquitoes is enough for many people to justify mosquito control activities.

[1] They include Western Equine, Eastern Equine, Japanese, St. Louis, and more.
[2] They include West Nile, Ross River, and others.

The third problem with mosquitoes is not a function of mosquito activity, but of human reaction to mosquito activity. The third problem with mosquitoes is the 'human problem'. This includes environmental damage and human health impacts caused by mosquito control programs, and community conflict regarding these control methods. Misha Mayer of El Passo Texas was nine years old when she wrote, 'I am the Ill Earth' in 1991. Though not specific to mosquito control, it describes negative impacts that human activities can have, and that damaging the earth is not only intrinsically bad, but is bad for the future of people. Concern for the environment predates Rachel Carson's *Silent Spring* (1962), but that book almost single-handedly created awareness on the issue of environmental damage caused by pesticide use, and 'shook the world awake' (Hynes, 1989). Carson discussed the problem of conducting pest management with chemicals.

I am the Ill Earth
By: Misha Mayr

I am the ill Earth
People have cut down the trees,
Which are my lungs.
They have polluted the streams,
Which are my blood vessels.
They have polluted the oceans,
Which are the chambers of my heart.
My wrath has gotten gigantic.
My wrath is hurricanes and tornadoes.
I am the ill earth.
If people trash me,
I will die and so will they.

> *"The concepts and practices in applied entomology for the most part date from the stone age of science. It is our alarming misfortune that so primitive a science has armed itself with the most modern and terrible weapons, and that in turning them against insects, it has also turned them against the earth"* Rachel Carson, *Silent Spring*.

People have become sensitive to problems associated with pesticide use. Citizen groups striving to reduce pesticides have sprung up in Canada and the United States. The Canadian Coalition for Health and the Environment is the national campaigning body to which dozens of local anti-pesticide groups belong (CCHE, 2003). In Manitoba, CROW (**C**oncerned **R**esidents **o**f **W**innipeg) focuses on the reduction of pesticides relating to mosquito control in Winnipeg. Beyond Pesticides is the American national anti-pesticide campaigning body that seeks 'safe air, water, land and food for ourselves and future generations' (Beyond Pesticides, 2003). Beyond Pesticides has engaged in the mosquito control debate, especially in light of WNv. Dozens of municipalities in Canada have adopted 'cosmetic' chemical by-laws, indicating a decreasing tolerance level to non-essential pesticide use. Reducing the amount of chemicals being used has implications

for the way in which mosquito control is conducted. Fewer chemicals will require greater innovation and improving other components to the program.

However, as with all issues, there are two sides. Many people feel that the risks from chemical mosquito control are small or none, and feel that the benefits derived from control, be it reduced annoyance or potential for disease transmission, are worth the risks.

> *"Look, I'd sooner live a few less years and enjoy my yard."* – Dennis Jason, Wolseley Resident on the matter of fogging for adult mosquito control. (O'Brien, 2000).
> *"I appreciate the concerns (of opponents to fogging) but it's real frustrating not to be able to enjoy being outdoors. Our summers are so short as it is."* – Scott West, Wolseley Resident speaking to the issue of fogging for adult mosquito control (O'Brien, 2000).

Communities in Winnipeg have been divided on how the city should conduct mosquito control. Responding to these opposing opinions has been the challenge which faces mosquito control districts.

The risk mosquitoes can pose to human health, the annoyance they can cause, and the risks involved with the attempt to control these insects culminate to create the 'mosquito problem'. Mosquito control experts strive to create effective programs, and balance them with the feedback that they receive from the public regarding chemical use.

2.3 Risk and Pesticides

Pesticides have created improvements to the quality of human life. The reduction of vector-borne pathogens, increased agricultural productivity, enhanced aesthetics, and increased comfort for people and animals has been facilitated, at least in part, by pesticide use. Most modern chemical pesticides, when applied in accordance with their label specifications, are safer than their predecessors. Since the 1960's, there has been a shift in developed countries, and to a lesser extent in developing countries, from persistent, bioaccumulating pesticides, to much less persistent pesticides (van Emden and Peakall,

1996). Other advances in pesticide usage include the IPM approach, which may reduce the amount of pesticide used, and life-cycle analysis, or the 'cradle-to-grave' approach for handling chemicals, which ensures that proper production, use, and disposal of the chemical take place.

Despite the advances made in handling, use and registration regulations, there continues to be an innate element of risk associated with pesticide application. The ultimate function of pesticides is to kill 'undesirable' living organisms including plants, mammals, birds, and insects; in other words, they are biocides. All of the best use and regulation registrations could not completely remove the risk associated with chemical pesticide use. The level of specificity with which pesticides address their target ranges from broad spectrum to fairly specific, though none are explicit. Human health and the environment are not exempt from poisonous effects, and can be affected by pesticides in a serious and negative manner (Pimentel *et al.*, 1993).

The World Health Organization and United Nations Environmental Programme (1989) reported that there are one million human pesticide poisonings in the world each year, with about 20,000 deaths. There are six major categories that encompass human health effects from pesticide over-exposure (Schuman, 1993). Though only listed briefly in this work, each of the categories has a detailed body of medical literature based on human and animal data. The categories one and two are generally related to industrial accidents or gross misuse of pesticides. Categories three to six are more relevant to this study as they have greater potential to apply to the average citizen. The six categories are:

1) *Acute toxicity* – acute exposure with direct physical damage
2) *Subacute, delayed toxicity* – delayed physical effects requiring weeks or months after the acute exposure to be detected
3) *Chronic, cumulative toxicity* – the most difficult to establish due to long latency period between exposures and detectable health effects
4) *Reproductive effects* – including sterility and birth defects
5) *Hypersensitivity* – difficult to diagnose. Most common effects can include lung complications and cardiovascular anaphylactic shock.
6) *Psychological conditioning* – this is well documented to time/place exposures to chemicals and is difficult to treat and diagnose.

The acute and the more chronic health effects of pesticides warrant social concern. Unfortunately, while acute and subacute toxicity of most pesticides are well documented, information on chronic pesticide-related human illnesses is not as sound (Wilkinson, 1990). The International Agency for Research on Cancer found 'sufficient' evidence of carcinogenicity for eighteen pesticides, and 'limited' evidence of carcinogenicity for an additional sixteen pesticides based on animal studies (WHO/UNEP, 1989). The understanding and acceptance of the inherent risk involved with pesticide use is important because, as Pimental *et al.* (1993) put it, "Chronic health problems are a public health issue, because everyone, everywhere, is exposed to some pesticide residues in food, water, and the atmosphere."

Perhaps the most controversial risks associated with pesticide use are the potential effects on the most vulnerable members of our society, children. During the early years of life, the body and brain are not fully developed. It has been shown that early exposure to pesticides, even at low doses, can cause permanent and irreversible damage (Zahm and Ward, 1998; Ma *et al.*, 2002; Bremmer, 2003). Guillette *et al.* (1998) examined pre-school children from the same genetic background to compare those living in a farming valley where pesticides were used, with those from the hills where pesticides were not used. The only significant environmental difference between the two groups of children was their exposure to pesticides. The children from the valley had lower gross and fine motor skills, less stamina, poorer memories, and were less creative in their play than those from the pesticide-free hills. The study shows that pesticide exposure, at an early age, can have serious developmental consequences on children.

The federal Standing Committee on Environment and Sustainable Development (2000) explained that children are more vulnerable because they run a greater risk of exposure to pesticides. They eat more food, drink more water and breathe more air per kilogram of body weight than adults. "Thus, they can absorb larger quantities of the pollutants persistent in the environment." (SCESD, 2000). Furthermore, children have an appreciably different diet than adults, consisting largely of milk, fruits and vegetables,

and the younger they are, the more limited their ability to metabolize and eliminate residual toxic substances (Anonymous, 1999; Curl *et al.*, 2003). Regulations and policies are designed to protect adults and refer to the healthy seventy-kilogram male, not the seven-kilogram child (Canadian Institute of Child Health, 1999). All of these factors combine to create a greater risk to children when pesticides are utilized.

Pesticide use, depending on the types of chemicals applied, and the application method and dosage, also creates a certain level of risk to the natural world outside of human health. The Union Carbide insecticide plant disaster in Bhopal, India, is a potent example of the extreme damage that pesticides can cause to the environment (Sufrin, 1985). Incidents as catastrophic as this, though much discussed and scrutinized, are few and far between. Perhaps more important and less recognized are instances of smaller scale environmental damage from chemical pesticides, which are much more common than the Bhopal disaster (Bradford, 1993).

Contamination of water sources is an example of prevalent worldwide environmental damage that can result from pesticide misuse or overuse. Globally, concern for water safety has become a major issue (Bradford, 1993). Aquatic organisms are particularly susceptible to pesticides because contamination can spread rapidly through an aquatic system, and there may be no escape for the inhabitants (Edwards, 1993). In most developing countries, reports of fish kills by pesticides are very common, particularly in summer (Muirhead-Thomson, 1971). Pesticides can fall out from aerial sprays on water or eventually reach aquatic systems such as rivers or lakes through drainage or by runoff and soil erosion.

Pesticide damage to terrestrial non-target organisms such as bees and earthworms is another environmental risk imposed by pesticide use (PMEP, 2001). Many of these species carry out important biological tasks, and pesticide application runs the risk of disrupting the environmental balance. Birds are susceptible to many pesticides and were a central focus of *Silent Spring* (Carson, 1962). They are identified as an important indicator of toxicity and pesticide registration processes often require effects on

designated species be examined. Recording the number of birds killed by pesticides is a common practice in many countries (Hardy, 1990). Mammals are also at a certain level of risk with pesticide use. Many chemical pesticides are not for use on crops where wildlife may be foraging nearby (PMEP, 2001).

Bioaccumulation or bioconcentration of pesticides in the environment is a problem. Pesticides are taken up into the bodies of organisms, and many are metabolized rapidly. However, some compounds (including most organochlorines) bioaccumulate. At each step of the food chain, the pollutant is concentrated as organisms consume and absorb more pesticide than they are able to metabolize and excrete. In 1967, fish-eating birds from a Long Island salt marsh estuary contained almost a million times more DDT than could be found in the water (Keeton, 1980). Women's breast milk, often an infants' sole food source for the first months of life, has been found to contain more than five times the 'safe' levels of PCB's and pesticides in some geographical areas (Calamai, 2000; Ayotte *et al.*, 2003). Findings such as these reinforce the need to use the safest pesticides available and to reduce the use of chemicals to the extent possible.

"Organophosphate insecticides are a major health hazard globally" (Karalliedde and Senanayake, 1990). Concerns have been raised on the possibility that repeated (over months or years) exposures to organophosphates may cause central nervous system damage in the absence of overt toxicity (Davies, 1991; Mearns *et al.*, 1994; Stephens *et al.*, 1995). Individuals repeatedly exposed to low levels have been reported to suffer from different and subtle alterations of memory, concentration, mood or behavior (Lotti, 1992). However, Epidemiological studies conducted so far lack a precise assessment of exposure levels or expected neurological symptoms resulting from the exposure (Maizlish *et al.*, 1987; Stephens *et al.*, 1995).

Malathion is currently the mosquito aduliticide of choice in Winnipeg, Manitoba because of its low toxicity to mammals as compared with insects, and it is not as persistent in the environment as other like pesticides (Brown *et al.*, 1993). However, it is important for both the public and pest control program managers to understand the innate risk

associated with any level of chemical pesticide use. "No pesticide is 100% safe and care must be exercised in the use of any pesticide." (Floore, 2003). The majority of reported pesticide poisonings occur in developing worlds where the registration and handling instructions and regulations are generally not as rigorous (Committee, House of Commons Agriculture, 1987). However, it may be that chronic effects of pesticides ultimately have the greatest impact on people, as they have the potential to affect a much larger portion of the population. Similarly, subtle environmental effects may prove to have much greater and far-reaching impacts than large scale, but rare, environmental disasters such as Bhopal.

2.4 Recommendations for Pesticide Use

> ***The use of pesticides must come to be regarded as a measure of last resort rather than the option of choice. Attitudes about pesticide use must be changed through aggressive public education programs. Effective steps must be taken now to protect human health and the environment against the risks associated with pesticide use.*** – *Recommendations from the Standing Committee on Environment and Sustainable Development, 2000.*

Despite improvements in pesticide handling, application, and the compounds utilized, public scrutiny surrounds the issue. Concerns focus on the effects of chemicals on the environment, and human health (Paparo-Stien, 1988; Gaffney, 2001; CCHE, 2003). Pesticide use in urban areas and for cosmetic or non-essential purposes is often debated. The amount of chemical being used, the number of different compounds being used and mixing in the environment, health problems related to persistent exposure, and the uncertainty of exposure effects on children are the main points of concern. The crux of the issue is that the chemical use is for non-essential purposes: not for food production or disease prevention, but for cosmetic and comfort purposes.

Government agencies are responsible for regulating and directing the registration and utilization of chemicals and pesticides. In Canada, the federal Pest Management

Regulatory Agency (PMRA) is responsible for all pesticide registration and labeling. Provincial governments have authority over licensing pesticide dealerships and issuing pesticide use permits.

In May of 2000, the federal Standing Committee on Environment and Sustainable Development (SCESD) submitted a report entitled *Pesticides: Making the Right Choice for the Protection of Health and the Environment* to the Canadian Government. The report dealt with the extent of, and the reasons for, the use of pesticides. The impact of pesticides on human health and the environment were examined closely, as well as economic implications and the administrative responsibility for regulating pesticides.

In the executive summary of the SCESD report, it was stated that if Canada is to retain good public health and rich natural biodiversity, "decisive action must be taken to curb the use of pesticides and other harmful pollutants". The committee found that "urban populations contribute significantly to the presence of pollutants in the environment." In particular, the sensitivity of children to pesticides and their increased likelihood of being exposed to them were examined. The committee recommended that the upcoming redrafting of the thirty year-old *Pest Control Products Act* embrace some fundamental principles that will guide future pest management decisions. The committee stated "...the new Pest Control Act prohibit the registration or re-registration of pesticides intended for cosmetic use", and that "...the government...develop a strategy for the gradual phase-out of pesticides used for cosmetic purposes."

The federal government's response to the Standing Committee's report (2000) was to affirm the principle of "absolute priority for health and environmental protection" as well as a number of other fundamental principles espoused by the SCESD. Further to this comment, the government stated, "the PMRA is undertaking a priority re-evaluation of the most commonly available insecticides". However, the government did not agree with the SCESD recommendations to eliminate cosmetic pesticides. The federal government stated that the Pest Control Products Act places absolute priority on health and the

environment by "prohibiting the registration for use in Canada of any pest product that may pose an unacceptable risk to people's health or the environment."

In light of the government response, some changes are being made to pesticides under review, which will have direct relevance to mosquito abatement programs. Chlorpyrifos[3] registration is currently undergoing a phasing-out program in alignment with the actions taken by the Environmental Protection Agency of the United States. The product will no longer be available for residential uses, and will be removed from labels of Commercial Class products. In addition, other uses of Commercial Class products in areas such as schools and playground will be discontinued (PMRA, 2000). In the 2000 Annual Report on Mosquito Surveillance & Control in Winnipeg, Gadawski said the change to chlorphrifos use "...has serious implications for the Insect Control Branch because of our reliance of chlorpyrifos for the majority of our mosquito larviciding program." (Gadawski, 2001). Changes to the Winnipeg mosquito control program were fully implemented by the summer of 2002 (Gadawski, 2003).

A growing trend is emerging in Canada regarding the legislation of the use of cosmetic pesticides. In 1991, the town of Hudson, Quebec became the first Canadian municipality to enact legislation banning the use of cosmetic pesticides (Town of Hudson, 1991). The Halifax Regional Municipality enacted similar legislation in 2000 (Halifax Regional Municipality, 2000). Dozens of other smaller municipalities have done the same. Most recently, on May 22, 2003, the Toronto city councilors voted in favour of a by-law to restrict cosmetic pesticide and herbicide use (Muhtadie, 2003). These by-laws generally include a list of environmentally acceptable pesticides, and a notwithstanding clause that enables pesticide use when a serious infestation occurs or there is a health threat. In addition, these by-laws feature a phasing-in period that starts with education, then reduction, and finally total cessation of cosmetic pesticide use.

There has been some struggle to enact these by-laws in Canadian municipalities. The Hudson by-law was challenged by a chemical company, and carried to the Supreme

[3] Chlorphyrifos is a chemical larvicide currently in use by the City of Winnipeg Insect Control Branch.

Court of Canada. In the case of 114957 Canada Ltée (Spraytech, Societé d'ârrosage) v. Hudson (Town), the Supreme Court of Canada upheld the right of the town of Hudson to legislate the use of cosmetic pesticides within the boundaries of the municipality (SCC, 2001). On June 23, 2003, a collective from the pesticide industry announced they would challenge the Toronto by-law on the grounds that the City Council did not have the right to restrict pesticides based on the Ontario Municipal Act (Lu, 2003). City councilors speculate that the Hudson decision will set a precedent and the by-law will stand.

In Winnipeg, there have been some casual talks regarding a pesticide by-law (Cowan, 2003), but thus far no formal action has been taken to create one. A recent Civic Environmental Committee of Winnipeg survey (2002) probed public perception regarding pesticides. About 40% of participants felt they needed to be better informed on pesticide issues and almost 90% felt that, as a community they should increase spending on organic pesticides. A willingness to avoid pesticide use was indicated by approximately 75% of those polled. It would appear that banning or regulating non-essential pesticides could become a reality in Winnipeg, given that people are concerned about the issue. The opinions expressed in the survey certainly have implications for pesticide use in the mosquito abatement program in that people are more interested in organic alternatives to chemical pesticides.

2.5 A Detailed Review of the City of Winnipeg Mosquito Abatement Program

The City of Winnipeg has the longest history and currently conducts the most extensive and organized mosquito control program of any municipality in Canada. The program has been running since 1927, and has undergone a number of changes through the years in terms of how mosquito control is conducted, the products used, area covered, and budget allocated to this endeavour.

Abatement efforts were historically based on the *City of Winnipeg Act*. However, in 2002, the *City of Winnipeg Charter* was passed, and this has replaced the *City of Winnipeg Act*.

In an annual report, (Gadawski, 2001), it was stated that an IPM program for mosquito control is conducted in Winnipeg. The Branch listed breeding habitat surveillance and alteration, larviciding with chemical and biological insecticides, adulticiding with chemical insecticides, disease monitoring, public relations and public education as tools used to control mosquitoes in Winnipeg. In 2000, 85% of the Branch operational budget was spent on spring and summer larviciding, and 11.3% was spent on adulticiding. According to the 2000 Annual General Report, 3.6% of the budget remained for other aspects of the mosquito control program (habitat alteration/reduction, public education/relations, and monitoring and surveillance).

In the 2001-2003 period, the Insect Control Branch mosquito control program has changed significantly with the operational budget having increased by more than 100% (Gadawski, personal communication, November 25, 2003). The Branch spends more than $100,000 each year on mapping standing water sites in and around the city, they have increased the number of New Jersey Light Traps and CDC Light traps that they operate for adult mosquito surveillance, they an estimated $21,000 annually on 'dead bird surveillance' relating to West Nile virus, and they have increased the sentinel bird flock by approximately double (Gadawski, personal communication, November 25, 2003).

The Branch has not been overly active in the area of public education and communication in the past relative to other North American mosquito control programs. The total of the communication and public education efforts, according to branch employees, has been:

- media coverage of the branch activities
- public displays at community events (two events in 2003)
- approximately one hundred 'back yard inspections'[4] in the latter half of the season (when employees get some free time)
- responding to questions that come in on the 'bugline'
- maintenance of the Insect Control Branch website – (Moffat, Winnipeg Insect Control Branch employee, personal communication, telephone, 12 June, 2003)

[4] Employees respond to complaints of excessive mosquito breeding sites, leaving suggestions for improvements.

In the past, some school outreach has been conducted, but not in recent years according to Branch employees (Moffat, Winnipeg Insect Control Branch employee, personal communication, telephone, 12 June, 2003). There has been no advertising conducted by the Branch (billboards, newspaper or radio ads, or television commercials) regarding mosquito issues. In the spring of 2003, the Province of Manitoba began an advertising campaign to educate Manitoba citizens about reducing mosquito-breeding habitat. This campaign featured television commercials and billboard advertisements.

The webpage and a 'bugline' are maintained to keep Winnipeg residents informed and educated on mosquito issues in Winnipeg. A Branch employee was tasked with responding to bugline calls as part of her responsibilities. The webpage was limited to the format of the City of Winnipeg website layout, and therefore did not include extensive and detailed information on mosquito issues in Winnipeg. The webpage included a description of the mosquito life cycle, including pictures of each stage, a link to a West Nile Virus Fact Sheet (supported by Manitoba Health), information about reducing standing water on private property, and information about personal protection from mosquitoes. The website could be accessed through www.bugline.com.

A new education project called 'TEAAM' was initiated by the Branch during the spring of 2003. TEAAM stands for **T**argeted **E**nvironmental **A**ction **A**gainst **M**osquitoes, and had the goal of reaching 40% of homes (approximately 1,000) in Wolseley and Garden City to conduct environmental education, dispense personal protection information, and conduct backyard audits. Sixteen summer student employees were allocated to the task of visiting these homes and carrying out the TEAAM objectives. Community consultation was conducted with members of the Wolseley community regarding the design of this project (Davis, Winnipeg Insect Control Branch employee, personal communication, telephone, 17 June, 2003).

The City of Winnipeg Insect Control Branch has received increases in budget allocation over the past few years, and in 2003 the provincial government proposed a partnering in mosquito control (Manitoba Provincial Government, 2003b). Little of these funds have

been allocated to any aspect of the mosquito control program except larviciding and adulticiding. Additional funding has been provided by the 'Blueprint for Action', an additional co-operative venture between the city and province. Some of this funding has been allocated to improved education ($145,000) and some to the TEAAM project ($150,000).

2.6 Other Mosquito Abatement Programs

The City of Winnipeg mosquito abatement program conducts the most extensive control measures of any district in Canada. However, in the United States of America, there are dozens of mosquito control districts with larger budgets and more extensive control operations than Winnipeg. The American Mosquito Control Association is the umbrella organization in the United States that functions to disperse information relevant to mosquito control, and to facilitate discussion between entomologists and industry professionals. Australia is similar to the United States, with a central umbrella organization and a number of members that conduct mosquito control across the country. Europe features an integrated mosquito control program that combines the efforts of numerous countries and conducts mosquito control that focuses on environmentally sensitive control options.

The majority of mosquito abatement programs embrace an Integrated Pest Management (IPM) approach, at least in theory. However, the mosquito abatement programs themselves are unique from jurisdiction to jurisdiction. As discussed in the first chapter, an IPM approach may include any of the following components, the roles of which may vary;

- *Education (formal programs, media relations, and public outreach)*
- *chemical control (larval, pupal, adult stages)*
- *non-chemical control (larval, pupal, adult stages)*
- *habitat alteration (source reduction)*
- *monitoring and surveillance.* (Rose, 2001)

Mosquito control and the structure of mosquito control programs have often been subject to public and political debate. "Community mosquito control is one of the more political struggles with which a pesticide reform activist can be involved." (Swadener, 1994). There are a number of variables that must be considered prior to the implementation of a program. Disease threats, the degree of summer mosquito infestation, access to information (alternatives, implications of control methods, and so on), and the particular values and worldviews of a community affect the type of program implemented (Swadener, 1993).

Worldviews include social priorities, economic considerations, and environmental priorities. These factors are important in understanding the scope and means of an abatement program. Also important are environmental factors in the control area. Differences in mosquito species present, selected breeding habitat, emergence patterns, and mosquito biology necessitate variation between control programs. "To provide an effective solution to each particular problem, the approach towards mosquito control must necessarily vary, so that a method of attack found effective in one district may only be of marginal value in another." (WHO, 1967). The following section is a review of selected mosquito control programs and reveals that IPM approaches can vary substantially from jurisdiction to jurisdiction. In fact, many of the jurisdictions that claim to implement an IPM program are implementing only one or two mosquito control approaches, and not capturing the 'integrated' portion of IPM.

Edmonton, Alberta

This program dates back to a 1940's volunteer-based effort. The formal abatement program, developed by the University of Alberta, has been in place since 1974. The program targets strictly the larval stage of nuisance mosquitoes. Adult control measures are not utilized in Edmonton. Chemical (Dursban 2.5G, active ingredient chlorpyrifos), biological (Vectobac®, active ingredient *B.t.i.*), and growth hormone (Altoside®, active ingredient methoprene) products are used to kill mosquito larvae. The chemical product is more economical to use, and biologicals are reserved for 'sensitive' areas, such as near beehives or playing fields. In 1991, a source reduction program was implemented.

Intensive monitoring of breeding sites is conducted over an area of 1400 square kilometers. Written consent from landowners is required for larviciding and 90% of landowners give permission to carry out abatement efforts on their property. Edmonton does not have an education program. Public education is limited to sparse information on a City website and through the media (City of Edmonton, 2001). With larviciding and surveillance comprising the two main program components, Edmonton falls short of a true IPM program.

Calgary, Alberta

Adulticiding is not conducted in Calgary because mosquitoes are a nuisance and quality of life issue, not a disease issue (Andrew Gaffney, Entomology Technician, City of Calgary, personal communication, email, 7 March, 2001). Public opinion has presented challenges to the program organizers. Until 2000, both chemical (Dursban 2.5G, active ingredient chorpyrifos), biological products (*B.t.i.*), and juvenile hormones (Altosid®, active ingredient methoprene) were used for larviciding. Like Edmonton, Calgary recognized that chemical products are cheaper, and somewhat more effective in cooler temperatures. However, in light of research indicating potential negative effects on human health, and an intense public outcry in response to that research, Calgary made a political decision to cease using Dursban in 2001. Calgary does not have a comprehensive educational or habitat reduction program. A surveillance program exists, but is limited compared to other jurisdictions. Calgary therefore really only conducts larviciding, and does not carry out an IPM program.

Brandon, Manitoba and Regina, Saskatchewan

These jurisdictions conduct similar abatement programs. Both conduct larviciding only. Mosquito larvae are controlled using only the biological product Vectobac 200G. Education is an important component of the Brandon program according to program managers (R. Bailey, City of Brandon Entomology Technician, personal communication, email, 15 February, 2001). However, education is conducted mostly by media, with some limited outreach at public events. The City of Regina also conducts public education through media and on their web site (City of Regina, 2001). Breeding site

evaluation and population monitoring are conducted in both cities. These programs do implement fairly extensive monitoring, and have conducted some breeding site 'evaluation', but those aspects, even when combined with the small education efforts do not amount to a mosquito control program that follows the philosophy of IPM.

Greater Moncton Pest Control Commission, New Brunswick

Moncton first conducted organized mosquito abatement in 1954. Today, the Greater Moncton Pest Control Commission (GMPCC) oversees abatement efforts. The GMPCC is comprised of three municipalities and gathers outside support from provincial financial contributions. The program consists of three distinct phases:

1) Monitoring of mosquito larvae densities throughout the Greater Moncton area.
2) Application of (only) biological larvicides.
3) Follow-up post application counts.

It is estimated by the GMPCC that the program successfully reduces the mosquito population by 70%. Monitoring is an essential and significant component of the abatement program with more than one hundred and ninety sites that are monitored on a continuous basis. Alterations to natural drainage systems and filling of low-lying areas are also undertaken to enhance the program effectiveness. Educational efforts are improved over previously discussed mosquito abatement programs in Canada, though they are still rudimentary in comparison to some American programs. Educational efforts include:

- communication through the media;
- personal visits to owners of land that may breed significant numbers of mosquitoes;
- maintenance of an extremely detailed web site. The site includes annual reports, tips to reduce breeding habitat, methods to avoid getting bitten, mosquito facts and fiction, a list of services provided by the GMPCC, as well as detailed information on larval counts, larviciding techniques, and muskrat, nesting bird, and stream surveys.

Metropolitan Mosquito Control District, Minnesota

The Metropolitan Mosquito Control District (MMCD) is one of the largest mosquito control districts in the United States, and is nationally recognized for its expertise and uses of the latest mosquito control techniques (MMCD, 1998). MMCD provides a comprehensive and integrated pest management program that utilizes a variety of mosquito abatement techniques to provide mosquito relief over a geographically large area. The program covers an area of almost 6,740 square kilometers (seven metropolitan counties in Minnesota) and 2.5 million people. The mission is to "promote heath and well being by protecting the public from disease[5] and annoyance caused by mosquitoes, black flies, and ticks in an environmentally sensitive manner" (MMCD, 2000). The management strategy includes: larviciding, adulticiding, public education, mapping of breeding habitats, and monitoring of habitats, population numbers, non-target species, water quality, and disease vectors. MMCD also monitors public perception and value of the mosquito abatement program. This information is used to establish the efficacy of and need for the program.

MMCD uses Altosid® (active ingredient methoprene) and Vectobac® (active ingredient *B.t.i.*) for larval control. Adulticiding is conducted using permethrin and resmethrin, synthetic pyrethriods that are broad-spectrum, non-target-specific pesticides. They are mildly toxic to birds, but are very toxic to fish and other aquatic species, as well as bees and other insects (PMEP, 2001). Like the Winnipeg program, adulticiding implementation depends upon a threshold of trapped mosquitoes.

Education and public outreach is a larger component of the MMCD program than in other programs thus far reviewed. Public relations work takes place through the media, public events, the MMCD website, the Adult Mosquito Control Information Line, information booths, public opinion surveys, notification studies, customer satisfaction surveys, the 'Adopt-A-Site' program, and pamphlet information. In 1998, an expanded customer survey was undertaken to gauge customer satisfaction with the abatement program and

[5] Mosquitoes transmit disease in this abatement jurisdiction. In 1999, three cases of LaCrosse encephalitis occurred in the District. Sentinel chicken flocks detected no evidence of Western equine encephalitis.

need for the program. The survey showed that "all participants had negative experiences with mosquitoes and valued the services provided" (MMCD, 2000). The survey also determined that "some participants were concerned about the environmental impact of the District services, but most felt that the value of having some relief outweighed these concerns" (MMCD, 2000).

Pamphlets were comprehensive, containing technical aspects of the abatement program as well as mosquito biology and facts, surveillance information, tips on backyard control, and mosquito borne diseases (MCCD, 2001). One shortcoming of the brochure is that it does not provide the risk to humans, the environment, and non-target organisms with program implementation. "Participants responded well to educational materials that provided information about the generally benign nature of the District's treatment services, and felt that it would be important to disseminate this information to quell public fears about the toxicity of the treatment."(MCCD, 2001). This result is not surprising, because the pamphlet lacked information regarding negative effects.

Overall, the MMCD is conducting a well-rounded mosquito abatement program that includes all of the components of an IPM program.

Saginaw County Mosquito Abatement Commission (SCMAC), Michigan

The Saginaw County Mosquito Abatement Commission conducts a diverse and balanced mosquito control program (SCMAC, 2001). The program is implemented through five departments: Administration, Biology, Field, Public Education, and Source Reduction. Surveillance includes tracking populations, mapping and investigating potential breeding habitats on a regular basis, and monitoring potential disease carrying species. Birds and small animals are sampled, with sentinel pheasants employed for disease surveillance. Other than surface oils (Golden Bear®), only biological larvicides (*B.t.i.* and *B. spaericus*) are utilized by the SCMAC for larviciding.

Adulticiding is conducted regularly using malathion and a synthetic pyrethroid. The SCMAC offers a 'no spray' program similar to Winnipeg, where residents can register to

exempt their property. Unlike the Winnipeg program, residents are not required to re-register for the program for consecutive seasons, rather the district contacts the citizen to ensure that information in the database is up to date and accurate. If a citizen does not verify the information for three consecutive years, they are removed from the program.

The SCMAC is 'committed to educating and informing Saginaw County residents about mosquito-related issues' (SCMAC, 2001). Some SCMAC employees are dedicated specifically to this purpose. Education activities include: presentations to pre-Kindergarten up to grade twelve classes, sponsoring or attending public events, hosting a web site, and supplying resource materials to the general public. Approximately 5,000 students are reached annually with the school program. Story and poster contests are conducted by the district, offering prizes for the winners of each. The district claims that they have 'witnessed growth in community participation and involvement through our educational programs.' (SCMAC, 2001). A number of pamphlets are offered by the SCMAC district, each covering the following topics: the scope of the control program and one on the public education program, diseases transmitted by mosquitoes, source reduction, and WNv. The SCMAC displays an impressive commitment to the 'education' component of the IPM philosophy as compared to any of the Canadian mosquito control districts.

The SCMAC, while operating on a lower budget than many of the other American programs, still manages to conduct an IPM program that is creative and accountable to the public that supports it.

Greater Los Angeles County Vector Control District (GLACVCD), California

The GLACVCD conducts one of the most extensive mosquito control programs in the United States. St. Louis Encephalitis is endemic in this region of California, thus a good portion of the educational program focuses on mosquitoes as a serious danger to health. The GLACVCD conducts both chemical (chlorpyrifos) and biological (*B.t.i.* and *B. spaericus*) larviciding, as well as adulticiding when disease-carrying mosquitoes have been detected or mosquitoes numbers pass a certain threshold (Walker, 2003).

Surveillance and habitat reduction are conducted within the control district. Efforts in the area of public education are impressive with this control district.

The GLACVD offers a number of formal education programs for school-aged kids. The 'Vector Inspector' program is for 3rd-7th grade children, and includes hands-on instruction covering identification of mosquito body parts, mosquito life cycle and habitat, effect of mosquitoes on humans, the disease transmission cycle, and how to control mosquitoes. Live specimens are utilized, with a video and workbook provided. This program reaches about 4,000 children each season. A free field trip program guides students through hands-on activities and demonstrations at the district headquarters of the GLACVCD. In 2000, the district began a new VecMobile program for 5th grade students. This program involves the use of a 35-foot traveling RV classroom. Pre-visit materials are provided to students and teachers, and students spend one hour touring the VecMobile and the outdoor Exploritorium Research Center that accompanies the VecMobile. This program will extend the reach of the formal educational program to 20,000 students each year (Namanny, 2003).

The GLACVCD program features the most extensive and comprehensive public education component of all the IPM mosquito control programs examined.

Europe

Europe has a highly organized, cooperative, environmentally-sensitive mosquito control program. The European Mosquito Control Association (EMCA) was formed in 2000. Supported by the EMCA is the European Consortium for Integrated Biological Control (ECIBCO). Fifteen European Union (EU) member countries[6] make up the consortium. The consortium exists as "an environmental solution to the problems caused by mosquitoes of public health and economic importance." (EMCA, 2003). The overall objective is 'to strengthen cooperation between members and others in mosquito abatement'. The project seeks to develop and implement integrated biological control in

[6] Member countries include Italy, Sweden, Spain, Greece, Germany, Israel, France, Switzerland, Poland, Hungary, Croatia, Yugoslavia, Czech Republic, Turkey, and Romania.

EMCA countries by 'replacing chemical pesticides which have detrimental effects on the environment and induce resistance in pest insects.'

The program is based on the principles of IPM. Program components include: environmental manipulation, physical intervention, propagation of natural enemies (invertebrate predators), predator fish feeding on mosquito larvae, and application of Vectobac® (active ingredient *B.t.i*) and Vectolex® (active ingredient *B. sphaericus*). "One single mosquito control method might not have the adequate impact in all situations, thus complementary or synergistic effect of two or more methods should therefore be considered."(EMCA, 2003).

> **The successful attainment of the ECIBCO's objectives will lead to improvement of public health, quality of life and sustainable economic prosperity throughout the ECIBCO countries by reducing the mosquito nuisance level and the risk of reemerging mosquito-borne infectious diseases.** – ECIBCO Executive Summary (EMCA, 2003)

The unique aspects of this program are the number of countries involved, the high degree of cooperation, and the strict adherence to environmental sensitivity. Additionally, in areas with endemic mosquito-related disease, the ECIBCO did not use chemical control.

The ECIBCO embraces environmental sensitivity for two reasons. Firstly, 'the suppression of... mosquitoes by means of traditional chemical insecticides is becoming more and more difficult due to resistance'. Secondly, 'the reduction of conventional pesticide usage has come under increasing public pressure...due to the unfavorable image they have gained as a result of their wide spectrum, non-selective activity and the environmental damage which they cause.' (EMCA, 2003). The reasons that caused the EMCA to eliminate chemical use are not unique to Europe, and mosquito control experts around the world face public pressure and mosquito chemical resistance.

2.7 West Nile Virus – An Arbovirus New in North America

> ***"It has something to do with the name: West Nile Virus. Had it been the North Saskatchewan Virus, we would have cocked an ear, done the math and left the room."*** *– William Thorsell, 2001*

West Nile virus (WNv) was first reported in the Western Hemisphere in 1999. During the late summer and fall of 1999, health officials struggled to diagnose the illness that sickened dozens and killed seven people, and to make the connections between the human illness and the numerous dead birds being reported in the New York City area. Since that time, scientists and health officials have observed a great deal of WNv activity. By the end of 2002, WNv had been detected in forty-two of the mainland states and five Canadian provinces. It has caused encephalitis and fever in humans in most of the American states, been an epizootic in native and exotic avian populations, and had an impact on equine populations. WNv has emerged as one of the most important considerations in the planning of mosquito control programs in North America (NYAS, 2001; Manitoba Government, 2002a).

The virus was first identified in 1937 in the blood of a human female in West Nile province of Uganda, and was named West Nile virus (Smithburn *et al.*, 1940; Hayes, 1988). In this region it is regarded as little more than a common childhood illness that the body fights off and resulting in lifelong immunity. Most infected persons do not become ill or show symptoms, and even when they do display symptoms, they are generally limited to headache, sore throat, backache, low-grade fever, or fatigue. A small percentage of people develop serious symptoms, including high fever, encephalitis, which in some cases may result in death (Southam and Moore, 1954; GAO, 2000).

No definite account can be made as to how WNv was transported to North America. It could have been by a mosquito caught on the winds, or stowed away in a plane, or possibly a bird infected with WNv travelled to the Western Hemisphere. Media speculation on this matter has been extensive, and at times ridiculous. Following the

2001 terrorist attacks on the United States, less reputable magazines issued headlines such as "ALQUAEDA BREEDING KILLER MOSQUITOES & SENDING THEM TO ATTACK THE U.S.! WEST NILE TERROR PLOT!" (Farouk, 2002). Though this theory sounds rather unlikely, a session at the 2003 Annual American Mosquito Control Association conference was devoted to the discussion of mosquito-borne disease as a potential terrorist weapon (Presley, 2003; Kent, 2003).

Regardless of how the virus arrived, its presence and virility have implications. First, WNv in North American seriously affects a broader range of birds than in the Old World (Mackenzie, 2002). Secondly, the virus can be a significant health concern to the elderly and immuno-compromised (Peterson and Marfin, 2002.) Thirdly, after five seasons of spread, it is likely that WNv will be a permanent fixture on the North American 'mosquito-scene'.

The spread of the virus across North America has been inconsistent. In 1999, fifty-nine human illnesses and seven West Nile-related deaths occurred in New York City and surrounding areas. In 2000, twenty-one human cases were confirmed, with two deaths resulting. During 2000 the virus spread to twelve states from Vermont and New Hampshire in the north down to North Carolina in the south (CDC, 2000). In 2001, only sixty-six people fell ill, with nine deaths, and virtually no new areas experienced the virus. Those who were studying and watching WNv hoped that the virus would not be the epidemic that it seemed to foreshadow during the summer of 1999. Then came 2002. There was an explosion in the incidence and range of the virus, with more than 3,870 people fell ill with either fever or encephalitis, and 246 of those died (CDC, 2000). In the summer of 2003 WNv continued to spread. There were 8,470 human cases and 189 deaths, and of the continental states, only Washington and Oregon remained free of WNv (CDC, 2003c).

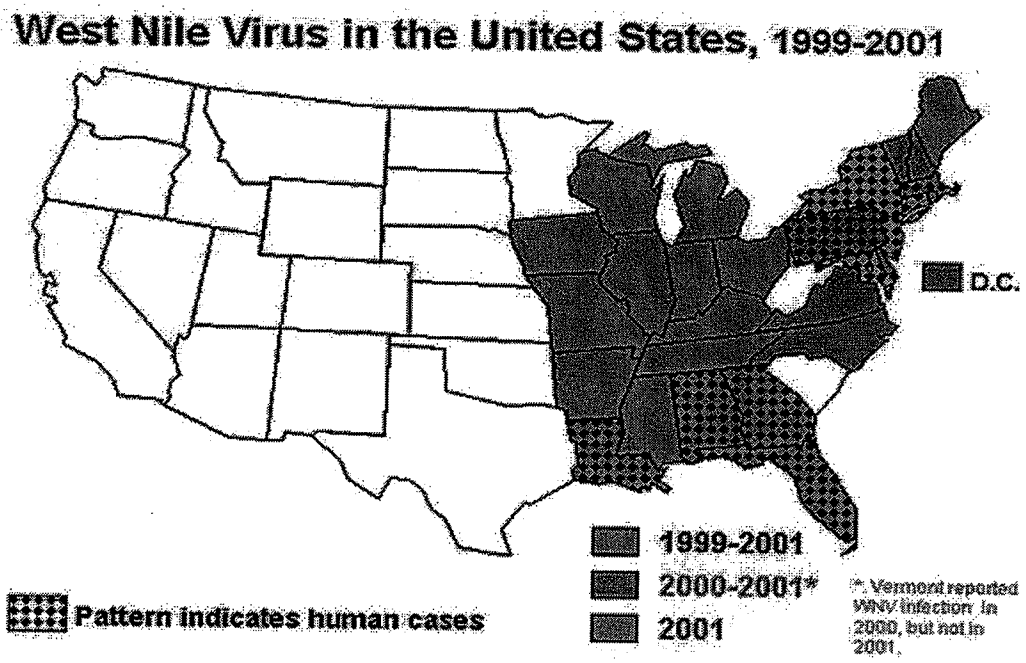


Figure 1. Spread of WNv in the USA, 1999-2001 (CDC, 2003a).

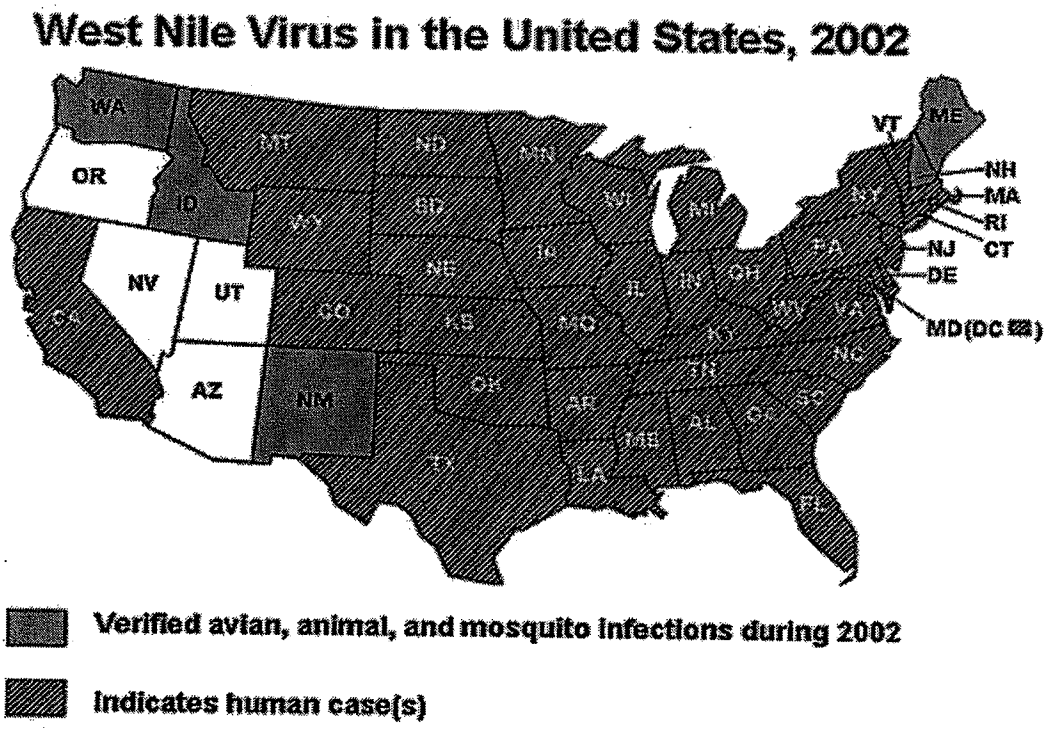


Figure 2. 2002 Distribution of WNv in the USA (CDC, 2003b).

In addition to the spread of the virus to new areas and the largest human, avian, and mammal epidemic/epizootic thus far in North America, 2002 revealed new methods of viral transmission. Health officials witnessed the first cases of person-to-person transmission of WNv through organ transplantation, blood and blood product transfusion, and breastfeeding (CDC, 2002b).

Less than 1% of persons who are infected with WNv develop severe illness (CDC, 2002a). The two types of serious illness that result from WNv infection are West Nile meningoencephalitis (WNME), and West Nile fever (WNF) (CDC, 2002b). Clinical studies in nonimmune populations during an epidemic in Israel indicated that the severity of the disease may increase with age. Neurological involvement was seen most frequently in elderly patients (Spigland *et al.*, 1958). According to Peterson and Marfin (2002), "Advanced age is by far the most significant risk factor for severe neurologic disease after infection (with WN); risk increases markedly among persons 50 years of age and older." Peterson and Marfin (2002) have shown that people 80 years or older have a risk of serious neurologic disease forty-three times higher than the 0-19 age category.

During the 1999 epidemic, the median age of those who contracted WNv was 71 years, and ranged from 5-95 years (Nash *et al*, 2001). In 2002, there were 3,852 diagnosed WNME and WNF cases, and of those, 232 mortalities from 39 states resulted. Among all reported cases in 2002, the median age of those who became ill was 55, with a range of one month to 99 years of age (CDC, 2002b). The mortality rates for WNF and WNME are different. In 2002, WNME was more deadly than the WNF with a 9% mortality rate, while WNF had a 0.3% mortality rate. The WNME median decedent age was 78 years (range 24—99) and the MF had only two decedents, both of whom were over 80 years of age.

In addition to human health, there is concern regarding wildlife and ecological effects from the virus in North America. "The introduction and extensive expansion of West Nile virus in the United States... is having a dramatic impact on native wildlife."

(McLean, 2002). Scientists have predicted that "some (avian) species may never recover." and a soon to be published work from Cornell University estimates in worst-affected areas, 90% of crows, one of the most susceptible species, have died (Mackenzie, 2002). The American Centres for Disease Control reported WNv caused mortality in more than one hundred species of birds. The number of affected species creates difficulties in predicting long-term effects of the virus on North American avian populations. In Illinois in 2002, more than 50% of American Crows studied succumbed to WNv (Yaremych, 2003). In a 2002 anecdotal study, a decline of 91% occurred in Illinois American Crow populations (Bonter and Hociiaciika, 2003).

During the 2002 season, 99.9% of all non-human mammal cases were equine. There were more than 9,000 equine cases of WNv infection reported in the United States, with additional cases occurring in Canada (CDC, 2002a; CDC, 2002b). A vaccine for the disease was approved during the spring of 2002, but has yet to prove the level of protection it effectively offers.

> ***Scientists are beginning to take stock of West Nile virus's North American invasion, and they are taken aback by the scale and sweep of its ecological impact. In North American wildlife the virus has proven to be capable of infecting a surprisingly diverse array of animals.*** – Weiss, 2002.

The risk of contracting WNv is not necessarily correlated with a greater abundance of mosquitoes (Andreadis *et al.*, 2001). As with other mosquito-carried pathogens, some mosquito species more than others are better suited to transport the virus and infect a host. In Winnipeg, the summer may be clouded with dense populations of mosquitoes, very few of which can carry WNv. Then in the fall, total mosquito numbers can be very low, but there may be a higher proportion of vectors, and the risk of illness can be higher (Manitoba Health, 2003a)

Testing field-collected mosquitoes for WNv has revealed *Culex pipiens, Culex quinquefasciatus*, *Culex restuans,* and *Culex tarsalis* as important vectors of WNv in

North America. Testing field-collected mosquitoes has revealed the existence of a number of secondary or bridge vectors (CDC, 1999, 2000b; Sardelis *et al.* 2001, 2002). During the period of 1999 to 2002, 33 mosquito species were found infected with WNv in the wild (CDC, 2002b). These findings may indicate that WNv has an ability to spread and multiply that surpasses other mosquito-borne pathogens currently present in North America. However, many of these potential secondary vectors only rarely feed on birds, making their capacity as a vector of WNv fairly low compared to those species that seek avian blood meals. Control of *Culex* species is cited by the American Centre for Disease Control (2002b) as one of the most important strategies for reducing the risk of WNv transmission to humans.

By the end of 2002, WNv had been identified in five Canadian provinces. Dead birds have tested positive in Nova Scotia, Quebec, Ontario, Manitoba and Saskatchewan, and there had been 147 probable human cases in Ontario, and 10 West Nile-related deaths (Health Canada, 2003a). No other provinces have seen human fatalities, and Saskatchewan, Manitoba, Nova Scotia had not had any human cases at that time. Alberta has registered one human case, but it is strongly suspected that the individual became infected while travelling in Louisiana and Texas during the summer of 2002. (Alberta Government, 2003). In 2003 there were human cases of WNv in Nova Scotia, Quebec, Ontario, Manitoba, Saskatchewan, Alberta, British Columbia, and the Yukon Territory. The number of probable cases was 843, the number of confirmed cases was 463, and the number of deaths relating to WNv was 10 (Health Canada, 2003c).

The first WNv-infected bird was discovered in Manitoba during July of 2002. By the end of the season, 88 birds had tested positive for the virus. There were also 236 cases of WNv infection diagnosed in the equine population of Manitoba. Seven of the City of Winnipeg's sentinel chickens, and 15 mosquito pools tested positive for WNv. There were no human cases in Manitoba during 2002 (Manitoba Government, 2002b). The Manitoba distribution of WNv is illustrated in Figure 3. In 2003 three human cases were identified in Manitoba. A total of 141 cases (35 confirmed, 106 probable) and two deaths relating to WNv were recorded (Manitoba Health, 2003a). In Manitoba, *Culex tarsalis* is

the mosquito that has been identified as the most important, though not the only vector for WNv transmission (Manitoba Health, 2003a).

> *"People climb mountains and expose themselves voluntarily to all kinds of risks, but they don't like risk inflicted upon them that they don't understand or have control over, like West Nile. Partly because Americans have not had to suffer the worst effects of the world's most devastating wars, plagues and famines of the last one hundred years, they have a deep sense of optimism and a belief in the perfectibility of the world that risk experts say plays heavily into the theatre of fear. They tend to despise fatalistic acceptance and believe that all problems probably have solutions. If there are bad mosquitoes... let's wipe them out."* (Johnson, 2000).

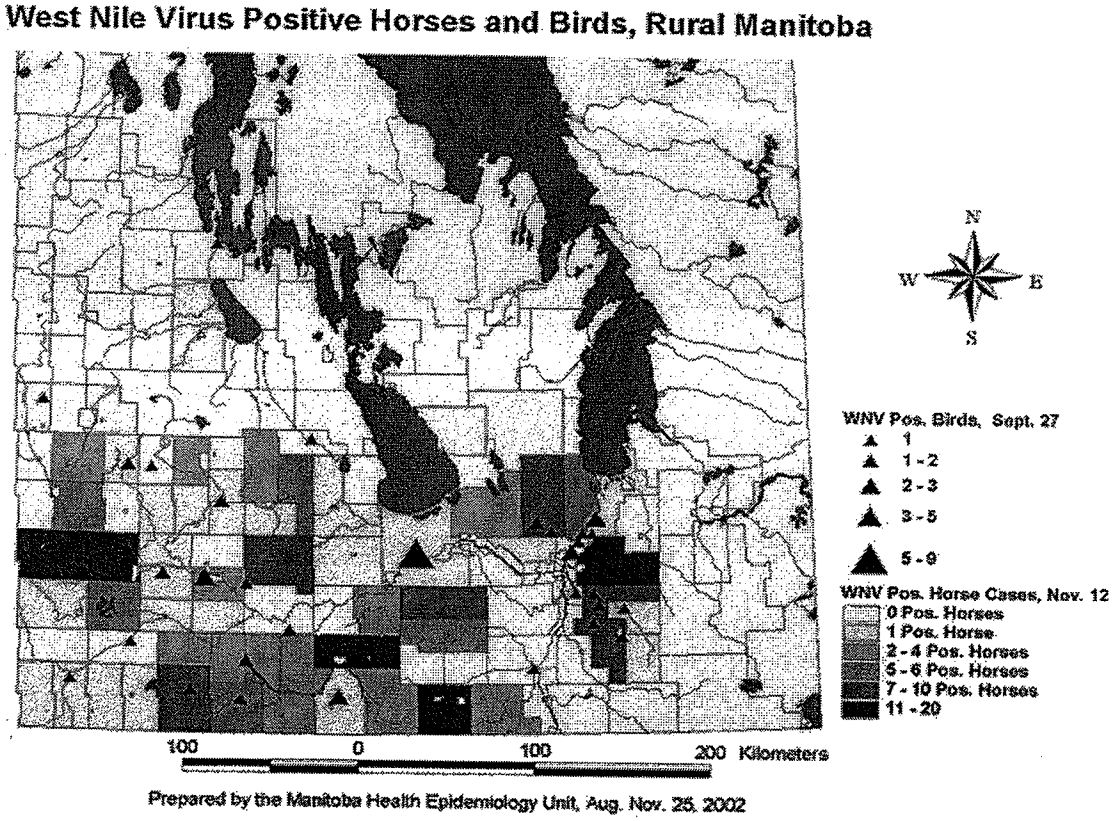


Figure 3. 2002 Distribution of WNv in Manitoba, Canada (Manitoba Health, 2003b).

According to the American Centre for Disease Control (2002b), "The 2002 WNv epidemic in the United States was the largest arboviral meningoencephalitis epidemic documented in the western hemisphere and the largest reported WNME epidemic". The extensive nature of the 2002 epidemic/epizootic would seem to ensure that mosquito

control will continue to be a very visible and important component of services offered by the government.

When dealing with WNv, everyone seems to have a plan. Groups against the use of pesticides have proposed methods of addressing WNv without applying chemicals (McKinney, 2002; CCHE, 2003). Mosquito control districts have outlined new steps and surveillance measures to be implemented in the face of WNv (Gray, 2003; New York State Department of Health, 2003; Parsons, 2003). Provincial and Municipal governments have become more 'hands-on' with the mosquito control process, issuing press-releases containing action plans, and increasing their public outreach on the issue (Manitoba Provincial Government, 2003; Government of Ontario, 2002). In the 2003 Manitoba Provincial Election, candidates were questioned about their stance on mosquito control and ensuring public health. Mosquito control has become a hot political and public topic, and the arrival of WNv has boosted public awareness and education on all mosquito issues.

2.8 Potential alternatives for IPM incorporation

In light of recent studies, environmentally sensitive mosquito control would likely be preferred over equally effective and economical chemical control (Civic Environmental Committee, Winnipeg, 2002). In response, a plethora of non-chemical or natural mosquito control products are marketed. Most are designed for personal or local use, like traditional repellents or for use in the backyard or on a deck. Discerning which products are effective for the private citizen, or in the context of a municipal integrated pest management program, is important in improving programs and reducing pesticides use. Some products have potential for effective mosquito control, while others are based on little scientific research. A number of these products are reviewed.

> ***Virtually every year, a new product appears on the market that claims to be the answer for the elimination of mosquito nuisance. The American public has invested billions of dollars in zappers, repellers, and plants that claim they will keep mosquitoes from biting. Products and promotions for mosquito control are big business; unfortunately most have limited value in reducing mosquito annoyance.*** *– W.J. Crans, 1996.*

Microbial Larvicides

Microbial larvicides are bacteria registered as pesticides for mosquito larva control and are generally used in "irrigation ditches, flood water, standing ponds, woodland pools, pastures, tidal water, fresh or saltwater marshes, and storm water retention areas" (EPA, 2003). *Bacillus thuringiensis* var. *israelensis* (*B.t.i.*) and *Bacillus sphaericus* (*B. sphaericus*), two naturally occurring bacteria, are the main microbials used for mosquito control. *B.t.i.* was discovered in 1976 and 'inaugurated a new chapter in vector control' (Becker and Margalit, 1993). To date, *B.t.i.* and *B. sphaericus* have been the most successful non-chemical larvicides (Becker and Ludwig, 1993). They are used commonly in programs around the world, though only *B.t.i.* is registered in Canada.

The effectiveness of microbial larvicides is affected by mosquito species, formulation, environmental conditions (temperature, wind, UV rays, etc.), and water quality (Margalit and Dean, 1985; Gharib and Hilsenhoff, 1988; Lee *et al.*, 1996; EPA, 2003). Becker *et al.* (1992) showed environmental conditions significantly altered larval mortality when *B.t.i* was used. The insecticidal effects of *B.t.i.* and *B. sphaericus* are created by lethal changes within cells of the midgut, produced by synergistic effects of different proteins of the parasporal body of the bacteria (Becker and Ludwig, 1993). Becker and Ludwig (1993) found no resistance in a mosquito population that was exposed to *B.t.i.* for ten years. They hypothesized that *B.t.i.* resistance does not readily occur due to the complex reaction that causes mortality, short exposure period, and the variable gene pools in target populations. Recent laboratory studies have shown resistance to some strains of *B. sphaericus* (Wirth *et al.*, 2000; Zahiri *et al.*, 2002), and operational suggestions were made to slow this process (Chevillion *et al.*, 2001; Mulla *et al.*, 2003). However, relative

to resistance that has occurred to chemical insecticides, *B. sphaericus* is still currently an attractive option.

In addition to low resistance, microbial larvicides are attractive because few non-target species are damaged (Gharib and Hilsenhoff, 1988; Sebastien and Brust, 1981). Microbial larvicides are innocuous to mammals, even at high dosages (Becker and Margalit, 1993). Negative aspects include relative expense and lower effectiveness than chemical larvicides (Gadawski, 2001).

Insect Growth Regulators

Growth regulators or inhibitors are products or materials that interrupt or inhibit the life cycle of a pest (EPA, 2003). Growth regulators are applied to insects at the immature stages of development, and can be an attractive alternative to chemical control as they are fairly target specific. "Some insect growth regulators have been shown to be highly selective in controlling mosquitoes and are relatively long lasting and effective at low application rates" (Linthicum *et al.* 1989).

Methoprene is a growth regulator used as a larvicide, and has been in regular use for mosquito control since 1975 in the United States (EPA, 2003) and 1977 in Canada (Health Canada, 2003b). Methoprene interferes with mosquito growth, prohibiting progression to the adult stage. Some isolated incidences of resistance to methoprene have been identified, but it has not been wide-spread (Dame *et al.*, 1998). According to the PMRA (Health Canada, 2003b), methoprene poses little risk to people and the pesticide has very low acute oral and inhalation toxicity potential. Though the product is more target specific than broad-spectrum pesticides, it is highly toxic to some freshwater invertebrates, and has been the suspected cause of frog deformities (La Clair *et al.*, 1998; Beyond Pesticides, 2001). According to the PMRA (Health Canada, 2003b), negative impacts on non-targets were not permanent and populations were able to recover.

Lagenidium giganteum

Lagenidium giganteum (Oomycetes: Lagenidiales) is a watermold that parasitizes the larval stage of freshwater mosquitoes. This microbial parasite belongs to a group of organisms related to brown algae, "although they look like fungi and have a 'fungal lifestyle'" (Kerwin, 2003). According to Kerwin (2003), the infective stage is a motile spore, and the basis of its host specificity is selective recognition and attachment to mosquito hosts. *Lagenidium giganteum* is not an obligate parasite, though it does much better on mosquito larva than off, and will infect and kill most species of mosquitoes breeding in fresh water (Hornby *et al.*, 1992). The mold enters the mosquito body through the cuticle and hyphae grows in the body cavity. As infected larvae feed, *Lagenidium giganteum* removes nutrients from the haemolymph, causing starvation (Kerwin *et al.*, 1994; Turner, 1999). Cuda *et al.*, 1995, reported mosquito emergence from the immature stage was reduced by 77% in treated verses untreated pools. *Lagenidium giganteum* caused no harmful effects on any organisms except susceptible mosquitoes (EPA, 2001).

Surface Films

A number of oil-based products and monomolecular products have been developed for the purpose of mosquito control, though few are available in Canada. Historically, unrefined oils, diesel oil, and kerosene and tar oils were used for larval mosquito control. However, many environmental impacts stemmed from their application (Adams *et al.*, 2001). Modern surface films are either light oils or surfactants. Light oils cover the surface of the water and smother larvae and pupae as they attempt to breathe. Surfactants alter the surface tension of water, causing egg-laying females to sink, egg rafts to sink, and pupae and larvae to drown when they cannot attach to the surface (Adams *et al.*, 2001). The effectiveness of these products is variable and depends on contaminants in the water, type of oil, type and size of container, and application (Adams *et al.*, 2001).

The City of Winnipeg utilized **Flit MLO**, as part of their IPM control program until the Canadian registration was discontinued (Gadawski, 2000). This product is not currently in use in North America as the registration was discontinued. **Golden Bear Oil** is

presently the most widely used light oil in the United States. Golden Bear Oil is distilled from petroleum, purportedly evaporates or photodegrades into harmless components, and does not persist in the environment (Witco Corporation, 1995). According to Adams *et al.* (2001), the duration of light oil effectiveness is shorter than surfactants, and surfactants have a more environmentally benign decomposition process than the oils. Some concerns have been raised by ecologists regarding the effect of Golden Bear Oil on waterfowl, though no damage has been reported when the product is applied at label specifications (Hoffman *et al.*, 2000).

Agnique MMF™, a surfactant produced by Cognis Corporation, is both a mosquito larvicide and pupicide that is, "An effective and environmentally friendly solution to the world wide problem of mosquito control." (Cognis Corporation, 2001). Agnique MMF is a monomolecular surface film that restricts the pupae from breathing. The product spreads to form a monomolecular film that reduces water surface tension. Cognis Corporation (2001) stated that mosquito control begins minutes after application and that the film remains potent for ten to fourteen days. They boast impressive spreadability, no adverse health or environmental effects, and low labor costs and usage rates. Cognis Corporation (2001) also stated that it is "highly unlikely that the larvae or pupae stages could develop resistance". Non-target effects are limited to insects that require water surface tension. There are no acute effects on any life stage of the tested organisms[7] (Cognis Corporation, 2001). This product is not currently registered for use in Canada.

Acoustics

An invention by a fifteen year old science fair winner is one of the newest non-chemical larval mosquito control tools (Wingbeats, 2002; Falding, 2003). The *Larvasonic™* emits a sound wave that resonates at a frequency that causes mortality in mosquito larvae. Application opportunities, effectiveness, and non-target effects are being examined. Thus far the impact on non-targets seems to be limited (New Mountain Innovations, 2003).

[7] Organisms tested include snails, freshwater shrimp, long-nose killfish, fiddler crab, dragonfly, mallard duck, green tree frog, and numerous plant species.

Mosquito Magnet™

The *Mosquito Magnet™*, made by American Biophysics Corporation (ABC), is a machine designed to attract mosquitoes by emitting carbon dioxide, water vapour, and octenol." (ABC, 2001). ABC (2001) claimed that this combination is "irresistible to mosquitoes, no-see-ums, biting midges, black flies, and sandflies". *Mosquito Magnet™* is the size of a small backyard barbeque, and is powered by propane or electricity, depending on the model. As mosquitoes approach the unit, they are sucked in by a fan and collected in a net, where they die. The premise is that the *Mosquito Magnet* attracts and sucks up so many female mosquitoes, that few or none are left alive to bite or reproduce.

Mosquitoes respond at a maximum range of about eleven meters from the chemical source (McIvor and McElligott, 1989). As mosquitoes can travel long distances in the course of a few days (Brust, 1980; Tietze *et al.*, 2003), the machine will be challenged to depopulate an area, especially when local populations are often measured in millions.

In March of 2003, the Environmental Protection Agency (EPA) in the United States fined ABC $1 million for allegedly including a potentially toxic chemical (octenol) and labeling it as "environmentally friendly" (Burgess, 2003). The EPA briefly ordered the machine off the market, and then selling resumed with a labeling change.

Since the release and successful sales of the Mosquito Magnet, the market has been flooded with similar products, including: Mosquito Terminator®, Dragonfly System®, Mosquito Deleto®, PowerTrap®, and others.

The ***Mosquito Terminator*** function is similar to the Mosquito Magnet. The manufacturer claims the Mosquito Terminator attracts mosquitoes in three ways: by mimicking the prey using a 'temperature controlled skin emulator to simulate different body temperatures', by expelling CO_2, and by using a lighting combination 'to attract certain types of female mosquitoes'. Mosquitoes are drawn into a 'capture chamber' where they

die of 'hunger and dehydration' (Mosquito Terminator, 2003). The makers of the Terminator guarantee a 'minimum reduction of 50% in the mosquito population'.

The ***DragonFly System*** by Mosquito Solutions uses heat, size and light to attract mosquitoes. It emits a patented mosquito inhibitor called 'Conceal' that is supposed to block the scent-tracking ability of biting insects. This system is unique as it 'packs a one-two punch' with the 'Dragonfly' and the 'Mosquito Cognito' (Mosquito Solutions, 2002). The Dragonfly is an electronic trap that 'looks like a shaved rabbit to a mosquito'. Field tests on the 500cc Dragonfly in rural Colorado showed no reduction in mosquito populations (Lara and Teyler, 2003).

Frequency Repellents

The electronic frequency repellent is a personal mosquito control machine, generally small, and attachable to clothing or your person. Sound is emitted that is supposedly unpleasant to female mosquitoes. Those selling the product say the noise mimics the aggressive male mosquito wing beat (causing females to flee) or else mimics the wingbeat of a dragonfly, a predator. Crans (1996) stated, "Electronic mosquito repellers do little to reduce mosquito annoyance. In most cases, the claims made by distributors border on fraud." Studies show that these high frequency products do not work (Lewis *et al.*, 1982; Foster and Lutes, 1985; PMRA, 2003)

Zappers

Numerous models of insect 'zappers' have been on the market for years. The *Mosquito Killer™*, the *E-Trap™*, and the *Zapper™* are machines that attract mosquitoes, and kill them (usually by electrocution). "Biting insects, in general, make up less than 1% of these insects killed in zappers. Unfortunately, beneficial insects are usually well represented in an average night's catch" (Crans, 1996). In one study, less than 4% of the insects killed per night were female mosquitoes (Nasci *et al.*, 1983). With no evidence that 'zappers' actually control mosquito populations (Surgeoner and Helson, 1977; Frick and Tallamy, 1996), they are not a viable mosquito control alternative.

Plant-based products

Plant-based or natural mosquito control products are often marketed as a safe option for personal protection against mosquitoes or controlling local mosquito populations. *Don't Bite Tonight™*, for example, is a citronella 'mosquito and bug repellent'. The product is made by Not Tonight Deer, Natural Animal Repellents, and apparently creates a natural citronella airborne barrier, and is designed to be sprayed on outdoor surfaces. Citronella-based repellents are popular purchases, and one study showed some improvement from their use (Lindsay *et al.*, 1996).

A recent study has revealed the potential for the use of certain essential oils as mosquito repellent. Choi *et al.* (2002) examined the effectiveness of *Eulcalyptus globulus, Lavender officinalis, Rosemarinus officinalis,* and *Thymus vulgaris*, and all four effectively repelled mosquitoes on hairless mice. Further research is ongoing to examine potential application as mosquito repellents for humans.

Mosquito and Gnat Repellent™, made by Dr. T's Nature Company, is a natural product comprised of lemon grass oil, mint oil, and garlic oil. It is applied to lawns, and the manufacturer stated, "it helps to reduce mosquito populations". The product is listed as effective for two to three weeks following application. No conclusive information regarding the effectiveness of natural compounds has been released.

Repel Lemon Eucalyptus Insect Repellent Lotion™, by WPC Brands Inc., and applied to the skin as a lotion, contains oil from the *Eucalyptus citriodora* tree. Eucalyptus has some value as a mosquito repellent (Choi *et al.*, 2002; Moore *et al.*, 2002). Neem oil, from neem trees in India has long been thought to have mosquito repellent properties. In India, it has been used for centuries to repel mosquitoes and treat malaria, though studies have shown it generally non-effective in repelling mosquitoes (Moore *et al.*, 2002; Nurtaceutic, 2003; Ottawa Orchid Society, 2003). Neem may have the ability to kill mosquito eggs prior to hatching (Tianyun and Mulla, 1998).

Predators

Natural predators have often been cited as a potential method of reducing mosquito population and this idea of having 'nature' take care of mosquito problems is a popular idea with the general public. Fish that prey on mosquito larvae, insectivorous birds, bats, and insects are included on the list of the mosquito's natural predators. However, research supporting the effectiveness of these natural predators in effectively reducing mosquito populations is lacking (Crans, 1996).

> **"Insect populations have no trouble compensating for their losses to bats or insectivorous birds. The populations of many mosquito species, are measured in the millions, and commonly the hundreds of millions."** – R. Corrigan, 1997

While dragonflies definitely eat larval and adult mosquitoes, there is no evidence that dragonflies can significantly reduce mosquito populations. However, the lack of scientific proof has not deterred people from supporting dragonfly populations or forming positive opinions on the effectiveness dragonfly-inflicted mosquito control (Associated Press, 2001; Ross, 2001). A number of IPM mosquito guides recommend supporting healthy dragonfly populations as one contributor to the reduction of total mosquito numbers (Washington State Department of Ecology, 2003; Missouri Department of Natural Resources, 2003).

A number of fish species have been identified as mosquito larval predators (Hurst *et al.*, 2003; Washington State Department of Ecology, 2003). The best known, most effective, and longest employed of these fish, *Gambusia affins* (Baird & Girard), is commonly called the 'mosquito fish' (Gooley and Lesser, 1977). According to the Centers for Disease Control and Prevention (2000), these predaceous fish can be placed in permanent or semi-permanent water bodies where mosquito larvae develop, and provide some measure of control. Mosquito fish have been used for decades as part of many mosquito control programs in the United States (Kent, 1994). Many American mosquito control programs will supply mosquito fish without charge to individuals or groups in the municipality interested in reducing mosquito populations. The effectiveness of the fish

depends on a number of variables including water quality, temperature, depth, and cohabitants in the habitat (Davis County Mosquito Abatement, 2003).

Special consideration must be taken when evaluating the appropriateness of using non-native fish species for mosquito control. Exotic species may provide some measure of control, but can bring new environmental problems (Hurst *et al.*, 2003). The introduction of exotic species may result in competition, and the threatening of native species (Milton and Arthington, 1982). Some American states have restricted the use of exotic fish for mosquito control purposes because of the potential threat to native species (Kent, 1994).

Purple Martins are present in most of North America and building martin houses is fairly popular, and often thought of as a way to help control mosquitoes. Although martins do eat mosquitoes, mosquitoes are a small component of the diet. Kale (1968) concluded that the birds do little to reduce mosquito populations. By reviewing previous studies, he dispelled the myth that martins consume an average of 2,000 mosquitoes per day. One study found no mosquitoes in the stomachs of 205 birds (Beal, 1918), another found 3% mosquitoes in 34 birds (Johnston, 1967). Kale (1968), explained the period of martin feeding has little overlap with the period of mosquito activity. Furthermore, Kale stated that even if martins did consume 2,000 mosquitoes per day, it would take more than 2,000 birds per acre of marshland to control the mosquitoes produced.

Bats are also commonly referred to as an option for environmentally sensitive mosquito control. However, bats are opportunistic and selective feeders, and there are several factors involved as to which species of insects are consumed in the greatest quantity (Corrigan, 1997). Given the option, bats prefer larger soft-bodied insects (such as moths) to the smaller mosquito meal. Larger insects are directly correlated with a reduced energy expenditure in the feeding process (Corrigan, 1997).

2.9 Education as a Component of Mosquito Control

Education is perhaps the least tangible portion of the IPM mosquito abatement program. Counting mosquitoes, applying product, manipulating drainage and other such activities consist of very physical processes and outcomes, but education and public relations are less easily measured. Though less quantifiable, education is not less important than other components of IPM (Nasci and Harrington, 1997). Environmental education is a formal education strategy that plays an important role in mosquito control.

> ***Today's students are tomorrow's decision-makers. Environmental education today must be a priority if we care about the future of our world.*** *– John Chasty, The Green School, 1991*

Mosquito experts encourage the public to reduce standing water on private property, saying the action could result in the reduction of thousands of mosquitoes (Becker, 1997; MEPI, 2001; Rabson, 2001). An educated and motivated public would be able to evaluate the situation and create a better outcome (fewer mosquitoes). By conducting formal, holistic, environmental education focussing on mosquito issues in schools, the next generation of decision-makers would be educated, motivated, and able to participate effectively in the solution to mosquito problems. In addition, the next generation would be able to identify the political aspects of mosquito control, and with the appreciation of the interconnectedness of people and nature, make critically assessed decisions regarding the necessity of chemical application for mosquito control. With environmental education and formal education as a strong component of an IPM program, there is potential for a new philosophical outlook on mosquito control. The new outlook would demand environmental sensitivity.

> ***In times of change, the learners inherit the earth, while the learned find themselves beautifully equipped to live in a world that no longer exists."*** *– Anonymous.*

As soon as scientists unraveled the difficult mystery of the transmission method of malaria, yellow fever, dengue fever and other like illnesses, they were faced with another challenge: educating the public about mosquito-borne pathogens. Teaching the benefits of installing screens, reducing standing water, and taking other actions for self-protection and reducing mosquito breeding habitat, was essential in order that fewer people become ill from these pathogens (Spielman and D'Antonio, 2001). Musa (1999) recounted educational efforts necessary for the initiation of mosquito control programs in New Jersey at the turn of the last century. Entomologist John Smith 'pioneered methods that would be copied around the globe' (Spielman and D'Antonio, 2001), but before these methods would be widely accepted, he had to conduct persistent public education (Musa, 1999). "Smith spoke of 'mosquito control' rather than extermination... However, writers (in the press) ridiculed Smith for even suggesting that mosquitoes could be dealt with, and the public at large generally agreed." (Spielman and D'Antonio, 2001) The educational efforts primarily focus on the small segment of the population that made decisions about the allocation of public funds. "Repeated education had to be undertaken to get mosquito control accepted and established in New Jersey. This was a critical part of the early process and an essential component to "real" mosquito control programs." (Musa, 1999). Education is not one specific task to be performed, but rather can consist of formal (learning within schools) and/or informal education, and include a number of varied approaches.

> **Education in mosquito control is a form of marketing. Also, it serves the purpose of enlisting assistance in the actual control of mosquitoes.** – Musa, 1999.

Children grow up to be decision-making adults. Ideas and beliefs that the younger generations hold close will stick with them as they grown and become the decision-making adults of the population. As early as 1920, the benefits of incorporating mosquito control into biological sciences at the high school level were recognized and occurring in some counties in New Jersey (Musa, 1999). The Greater Los Angeles Vector Control District currently undertakes extensive formal education, reaching thousands of school

children every year (Namanny, 2003). Many other mosquito districts conduct formal education by visiting classrooms, running contests in schools, offering field trips for kids, and supplying mosquito educational materials to interested teachers.

Informal education is often conveyed by media outlets and generally targets adults. Public Service Announcements, news features in the paper on radio or the television, advertising to the public in the form of commercials on billboards, television, buses and the like are all common methods of educating the public on mosquito issues. Many control districts incorporate public displays and booths at community and commercial events. Distribution of pamphlets dealing with mosquito issues is another common method of 'getting the message out' to the public. In the United States, the American Mosquito Control Association started 'National Mosquito Awareness Week' in 1997 so that mosquito professionals could coordinate their efforts and communicate to the public in a louder voice. Mosquito control districts were encouraged to participate in this event and hold community events and foster opportunities for the public to learn and engage in discussions regarding mosquito control.

Musa explained the role of education in a mosquito control program in her 1999 article.

> *"Educating the general public helps increase the understanding of a scientifically-based, environmentally sensitive approach to mosquito control and the reasons for doing so. Education helps smooth the path by lessening the possible opposition from residents in the area, anti-pesticide groups, local, county and federal officials and legislators. This facilitates the ability of mosquito control districts to get the job done. Education should hold a high position in any mosquito control program in an ongoing effort to provide and maintain effective mosquito control."*

Formal Educational Opportunities

Formal mosquito education, conducted in schools with grade-school children, can be an important component of the integrated pest management approach (SCMAC, 2001; Nammany, 2003). Children can study mosquito biology, life-cycle, habitat, diseases, and ways to control them. Playing games, using computers, reading books, undertaking projects, story and poster contests, and reading and writing poems, are fun and creative

ways to help children learn. Children exposed to this information and teaching will grow up with a better understanding of these issues than those who were not. Kids also bring their ideas home to their parents and potentially influence the decisions made by the parent regarding mosquito issues.

Formal education on environmental issues has been practiced for decades for the very purposes of creating a better-informed next generation that behave differently than their predecessors. 'Environmental Education' involves recognizing values and concepts that will result in the development of skills and attitudes necessary to appreciate the interrelatedness of people and the environment (Unesco, 1985). The goals of environmental education explain what mosquito experts try to accomplish when conducting formal education with children.

a) *to foster clear awareness of, and concern about, economic, social, political and ecological interdependence in urban and rural areas;*
b) *to provide every person with opportunities to acquire the knowledge, values, attitudes, commitment and skills needed to protect and improve the environment;*
c) *to create new patterns of behaviour of individuals, groups and society as a whole towards the environment.* (Greig *et al.*, 1987)

The following is a list of sample tools that could be used by teachers or mosquito abatement professionals in the formal education setting.

> ***The VECMobile will empower youngsters and their families to detect and remove vector sources around their homes, which will significantly reduce the chance of disease transmission by mosquitoes and other vectors and strengthen existing and create new community partnerships.*** – Miladin, 2002

Games

The *Know Mosquitoes* Board Game was designed by the American Mosquito Control Association. The game is a "fun tool for elementary school kids to learn about mosquito biology, habitat, and reducing mosquitoes around the home." (AMCA, 2001). This is a

fully portable board game intended for use in classrooms, community centers, and other places where children gather. The game because available in 1999, and by the summer of 2003 had sold more than 6,000 copies to schools in the United States (Jimenez, 2003).

Curricula

A number of comprehensive grade school (K-12) mosquito curriculum guides specific to mosquito education have been developed.

Neato Mosquito is a curriculum and CD-ROM developed by the CDC. It provides guidance for elementary aged children, focusing on grade four. A 66-page curriculum covers five lesson plans, and interactive lessons are available on the CD-ROM. The interactive component is hosted by two talking cartoon mosquitoes, and uses video images, still images, interactive games, and student projects to enhance student/teacher access to information about mosquitoes.

Mosquitoes in the Classroom: Insecta horridia (1995) is a teacher resource guide and curriculum written by Dr. Frances Spray of the Teacher Enhancement Program in Biology, University of Wisconsin-Madison. Dr. Spray won the North American Association of Summer Sessions, Creative and Innovative Program award for the Most Outstanding Credit Program (2000). *Mosquitoes in the Classroom* is recommended as a high quality and comprehensive mosquito textbook (Enslen, 2000). It is a complete mosquito curriculum designed for children of all ages. Laboratory experiments help introduce scientific method. History and health impacts of mosquitoes are detailed, and literature, art and games are included.

Books

Books are another medium to facilitate learning. A number of children's books, books for young adults, and technical field guides have been written on the topic of mosquitoes. Books can be incorporated into learning scenarios to facilitate learning.

For children, there are numbers of mosquito books available. *Aquatic Habitats: Exploring Desktop Ponds (*1998), designed for grades two to six, examines the aquatic portion of a mosquito's life. *Why Mosquitoes Buzz in Peoples Ears: A West African Tale* (1975), by Verna Aardema uses the mosquito to teach the lesson of why it is important to tell the truth. *Mosquito (Bug Books)* (1998) is a fun mosquito book for children ages four to eight. *A Mosquito in the Cabin* (1996) by Richard Brown and Kate Ruttle is a collection of poems about the insect world. *Mosquitoes* (1997) by Enid Broderick Fisher, is part of The New Creepy Crawly Collection, and includes a glossary and list of alternative books and videos. The above is a sampling of the many mosquito-related children's books available.

Reading for older children and adults is also available on the topic of mosquitoes. *The Mosquito Book* (1998) by Scott Anderson and Tony Dierckins provides a fun and enlightening approach to learning about mosquitoes. In 2001 Micheal D'Antonio and Andrew Spielman published *Mosquito: A Natural History of Man's Most Deadly Foe.* This book includes mosquito biology, disease facts, and some colorful examples of how mosquitoes have wound their way into the human history.

A plethora of internet sites suited to children, adults, and the technical entomologist are available. Many American and Canadian municipal governments support a mosquito abatement website. These sites usually detail abatement efforts in that area, potential disease issues, and a local history of mosquitoes. A number of sites are available that consist of insect proverbs, poems about mosquitoes, silly mosquito stories, and insect songs. A list of appropriate sites for children could be an effective tool for teachers covering mosquito issues.

2.10 Monitoring Mosquito Populations

Measuring and monitoring mosquito populations, if done correctly, can provide important information. Virtually every modern program includes monitoring. Traps placed in the same location annually can provide data on the size of trap catches relative to other years.

According to Copps *et al.* (1984), "the success of a mosquito control program can depend on accurate monitoring of mosquito numbers." Also, measuring changes in mosquito populations provides information regarding the effectiveness of abatement efforts.

> ***Day-to-day changes in adult mosquito populations are difficult to measure due to the interactions between specific mosquito behavior, environmental influences upon behavior, and the mode of operation of the sampling technique.*** *– Bidlingmayer, 1985*

"The basis of any sampling process is the collection of representative samples." (Bidlingmayer, 1985). Before measuring mosquito populations, a number of issues must be considered: selecting trap location(s), collecting method(s), duration of experimentation/monitoring, and repeatability of results.

Bidlingmayer (1967) indicated there are three main causes in variability from same-site consecutive samples (other than a change in the population size).

1) Environmental. *These factors can be divided into positional and meteorological. The first includes distance from breeding area, habitat, competing attractants, food sources, reflecting surfaces, control activities and predators. The second includes the effects of temperature, humidity, wind, and light intensities.*
2) Biological. *Caused by behaviour patterns characteristic of specific species and sexes, and behaviour changes during the life of an individual according to its physiological state.*
3) Operational. *Differences between apparently identical equipment and techniques, or, at times operational effectiveness of the method may change.*

Light traps are a common tool for sampling mosquitoes. They are generally comprised of a power source, light source, suction mechanism, collecting container, and sometimes additional attractants to lure mosquitoes. New Jersey light traps (NJLT) and Centre for Disease Control (CDC) light traps are two common mosquito monitoring traps (Copps *et al.* 1984). The landing count (a person counting the mosquitoes landing on them during a specific period) is another method of assessing mosquito abundance (Service, 1976).

The mechanism by which the artificial light captures animals is thought to be 'abrupt dazzlement' after the animal crosses a certain threshold of illumination (Verheijen, 1958). Brandley and McNeel (1935) compared NJLT collections with landing count collections. New Jersey light trap samples included a wider range of species and in different proportions than the landing rate collections. Variation occurs among species in light response, chemical stimuli response, and the physiologic states of proximal females. This variation affects the sample profile (Brandley and McNeel, 1935).

Even when comparing traps that use similar attractant (such as light), variables will affect sample size and composition. Holbrook (1989) showed that NJLT traps collected larger numbers than the CDC trap. Shorter light wavelength, and ultra-violet vs. non-ultraviolet light attract larger numbers of mosquitoes (Headlee, 1937; Williams *et al.* 1955). In addition to the light source, moonlight will affect the sample, as will supporting instrument variability such as fan strength (Bidlingmayer, 1967). Bidlingmayer reported 'all suction-light and New Jersey light trap collections were depressed at full moon.'

Landing counts can be used to cross-reference light trap measurements (Service, 1976). Variation in the number and species collected is affected by many variables. The person conducting the landing count may, by virtue of personal body chemistry, temperature, shape and size, have an influence on the number of mosquitoes landing during the test (Maiback *et al.*, 1966; Eiras and Jepson, 1994; Healy and Copland, 2000; Shirai *et al.*, 2002). Certain mosquito species will bite readily when exposed to a host (Haddow, 1954), others are 'shy', and are easily disturbed after landing. 'Shy' mosquitoes are underrepresented in the sample while the less easily disturbed species will be over-represented as they are easier to capture. Bidlingmayer (1967) stated 'the presence of any species is assumed to indicate biting would have occurred had more time been given.'

When establishing the trap location, environmental variables must be considered. Sunlight and shade affect mosquito numbers. Bidlingmayer (1967) stated that high light intensities stimulate flight activity, resulting in larger suction trap collections.

Temperature will affect species differently. Bidlingmayer (1967) stated that species reaching peak numbers in the summer are positively correlated with increasing air temperatures, while species abundant in the spring and fall are negatively correlated. Wind velocities and prevailing direction of the wind are important to consider. Bidlingmayer *et al.* (1985) identified an inverse relationship between wind and mosquito flight activity, with flight activity being lower when wind velocities are higher. In matched pairs experiments (with a control and test location) care must be taken to ensure that both light traps are located in similar wind conditions, temperature conditions, and light intensities if the traps are to collect representative samples.

> **'Trap site bias' is a term used to recognize the existence of various little-known factors held responsible for the large differences that often occur between mosquito catches in traps at apparently similar locations.** – Bidlingmayer and Hem, 1980.

Trap counts and Landing Counts can also be influenced by visual attractants. Physical objects can be a source of attraction for mosquitoes, especially during moonlit periods (Bidlingmayer and Hem, 1980). Adults of several mosquito species are known to respond to colours and objects. Visual cues play a role in the flight behaviour of nocturnal mosquitoes (Bidlingmayer and Hem, 1980). A number of common Winnipeg species, including *Aedes vexans*, appear to possess a visual range of 7.5 meters or less. "For most species, trap catches increased about 50% with each unit decrease in the number of competing visual targets. It is apparent that traps with the greatest visual exposure captured the greatest numbers" (Bidlingmayer and Hem, 1980).

Mosquitoes are not strong fliers, though they have been observed travelling 0.89km/day in one study (Tietze *et al.*, 2003) and recaptured up to eight kilometers from a release site in another (Brust, 1980). In the Brust study, some *Aedes vexans* were observed to have traveled three kilometers the first night after release. This distance of travel has implications for trying to measure 'local' populations.

Mosquito populations and trap counts are affected by many variables. Often it is difficult to know which variables are at work, how multiple variables are interacting, and what effect they are ultimately having on samples. Efforts must be taken to minimize the likelihood of variables interfering with the trap collections, though it is important to realize that eliminating environmental or operational variables is virtually impossible.

2.11 The Situation In Review

Mosquitoes are a prominent feature on the Winnipeg summer landscape. They are a major nuisance factor, and now, with WNv, a health risk. Integrated pest management is the current method of choice for managing pest populations. Winnipeg residents have debated the merits of conducting mosquito control with the organophosphate malathion, as a component of IPM. A review of pesticide risks and recommendations for use, mosquito abatement programs from around the globe, mosquito control alternatives, and mosquito education as a component of IPM have revealed opportunities for improvement to the Winnipeg mosquito abatement program.

Chapter 3 Methods

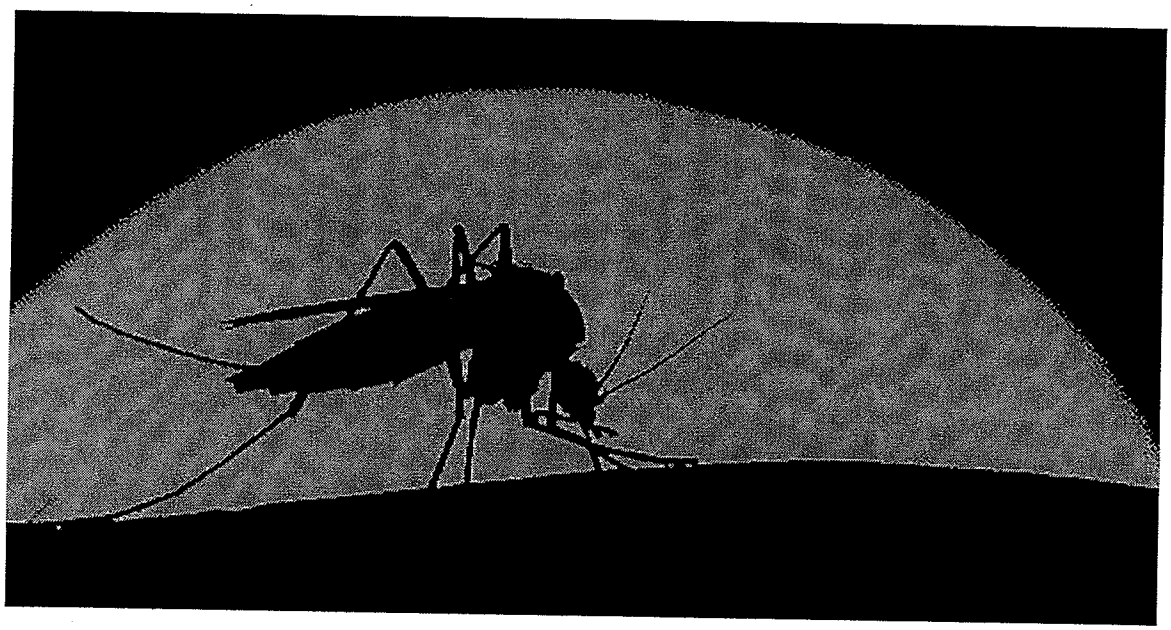


Photo: M. Tomalty

3.1 Introduction

This thesis work consisted of three projects that, in concert, make up the total thesis effort. These included environmentally sensitive product testing, community level communication and education by surveying Winnipeg residents, and creating an annotated bibliography of mosquito-education tools for middle years school children.

Testing of environmentally sensitive products was conducted during the summer of 2001 and then repeated in 2002. Test products were the *Mosquito Magnet™* by the American Biophysics Corporation, and *Mosquito and Gnat Repellent™* by Dr. T's Nature Company. The testing of both products was conducted in the same manner. As well, handling and quantification procedures of samples were similar for both products. Fieldwork was conducted from June to August of 2001 and 2002, and data analysis took place following each season, with the final analysis occurring during the winter of 2002-03. The chosen study area was the City of Winnipeg, specifically the district of Wolseley and the Fort Whyte Nature Centre. The majority of the quantitative product-testing experimental studies were conducted in Wolseley, located in central Winnipeg. One product-testing experiment was conducted at the Fort Whyte Nature Centre, located in south-west Winnipeg.

Community level communication and education were conducted in the form of surveying of Winnipeg residents. This project was conducted for the purpose of gathering information from residents regarding mosquito issues in Winnipeg. Primary data collection was conducted using semi-structured interviews to record the experiences, beliefs and opinions of Winnipeg residents. Three areas of the city were selected for interviews. Pamphlets were distributed to random blocks of houses and the researcher returned five to seven days later to request an interview with the resident. Interviews were conducted during September and October of 2002, with a total of fifty-eight (58) interviews being conducted. Interviews were transcribed during the winter of 2002-03 and analyzed during the spring of 2003.

Formal educational approaches were addressed through the creation of an annotated bibliography of mosquito-related educational tools that will be made available to middle school teachers in the Winnipeg areas and possibly in all of Manitoba. An extensive market and literature review of educational tools was conducted, and many were purchased. Educators were provided with the tools to sample and review with their classes or on their own. It was requested that educators submit a review of each of the products. This portion of the project commenced in the spring of 2001 with the initiation of the market search, and concluded in May of 2003 with submissions from educators containing their feedback on the products they reviewed.

3.2 Environmentally Sensitive Product Testing

3.2.1 Choosing the Test Products

The mosquito control products selected and tested for effectiveness were *Mosquito and Gnat Repellent™* (Dr. T's Nature Company), and the *Mosquito Magnet™ Pro* (American Biophysics Corporation). A review of mosquito control products was conducted, and a comprehensive list of those products was created. Environmental sensitivity, applicability to property owners and backyard habitat, availability, and the mechanism by which the products operate to control mosquitoes were considered in selecting the two chosen products. The list of environmentally sensitive mosquito control options considered is in Appendix A.

Mosquito and Gnat Repellent is a dry, grey, granular product that can be applied around homes, lawns, pool, and patio areas. Application consists of liberal casting of product over top the target area. It is recommended that the application area not receive water for forty-eight hours following application. *Mosquito and Gnat Repellent* is non-toxic and biodegradable, is purported by the manufacturer to have a pleasant odour and to last up to three weeks per application. The product is described as an excellent soil enhancer and turf builder. Active ingredients include lemon grass oil, mint oil, and garlic oil that are plated on an attapulgite homite clay carrier. The product is designed to release the aromatics over time, which act as a repellent for the application area.

American Biophysics Corporation manufactures a number of different models of *Mosquito Magnet™*. Two *Mosquito Magnet™ Pro* were donated to this study. According to the manufacturers, the *Mosquito Magnet™* "mimics a large mammal by emitting a plume of carbon dioxide, heat and moisture, which when combined with octenol, is irresistible to mosquitoes, no-see-ums, black flies, and sandflies." The *Mosquito Magnet™* produces carbon dioxide by catalytically converting propane contained in a twenty-pound propane tank. The unit is powered by propane. The American Biophysics Corporation claims that the Pro model provides mosquito control for one acre.

3.2.2 Experimental Design

The experiments were designed to test the effectiveness the *Mosquito Magnet™ Pro* and *Mosquito and Gnat Repellent™*. Three separate experiments were conducted in the summer of 2001, and then repeated in 2002. All three experiments were set up in a similar manner, though direct comparison between experiments was not intended.

Experiment #1 tested the effectiveness of the *Mosquito and Gnat Repellent* in an urban area (Wolseley – a Winnipeg neighbourhood). Experiment #2 tested the effectiveness of the *Mosquito Magnet™ Pro* in an urban area (Wolseley). Experiment #3 tested the effectiveness of the *Mosquito Magnet™ Pro* in a rural area (Fort Whyte Nature Centre, Winnipeg).

The products were tested in urban areas, as urban areas represent the places of highest consumer use. Wolseley, due to the interest expressed by community members to investigate environmentally sensitive mosquito control options, was chosen as the test neighbourhood. The Fort Whyte Nature Centre, was also used as a test area due to high mosquito populations.

Testing Sites

The experiments featured standardized test sites. Each experiment included at least one control site and one test site. All of the sites were selected based on similarity in

vegetation, open space, size, distance from mosquito breeding sites, wind currents, and sunlight exposure. Each experimental site was approximately 85 square meters. The vegetation on each site consisted of six-foot high shrubs, and a maximum of two full-sized trees on each site. While care was taken to ensure that the experimental sites were similar in many of the variables that affect mosquito populations, no sites were identical.

In Wolseley, the control and test sites were located on the same block of a single street for each experiment. The researcher canvassed the neighbourhood looking for property owners who were interested in becoming involved in the experiment. Not everyone approached was enthusiastic about the proposal. The landowner's commitment of a yard to the project meant tolerating equipment, restriction from conducting any additional mosquito control on the property, and having landing count volunteers traipsing through the yard for a period of weeks during summer, the most coveted part of the year. Benefits to the property owner included possibly having a successful product tested in the yard, being involved in a pro-active project that could benefit the community, and meeting friendly volunteers. Overall the response from involved property owners was very positive. Most commented that they found the scientific process interesting to observe, and they found the volunteers getting eaten alive outside their window, were also an observational treat. One property owner did not wish to be involved for a second year (2002), citing that the volunteer traffic was detrimental to the enjoyment of their summer. The adjacent property owner was more than willing to become involved, and the integrity of the repeated testing was not thought to be compromised.

Once the first willing property owner was identified, subsequent property owners were generally identified via references from the first. As it was required that the backyards be as similar as possible, considerable searching was required to identify suitable yards. The use of the networking method to find yard-donors ensured that community members were aware of the research. Those living on the two affected blocks recognized the researcher, and were aware of the intentions and purpose of the hooded volunteers, with stopwatches around their necks and long tubes in hand. At the height of the testing, there were as many as ten volunteers moving among the sites on a favourable summer evening.

To further improve the level of understanding of the experiments by homeowners, a letter was delivered to properties near or bordering the selected yards. The letter contained a description of the tests being conducted, and requested that if the property owner undertook any mosquito control measures (such as spraying of chemicals) that the researcher should be notified (Appendix B). No reports were made to the researcher.

At Fort Whyte Nature Centre, sites were selected that would not affect the visitors or be affected by the visitors to the centre. The area chosen was located in an open prairie area on the north-eastern side of the bison enclosure (see Appendix C for map).

Mosquito Population Estimates

Measurements of local mosquito populations were used to investigate differences between the control sites and the test sites, and therefore the effectiveness of the test products. It was assumed that, all variables were as similar as possible among the sites with the exception of the mosquito control device being employed on the test plot. Differences in the local mosquito populations could be attributed to the effectiveness of the products being tested.

Two methods were employed in estimating the mosquito activity on experimental sites. Light traps (Centre for Disease Control traps and New Jersey Light traps) were employed, and volunteers conducted Landing Counts. Two methods of measuring mosquito activity were used so the data could be cross-referenced to verify the outcomes and strengthen the validity of the experiments.

Light Traps

Both CDC and NJLT traps feature a light source that attracts mosquitoes. Mosquitoes were sucked by a fan into a collection container. The main difference between the two traps is the power source, and the NJLT has a somewhat brighter light source and stronger fan than the CDC trap. CDC traps were powered by re-chargeable eight-volt batteries, and the NJLT required an electrical power outlet. NJLT were used to test the

Mosquito and Gnat Repellent. Power outlets were accessible in the backyards of Wolseley, but not at Fort Whyte, and CDC traps were used there. CDC traps were also used in the Wolseley *Mosquito Magnet* experiment. Traps were placed in standardized locations on the experimental plots, and data were collected from the traps every second or third day. The traps were placed on the east side edge of the experimental sites.

Landing Counts

Landing Counts were conducted by volunteers. Thirty people per season (ten people per experiment) were enlisted for landing counts, receiving little more than a mosquito T-shirt and the gratitude of the researcher. A small number of volunteers (six) from the 2001 returned for the 2002 season, for a total of forty-nine volunteers collecting data over the two seasons. Volunteers included residents of the Wolseley area, students from the Natural Resources Institute, and friends and family members of the researcher.

Orientation sessions were required to educate the volunteers on how to conduct the Landing Counts. It was essential to ensure that volunteers were collecting the data in as similar a manner as possible. Orientation was held at the R.A. Steen Community Centre, and refreshments, Tall Grass Bakery cinnamon buns, and data collection packages were provided. The sessions lasted for approximately half an hour in which time the researcher provided the details of how to conduct the testing, experiment locations, data collection period, and answered questions. The volunteer information sheets, including the Landing Count forms, can be found in Appendix C.

For two reasons volunteers worked in pairs. Firstly, sending two people together to collect the data made it a social experience. Volunteers shared the experience of scientific experimentation, working as a team through the technical details of data collection. When the mosquitoes were severe, there was someone to complain with, and when the evenings were beautiful and you were surrounded by deer and hawks at Fort Whyte, there was someone to share it with. The second reason for partnering volunteers, and the more important reason from the scientific perspective, was that having a partner

helped keep people honest in conducting and recording data. Thus, when the mosquitoes were dense, the temptation to cheat was minimized because of your partner.

Landing Counts volunteers exposed their forearms, with no repellents, perfumes, or clothing cover, for a five-minute period. The mosquitoes landing on the exposed skin were counted. Participants dressed in long thick pants, long sleeves, gloves, hats, mosquito netting over the face and neck, and closed shoes. Volunteers could use whichever arm they felt most comfortable in offering. As mosquitoes settled on the exposed forearm, volunteers removed mosquitoes using an aspirator. The aspirator was a tubular device that has a coarse mesh screen and a fine filter in the middle to ensure that no mosquito legs or bits were inhaled or swallowed. One end of the tube is held in the mouth and the other end in the free hand. As mosquitoes land, suction provided by the mouth causes the mosquito to be trapped at the end of the tube before they have a chance to bite. The volunteer then deposited the mosquito into a cage, a small rectangular container with a cork sealing one end. The caged mosquitoes were submitted to the researcher for identification of species.

Tests were five minutes in duration, with the exception of situations with 'extremely high mosquito pressure'. When the mosquitoes passed a threshold level in severity (thirty in two minutes) the volunteer could conclude the test early and results were extrapolated to a five minute test. The Landing Counts conducted at Fort Whyte were concluded early 15% of the time due to high mosquito pressure. The highest number landing in the shortest time was thirty mosquitoes in forty-four seconds.

In order to reduce variability, all landing counts started within a ninety-minute window (6:30pm to 8:00pm). Participants filled out standard landing count forms (Appendix C) recording personal data, date and time, weather conditions, the results from the tests, and any additional observations.

Volunteers were requested to conduct a total of ten matched-pair (one control, one test) measurements by the completion of their volunteer service. Not every volunteer

conducted all ten measurements. Volunteers participating in this experiment were donating their time and energy during many beautiful summer evenings. Evening commitments, unfavourable weather, scheduling conflicts with partners, and in 2002, the arrival of West Nile Virus to the Winnipeg area, were deterrents to completing the volunteer service. In addition, all of the volunteers were made aware at the orientation session that, though they had agreed to participate, it was within their right to quit at any time, for any reason (Appendix C). The researcher conducted as many additional Landing Counts as possible in situations where volunteers were not able.

Test Period

The testing of mosquito control products was dependent on functioning light traps, trained and organized volunteers, procurement of the test products, carefully selected test sites, and the presence of mosquito populations. The last point was not of concern until June of 2001, when there were few mosquitoes in the Winnipeg area. Given the lack of mosquitoes on which to test the effectiveness of the product, the start of the 2001 experiment was delayed until 12 July. Heavy rains and hot weather caused a large emergence of mosquitoes in mid-July, and provided sufficient mosquito numbers to continue testing. The experiments concluded between 3 August and 1 September, 2001. In 2002, the test period commenced on the 14 June, and volunteers completed their service by the first week of August.

Test Product Application

Mosquito Magnet machines were turned on 7-10 days prior to the commencement of the collection of landing count data. The Mosquito and Gnat Repellent was applied to the test properties two days prior to the beginning of the experiment. It was applied at a rate of one container per test site, or approximately 40grams per square metre.

3.2.3 Data Management

Data management of both the physical samples from the NJLT, the CDC, and the Mosquito Magnet, and the volunteer-collected samples consisted of data collection, organization, and quantification. Landing count data were logged on a spreadsheet with

observations of wind conditions, cloud cover, and other information monitored for each sample.

The physical data from the light traps and the Mosquito Magnet were organized by counting the number of mosquitoes in each sample, either by hand-counting the entire sample, or for larger samples, sub-sampling and extrapolating the results to obtain an estimate of the number of mosquitoes. Mosquitoes were identified to species and sex to calculate the proportions present in each sample.

'Physical Data' refers to samples consisting of mosquitoes (and often other insects) collected from light traps and test products located on the test and control plots. Each of the different collecting mechanisms produced samples that were unique in their organic content and size, and therefore the different sample types required different quantification procedures.

Mosquito Magnet

The Mosquito Magnet was emptied every few days throughout the experiments and the mosquitoes were counted. These samples were composed almost entirely of female mosquitoes, thus there was no need to sex these samples. However, the large size of many of the Mosquito Magnet samples required sub-sampling to estimate the sample size.

NJLT

NJLT samples were quite different than the Mosquito Magnet™ samples in their composition. These samples contained a wide range of insects including moths, flies, butterflies, and bees. Mosquitoes had to be separated from the other insects in these samples before they could be counted. Some of the larger non-mosquitoes appeared to have thrashed around a good deal in the collecting container before expiring, which meant smaller insects in the container were broken into small pieces, increasing the time needed for sorting. Furthermore, both male and female mosquitoes were abundant in the NJLT samples, and the samples also needed to be sorted for female mosquitoes.

CDC

CDC samples were similar to the Mosquito Magnet™ samples. Quantification of these samples was less difficult than the NJLT because they were comprised almost exclusively of mosquitoes. The netting on the CDC traps afforded more room for the trapped insects, and there was little damage done from thrashing and rubbing of moths in the sample. Both male and female mosquitoes were present, so sorting was required.

Collection Procedures

Data collection from the NJLT generally occurred every third day, from the Mosquito Magnet™ every two to three days, and from the CDC light traps every second day. Some variation occurred in the data collection schedule due to weather conditions, mechanical breakdowns, and other factors. Mechanical breakdowns were common with the CDC traps. These traps were not new, and the wiring tended to be brittle, and the electrical connections often poor. Where a trap stopped functioning, it and its pair were removed from the analysis for the evening in question.

Collection of the samples started with the removal of the sample nets or containers from the traps. Ensuring the expiration of all of the insects collected was the next step. This was accomplished by placing the sample containers in a freezer for 48 hours. Once the insects were dead, samples were transferred to freezer bags and labelled with the time, date, and trap location. Samples were preserved at –5C.

The Sorting and Counting Process

Single samples ranged in size from several dozen mosquitoes to approximately 400,000 mosquitoes. There were two counting processes, depending on the sample size.

Smaller samples (approximately 2,500 mosquitoes or less) were treated by the following process:

1) Sorting of mosquito and non-mosquito insects (if necessary).
2) Sexing of mosquitoes (if necessary).

3) Hand-counting of mosquitoes. The number of males, females, and a total sample count were recorded.

Approximately three-quarters of all of the samples were quantified using the above method.

For large samples, counting each mosquito individually was not feasible. Large samples were counted by taking up to ten sub-samples from the main sample. **Statistics** were used to determine the number of sub-samples required to achieve a sufficient level of confidence and margin of error in the process. The minimum confidence level was set at 95%. Each sub-sample was relatively uniform in size, ranging from approximately 75-125 mosquitoes.

1) The entire sample, contents and bag, were weighed.
2) The bag was weighed once emptied.
3) Total weight of sample found (Total sample weight – bag weight).
4) The sample material was spread evenly over a piece of heavy paper. Up to ten sub-samples were selected by choosing random clusters of mosquitoes from the sample. The random clusters were obtained by dropping a small petri lid onto the spread sample, the mosquitoes covered by the lid comprised one sub-sample.
5) The weight and the number of mosquitoes for each sub-sample were determined. First, every sub-sample was weighed, once they were all weighed, they were counted. This minimized variation in sample weights that might occur due to the drying of the samples.
6) Calculate an average weight per mosquito. The average weight of a mosquito in each sub-sample was calculated using the sub-sample weight divided by the number of mosquitoes in the sample. The average weight per mosquito for the entire sample was calculated by taking an average of the sub-sample mosquito weights.
7) The total sample weight was divided by the average mosquito weight to get the estimated number of mosquitoes in the sample.

Random samples of mosquitoes were selected from NJLT, CDC, and Mosquito Magnet samples, and from mosquito cages filled by Landing Count activities. Manitoba is home to thirty-eight species of mosquitoes (Gadawski, 2001a). In order to gain insight into the different species present on the experimental sites, and the proportion in which they are present, some samples were examined under the dissecting microscope and identified to species. Many of the NJLT samples were badly damaged, making species identification difficult or impossible. Adults were identified using *Mosquitoes of North America (North of Mexico)* (Carpenter and Lacasse, 1974). Voucher specimens of each species were pinned and submitted to the J.B. Wallis Museum in the Department of Entomology, University of Manitoba.

Landing Count Data

The landing count data was submitted to the researcher in the form of the landing count forms (Appendix C). Forms included information on date and time of the measurement, and related weather conditions. Information from the forms was entered into the program SPSS 11.5 (SPSS Inc., 2001), and grouped according to the measurement date.

Wind, temperature, cloud cover, and 'person effect' were examined to identify effects on mosquito populations. If there are effects, it is also possible to examine if they were uniform across the experimental plots. If there were differences across the plots, it could potentially explain differences between the NJLT and Landing Count data. Wind was described as one of four categories. Calm = 0, slight breeze = 1, medium wind = 2, and strong wind =3. Temperature was measured using thermometers that were located at each of the experimental plots. Cloud cover was described in three categories. No clouds = 0, partially cloudy = 1, overcast =2. Person effect was tracked as each volunteer was given a number and the volunteer number that corresponded with each data set was inputted into the spreadsheet.

3.2.4 Statistical Analysis

Data sets were analyzed to identify differences between the control plots and the test plots, and thereby gain insight into the effectiveness of the test products.

To test the null hypothesis that there were no differences between the control and test treatments, paired T-tests were used to compare the two paired treatments. A matched pairs T-test measures observed differences between the two treatments (Moore, 1995). Differences between treatments were considered significant when $p < 0.05$.

Landing count data were examined using the General Linear Model Univariate procedure (SPSS Inc., 2001) to test the effect of one or more independent variables on a single independent variable. The interaction between factors, and the effects of individual factors, were investigated. The effects of temperature, wind, cloud cover, and volunteers on the number of mosquitoes collected, were investigated.

Statistical analysis started with testing the data for normality. The skewness to standard error of skewness ratio, the kurtosis to standard error of kurtosis ratio, mean to variance ratio, and the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality were used. Data that were not normal in accordance with these tests were log 10 (n+1) transformed to improve the distribution of the data for parametric testing.

3.3 Community Level Surveying

3.31 Setting the Scene

In this study, the specific purpose of the interviews was to collect feedback on a mosquito pamphlet, awareness and support for the local mosquito control program, engagement in mosquito habitat reduction on private property, concern and awareness of West Nile virus (WNV), and methods of learning regarding mosquito issues. The goal was to gain insight into the role of informal education and the mosquito situation in Winnipeg, and themes of approval or concern regarding mosquito control and disease issues. From these insights, recommendations were made for improving the IPM program.

Interviews were conducted during September and October of 2002. Sample areas selected for surveys were within the city of Winnipeg and included the neighbourhoods of Wolseley, The Maples, River Heights, and riverfront property owners within the city. These sample areas were chosen as a result of consultation with members of the project committee, and with the Honourable Jean Friesen, MLA for the Wolseley area. Random blocks of homes were chosen for potential interview participants.

Interviewing was explained by Merriam (1998) as a person to person or group conversation, specifically, a conversation with a purpose. The main purpose of interviewing is to obtain a special kind of information, and data analysis is based on commonality in experiences and opinions, based on patterns within the data (Bernard, 1994).

> *We interview people to find out from them those things we cannot directly observe... We cannot observe feelings, thoughts, and intentions. We cannot observe behaviours that took place at some previous point in time. We cannot observe situations that preclude the presence of an observer. We cannot observe how people have organized the world and the meanings they attach to what goes on in the world. We have to ask people questions about those things. The purpose of interviewing, then, is to allow use to enter into the other person's perspective.* (Patton, 1990)

When gathering data by the surveying process, the researcher should strive to minimize sources of error that might detract from the overall validity of the study. Foddy (1993) described a number of causes of error in the gathering data through survey procedures.

a) *Respondent's failure to understand the question as intended.*
b) *Lack of effort, or interest, on the part of the respondents.*
c) *Respondent's unwillingness to admit to certain attitudes or behaviours.*
d) *Failure of respondent's memory or comprehension processes in the stressed conditions of the interview.*
e) *Interviewer failure of various kinds (i.e. tendency to change wording, failures in presentation practices, adoption of faulty recording procedures).*

These most common of causes of error were acknowledged and addressed by the interviewer in the construction and conducting of the interviews. Test interviews were conducted such that potential problems with the clarity of the questions could be addressed prior to beginning the interview process. Participation in the project was

voluntary, and there was no incentive (monetary or otherwise) offered for participation – resulting in participants who were interested in the process of the research or the topic of the research, or both. Every effort was made to make participants feel at ease, with interviews being conducted in the home, and the interviewer attempting to project the most open and understanding image as possible, in order to address errors c and d. Finally, the potential for interviewer failure was reduced by clarity and consistency in the asking of questions, and use of a Dictaphone to record all details of responses. However, as with all qualitative research, there is an innate element of subjectivity involved.

> ***The use of verbal data has been made the keystone of contemporary social science and there is no sign of this situation changing. There is much evidence, nevertheless, to support the conclusion that the verbal data we collect are very often of dubious validity and reliability.*** – Foddy, 1993.

3.3.2 Survey Set-up

Primary data collection was conducted using one-on-one, semi-structured interviews to record the experiences, beliefs and opinions of Winnipeg residents. This surveying approach was chosen because it would allow interview participants to express themselves in their own terms and without the influences of other participants, as might occur in a group interview or panel discussion. In addition, participants were able to put forth their views in the comfort and familiarity of their home setting. Finally, flexibility was built into the interview schedule such that the participant could raise and speak to issues that were important to them, that may not have been specifically included in the interview schedule. This qualitative format allowed for greater depth than would have been possible with, for instance, a quantitative mail-out survey or other formats. With the permission of the participant, interviews were tape-recorded in order to ensure accuracy. The recordings were transcribed verbatim, and reviewed at a later date.

The Sample Areas

In order that the survey participants were randomly selected, and represented as close to a cross-section of Winnipeg residents as possible, interviews were conducted in three areas of the city. The intent was to obtain a sample of interview participants that were as close

to 'probability sample'[1] as possible. While the surveying was designed for random access to interview participants, this was difficult to achieve as those who consented to participate in an interview likely held common traits compared to those who refused an interview. Wolseley, The Maples, River Heights, and riverfront property owners were the four groups targeted for the survey.

In Wolseley, citizens have been very involved in municipal mosquito control issues, and this neighbourhood constitutes a case study of citizens generally motivated to participate in control programs. Additionally, Wolseley was selected because the citizens had been involved in other aspects of this thesis project, and interest had been expressed from the Wolseley Resident Association, and directly from private citizens. Furthermore, the support of the local Member of the Legislative Assembly had been invaluable, and she requested that a portion of this research be conducted within her constituency.

River Heights citizens have not been as involved in mosquito control issues relative to Wolseley residents. River Heights was included as a neighbourhood representing citizens less involved in the mosquito control issue.

The Maples was the third neighbourhood chosen for the project, and was identified for its ethnic diversity and the fact that its level of affluence was different from the Wolseley and River Heights areas (The Frontier Centre for Public Policy, 2002). It was also hypothesized that previous exposure to mosquito-borne pathogens could be higher among the Maples population, as many residents are immigrants or first generation Canadians.

Riverfront property owners constituted the fourth case study. These citizens potentially have special interests regarding mosquito control due to their proximity to the river and larger property size. Riverfront property owners were located along the Assiniboine River within the boundaries of the City of Winnipeg.

[1] Probability sampling includes the common simple random sample technique (Moore, 1995)

The objective was to conduct interviews with at least fifteen residents in Wolseley, fifteen in River Heights, ten interviews with riverside residents, and fifteen with Maples residents, for a total of at least fifty-five interviews. Appendix D lists interview questions.

The Interview Schedule

The interview schedule consisted of twenty-five main questions, with some questions added or deleted during the interview, depending on the needs and interests of the participant. The preliminary list of questions for the schedule was derived from the literature review and current topics of debate pertaining to mosquito issues in Winnipeg. That list was sent to the Insect Control Branch and the MLA of Wolseley for review. Questions were added, deleted and revised based on the suggestions and areas of interest of these two parties. When the final interview schedule was created, it was tested in five preliminary interviews to ensure that participants understood what was being asked, and that the flow of the questioning was reasonable and allowed for easy discussion of the issues. Following the preliminary interviews, some final editing of the interview schedule was completed prior to commencing interviews in the field.

Attaining an Interview

City of Winnipeg 'Fight the Bite' mosquito pamphlets were delivered to the mailboxes of random blocks of homes within the targeted study areas (Appendix E). The pamphlets were not accompanied by any communication that indicated that a researcher would be coming to discuss mosquito issues. Four to eight days following the delivery of the pamphlet, the researcher conducted 'cold calls', approaching residents and requesting an immediate interview. Once a resident opened the door, they were greeted and informed of the nature of the research, and the interview was requested. Potential participants were approached with the '*Fight the Bite'* pamphlet in hand, so that if a resident had not seen the pamphlet, it was still possible for them to participate in the interview. Interviews lasted fifteen to twenty-five minutes.

Validity, Reliability, and Ethics

"All research is concerned with producing valid and reliable knowledge in an ethical manner." (Merriam, 1998). When an individual agreed to participate in an interview, a letter (Appendix F) was presented offering project details, informing on participant rights, and providing contact information for the University of Manitoba Ethics staff and Dr. John Sinclair, project advisor. The research was conducted in accordance with the University of Manitoba ethics committee. Participation in the study was voluntary, and participants could decline to answer questions for any reason, or withdraw from the study at any time. Participants were not subjected to any manipulation (leading questions, invoking emotive responses, etc.) during data collection. A business card of the principal investigator was provided to the participant. Participants were informed of their eligibility to receive summarized survey results, and mailing information was recorded for those interested. Participants were made aware of the research objectives, and assured a confidential nature of the responses. Overall, every effort was made to ensure that the data collected were valid and error-free.

Analysis

> **"Data analysis is the process of making sense out of the data. And making sense out of data involved consolidating, reducing, and interpreting what people have said and what the researcher has seen and read – it is the process of making meaning.** - Merriam, 1998.

The interview recordings were transcribed and reviewed. Data were logged and categorized. Each participant was assigned a code number (1-58) to provide anonymity. Recommendations were based on commonality of responses in the interview data. Triangulation of the data was used in the analysis. Multiple sources of data, including the literature review and multiple interview participants, were used when formulating outcomes. The analysis included data compression and a descriptive account of the compressed results. Themes of interest were identified and probabilistic speculation was conducted to make informed guesses about future events based on survey data. Gotez and LeCompte (1984) described this final method of predicting future outcomes based on

what has been learned in the past and linkages and comparisons about what is presently known about the same phenomena.

3.4 Formal Education – Annotated Bibliography

Introduction

This portion of the project was initiated in order to address formal education as a component of the Integrated Pest Management (IPM) approach. Formal learning takes place within an institutional setting (grade school, university, college, etc.), in a process that generally leads to the conferment of some form of recognition of participation (Merriam and Caffarella, 1991). Though conducted in the past, the City of Winnipeg Insect Control Branch does not currently carry out in-school mosquito education.

As part of the IPM mosquito control program, a number of American mosquito control districts conduct educational programs that can include classroom/assembly presentations, field trip opportunities, story/poster contests, mosquito classroom kits for educators, offering free mosquito educational tools to schools, and in one district an RV, outfitted as a travelling classroom (SCMAC, 2001; NJMCA, 2003; Namanny, 2003). The City of Winnipeg does not currently offer formal education for children, and an annotated bibliography could be used as a tool for formal mosquito education endeavours.

Project Set-up

The search for mosquito educational tools commenced in the spring of 2001. Internet and library searches, and inquiries to other mosquito control districts were conducted. Teacher review of the products was on going through the 2002-03 school year, and concluded in May of 2003 when educators submitted their feedback.

Once educational tools were identified, many were purchased. Following this, Middle Years educators interested in becoming involved in the project were identified through letters of intent and invitation. These letters and invitations were sent to all of the schools in Wolseley and some in the Fort Rouge area (Appendix G). Teachers from the Laura

Secord Middle School in Wolseley comprised the majority of those involved in the study. Interested educators were provided with the educational tools to sample and review. Educators were requested to submit an analysis of each product reviewed. A letter accompanied the educational tools, and included a list of guiding questions that the teachers could use when formatting their feedback on the products (appendix H). The feedback was then compiled and included in the final annotated bibliography (Appendix I). The annotated bibliography was presented to all of those who participated in the project, the City of Winnipeg Insect Control Branch, the Province of Manitoba Middle Years Science Co-ordinator, educators, and may be placed on the internet to allow broader public access the document.

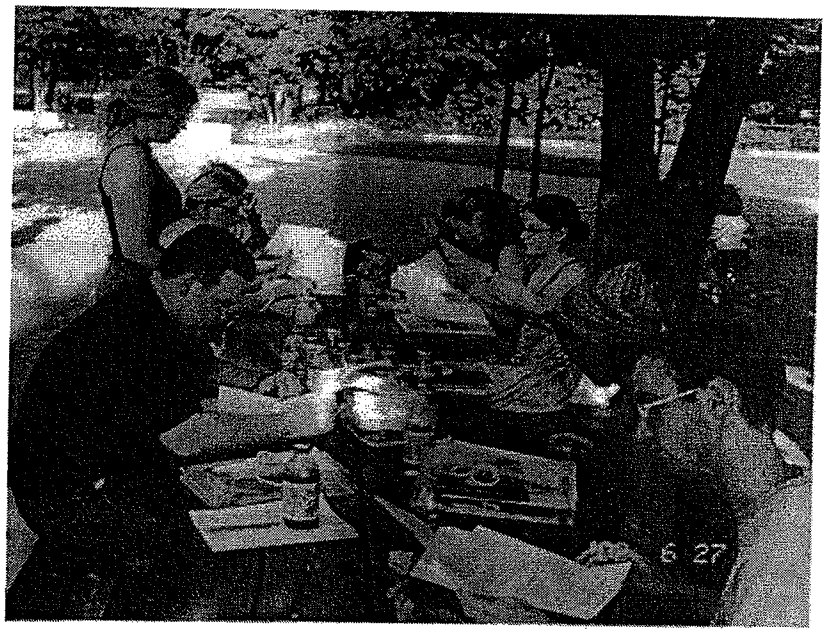


Photo: Matthew Henderson

Photo: Dr. T's Nature Products

Photo: American Biophysics Corporation

"The first time we went out, what was going through my head was, 'Damn – I must really like Julie." - Alisa Ramrattan, Landing Count Volunteer, Winnipeg Sun, date.

Chapter 4
Product Testing – Results, Findings, Outputs

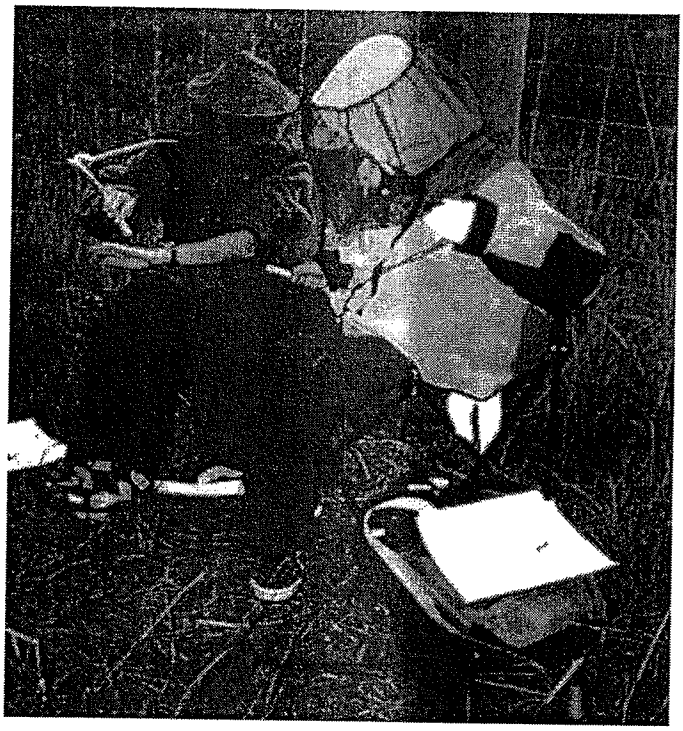


Photo: Julie Price Henderson

4.1 Introduction

There is no happy news of a wonder-product or fantastic mosquito relief contained within this chapter. The Mosquito Magnet™, by the American Biophysics Corporation, and the Mosquito & Gnat Repellent, by Dr. T's Nature Company, were tested vigorously, thoroughly, and according to the scientific literature, for their effectiveness. Neither product significantly reduced mosquito populations. Though the effectiveness of the products was disappointing, information on the interactions between mosquitoes and environmental factors, and species information are potentially valuable to mosquito control experts in the Winnipeg area.

4.2 Experiment #1 – Mosquito & Gnat Repellent

Dr. T's Mosquito & Gnat Repellent, as described in Chapter 3, is supposed to reduce the number of mosquitoes present in a localized area by repelling mosquitoes from the area. The effectiveness of this product was tested using two test sites and one control site, and measurements were taken from these sites using New Jersey Light Traps (NJLT) and landing counts. If the product was working, there should have been fewer mosquitoes collected by the NJLT and the landing counts on the test plots than on the control plot.

4.2.1 NJLT Results

The summary statistics from the NJLT data for the 2001 – 2002 field seasons can be found in Table 1. In 2001, there were nine samples collected between 12 July and 3 August, a twenty-three day period. The largest samples were all collected on the same day, 15 July, the first day of testing. The smallest samples were collected on 25 July for test plot #2 and the control plot, and on the 27 July for the test plot #1.

In 2002, there were fifteen samples collected between the 1 July and 6 August. As with the 2001 season, the largest samples were all collected on the same day (though not the

first collection day) which was 8 July. The smallest samples for test plot #1 and test plot #2 were both collected on 26 July, and for the control plot, two days earlier on 24 July.

	Duration of collection	Total # collected	Largest sample		Smallest sample	
			Total	#/ hour	Total	#/ hour
Test 1, **2001** N=9	07/12-08/03	2,959	1,008	14.4	99	2.1
Test 2, **2001** N=9	07/12-08/03	775	239	3.4	34	0.7
Control, **2001** N=9	07/12-08/03	5,937	2,402	34.3	147	3.0
Test 1, **2002** N=15	07/01–08/06	6,794	1,104	22.7	45	1.0
Test 2, **2002** N=15	07/01–08/06	5,648	1,025	21.0	45	1.0
Control, **2002** N=15	07/01–08/06	14,322	3,136	64.3	88	1.78

Table 1. 2001-2002 summary statistics, number of mosquitoes collected by NJLT, Mosquito & Gnat Repellent experiment.

Prior to testing, differences between the experimental plots in the 2001 and 2002 field season, the data were tested for normality and were transformed (log10).

There was a significant difference in the number of mosquitoes collected on the test plots and on the control plot, with the test plots having significantly *fewer* mosquitoes than control plots (Table 2). This result would be expected it the test product is functioning to repel mosquitoes from the area. Test #2 had significantly fewer mosquitoes than Test #1 (Table 2).

In 2002, the paired T-test, when applied to the matched pairs (n=16), showed significant differences (Table 2). As with the 2001 season, the two test plots had significantly fewer mosquitoes.

	Test 1		Test 2		Control		C-T1 *P*	C-T2 *P*	T1-T2 *P*
	Mean	Standard error mean	Mean	Standard error mean	Mean	Standard error mean			
Total **2001** N=9	328.8	99.4	86.1	21.1	659.7	232.7	**0.001**	**<0.001**	**<0.001**
First Half (07/15-07/23) **2001** N=5	451.6	156.7	105.8	35.2	890.6	398.3	**0.009**	**<0.001**	**0.001**
Second Half (07/23-08/03) **2001** N=4	175.2	65.1	61.5	15.6	731.0	102.5	0.070	**0.001**	**0.035**
Total **2002** N=15	452.9	99.2	376.5	82.4	954.8	245.4	**<0.001**	**<0.001**	**<0.001**
First Half (07/02-07/15) **2002** N=7	802.1	87.5	621.1	112.2	1697.6	346.1	**0.001**	**<0.001**	**0.020**
Second Half (07/15-08/06) **2002** N=8	147.4	50.9	162.5	44.8	304.9	81.4	**<0.001**	**<0.001**	0.528

Table 2. 2001-2002 paired T-test results, number of mosquitoes collected by NJLT, Mosquito & Gnat Repellent experiment.

4.2.2 Landing Count Results

In 2001, one hundred matched landing counts measurements were conducted, and in 2002 seventy-six were conducted. The minimum and maximum number of data sets collected by volunteers, minimum and maximum landing counts collected on each site,

total number of mosquitoes counted on each site, and the mean and median values for the total data sets are shown in Table 3.

The means, and the standard error of those means, for mosquitoes landing, temperature, and wind for each site and season are shown in Table 4. In both years, there is little difference between the sites in terms of wind and temperature. The mean number of mosquitoes on test site #2 is double the means on test site #1 and the control site in 2001, and higher again in 2002. The various interactions between variables and mosquito counts, and between the variables and the plots on which the counts were taken are shown in Table 5. P-values at or below 0.05 are presented in bold.

	# of volulnteers	Collection period	Range of # data sets / vol.	Total counted per plot	Range of landing counts
Test 1, **2001** N=100	10	07/13-07/24 = 12 days	10	204	0-14
Test 2, **2001** N=100	10	07/13–07/24 =12 days	10	407	0-53
Control, **2001** N=100	10	07/13–07/24 = 12 days	10	201	0-10
Test 1, **2002** N=76	10	07/03–07/17 = 15 days	2 – 10	587	0-46
Test 2, **2002** N=76	10	07/03-07/17 = 15 days	2 – 10	511	0-59
Control, **2002** N=76	10	07/03-07/17 = 15 days	2 – 10	512	0-47

Table 3. 2001-2002 summary statistics, mosquito landing counts, Mosquito & Gnat Repellent experiment.

	2001 N = 100						**2002** N = 76					
	Control		Test 1		Test 2		Control		Test 1		Test 2	
	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean
Mosquitoes	2.01	0.23	2.04	0.28	4.07	0.81	6.74	1.05	6.72	0.93	7.72	1.22
Temperature	24.72	0.28	25.00	0.29	24.44	0.28	26.95	0.40	27.21	0.41	27.11	0.36
Wind	0.24	0.04	0.24	0.04	0.24	0.04	0.63	0.09	0.74	0.09	0.67	0.09

Table 4. 2001-2002, mean values for mosquitoes, temperature, and wind, mosquito landing counts, Mosquito & Gnat Repellent experiment.

Significant at p<0.05	**2001** N = 100			**2002** N= 76		
	Control vs. Test 1	Control vs. Test 2	All three sites	Control vs. Test 1	Control vs. Test 2	All three sites
	P	*P*	*P*	*P*	*P*	*P*
mos. x treatment	0.935	**0.016**	**0.006**	0.993	0.540	0.751
mos. x wind	0.513	0.120	0.122	**<0.001**	**0.003**	**<0.001**
mos. x temperature	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
mos. x person	0.181	**0.021**	**0.004**	**<0.001**	**0.001**	**<0.001**
mos x cloud	**0.001**	0.684	0.458	0.064	0.144	**0.044**
mos x trt x wind	0.785	0.240	0.251	0.953	0.484	0.802
mos x trt x temp	0.783	0.059	0.082	**0.009**	**0.008**	**<0.001**
mos x trt x person	0.958	0.123	0.162	0.983	0.972	0.999
mos x trt x cloud	0.881	0.460	0.567	0.498	0.769	0.850

Table 5. 2001-2002 GLM Univariate analysis of interactions between variables, mosquito landing counts, Mosquito & Gnat Repellent experiment.

4.2.3 Experiment #1 Discussion

In experiment #1, the testing of the Mosquito and Gnat Repellent, the NJLT data and the Landing Count data did not support each other. Based on the NJLT data, the Mosquito and Gnat Repellent was effective at reducing mosquito activity in the test areas. The Landing Count data did not show any reduction in mosquito activity, and thus it is difficult to conclude that the product was effective as landing counts were similar between controls and treatments.

Both field seasons had statistically fewer mosquitoes being collected in the NJLT on the test sites than on the control sites, with high levels of significance ($p<0.001$). These results seem to indicate that the product is reducing the number of mosquitoes present in the application area, and therefore is effective. It was difficult to tell if there were variables other than the test product affecting mosquito populations. The 2002 baseline data suggested that the sites had similar numbers of mosquitoes prior to product application.

The Landing Count data analysis was more complex than the NJLT analysis, and revealed more information regarding the interaction of mosquito populations with environmental variables on each of the sites. In assessing the results of the two methods of measuring mosquito activity, the ultimate goal of purchasing a mosquito control product is to reduce the annoyance level of mosquitoes. The two data collection methods showed different results, but ultimately, being bitten less is more important than fewer mosquitoes being collected in a trap.

There was a significant interaction from landing count results between the control and test #2 data in 2001. The result was *more* mosquitoes landing on test #2 site, which is opposite of the expected outcome if the Mosquito & Gnat Repellent is reducing mosquito populations in the application area. In 2002, no interactions occurred between mosquitoes and the treatment, showing the number of mosquitoes landing were the same across all three experimental plots.

In 2001, there was no significant interaction between mosquitoes and wind. This was surprising as mosquitoes are not strong fliers and are quite affected by wind movements. Mosquitoes fly less in windy conditions, and the stronger the wind, the more pronounced the suppression of flying activity will be (Bidlingmayer *et al.*, 1985). However, the wind measurements for the 2001 season were low. Out of the 300 samples taken, wind was categorized as '0' in 228 samples, and at '1' in 72 samples. The wind measurements never exceeded 1 in this data set. In 2002, the wind vs. mosquito interaction did show an inverse relationship. During this field season, the wind velocities were more varied and each category was well represented. There were a total of 228 records, with wind 0 = 112, wind 1 = 92, wind 2 = 12, and wind 3 = 12. When the treatment was included in the analysis, there was no difference between the sites in either of the field season. The wind effect was the same on each of the experimental sites, proving the similarity of the sites with respect to wind.

Individual people may have specific body chemistry and characteristics that determine how attracted mosquitoes are to them (Maiback *et al.*, 1966; Eiras and Jepson, 1994; Healy and Copland, 2000; Shirai *et al.*, 2002). The effect of the person collecting the data, in relation to the number of mosquitoes counted, was examined. In both field seasons there was a discernible person effect taking place. Some people seemed be more attractive to mosquitoes, and therefore have more mosquitoes landing on them, than other people. When this effect was examined between the experimental plots, there was no significant difference between the person effect and the mosquitoes collected on each of the sites (Table 5). This is not surprising as every volunteer was taking measurements on each of the plots, so any differences in the attractiveness of mosquitoes would be displayed in the data collected on every plot.

The effect of cloud cover on the number of mosquitoes landing was varied in the two field seasons. Cloud cover was loosely correlated with increased mosquito counts. As with the person effect and the wind effect, when the cloud cover influence was measured between the plots, there was no significant difference.

Temperature can affect the activity of mosquitoes. Different mosquito species have different optimal activity temperatures. Differences in the temperature – activity relationship have been observed (Bidlingmayer, 1985). Mosquitoes and temperature resluts showed a significant interaction between the number of mosquitoes collected and the temperature in both field seasons. In 2001, the temperature effect was not a problematic factor between the sites as both sites experienced the same effects. In 2002, there were discrepancies in the extent of the effect that temperature was having between site (Figure 4). At 24°C there was a peak in the number of mosquitoes collected (Figure 5). On 7 July, an unusually high number of mosquitoes were recorded on two of the experimental sites, and the temperature that day was 24°C. When the 7 July data is removed from the data set, and temperature re-analyzed, the difference between the plots is not significant. Additionally, some of the data sets for each temperature point are small (n=4, n=8). Small data sets make it possible for anomalies to have a greater effect on the analysis. Overall, the mean temperatures between the plots were very similar (Table 5), and it is unlikely that temperatures were affecting the mosquito counts between plots.

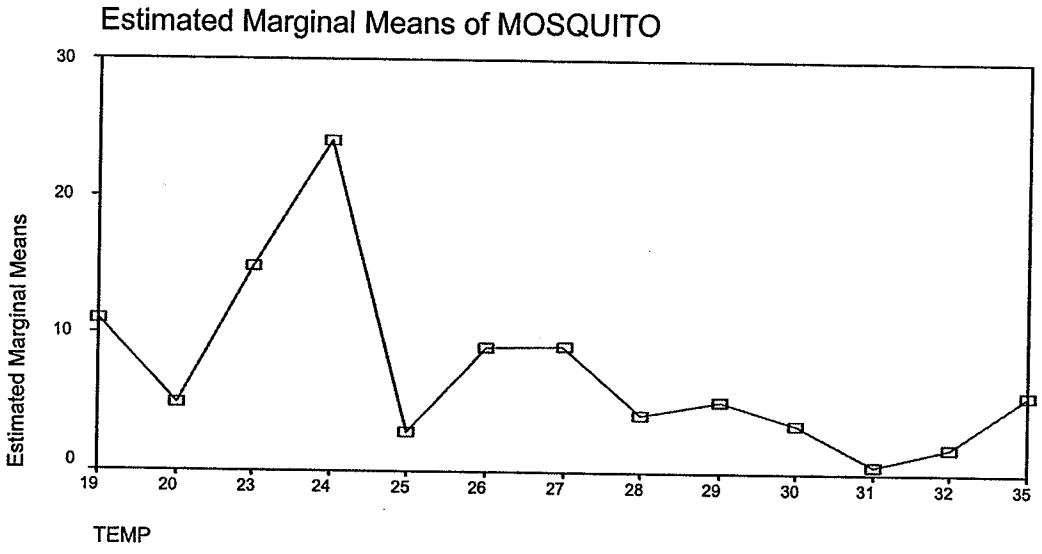


Figure 4. 2002, relationship between temperature and the number of mosquitoes landing, Mosquito & Gnat Repellent experiment.

Mosquito & Gnat Repellent was not effective in repelling mosquitoes from the application area. There were fewer mosquitoes collected by the NJLT on the test sites, but this result was not mirrored by landing count data, where there were no significant differences between test and control sites. A consumer would be getting as many mosquito bites post application as pre-application, and would not be experiencing benefit from the addition of the product. The Mosquito & Gnat Repellent by Dr. T's Nature Company was not efficacious in lowering mosquito biting activity in test yards.

4.2.4 Experiment #1 Species Results

For the Mosquito & Gnat Repellent experiment, two samples were identified to species, and both samples were collected by NJLT. The results for the samples are featured in Table 6. *Aedes vexans* (Meigen) was the most numerous species collected in the two samples by the NJLT in Mosquito and Gnat Repellent experiment yards. The category with the second most abundant mosquitoes was 'non-identifiable'. The non-identifiable insects were those that were damaged, and therefore impossible to identify. In each sample, more than a quarter of mosquitoes were damaged. *Ochlerotatus sticticus* (Meigen), *Ochlerotatus spencerii* (Theobald), and *Coquillettidia perturbans* (Walker) were found in each sample, though not in large numbers.

	Total sample size	*Aedes vexans*	*Ochlerotatus sticticus*	*Coquillettidia perturbans*	*Ochlerotatus spencerii*	Non-identifiable
07/15/01, Control	135	95	3	1	1	35
% total	100%	70.4%	2.2%	0.75%	0.75%	25.9%
07/15/01, Test #1,	121	73	8	3	-	37
% total	100%	60.3%	6.6%	2.5%	-	30.6%

Table 6. 2001, species identified, Mosquito & Gnat Repellent experiment. Source: NJLT.

4.3 Experiment #2 - Mosquito Magnet™, Urban Area

The Mosquito Magnet™, as described in Chapter 3, is supposed to reduce mosquito populations by removing mosquitoes from the environment. The effectiveness of this product was tested using one test site and one control site, and measurements were taken from these sites using CDC traps and landing counts. If the product was effective, there should have been fewer mosquitoes collected by the CDC light traps and the landing counts on the test site than on the control site.

4.3.1 Mosquito Magnet™ Results

In 2001, the Mosquito Magnet™ was tested in an urban area between 12 July and 15 August. Data were collected from Mosquito Magnet machines, and the total number of mosquitoes collected in 2001 was 25,838. The smallest sample occurred on 25 July, and the largest sample on 18 July. The mean number of mosquitoes per sample in 2001 was 2,348 (Table 7).

	Duration of collection	Total # Collected	Largest Sample		Smallest sample		Total season	
			Total	#/hour	Total	#/hour	Mean	S.E. mean
2001 N=11	07/12-08/15 = 35 days	25,838	7,060	94.8	185	2	2,349	688
2002 N=13	06/30-07/29 = 30 days	254,361	142,460	1462.1	464	6.6	19,566	11,044

Table 7. 2001-2002, summary statistics, number of mosquitoes collected by the Mosquito Magnet™, Mosquito Magnet urban experiment.

In 2002 samples were collected from 30 June and 29 July at the urban experimental site. The total number of mosquitoes collected in 2002 was 254,361. The smallest sample was 22 July the largest sample was 8 July. The 8 July sample comprised an incredible 56% of the total mosquitoes collected during 2002. The mean number of mosquitoes collected was 19,566 (Table 7).

4.3.2 CDC Results

CDC traps were operated throughout the 2001 and 2002 field seasons (Table 8). In 2001, samples were collected between 12 July and 18 August. The total number of mosquitoes collected during 2001 on the control plot was 158 and on the test plot was 2,176. The smallest samples were collected on congruent dates, both on 21 July and both with zero (0) mosquitoes being collected. The largest sample from the control plot was collected on 10 August and on 7 August for the test. The highest test site collection is skewed from the rest of the data (Table 8).

The total number of mosquitoes collected and the mean from the test plot data are not representative of what the trap was generally collecting. One sample was extremely large (1,808) and comprised 83% of the total number collected for the season. This was an anomaly, as the subsequent sample from the test plot totalled only two mosquitoes.

In 2002, samples were collected between 22 June and 26 July. The total number of mosquitoes collected on the control plot was 384, and 725 on the test plot. The smallest samples were collected on the last sample day, 26 July. The largest samples were collected on 2 July for the test plot and on 6 July for the control plot. The test plot had higher numbers of mosquitoes collected than the control plot (Table 8).

	Duration of collection	Total # collected	Largest sample		Smallest sample	
			Total	#/hour	Total	#/hour
Test **2001** N=10	07/12-08/18 = 38 days	2,176	172	2.5	0	0
Control **2001** N=10	07/12-08/18 = 38 days	158	35	0.5	0	0
Test **2002** N=12	06/30-07/26 = 27 days	510	249	4.7	1	0.02
Control **2002** N=12	06/30-07/26 = 27 days	218	41	1.0	0	0

Table 8. 2001-2002, summary statistics, number of mosquitoes collected by the CDC, Mosquito Magnet urban experiment.

	Test		Control		*P*
	Mean	S.E. mean	Mean	S.E. mean	
2001 Total Experiment N=11	197.8	161.8	14.4	3.7	0.208
2001 First Half (07/15-08/03) N=6	55.3	26.9	11.2	5.2	**0.036**
2001 Second Half (08/03-08-18) N=5	368.8	359.8	18.2	5.3	0.788
2002 Baseline Data N=4	53.8	27.6	41.5	25.6	0.217
2002 Total Experiment N=12	42.5	19.5	18.2	4.5	0.074
2002 First Half (07/02-07/13) N=6	69.3	36.6	25.7	6.3	0.236
2002 Second Half (07/13-07/28) N=6	15.7	6.3	10.7	5.1	0.074

Table 9. 2001-2002, paired T-test results, number of mosquitoes collected by CDC, Mosquito Magnet urban experiment.

In 2001, there were no significant differences between matched pairs (n=11) (p=0.208). The Mosquito Magnet™ is supposed to lower a population of mosquitoes over time by removing all of the breeding/biting females. To determine if there was any change in the effectiveness of the machine over time, the field season was divided into first and second halves. There was no significant difference between treatments in the second half of the season (Table 9), but there was a significant difference between sites during the first half of the experiment, with the test plot having significantly *more* mosquitoes present than the control plot (Table 9).

In 2002, the baseline data (n=4) showed no significant difference in the number of mosquitoes between the plots (p=0.286) (Table 9). There was no significant difference between the two sites prior to the operation of the Mosquito Magnet.

The Paired T-test results (n=12) was p=0.074, not significant. The test mean was actually higher than the control mean, indicating that the test is approaching a significance level,

which indicates more mosquitoes on the test site than on the control site, opposite to what is expected if the machine were effective.

As with the 2001 data, the 2002 data were broken into first and second half of the experiment to examine any differences in the effectiveness of the machine over time. 2 July – 13 July yielded a p value of 0.236, no significant difference. 13 July to 26 July revealed a p value of 0.074, again no significant difference (Table 9).

4.3.3 Landing Count Results

The Landing counts were conducted on the test site and control site. In the 2001 season, 55 matched data sets were collected, and in 2002, 76 matched sets were collected. The minimum and maximum number of data sets collected by volunteers, minimum and maximum counts collected on each specific site, total number of mosquitoes counted on each site, and the mean and value for the data sets, as shown by Table 10. There were more mosquitoes present in the 2002 field season, with approximately twice the number of total mosquitoes counted on each plot.

	# of Volunteers	Collection period	Range of data set collected	Range control	Range test	Total control	Total test
2001 N=55	7	07/23–08/05 = 14 days	2-14	0-96	0-115	349	412
2002 N=76	10	07/03–07/17 = 15 days	2-10	0-53	0-48	952	1,381

Table 10. 2001-2002, summary statistics, mosquito landing counts, Mosquito Magnet urban experiment.

The various interactions between variables and mosquito counts, and between the variables and the plots on which the counts were taken are shown by Table 11. The means for mosquitoes landing, temperature, and wind for each plot for each season are shown in Table 12.

Significant at p<0.05	**2001** N=55	**2002** N=76
	P	*P*
mos. x treatment	0.720	**0.017**
mos. x wind	0.054	0.108
mos. x temperature	**<0.001**	**<0.001**
mos. x person	**<0.001**	**0.050**
mos x cloud	**<0.001**	0.175
mos x trt x wind	0.573	0.057
mos x trt x temp	0.891	0.188
mos x trt x person	0.317	0.078
mos x trt x cloud	0.069	**0.005**

Table 11. 2001-2001 GLM Univariate analysis of interactions between variables, mosquito landing counts, Mosquito Magnet urban experiment.

	2001 N = 55				**2002** N = 76			
	Test Plot		Control Plot		Test Plot		Control Plot	
	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean
Mosquitoes	7.49	2.31	6.35	2.19	18.17	1.43	12.53	1.00
Temperature	22.20	0.40	22.20	0.43	25.00	0.37	24.21	0.33
Wind	0.76	0.11	0.55	0.11	0.58	0.06	0.53	0.06

Table 12. 2001-2001, mean values for mosquitoes, temperature, and wind, mosquito landing counts, Mosquito Magnet urban experiment.

4.3.4 Experiment #2 Discussion

The CDC and landing count data results were similar. The analysis of mosquitoes interacting with wind, temperature, person effect, and cloud cover did not reveal any discrepancies between the two experimental sites, and both sites appear to have had similar environmental conditions occurring. Both the CDC and landing count methods of measuring mosquito populations revealed the Mosquito Magnet to be ineffective in reducing mosquito populations in this backyard scenario.

The number of mosquitoes collected by the Mosquito Magnet varied greatly between the two years, with almost ten times as many mosquitoes being collected in 2002 as in 2001 (Table 7). The difference in the number of mosquitoes collected each season is likely a reflection on local seasonal mosquito populations rather than product effectiveness.

There was no significant difference between the number of mosquitoes being collected on the experimental sites when the total data set was analyzed (Table 9). The 2002 baseline data showed no difference between sites, confirming the similarity in mosquito populations between sites at the outset of experimentation. When the 2001 and 2002 seasons were broken into halves, the test plot showed consistently higher mosquito numbers, though this was only significant during the first half of the 2001 season (Table 9).

There were no differences in landing count data between sites in 2001, and significant differences in 2002, with more mosquitoes on the test site (Table 10). This 2002 result is opposite the hypothesized results if the product reduced mosquito numbers.

Not surprisingly, there was significant interaction between the number of mosquitoes collected and wind strength in 2001, though not in 2002 (Table 11). Wind inhibits flight activity. In 2002, there was little diversity wind strengths recorded, likely causing the lack of significant interaction. When the treatment was included, there was no difference between the plots in either field season, meaning the same interactions were taking place

on both of the experimental sites. Therefore, wind can be ruled out as a variable affecting the perceived effectiveness of the Mosquito Magnet.

As with the Mosquito and Gnat experiment, there was a significant person effect on the number of mosquitoes collected in both seasons, and this effect was the same for both treatments (Table 11). Therefore, 'person' can be ruled out as a variable affecting the perceived effectiveness of the Mosquito Magnet.

The cloud cover effect on mosquito numbers was significant in 2001, though not in 2002 (Table 11). Conversely, there was no difference in the cloud cover effect between treatments in 2001, but in 2002 there was a significant difference (Table 11). The 2002 difference between treatments is not a strong concern in the final conclusion because when the entire 2002 data set was examined, there was no strong effect between mosquitoes and cloud. The difference between treatments was significant, within a very small variation.

There were significant interactions in the number of mosquitoes landing verses temperature in both years (Table 11). However, there was no temperature interaction between treatments in either year (Table 11). Therefore, temperature was ruled out as a variable affecting the perceived effectiveness of the Mosquito Magnet.

The final conclusion from the analysis is that the Mosquito Magnet did not reduce mosquito populations in the test area. If anything, the machine increased mosquito populations. The CDC results did not show a benefit. The landing count data showed no benefit in 2001, and in 2002 the test plots had significantly more mosquitoes landing. This is contrary to the expected result if mosquito populations in the area had been reduced. The conclusion reached from this experiment is that the Mosquito Magnet was not an effective mosquito control device in this backyard scenario.

4.3.5 Experiment #2 Species Results

	Total Sample	*Aedes vexans*	*Ochlerotatus sticticus*	*Coquillettidia perturbans*	*Ochlerotatus dorsalis*	*Ochlerotatus stimulans*	*Ochlerotatus spencerii*	Non-Identifiable
July 15, **2001**	391	239	8	123	2	1	1	17
% total	100%	61.1%	2.0%	31.5%	0.5%	0.3%	0.3%	4.3%
July 18th, **2001**	177	98	3	70	6	-	-	-
% total	100%	55.4%	1.7%	39.5%	3.4%	-	-	-
July 8th, **2002**	248	159	13	63	4	-	-	9
% total	100%	64.1%	5.2%	25.4%	1.6%	-	-	3.6
July 13th, **2002**	115	76	9	16	3	1	-	10
% total	100%	66%	7.8%	13.9%	2.6%	0.9%	-	8.7%

Table 13. 2001-2002 species identified, Mosquito Magnet urban experiment.

There were two species samples from each of the 2001 season and 2002 seasons (table 13). *Aedes vexans* was the majority species in all samples. *Coquillettidia perturbans*, is not generally one of the main Winnipeg area species due to specific habitat requirements. However, *Coquillettidia perturbans* was consistently the second most abundant mosquito. The presence of *Coquillettidia perturbans* was likely due to the proximity of a small creek that fulfilled the specific habitat needs. *Ochlerotatus sticticus* was not very prevalent, though it was found in every sample. Other species included *Ochlerotatus dorsalis* (Meigen), *Ochlerotatus spencerii* , and *Ochlerotatus stimulans* (Walker).

4.4 Experiment #3 – Mosquito Magnet™, Natural Area

In this experiment the Mosquito Magnet™ was tested in a 'natural environment', with the idea that the numbers of mosquitoes would be higher, and more challenging to the

machine, in this experiment. As with the previously discussed experiments, a successful product would yield results that showed fewer mosquitoes on the test plot than on the control plot.

4.4.1 Mosquito Magnet™ Results

In 2001, data were collected between 12 July and 4 September. The total number of mosquitoes collected was 1,070,489. The smallest sample occurred on 25 July and the largest on 7 August. The mean number of mosquitoes per sample in 2001 was 56,341 (Table 14). The huge 7 August sample was not as large as it could have been. A swift and massive emergence caused the collection net to become heavy with bodies, and weight dislodged the collection bag from the intake. Mosquitoes overflowed within the machine and many were sucked through the fan. When the sample was collected, the fan was jammed and had the appearance of being coated with a thick muddy substance, which were actually mosquito carcasses. This large number of mosquitoes, appearing simultaneously, illustrates how heavy rains result in rapid population increases.

	Duration of collection	Total #	Largest sample		Smallest sample		Season	
			Total	#/hour	Total	#/hour	Mean	S.E. mean
2001 N=19	07/12-09/04 = 55 days	1,070,489	323,382	3,351	1,035	10.9	56,341	16,075
2002 N=14	06/28–08/07 = 41 days	743,359	396,188	8,755.5	312	6.6	53,097	29,212

Table 14. 2001-2002, summary statistics, number of mosquitoes collected by the Mosquito Magnet™, Mosquito Magnet natural experiment.

In 2002, samples were collected from 28 June to 7 August. The total number of mosquitoes collected in 2002 was 743,359. The smallest sample was collected on 7 August the largest sample was collected on 30 June. The first sample was the largest, totalling more than 50% of the 2002 total catch, and the last data sample was the smallest, at only .04% of the season total. The mean number in a sample was 53,097 (Table 14).

4.4.2 CDC Results

In 2001, CDC data was collected from 12 July to 4 September. In 2002, samples were collected from 20 June to 5 August. The summary statistics for the two seasons are found in Table 15.

	Duration of collection	Total # collected	Largest sample		Smallest sample	
			Total	#/hour	Total	#/hour
Test **2001** N=20	07/12–09/04 = 55 days	12,695	3,060	41.4	28	1.1
Control **2001** N=20	07/12–09/04 = 55 days	4,237	925	21.3	9	0.3
Test **2002** N=14	06/28–08/05 = 39 days	3,580	1,544	30.4	8	0.2
Control **2002** N=14	06/28–08/05 = 39 days	1,612	651	12.8	9	0.2

Table 15. 2001-2002, summary statistics, number of mosquitoes collected by the CDC, Mosquito Magnet natural experiment.

	Test		Control		*P*
	Mean	S.E. mean	Mean	S.E. mean	
2001 Total Experiment N=20	634.8	183.5	211.9	521.1	**<0.001**
2001 First Half (07/15-08/13) N=10	795.3	318.6	185.8	56.0	**<0.001**
2001 Second Half (08/13-09/04) N=10	474.2	186.9	237.9	90.4	0.091
2002 Baseline data N=4	63.5	43.9	55.3	254.7	0.353
2002 Total Experiment N=14	255.7	107.7	115.1	48.7	**0.013**
2002 First Half (06/30-07/15) N=7	428.0	199.2	207.4	86.0	0.340
2002 Second Half (07/15-08/05) N=7	83.4	25.6	22.9	4.1	**0.006**

Table 16. 2001-2002, paired T-test data, number of mosquitoes collected by the CDC, Mosquito Magnet natural experiment.

There was no difference in the baseline data (n=4) between sites. There were significantly more mosquitoes on the test than the control (Table 16). When broken into halves, the difference was not significant in the first but was in the second.

In 2001, there was a significance difference in the number of mosquitoes collected on the experimental sites, with *more* mosquitoes on the test than the control (Table 16). When divided into halves, the first is significant and the second half was not (Table 16). There were more mosquitoes on the test than the control site.

4.4.3 Landing Count Results

In the 2001 season, 94 matched data sets were collected, and in 2002, 72 matched sets were collected (Table 17). The range in the number of data sets collected by volunteers show the differences in the commitment level of various volunteers. The range in the number of mosquitoes landing in the tests show the variability that was occurring on both the test and control sites. The 2001 and 2002 experiments were similar in duration, at thirty and twenty-eight days, respectively.

	# of volunteers	Collection period	Range of # of data sets collected by volunteers	Range: # mosquito landing/ sample: control	Range: # mosquito landing/ sample: test
2001 N=94	12	07/29-08/28= 30 days	2-24	0-125	0-160
2002 N=72	9	07/03-07/31= 28 days	6-12	0-155	0-75

Table 17. 2001-2002, summary statistics, mosquito landing counts, Mosquito Magnet natural experiment.

The interactions between variables affecting mosquito activity and the number of mosquitoes landing, and between these variables and the treatment sites, are shown in Table 18. The means for landing count data for mosquitoes landing, temperature, and wind for each site and season are shown in Table 19.

Significant at p<0.05	2001 N=94	2002 N=72
	P	*P*
mos. x treatment	0.065	0.118
mos. x wind	**<0.001**	**<0.001**
mos. x temperature	**<0.001**	**<0.001**
mos. x person	**<0.001**	**0.011**
mos x cloud	**<0.001**	**0.006**
mos x trt x wind	0.696	0.481
mos x trt x temp	**<0.001**	**0.025**
mos x trt x person	0.642	0.617
mos x trt x cloud	0.366	0.794

Table 18. 2001-2002, GLM Univariate analysis of interactions between variables, mosquito landing counts, Mosquito Magnet natural experiment.

	2001 N = 94				2002 N = 72			
	Test		Control		Test		Control	
	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean	Mean	S.E. mean
Mosquitoes	29.75	2.64	40.97	3.61	15.78	1.58	21.90	2.78
Temperature	23.43	0.25	23.85	0.23	24.22	0.31	24.06	0.28
Wind	0.51	0.07	0.54	0.08	0.56	0.09	0.58	0.08

Table 19. 2001-2002, mean values for mosquitoes, temperature, and wind, mosquito landing counts, Mosquito Magnet natural experiment.

4.4.4 Experiment #3 Discussion

The Mosquito Magnet collected hundreds of thousands of mosquitoes in each of the test years. The CDC and landing count data results supported each other, and neither indicated that the Mosquito Magnet was effective in reducing the number of mosquitoes in the natural area where it was tested. Analysis of the number of mosquitoes landing and their interaction with wind, temperature, person effect, and cloud cover did not reveal

any major discrepancies between the two experimental sites, and both sites appear to have had similar interactions taking place during data collection.

The number of mosquitoes collected by the Mosquito Magnet was very large, more than a million in 2001, and three quarters of a million in 2002 (Table 14). Interestingly, this result is opposite to the urban area Mosquito Magnet experiment result, where there were many more mosquitoes collected in 2002 than 2001 (Table 7).

There were significant differences in 2001-2002 CDC results between treatments when analyzed as a whole (Table 16). In both scenarios, there were significantly *more* mosquitoes on the test site than on the control site, opposite of what is expected if the machine is reducing mosquito numbers. There was no difference in baseline data between the sites, confirming the similarity between the sites at the outset of experimentation (Table 16). When the test seasons were divided by first and second half, only the first half of 2001 was significant (Table 16) and in 2002, only the second half was significant (Table 16). In all tests, there were more mosquitoes on the test site than the control. The CDC results did not reveal the Mosquito Magnet to be effective.

There were no differences in landing count data between the test and control sites in either season (Table 17). No benefit or detriment was shown by the landing count data from the addition of the Mosquito Magnet machine.

There was a significant interaction in both seasons between the number of mosquitoes landing and wind strength (Table 18). This experiment was located in an open location compared to experiments #1 and #2, and wind measurements ranged widely. The wind effect was the same for both treatments (Table 18), proving the similarity of the sites regarding wind. Therefore, wind can be ruled out as a variable affecting the perceived effectiveness of the Mosquito Magnet.

As with previous experiments, both years revealed a significant person effect, though there was no difference between treatments (Table 18). The effect of cloud cover on the number of mosquitoes landing was significant in both seasons, but as with 'person', there

were no differences between treatments (Table 18). Both 'person' and 'cloud cover' can be ruled out as variables affecting the validity of the data collected.

There was a significant interaction between the number of mosquitoes landing and temperature through both years, and this interaction continued to be significant between treatments (Table 18). The relationship between temperature and number of mosquitoes landing is shown in Figure 5. The 26°C and 27°C measurements are quite a bit lower than the other temperature data points. When the relationship between 26°C and 27°C and the wind in those measurements was examined, it was a wind interaction rather than a temperature interaction occurring that depressed the number of mosquitoes landing.

At 27°C, n=12. Wind 2, n=4. Wind 0, n=8. (33% of measurements at wind 2)

At 26°C, n=28. Wind 2, n=16. Wind 0, n=12. (57% of measurements at wind 2).

At 23°C, n=36. Wind 1, n=24. Wind 0, n=12. (67% at wind 1).

Three of these temperature points have abnormally high wind interactions occurring. The breakdown of wind measurements for the season was wind 0 = 114, wind 1 = 46, wind 2 = 28. The temperature data are skewed because of the abnormal distribution of wind at those three temperature points. As seen in Figure 6, the wind had a significant effect on the number of mosquitoes landing, and was a powerful enough variable to make the temperature interaction look as though it were different between the test and control treatments.

The Mosquito Magnet did not reduce mosquito populations on the natural area test site. If anything, the machine increased the number of mosquitoes. Based on the CDC and the landing count results, there was no benefit to the product, and on occasion, there were significantly more mosquitoes landing on the test site.

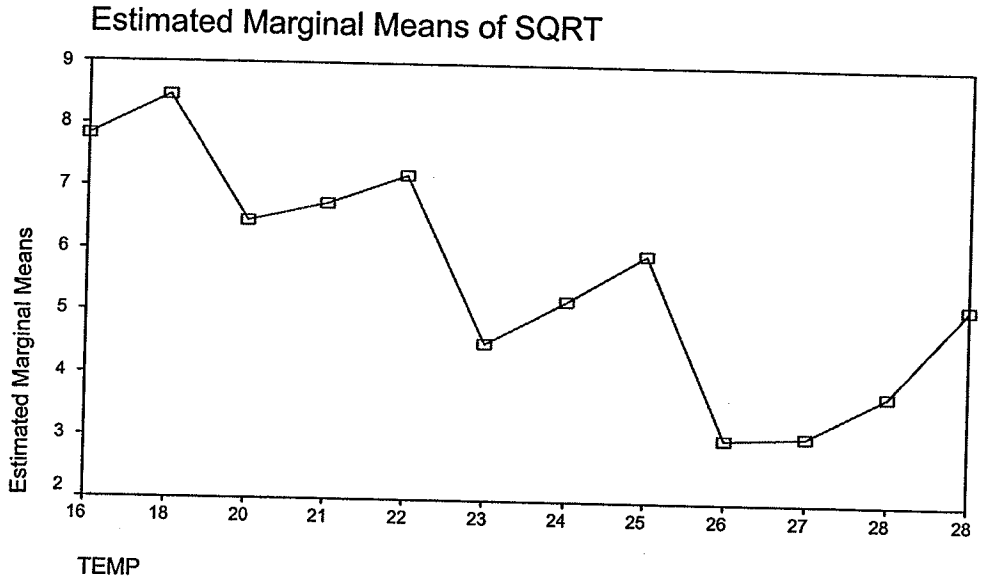


Figure 5. Relationship between the temperature and the number of mosquitoes collected in 2002, landing count data, Mosquito Magnet natural area experiment.

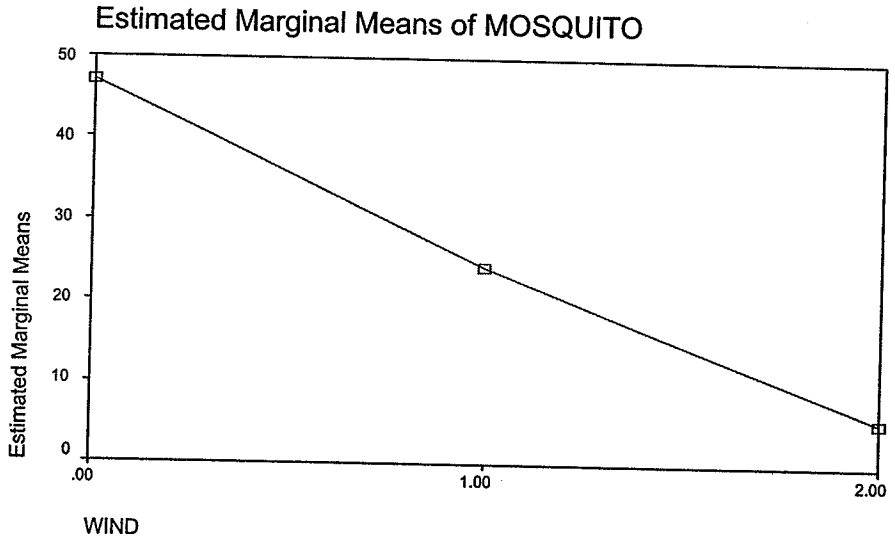


Figure 6. Comparison of wind strength and the number of mosquitoes landing, Mosquito Magnet natural area experiment, 2002.

4.4.5 Experiment #3 Species Results

Four samples were identified to species in 2001 and three in 2002 season (Table 20). In 2001, the samples taken from the Mosquito Magnet™ natural area experiment show a

majority of *Aedes vexans* (82.1% - 95.3%) with *Ochlerotatus sticticus* consistently comprising a distant second (1.8%-9.1%) (Table 23). *Coquillettidia perturbans, Ochlerotatus dorsalis, Ochlerotatus spencerii,* and *Culiseta inornata* (Williston) were present, but rare.

	Total	*Aedes vexans*	*Ochlerotatus sticticus*	*Coquillettidia perturbans*	*Ochlerotatus dorsalis*	*Ochlerotatus spencerii*	*Culiseta inornata*	Non-identifiable
July 19, **2001**	213	203	7	2	1	-	-	-
% total	100%	95.3%	3.3%	0.9%	0.5%	-	-	-
July 25, **2001**	156	128	6	5	2	1	2	12
% total	100%	82.1%	3.8%	3.2%	1.3%	0.6%	1.3%	7.7%
August 24, **2002**	165	152	3	-	-	-	1	9
% total	100%	92.1%	1.8%	-	-	-	.6%	5.5%
September 2, **2001**	232	198	21	-	-	-	-	13
% total	100%	85.3%	9.1%	-	-	-	-	5.6%

Table 20. 2001, species identified, Mosquito Magnet natural experiment.

As with 2001, the 2002 samples from the natural area experiment were mostly *Aedes vexans* (66.8%-73.2%). In 2002, *Ochlerotatus sticticus* was again second in abundance, but a much larger component compared to the 2001 data (19.7%-27.9%) (Table 21). *Coquillettidia perturbans, Ochlerotatus dorsalis,* and *Ochlerotatus nigromaculis* (Ludlow) were rarely collected (table 21).

	Total	*Aedes vexans*	*Ochlerotatus sticticus*	*Coquillettidia perturbans*	*Ochlerotatus dorsalis*	*Ochlerotatus nigromaculis*	Non-Identifiable
June 30, **2002**	429	304	118	1	4	2	-
% total	100%	70.9%	27.5%	0.2%	0.9%	0.5%	-
July 17, **2002**	190	127	53	-	3	1	6
% total	100%	66.8%	27.9%	-	1.6%	0.5%	3.2%
August 7, **2002**	71	52	14	-	1	-	4
% total	100%	73.2%	19.7%	-	1.4%	-	5.6%

Table 21. 2002, species identified, Mosquito Magnet natural experiment.

4.5 General Species Discussion

Aedes vexans (Meigen) was the dominant species in every experiment. This finding is consistent with data from the Winnipeg Insect Control Branch, as they list *Aedes vexans* as being the most abundant late summer species in the Winnipeg region (Gadawski, 2000; 2001). *Aedes vexans* is a multivoltine species (having many generations per season) and successfully breeds in shallow, temporary, pools left after summer rains, where few predators exist. These characteristics lend themselves to large *Aedes vexans* populations when meteorological and geographical conditions are favourable. *Aedes vexans* was easily recognizable, having the distinct pointed *Aedes* abdomen and short palps, and narrowly banded legs.

It was unexpected to find *Coquillettidia purturbans* (Walker) comprising such a large portion of the urban area species samples. *Coquillettidia* mosquitoes are unique in their larval breathing adaptation as they attach to underwater vegetation, drawing oxygen from the plant stalk instead of attaching to the water surface to breathe (Carpenter and LaCasse, 1974). This adaptation makes it difficult to kill *Coquillettidia* species with surface oils, and necessitates specific habitat for their development: permanent water with

appropriate vegetation. *Coquillettidia perturbans* were likely breeding in a stream located close to the urban area test site. *Coquillettidia perturbans* was an easy mosquito to identify due to the large size, blunt abdomen, uniquely banded legs, and very 'hairy' appearance.

Ochlerotatus nigromaculis (Ludlow) was very rare in a few 2002 Experiment #3 samples. This mosquito was easy to identify because of the very broad and brilliantly white basal leg bands. The legs of this species were so bright that it could be spotted with the naked eye when among other species. *Nigromaculis* also has a white, centrally banded proboscis. Under a dissecting microscope, this mosquito was exceptionally beautiful.

Another shockingly beautiful mosquito was *Ochlerotatus sticticus* (Meigen). This species can be recognized by its dusky legs and brilliant white venter. The differences in the proportions of *sticiticus* in 2001 verses 2002 at the natural area were interesting. While second most abundant in both years, *sticticus* was much more prevalent in 2002. In 2001 it was around a quarter of the sample compared to 2001 where it was around the 5% level. Finding *Ochlerotatus sticticus* as the second most abundant species was again consistent Winnipeg Insect Control Branch data (Gadawski, 2001).

Only three *Culiseta inornata* (Wiliston) were found, all from the 2001 natural area samples. *Culiseta inornata* was easy to spot because of the blunt abdomen and large size compared to most of the smaller *Aedes* species. This is a species of interest as it is capable of carrying and transmitting Western Equine Encephalitis and West Nile virus.

Anopheles mosquitoes were very rare, with only three found in all samples. These mosquitoes were obvious to the naked eye because of their long palps, which were equally as long as their antennae.

Ochlerotatus dorsalis (Meigen) was an interesting mosquito to examine because of the distinct white scale pattern on the abdomen. It is named for the distinct dorsal pattern of

a white vertical stripe of scales cross cut by white scales on the basal portion of the tergites. The presence of this mosquito was again consistent with the data collected by the Winnipeg Insect Control Branch (Gadawski, 2001).

Culex tarsalis is the mosquito that is targeted as the most important vector of West Nile Virus in Manitoba (Manitoba Health, 2003). No *Culex tarsalis* were identified in any samples.

4.5 Product Testing Summary

Experiment #1 was a test of the Mosquito & Gnat Repellent and the results were consistent between years. In both seasons, there were fewer mosquitoes present on the test sites, and implied effectiveness. However, the landing count results did not support the NJLT results, and in 2001, there were significantly more mosquitoes landing on treatment #2 than on the control. Other than that result, no differences were observed in 2001 or 2002. According to these results, a consumer would be getting as many mosquito bites pre and post-application. Though the product reduced the number of mosquitoes, it did not accomplish the more important result of reducing the number of mosquitoes landing.

Experiment #2 was a test of the Mosquito Magnet in an urban area. In both the CDC light trap results and the landing count results, the Mosquito Magnet was ineffective. In fact, in 2002 there were significantly more mosquitoes landing on the test than the control site. The product may have increased mosquito numbers in its vicinity.

Experiment #3 was a test of the Mosquito Magnet in a rural area with high mosquito pressure. Though the machine collected hundreds of thousands of mosquitoes, the landing count and CDC light trap results did not indicate benefit from the machine. In both years there was no difference in landing counts between the test site and on the control site. The CDC results consistently revealed significantly more mosquitoes

landing on the test plot than on the control plot, opposite of what is expected should the machine be working to reduce mosquito populations.

Measurements and observations made by volunteers collecting landing count data allowed for insight into interactions between mosquito populations and environmental variables. The environmental variables 'person', 'wind', and 'temperature' were related to the number of mosquitoes landing in each test. Each variable affected the number of mosquitoes landing. These findings are consistent with the literature, and confirm the sensitivity of mosquito activity to environmental variables.

Mosquito numbers declined with increasing wind speeds in four of the six test seasons. The two seasons with no interaction featured low variability in the wind speeds. Also observed in four of the six seasons was the interaction between cloud cover and the number of mosquitoes landing. The relationship between cloud cover and mosquito numbers was not so apparent as other environmental variables examined. Greater mosquito activity was observed with increased cloud cover.

The 'person' effect was observed in every field season. At close range, skin temperatures and moisture can be attractants to host-seeking mosquitoes (Maibach *et al.*, 1966). The proportion of chemicals exhaled during normal breathing can vary between people and affect the level of attractiveness to mosquitoes (Brock and Cardew, 1996). Individual differences in body chemistry were affecting the number of mosquitoes landing on each volunteer. Though the person effect was consistently observed, it did not play a role between experimental sites. The same volunteers conducted landing count tests on both test and control sites, thus eliminating the potentially problematic effects of the interaction between person and the number of mosquitoes landing.

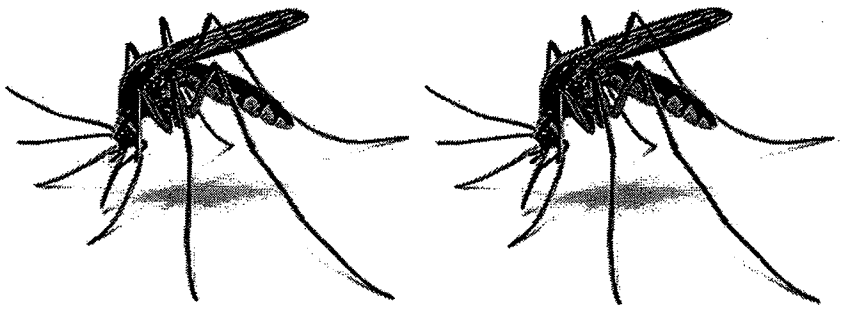
An interaction between the temperature and mosquitoes landing was observed throughout. Again, this is consistent with results in the literature. Mosquitoes, depending on the species, have an optimum temperature range for activity (Bidlingmayer,

1985). The temperature interaction did not play a role between sites, likely due to the low variation between test and control sites.

Baseline data were collected for experiments #2 and #3 in the 2002 season, there were no differences between mosquito populations on the sites prior to the testing. This result confirmed the similarity in the sites chosen for experimentation. The strength of all three experiments would likely have benefited from the collection of baseline data and the beginning of every experiment and in every year.

While neither of these products could be recommended to a consumer based on their failure to reduce the number of mosquitoes landing on people in the application area, there is something to be said for the personal empowerment that takes place when an individual takes action regarding a perceived problem. A number of Mosquito Magnet™ owners have sworn to the success and good graces of the product, and pages of testimonials posted on the American Biophysics Corporation website sing its virtues. These personal testimonials indicate consumer satisfaction with the product. It is suspected that more than anything, people feel good because they have taken responsibility to improve a situation. Based on the results from this study, mosquito reduction is not likely occurring, but people feel better about the situation. There is some value to that phenomenon, especially when dealing with strictly nuisance mosquitoes. However, the search for effective mosquito products should continue, and if a worthy product is identified, consumers should be armed with that information such that an actual reduction in mosquito populations can be coupled with increased personal satisfaction about the mosquito situation.

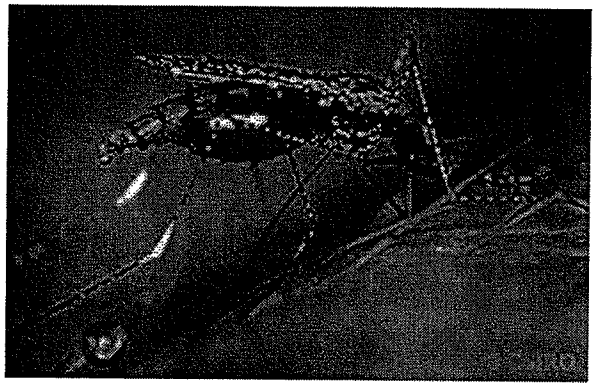
"I don't like all of the chemicals that the city uses, but I certainly don't love mosquitoes either!" - Riverfront resident



Chapter 5

Mosquitoes and People: Awareness and Education

I used to live in Ottawa, and feel that the mosquitoes could be just as bad there as they are here. Winnipeg has a culture of complaining about mosquitoes. - Riverfront resident



"Nature is nature, and I don't think we should try to make it too comfortable." – Riverfront resident

"I would love to invent a beer that makes you less attractive to mosquitoes. I think that would be a great product." - Maples resident

I've heard that in Florida they spend about $25 million US on mosquito control. They spray every week way high in the sky and then the tourists come down and never get bitten. Now I don't know how many turtles are being born with twelve heads, but I have been down there three times and never been bitten. – Wolseley resident

I think the politicians have to get over worrying about who is voting for them and who is not voting for them and do what they feel is right for the overall population. – Maples resident.

5. 1 Introduction

Winnipeg has a history of debate and controversy surrounding its mosquito control program. In recent years, fogging with malathion, and the arrival of West Nile virus (WNv) have been two points of concern. Other municipalities have conducted outreach (surveying, interviewing, referenda) to identify public perception and aspects of their mosquito control program needing improvement (MMCD, 2000). The purpose of the survey project was to collect feedback on the Winnipeg mosquito abatement program in terms of awareness, satisfaction, and concerns, and to gauge impressions of the public educational materials currently being used. Fifty-eight interviews were conducted. A high proportion of the survey respondents indicated the mosquito abatement program was a valuable service, and placed an emphasis on education as a component of this program.

The non-response rate was low compared to other studies (Purdon *et al.*, 1999) indicating a strong topical interest. Some participants expressed gratitude at being able to voice opinions, and suggestions. Non-participants often expressed an interest in participating, but were not available at the time that the interview was requested. Many of these people requested a different time in order to conduct the interview. Very few people indicated zero interest in participating. The non-response rate was the lowest in Wolseley, at 29%, while the non-response rate for the entire project was 40%. According to Purdon *et al.* (1999), cold-call interviewing generally results in a participation rate of 20-35%, depending on the time of day at which the call is made. This project featured a participation rate of 60%. A stranger at the door requesting your time is not generally an overly-welcome sight. However, this cold-call approach proved to be compatible to the attainment of the survey goals.

The level of interest in education that the survey revealed, and a gap in the educational component of the Winnipeg program as identified through the course of the literature review, prompted the formal education project. The product was an annotated bibliography of educational tools suitable for grade school children. This chapter is a review and discussion of the surveying and annotated bibliography projects.

5.2 Survey Focus

The three main areas and sub-topics that the survey attempted to address are outlined in Table 22. The main areas include; Education, Awareness, and WNv.

Education	City program educational efforts	Suggestions for improvement
	West Nile virus	How are citizens learning about the virus?
		Are informational needs being filled?
	Fight the Bite pamphlet	Do people remember receiving it? Did they read it?
		Was this new information?
		Did they do the things suggested?
	Information distribution for informal adult learning	Are pamphlets well received with mailbox drop-off?
		Are public places effective for pamphlet distribution?
Awareness	Source reduction and personal protection	Actions by private citizens to reduce standing water
		Product purchased for mosquito relief on private property
	City of Winnipeg mosquito abatement program	What do people know about it?
		What is the approval rating for the program?
West Nile virus	Awareness/Concern	Existence/presence in Manitoba
		Level of concern, changes in behaviour?
	Handling the situation	Health Emergency
		Wolseley fogging

Table 22. Areas of investigation targeted by the survey.

In the area of 'education' there were four sub-topics. The success of public education efforts was measured and feedback on improving the Winnipeg program was gathered. WNv was new to Winnipeg, and there was an opportunity to examine how people were learning, and if informational needs were being filled. The effectiveness of door-to-door distribution of the *Fight the Bite* pamphlet in imparting knowledge and creating action was examined. Finally, how people prefer to receive information was considered.

'Awareness' included an examination of the knowledge of and the approval rating for the Winnipeg abatement program. Citizen awareness regarding how to, as well as actions taken, to reduce local mosquito populations, were examined.

WNv provided a number of challenges for mosquito control experts. Issues relating to WNv, such as the level of concern that people feel, changes in behaviour, and how the government should be handling the situation, were reviewed.

The survey information is presented first as a selected descriptive review (the most basic level of analysis according to Merriam (1998)) and is followed by detailed analysis of the data involving the identification of themes that capture recurring patterns which cross-cut the data. Representative samples of direct quotes from survey participants have been included for illustration and highlighting participant opinion.

5.3 Descriptive Survey Results and Discussion

5.3.1 Education - Descriptive

Perception regarding the City of Winnipeg's efforts in public education and communication regarding mosquito issues was investigated (Table 23).

Good job	44%
Could improve	45%
Failing	7%
Not the city's job	3%

Table 23. Survey response to Winnipeg's public education and communication program (n=58).

The main criticism was that there is not enough information coming directly from the city, and most information was from media sources. Participants frequently referred to the Fight the Bite pamphlet as a method of direct communication that should be used more often. Some participants felt the Branch web site could be more user-friendly, providing a broader range, and more detailed, information.

> *They could be doing a better job on this. I need more information. You see them on the media talking about standing water, but no information on the chemicals or on other alternatives is given out."* - Riverfront Property owner

> *I think the city should do more with practical ways that people can avoid mosquitoes. Foggers, coils etc, do these things work? Because telling me to stay inside is not appropriate. I am not going to keep my four kids inside all summer to try to avoid mosquitoes.* – River Heights Resident

WNv is a new and emerging disease in North America, and mosquito abatement specialists should be aware of how people are learning about this topic, and if additional or improved information is desired. Media were the main information sources for participants, and newspapers were the most popular format (Table 24). Very few people received information about WNv from sources other than the media.

Media	Newspapers (53)
	Television (30)
	Radio (15)
Internet	(9)
Doctor	(2)
Pamphlet	(1)

Table 24. Participant description of WNv information sources, and the number of times mentioned (n=58).

The range of opinions as expressed by participants regarding receiving additional WNv information is shown in Table 25. The 'No more information!' group expressed subject saturation. Most people felt that if a WNv pamphlet from a reputable source (Public Health Authority, Insect Control Branch) arrived in the mail, they would likely read it. A number of participants commented on the desire for *good* information from a government source, as opposed media-transmitted information. Media-relayed information was not always viewed as confidence-inspiring.

Really want more information	33%
Would look at information if it came to them	25%
No more information!	42%

Table 25. Survey response to question on interest in additional information on WNv (n=58).

> *"I don't want to know any more about it (WNv). The more I know about it the more I will worry about it."* – Wolseley resident

> *"I would like as much 'good' information as I can get. Sometimes I wonder about the media reports. I would love to receive some information from a really reputable government source."* – Wolseley resident

For a pamphlet to be effective, the target recipient must notice it and then read it. The survey results for receiving and reading the pamphlet are shown in Table 26. 'Circumstances' for those who would have read it generally include time of year, amount of leisure time, and personal issues. A number of participants said that if the pamphlet had been distributed during mosquito season, they would have read it. About 40% of participants said they would keep the pamphlet for reference, 60% discarded it (n=58).

Remembered receiving pamphlet (72%)	Read the pamphlet (82%)
	Saved it, or would have read under different circumstances (10%)
	Did not read it (8%)
Did not remember receiving pamphlet (28%)	Would have read it (33%)
	Would not have read it (67%)

Table 26. Survey response to receiving and reading the pamphlet (n=58).

> *I would have read the pamphlet if I had taken it in from the mailbox. I have been reading everything I can on mosquitoes, it's frightening what happened this summer. It was very stressful.* – Maples Resident

New or useful concepts learned from the pamphlet were investigated, because an important component of an educational campaign is the learning that takes place. Overall, people were receptive to the pamphlet and interested enough to read it. However, very few could give examples of new information gained from it with a

number of participants saying it was just 'common sense'. Of those that learned something (n=14), eavestroughs as mosquito breeding habitat (nine comments), and the number of mosquito species in Winnipeg (four times) were mentioned the most.

> *I noticed some little things that you don't even usually think about, like water in a birdbath, or low lying areas where water might sit. You don't really stop to think that you are helping the mosquitoes grow when you are leaving those areas wet.* – Preliminary Interview.

> *It (the pamphlet) doesn't give us anything that we didn't already know. I feel frustrated because I do all of these things and it doesn't really make a difference.* – River Hieghts Resident.

Visual aspects of the pamphlet were discussed and the overall response was positive. Most felt the fonts were appropriate and the pictures made it accessible to kids, adults, and people with English as a second language. About 10% of respondents suggested that the front cover could be brighter and more eye-catching (n=58).

> *"The picture (in the pamphlet) is very good, because even if your English wasn't very good, you could still understand the message."*–Maples resident

> *"I liked the picture and realized that I have probably contributed significantly to the mosquito population."* – Riverfront Resident.

It was important to know if the pamphlet left the reader with unanswered questions. Half of those surveyed had suggestions for additional information that the pamphlet should include. The main suggestion (65%, n=58) was to include City of Winnipeg program information. Information on control products, budget size, alternative technologies, effectiveness and risks associated with current products, and if the city is conducting research on these issues, were mentioned by participants. The next most common suggestion (30%, n=58) was the inclusion of WNv information, or a WNv weblink.

> *All they talk about in the pamphlet is what you can do (to control mosquitoes). It would be interesting to learn about what the city does and what products they use.* – Maples Resident.

The *Fight the Bite* pamphlet focused on conveying information on what can be done to reduce mosquito-breeding habitat. The majority (90%, n=58) of participants said that they had, at some point, taken actions as suggested in the pamphlet. However, many acknowledged that they were not diligent in this regard. A common comment was that they did not reduce breeding sites until after mosquito populations became large.

> *I don't typically do stuff to our yard like emptying standing water. My perception is that our yard could be pristine, but then the mosquitoes are just going to come from next door.* – Test Interview

An integral component to controlling mosquito populations is educating and communicating to the public on mosquito issues (Rose, 2001). Therefore, effective methods for informing the target population are important. Survey participants were asked how effective they felt door-to-door pamphlet distribution was in disseminating information on health issues or community programs (Table 27). The majority of participants felt that door-to-door delivery was effective. The 'other factors' influencing 17% (n=58) of participants included; free time, interest in the topic, if pamphlet is well done, and if the source is reputable. Some people admitted to never reading this type of material.

Effectiveness of distributing pamphlets door-to-door	effective (62%)
	Sometimes effective (17%)
	Never effective (21%)
Effectiveness of distributing pamphlets in a public place	Effective (14%)
	Sometimes effective (54%)
	Never effective (32%)

Table 27. Participant response to evaluating the effectiveness of distributing pamphlets door-to-door, or in a public place (n=58).

The likeliness of picking up a mosquito pamphlet in a public place was reviewed (Table 27). Those that felt this might be effective generally stated the level of effectiveness depended on if the pamphlet was eye-catching and located prominently. Participants

identified waiting areas (doctor's office or pharmacy) as potentially effective locations, but not in high traffic locations such as a supermarket entranceway. Some participants felt that public places were a good idea, but also commented that the *Fight the Bite* pamphlet was so important it warranted city-wide household distribution.

5.3.2 Education – Discussion

According to Swan (1974), "Our environmental problems stem from our inability to develop a system of social values, life styles, and institutions which enable us to live in harmony with the environment." This is true of the mosquito 'problem' in Winnipeg. Many people are simply not willing to tolerate nuisance mosquitoes, especially when populations escalate. The arrival of WNv to Winnipeg seems to have contributed additional justification for the use of broad-spectrum chemicals, and reduced the demand for proving the effectiveness of adulticiding. A broader understanding of mosquitoes, the environment, global mosquito scenarios, and the other components of mosquito control programs could lead to a shift in the level of support for malathion spraying. However, as one interview participant put it when asked about the decision to fog for WNv,

> *"It's all about optics. There was a new and scary disease in Winnipeg, and the government had to be seen as doing something. It didn't matter if they were spraying malathion or water vapour, it was the truck rolling down the street that made everyone feel better, that made people think that someone was looking out for them."* – Maples Resident.

In fact, Ted Williams, a mosquito expert from Grafton Massachusetts, learned that his mosquito-control officials had filled the spray truck with pure water and sprayed the town. Local residents reported dramatic relief (Williams, 2001). This anecdote strengthens the argument that a level of security and satisfaction is derived from the knowledge that 'something has been done', regardless of the effectiveness of that something.

A greater understanding of the issues surrounding adulticiding for mosquitoes could lead to an improved understanding that fogging many not necessarily be the most appropriate course of action.

> *"The long-range goal of environmental education should be to develop a citizenry which is knowledgeable about the biophysical environment and its associated problems, is aware of how to become effectively involved in working toward the development of a more liveable future, and is motivated to do so."* (Swan, 1974).

Interview participants identified room for improvement in the education component of the Winnipeg abatement program. More than half the participants felt the city should improve outreach efforts. Participants asked why they had never seen the *Fight the Bite* pamphlet before. "How hard is it to send (the pamphlet) out with the hydro bill or something?" (River Heights resident). People asked why there were no commercials, billboards, advertisements in the paper or public service announcements on the radio. "They could certainly make a PSA reminding people about standing water that could be played in CJOB and CBC radio – I don't think that would be too expensive would it?" (Maples Resident). Folks expressed their need for information directly from the Branch, and not filtered through the media. "I get quite a bit of information, but it all comes from the media, so I don't know how good it really is. I like that this pamphlet is from them. I should have gotten this years ago." (Wolseley resident).

Close to 60% (n=58) of the interview participants wanted WNv information from a reputable source such as the Winnipeg Regional Health Authority or the Insect Control Branch. The majority of participants were looking to the government for leadership on this issue. Participants frequently expressed concern that information is obtained mostly from media sources.

The public desire for credible information sources has been documented. When a credible source presents the informational message, it will have a dramatic impact on how the information is received, with the recipient taking the information much more seriously than if the information was from an unknown or less-credible source (Eagly and Chaiken, 1975). The impact of the credible source should not be undersold, and informational materials distributed by health authorities or the Insect Control Branch should clearly feature the name or logo of the source. It is important to disseminate

information by more than one method, as mass-media campaigns alone have had little success in changing behavioural patterns, due in part to the inadequate design of the messages, but more importantly to an underestimation of the difficulty of changing behaviour (Costanza *et al.*, 1986).

The *Fight the Bite* pamphlet is not currently distributed door-to-door, and the survey indicated that few Winnipeg citizens have been exposed to it. Only one of the fifty-eight survey participants had seen the pamphlet before (received by mail after de-listing property). There are potential problems with mailbox distribution. Firstly, one resident takes in the mail. Other household members do not have equal access to the material. Secondly, abundant 'junk mail' likely causes many people to throw out printed material without looking it. Insect Control Branch managers expressed concern that the pamphlet could be mistaken for junk mail, and not read. While these concerns undoubtedly occur, the survey results did not show this happening very often. A number of participants kept the pamphlet for other family members to read. Some said that they had their kids read it, or passed it on to neighbors and relatives.

Uptake of the pamphlet was high; mailbox delivery was effective in reaching people with mosquito information. However, in order to affect long-term behavioural change, such as consistently monitoring property and removing standing water, repeated reminders must be issued to the target audience (McKenzie-Mohr, 2000). In addition, pamphlet distribution alone is generally ineffective in modifying behaviour, but pamphlet distribution coupled with feedback has a much greater effectiveness (Midden *et al.*, 1983; Luyben, 1984).

If the goal of pamphlet distribution was to convey new information regarding mosquito habitat reduction, then the pamphlet was not effective. Most participants said the information was not new, and were aware of the basics: mosquitoes reproduce in water, and backyards can potentially facilitate this. Virtually all participants understood that reducing standing water helps reduce mosquito populations.

However, the goal of most educational campaigns is not just to impart information and understanding of a situation, but also to influence the behaviour of the target audience (Public Education and Outreach Issue Table, 1998). A number of studies have shown that education alone has little effect upon behaviour, and there is often little relationship between attitudes and behaviour (Jordan *et al.*, 1986; Finger, 1994; Archer *et al.*, 1987).

The *Fight the Bite* pamphlet successfully influenced behaviour by stimulating many participants to actively reduce standing water on their property. Though the pamphlet did not provide new information, it was an excellent reminder and motivator for many. Judging by this, the pamphlet was effective. Respondents checked their yards after receiving the pamphlet, and a number commented if they received it earlier in the season, they would check for water before the mosquito populations became problematic, and not after. One participant stated the problem clearly, 'I know what I am supposed to do to try to control mosquitoes, but I never do any of it until after mosquitoes get really bad, and then it seems too late.' (River Heights resident) The pamphlet functioned as a reminder, and proved for many to be the catalyst to change knowledge into action.

While the pamphlet was well received, potential improvements in pamphlet content were indicated. Details on the Winnipeg control program and alternatives were most often cited as items that should be added to the pamphlet. Respondents wanted information on malathion, including risks and benefits. Another improvement suggested was the inclusion of WNv information. This was not surprising given that WNv was a new issue. People wanted 'good' information about the disease, including risks, and effective personal protection measures.

Fight the Bite focused on personal protection, mosquito biology, and habitat reduction. The Branch also has a pamphlet discussing bats and mosquito control. Currently there is no pamphlet dealing with branch activities. The Saginaw County Mosquito Abatement Commission (SCMAC) created a pamphlet specific to mosquito control program components. It is a 'what we do for you' pamphlet. They also have a detailed WNv pamphlet.

The creation of such pamphlets is one option to fill the need expressed by participants for more information. Alternatively, *Fight the Bite* includes a weblink to the Branch web page, but the city program is not detailed on that site, though it offers a link to FAQ's about WNv. The site should be improved to include program information and risks and benefits associated with adulticiding. The New York State Department of Health (2003) has addressed specific concerns surrounding malathion use on a link from the mosquito control web page. This information includes facts about malathion risks and benefits, and lists precautions that the public may wish to take when it is applied. A number of participant concerns could be addressed with a detailed webpage.

The weblink is currently located on the back of the pamphlet, at the bottom among other print. It is not highlighted. The weblink could be in bold on the front of the pamphlet, or an improved space on the back. Either way, it should be displayed in a prominent manner that is more eye-catching than the current location and font.

From the survey feedback, the pamphlet in its current format and without the suggested changes still has significant merit in public education and communication. Prior to the next printing of the pamphlet the suggested changes could be made to further improve the effectiveness in delivering the mosquito message to the public. Website changes could be made immediately to improve the information available to interested residents.

"All persuasions begin with capturing attention, without attention, persuasion is impossible." (Stern and Aronson, 1984). A review of government pamphlets and flyers found that most did not meet even the most basic requirements of conspicuousness (Stern and Aronson, 1984). Pamphlets must be noticeable and eye-catching. Distribution of the *Fight the Bite* pamphlet in public places is not likely to be effective unless measures are taken to ensure that it is highly visible and in a location where people are not hurried. Waiting rooms may be a location that the city wishes to examine for the distribution of educational materials. As well, a number of individuals suggested the pamphlet would be well received if situated in the bug-repellent section of a supermarket. Locating the

pamphlet publicly would be more economical than city-wide delivery, but fewer people would have the opportunity to be reached by this process.

5.3.3 Awareness – Descriptive

Awareness of the current mosquito control program was investigated (Table 28). Virtually every participant was aware that Winnipeg conducted a mosquito control program and often the response tone implied 'who wouldn't know that?' Every participant knew that fogging was conducted, though there was variation in how much they knew about the fogging program. Some thought this was the only mosquito control method implemented, and some knew that fogging occurred when mosquito numbers exceeded a set threshold. With larviciding, there was also large variation in the knowledge of this process. Participant response varied from 'I think they do something to the water in ditches' to 'Larviciding is conducted to treat standing water where mosquitoes breed – both in the city and in the areas surrounding it'. A few people were aware that the city conducts research into mosquito behaviour, control, and alternatives. A few participants held misconceptions, such as the city releases dragonflies and large numbers of bats to kill mosquitoes.

	Fogging	Larviciding	Population surveillance	Education	Source Reduction	Research	Spraying sewers	Oil on ponds	Mapping standing water
Identification of local mosquito control methods	100%	80%	12%	10%	7%	<5%	<5%	<5%	<5%

Table 28. Participant knowledge/perception of the components of the Winnipeg mosquito abatement program (n=58).

Participants were asked to give a description or assign a grade (with reasoning) to gauge the success of the Winnipeg program in controlling mosquito populations. Surprisingly, 86% participants felt the city was doing a 'good job, considering....'. The common theme in the responses was Winnipeg is a tough place to control mosquitoes. Very few

participants were critical of the effect of the abatement program. Some participants commented it was impossible to judge effectiveness, as no control was available for comparison.

"They try their best, but I wouldn't say it's a successful program. They are fighting Mother Nature." - Riverfront Property owner

"It is a tricky issue, I think they do really well with it." – River Heights resident

"They are doing a pretty good job because last year it was fine for a while and then we had all of the rains, and I think it's very hard for them to keep up when that happens." - Riverfront Property owner.

"I think they have a very difficult job because we live in a climate that is absolutely perfect for mosquitoes." – Riverfront property owner

"I would give them a C+. They need to be a lot more creative in how they try to control mosquitoes in this city. The traditional methods aren't working, and they need to look more into alternatives". – River Heights resident

"They are trying. But I have learned this year from my daughter (who works at the Branch) what a futile effort it really is." – Maples resident

Adulticiding with malathion has been much debated in Winnipeg, and participants were asked to express their feelings on the issue. Participant opinion on the fogging issue is shown in Table 29. Many participants (40%, n=58) were undecided, or felt that the fogging program was not effective in significantly reducing mosquito populations. Half of the participants were concerned at some level about the impact of malathion on human health or the environment. The level of support for the fogging program was fairly evenly distributed among the three categories of opinion expressed within the data, with less than half of those surveyed saying that they were fully in support of the program. A sizeable proportion of respondents had doubts or concerns with malathion use.

Effectiveness	60% very effective	15% undecided	25% not effective
Human health	38% concerned	12% low concern	50% no concerns
Environmental	38% concerned	16% low concern	46% no concerns
Support	43% full	28% support, 'but'	30% opposed

Table 29. Participant opinion on issues relating to fogging with malathion for adult mosquito control (n=58).

> *It's not fair to the other bugs that they all get killed because of mosquitoes.* – Test Interview

> *I don't like it, but I think I have to trust that when the decision is made to fog that it is the only option left. I believe this is the case. I don't think they do it prematurely.* – River Heights resident

> *I have some environmental concerns about fogging, but not to the extent that I am objecting to it in our area, but I don't think an all-out campaign to blanket the city in deadly poisons and destroy everything in sight is an advisable idea.* – Test interview participant

> *I don't think they would spray if it would cause cancer or something like that, the city would not do that.* – Maples resident

> *I am not pleased that it (fogging) happens, but when it get to the point of being out of control and unacceptable then they have to be visibly seen as doing something. I think it is more optics than anything else.* – Maples resident

> *Obviously Malathion isn't going to kill us outright, but you wonder about what long-term exposure can do to you. I worry for children more than anything, they are the most vulnerable.* – Riverfront property owner

Winnipeg residents may exempt their property from municipal chemical applications, including malathion. There is a buffer zone around registered property to ensure minimal chemical exposure to it. Interview participants commented on the current de-listing program when nuisance mosquitoes are the focus of the mosquito problem (and not disease-carrying mosquitoes) (Table 30). The responses ranged from full support, to support but with suggested changes, to no support for the de-listing program. Those what suggested changes commonly felt the buffer zones were too large, affecting too many people. Others felt the government should be the decision-maker for all citizens on the issue, and what they decide should happen to everyone uniformly. Some participants felt fogging was less effective due to patchiness caused by de-listed properties. Many of those who felt de-listing should not exist in any form said the 'majority should rule'. Some people in this group expressed that, though they felt the de-listing program should be discontinued, specific notification must be given to individuals wishing to avoid exposure, so they could take steps to protect themselves.

Program should not be changed	55%
Program should exist, but with changes	12%
Program should not exist at all	32%

Table 30. Participant response to whether de-listing from the fogging program should be an option for citizens (n=58).

"If they are bothered that much, then go ahead and de-list" – Riverfront property owner

The de-listing program should not exist. If you don't like what the city does, then move out and stop paying taxes. – Maples resident

The buffer zones should be reduced to basically zero. Just let people think that they are not getting sprayed. – River Heights resident.

People need to be able to protect themselves and control what happens on their own private property. I would never de-list myself, but I think that the program should definitely exist. It is also a way for the city to gauge the level of concern on the issue. – Wolseley resident.

I don't believe in it (fogging with Malathion). It boils down to a human rights issue. I think that people who don't want to be exposed to it should not be forced to be exposed to it. – Riverfront Property owner

The investment of private dollars into personal protection from mosquitoes indicates the willingness that citizens have to attempt mosquito reduction. About 80% (n=58) of participants had invested in mosquito control, 20% had not. The majority of the products purchased were small, inexpensive items. Citronella products (candles, torches, sprays) and chemical coils were the two most popular purchases. Mosquito hats and garden sprays were also represented. A number of 'bigger ticket' items were on the list of things purchased, and these included home foggers, screened porches/gazebos, and one Mosquito Magnet. Proportionally, smaller items were purchased at a 4:1 ratio to expensive items.

Participants were questioned about willingness to pay for a 'dream' product that was extremely effective controlling mosquito populations. Participants were encouraged to imagine a product fitting all personal needs (environmental sensitivity, unobtrusive, etc) and something that could be purchased once, set up, and no further expense incurred. Approximately 12% (n=58) of people would not spend money on such a product. Their reasoning for this was either they were not bothered by mosquitoes, or they could not

believe that such a product would ever exist. The distribution of the willingness to pay expressed by the participants is shown in Figure 7.

> *"We have a screened in porch, so the mosquitoes don't bother us unless we are gardening"* – Riverfront Property Resident

> *I would spend $1000 if it (a mosquito control product) really worked. If it was a miracle cure it would improve our quality of life so much.* – Maples Resident

> *Maybe two or three hundred dollars. It depends on what happens with the WNV. If that becomes more of a problem, then we would be willing to pay more for something.* – River Heights Resident.

> *I don't think anything could ever really work to control mosquitoes. They travel and move around, one product can't fix such a large problem.* – Test Interview.

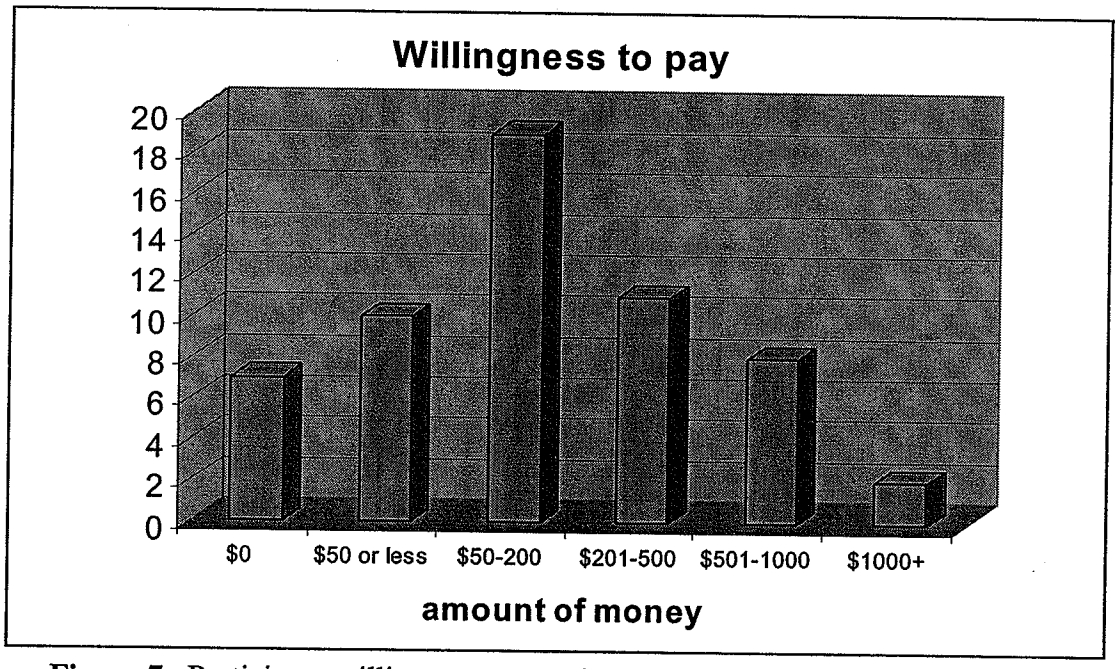


Figure 7. Participant willingness to pay for mosquito control product.

5.3.3 Awareness – Discussion

In Winnipeg, virtually everyone knows about the mosquito control program. The most typical response was 'of course' coupled with wide-eyed surprise that one would need

ask such a question. There are not likely many other municipal programs that enjoy the high public profile that the mosquito abatement program has.

While everyone interviewed was aware of the fogging program, there was lesser awareness of other program aspects (Figure 8). An inverse relationship was identified between awareness of program components, and support for malathion use. Individuals with information on multiple aspects of the abatement program were less supportive of the fogging component compared to the whole data set or those who knew only about fogging (Table 31). The responses were broken down into the three categories of total support, supportive, but would prefer something less damaging if available, and opposed to fogging. A link between the level of awareness, and the level of support held for the fogging program was revealed upon examination. Those aware of three or more program components were less supportive of fogging than those who thought fogging was the only way that the city attempted mosquito control. The higher level of awareness seems to be associated with a broader perspective on fogging as a component of mosquito abatement. The inverse relationship between program awareness and support for fogging suggests that increased public education, and elevated public awareness of program components in addition to adulticiding, could lead to a lower overall approval rating for the use of malathion for mosquito control.

Citizens expressed a very high awareness of how they can reduce backyard habitat and aid in mosquito reduction and most people had at some time taken actions to reduce standing water. Awareness was not a problem, but as discussed, the key issue is moving beyond awareness and into sustained action based on that awareness.

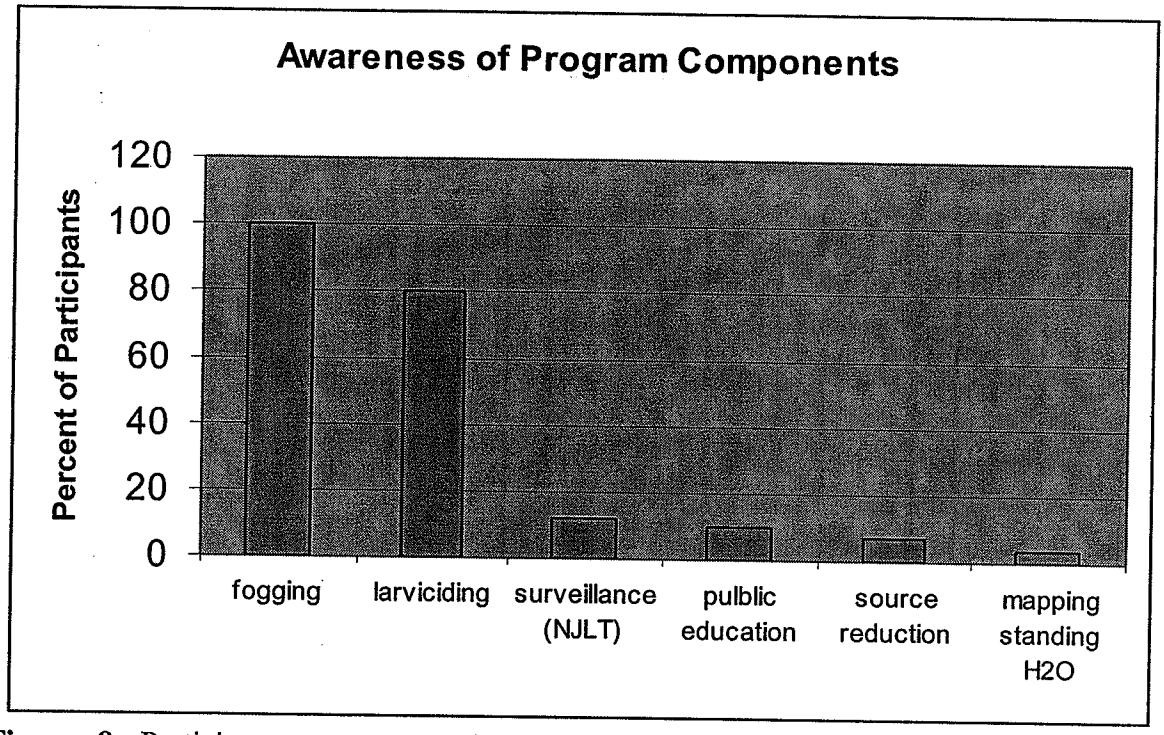


Figure 8. Participant awareness of components of Winnipeg mosquito abatement program (n=58).

	Approve	Approve, but…	Oppose
Total sample (n=58)	42%	28%	30%
Fogging Only (n=10)	80%	10%	10%
Three or more aspects (n=18)	22%	17%	61%

Table 31. Relationship between awareness of program components and support for fogging.

5.3.4 West Nile Virus – Descriptive

All but two survey participants knew about West Nile virus (WNv) and its local arrival in 2002. Many participants asked 'how could you not (know about WNv)?' Of the two that were unaware, one had been out of the country. The other knew the name 'WNv', but was unaware that mosquitoes and birds were involved with the pathogen transmission.

After the first local bird tested positive for WNv, a health state of emergency was declared for Winnipeg. This resulted in the entire city, including all de-listed properties,

being fogged. Almost 80% (n=58) of participants said spraying was the correct decision, 16% felt it was the wrong decision, and 5% were undecided. Participants really seemed to struggle with this question. It took the longest of all questions to answer, and the answers were most often tentative and indecisive. Participants expressed that the move was highly political, and government had to be seen as 'doing something' about the problem, regardless of the effectiveness of that 'something'.

> *It (the decision to fog all of Winnipeg) was a political issue, and got covered up with the 'emergency re: human health' crap.* – Riverfront property owner

> *It becomes an issue between the private citizen and the public in every walk of life, like being able to refuse a blood transfusion. It is a philosophical question that goes very, very deep. And I don't think that it is a yes or no answer.* – Test Interview participant

> *It is hard to say if it was the right thing to do. You are damned if you do, damned if you don't and there is no pleasing everybody. But I think they had to do what was seen as the best thing, the greatest good, for the most people. They had to put public health and safety first and concerns about pesticide use second.* – River Heights resident

> *Considering how many people are affected by the fogging with asthma and allergies, and hearing the statistics on how small a percentage of the population will get WNv, I don't agree that it was the right thing to do. I think the risks were greater than the benefits.* – Maples resident

> *I felt really glad that the city fogged everybody again. They really took things seriously and stood up for the majority of the people. It gave me confidence in my government when they did that.* – River Heights resident.

> *I remember being outside for a walk the night that protestors were blocking trucks and all of the things were going on here (in Wolseley) and that there were no mosquitoes out that night. I asked myself 'why are they fogging? Have they done trap counts?' Because there were no mosquitoes out.* – Wolseley resident.

Related to the above question was a discussion of the specific Wolseley situation. This discussion was held with twenty-one participants, and this aspect was only discussed if the interview participant initiated it. Of the 58 interview participants, 21 people initiated the discussion. The 21 participants that initiated the discussion were mostly from Wolseley, but there were individuals from each of the four interview area in this group.

A number of citizens in Wolseley engaged in civil disobedience to block fogging, and were mostly successful for two evenings. The Insect Control Branch removed Wolseley from the 'bugline' list of communities to potentially be fogged that evening, so protestors slept, believing the trucks were not coming. The Insect Control Branch, without interruption, fogged that evening. The participant opinion on the decision to conduct fogging in that manner is shown in Table 32. Most strongly disagreed with the decision. A small number of people felt that the actions of the protestors left the city no other option than the one they took. Of those who strongly disagreed, many felt citizens have to be aware of when to expect fogging trucks, so people could protect themselves from exposure to the chemical. Some felt this punished everyone in Wolseley for the actions of protestors.

Strongly disagreed	81%
Disagreed, not strongly	5%
Agreed	10%
No other choice	4%

Table 32. Participant response (n=21) to the manner in which Wolseley was fogged following protests in 2002.

I was very upset that they did that, it was a very low blow. – Riverfront property owner.

The Wolseley people are so militant that I almost thought they deserved it. – Maples resident.

I got woken up by a woman screaming that they were spraying and I closed my windows. I just wish our politicians had more balls and they just arrested all of those assholes protesting and then go in with the trucks. – Wolseley resident

Concern about this new disease was examined. Most people expressed little or no concern about WNv, though some concern was expressed at the medium and high levels. Half of those in the medium category admitted to being overly-concerned with health issues, and self-proclaimed hypochondriacs. The three participants registering 'high' concern were horse owners worrying for their animals. Given the susceptibility of horses to WNv, this was probably not an irrational concern. The distribution in the level of concern felt regarding WNv is shown in Figure 9.

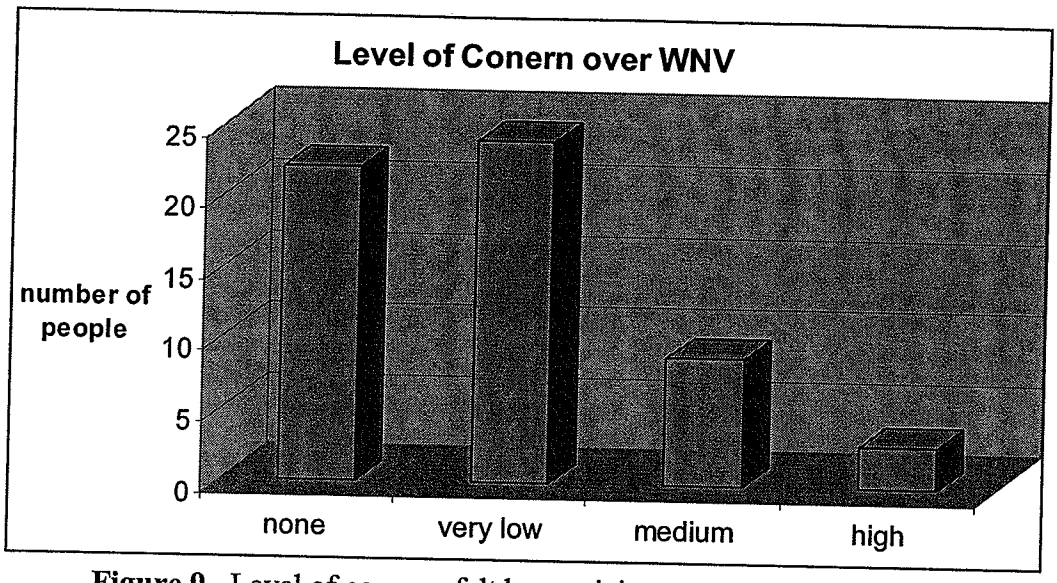


Figure 9. Level of concern felt by participants regarding WNv.

It's (WNv) like everything else, cancer, heart problems, if it happens it happens, you can't worry about it. – Maples resident.

I think the media blew it (WNv) way out of proportion – to 'we're all going to die any minute'. – Maples resident

5.3.6 West Nile Virus – Discussion

The data gathered from interviews demonstrates that most participants were not very concerned about WNv, yet. Little or no concern was expressed by 80% of those surveyed (n=58), though some felt their concern would likely elevate proportionately to the number of local human cases. The government should be prepared to take a leadership role should the situation change from no human cases to multiple human cases. As discussed, the participants are looking for good information from reputable sources, and this need is likely to increase with the arrival of human cases of WNv.

It was the widespread opinion that fogging was the correct course of action in 2002 following the arrival of WNv. This acceptance was often coupled with the recognition that regardless of fogging effectiveness, the government has to be seen as doing everything possible to protect the public health. It was an issue of optics. A number of people also commented that if Winnipeg did not normally implement fogging, it would

have been a more controversial decision. The fact that fogging was regularly conducted for nuisance mosquitoes set a precedent to fog in the presence of WNv.

5.4 Annotated Bibliography – Outcome and Implementation

Formal education with school children has been identified as an important component of mosquito control activities (Nasci and Herrington, 1997; Nammany, 2003). Education on mosquito issues can improve a local mosquito situation in two ways. Firstly, physical environmental change will occur as people reduce breeding habitat locations on private property, and secondly, by improving the public perception of the situation with improved understanding and awareness of the issues involved with mosquito control (Nasci and Herrington, 1997). By conducting formal, holistic, mosquito education in schools, the next generation of decision-makers will be educated, motivated, and able to participate more effectively in the solution to mosquito problems.

The Winnipeg Insect Control Branch does not currently conduct structured formal mosquito education (Gadawski, 2000; 2001; Davis, 2003). An annotated bibliography of mosquito educational tools was created as an outcome of the identification of this gap. The annotated bibliography includes a list of books, games, curricula, websites, and other items that could be used in a classroom setting for the purpose of mosquito education. Feedback on as many products as possible is included. This annotated bibliography will be available to Winnipeg Insect Control Branch for use and application as they see fit, hopefully as a tool by which to enhance the current mosquito control program.

Three local middle years educators, parents, the principle researcher, and other documented reviews of educational tools, were the sources of feedback in the annotated bibliography. Educational tools were distributed to educators, and they were free to use the items with their students as they saw fit. Two teachers organized the students into groups to prepare projects on mosquitoes. One class experienced lectures on mosquitoes, and were given the educational tools as supplementary materials.

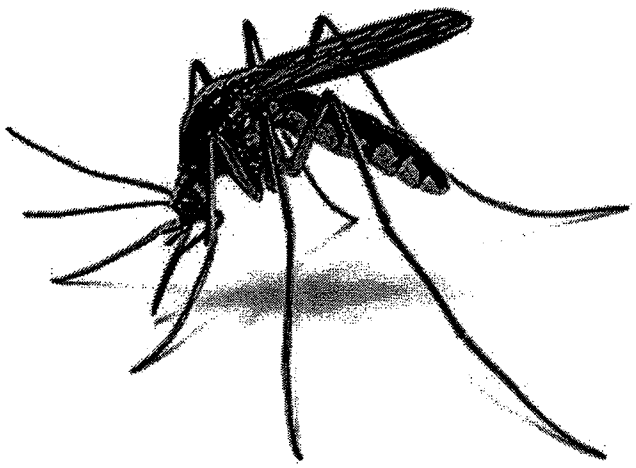
The responses regarding the materials dispensed for evaluation were all very generally positive, though not every educational tool received a 'five star' review. The trend of encouragement and enthusiasm is likely reflective of the fact that those who participated in the project volunteered freely. Their participation in the project was likely due to an interest in the subject area or a general desire to expand on current curriculum and try new things. One teacher expressed her enthusiasm for the Annotated Bibliography project as follows,

> *"My class has been working with the mosquito kit, and loving it! Thank you for including me in the trial run. I have also shown the kit to parents and lent the game out. They think it's all great stuff!"*

Another teacher expressed her relief and gratitude that this project was being undertaken. She explained that teachers do not have enough of this type of resource, ones that offer feedback from other educators on educational topics and tools. This particular educator thought so highly of the project that she notified the division science co-ordinator, who has requested a copy of the annotated bibliography upon completion.

A number of professionals working in the field of mosquito control have requested copies of the Annotated Bibliography. In fact, virtually everyone in the industry that learned about the project sent a request for access to the information. Calgary, Los Angeles, the Saginaw County Mosquito Abatement Commission in Michigan, and Minneapolis have all requested access to the Annotated Bibliography. The widespread interest and enthusiasm for this project confirms the interest in, and importance of, formal mosquito education as part of an integrated pest management-based mosquito control program.

The immediate project result for the Annotated Bibliography is the creation of it; however, the level of use and application, the interest in, and the radius that the tool is ultimately spread, will truly be the 'result' of the project.



Chapter Six
Conclusions, Recommendations and Reflections

No animal on earth has touched so directly and profoundly the lives of so many human beings. For all of history and all over the globe she has been a nuisance, a pain, and an angel of death. Mosquitoes have felled great leaders, decimated armies, and decided the fates of nations. All this, and she is roughly the size and weight of a grape seed. – Spielman and D'Antonio, 2001

6.1 Looking back

When this project commenced in December of 2000, it was ambiguous as to what shape it would eventually take. Ideas about Purple Martin populations, mobilizing Wolseley residents to participate in a large-scale source reduction program, and bat houses, were some of the items that floated through the course of discussion about what the scope of the project would ultimately be. Upon completing the literature review, it was clear that there were unanswered questions that the project could attempt to address. The rapid movement of West Nile virus (WNv) across North America added more fuel to the already tense atmosphere surrounding mosquito discussions in Winnipeg. After thinning the host of initial objectives, three projects and four objectives were identified. All of these projects and objectives are tied to the concept of Integrated Pest Management (IPM), the current pest management philosophy that incorporates multiple methods of pest population control.

The resulting research objectives included:

1. To gather and analyze information from Winnipeg residents regarding their knowledge of mosquitoes and issues surrounding their control
2. To identify non-toxic mosquito control methods and test them for effectiveness and viability in an urban setting.
3. To create an annotated bibliography of mosquito educational tools appropriate for middle years school children.
4. To make recommendations based on the findings of the first and second objectives

This project, due to the popular nature of the topic, was a media darling, and the public outreach conducted was constant. Out reach included numerous radio and print interviews, public presentations, information provided to high school and university students studying the topic, liasing with community groups, and responses to private citizens that had 'heard of the work'. Participation took place in a National Film Board project proposal, with the project focussing on mosquito problems in Winnipeg. Overall, it was both interesting and challenging to deal with the attention the project generated.

In this final chapter, conclusions drawn by each objective are described, and outcomes and recommendations that flow from the objectives are discussed. Some of the implications and opportunities that can be derived from this research are identified. The chapter will close with final reflection on the study subject.

6.2 Results and Outcomes

6.2.1 Information from Winnipeg residents

The first project objective was to gather and analyze information from residents regarding mosquitoes issues in Winnipeg. Education, Awareness, and WNv issues were the three main areas of investigation. Fifty-eight residents were interviewed. The primary impression from the process was that Winnipeggers want to, and like to, talk about mosquitoes. This finding was revealed by the high participation rate, and the general hospitality and interest with which people received the primary researcher at their door.

Education and communication of mosquito issues were revealed as an important part of the 'big picture' in Winnipeg, as well as an area that could be improved upon. More than half of the participants felt that the city should improve educational outreach and communication efforts on mosquito issues. Although participants did not learn much new information from the pamphlet, participants indicated a desire for information that was from a reputable source (municipal government or health authority as opposed to media).

The *Fight the Bite* pamphlet garnered a good response: more than 70% remembered receiving the pamphlets, and of that group, 82% read it and 10% saved it or would have read it if it had been delivered in the spring or summer. Participants were generally curious about why this was their first exposure to the pamphlet, and many stated it should be delivered en mass. The *Fight the Bite* pamphlet caught the audience's attention, delivered the message clearly and straight forwardly, and motivated many recipients to inspect their properties for mosquito breeding habitat.

Results from investigation into awareness of mosquito control issues revealed important and interesting information. Not surprisingly, awareness of the Winnipeg mosquito control program itself was 100%, though knowledge of the various program components was not as high. Every participant knew about fogging, and 80% had some understanding of larviciding. About 10% or less of participants knew about surveillance, education, source reduction, research, and mapping mosquito-breeding habitats.

An interesting relationship was revealed when the awareness level of program components was related to the approval rating of the fogging program. Those who thought fogging was the only method of mosquito control employed were 80% in favour of it, and those aware of three or more program aspects were only 22% in favour of the action. The survey average was a 43% approval for fogging. This correlation implies that increasing the overall awareness level that citizen have of the Winnipeg mosquito control program components could lead to a lower general desire for the city to fog for mosquitoes.

When participants were questioned about how the city really fared in controlling mosquito populations, participants thought the city was 'doing a good job, considering...'. The common theme was empathy for those trying to control mosquitoes. Though they try hard, the scenario was like David and Goliath, and 'mosquito control' is an oxymoron in Winnipeg. It was interesting to observe participants expressing desires to have the city 'do something' about mosquitoes, and in the same breath say mosquito control was essentially impossible.

The 'de-listing' program has been contentious due to its ability to affect a number of houses, and in some cases entire neighbourhoods. Only about half of participants felt the program should remain as it is, 12% felt it should exists but needed modification, and more than 30% of participants felt the program should not exist at all.

Winnipeg citizens are willing to pay out of their own pocket for products that may improve the quality of their outdoor experience by reducing mosquito populations. More than 80% of respondents had invested in mosquito control in the past, and questioning regarding a mosquito 'dream product' revealed that many of the participants would be willing to pay $200-$1,000 for effective mosquito control around their homes. This willingness to pay for mosquito control indicates the level of importance that participants attributed to having a comfortable summer experience (i.e., as few mosquitoes as possible).

This survey was conducted following the arrival of West Nile virus (WNv) to avian and equine populations, but prior to the first human WNv cases. Participants were surprisingly unconcerned about the virus affecting their lives, with the exception of horse owners and a few self-admitted hypochondriacs. However, many of the participants felt that they would like 'good' information about the disease. Information from the city or from the regional health authority would suffice.

The surveying also revealed an interesting sentiment from participants regarding the decision to fog all of Winnipeg with malathion following the arrival of WNv in 2002. The majority (80%) of participants felt that spraying was the correct decision, though most of that group felt that the city had little other choice and had to be seen as 'doing something' about the situation. There was a general opinion that the move was highly political in nature.

6.2.2 Identifying non-toxic, effective, mosquito control methods

The environmentally sensitive product testing was conducted in a rigorous and scientific method. The length and repetition of the testing, the number of assessment methods used, and the input of time in educating volunteers on data collection methods, were just some of the aspects that made this testing both gruelling and rewarding.

A list of environmentally sensitive control products was compiled. The two products selected for testing were the Mosquito Magnet™ and Dr T's Mosquito & Gnat Repellent, neither of which proved successful at reducing mosquito populations on the targeted area.

In experiment #1, the Mosquito & Gnat Repellent was tested, and mosquito numbers were measured on test and control sites using both NJLT and landing counts. The testing was first conducted in 2001 and then replicated in 2002. The results were consistent between years. From NJLT results, there were fewer mosquitoes present on the test sites in both years, and the product was effective at reducing mosquito populations in the application area. However, the landing count results did not support the NJLT results. In 2001, there was one treatment with significantly more mosquitoes landing than the control. Other than that one result, there were no differences shown in the number of mosquitoes landing between any of the sites in 2001 or 2002. Presumably a consumer would get as many bites pre and post-application. Therefore, though the product may have reduced the number of mosquitoes in the area, it did not accomplish the more important goal of reducing the number of mosquitoes attacking people.

In experiment #2, the Mosquito Magnet was tested in an urban area, and mosquito numbers were measured on the test and control sites using CDC light traps and landing counts. The experiment was conducted first in 2001 and then replicated in 2002. The CDC light trap results and the landing count results were similar; the Mosquito Magnet was ineffective. In fact, from the landing count results from 2002, significantly more mosquitoes were landing on the test plot than on the control plot. The product may actually have been functioning to increase mosquito numbers in its vicinity.

In experiment #3, the Mosquito Magnet was tested in a rural area where the mosquito pressure was high. As with the other experiments, experiment #3 was conducted in 2001 and repeated in 2002. During the course of experimentation, the Mosquito Magnet collected hundreds of thousands of mosquitoes. However, neither landing count or CDC light trap results indicated any benefit from the operation of the machine. In both years, there were no differences between the number of mosquitoes landing on the test site and

on the control site. The CDC results consistently revealed significantly more mosquitoes landing on the test plot than on the control plot, opposite of what is expected should the machine be working to reduce mosquito populations.

The product testing revealed more information than the effectiveness of the test products. Detailed volunteer landing count measurements and observations allowed for insight into interactions between mosquito activity and environmental variables. Interactions between the number of mosquitoes landing and the 'person', 'wind', and 'temperature' variables were observed throughout the three experiments. These findings were consistent with the literature, and strengthen the argument that mosquito populations are vulnerable to environmental variables.

An inverse relationship between wind strength and mosquito numbers was identified in four of six test sessions. The number of mosquitoes landing declined with increased wind speed. The two sessions that did not show an interaction featured little variability in the wind speed.

The 'person' effect was strongly observed in every field season. Individual differences in body chemistry were affecting the number of mosquitoes landing on each volunteer. Though the person effect was consistently observed, it did not play a role between experimental sites as the same volunteers took measurements on both test and control sites.

An interaction between the temperature and the number of mosquitoes landing was observed in every field session. As with the person effect, the temperature interaction did not play a role between sites. This is likely due to the small variations in temperatures between matched landing counts.

Finally, an interaction between cloud cover and the number of mosquitoes landing was observed in four of the six sessions. The relationship between cloud cover and mosquito numbers was not so apparent as with other variables examined. When there was cloud

cover, there was generally a slightly higher level of mosquito activity as compared to when there was direct sunlight.

The collection of baseline data for experiments #2 and #3 in the 2002 season showed that there were no differences between the mosquito activity prior to the commencement of the testing. This result confirmed the similarity in the sites chosen for experimentation. The strength of all three experiments would likely have benefited from the collection of baseline data and the beginning of every experiment and in every year.

Neither the Mosquito Magnet nor the Mosquito & Gnat Repellent proved successful in reducing the number of mosquitoes landing on volunteers on the test sites as compared to the control sites. The Mosquito & Gnat Repellent did seem to have some affect on the number of mosquitoes being collected by the NJLT, but there was no benefit derived (in the form of fewer mosquito bites) by persons spending time on the test sites. Therefore, neither of these products are recommended for purchase to control mosquito populations in a localized area.

6.2.3 Annotated Bibliography

This project outcome was a result of the gaps identified by the literature review and sustained by the survey data. The current annotated bibliography represents the first steps of what should be a long-term project. The bibliography is a list of all of the mosquito educational tools that could be found. Beyond listing the items, cost, and availability, item-specific feedback was included whenever possible. Teachers, parents, the principal researcher, and peers to those who will use the bibliography provided feedback. This will help guide educators as they incorporate mosquitoes into curricula.

However, stopping at this point, would fall short of the intention of the project. The bibliography will be given to the Insect Control Branch with the hope that the branch will embrace and incorporate it into its IPM program. Other mosquito control jurisdictions have also requested copies, saying that sharing this type of information benefits everyone.

It should be available to all interested educators, in Manitoba and beyond. New feedback and products should be added to update the bibliography. These actions will improve the product information and enhance the decision-making capacity of educators.

Those who were involved in the project were positive, enthusiastic, and motivated to personally evaluate the mosquito educational tools and try them with their students. These participants were volunteers, and their volunteer commitment likely indicates a previous interest in the area of study. The free nature of the way that these people involved themselves in the study lends itself to the positive result and feedback that was obtained on the importance of the project. However, without conducting a survey of all Winnipeg educators, it is impossible to know what proportion would share the sentiments of the project volunteers. It is likely that if these three educators were so easily located, that there are many others that share their interest and enthusiasm in incorporating quality mosquito education into their curriculum. Two of the educators specifically commented that the arrival of West Nile virus to the Winnipeg area has increased their interest in the topic. Given the high profile of West Nile virus in local media outlets, again it is likely that other educators would be interested in the topic. Only after introducing the annotated bibliography to the public will the general interest level become apparent.

6.2.4 Recommendations for change and action

The crux of the recommendations stemming from the survey data is that Winnipeg is not currently conducting a true IPM program, and changes should be implemented to improve it. The recommendations focus on education, source reduction, research on best application techniques and alternatives, and communication with other experts. These areas are currently under-represented from the current Winnipeg mosquito abatement program.

Winnipeg currently offers the largest and best-funded mosquito control program in Canada, though it has not yet reached its full potential. Winnipeg could be a leader in innovative integrated mosquito control in Canada, and North America. Currently the

education component of the Winnipeg program is lacking, compared to Los Angeles, New York, Florida, or Saginaw County. Recent joint efforts sustained by the Province of Manitoba and the City of Winnipeg have addressed some gaps in the IPM program, though more can be done to take this abatement program to truly integrated status. Research on best application techniques is limited and should be expanded, and attendance at local, regional, national, and international conferences relating to mosquito control issues should be increased.

The pamphlet

Doug McKenzie-Mohr, an expert on community-based social marketing describes the three most important features of an effective pamphlet as follows;

1) *pamphlets must be noticeable*
2) *they must be self-explanatory, graphics and text must clearly and simply explain the message, and*
3) *the pamphlet should be presented as close in time and space as possible to the targeted behaviour.* (McKenzie-Mohr and Smith, 1999)

The *Fight the Bite* pamphlet was noticeable, clear and simply written, and could be distributed to residents at a time appropriate to mosquito control. *Fight the Bite* is currently positioned to be an important component to the mosquito control program in Winnipeg.

The pamphlet should be distributed to every household in Winnipeg in late spring. The method of delivery could be by hand, or with a mailout. Survey participants responded very well to *Fight the Bite*. New information was not generally imparted, but more importantly, the pamphlet was the catalyst to move people from inaction to action in reducing standing water on their property. As repeated reminders are important to encouraging sustained changes in behaviour (McKenzie-Mohr, 2000), the pamphlet should be distributed to each house every two to three years, or more often if budgets warranted.

From the survey results, suggested modifications to the pamphlet are not overly extensive, and include relocation of the website address and bugline phone number, and

increased visibility as to the source of the pamphlet. The website address should have its own space and be easy to locate. The front cover is the best spot. The bugline phone number should undergo the same promotion, from the back tucked in text, to the front of the pamphlet in an uncluttered location. This would make it simpler for people to further inform themselves should unresolved questions remain following reading. Finally, the City of Winnipeg logo should be featured on the front – adding colour, and enabling easy identification of the pamphlet source. This last point is especially important as the literature shows that information from a respectable source is much more likely to be read than information from an unreliable or unidentified source (Eagly and Chaiken, 1975).

The website

The Insect Control Branch website must be improved. The website is currently located at www.bugline.com and it is formatted to the standard City of Winnipeg department website style. One branch employee expressed a frustration at the limited amount of information that could be posted on this page.

The website should include the information listed below on the Winnipeg mosquito abatement program. These changes would be relatively inexpensive, and would be the first step to improving the information to which the public has access.

- A discussion of all aspects of mosquito control, the philosophy of Integrated Pest Management, and the guiding principals of the Insect Control Branch.
- Information on the products used to control mosquitoes in Winnipeg, and the effectiveness and risks associated with those products. Links to, or abstracts of studies conducted relating to these mosquito control products.
- A detailed and frank discussion of malathion should be included. The New York State Department of Health posted an excellent fact and information sheet that Winnipeg could use as a guideline. Leadership on this specific topic is badly needed, and thus far, the branch has not responded with an open and frank discussion of the chemical.
- The branch has recently added an excellent WNv fact sheet to their web page. This would have been a recommendation had it not already happened.

- Links to other mosquito control programs, and websites that relate to mosquito issues – for those that need additional information.
- Information for educators wanting to incorporate mosquitoes into curricula (the annotated bibliography).

Early Season Media Campaign

Timeliness of the delivery of an information message has been identified as one of the most important factors in changing the behaviour of the target audience (McKenzie-Mohr and Smith, 1999). As was suggested by many respondents, and as is implemented in other mosquito control districts, Winnipeg should conduct an early season (May and June) media campaign. This media campaign should include all aspects of media outreach. Public service announcements on the radio, billboard advertisements, advertisements on buses and in other public areas, commercials on television, and advertisements in the newspaper. People were aware of the information in the pamphlet, but many stated they don't think to check their yard until the mosquito populations get out of control. Since the pamphlet motivated participants to check their property for standing water, an early season media campaign would likely have a similar effect. In the spring of 2003, the Manitoba government released a WNv commercial detailing home mosquito breeding habitat reduction. This commercial should be a first step in a greatly expanded media campaign.

Backyard Inspection

This program should be extended beyond its current, limited capacity. If fact, this recommendation has been addressed in part with the TEAAM project initiated during the spring of 2003. As would have been recommended, TEAAM featured employees who focused on property owners and yard inspection. This program is currently limited to Wolseley and Garden City, and should be extended to include all areas of the city. TEAAM employees conduct public education on mosquito issues. A further improvement would be holding public presentations issues through the spring and summer period on mosquito issues and backyard maintenance. Public presentations

should not be limited to homeowners, and should include presentations to schools (classroom and assembly) and other interested groups.

Formal Education

The Insect Control Branch should develop a formal education component to their current mosquito abatement program. This could include any number of options.

- Supply educational materials to teachers in Manitoba interested in incorporating mosquitoes into their curricula (the KNOW MOSQUITOES board game and the Neato-Mosquito CD ROM are currently distributed to schools free of charge by some American mosquito control districts).
- The annotated bibliography should be provided as a resource to interested teachers. This could be on the Branch website or provided by mail or email to schools (or anyone) who requests it.
- A field trip program should be offered so students can observe Branch activities. Ideal for this trip would be surveillance methods (larval sampling, adult trapping, and checking for species) and a discussion and tour of equipment used for mosquito control and considerations when conducting larviciding and adulticiding.
- In conjunction with schools, run poster, advertisement, or story contests telling people about mosquitoes. Saginaw County conducts this type of outreach, offering mountain bikes and other prizes from local retailers.
- The branch should ultimately aspire to provide a program similar to the Greater Los Angeles Vector Control District – a travelling classroom that reaches thousands of students every year. This would be the best possible development in a local formal education program for two reasons; the detailed level of learning that children can attain through this experience, and the sheer number of children that can be reached.

Research

The branch must maintain a commitment to investigating alternatives, best application techniques, and keeping close contact with other mosquito control experts. These aspects

must not be relegated to time 'leftover' from other duties. Public attitudes and perceptions regarding chemical use is changing. With WNv, the face of mosquito control in North American is changing. The branch needs to do everything possible to stay abreast of new research, and the most effective mosquito control programs. A research and outreach team should be developed specifically for this purpose. At best, new more effective, economical, or environmentally sensitive mosquito control techniques might be adopted as a result. At worst, a greater confidence held by the public as they see the research into product effectiveness and best application techniques displayed on the website.

The Budget Allocation

In order to accomplish the above recommendations budget reallocation must occur. Recent budget increases have revealed little additional funding for aspects of the mosquito control program other than larviciding and adulticiding. The current narrow view on mosquito control is limiting the potential of what the branch could really be accomplishing. A serious monetary dedication needs to be specifically allocated to the 'other' components of IPM. Perhaps some money could be shifted from larviciding and adulticiding to education and research, or as with Los Angeles, a patron sponsor could dedicate funds to research and education.

The result of the implementation of these recommendations would be a true IPM program. It would provide mosquito reduction to the extent possible, and engage, activate, and empower the public with knowledge about mosquito issues. It would also provide public assurance that the program conducted is responsible and proven mosquito control.

6.3 Public communication of project outputs

A great deal of public outreach was conducted relating to this project. A complete appendix of outreach activities is listed in Appendix J. As this project was publicly funded, it is important that the results were fed back to the community in a meaningful

way. In addition to the public having access to the research, the goal was to make the results as widely publicized as possible to increase the impact of the research. The sharing of findings with the local and larger communities was largely successful, though a number of outreach steps still must be completed prior to the total closure of the project.

In April 2003, a public meeting was held in Wolseley, the host community for the project. Debate and de-listing activities in Wolseley were likely instrumental in the initial funding attainment. The public meeting was open to all Winnipeg residents, but focussed on Wolseley. All research aspects were discussed and questions answered. A good deal of time was spent in Wolseley, attending public meetings, Wolseley Working Group[1] meetings, and being available to the community regarding mosquito issues. At the project outset, support and guidance from the Wolseley Residents' Association was solicited, and a progress report was presented at a fall 2001 meeting

In addition to the meeting, exposure through media outlets allowed project results to reach people across Canada and in parts of the United States. The project was accountable to the Sustainable Development Innovations Fund, for which a number of technical reports/updates, and final report were prepared. It was also accountable to the MLA for the Wolseley area, the Honourable Jean Friesen and a number of meetings were held to discuss progress and direction of the project.

Finally, a short list of other outreach activities include;

- participation a National Film Board project proposal
- aiding and advising students researching mosquito issues
- talking to salesmen with mosquito products they want to sell, test, get advice on
- answering questions from the public, originally sent to the City of Winnipeg, and then diverted to the principal researcher

[1] Born from a large general public meeting in summer, 2002, the WWG with the mandate to find feasible solutions to the mosquito problem in Wolseley.

- presenting at the American Mosquito Control Association annual general conference in Minneapolis, March 2003.
- presenting at a local non-governmental organization annual general meeting

Results and recommendations will be provided to a number of the interview participants, the City of Winnipeg Insect Control Branch, to the City of Winnipeg mayor and council, and potentially Consumer Reports and a journal article.

6.4 Summing up

Ancient history, cutting edge science, changing social values, qualitative and quantitative study, pesticide registration and de-registration, pest management philosophy, government policy and recommendations, children and adult learning, abatement programs close to home and half way around the world....

At first glance, it seems that this project is far-ranging in both research topic and methodological approach. Some who read this document may feel the literature review is too extensive, and perhaps that that the project is fuzzy in terms of focus. Indeed, it could possibly be successfully argued that these things are true. However, the diversity in discussion and investigation only highlights the complex and interrelated nature of this thesis topic – the mosquito.

Those who study the mosquito seeking understanding, or those tasked with conducting effective mosquito abatement, are faced with a reality: there are innumerable variables to consider with this insect. She is no ordinary pest. From a common nuisance to bearer of illness and death, everyone knows the mosquito. Thousands of species feature unique characteristics that make effective control strategies subtly, or not so subtly, different. The scientific challenge of understanding *how* to control comes first, and then there are the operational and social challenges of actually implementing control.

The latter challenge is a political tightrope-walk. Once the complex and ever-changing nature of local mosquito populations, and available operational techniques, is understood,

people must be considered. Support and approval for an abatement program must come from the public that financially supports it and is exposed to the program outcomes. What methods are best for the local people? What special needs do local situations feature? Indeed, the understanding of how people relate to mosquitoes as a part of the environment is almost as complex as understanding how the mosquito relates to the environment.

The two-fold challenge of insect and people must be considered together for a program to prove effective at controlling local mosquito populations and satisfying the needs of the local human populations. It is a complex puzzle that has distinct areas. However, science, operational techniques, and people have an interconnectedness facilitated by this fragile little insect. One puzzle piece will provide some small clarification, but for true progress and peace to be made with mosquito control, every puzzle piece must be duly considered, then fit carefully together to create the whole social and scientific picture, within which, mosquitoes and people buzz.

> *It may be difficult to love the mosquito, but anyone who comes to know her well develops a deep appreciation.* – Dr. A. Speilman.

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Alternative Mosquito Control Products

Mosquito Attractant Machines

1) **Mosquito Magnet** – American Biophysics Corporation, www.mosquitomagnet.com
   Attracts mosquitoes via size, carbon dioxide, moisture, heat, and octenol. Insects are sucked into a trap and dehydrated. A number of sizes are available, covering from half an acre to one acre.
   Product testing has been conducted by Daniel Kline (U.S. Department of Agriculture). The product was tested on a small island off the coast of Florida, with twenty traps placed on the island. The analysis showed that the traps were effective in reducing mosquito populations in this isolated environment.

2) **Dragonfly System** – Mosquito Solutions, www.mosquitosolutions.com
   Utilizes two attractants, the larger machine, and then smaller 'Mosquito Cognito' units. Attracts mosquitoes via heat, size, light and carbon dioxide. Utilizes a product called 'conceal' to supposedly block the scent-tracking ability of biting insects.
   Effectiveness study was conducted on this product by C. Claire Lara and Holly Teyler of the University of Northern Colorado. The study results did not show the system to be an effective method of mosquito control in the rural location in which it was tested.

3) **Mosquito Eradicator** – Brookstone Company Inc.
   Attracts mosquitoes in the same manner as the above two products. The company claims that the product works to reduce the mosquito population by 95% in three to four weeks of use. Cost of this product is $595 USD.

4) **MosQUITo™ Trap** – by EPAR
   This is an Australian product by AbcomOnline. www.mosquito.com.au The machine provides 'seven steps to mosquito eradication' according to the manufacturer.
   1) $C0_2$ – 1st step in the attraction process.
   2) Lactic Acid – an irresistible lure for biting insects
   3) Octenol – the third essential lure
   4) Heat and Moisture – close-range attractants
   5) Spectrum Light – ensures there is no escape for biting insects
   6) Ultraviolet Light
   7) Sound – the final nail in the coffin for biting insects.

5) **Mosquito Power Trap** – by Flowtron, www.mosquito-zapper.com
This trap functions in the same manner as many of the above. It has a unique feature in the timer that operates the machine at the desired times. The Mosquito Power Trap runs on electricity, but uses propane to produce the attractant.

Natural Mosquito Repellents

6) **Dr. T's Mosquito & Gnat Scat.** – Dr. T's Nature Products, Inc. PO Box 682, Pelham, GA, 31779. Email: drts@rose.net
The product contains lemon grass oil, mint oil, and garlic oil on an attapulgite homite clay carrier. It is supposed to be repellent to mosquitoes and keep them from entering the space of application (yard, etc). Manufacturer claims that the product deters mosquitoes from the targeted area for up to three weeks.
Available at www.mosquito-zapper.com or www.animalrepellents.com for cost of $25.95/container. 3kg of product will treat 370m^2 of lawn.

7) **Don't Bite Tonight' Mosquito and Bug Repellent** – Not Tonight Deer! Box 71 Mendocino, CA, 94102. www.nottonightdeer.com
The active ingredient in this product is citronella. It is not for use on clothing or skin, but instead to be sprayed on 'outdoor surface areas'. The product is designed to replace the use of citronella candles. It is to be sprayed 'around decks, patios, under picnic tables, and benches, door frames, recreational equipment, and any area that mosquitoes are a nuisance'.

8) **Repel Lemon Eucalyptus Insect Repellent Lotion** – WPC Brands, Inc. Jackson, WI, 53037. www.wpcbrands.com
This product is to be applied to skin as an insect repellent. According to the manufacturer, the product contains plant extracts of Lemon Eucalyptus and protects your entire family from mosquitoes and deer ticks for up to six hours. The product is made from a renewable resource and is derived from *Eucalyptus citriodora* leaves.

Surface Oils for Larviciding

9) **Flit MLO** –
An oil product that works by spreading over breeding habitat and reducing the incidence of successful transformation from larval and pupal stages to the adult stage.

10) **Agnique MMF** – Cognis Corporation

Very similar to #3. It is a monomolecular product that boasts 'impressive spreadability' and environmental sensitivity.

Frequency Mosquitoes Repellers

11) Frequency Repellers

These products are supposed to repel mosquitoes on a more local/personal level by emitting frequencies that are unfavorable to female mosquitoes.

Electric Mosquito Killers

12) The Stinger – Stinger Division of Kaz Inc., Hudson, NY. 12534. www.kaz.com

Company claims that 'the Stinger kills thousands of flying insects daily, greatly reducing the spread of disease caused by these insects. This results in safer and healthier environment for all outdoor activity.' The product includes a mosquito attractant and a fly attractant to be attached to the product and increase the attraction to flies and mosquitoes.

13) 'Zappers'

These products are supposed to attract mosquitoes with light, and then kill them when they come into contact with the power source. These products are not successful at reducing mosquito populations, and in fact, often increase mosquito populations within the vicinity of the device.

Larvicides

14) Underwater acoustic larvicide

The 'larvasonic' is made by New Mountain Innovations.

Various unit sizes are available depending on the target application (ponds, storm sewers, industrial installation (permanent).

This product emits a sound underwater, and when mosquito larvae are 'hit' with the sound wave, their air bladder explodes, causing the larvae to sink and die. This product is supposed to be very specific to mosquito larvae, and not harmful to other aquatic residents.

Information is available at info@larvasonic.com

15) *Bacillus thuringiensis israelensis* (Bti)

This product is available under a number of different trade names. Vectobac is one of the Bti products used by the City of Winnipeg Insect Control Branch in their larval

control program. This product is a bacterial pathogen that is lethal to larvae once ingested. This product is lethal to a small number of diptera species, including blackfly and mosquito larvae.

Natural Predators

Includes dragonflies, bats, Purple Martins, ...

While all of these predators consume mosquitoes as part of their diet, there is no recorded evidence that any of these predators can produce a significant change in local mosquito populations.

July 11, 2001

Dear Sir or Madame,

My name is Julie Price Henderson, and I am a graduate student at the Natural Resources Institute at the University of Manitoba. I am currently working on a thesis research project as part of the Master of Natural Resources Management degree requirements.

I am conducting research into integrated, community-based, environmentally sensitive methods of controlling mosquitoes in urban areas. I would like to make you aware that I will be conducting research in your neighborhood over the coming weeks. A product will be tested on properties that are near to yours. The test product is an all-natural granular lawn application that is supposed to repel mosquitoes from the yard.

Pest control is a continuously evolving field. New products that manufacturers claim to be more effective and environmentally sensitive than previous products are often made available to both pest control managers and the general public. This study specifically examines the effectiveness of environmentally sensitive mosquito control products in an urban environment. It is though that by ascertaining the effectiveness of some of these products and increasing the knowledge and understanding of the values and attitudes held by the public regarding mosquitoes and their control, a more effective and publicly acceptable mosquito abatement system may arise.

The ethics committee at the University of Manitoba has approved this research project. Funding has been provided by the Manitoba Sustainable Development Innovations Fund and is being conducted under the supervision of Dr. A.J. Sinclair of the Natural Resources Institute. I would very much like to speak with you to address any questions or concerns that you many have. Please feel free to reach me at the contact information provided.

The accuracy of my research many be affected should you undertake personal mosquito control measures on your property such as the spraying of commercially available insecticides. Should you feel it necessary to conduct such mosquito control on your property, I would appreciate it if you could notify me as to the time and type of control undertaken, so that I may accurately interpret the data collected.

Thank you very much for your time and attention. Again, please feel free to contact me for additional information regarding the project.

Sincerely,

Julie Price Henderson
M.N.R.M. Candidate
Natural Resources Institute
University of Manitoba

Mosquito Volunteer Information Sheet

Let me start by saying **THANK YOU** for volunteering to help me with my thesis research. It is my hope that this thesis project will represent another step towards the achievement of sustainable living. You should feel good knowing that your efforts are part of the solution to reduce chemical dependency in urban areas, and not part of the problem.

This package should provide all of the information, tools, and directions that you require to participate in the study. I hope to make this experience as interesting and enjoyable as possible for all of my volunteers. Please do not hesitate to let me know about any questions, problems, or concerns that you may have. I can be reached at xxx-xxxx or by email at xxxxx.

The portion of the project that you have volunteered for is the *Landing Test*. You are part of Group 1. The Landing Test will be used to measure the level of mosquito pressure on a test plot. The results for each plot will be compared to determine the effectiveness of an environmentally sensitive mosquito control method.

A copy of the summarized test results will be made available to every one who participated in the project and wishes to receive results. The final thesis product will likely be completed in early 2003, and will be a public document.

Every volunteer will receive a T-shirt as a token of my appreciation for your efforts.

Thanks again to all of you. Without your help, this research would not be possible.

Sincerely,

Julie Price Henderson
M.N.R.M. Candidate

1. The following items are tools that will be required to participate in the study. All of these items will be provided and it will be your responsibility to look after them in the appropriate manner.

- thermometer (attached to site)
- aspirator
- mosquito cage (two per person)
- landing-biting forms (twelve per person)
- headnet
- name tag
- stopwatch (one per team)
- pen

2. The following is the attire to be worn while taking measurements

- name tag
- headnet
- hat (to hold headnet in place and reduce insect irritation)
- long pants (loose fitting – a thicker fabric is optimal)
- long sleeved shirt
- gloves (if the gloves are impeding data collection, they do not have to be worn)
- all clothes should be fairly loose fitting so that mosquitoes cannot bite through them.
- IMPORTANT – you must not be wearing bug repellents! If at all possible, do not wear perfumes or heavily scented deodorants. These scents may have the capacity to deter or attract mosquitoes. If you wear scents during the day, please attempt to shower prior to data collection.

3. Duties outline

I require that you and your partner visit the assigned test sites and take measurements five times during the test period. The measurements must be taken in the evening. Please arrive at the site between the times of 7:00pm – 8:30pm.

Time period is from _____ to _____

Tests sites are located at _____

4. Steps for taking measurements

1. Check that you are dressed properly, and that you have all of the necessary equipment. Proceed to the first test site with your partner.
2. Once at the site, use the information sheets provided to record temperature and time of arrival. Describe cloud cover, wind conditions, precipitation (if any) and any other notable conditions.
3. Position yourselves close to the red flagging tape on the test site and decide who will go first.
4. The test partner and the observing partner must hold still for three minutes prior to beginning the test. **THIS IS IMPORTANT.** Mosquitoes are attracted to movement, if you begin the test immediately, you could obtain higher than normal counts. Sit still in the chairs provided at the test site.
5. Once you have been still for three minutes, the **FIVE-MINUTE** landing-biting test can begin.
6. To begin, pull up the sleeve on your forearm to the elbow. Of you are right handed, it will probably be easier to use your left arm. Use the stopwatch to time the test.
7. Remain as still as possible during the test. The observing partner should assist the test partner in catching and caging mosquitoes.
8. As mosquitoes land and attempt to feed on the exposed arm and hand, suck them into the aspirator and transfer them to the cage. USE AS LITTLE MOTION AS POSSIBLE.
9. As you do this, **COUNT** the number of mosquitoes that you are sucking up. A number of mosquitoes may escape before you can aspirate them, include these mosquitoes in the count. Counting out loud with your partner will ensure an accurate measurement is taken. The observing partner will record the count as it is taken. Ignore all mosquitoes that are not attempting to feed on your forearm. Don't go chasing after them with the aspirator if they are buzzing around you – no matter how tempting it is!

NOTE – *If the mosquito pressure on the test site is severe, you may conclude the test before the five minutes is up. Thirty mosquitoes in two minutes is considered to be severe pressure. Record the number of mosquitoes and the length of the test.*

10. At the end of five minutes, stop, and tabulate the number of mosquitoes that landed on your forearm.
11. Record the time interval that you were testing (eg. 8:04-8:09pm)

12. Now it is your partners turn. As long as you have been relatively still during the test, there should be no reason to repeat the three minutes of immobility. Your partner may begin the next five-minute landing-biting test period.
13. The mosquito cages may be emptied following the completion of each evenings testing.

EACH person will conduct the test **TWICE** per site per evening. As noted, there are two sites involved in this test. By the end of each evening, you will have conducted a total of six tests. At the end of your volunteer service, a total of twenty tests will have been conducted.

Keep all of your information sheets together until you have completed all five trips to the site. Following the completion of all testing, I will gather up the volunteer packages and information sheets.

Biting Test Information and Consent

Julie Henderson
Natural Resources Institute
303-70 Dysart Road
Winnipeg, Manitoba R3T 2N2

June, 2002

Dear Sir/Madame,

My name is Julie Henderson and I am a graduate student at the Natural Resources Institute at the University of Manitoba. I am currently working on a thesis research project as part of the Master of Natural Resources Management degree requirements.

I am conducting research into integrated, community-based, non-chemical mosquito control options in urban areas within the city of Winnipeg, Manitoba. Pest control is a continuously evolving field. New products that manufacturers claim to be more effective and environmentally sensitive than previous products are often made available to pest control managers. The majority of Winnipeg citizens would like to see mosquito populations controlled during the summer months. Additionally, given the choice between equally effective products, most citizens would likely prefer non-chemical or environmentally sensitive mosquito control products to chemical or less environmentally sensitive mosquito control products. This study specifically studies the effectiveness of environmentally sensitive mosquito control products in an urban environment. Winnipeg has a history of public opposition to chemical mosquito control. It is thought that by ascertaining the effectiveness of environmentally sensitive mosquito control products and increasing the knowledge and understanding of the values and attitudes held by the public regarding mosquitoes and their control, a more effective and publicly acceptable mosquito abatement system may arise.

This research depends on the participation of a number of volunteers. Thus, I would like to request your participation in measuring the effectiveness of a number of alternative mosquito control products that are non-chemical. Your participation will include counting the number of mosquitoes that attempt to feed during a short window of time. All participant identities and any written comments will be kept strictly confidential, and

you may discontinue the test at any time. Any information that you provide, and which may be used in this study, will be kept anonymous. Your mailing address is required if you wish to receive a summary of the findings of this study.

The ethics committee at the University of Manitoba has approved this research project. Any questions or problems in this regard can be directed to M. Bowman at (204) 474-7122. The project is funded by the Manitoba Provincial Sustainable Development Fund and is being conducted under the supervision of Dr. John Sinclair of the Natural Resources Institute, University of Manitoba.

Thank you very much for your time, and I hope that you will be able to participate in this study. If you have any questions or concerns regarding this study, please feel free to contact John Sinclair at (204) 474-8574.

Sincerely,

Julie Henderson
Natural Resources Institute
University of Manitoba

Mosquito Landing Count Form

Your Name _____ Partner's Name _____

Day/Month/Year _____ Test Location _____

Time of arrival at test location ____ Temperature _____ °C

Wind Speed _____

Cloud Cover _____

Test #1 Start Time (_____) Stop Time (_____)

Number of mosquitoes that landed _____

Test #2 Start Time (_____) Stop Time (_____)

Number of mosquitoes that landed _____

Additional Comments: _____

_____

_____

_____

Pamphlet

1. A '*Fight the Bite*' mosquito pamphlet was deposited in your mailbox recently. Do you, or does anyone in your household recall receiving the pamphlet?

2a. If the pamphlet was received, did you or anyone in your household read the pamphlet? If yes, how closely did you read the pamphlet? [all, most, skimmed, read more than once, etc.]

2b. If no, would you be interested in reading the pamphlet and participating in the interview?

3. This pamphlet is part of the City of Winnipeg Insect Control Branch's public education program. Have you ever seen this pamphlet before that you can recall?

4. Can you recall any of the specific information contained within the pamphlet? And of the information that you can recall, What do you consider to be the most important?

5. Have you taken any actions on your property as described in the pamphlet to decrease mosquito populations? If so which actions?

6. What did you do with the pamphlet you received? (throw out, read and throw out, keep for reference, post on fridge)

7. Do you feel the pamphlet could have been improved upon? If so how? Was there anything that you expected to be included in the pamphlet that was not?

Insect Control

8. How much money have you spent or would you be willing to spend for mosquito control on your property or person? [$5-50 on bug spray, $60-150 on products to be applied to personal yards, ~$200 on a tent gazebo, $1500 on Mosquito Magnet-type machines, $2-3,000 on a permanent Gazebo]

9. If there were a product that was guaranteed to work, how much would you pay for that product?

10. Are you aware of the existence of the City of Winnipeg mosquito control program?

11. Are you aware of the methods used by the City of Winnipeg to control mosquitoes?
12. How would you describe the job that the City of Winnipeg Insect Control Branch is doing regarding mosquito control? Give specific reasons for your answers.
13. How would you describe the job that the City of Winnipeg Insect Control Branch is doing regarding public education on mosquitoes? (reduction of/protection from/West Nile Virus) Give specific reasons for your answers.
14. How do you feel about the approach that the City of Winnipeg Insect Control Branch takes to kill adult mosquitoes?
15. Following the identification of birds infected with WNV in Winnipeg, the Provincial Minister of Health announced that adulticiding (spraying for adult mosquitoes) would be conducted in the entire city. What are your thoughts about responsibility of the government to ensure public health, and the ability of citizens to restrict the application of chemicals on their private property?
16. Should the de-listing program continue to exist? Should there be changes to the program?

West Nile

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17. Have you heard about West Nile virus (WNv)?
18. Do you have any concerns about contracting this virus? (or any other mosquito-borne viruses?)
19. So far, what has been your main source of information on WNv?
20. Have you asked your doctor about WNv?
21. Would you like more information regarding WNv?

Receiving Information

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22. Would you like to receive more mosquito-related information in your mailbox in pamphlet format similar to the '*Fight the Bite*' pamphlet?

23. In what other ways would you like to receive information? (schools – radio – TV – video – etc).

24. Would you like this kind of information to be available at public locations such as shopping centres, parks, local stores, etc.?

Final

25. Are there any further questions or comments you have regarding mosquitoes, or regarding this interview?

Personal Protection

Personal protection reduces the discomfort caused by adult mosquitoes. The following suggestions will help reduce your exposure to mosquitoes:

Ensure all doors and windows fit properly and are equipped with tight fitting, fine mesh screen.

Wear light coloured, loose fitting, long sleeved shirts and long pants.

Avoid outdoor activity where mosquitoes can be found; mosquitoes are most active near sunrise and sunset and prefer tall, moist vegetation in sheltered areas and calm, cloudy, or humid days.

Use insect repellent on ankles, wrists, neck and ears, avoiding areas around eyes, nose and mouth. Do not use on scrapes or cuts and on infants or pets.

Equip baby carriages and strollers with fine mesh netting to protect infants.

Mosquitoes carry dog heartworm disease which can be fatal to your pet. See your veterinarian for advice on preventing or treating this disease.

Backyard Inspection

By using this handy inspection form you can help eliminate areas in your backyard which contribute to mosquito breeding.

Backyard Mosquito Breeding Inspection Form

- ☐ Eavestroughs free of debris
- ☐ Bird baths flushed
- ☐ Pet water dishes flushed
- ☐ Potted plant saucers flushed
- ☐ Rain barrels covered with tight screens
- ☐ Large containers emptied
- ☐ Tires stored indoors
- ☐ Canoes and boats properly stored
- ☐ Pools chlorinated
- ☐ Outdoor faucets in good repair
- ☐ Low lying areas filled in
- ☐ Grass cut

If you are unsure of how to deal with standing water in your backyard, call the Bugline at 986-3210 for further information or visit our website at www.bugline.com

The Insect Control Branch

encourages you to...

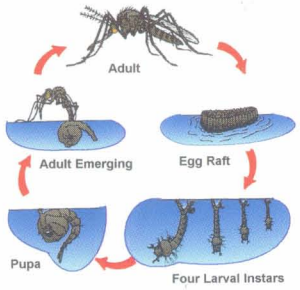
Mosquito Control for the Homeowner

City of Winnipeg
Community Services Department
Insect Control Branch

In the spring, Winnipeg traditionally receives large quantities of precipitation which revives the city from its dormant state. Unfortunately, this and subsequent summer rains, result in large amounts of standing water - setting the stage for a mosquito infestation.

In Winnipeg, there are 38 different types of mosquitoes, and each has a particular biology and behavior. However, there are certain similarities among mosquitoes.

The mosquito has four distint life stages: egg, larva, pupa and adult.



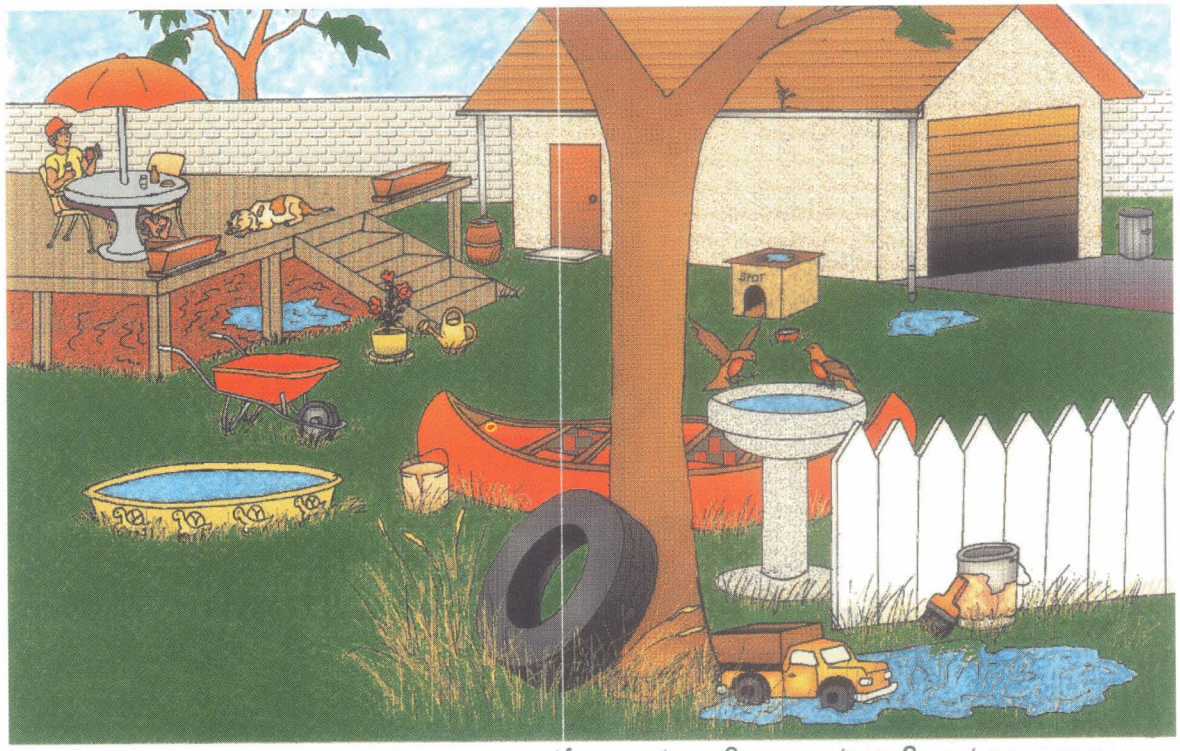
Only the female adult mosquito bites. It requires protein from blood to produce eggs. A female can produce up to 250 eggs from one blood meal. All females lay eggs in or around water.

After being flooded, the eggs hatch into larvae or wrigglers. The larvae grow to a quarter of an inch in length in 4 to 10 days, depending upon the water temperature in which they live.

The larva then changes into a pupa. This stage lasts only about 2 days. During this time, the mosquito changes into an adult.

The adult emerges at the water surface. Adult females can live up to 4 weeks while the males live only long enough to mate with the females, usually up to two weeks.

locations where mosquitoes can develop?



Answers: Low lying areas under deck, by garage and tree, wading pool, canoe, paint can, tire, toy truck, flower planters, flower pot, rain barrel, eavestrough, dog house roof, tall grass, watering can, ashtray, and drink can.

Backyard Mosquito Control

- Remove or empty small water containers
- Cover or empty large water containers
- Change pet water regularly
- Flush bird baths
- Flush potted plant saucers
- Cover rain barrels with tight fitting screens
- Store tires indoors
- Keep eavestroughs free of debris
- Turn canoes over and cover boats
- Chlorinate pools
- Repair leaky outdoor faucets
- Fill in low lying areas where water accumulates
- Cut tall grass and weeds which harbour adult mosquitoes

September, 2002

Dear Sir/Madame,

My name is Julie Henderson and I am a graduate student at the Natural Resources Institute at the University of Manitoba. I am currently working on a thesis research project as part of the Master of Natural Resources Management degree requirements.

I am conducting research into integrated, community-based, mosquito control in urban areas, with a specific focus on Winnipeg. Much of this research depends on the input from local citizens of Winnipeg. Thus, I would like to request your participation in an interview. The purpose of the interview is to gain some feedback on the City of Winnipeg 'Fight the Bite' pamphlet, your knowledge of the City of Winnipeg mosquito abatement program, and your thoughts and feelings on many mosquito issues.

Please feel free to take as much time as you need to answer the questions. As well, all answers will be kept strictly confidential and you may discontinue the interview at any time. Any information that you provide, and which may be used in this study, will be kept anonymous. Your mailing address is required if you wish to receive a summary of the findings of this study.

The ethics committee at the University of Manitoba has approved this research project. Any questions or problems in this regard can be directed to M. Bowman at (204) xxx-xxxx. The project is funded by the Manitoba Provincial Sustainable Development Fund and is being conducted under the supervision of Dr. John Sinclair of the Natural Resources Institute, University of Manitoba.

Thank you very much for your time, and I hope that you will be able to participate in this study. If you have any questions or concerns regarding this study, please feel free to contact either myself (xxx-xxxx), or Dr. John Sinclair at (204) xxx-xxxx.

Sincerely,

Julie Henderson
Natural Resources Institute
University of Manitoba

January 8, 2003

Dear Teacher,

My name is Julie Price Henderson, and I am a graduate student at the University of Manitoba, at the Natural Resources Institute. Part of my research relies on the help of middle years teachers, preferably from Wolseley area schools.

My thesis project is focused on mosquitoes and mosquito control issues in urban areas. There are three components to the thesis including, testing environmentally sensitive mosquito control products, interviewing Winnipeg residents regarding a host of mosquito issues, and finally, *creating an annotated bibliography of mosquito educational tools that could be used by teachers who are interested in incorporating mosquito education into their curriculum.*

The end goal of the project is to help teachers, specifically by creating an annotated bibliography that would be available to all teachers in Manitoba. The bibliography will include a list of all of the educational tools I could locate, and information on these items. Details that will be included are cost, availability, and the effectiveness and applicability in aiding the teacher in delivering mosquito learning.

In order to assess the effectiveness of each of these items, I require teachers to review the products, and possibly try them with students. If you are interested in participating the commitment level is flexible, with a minimum of providing a few written lines of feedback on each products. The tools are yours to keep, and use as needed, in appreciation of your participation.

I would love to speak with you if you are interested in participating in this project. I would be happy to discuss the items that I have available and drop of at the school those that are of interest.

Thank you very much for your time, and I look forward to speaking with you.

Sincerely,

Julie Price Henderson
M.N.R.M. Candidate, Natural Resources Institute
University of Manitoba

January 29, 2003

Guiding Questions for Teacher Educational Tools Review

Dear Teacher,

Thank you for your participation in this project, I greatly appreciate the time and effort that you have contributed!

As you know, the final product from this project will be an annotated bibliography of mosquito educational tools, meant to be helpful to teachers interested in incorporating mosquito education into their classroom activities. The following list of questions is to be used as a guide to help format your feedback on the mosquito educational products you have been provided with. This list is only a guideline, and you may omit questions or add any other comments, criticisms or suggestions that you feel would be instructive to fellow teachers.

For what age(s) do you think the tool is appropriate?

How would you use the tool in a classroom setting?

What would you say are the strengths of the tool?

Weaknesses of the tool?

How would you describe the tool to other teachers?

For what specific purposes would you recommend the use of this tool?

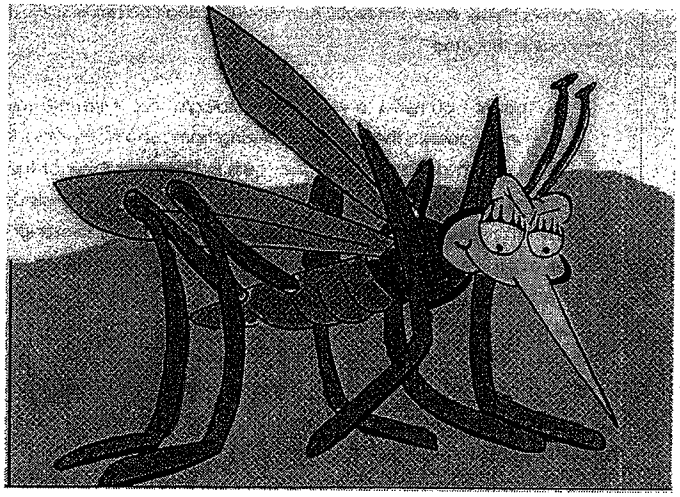
How did your students react to this tool? (if appropriate)

The feedback can be emailed to [redacted] or mailed to 303-70 Dysart Road, Natural Resources Institute, University of Manitoba, Winnipeg, Manitoba, R3T 2N2 (attention: Julie). If you have any questions on this, please do not hesitate to email or call .

Sincerely,

Julie Price Henderson
M.N.R.N. Candidate
Natural Resources Institute

Annotated Bibliography:
Mosquito Educational Tools for Children



Created by Julie Price Henderson, B.Ag.Sc., MNRM

Fall 2003

This annotated bibliography was created by Julie Price Henderson, in partial fulfilment of the requirements for the Degree of Master of Natural Resource Management, University of Manitoba.

With support from the Sustainable Development Innovations Fund (Manitoba), Dr. A.J. Sinclair, Dr. R. Westwood, Dr. T. Galloway, Mr. R. Gadawski, and the Honourable Jean Friesen.

> Today's students are tomorrow's decision-makers. Environmental education today must be a priority if we care about the future of our world. – *John Chasty, from The Green School, 1991.*

Q: What's the difference between a fly and a mosquito?

A: A mosquito can fly, but a fly can't mosquito!

For additional copies of this document, contact Dr. A.J. Sinclair (phone) 204-474-8374 (email) jsincla@Ms.Umanitoba.ca or (post) Natural Resources Institute, University of Manitoba, 303-70 Dysart Road, Winnipeg, Manitoba, R3T 2N2

Natural Resources Institute
University of Manitoba
Winnipeg, Manitoba

Contents

Introduction

Controlling mosquitoes and reducing the incidence of mosquito-borne disease is a multi-faceted endeavour. Formal education with school children has been identified as an important component of mosquito control activities (Nasci and Herrington, 1997; Nammany, 2003). Education on mosquito issues can improve a local mosquito situation in three ways. Firstly, physical environmental change will occur as people reduce mosquito-breeding habitat on private property. Secondly, public perception of the situation will be improved with increased understanding and awareness of the issues involved with mosquito control. And finally, improved understanding will allow people to take the necessary steps to protect themselves against mosquito-borne diseases (Nasci and Herrington, 1997).

This annotated bibliography was created primarily for middle years elementary teachers, and is aimed at children in kindergarten to grade six. The purpose of this document is to aid educators who are interested in incorporating education on mosquitoes into their classroom activities. This annotated bibliography includes books, games, curricula, websites, and other items that can be used in a classroom setting for the purpose of mosquito education. Many of the items were distributed to Winnipeg educators and parents for review and comment. Teachers were encouraged to use the items with their classes as they saw fit. Reviews from other relevant sources were also collected. The feedback is intended to enable teachers to make educated decisions regarding which tools are appropriate for their specific educational goals.

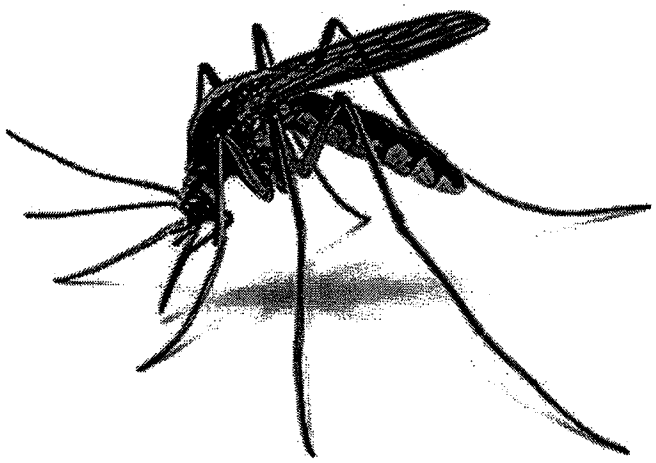
By conducting formal, holistic, mosquito education in schools, the next generation of decision-makers will be educated, motivated, and able to participate more effectively in finding solutions to mosquito problems.

Mosquitoes
By Bryan Paradise (Grade 6)

Mosquitoes, Mosquitoes are a pain in the neck
They bite so hard that it hurts like heck.
Mosquitoes, mosquitoes, they are mean, nasty pests.
They go in the water and use it as a nest.
Mosquitoes, mosquitoes carry Yellow Fever,
Just imagine how sick it could make a beaver.

Mean Mosquitoes
By Georgia Akehurst (Grade 6)

Annoying mosquitoes are
Nasty bugs that
Buzz around my head
And bite me really hard
Leaving itchy welts.
I hate Mosquitoes!



A) Games

A1) Know Mosquitoes (Board Game)

Created by the American Mosquito Control Association and Jim McNelly, 1999. The Environmental Protection Agency contributed a grant for the initial printing of 3,000 games that were distributed free to agencies that placed orders. A number of municipal mosquito control organizations distribute the game free to schools and other interested parties.

> *"This game exists because teachers across the United States approached mosquito control districts in an effort to obtain information about mosquito biology and ecology for their students. The American Mosquito Control Association, Inc. recognized that tomorrow's citizens, scientists, and teachers are today's children. Once taught to appreciate and understand the relationship that often exists between humans and mosquitoes, a child has the potential to reduce the impact of mosquitoes to their families and pets, their neighbours and community – for a lifetime!"* - Know Mosquitoes, 1999.

This game is Monopoly-style game that incorporates knowledge of mosquito biology and control. It consists of 2 dice, 12 game pieces, 140 'Question and Answer' cards, and 32 Life Cycle cards. As players answer questions correctly they move their game piece and attempt another question. An extensive glossary of terms with definitions is included.

Orders for the game can be placed with the AMCA central office by email at amca@mosquitol.org by telephone at (732) 544-4645 or fax (732) 542-3267. Pricing Structure (USD): 1-20 games $24/game+$6 S/H (unit discounts on larger orders)

Reviews

Primary Researcher (PR) - Students have to have some knowledge of mosquito biology to play effectively. Children could play in small teams, or class could play as two teams. Playing the game could be a fun finale to a mosquito unit. The game would allow for recall and reinforcement of previously learned materials.

Teacher #1 (T1) – The game Know Mosquitoes is great! The kids are finishing their work so they can play. They seem to do well with the multiple choice and true/false format. We limit the turns for correct answers, or they would play the whole board.

Teacher #2 (T2) – The game is a good finale to the section, to play after the kids have learned about things. Would like more Canadian content in it. Good group activity to end things off.

Parent – The game is quite good, but probably requires study on mosquito biology and issues prior to playing. A competitive game rather than a co-operative game. Players could work in teams as well to promote co-operation.

B) Curricula

B1) Aquatic Habitats, Exploring Desktop Ponds.

Katherine Barrett and Caroline Willard 1998. GEMS Publications, University of California, Berkley. 136 pp. Grades 2-6. $16.00 USD available at http://lhsgems.org/GEMaquatic.html

> *"Creating and expanding their own little aquatic worlds over a period of weeks, student groups learn to observe, record, predict and draw inferences; these are the mainstreams in Aquatic Habitats. ...desktop model ponds develop and change over time, allowing students to discover firsthand some of the complex interactions within a typical pond ecosystem."* GEMS Publications

Reviews

Science Books and Films – In addition to the basic activities, recommendations for extensions and a field trip to a pond are included. There is sufficient material here for teachers to involve children in four to six weeks of an ongoing inquiry. The book includes comprehensive, clearly stated directions, a list of all required materials, a list of suppliers, and suggestions for substitute materials. The writers also provide teachers with background information, questions to guide the children's inquiries, and an annotated list of related curriculum materials and books for children to read. This is an excellent instructional resource, and I recommend it highly.

B2) Australia's Global Education Program (Mission Mosquito).

Mission Mosquito is a middle primary school case study available on the web at www.globaleducation.edna.edu.au/archives/primary/casestud/mozzies.html The site is

free and supported by the Australian government, and the Mission Mosquito case study is part of a larger teaching project focussed on global social and environmental issues.

> "*The Global Education website is an education resource for students and teachers. It contains information on a wide diversity of global issues, including development economics, governance, HIV/AIDS, human rights, health, refugees, women, the environment, food security, and agriculture. The Global Education program provides teachers and students with the chance to investigate these issues on a local, regional and global scale. Each case study is written by a professional curriculum writer and targeted to Australian state and national curriculum. All case studies are reviewed prior to being published and ensure they are of high educational quality... The material shows positive approaches to the challenges and opportunities that the global environment presents.*" – Global Education home page.

The Mission Mosquito case study highlights malaria health issues in the pacific region. It illustrates the vulnerability of people in Pacific areas to mosquito-borne pathogens. The case study includes five sections titled 'Martina's Story', Fact File: Vector borne diseases in the Pacific, How is the Australian Government working with our Pacific neighbours to control these problems?, Teacher's notes, and Student activities. The project features four student objectives including; explain the need for access to and use of appropriate resources, describe similarities and differences between conditions, illustrate linkages between causes and effects, develop concern for the welfare of people in all societies.

Reviews

PR- This case study provides a perspective that most of the other educational tools do not address as it focuses on health issues in a developing region. It reviews mosquito pathogens, prevention methods, and encourages fun and interactive learning activities. This site would be an excellent follow-up to mosquito study that was local or regional in focus. Any teacher interested in including a global perspective in class study should view this page.

B3) Mosquitoes: A Resource Book for the Classroom (Elementary Science Study). Publisher: McGraw-Hill Education-Europe. Copyright, 1971. 26 pp. Out of print. – Difficult to obtain. Listed on www.amazon.com but not available when last reviewed.

B4) Mosquitoes in the Classroom: Insecta Horridia.

Author: Dr. Frances J. Spray. Teacher resource guide and classroom curriculum of the Teacher Enhancement Program in Biology, University of Wisconsin-Madison. Though frequently referenced as an excellent guide for middle years mosquito education, the book is out of print, and difficult to obtain.

This is a complete curriculum, for middle years students. It aids teachers in demonstrating how something as unlikely as a mosquito can be used to teach a variety of subjects, from basic science and health to music, art, math, geography, and much more. Dr. Spray was the recipient of the Creative and Innovative Program Award for the Most Outstanding Credit Program (2000) for her course 'Mosquitoes in the Classroom: Lifestyles of the Itch and Infamous', adapted from the above text.

> *"I was very excited to move from research to teaching. While working in the lab was interesting and educational, I found I was constantly struggling with the extremely focused projects that I was working on. So, I left the lab to begin my outreach career and believe me, walking into a room of 3rd graders for the first time was quite daunting. I begin my class presentations with making sure that everyone knows what a relevant question is."*- Dr. Frances J. Spray

Reviews

Stacy Enslen: K-12 Teachers Jump-Start Page – This book is an invaluable resource for any teacher that would like to develop an insect unit and include mosquitoes. It covers basic biology, ecology, lifecycle of mosquitoes, their effects on health and history. It even covers mosquitoes in art, language and literature. I highly recommend this book.

B5) Neato Mosquito (American paper curriculum guide)

Created by R. Nasci and J. Herrington, Division of Vector-Borne Infectious Diseases, National Centre for Infectious Diseases, Centre for Disease Control (USA). Developed for grade four, it can be downloaded at www.cdc.gov/ncidod/dvbid/arbor/neato.htm (free).

Reviews

T1 – the curriculum is very dry to use. I would not likely use it at all. Also, it is very 'American' in focus. Too much work to read the fine print and assemble lessons. I also think it's more advanced than grade 4, might even be Junior high level.

PR- There is a great deal of scientific vocabulary, mosquito ecology and information on how to reduce mosquito populations in the guide, and it would likely provide a good backbone to mosquito study in class. The American focus detracts from the good information contained within the curriculum. St. Louis Encephalitis, the main mosquito-borne disease discussed, is not currently present in Canada. The Canadian version (B6) would be more suitable to Canadian classes.

B6) Neato Mosquito (Canadian paper curriculum guide)

Adapted from the above Centres for Disease Control guide by the Calgary Health Region in 2003. This Canadian version of the Neato Mosquito guide can be downloaded (pdf, free) at www.westnilevirusalberta.ca/media/pdfs/neatomosquito/pdf.

This curriculum has been 'revised from the original version to make it more generally applicable for use in areas of Canada that are dealing with West Nile virus.' The curriculum is virtually identical to B6, except for West Nile virus replacing St. Louis Encephalitis discussions. The Calgary Health Region provides support materials (slides, math games, and videos), and can be accessed through the web page at www.calgaryhealthregion.ca.

> *"While the risk of becoming ill due to West Nile virus remains low, experts agree that public education will play a vital role in preventing individuals from contracting disease. Several environmental and behavioural risk factors associated with WNv infection have been identified. Reducing WNv risk primarily involves taking actions to reduce contact between individuals and mosquitoes. The most important risk reduction actions are removing mosquito habitats from around the home and using personal protection measures when working or playing outdoors during the summer months.*
>
> *One of the most effective ways to communicate a public health message is through children, by presenting information logically and in an interesting fashion in school. Not only is the information incorporated into the experience of the student, but the message is often carried home to the parents. This is our goal in adapting the CDC's Neato Mosquito educational program."* –Calgary Health Region.

Reviews

PR – This is an improvement over the original for Canadian educators. WNv in place of SLE information makes the package more relevant to educators whose interest in mosquito education was spurred by the arrival of WNv to Canada. The package still has a very scientific base to it, plunging into sophisticated vocabulary like 'transmission cycles' and the scientific names for some mosquito species such as *Culex tarsalis*. Incorporating the class activity at the end of the booklet will increase the 'fun' factor of the booklet, as well as using the fun mosquito facts located at the back of the book.

B7) ***Neato Mosquito – CD ROM*** by Centre for Disease Control(CDC) (USA).

This is the CD ROM version of the classroom curricula, and in the public domain and may be reproduced in whole or part without permission. It is possible to download the CD ROM at www.cdc.gov/ncidod/dvbid/arbor/neato.htm but the large file (~137MB) may be a deterrent to some. The program is $12 USD per CD, $32 for packages of five copies, or discounts on 100 or more copies. They can be ordered though the Public Health Foundation Training Resource Centre (Vector-borne Infectious Diseases) at www.bookstore.pdf.org/prod127.htm

Compatible with **Microsoft windows**, minimum requirements as follows:

Pentium 100 MHz or better, Windows 95/NT
16 MB RAM or more, 16-bit colour or better
4xCD-ROM drive or better, QuickTime 3.0, QuickTime 4.0 (included)
Sound card

Compatible with **Macintosh**, minimum requirements as follows:

Power PC 75 MHz or better, System 7.5 or later
16 MB RAM or more, 16-bit colour or better
4xCD ROM drive or better, QuickTime 3.0, QuickTime 4.0 (included)

Lesson One - Lifecycle, mosquito species, background on mosquitoes (origin of the name, etc).

Lesson Two - Mosquito nutrition, how female mouthparts take blood, who they like to take blood from, etc.

Lesson Three - Mosquitoes as part of the foodchain, as flower pollinators (the good) and introduces the idea of disease transmission (the bad).

Lesson Four – Review of encephalitis in the USA (EEE, WEE, St. Louis Encephalitis, and LaCrosse Encephalitis). Introduces the idea of cleaning up you yard to start mosquito control at home.

Lesson Five - Emphasises cleaning up containers and standing water in the yard. Class activity is the focus. Children go home and check the yard for mosquito breeding sites. Risk factors for contracting mosquito-borne viruses are reviewed.

Games - Each section ends with a game. "Find the Blood", "Habitat Zap", and others reinforce the main points of each of the lessons.

Teacher Section - includes slides, useful for discussing lifecycle and other aspects. It includes mosquito sketches. A 10-minute video, *The Lifecycle of* Aedes triseriatus *(the treehole mosquito),* displays the emergence of a mosquito, pupal and adult stage, and shows various human-made places where mosquitoes can breed.

Reviews

PR – The CD is hosted by two very 'cheeky' cartoon mosquitoes (Neato and Neata), incorporating humour children will appreciate. This is a great tool and would be very helpful in a mosquito unit. Use the lesson as a portion of each class to help guide the discussion. Access to computers would be an important component to being able to use this tool effectively.

Parent – Neato Mosquito is excellent, especially for the life cycle aspects. It needs to be used in small groups because of limited viewing on a computer monitor

T2 – CD is very well done and would make a great center to mosquito study.

B8) Using Insects in the Classroom: A Teachers Guide to Six-legged Science. The University of Kentucky developed the curricula. The entire curriculum is available on-line at www.uky.edu/agriculture/entomology/ythfacts/4h/teacher1.htm The guide is not specific to mosquitoes, but includes mosquito information.

"Insects are an excellent source for scientific study. Many insects can be inexpensively and easily maintained in classrooms, and can survive despite being handled in captivity. The remarkable diversity in form and function of commonly-found insects promote interest and enthusiasm in observing the natural work. Insects can model scientific principles, or simply be used for enjoyment.

The objectives of this publication are to give educators basic information about insects, tips on maintaining insects in the classroom, and several classroom activities including demonstrations, experiments and crafts which will help students understand the importance and diversity of the insect world.

Outcomes to expect:

1) *Science is fun!*
2) *Biology makes sense!*
3) *Discovery and organizational skills are inseparable!"*

–Introduction, *Using Insects in the Classroom: A Teacher's Guide to Six-legged Science.*

Reviews

PR - This web site provides background information to beginners learning about insects and collecting insects. Information on methods of insect collection (net types, jar types, etc.), rearing insects, secrets for insect success, insect diversification: how and why, and many experiments and activities that could be conducted in class. The curriculum includes an excellent general insect booklist for further reading and information on learning about insects. This resource would be the perfect place for an educator to start when introducing the larger topic of insects.

B9) Vector Inspector Booklet: The Case of the Most Dangerous Insect on Earth!

Assembled and used by the Greater Los Angeles Vector Control District (kids version and teacher copy).

The Greater Los Angeles Vector Control District is located at:
12545 Florence Ave.
Santa Fe Springs, Ca 90670
(562) 944-9656 (phone)
(562) 944-7976 (fax)

'Vector Inspector' is distributed to Elementary School Teachers within the boundaries of the district. Employees of the GLAVCD have granted me permission to reproduce and distribute the booklet, provided that they are recognized for creating it. The GLAVCD is

willing to share their booklet with other interested educators. And should be contacted by phone to request a copy of the student and teacher workbooks.

The booklet features both cartoon and realistic illustrations, and starts with explaining the definition of a vector and progresses through mosquito biology. Crosswords incorporating newly learned words, mosquito facts, life cycle, biological control and other control methods, and tools used in general mosquito control are provided. The booklet includes three glossaries of terms, and pictures for children to examine and identify mosquito-breeding habitat.

Reviews

T1 – The Vector Inspector guide is great! I have made a class set and we are reading through it. The print is large, which is good for technical information, and the diagrams are just right, not too detailed but informative. I'll probably use it in future years.

T2 – This is a nice workbook full of good information for the kids. I would eliminate the colouring sheets or add a suggestion that teachers not use the colour sheets, kids are very capable of making their own! Other than that, this booklet is a nice concise tool to use in the classroom.

PR – The student work booklet is written in a 'case study' fashion, is hosted by a Vector Inspector from the GLAVCD. The booklet is a great start-to-finish approach to educating kids on the basics of mosquito control in North America, and provides an excellent work-book format that none of the other tools offer. The booklet would be improved if it included more Canadian content, a discussion of global mosquito scenarios, and environmental implications of mosquito control. However, the current format would still be very useful in the classroom.

B10) Why Mosquitoes Buzz in People's Ears: Unit Guide for Grade 3. Publisher: Kendall/Hurt Publishing Company. Copyright, 1992. Available through Amazon, listed at $36.99 (USD) per copy.

No further information is currently available on this educational tool.

C) Books (Children's)

C1) A Mosquito in the Cabin. (Poetry)

Editors: Richard Brown, Kate Ruttle, Publisher: Cambridge University Press. 32 pp. Copyright 1996. Available through online booksellers.

This book is a collection of poems about the insect world. It does not contain scientific educational material about mosquitoes, but rather twenty-one poems on insects and arthropods. The book ends with 'Hurt No Living Thing', which sums up the intent of the book – to help children appreciate the beauty of small creatures and the roles they play on the earth.

Reviews

PR - This book could balance the 'science' side of learning about mosquitoes, and would probably be best for grades 1-3. It is a handy tool for educators who want to impart ecological respect, creative thinking, and a general understanding of insects. Personally I love these poems, and prefaced my thesis with 'A Mosquito in the Cabin' (the poem).

C2) Flies: From Flower Flies to Mosquitoes.

Author: Sara Swan Miller, Publisher: Franklin Watts – A Division of Grolier Publishing, USA. 48 pp, Copyright 1998. Available through online booksellers, $6.95 USD.

An introduction to flies (*diptera*, meaning two wings), the taxonomic order of insects that includes descriptions of fourteen species and recommendations for finding, identifying, and observing them. This book touches only briefly on mosquitoes, but includes good information on other diptera species. An interesting section on 'How to be a fly watcher' is included at the back, along with a list of 'words to know'.

> *Sara Swan Miller is an outdoor environmental educator at the Mohonk Preserve in New Paltz, New York. She is the director of the preserve program and has directed hundreds of children on field trips and taught them the importance of appreciating and respecting the natural world, especially its less loveable 'creepy crawlies'.* – Flies: From Flower Flies to Mosquitoes

Reviews

PR - A good book for children learning about mosquitoes for the first time. It would orient student, and provide a basic scientific vocabulary needed for discussion. I think it is a great book, well done and scientific, with excellent photographs, and it gives a good base to discuss flying insects.

Parent – It could be of interest on the theme of insects, but not much on mosquitoes here.

T1 – With so many other good books, I would not bother with this one. (although I did not know that the crane fly was not a mosquito!). This book tipped the gross scale!

T3 – The photographs in this book are outstanding! The 'Order of living things' at the beginning of the book will introduce/reinforce biological classification.

C3) ***"I don't like Mosquitoes".***

Author: Michael Ambrosio. Publisher: Lionx Publishing. Copyright 2003. Ages 9-12. Available through Amazon (www.amazon.com) $12.00 (USD)

Book Description from Amazon

> *Poochiegrass is a cute and lively golden retriever puppy. He loves to frolic in the tall grass and play Frisbee catch with his master. On this particular day he runs into a pesky Minnesota mosquito that thinks Poochiegrass would make a fine meal. When Poochiegrass accidentally smacks the aggressive insect into a tree, the mosquito becomes quite angry, and goes to get friends, lots of them. Time after time the adorable Poochiegrass battles through near misses with the mosquito and his swarm. Using amazing puppy ingenuity and a little help from his friend, will Poochiegrass prevail in the end?*

Review

PR – This book is a fun story but offers little in the way of mosquito education. In fact, if actually perpetrates mis-education as the blood-seeking mosquito that harasses Poochiegrass is a *male* (and only female mosquitoes take blood meals). This book is not recommended for mosquito educational purposes, unless it is to have children identify the incorrect information in the story (a male mosquito would not be harassing Poochiegrass, mosquitoes don't communicate and work together to 'attack prey').

C4) ***Insects are my Life.***

Author Megan McDonald. Publisher: Orchard Books, New York, New York. Copyright, 1995. Available through Amazon (www.amazon.com) for $7.00 (USD). Grades K-3.

This book is about a girl named Amanda who loves bugs. Amanda collects bugs, examines them, imitates them, talks about them and claims that 'insects are my life'. This is a book about being different and having passions, and shows the heroine standing up for herself and her interests. It shows that insects can be interesting and diverse.

Reviews

PR - The book does not offer specific information about mosquitoes, but would be a good book to include in an insect study that focused more on social aspects of dealing with insects and mosquitoes.

School Library Journal – Amanda loves bugs, a fact that no one else seems to appreciate. She examines them, collects them, protects them, and imitates their behaviour. She even gets into trouble at home and at school because of them... It's refreshing to have nonsqueamish females who are willing to take on all adversaries in defence of their causes. Illustrations ...are energetic, engage, and entomologically correct. *Insects Are My Life* is an almost-perfect specimen.

C5) ***Let's Find out about Mosquitoes.***

Author: David Webster. Publisher: Franklin Watts, Inc. Copyright, 1974. 48 pp. Out of print, but used copies may be available through Amazon www.amazon.com.

Includes information about how mosquitoes take blood meals, *anopheles*, *culex*, and *aedes* species, breeding habitat, detailed lifecycle information, natural predators of the mosquito, physical description with scientific terminology for body parts, mosquito-borne disease, and mosquito control techniques.

Reviews

Card catalogue description – introduces the physical characteristics and habits of the mosquito.

PR – Given the publication date, you would think that the information might be dated. However, Webster provides excellent information and *Let's find out about Mosquitoes* surpasses other similar books in depth of description. Webster takes the time to fully discuss physical characteristic and other mosquito issues. Some contradictory information of over-wintering is presented. The book is illustrated (in two colours) and though they are less eye-catching than colourful photos, they accurately display body parts and depict the mosquito in the marsh habitat clearly.

Webster peppered the book with questions that make the reader think and reflect more deeply on the information. Do you know how a mosquito bites? Did you ever think about where all of the mosquitoes come from? Can you guess why you do not shed your skin as your grow? The book ends with, 'Are mosquitoes good or bad?'. Human control of mosquito populations is discussed without 'cheerleading' the endeavour. Webster also takes the rare approach of suggesting that mosquitoes are an important part of the ecosystem, and hints that eradication might not be desirable.

Overall, Webster has penned a mosquito book that is a refreshing read after the short and flashy modern children's texts. It is a shame that American Libraries are removing the book from their shelves.

C6) ***Mosquito (Bug Books).*** Author: Jill Bailey. Publisher: Heineman Library. Copyright, 1998. 32 pp. Children's book (ages 4-8). Available on www.amazon.com for $5.95 (USD).

This book is one of a three-part series, in which ladybugs, snails, and mosquitoes are discussed. This book is available in English or Spanish, and covers mosquito habitat, physical characteristics, and mosquito control and protection measures. Beautiful colour photographs are included to depict and describe the items being discussed. A map of the mosquito body, glossary, additional reading, and index are included.

Reviews

Karey Wehner, San Francisco Public Library – A large, full-colour photograph dominates almost every page, while a short paragraph of large-print text appears either above or beneath it. Organization of material is good. Each two-page section covers a different topic. The books are clearly written and do a good job of presenting basic facts.

PR - The photographs in this book are beautiful, and the page layout is excellent. Overall this book is very visually pleasing and presents the information in an accessible format. This book covers personal protection and mosquito control in more detail that others in its class, discussing bed nets and how people around the world protect themselves from bites. It is a very well put together beginner book.

C7) ***Mosquito.***

Author: Ron Reese, Publisher: Aro Publishing Co., Utah. 20 pp, copyright 1975. Occasionally available through online booksellers. Out of print.

This book is written for very young children. There are only a few words per page, accompanied by an illustration. This is not a science text, but a short story of a mosquito buzzing while a child tries to sleep. Includes a list of 'my new multi-syllabic words'.

Reviews

PR – This book would not have application to teaching about mosquitoes unless it was perhaps to a nursery or kindergarten class, and was perhaps accompanied by a discussion about mosquitoes.

C8) ***Mosquito.***

Authors: Jennifer Coldrey, George Bernard, Publisher: originally A&C Black, Copyright 1990. In 1998 by Silver Burdett Press. 25 pp. Available from on-line booksellers.

This book focuses exclusively on the mosquito lifecycle, and shows it in a detailed step-by-step manner using vivid photographs and some drawings. A short pictorial quiz is located at the end of the book, and an index is included.

Reviews

PR- An excellent scientific book for younger grade school children. The text is full of rich photographs to illustrate physical changes during the lifecycle, which is the exclusive focus of the book. This is perhaps my favourite mosquito biology book for grades 3-5 children for teaching about the lifecycle. However this book does not cover personal protection, population control, urban habitats, disease issues or history. Other books would be a better first choice for a more robust offering of information. If biology and lifecycle are the focus, this book is perfect.

Parent – This book ties in very well with the CD ROM (Neato Mosquito), especially for lifecycle. A good quick overall view of mosquito life cycle.

T1 – Amazing pictures. This book really takes the kids through the life cycle in great detail. Good for grades 3-6.

T2 – Great presentation! Pictures and information are done extremely well.

C9) ***Mosquitoes.*** (The New Creepy Crawly Collection)

Author: Enid Broderick Fisher, Publisher: Gareth Stevens Publishing, Milwaukee, Wisconsin. 24 pp, Copyright, 1997. Available from on-line booksellers for $21.26 (USD).

This book is part of an insect series compiled under the 'Creepy Crawly Collection' designed for reading age levels 4-8. It covers habitat, anatomy, some specific species, malaria, mosquito behaviour, mosquito control, and more. The book concludes with a question/answer page of commonly asked mosquito questions. Glossary, book and video references, and an index are also included.

Reviews

Parent – not as attractive to read as the Coldrey book. An overall view with a limited appeal to children.

T1 – This is another fantastic book. I love the page 2 spread (biological description of the insect). I plan on grouping the children and having them read a page and take notes. Then they will teach the rest of the class what they learned. This book has excellent information about the spread of disease. I will recommend the series (The New Creepy Crawly Collection) to the Librarian at our school.

T2 – This is not a horrible source and has some good information. It is written a wee bit condescending to kids.

PR – This book combines educational information and fun. The text is accompanied by illustrations of a somewhat cartoon-y nature. This book is written in a fun, flowing manner of a storybook as opposed to a textbook, yet contains excellent information on mosquito biology, habitat requirements, and more in-depth information on disease transmission than many of the other texts dare to go.

C10) ***Mosquitoes.***

Author: Cheryl Coughlan, Publisher: Pebble Books/Capstone Press, Mankato, Minnesota. 24 pp. Copyright 1999. Available from Amazon www.amazon.com $14.60 (USD)

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Very basic science text contains information about mosquitoes. Further book references, words to know, and internet references for teachers to access are included at the end of the text.

Review

Parent – excellent book for grade 1 children. Easy to read with good visuals.

T1 – good for nursery, Kindergarten, Gr. 1 at the most. The pictures are adorable. They grossed my kids out.

PR - An educational book for very young children (kindergarten or first grade). Excellent colour photographs of mosquitoes on each page. The information given in the book is extremely basic (starting with 'mosquitoes are insects'). This would be an

excellent book for K-1 kids to accompany '*Insects Are My Life*' or '*Why Mosquitoes Buzz in People's Ears*'

C11) ***Mosquitoes (Wild Wild World).***

Author: Liza Jacobs. Publisher: Blackbirch Marketing. 24 pp. Copyright 2003 Ages 9-12. Available through Amazon, $18 new.

This book is part of the 'Wild Wild World' series that includes books devoted to mosquitoes, dragonflies, fiddler crabs, ostriches, and more. No further information is available.

C12) ***Mosquitoes.***

Author: MaryAnn McDonald, Publisher: Child's World, Nature Books. 32 pp. Copyright, 2000. Ages 9-12. Available through Amazon, $25.64 new.

This book is part of a series. It covers basic mosquito biology information and features large colourful pictures. An index, glossary, and web sites are included.

Reviews

PR – The pictures are large and colourful, and very well done. The close-up pictures of mosquitoes are beautiful, and there is a spectacular picture of a dragonfly and mosquito under magnification. The text is written in a descriptive and flowing manner that is easier to read than other similar books. This book mentions reducing standing water, but does not illustrate that idea as well as others. Overall it would be an excellent book to introduce children to mosquitoes.

C13) ***Mosquitoes (Insects).***

Author: Cari Meister. Publisher: Checkerboard Library. 24 pp. Copyright, 2001. Ages 4-8. Available through Amazon, $21.35.

This book is organized into basic ideas about mosquitoes. The mini-chapters are brief discussions of physical structure, growth, diet, habitat, enemies, and relationship to

humankind. Unfamiliar words, highlighted in coloured type, are redefined in the glossary, "fun facts" are appended, and Internet sites for further information are included.

Review

American Library Association – Grades 2-4. Insect series introduce children to the world of insects. Exceptionally nice colour photographs and simple graphics will draw browsers. A nicely designed, well-thought-out series that will give kids basic information.

Children's Literature'—Cari Meister has written a serious of books about insects that are part of the 'Checkerboard Science and Nature Library'. Each book has a table of contents followed by a description of the insect and interesting facts – mosquitoes don't bite, the red bump is an allergic reaction to the mosquito saliva. Body parts are clearly described and identified with full colour pictures and drawings. Targeted for grade three, this book will be of interest to readers in kindergarten to grade five. ***Reviewer: Marilyn Courtot.***

PR – This book provides more detailed mosquito information than other similar offerings. Internal mosquito organs are discussed and diagrammed, many sophisticated words are introduced (exoskeleton, capillary), and an exploration of the history of the mosquito (discussion of the panama canal project) is undertaken. This book is a basic beginner's book for younger grades, but goes beyond what most of the others in this category offer in detail, history, and description. The pictures are smaller, but overall I would choose this book over others because of the greater usage it provides.

C14) ***Mosquitoes (Animal Kingdom).***

Author: Julie Murray. Publisher: Abdo & Daughters. 24 pp. Copyright 2003. Ages 4-8. Available through Amazon (www.amazon.com) for $12.35 (USD).

This book is part of the Animal Kingdom series. The book is an introduction to the habitat, physical characteristics, behaviour, and life cycle of mosquitoes. It introduces mosquitoes as insects capable of transmitting diseases, and explains methods of reducing breeding habitat. The book contains fun facts, a glossary, websites, and an index.

Reviews

PR – Murray does a comprehensive job of introducing clearly the most basic of mosquito information. Photographs, diagrams, and illustrations aide in information presentation. Illustrations are not as eye-catching as photographs in other similar books, and are dry by comparison. This book does not present new information despite its 2003 copyright. While it is a decent book that would be a helpful tool in classroom discussions, it is not as well done as others in this category.

C15) ***Ricky Ricottas Giant Robot vs. the Mutant Mosquitoes from Mercury.***

By Dav Pilkey, Published by Blue Sky Press. Copyright 2000. 128 pages. Available through on-line booksellers, approximately $12 USD per new condition copy.

> *"Wouldn't it be great to have a giant flying robot as your best friend? Ricky Ricotta's Robot gets Ricky to school on time, keeps the neighbourhood bullies away, and even helps Ricky solve his math problems...."* – from the inside cover.

Reviews

PR- This is a fun book, not educational or containing mosquito information. It features a great story, beautiful illustrations, and fun activities at the back, but would not have application where the object was to impart learning on mosquitoes and mosquito issues.

C16) ***The Day They Parachuted Cats on Borneo: A Drama of Ecology.***

Author: Charlotte Pomerantz. Young Scott Books/Addison-Wesley, Reading, Massachusetts. Copyright 1971. 48 pp. Designed for grades 4-7.

This cautionary verse, based on a true story, related how spraying DDT to kill malaria-spreading mosquitoes in Borneo eventually affected the entire food chain. It killed insects, cats, and caused a plague of rats. The ultimate solution was to drop cats by parachute to solve the rat problem.

Reviews

PR - This story illustrates the possible negative consequences of human intervention. The strong, humorous text makes the book a success whether read out loud or performed as a play. The explanation of the food chain makes a nice connection to ecological study.

Amazon review – This book is about the insect pesticide DDT, and what it did to the ecology of Borneo. First they sprayed to get rid of the mosquitoes that carried Malaria. Then the caterpillars and the cockroaches came out. They weren't killed but they were covered with the spray. Then the geckos ate them. But the DDT was poison to them. The cats got the geckos, soon the cats died out and rats came from the forest. The farmers needed to get rid of them so they parachuted cats on Borneo.

C17) ***The Mosquito Book.***

Authors: Scott Anderson, Tony Dierckins, Publisher: Dennoch Press, Duluth, Minnesota. 121 pp. Copyright 1998. Phone Number for ordering – 800-678-7006.

Designed for older children, teens, and adults. Full of fun facts about mosquitoes, with a quiz at the end of the book. Includes bibliography and index.

Reviews

PR - A book designed for older children, teens, and adults. Some of the humour is too mature for young children. Fun facts, good cartoon illustrations, and witticisms about tangential items make this book unique in its approach to mosquito education. It would be a good balance to scientific study books.

Parent – Some good information, but presented with questionable humour (page 5). Also, some misinformation (page 2 refers to daddy long legs as spiders).

T1 – Fun-filled. The kind of thing where I read a page to the kids while they are in line, or as a short time-filler. Grades 6&7, although some younger kids love trivia.

T2 – I really like this book, the content that might be a problem is the reference to sex. You might include a wee attention to teachers and then they can select it if they wish.

C18) ***Why Mosquitoes Buzz in Peoples Ears: A West African Tale.***

Author: Verna Aardema, Publisher: Pied Piper Books, registered trademark of Dial Books for Young Readers, member of Penguin Putnan Inc. 27 pp. Copyright 1975.

Winner of the Caldecott Award, this is written as a fable. It is a story about the importance of honesty, giving explanation to why mosquitoes buzz in peoples ears

Reviews

PR -. Very little technical mosquito education included in this book, but might be a good book to use in concert with other 'soft' mosquito books for very young ages (kindergarten) in the facilitation of a discussion about mosquitoes.

C19) ***Zzzng! Zzzng! Zzzng! A Yoruba Tale.***

By Phillis Gershater, Illustrated by Theresa Smith. Published by Orchard Books, Copyright 1998. 32 pp.

This is a story about the mosquito trying to find someone to 'marry', firstly thinking that 'ear' is the handsomest of all, but then she is rebuffed by her attempts. No biological or scientific information regarding mosquitoes is included.

Reviews

PR – The illustrations in this book are stunning works of art! As with '*Why Mosquitoes Buzz in People's Ears*' this book would be a nice story to read young children and then facilitate a discussion about mosquitoes.

D) Books (young adult/ adult)[1]

D1) *Malaria, West Nile, and other Mosquito-borne Diseases.*

Author: Nancy Day. Publisher: Enslow Publishers Inc. 128pp. Copyright 2001.

This book is part of the 'Diseases and People' series for young adults, and examines the major diseases carried by mosquitoes, including malaria, West Nile virus, Yellow fever, dengue fever, encephalitis, and elephantiasis. It gives a complete picture of these complex diseases, from diagnosis and treatment to the history of their discovery and attempts at eradication. The book uses simple language with definitions when specific terms are mentioned. Chapters are devoted to mosquitoes and disease, mosquitoes-borne disease in history, West Nile, yellow fever, malaria, animals and mosquito-borne disease, prevention, and future implications. A Q&A section, timeline of important mosquitoes and disease events, glossary, 'for more information', chapter notes, further reading, internet addresses, and index are included.

Reviews

PR – This book is a great tool for older children studying the specifics and history of mosquito-borne diseases. The information is presented clearly, with good explanation of scientific terms. The author effectively illustrates the immensity of the impact of mosquito-borne diseases on humans by comparing it to other mortality factors such as natural disasters and wars. Many of the chapter note citations are media sources, which are not as reliable as primary research sources. The further reading and internet address are lacking in depth and relevancy. Overall the book would be very accessible for young people and provide excellent and up-to-date information.

D2) *Mosquito: A Natural History of our most Persistent and Deadly Foe.*

Authors: Micheal D'Antonio & Andrew Spielman. Published by Hyperion, New York. Copyright 2001.

[1] Many dozen books could have been included in this section, this particular book was selected because of its current information and applicability to educators.

This is a book for adults that includes mosquito biology, disease facts, and colourful stories.

Reviews

Dr. R. Westwood – There are some of us who may lament that Winnipeg is sometimes called the mosquito capital of Canada. After reading Mosquito, you many change your mind and realize that our mosquito problems pale in comparison to those faced by millions of people around the globe. Many aspects of mosquito biology are discussed in simple, straightforward terms that allow the layperson to easily grasp the huge impact this tiny insect has had on human history.

PR – I really enjoyed reading this book. The writing style is very accessible, the content understandable to anyone (with or without an entomology background), it provides a holistic picture on the history of the mosquito, and how its fate is often intertwined with humans. Any educator looking to incorporate mosquito education into their curriculum would do well to first read this book to improve their overall understanding of mosquitoes, past and present.

Booklist – Mosquito expert Spielman tells us in this creepily fascinating book, that there are more than 2,500 kinds of those tiny, annoying, and extremely deadly creatures. Spielman and co-author D'Antonio tell us everything we could possibly need to know about the mosquito: its lifecycle, natural enemies and predators, and, of course, its monumental impact on human history. This is truly an unexpected delight, an informative, entertaining, and sometimes skin-crawly book that should appeal to anyone with a taste for popular science.

The Economist – "If you have never read a book on entomology, be sure to start with this one."

D3) ***Pest Web***

www.pestweb.com/education or www.pestweb.com/education/mosqbook/cfm

or www.pestweb.com/generalpestinfo/index2.cfm?pestgroup=mosquitoes

The ***Pest Web*** site includes a range of information from ordering products online, MSDS labels, online training, news and events relating to pest management, pest identification, and extensive educational tools and resources.

This site includes all types of mosquito resource books (control, biology, chemical & environmentally sensitive management, IPM…) and links to internet mosquito resources. Most of the books are scientific in nature and geared to the entomologist. Books may be ordered from this site. The internet links are grouped into four categories: Asian Tiger Mosquito, General Mosquito Information, Mosquito Borne Diseases, and Mosquito Control.

Reviews

PR – This site offers such a large number of resources on a wide range of topics relating to mosquitoes that it would definitely come in handy if an educator was looking for some information specific to a disease, IPM, or species of mosquito. Information on mosquito control ranges from repellents, to surveying, to fact sheets on malathion use for mosquito control. Internet links are to reputable sources such as the American Centres For Disease Control and Prevention, the American Mosquito Control Association, and the Environmental Protection Agency. Preparing lesson plans for older children would be made easier with the use of this site.

E) Web sites

E1) *The American Mosquito Control Association* www.mosquito.org

The American Mosquito Control Association is the umbrella body to American mosquito control districts. Basic mosquito information, publications, and links to other sites are included on this website. Frequent updates on political lobbying or commentaries on mosquito control issues are also featured.

Reviews

PR – The AMCA is active in political lobbying regarding mosquito control issues. Often considered 'pro-chemical' the AMCA has collected and displayed a sizable body of information on their website. Teachers interested in the basics of mosquito control and exploring social and political aspects of modern North American mosquito control will find this site of interest. Back issues of *WingBeats* (a Florida mosquito publication) are available (pdf) on the site.

E2) ***Bug Me! – Classroom Activities for Teaching about Bugs.***

Available at www.educationworld.com/a_lesson/lesson192.shtml This site is hosted by *Education World: The Educator's Best Friend*, and is found in the science section of the site.

The *Bug Me!* page includes lesson plans and ideas for classroom activities. This curriculum is not specific to mosquitoes, but includes mosquito information. The page is updated weekly with new activities that range from creating posters, recording bug journals, playing games, skits, and exploring the nutritional value of eating bugs. Each activity includes a complete lesson plan

> *"Do your students know the real difference between a fly and a mosquito? Between an insect and a spider? Maybe your students think all bugs are alike. There is no better time than summertime to show then the error of their ways!"* – Education World

Review

PR- This page features some fun activity ideas that could be tweaked to focus on mosquitoes. It provides background bug information that would enhance student's overall understanding of mosquitoes. Some activities uniquely incorporate social and cultural issues with bugs. This page is definitely worth reviewing to see if there are appealing activity ideas or activities related to current study.

E3) ***Centers for Disease Control and Prevention*** www.cdc.gov

The CDC is recognized as the lead US federal agency for protecting human health and safety. This site contains detailed historical and current information on virtually every mosquito-related illness.

Reviews

PR – Educators interested in incorporating accurate and up-to-date information on mosquito-borne disease into their class work should reference this site. The CDC is one of the most respected and well-known agencies in the world, and the depth and breadth of information contained on this site is incredible. West Nile virus information is continually updated and is general as recent as one week. Maps of the disease spread would make a good visual tool in a discussion of West Nile virus in North America.

E4) ***Flies and Mosquitoes*** http://www.ent.iastate.edu/imagegal/diptera

Operated the Iowa State University of Science and Technology.

This site offers twenty-one pictures of mosquitoes. Photos show different species, and some illustrate differences between male and female mosquitoes.

Reviews

PR – This site is a useful resource for educators wishing to illustrate physical differences between mosquito species, and between sexes. For instance, *Culiseta inornata* has a blunt abdomen, while the *Aedes* species have pointed abdomens.

E5) ***Desert Mosquito - K-12 Jump-Start***

Located at www.desert-mosquito.org this site was developed and is maintained by Stacey Enslen (M.Sc.), University of Arizona, Agriculture Educational department. The site includes information for kids, presented in a fun manner, and includes a quiz for kids to see 'what they know'. Information on Biology and lifecycle are included. The site also includes information for adults. The goals of the site are

- To distribute information about mosquitoes to the general population
- To help neighbourhoods organize and rid their areas of mosquitoes
- To help people recognize the various types of mosquitoes throughout their lifecycle
- To provide lessons for teachers and their students so that mosquito control information has another avenue out to the public
- To dispel myths that exist about mosquitoes, their lifecycle, and the diseases that they carry.

Review

PR – This site could be very helpful to an educator wishing to incorporate mosquito learning into curricula. The basic information and links to other sites are all provided, along with good games and quizzes for kids. However, the lack of funding that the site has received has caused updates in links and information to be lacking, and ultimately hampers the effectiveness of the site.

E6) ***Manitoba Health, West Nile virus 2003*** http://www.gov.mb.ca/health/wnv/

This site includes frequently updated information on the Manitoba West Nile virus statistics, information on symptoms, mode of transmission, maps, and many FAQ's relating to West Nile virus.

Reviews

PR – This site is very useful for retrieving current information on WNv in Manitoba as well as the basic information needed to discuss or review West Nile virus with a class.

E7) New Jersey Mosquito Homepage www.njmosquito.org

Information on the New Jersey control program, mosquito biology and behaviour, links to other websites and to research.

Review

PR – The main reason for the inclusion of this website is the four short videos of mosquitoes that are available on it. The videos illustrate the mosquito lifecycle by displaying larvae hatching from an egg, an adult emerging from the pupal skin, a female inserting her proboscis into the skin, and a female filling with blood. These short clips

would be helpful aides in teaching children about the mosquito lifecycle by giving them an accurate visual aide. Ideas for creative mosquito projects such as poster and poetry projects are also included. Finally, the site links to an article that may be of interest to teachers titled *Education: An Essential Mosquito Control Tool.*

E8) ***World Health Organization*** www.who.int/en

The WHO is a United Nations specialized agency for health, established in 1948, with the objective of the attainment by all peoples of the highest possible level of health. The WHO is governed by 192 member states. This site contains excellent, accurate, and recent information on mosquito-related health issues. Detailed explanations of WHO initiatives to reduce the impact of mosquito-borne pathogens are included.

Reviews

PR – This site is essential for any educators interested in facilitating a detailed and accurate discussion of mosquitoes and global health (current and historic). It is also an excellent resource for children conducting research projects on mosquito-borne illness.

E9) ***The Why Files*** www.whyfiles.org/016skeeter

The Why Files were created by the National Institute for Science Education and the National Science Foundation (USA) and are funded by the University of Wisconsin-Madison. The 'Mosquito Bytes' section includes information on many mosquito issues. Links to other web sites, a Q&A, discussion of mosquitoes and climate change, personal protection, and links to relevant research are included on this site.

Reviews

PR – This site hosts a plethora of relevant mosquito information, and would be a good resource for teachers and students. The Why Files are written in a casual manner, making online exploration of mosquito issues interesting to the reader. The global warming discussion is unique to this site, and incorporates another angle of mosquito-study that is not always immediately apparent. A discussion of Integrated Pest

Management, mosquito lifecycles, and mosquito-borne diseases are included. This is an excellent tool, and would likely be suitable for children in grades four to six and beyond.

E10) ***Winnipeg Insect Control Branch,*** www.winnipeg.ca/cms/bugline

The Winnipeg Insect Control Branch web page describes mosquito lifecycles, breeding habitat, and how to reduce mosquito-breeding habitat on your property. Links to West Nile virus information is included.

Review

PR – This site provides basic information regarding mosquitoes and their control. It could be improved greatly with the addition of information specific to the Winnipeg situation and program, the products used in Winnipeg, information on health and safety issues relating to mosquito control, and links to relevant research. A brief history of mosquito control in Winnipeg would also be an interesting and helpful addition.

F) Other Mosquito-Related Stuff

F1) Bat Information/ Houses

1) North American Bat House Research Project. www.batcon.org/bhra/

2) North Dakota Wildlife – government. Offers blueprints for building two different styles of bat house, the Small Bathouse and the Johnson Bathouse.

www.npsc.nbs.gov/resource/tools/ndblinds/smallbat.htm or…

www.npsc.nbs.gov/resource/tools/ndblinds/johnbat.htm

Reviews

PR – Bats consume adult mosquitoes as part of their regular diet. However, they are not able to provide effective biological control of mosquitoes on their own. Educators could use bat information and building bat houses to connect mosquito discussions with other related ecological discussions. The inter-relatedness of nature is displayed through food-chain and habitat links shared by the mosquito and the bat.

F2) Bug Viewer

Author: John Stidworthy, Publisher: Parragon Publishing Book, 31 pp. Copyright 2000. Available through Barnes & Noble online booksellers, $5.00 US.

This kit includes a clear bug-collecting box with three high magnification chambers, tweezers for handling insects, and a 'Bug Viewer' book. The book describes a wide range of insects and other organisms from slugs and snails to dragonflies, stick insects, and mosquitoes.

Review

PR – This kit is a great tool for kids that can go outdoors on insect collecting trips. The three chambers in the collecting box make it easy to collect and store insect samples separately. The book contains interesting information (how ants defend their nest, how cicadas sing, how high fleas can jump, and why mosquitoes are our deadly enemy). The information in this book is presented in the question/answer format, is intended to hook kids by addressing fun, and unique insect facts. Mosquito information in this kit is limited, but the collecting case could be used in concert with the aspirator, and the book would be a good compliment to any insect study. Plus, for $5.00, the kit is worth a look.

F3) Mosquito Aspirator

Not available for sale, but easily constructed. The aspirator is an Entomological tool used to collect mosquitoes from the environment by 'hand'. The long tube features a coarse screen one-third from the bottom of the tube, and a fine filter halfway along the tube. The combination of these two will ensure that the person using the aspirator will not end up with a mosquito or mosquito pieces in their mouth. The aspirator can be used to collect mosquitoes from the environment which can them be looked at under dissecting microscopes and keyed to species.

Reviews

PR – I built a number of these for the volunteers participating in my thesis research. Following a brief orientation on how to use the device, adults were generally enthusiastic

about trying to catch mosquitoes with it. Aspirators can be part of an outdoor activity that compliments in-class mosquito study.

Parent – Need instructions on how to use this device along with a possible identification key of different species of mosquitoes in Manitoba. Possibilities to use this could be catching/identifying and sorting/graphing different species at different times of the year/locations etc.

T2 – Collecting materials are an excellent addition to the kit (a package of mosquito educational books and tools) and will make collecting more likely as teachers don't have to go out and locate the necessary equipment.

T1 – I thought the aspirator looked like a fun group project, maybe for a nice field-day in the spring before the mosquitoes really get too bad. It would be a good tool for the kids to move them from talking about mosquitoes, to actually looking at physical specimens.

T3 – My kids had fun chasing mosquitoes and sucking them up. It takes some skill to work the aspirator, but it was a good outdoor activity that we coupled with other ecological outdoor study. Information on how to tell what species have been caught would help improve the applicability of the tool.

F4) Purple Martins

A CD of information is available at www.sound.net/~deadbird. CD includes details on how to build purple martin houses, attract the birds, what to feed the birds, articles and other purple martin related information. $17.95 US/CD, when 3 CD's are purchased. Purple Martins are often said to perform biological control of mosquitoes. Scientific studies have shown this untrue, while martins certainly eat adult mosquitoes, they do not consume enough to make a significant impact on overall mosquito populations.

Review

PR –Educators could include information on these birds as part of a discussion of potential methods of biological mosquito control, emphasising the message that 'every little bit counts' and also that martins on their own are not going to significantly change the situation.

Links to Science Outcomes in Manitoba

The games, books, curriculum, and other educational tools can be used in the classroom in a number of ways. The activities link well with science outcomes in Manitoba, as suggested below.

Grade 2, Overall Skills and Attitudes.

These outcomes could be met through investigation and discussion of mosquito issues in Winnipeg and around the world.

2-0-1A Ask questions that lead to investigations of living things, objects, and events in the immediate environment. (mosquitoes, mosquito breeding habitat, and mosquito control efforts by the civic government of Winnipeg)

2-0-1B Make predictions based on observed patterns or on collected data. (In spring, predicting mosquito populations based on past years and weather patterns)

2-0-1C Identify practical problems to solve in the immediate environment. (Based on past years of unrest and community debate regarding mosquito control methods and tactics, how should we better deal with the mosquito situation in Winnipeg?)

2-0-2A Access information using a variety of sources. (newspapers, websites, books, games, etc. for accessing mosquito information, and the Winnipeg scenario).

2-0-3A Brainstorm, with the class, possible solutions to a practical problem; and in small groups, reach consensus on a solution to implement. (How should we deal with mosquitoes? What are the options, and what plan is best for Winnipeggers?)

2-0-3B Create, with the class, a plan to solve a problem or meet a need. (What is the plan to deal with mosquitoes in 2004?)

Grade 3, Overall Skills and Attributes

Many of these outcomes are the same or similar to the Grade 2 outcomes, with some increased sophistication. Again, an investigation and discussion of mosquito issues in Winnipeg, using research tools, and developing a plan to control mosquitoes would address most of the specified outcomes.

Grade 4, Overall Skills and Attributes

As with the other grades, this section could be adequately addressed by an in-depth investigation and discussion of mosquito issues in Winnipeg. The creation of a plan on how to deal with mosquitoes in Winnipeg, based on research and predictions would fill a number of the outcomes in this section.

Grade 4, Habitats and Communities

Discussion of the mosquito in its aquatic and non-aquatic habitats would address many of the outcomes described in this section.

4-1-01 Use appropriate vocabulary related to their investigations of habitats and communities.

4-1-02 Recognize that each plant and animal depends on a specific habitat to meet its needs. (Discussion of mosquito larvae habitat needs, and the habitat needs of insect, fish, and avian predators of the mosquito)

4-1-03 Identify components of an animal habitat (identifying the components of a mosquito habitat – this will work well as the components for each lifecycle stage can be examined for a thorough investigation of aquatic and non-aquatic habitats).

4-1-04 Identify physical and behavioural adaptations of animals and plants, and infer how these adaptations help them to survive in a specific habitat. (the mosquito larvae breathing siphons as an aquatic adaptation, the wiggling motion of larvae as a behavioural adaptation to evade predators. The physical and behavioural adaptations of mosquito predators could be discussed to add breadth).

Grade 6, Overall Skills and Attributes

Same as above.

Grade 6, Diversity of Living Things

6-1-01 Use appropriate vocabulary related of their investigations of the diversity of living things (many books in the Annotated Bibliography include glossaries that describe scientific words needed to discuss mosquitoes and biological issues relating to mosquitoes).

6-1-04 Identify living things using an existing classification key, and explain the rationale used (A number of classification keys have been developed for the identification of mosquito species, or the basic biological classification key can be used to identify mosquitoes and their predators).

6-1-11 Compare and contrast adaptations of common arthropods, and describe how these adaptations enable them to live in particular habitats. (Discussion and investigation of mosquito and mosquito predator adaptations. *Mansonia* mosquitoes have adapted to breathe by attaching to stems of aquatic plants, while other larvae attach to the water surface tension. Some species breed in treeholes, others in temporary pools/puddles. Eggs are laid in rafts, or scattered. Some species lay eggs at the water's edge, some on the water, some in damp areas that may be filled with water in the future. There are many was to relate mosquitoes to this outcome).

Grade 7, Overall Skills and Attributes

Same as above.

Grade 7, Interactions Within Ecosystems.

7-1-01 Use of appropriate vocabulary related of their investigations of interactions within ecosystems. (see above)

7-1-06 Identify environmental, social, and economic factors that should be considered in the management and preservation of ecosystems. (Mosquito control provides the perfect setting for a discussion of social, environmental, and economic factors in managing or preserving ecosystems. Mosquito control is a delicate balancing act between the social and health needs of humans, the ecological impact of mosquito control on the environment/ecosystem, and the economic incentives and disincentives of mosquito control. It would be a good balance to a discussion focussing on fragile or rare ecosystems.)

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Project Media Coverage & Public Outreach

2001-03	Numerous meetings with key individuals from the Wolseley area who organized the de-listing of houses that resulted in the exemption of the entire Wolseley area from fogging.
2001-03	Contact with numerous private citizens inquiring about product testing or other aspects of my thesis research.
2001-02	Numerous meetings with high school and university students conducting research projects on mosquitoes and mosquito control in Winnipeg.
7th May 2001	Wolseley Residents Association, Executive Committee
22nd May 2001	Honourable Jean Friesen (MLA Wolseley) and others, meeting.
25th May 2001	CKUW, The Hot Potato. Live Interview (telephone), 8:40-8:50am.
6th June 2001	Windermere Marketing Corporation, interested in testing and marketing personal frequency mosquito control devices.
6th August 2001	Beth Daily. Bug Battle is on: Creative home remedies target mosquitoes. *Boston Globe.*
26th August 2001	Carol Sanders. Buzz-busters get field study. *Winnipeg Free Press.*
August 2001	David Schmeichel. All in the name of science… Researchers' pals let skeeters land on them. *The Winnipeg Sun.*
August 2001	Suzanne Dufrane, A Work in Progress CBC National Radio

29th August 2001	Margo Watt, The Afternoon Edition, CBC Radio Winnipeg, live interview
30th August 2001	The Morning Show, CBC Radio Thunderbay, live interview
17th October 2001	East Wolseley Residents' Association, presentation at public meeting
October 2001	Technical Report #1
April 2002	Technical Report #2
5th July 2002	CBC Calgary Radio, interview CBC Windsor Radio, live interview CBC St. John's, live interview CBC Sidney, live interview CBC St. John, live interview CBC Regina, interview CBC Toronto, live interview CBC Quebec City, live interview CBC Edmonton, interview CBC Yellowknife, live interview CBC Whitehorse, live interview CBC Vancouver, interview.
8th July 2002	CBC Yellowknife, The Morning Show live interview
25th July 2002	Wolseley Residents' Association, Public Meeting
27th August 2002	Honourable Jean Friesen (MLA Wolseley) and others, meeting.
December 2002	Technical Report #3
2002-2003	Wolseley Working Group, attended meetings

3rd January 2003	Honourable Jean Friesen (MLA Wolseley) and others, meeting.
1st February 2003	Helen Falding. Skeeter killers a concern: Residents want to know more about safety of chemicals city uses. *The Winnipeg Free Press*.
3rd March 2003	Helen Falding. Mosquito experts making battle plans: U.S. conference to address West Nile virus. *The Winnipeg Free Press*.
March 2003	The American Mosquito Control Association Annual General Meeting, Minneapolis, Minnesota. Conference presenter and attendee.
April 2003	Canadian National Film Board, interview for project proposal.
22nd April 2003	CBC Radio, Winnipeg, Morning Show, live interview
28th April 2003	Natural Resources Institute Public Meeting, Wolseley Mosquito Research Seminar, presenter.
June 2003	Resource Conservation Manitoba, Annual General Meeting. Speaker.

BUG BATTLE IS ON
CREATIVE REMEDIES TARGET MOSQUITOES

Author: By Beth Daley, GLOBE STAFF Date: 06/08/2001 Page: B1 Section: Metro/Region

They're back. Just as the New England weather starts to warm up, the whine of mosquitoes cuts the evening air once again.

And just as surely as bug repellent displays are going up in stores and public health officials are warning everyone to wear long sleeves, many New Englanders have begun their annual search for a better – or at least different – way to repel the regions more than 20 species of mosquito.

What about wearing pastel colors? Foot antiperspirant? Slathering up with bear grease, luring bats to the backyard, or even not washing?

Over e-mails and barbeque grills, people are sharing strange home cures – adapted from as far away Africa or learned by hard experience – in hopes of avoiding chemical pesticides that many aggravate asthma and harm the environment. But sometimes, the cure – eating four bananas a day or sprinkling the lawn with powdered caffeine, for example – may prove more burdensome than more effective, mainstream methods.

"If you eat a significant amount of garlic maybe you won't be as attractive to mosquitoes. You won't be to me," said Ralph Timperi, director of the state Department of Public Health lab that tests for the West Nile virus.

Although no human cases of West Nile Virus have been detected in Massachusetts, public health officials expect an outbreak this year, based on infected mosquitoes and crows they found take last summer. The virus first appeared in Queens, N.Y., in 1999 and has killed several elderly people. Massachusetts officials are using more natural means, such as larvicide, to kill bugs before considering chemical pesticides.

"A lot of these home remedy suggestions haven't been evaluated. You can't really say if they work or not. But basically, if the mosquitoes aren't biting you, things are OK," Timperi said.

Mosquitoes find humans by the carbon dioxide we exhale or our body excretes. As they get close, they sense heat and dive in to get a protein-filled blood dinner. Humans also give off a series of chemical cues to the critters.

In fact, several popular products try to place human-like devices in backyards that give off carbon dioxide, heat, and chemicals to attract the insects. They are then electrocuted.

"They actually do trap mosquitoes, they are not outlandish," said Ulrich Bernier, research chemist at the US Agricultural Research Service's mosquito lab in Gainesville, Fla.

Over the years, Bernier's lab has researched home remedies, including a recent one making the rounds on a Massachusetts amateur astronomy e-mail list: Thiamin, or B1 vitamin. If taken in significantly high doses, the vitamin is said to be a repellent once it is sweated out in the skin.

"It doesn't work," Bernier said. "Neither does garlic."

But pink pantsuits might do the trick – seriously. Mosquitoes tend to fly close to the ground and look at people with the horizon as a backdrop. Against the sky, dark colors stand out more; some scientists say yellow is the best mosquito-deterrent color. Still, Bernier says a humans odour will probably win over a mosquito no matter what color he or she is wearing.

Foot odour, too, may attract some mosquitoes. An African malaria-carrying mosquito tends to bite lower parts of the body, and researchers wonder if foot odour or other body smells draw them. Some Web-based advice tells residents to use roll-on deodorant on bare feet. But scientists seriously doubt that smelly feet lure New England mosquitoes.

Bear grease and a slew of lotions are also said to kill or deter the bugs – either they get stuck in the goo or the location is a thin barrier. Bat and swallow houses are also selling well in Massachusetts. And, while it's true that both bats and swallows chow on mosquitoes, scientists remain divided about they eat enough to make a difference in a backyard.

Most, however, agree that bug repellent may be the best bet if someone wants to remain as free from bugs as possible, which certainly beats the homespun remedy of not washing. That, mosquito specialists agree, does not work.

"Still, there is psychology behind it – you feel that much better when you have something you think is working." said Julie Henderson, a graduate student at the University of Manitoba in Canada, who is studying natural and home remedies to ward off mosquitoes.

Natural Resources Institute

Wolseley Mosquito Research Seminar

Public Meeting – All Welcome

Monday, April 28th, 7:30pm – 8:30pm

Robert A. Steen Community Centre

A presentation of Mosquito research conducted in Wolseley during 2001 & 2002. Research includes product effectiveness, and public feedback regarding mosquito issues in Winnipeg

Research Supported by - Sustainable Development Innovations Fund

Followed by:

Wolseley Working Group

Presentation and information booth

For more information contact –xxx-xxxx or xxxx@hotmail.com

Mosquito experts making battle plans

U.S. conference to address West Nile virus

By Helen Fallding

MINNEAPOLIS — Frozen solid, dried-out, dormant eggs that will be the next generation of mosquitoes hardly seem like a threat in the dead of a Prairie winter.

But almost 700 mosquito-control experts from around the globe are gathering here to plan battle strategy after West Nile virus killed 274 North Americans last summer, including 11 Canadians. More deaths are expected this year as the virus continues its march across the continent.

There are even fears that America's enemies will infect mosquitoes with killer diseases in a new twist on the biological terrorist threat that has U.S. President George W. Bush ready to wage war on Iraq.

It's only fitting that the self-described mosquito capital of Canada is sending Julie Price-Henderson as an unofficial envoy to the 69th annual American Mosquito Control Association conference.

The University of Manitoba student is armed with research on ways to keep mosquitoes out of backyards without resorting to the toxic chemicals that turned Winnipeg's Wolseley neighbourhood into a battle zone last summer. After Ontario's chief medical officer approved fogging with the nerve poison Malathion last week, similar skirmishes are expected in that province.

Price-Henderson found about 30 intrepid volunteers willing to bare their forearms for science in the wilds of Fort Whyte and environmentally friendly Wolseley, where no Malathion fogging trucks prowled until mid-July last year. When West Nile started infecting Winnipeg birds, the province overrode buffer zones around the homes of people who believe Malathion makes them sick.

The Mosquito Magnet that silently lures the pests with a warm waft of breath-simulating gas before vacuuming them in to meet their fate showed promise in Price-Henderson's experiments, but the results were inconsistent.

The propane-powered devices that cost more than $800 can attract hundreds of thousands of mosquitoes over the course of a month, she found. In an open area like Fort Whyte, volunteers near the Mosquito Magnet found the insects landed on them less often.

Unfortunately, in Wolseley backyards with the devices, the volunteers sometimes found mosquitoes sucking their blood more often than in yards without. Price-Henderson said more testing under controlled conditions in a lab will be needed to sort out what is going on, but she has a theory.

Extra mosquitoes drawn into a backyard by the Mosquito Magnet may be getting distracted by other objects before they get sucked in, she suspects.

"I need to sit down with these entomologists and see what they have to say," Price-Henderson said.

Mosquito Magnets were also tested by a U.S. researcher on an island in the Florida Keys that is so overrun with mosquitoes that almost no one visits from June to October. He will report preliminary results at the conference that show 20 traps set up along a trail seemed to be effective.

Poulin's Pest Control Services sold 115 Mosquito Magnets last year and people are already starting to buy them this year, operations manager Tim Wilson said.

"West Nile really put a scare into people."

Meanwhile, restaurants from Winnipeg to Hong Kong are buying Mosquito Magnets for their outdoor patios.

Price-Henderson also tested Mosquito and Gnat Flying Insect Repellent, a natural alternative to the chemical lawn sprays used to keep pests away from weddings and lawn parties. The U.S.-manufactured repellent contains lemon, mint and garlic.

Light traps on the treated lawns captured fewer mosquitoes, but the graduate student didn't get the same results with her human volunteers.

Neither product Price-Henderson tested produced a mosquito-free yard. "Neither was a silver bullet."

Her research was financed by the province's sustainable development fund.

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Julie Price-Henderson, a University of Manitoba student, is attending the 69th annual American Mosquito Control Association conference in Minneapolis.

All in the name of science ...

Researchers' pals let skeeters land on them

DAVID SCHMEICHEL
Staff Reporter
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C. PROCAYLO Sun

McCallum (left) and Ramratten having been submerging themselves in mosquito land for science.

While the rest of the city is busy slapping, swatting, and spraying away this summer's onslaught of mosquitoes, a few brave souls are actually encouraging them to touch down on their bare flesh.

They're subjecting themselves to the tickly torture in the name of scientific research, and because they couldn't say "no" to buddy Julie Henderson.

'Submerging yourself'

"The first time we went out, what was going through my head was, 'Damn — I must really like Julie,'" said Alisa Ramrattan, one of about 40 people taking part in Henderson's experiment. "They're swarming all over you while you're sitting there, so if you're not wearing something that's protective, you're basically submerging yourself into mosquito land."

Henderson is a University of Manitoba student studying the effectiveness of environmentally safe mosquito control options in urban settings. As part of her research, she's enlisted an army of friends and volunteers willing to make themselves vulnerable to attacks from above.

After venturing to outdoor test sites in the Wolseley area and the Fort Whyte Centre, subjects expose an arm to the open air, then count how many mosquitoes land on them in the space of five minutes.

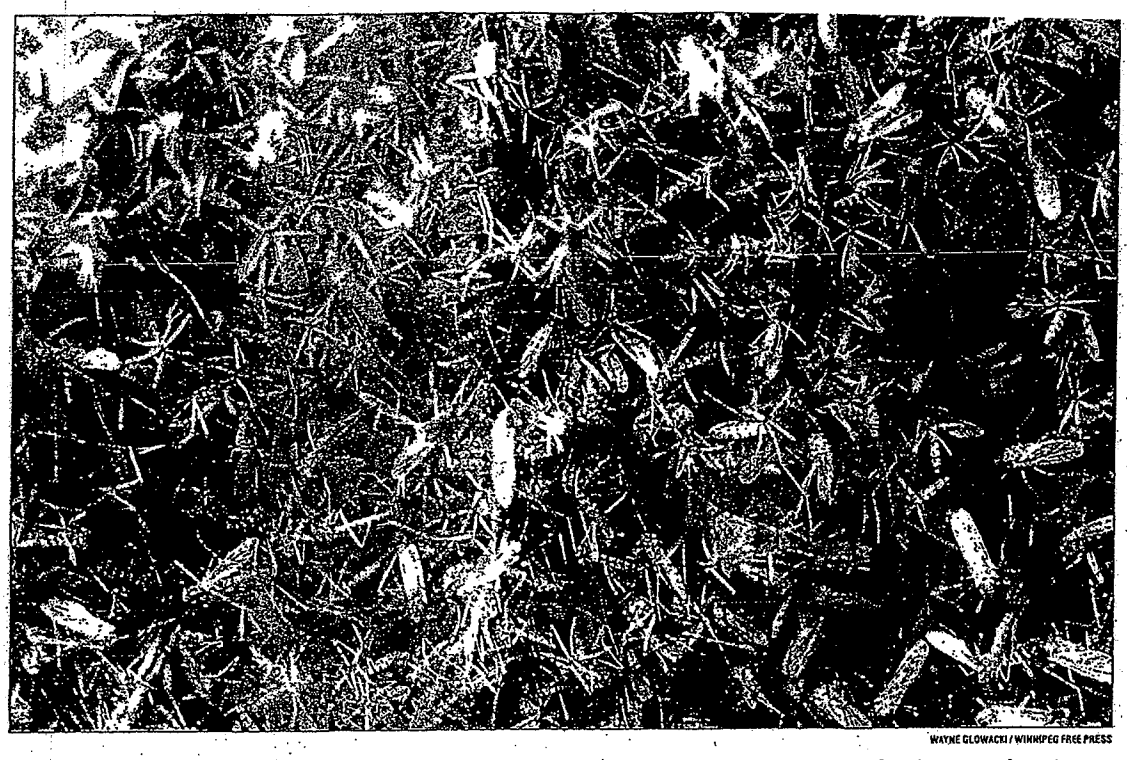
They don't actually get bitten, though. They're armed with a contraption that sucks the mosquitoes off their arms and into a tube, then traps them until they can be tallied and turned loose.

So far, Ramrattan and test partner Kim McCallum have completed three out of five trials — each of which requires them to be outside for about two hours. In some cases, the weather's been more bothersome than the bugs.

"The second time, it had just stopped raining, so everything was sopping wet," Ramrattan said. "Both Kim and I had to stop after two minutes ... because we'd had so many 'bites.' Kim had 32 in under two minutes."

Participants are outfitted with long clothing and mosquito netting, but they have been known to come home with a few battle scars.

"Two of them bit right through my pants," said McCallum, noting she's not allowed to shoo skeeters away while testing is being done. "When they get underneath you, you don't really notice them."



WAYNE GLOWACKI / WINNIPEG FREE PRESS

The quest to build a better bug trap includes Mosquito Magnet, which sucks skeeters into a vacuum bag (contents shown).

Buzz-busters get field study

By Carol Sanders

REMEMBER the Off! commercial with the man thrusting his hairy arm into a container full of famished mosquitoes?

Imagine having your entire body covered with the buzzing bloodsuckers — all in the interest of science.

"At first I almost had a panic attack," said Julie Price-Henderson, a University of Manitoba graduate student who's testing an arsenal of environmentally friendly mosquito weapons to separate the duds from the scuds.

Thirty volunteers in malathion-free Wolseley and at the Fort Whyte Centre have been baring their flesh in the wild to help Price-Henderson in her study.

Wearing long pants, long sleeves and mosquito-net headgear prevents bites, but doesn't stop the itchy sensation of being swarmed.

"It's a weird feeling — a blanket of mosquitoes covering you and you can hear them buzzing around your head net," said Price-Henderson, who's with the U of M's Natural Resources Institute.

WAYNE GLOWACKI / WINNIPEG FREE PRESS

Price-Henderson empties the Mosquito Magnet's bug bag.

With the debate over the use of the chemical malathion in Winnipeg and concerns about the arrival of the mosquito-borne West Nile virus in Canada, the university research project is timely, she said.

"It's in response to the fact that there's growing concern from the public over the use of chemicals," she said.

"Everyone wants to control mosquitoes in a more environmentally benign way."

Price-Henderson expects to have some preliminary results by the end of September. A full report should be out next year.

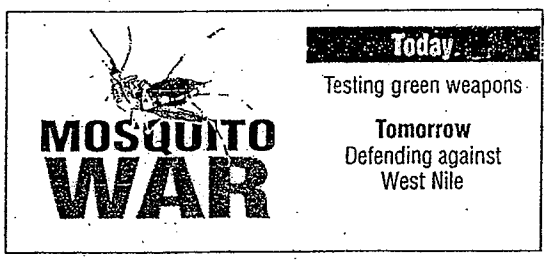
With a growing array of mosquito control options on the market, Price-Henderson's study aims to help consumers make more informed choices about products that don't contain harmful chemicals.

They were put to the test last week as city traps averaged 294 mosquitoes on Thursday — providing plenty of research material for Price-Henderson. (Yesterday's mosquito count stood at 371.)

"Some of the things I'm testing are the Mosquito Magnet and a type of zapper called The Stinger."

She's also testing DEET-free mosquito repellents and lawn sprays, using mosquito traps and human volunteers at Fort Whyte and Wolseley who do landing biting counts — noting how many mosquitoes land on an exposed piece of flesh for a specified length of time.

Continued
Please see **MOSQUITOES** A4



..Aosquitoes

c tinued from page A1

The Mosquito Magnet emits carbon dioxide — which humans exhale and mosquitoes find so attractive — then s cks the lured insects into a vacuum bag.

Nick Diacos bought one of the machines for his mother, ho has a pool in her backyard in St. James across the A ssiniboine River from his home in Charleswood.

"I live on the river. My mom lives on the river. We can sit her backyard. I can't sit in mine."

His sister Jennie Diacos emptied the bag attached to the t it Wednesday morning.

"It was disgusting," she said. The bag was full. The achine located in the backyard by the river seems to have made a difference, attracting mosquitoes away from the l ol area, she said.

Diacos, who golfed mosquito-ee earlier this week at Falcon Lake, doesn't see malathion spray-g making a difference in the rest the city.

"Outside the city they're not ad. I would've thought we ould've been killed (by mosqui-es) out on the golf course," she said.

"Spraying isn't working." She's raid mosquitoes here are devel-ping a resistance to the insecti-cide.

'We've been sprayed a number of times and they're as bad as ever. More are coming in from other areas'

— John Moore, a co-owner of Humboldt's Legacy

Randy Gadawski, city entomol-gist, said there's no evidence to suggest Winnipeg's mos-quitoes are becoming resistant to malathion. There have been documented cases of that happening in places where here's been more intensive malathion spraying throughout he year, he said. Gadawski couldn't say which places.

"Despite its lack of success, we continue to poison our-elves," said John Moore, a co-owner of Humboldt's Lega-y in Wolseley, which sells DEET-free insect repellent and eeds to grow flowers that repel insects. Eating a lot of garlic works, too, he said, although it may keep away more han mosquitoes. Garlic breath is preferable to malathion nd probably works better, said Moore, who lives in River Heights.

"We've been sprayed a number of times and they're as ad as ever. More are coming in from other areas."

Diacos isn't interested in the malathion debate — he just wants to do all he can to go bug free next summer. He plans o buy another Mosquito Magnet for his home in Charleswood at a cost of close to $1,400. He figures it costs about a dollar a day to run, refilling the propane tank every three weeks and changing the carbon dioxide cartridge.

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WAYNE GLOWACKI / WINNIPEG FREE PRESS

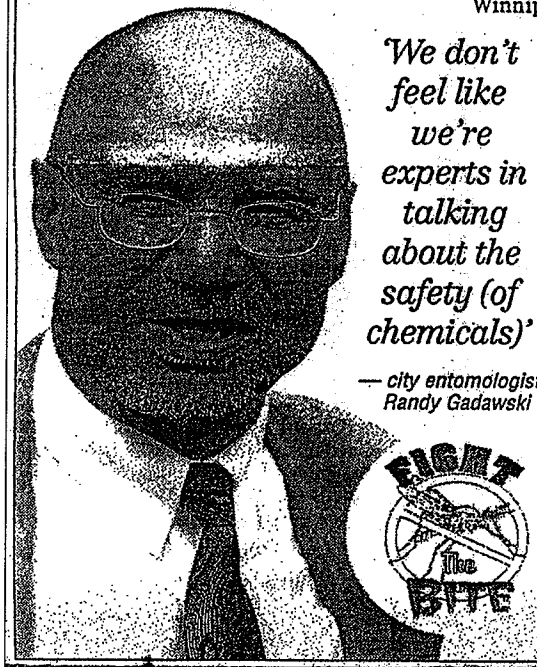
Price-Henderson traps mosquitoes on her arm.

Skeeter killers a concern

Residents want to know more about safety of chemicals city uses

By Helen Fallding

WINNIPEGGERS want to know more about what the city is doing to control mosquitoes and about the safety of controversial chemicals sprayed near their homes.



'We don't feel like we're experts in talking about the safety (of chemicals)'

— city entomologist Randy Gadawski

"I was surprised how many people outside of the Wolseley area had pretty strong reservations about the use of Malathion to control mosquitoes," said Julie Price-Henderson, a University of Manitoba graduate student who interviewed about 70 residents in River Heights, Wolseley and the Maples last fall.

Winnipeggers want alternatives explored so Malathion fogging becomes a last resort, she said.

Last summer's mosquito war in Wolseley, where residents put their bodies on the line to block city trucks from fogging their neighbourhood, seems to have raised the awareness of residents in the rest of the city, Price-Henderson said.

Wolseley residents are pretty well-informed about mosquito control, but the debate got residents of other neighbourhoods thinking maybe they should know more, she said.

The researcher knocked on doors a week after dropping off a copy of the city's Fight the Bite pamphlet.

She said most people read the pamphlet — even if they usually throw out other unsolicited mail — and they were eager to talk.

Price-Henderson's sample wasn't big enough to generate reliable statistics and she is still analysing the results, but she said she noticed some trends.

Only a minority were worried enough about the mosquito-borne West Nile virus that showed up in Manitoba for the first time last summer to change their behaviour — going outside less and coating themselves in more bug repellent.

At the other end of the spectrum were people who ignored the hype. "They said they were more likely to be killed on the way to work."

Most Winnipeggers were somewhere in the middle, thinking about the virus whenever they had a sniffle or a headache, but not running to the doctor, she said.

All but one person Price-Henderson interviewed was aware that dangerous mosquitoes can breed in containers in their yards and some took action by emptying the plates under pots after it rained or changing water in their bird baths.

Most people knew a fair bit about West Nile — mainly from reading the *Free Press* — but they wanted more information directly to their homes from an authoritative source like the city or public health officials.

City entomologist Randy Gadawski said the city distributes pamphlets at garden shows and on slow days workers visit homes to assess where mosquitoes might be breeding.

The city has never done a city-wide pamphlet drop all at once, but Gadawski said he has been waiting for the results of Price-Henderson's study and he is all ears to her suggestions.

The Fight the Bite pamphlet does not discuss the safety of the chemicals the city uses, which have all been approved by Health Canada. "We don't feel like we're experts in talking about the safety," Gadawski said.

Price-Henderson received $37,000 over two years for her research from Manitoba's Sustainable Development Innovations Fund.

She said Winnipeggers she interviewed complained about mosquitoes, but acknowledged there is only so much the city can do when hot weather hits after a heavy rain.

"It's interesting that people are so forgiving."

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