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# Efficacy of *Bacillus thuringiensis* H14 against the chironomid *Paratanytarsus grimmii* in a drinking-water supply system in the Paris area

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## Abstract

The chironomid *Paratanytarsus grimmii* has been found to reproduce parthenogenetically within the confines of a large water purification plant in the Paris area, where its larvae infest the granular active carbon filters. Because it can reproduce and spend the whole of its life cycle within the confines of the plant, control has proven difficult. Two biological formulations of *Bacillus thuringiensis* H14 (Vectobac 12 AS and Vectobac WDG) gave good control of *P. grimmii* larvae in laboratory assays, with WDG formulation proving to be the more effective. It is considered that *B. thuringiensis* H14 would be suitable for midge control in the carbon filters of drinking-water supply systems.

## Introduction

Discovery in 1999 of the presence of *Paratanytarsus grimmii* in the granular active carbon filters in the drinking water purification line at Méry sur Oise, one of the purification plants supplying the Paris Region, created a difficult situation because it was impossible to use conventional chemical control methods. Several earlier tentative attempts to solve this problem include physical removal (Armitage *et al.*, 1997) and chemical methods using a pesticide (Michael *et al.*, 1997) are unsatisfactory. Thus, an alternative, more acceptable, approach without risks to human health was tested, using the biological control agent *Bacillus thuringiensis* H14 as a larvicide against chironomids. *Bacillus thuringiensis* H14 has been reported to possess a high level of activity against larvae of several chironomid species in the laboratory (Kondo *et al.*, 1995).

## Methods and materials

Two formulations of *Bacillus thuringiensis* H14 were used in these studies: an aqueous suspension formulation (Vectobac 12 AS) and a granular formulation (Vectobac WDG). Both were tested at 23 $\pm$ 1 C° against *P. grimmii* larvae collected from the granular active carbon filters in the Méry sur Oise water treatment plant.

Four serial dilutions (10, 1.0, 0.1 and 0.01 µg/ml) of each formulation were prepared and tested against 100 larvae. For this, batches of 25 third/fourth instar larvae were exposed to the serial dilutions in plastic cups containing 200 ml of the dilutions.

In addition, a small scale trial was carried out in receptacles of 0.55 x 0.35 x 0.25 m., either containing a 10 cm deep carbon bed or free of carbon, and all containing 2 litres of serial dilutions (100, 10, 1.0 and 0.1 µg/ml) of Vectobac WDG. On the first day, larvae were fed with a biscuit in order to avoid the high mortality found in control cups in preceding tests. Mortality was read at 24 h, 48 h and 72 h; $LC_{50}$s and $LC_{90}$s were determined by log-probit readings

## Results

Table 1 shows the results of tests of the two formulations of *B. thuringiensis* H14 against *P. grimmii* larvae. A high mortality was observed after 1 and 3 day's exposure to both formulations. The granular formulation Vectobac WDG seems to be more effective than the aqueous suspension formulation, Vectobac 12 AS.

Table 2 shows the results of small-scale test of granular Vectobac WDG formulation in receptacles with and without carbon substrates. A high overall mortality was observed in spite of the presence of granular active carbon in some receptacles.

**Table 1.** Larvicidal activities of two formulations of *Bacillus thuringiensis* H14 against the chironomid midge, *Paratanytarsus grimmii*

| *B. thuringiensis* H14 formulation | Larval instar | Day after treatment | $LC_{50}$ (µg/ml) | $LC_{90}$ (µg/ml) |
|---|---|---|---|---|
| Vectobac 12 AS | third/fourth | 1 | 0.125 | 1.480 |
| | | 3 | 0.178 | 1.520 |
| Vectobac WDG | third/fourth | 1 | 0.112 | 1.223 |
| | | 3 | 0.144 | 1.421 |

**Table 2.** Larvicidal activities of Vectobac WDG (*Bacillus thuringiensis* H14) against the chironomid midge, *Paratanytarsus grimmii.* Test performed in receptacle with and without 10 cm carbon bed.

| *B. thuringiensis* H14 formulation | Larval instar | Day after treatment | $LC_{50}$ (µg/ml) | $LC_{90}$ (µg/ml) |
|---|---|---|---|---|
| Vectobac WDG (without carbon) | third/fourth | 1 | 1.8710 | 2.4752 |
| | | 3 | 3.1819 | 4.6392 |
| Vectobac WDG (with 10 cm carbon) | third/fourth | 1 | 3.4251 | 4.8465 |
| | | 3 | 5.3341 | 6.4293 |

## Discussion

The presence of *P. grimmii larvae* in the granular active carbon filters of the drinking water system poses a big problem in choice of product and method of application. Chemical methods of chironomid control in water supply systems are impossible in many countries unless these are authorized by the health ministry (Armitage *et al.*, 1997). However, *Bacillus thuringiensis* H14 could be the answer for control in this situation. The development of *B. thuringiensis* H14 as a biological agent for medical and public health pest control (mainly against mosquitoes and *Simuliium* spp.) has had large successes. There are several formulations of Vectobac 12 AS that are efficient against chironomid larvae. The difficulty is field treatment of larvae developing in the granular active carbon filters that are an integral part of the water purification process.

Generally, biological control with *B. thuringiensis* H14 contributes not only to elimination of *P. grimmii* larvae but may also contribute to development of other fauna existing in the carbon filters, such as, for example, oligochaete worms and gastropods which seem to be predators of midge larvae.

It is certain that complete eradication of target species will require an integrated approach, using biological control together with physical methods such as repetitive cleaning cycles, prevention of entry of larvae or adults into the filtration systems as well as sodium bisulfate treatments (Garcia & Laville, 2001; Monceau, 2000). Other methods, such as immersion heaters to expose larvae to lethally high temperature, have been proposed. Despite the demonstration of good midge control with *B. thuringiensis* H14, it is difficult to obtain approval from the health ministry for the use of bacteria in water supply systems.

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