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Mosquito control programme implemented in Wilanów (Warsaw, Poland) in summer 2002

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Abstract

A mosquito control programme implemented in Wilanów in summer 2002 was based on the use of bacterial larvicidal preparations (*Bti*). Wilanów is a district of Warsaw and covers an area of 3673 ha in the southern part of the city. Preliminary faunistic studies had been carried out during previous years. The inventory of all permanent and temporary bodies of water was made in the early spring 2002 and verified in the course of the summer programme, the occurrence of larvae being monitored every two days.

On this basis twelve spraying operations were conducted between 10 June and 20 September 2002 in order to minimise the mosquito nuisance in the vicinity of the historical royal residence and adjacent housing estates. It was necessary to spray adulticides three times only. The entire programme was carried out by two persons responsible for monitoring and spraying of larvicide, and a specialized team for spraying of adulticide. One of the two larvicide operatives worked full time and made monitory observations in addition to larvicidal spraying; the second assisted with spraying the larvicide. Only once was it necessary to engage two more persons, and then for three days only.

Introduction

In mosquito control programmes in the temperate latitudes of Europe *Bacillus thuringiensis israelensis (Bti)* has proved to be highly effective against troublesome mosquito species such as *Aedes vexans, Ochlerotatus cantans* and *Culex pipiens* (Becker & Rettich, 1994; Becker, 1998; Kubica-Biernat *et al*., 2001) and to be environmentally safe (Becker, 1998). *Bti* has another virtue; no target species has yet developed resistance to the product. In the Upper Rhine Valley in Germany *Bti* products have been widely used since 1981 and resistance has not developed even in areas treated for 15 years (Ludwig & Becker, 1997).

In the summer season of 2002, the authorities of the Warszawa-Wilanów municipality implemented a mosquito control programme in order to protect inhabitants and tourists who visit the district. Wilanów is a special place for Poles and the historic royal residence is an attraction for Polish and foreign tourists. The palace park and the surrounding green areas play an important recreational role for Varsovians. In summer, however, countless mosquitoes are a severe nuisance to all visitors. Mosquitoes in Wilanów breed in ecologically sensitive areas where broad spectrum insecticides could not be used because of their side-effects.

The control strategy described here was based on the assumption that the principal measures (bacterial control agents) would be targeted at mosquito larvae. Application of this method requires a very precise description of the place, conditions and time of each operation. The programme was prepared according to the main guidelines of the German Mosquito Control Association (Becker, 1998), which has more than 20 years of experience with use of bacterial agents to control mosquitoes on a large scale.

In order to prepare the programme and to provide a detailed control strategy the first steps were as follows:

1. a preliminary entomological study was conducted, when the larval sites of each species were recorded and the most important sites identified;

2. precise mapping and numbering of all breeding sites (all permanent and temporary water bodies - even very small ones) within a 2 km-wide belt round the royal residence and adjacent housing estates;

3. monitoring the presence of mosquito larvae, in order to evaluate the productivity of particular water bodies and to determine the optimum times and places for application of Bti.

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Description of the operational area

The Wilanów Municipal District covers 3673 ha of southern Warsaw and lies on the lower terrace of the River Vistula floodplain, which extends in a generally south to north direction through the district.

In the past when there were no flood banks, the area was regularly flooded, and it is still seasonally marshy in numerous places. There are traces of historical changes in the course of the Vistula. The most recent of the dead channels are now the sites of lakes and ponds, and the oldest beds have become more or less overgrown (Biernacki, 2000). These originally wet areas are intersected with channels draining excess water to the lakes and to the River Wilanówka.

The entire area, full of depressions easily flooded by rainfall, is managed as meadows or lies fallow. The channels and the lakes form a system of interconnected streams collecting water from a considerable part of Warsaw. After heavy rainfall these channels overflow and inundate nearby meadows and fields, creating vast temporary pools of stagnant water in which huge numbers of mosquito larvae develop. Heavy rainfall also causes water levels in the lakes to rise and inundate shoreline areas. Moreover, land bordering the Wilanówka, and the lakes and channels is intermittently swampy.

A considerable part of this terrain lies within the Warsaw Area of Protected Landscape, a conservation area allowed to evolve naturally. Consequently, the whole area, including the riverine and lacustrine seasonal wetlands, is overgrown with shrubs and is difficult of access.

The royal residence in the centre of the district is adjacent to housing developments, especially to blocks of flats built in the northern part. All these housing complexes are situated less than 1 km from areas containing breeding sites of mosquitoes.

Mosquito fauna in Wilanów

The entomological studies carried out during 2001 and 2002 showed the occurrence of 23 mosquito species in Wilanów (Wegner, 2002). The vernal study periods in both these years were rather dry; therefore most larvae had been stranded and dried out before they pupated. Thus, mosquitoes caused only localised nuisances (mainly in shady woods) during the spring of 2002, but after heavy rainfalls in summer, mosquito abundance reached plague numbers. *Ochlerotatus (Och.) leucomelas* (Meigen, 1804), *Oc. (Och.) communis* (De Geer, 1776), *Oc. (Och.) cataphylla* Dyar, 1916, and, locally, *Oc. (Och.) cantans* (Meigen, 1818) and the endophilic *Anopheles (Ano.) maculipennis* Meigen, 1818 (adults found in human dwellings) were the most numerous species in May and June. The floodwater mosquito *Aedes (Aedimorphus) vexans* (Meigen, 1830) occurred in mass numbers in summer. Other summer species, *Oc. (Och.) sticticus (*Meigen, 1838), *Oc. (Och.) cantans* (Meigen, 1818) and *Ae. (Aedes) cinereus* Meigen, 1818 were less abundant but were still numerous enough to be local nuisances.

In September and October, anthropophilic *Culex (Culex) pipiens* Linnaeus, 1758 occurred in high, but not mass, numbers and caused a nuisance in dwellings. The other species occurred in only small numbers and caused no nuisance.

Monitoring

All existing and potential bodies of water which might provide sites for the development of larvae of the most abundant mosquito species were mapped in the spring of 2002. Special attention was paid to the following:

1. roadside ditches and other deep ditches and holes in which water persists over fairly long periods;

2. swampy patches in depressions (shallow, and overgrown with irises and sedges);

3. floodwater pools and those formed after heavy rainfall, with grass and other non-swamp vegetation;

4. drainage channels.

Field observations were carried out throughout the whole spring-summer season of 2002, and monitored:

1. weather conditions – precipitation and temperature;

2. formation and duration of temporary bodies of water;

3. presence and abundance of larvae and their development rate in permanent and temporary pools;

4. abundance of adult mosquitoes prior to and after treatment in areas subjected to the control programme and also in some areas 2 to 5 km away.

In early spring, observations of the pools were made every 7 to 10 days and during the hot summer, when the temperature rose above 25^{o} C, every 2 to 3 days. On the basis of these monitory indications decisions were made as to where and when larvicide or adulticide should be applied. These indications were also necessary for evaluating the effectiveness of the treatment.

The effectiveness of larvicide applications was evaluated 1 or 2 days after the operation. Results of the observations made before and after spraying were the basis for that evaluation. The effectiveness of the operation was calculated from the mean number of larvae per 1 litre for a given water body. The larvicide is not effective against pupae, therefore if any pupae had been recorded before spraying, their number was added to the values recorded after the operation. The effectiveness of the treatment (E) was calculated by use of the formula:

$$E = \frac{(a - b) \times 100\%}{a}$$

where:

a – is the number of larvae and pupae in 1 litre before spraying

b – is the number of larvae and pupae in 1litre after spraying + mean number of pupae before spraying.

Monitoring of the presence of adult mosquitoes (biting females) after each operation was carried out in order to determine the proportion of mosquitoes coming from more distant areas and/or to evaluate the extent of the nuisance caused by these insects during a given period. Mosquito males tend to stay in the vicinity of their breeding sites thus their presence was also an indication as to whether the mapping had included all important water bodies acting as sites of larval development.

Imagines were collected in the evening (in the period from 1 h before to 1 h after sunset) during rainless weather. An observation consisted in collecting all mosquitoes attracted to one man sitting motionless for a quarter of an hour. The insects collected were identified to species. Also the vicinity of the breeding sites was examined for the presence of imagine males and females.

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Execution of the programme

The execution of the programme consisted of monitory observations (both before and after spraying) as well as spraying larvicide and adulticide. Simulin and Teknar were the *Bti* larvicide preparations and were applied to the water with a standard sprayer. The optimum dosages of preparations were taken from the labels given by the producers.

The spring of 2002 was warm and very dry, and most snow-melt pools had dried up before mosquito larvae pupated. Only very deep and shady pools lasted long enough for complete development and emergence of imagines. No spraying was necessary. However, temporary ponds appeared in obturated depressions after infrequent but heavy rainfalls during the mostly very hot and dry summer. Also, as a result of overflow from drainage channels during and after these storms water levels in the Wilanówka River and in the lakes rose, and meadows and crop fields were also flooded. The first storm causing a local flood during the spring-summer season, occurred on 28 May (Table 1).

Developing larvae were very abundant in the flood waters (on 1 June mass numbers were recorded). Larvicide was first sprayed on 6 June when some larvae had already pupated. Due to this, effectiveness of the treatment was fairly low (about 80%).

Because these larval sites dried up very quickly the number of imagines produced was not very high. After a heavy shower on 13 June, a further episode of pooling made it possible for another generation of larvae to hatch. The spraying on 17 June was 98% effective. Between 14 and 28 June, there was no rain and the pools gradually dried up. They reappeared after heavy rainfall on 3 and 4 July. Four days later larvae were recorded in the water. The spraying on 11 July was 99% effective (100% in most pools, 90% in a few).

There was no heavy rain for the next week (except a small storm on 15 July) and most pools dried up. On 16 July, new larvae were recorded in the remaining pools, and spraying was carried out on the following day. On 20 July, there was further heavy rainfall. creating small pools in the bottoms of some depressions. Larvae were recorded four days later and on 25 July application of larvicide proved necessary, but only in the few existing pools.

The greatest flood occurred when rain caused pooling in some depressions on 2 – 5 August and a further downpour (100 l per m^2) on 6 August flooded vast stretches along the channels and around the lakes in the control programme area, creating mosquito breeding sites occupying more than 60 ha. The weather was hot, and 1st instar larvae appeared in mass numbers as early as 7 August (also present were far less numerous 3rd and 4th instar larvae which had hatched earlier). Between 7th and 12th August, larvicide was applied systematically to all floodwaters situated less than 2 km from the housing estates.

The first pools treated with larvicide (on 7th and 8th August) had to be sprayed again, therefore the next operations were carried out with a double dose of the preparation. There was another factor which made spraying more difficult and less effective, namely the fact that when water reached catastrophic levels, newly formed breeding sites of mosquitoes included areas overgrown with lush herbaceous vegetation. Despite this the treatments had been very effective (99%) and yet, from 20 August onwards, increased numbers of mosquito females were recorded, but no males were observed in the vicinity of sprayed breeding sites. The presence of greater numbers of females was recorded in Wilanów 2 days later than in the areas where larvicide had not been applied.

Three further applications of larvicide proved necessary during the season, but the areas involved were small and spraying was 100 percent effective (see Table 1).

The entire larviciding programme, including monitoring, was carried out by two persons. One of these worked full time and made the monitory observations as well as spraying larvicide; the other was called upon when needed to help with larviciding. Only once was it necessary to engage two more people, and then for 3 days only. Adulticidal spraying was needed only 3 times (on 25th July and after 20th August) and then only in some parts of the housing estates, and was carried out by a specialised pest control team.

Table 1. Calendar of events. Dates in bold indicate heavy rainfall

Days with heavy rainfall	Date of positive observations	Date of larvicide application	Date of efficacy evaluation	Efficacy (%)
28. 05.	1. 06.	6. 06.	8.06.	80
13. 06.	16. 06.	17. 06.	18. 06.	98
3 **- 4. 07.**	8 – 10. 06.	11. 07.	12. 07.	99
15. 07.	16. 07.	17. 07.	19. 07	100
20. 07.	24. 07.	25. 07.	26. 07.	100
2 **– 6. 08.**	7 – 9. 08.	7 – 12. 08.	9 – 15. 08.	99
14 – 15. 08.	19. 08.	20. 08	22. 08.	100
28. 08.	29. 08.	31. 08.	2. 09.	100
5. 09.	9. 07.	10. 09.	15. 09.	100

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