BRIEF REPORT - *Bacillus thuringiensis israelensis* (*Bti*) and *B. sphaericus* (*Bs*) ecological impact

Quick overview & recommendation

The Middlesex London Health Unit (MLHU) uses the bacterial insecticide *Bacillus thuringiensis* vars. *israelensis* and *sphaericus* to control larvae of disease-vector mosquitos. The ecological impact of these insecticides was questioned.

Insecticidal use by MLHU appears to be carried out responsibly. I would not recommend changes to the *Bti*/*Bs* application method at this time, but this can be reviewed again when more literature is available. It would be nice to know how application affects other aquatic insects in Middlesex-London. Rationale for my sentiments:

- The *Bt* varieties employed are specific to flies (Diptera), which minimizes impact to other insect groups in aquatic habitats.
- Many studies show low/no ecological impact of *Bti*/*Bs*, however in some cases they have negative effects on blackflies (Simuliidae) and midges (Chironomidae).
- After extensive monitoring of mosquito larvae, trained personnel perform insecticide applications only when vector-type mosquito larvae dominate in a given aquatic habitat
- Application in ESAs requires special permit.
- Few studies exist on the ecological impacts of *Bs*. It should be noted that *Bti* and *Bs* differ in environmental persistence and efficacy based on temperature, water quality, solar radiation, plant density, larval density and feeding etc.

MLHU use of *Bti* and *Bs* in aquatic systems to control mosquito larvae

- The MLHU employs *Bti* and *Bs* to control mosquito larvae in standing water (ditches, woodland pools, ponds, storm water management facilities, some catch basins). Methoprene are typically used to treat catch basins, but *Bs* is used if the basin flows into an ESA.

- Mosquito larvae were monitored in all standing water sites weekly from March/April (when the first vector of West Nile Virus (WNV) is identified, *e.g. Culex pipiens, C. restuans*, or *Aedes vexans*). Of 16,702 larvae identified, 71% were WNV vector species.

- Class 2 larvicides are directly applied to water (unknown concentration?) by trained, licensed personnel. Other than in catch basins, the larvicide used primarily is *Bti*, which lasts approximately 48 h or less in the environment.

- Treatment starts upon identification of vector species, but MLHU does not treat water when non-vector species predominate. An IPM treatment strategy is used (larvicide application is based on prior collection, identification, and planning to maximize specificity/minimize impact to non-target species).

- The 2013 MLHU report states: "*This larvicide (Bti) is biologically safe and target specific, meaning that it only affects mosquito larvae when applied to standing water for a treatment*". No citation is provided for the statement.
  The concern: that the larvicide might have negative impacts on other dipterans (flies), which comprise a large biomass and richness in aquatic habitats. Aquatic dipterans can comprise ~80% of aquatic insects.

Environmentally Significant Areas

In order to perform treatments in ESAs each year the MLHU and CCMM must apply and receive a pesticide permit from the Ministry of the Environment. In 2013, 93 treatments were performed in the peripheral bodies of standing water across 12 ESAs, totaling 4.76 hectares of surface waters treated.

Summaries of literature pertaining to ecological impacts of *Bti*

Lundström *et al*. 2010. Production of wetland Chironomidae (Diptera) and the effects of using *Bacillus thuringiensis israelensis* for mosquito control. *Bulletin of Entomological Research*. 100(1). 117-125.

> 6-year study of *Bti* found no reduction in chironomid midge abundance, but potentially slight shifts in relative abundance of chironomid species. Four of five species in treated areas exhibited increased abundance. Lack of change may be partially-attributed to drought conditions (which correlated with low numbers of insects to begin with).

Hershey et al. 1995. Effects of methoprene and *Bti* (*Bacillus thuringiensis* var. *israelensis*) on non-target insects. *Hydrobiologia*. 308(3). 219-227

> No observed *Bti*-related decrease in richness of benthic invertebrate taxa.

Heyshey *et al*. 1998. Effects of *Bacillus thuringiensis israelensis* (*Bti*) and methoprene on nontarget macroinvertebrates in Minnesota wetlands. (ESA, issue?)

> Studied effects of *Bti* on benthic invertebrate communities of 9 wetlands.
> No effect in year 1, but in year 2 they observed substantial declines in several insect

numbers and richness. Many insect groups affected, but mostly dipterans. Minimal effects on non-insect macroinvertebrates.

"*Bti* is likely to be directly toxic only to nematoceran Diptera; thus effects of *Bti* on other insect groups may have resulted from disruption of the invertebrate food web. Due to the time lag in response of nontarget insects to larvicide treatment, longer-term studies are required".

Mulla *et al*. 1990. Control of nuisance aquatic midges (Diptera: Chironomidae) with the microbial larvicide *Bacillus thuringiensis* var. *israelensis* in a man-made lake in southern California. *Bulletin of the Society for Vector Biology*. 15(2). 176-184.

"Vectobac (5000 ITU/mg) yielded killed over 90% of *Chironomus decorus* larvae for a period of 2-4 weeks at the rates of 4-6 lb/acre. At a lower dosage (0.56 gal/acre), this formulation provided little or no control of this midge. Larvae of tanypodine midges (mostly *Procladius freemani*, *P. sublettei* and *Tanypus grodhausi*) were not affected, even by very high dosages of Vectobac, although numbers of *Cladopelma edwardsi* were.

All investigations have shown that the numbers of *Aedes* mosquitoes are drastically reduced but that all other insects continue to develop in the water and provide, as winged adults, a food resource for birds, amphibians and bats."

Guillet *et al.* 1990. Use of *Bacillus thuringiensis israelensis* for onchocerciasis control in West Africa. *In:* Bacterial Control of Mosquitoes and Blackflies. *Rutgers University Press*, New Jersey, pp. 187–199.

Bti was an effective control of blackfly (Diptera: Simuliidae).

Rey *et al*. 1998. Comparative histopathology of some Diptera and Crustacea of aquatic alpine ecosystems, after treatment with *Bacillus thuringiensis* var. *israelensis*. *Entomologia Experimentalis et Applicata.* 88(3). 255-263.

"*Bti* used at the concentration for operational field application is deleterious to all dipteran species, but not to Cladocera (Crustacea)."