Pesticide use for West Nile virus

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West Nile virus (WNV) caused an unprecedented amount of arthropod-borne illness in Canada in 2002. Since then, we have been working on approaches to mosquito control: one of us (H.S.) has been involved in a cooperative group of southern Ontario public health departments to work through some of the issues in implementing mosquito control measures (the Central East West Nile Virus Work Group), and the other (S.M.) has been researching the effectiveness of pesticides in preventing the spread of WNV (Public Health Research, Education and Development Program, City of Hamilton). In this article, we comment on the general approach to WNV being taken by a number of public health units in southern Ontario.

The prevention of human illness from WNV involves far more than truck-mounted spraying of pesticides. A full response to WNV comprises 3 main components: public education, surveillance and mosquito control. At a local level these components need to be coordinated with elected officials, various city departments (roads, parks, public works, animal services, by-law and communications), conservation authorities, provincial and federal ministries of health, and regulatory agencies.

Public education is essential to help people understand WNV, to encourage people to eliminate mosquito breeding sites on their own property and to promote personal protective measures to avoid mosquito bites. Unfortunately, it is difficult to change personal behaviours, and thus the efficacy of personal protective measures will be limited.[1] Education also plays a key role in helping people to understand what mosquito control is, how it works, why it is important and its potential health and environmental impacts.

Surveillance of bird deaths (e.g., of Corvidae birds such as crows and jays), adult mosquitoes, mosquito breeding sites and human cases of WNV will provide an indication of the extent and location of WNV activity throughout the season. This information will help guide local decisions to intensify activities during the WNV season, such as issuing an alert or increasing mosquito control in an area of high risk. In addition, surveillance data collected over a number of years will help to refine control strategies further.

The last component in the prevention of human WNV infection is mosquito control. Knowledge of mosquito biology and local conditions should be used to choose the best interventions (habitat modification, water management, sanitation or pesticides) on a site-specific basis.

The control measure that raises most public concern is pesticide use. Pesticides are designed to act at 2 of the stages in the mosquito life cycle (Fig. 1). Immature mosquitoes develop from eggs to larvae to pupae in standing water, and pupae develop into winged adults. Agents that work in standing water against mosquito larvae are termed larvicides, and those that work against winged mosquitoes are termed adulticides.

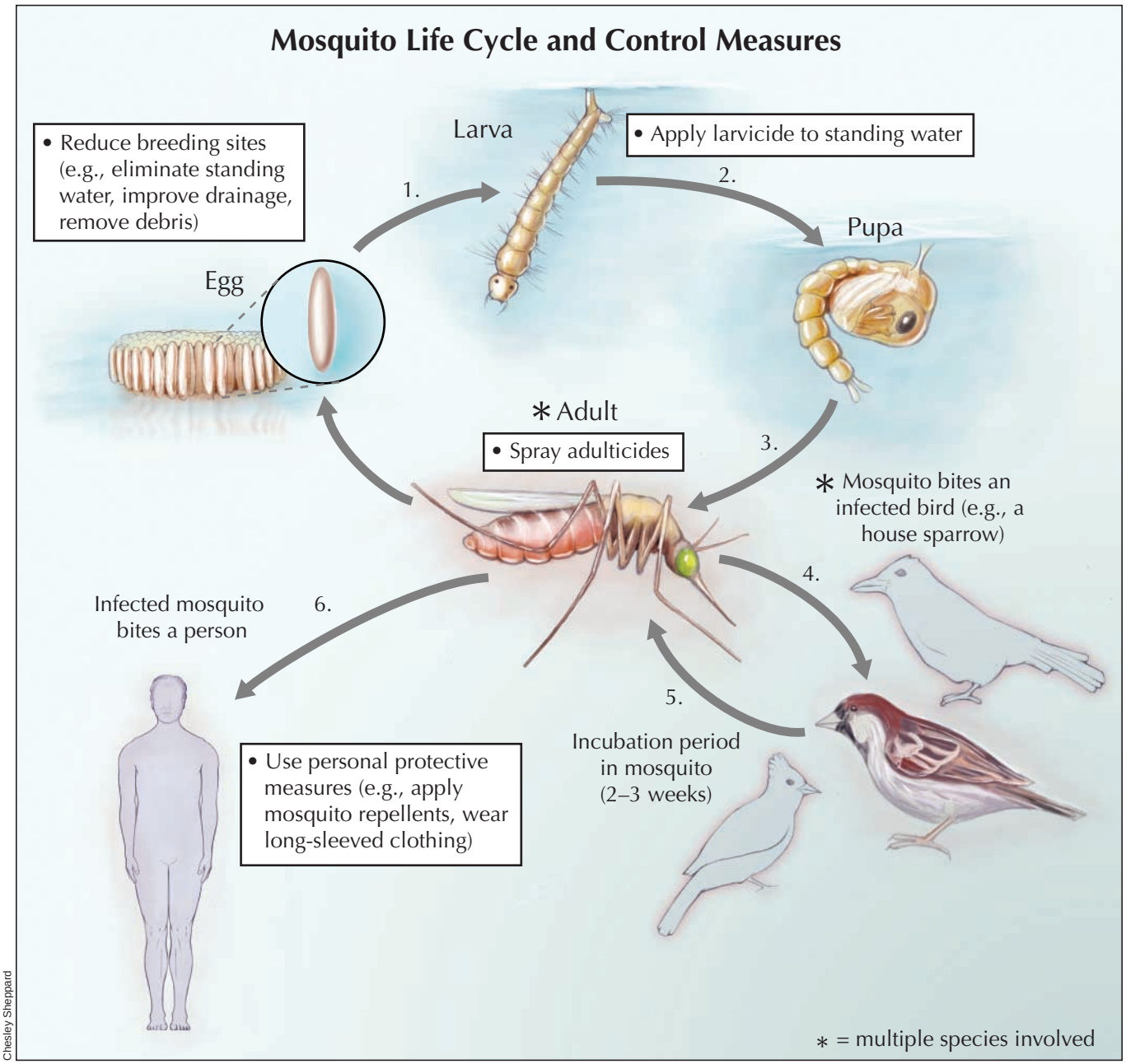
Larvicides have a number of advantages over adulticides. Their use can be targeted to mosquito breeding sites, which avoids a wide application over an entire neighbourhood or city. They can be applied in solid form (e.g., pellets, granules and sand), which limits human exposure. Some larvicide agents are specific to mosquitoes when used according to directions and have relatively little impact on the environment and human health. Formulations are available that can prevent the emergence of adult mosquitoes for up to 1 month, which decreases labour costs.

Adulticides are most often applied as a very fine ultra-low-volume (ULV) droplet spray from a truck or aircraft. Adulticide operations dominate media coverage of WNV control, although they are only one part of control efforts. Adulticides applied as a ULV spray work by coming into direct contact with adult mosquitoes as they are flying. One criticism of adulticides is their transient effect: mosquito numbers return to pretreatment levels within a few days without repeat applications. The use of adulticides in many jurisdictions is reserved for response to human cases of WNV infection or environmental findings (WNV-positive birds or mosquitoes) that indicate a high level of human risk of WNV infection from adult mosquitoes.[2,3]

Every pesticide in Canada has to pass a science-based assessment by Health Canada's Pest Management Regulatory Agency (PMRA). The agency takes this information into account and provides reassurance as to the safety and potential usefulness of the pesticides when used as directed. However, critics of pesticide use have expressed concerns about their effectiveness and their impact on human health and the environment.

The effectiveness of pesticides for mosquito control has been reported in many different ways, from controlled ex-

periments in a laboratory setting[4] to descriptive reports of mosquito control programs over a wide geographic area.[5] That pesticides kill mosquitoes (with varying levels of effectiveness depending on the product and species) when applied as larvicides to small, well-defined locations (e.g., ponds, catch basins, wetland areas) is supported by findings from controlled studies.[6,7] Reports of before–after studies also provide evidence that mosquito control efforts lower the numbers of mosquitoes in a given neighbourhood or city.[8] Unfortunately, randomized controlled trials of the effectiveness of mosquito control using human arboviral disease as an end point are not possible for practical reasons



Chesley Sheppard

Fig. 1: Schematic of the mosquito life cycle and control measures. The development of immature mosquitoes from eggs to larvae to pupae occurs in standing water. These stages of the mosquito life cycle can be disrupted by eliminating standing water where possible and by applying larvicides to water bodies containing larvae. When the pupae develop into winged adults, mosquitoes acquire West Nile virus by biting infected birds. The incubation period in mosquitoes is about 2–3 weeks. An infected mosquito might then bite a person, passing the virus on. Many bird species act as reservoirs for the virus, and many mosquito species are involved in passing the infection from bird to bird, or from bird to human, or both. Populations of adult mosquitoes can be controlled by spraying adulticides. Individuals can reduce their exposure to mosquitoes by undertaking personal protective measures.

(e.g., the wide variety of local environmental conditions, the variety of mosquito species and the usually small numbers of human cases). This lack of evidence, especially as it concerns mitigation of human disease, is echoed by many experts.[9,10] Nonetheless, mosquito control, especially the use of larvicides, is a recommended response to WNV by the US Centers for Disease Control and Prevention.[2] Draft guidelines from Health Canada make similar recommendations but are not yet publicly available (Dr. Robbin Lindsay, National Microbiology Laboratory, Winnipeg: personal communication, 2003).

The 2 larvicides being considered by most public health units in Canada — methoprene and *Bacillus thuringiensis* subsp *israelensis* (commonly referred to as Bti) — have been used for many years and have well-documented track records of human and environmental safety.[11–13] Both of these larvicides pose little risk to human health either through direct handling of the products or indirect exposure to them as a result of their use for mosquito control. Mild skin and eye irritation have been reported from direct contact with Bti.[12]

Methoprene has been shown to be toxic to some insects closely related to the mosquito, has very low toxicity to mammals, is moderately toxic to warm-water and freshwater fish, is slightly toxic to cold-water fish and is acutely toxic to some estuarine invertebrates.[13] Toxicity of methoprene to insects and animals other than mosquitoes and blackflies occurs at concentrations much higher than those used for mosquito control.[13] Bti is toxic to a lesser range of species than methoprene but is also effective against a lesser range of mosquito species.[12] Both larvicides break down rapidly in the environment.

Unlike the application of larvicides, which is in standing water usually remote from people and is limited in scope, adulticides must be applied widely in the air, which puts other insects, birds, fish, crustaceans and mammals, including people, at increased risk of exposure to them.

Malathion is the main adulticide being considered for mosquito control in Ontario. Many of the products used for mosquito control in the United States (e.g., synergized pyrethroids such as sumithrin and piperonyl butoxide) are not available for use in Canada. Malathion is an organophosphate pesticide that has been used in Canada since 1953. In addition to its use for mosquito control, it has registered residential uses for insects on lawns, gardens and ornamental trees, shrubs and plants in Canada and the United States. An extensive re-evaluation of malathion was completed by the US Environmental Protection Agency in 2000.[14] The PMRA has also re-evaluated malathion and approved its use as a mosquito adulticide.[15] Among the available agents used for mosquito control, malathion has the most current and comprehensive safety information available. It works by inhibiting cholinesterase and is detoxified by carboxylesterases into polar, water-soluble compounds that are then excreted.[16] Mammals have greater carboxylesterase activity than insects, which accounts for the selective toxicity of malathion toward insects. Cholinesterase inhibition in humans can overstimulate the nervous system and result in nausea, dizziness, confusion and, at very high exposures (e.g., accidents, major spills), respiratory paralysis and death.

A comprehensive literature review, risk assessment, and epidemiologic and attributable risk analyses of adulticides, including malathion, were performed by the Westchester County Board of Health, New York.[11] The board concluded that no significant adverse human health effects would be expected from adulticides used in accordance with its mosquito control plan. It concluded that the active ingredients in the adulticides may cause short-term effects, such as skin irritation or respiratory effects for some sensitive individuals, but were not expected to increase asthma events or other respiratory effects significantly. Similar conclusions have been reached by the US Environmental Protection Agency[14] and the PMRA.[15]

Malathion has low toxicity to birds and mammals and is not expected to pose a hazard to them.[14] It degrades rapidly in the environment, especially in moist soils. But there are some environmental concerns with malathion. It is highly toxic to insects and to aquatic organisms, including fish. The toxic effects on aquatic organisms can be decreased by limiting drift of the adulticide around water.

That pesticides kill mosquitoes when used as directed is not much in doubt. The issue is whether mosquito numbers can be lowered enough to have a significant impact on human illness from WNV. In trying to prevent WNV infection, public health units face a challenge of balancing the risk of infection against the risk of human and environmental exposure to the pesticides used for mosquito control. Given some of the uncertainties surrounding WNV, owing to the recent arrival of the virus in North America and the newness of resulting mosquito control programs, it would be scientifically responsible to ensure that WNV control programs are evaluated using appropriate methods and the findings disseminated to the community.

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Excluding pulmonary embolism with helical (spiral) computed tomography: Evidence is catching up with enthusiasm

Clive Kearon

Advances in computed tomography (CT) technology have enabled imaging of the pulmonary arteries with injection of contrast medium into an arm vein. This technique, which involves continuous imaging with a rotating gantry as the patient is moved through the scanner, is usually referred to as "helical," "spiral" or "continuous-volume" CT, and it is now widely used to diagnose pulmonary embolism. Enthusiasts have proposed that helical CT is accurate enough to "rule in" or "rule out" pulmonary embolism in most patients. These claims have been based on the results of mostly small studies that reported high accuracy of helical CT in the diagnosis of pulmonary embolism when compared with an established diagnostic standard, usually ventilation–perfusion lung scanning and conventional pulmonary angiography. However, until recently, the methodologic limitations of studies evaluating helical CT in the diagnosis of pulmonary embolism have cast doubt on this technique's accuracy and led to uncertainty as to how helical CT should be used in clinical practice.[1,2]

Using the estimated accuracy of helical CT and extrapolations from experience with ventilation–perfusion scanning, I recently recommended in *CMAJ* how helical CT should be used to diagnose pulmonary embolism.[3] The results of 2 recent, well-designed studies of helical CT in the management of patients with suspected pulmonary embolism[4,5] strengthen those recommendations and allow the role of helical CT for the exclusion of pulmonary embolism to be extended. These studies tested the safety of withholding anticoagulant therapy on the basis of negative results of both helical CT for embolism and ultrasound examinations of the legs for proximal deep-vein thrombosis. Single-detector helical CT scanners, rather than more modern multidetector scanners that have better spatial resolution, were used in both studies.

In France, Musset and colleagues[4] performed a standardized clinical assessment of pulmonary embolism probability, helical CT of the pulmonary arteries and bilateral ultrasonography of the proximal deep veins of the legs (including the calf-vein trifurcations) in 1041 patients with suspected pulmonary embolism. Anticoagulant therapy was withheld from 507 patients on the basis of a combination of low or moderate clinical probability of pulmonary embolism and negative results of both helical CT and ultra-