Biological Control Program against Simuliids in the State of São Paulo, Brazil

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In Brazil, the use of biological vector-control methods has been largely confined to experimental research, with little or no application of such techniques by public institutions responsible for implementing control programs. The notable exceptions have been the black fly control program carried out by the Health Secretariat in the State of São Paulo.

Sinće the 1980s, São Paulo's "Superintend ncia de Controle de Endemias" has been conducting studies on the viability of using Bacillus thuringiensis *(H-14) for simuliid control, and the results have been so encouraging that the agency has now incorporated this method into its Simuliid Control Program.*

Key words: vector control - black flies - Bti

The Health Secretariat in the State of São Paulo first began implementing simuliid control programs in 1957, initially using organochlorides (DDT and BHC), and subsequently (1971) switching to organophosphates (Temephos). The programs have been carried out over an area of 893 km^2 along the edge of the Serra do Mar coastal moutain range on the state's northern seaboard. The region lies at the foot of steeply inclined terrain, and takes the form of a relatively flat coastal plain, with the promontories formed by the furthest outreaches of moutains now lost, for the most part, underwater (Absaber 1955). The region contains a vast network of waterways, most of them small or medium in scale, carrying limpid, turbulent water through dense tropical rain forest (Veloso et al. 1991).

In a study of simuliids found in the region, Araújo-Coutinho et al. (1988) concluded that *Simulium pertinax* should be the main target species for control, given its wide distribution, high density and accentuated anthropophilism. Although no case of disease transmission by this target species has ever been recorded, a control program can be justified on the grouds that the region comprises four administrative districts whose economy is heavily dependent on tourism. The frequent and intensive attacks by simuliids on the fixed and transitory populations in the area inflict serious socio-economic damage, most notably in the form of reduced tourist flows in the summer months (January to March).

In 1984, in the contest of an overall review of the Simuliid Control Program, it was decided that the possibility of using alternative, non-chemical control techniques should be investigated. The main reason for this was that Neto (1984) had reported the appearance of Temephos resistance in *S. pertinax* in Rio Grande do Sul, and similar observations had been made in the course of routine control programs along São Paulo's northern coast. Studies by Colbo and Undeen (1980) and Undeen and Lacey (1982), among others, had shown that larvicides using *Bacillus thuringiensis* var. *israelensis* (Bti) exhibited high specificity, with little or no effect on non-target animal life in simuliid breeding sites.

In the light of these findings, it was decided that the susceptibility of the target species to such treatment should be investigated in the region described above. Tests were carried out in an artificial breeding site consisting of six P.V.C. channels (including one that was used as a control) supplied with water from a natural breeding site (Fig.). One hundred larvae were allowed to colonize each channel, and 24 hr later five channels

View of artificial breeding site.

Received 24 June 1994
Accepted 14 November 1994

were treated with the experimental larvicide, each with a different dose. After 24 hr the channels were checked for mortality rates. The 24 hr waiting period between colonization and treatment was intended to reduce the "stress" on the larvae prior to testing. The test demonstrated that Bti gives good results when used against immature forms of *S. pertinax*. Field trials were carried out to determine the larvicides's "effective carrying distance" (the distance to the furthest point downstream where mortality is greater than or equal to 80%) at a concentration of 10 mg/l of flow, per minute, following the methodology used by Lacey and Undeen (1984).

The results demonstrated a strong correlation between "effective carrying distance" and discharge of the breeding sites; the larvicide was highly effective in medium-flow sites, but far less effective in low-flow sites (Araújo-Coutinho & Lacey 1990). These findings had negative implications for rivers with a low level of water-flow, since to achieve adequate coverage it would be necessary to apply the larvicide at a large number of different points, a problem already noted in Guatemala (Undeen et al. 1981) and in Mexico (Gaugler et al. 1983).

In 1986, a pilot project was carried out with a view to establishing a methodology for Bti application in areas of rough terrain with dense vegetational cover, and also to evaluate the larvicide's efficacy in routine control operations. The project targetted 219 of the region's breeding sites, with an average monthly consumption of 54l of larvicide. The parameters used to select treatment points along waterways containing breeding sites were based on the results obtained by Araújo-Coutinho and Lacey (1990); the spacing betwen the points varied between 100 and 3,000m, depending on the water-flow at each site. The specific topographical characteristics of the region had to be taken into account when establishing a methodology for larvicide application. The roughness and inaccessibility of the terrain, combined with the dense vegetation cover, ruled out any possibility of using aerial techniques or pumps. Applications had to be carried out by hand, from one treatment point to the next, using calibrated, 5l watering cans. A capacity of 5l allowed adequate variation in the volume of larvicide used to attain a concentration of 10 mg/l, while at same time ensuring that the watering can was light, portable and easy to use. It was observed that the effective carryng distance is not only affected by water-flow, but also by the specific topography of each breeding site. This means that parameters for treatment-point spacing, as established in experimental studies, can only ever serve as approximate guidelines, rather than fixed markers. The initially selected points need to be evaluated during the course of a program, waterway by waterway, since any stretches where there are backwashes or deep channels will reduce the carryng distance and hence the coverage in terms of control. The overall conclusion was Bti represents an effective and safe alternative larvicide for use in control programs along São Paulo's northern seabord, with the added advantage that it should have less impact on aquatic ecosystems than organophosphates (Lacey & Mulla 1989).

Following the satisfactory results achieved in the pilot project, a full-scale control program covering the entire region was initiated in 1990, involving exclusive use of Bti preparations at 2,190 breeding sites, with an average monthly consumption of 503l. The results of the program were evaluated on a regular basis, leading to modifications in the number of targetted breeding sites, and in the location and number of treatment points. By 1992, 1,456 breeding sites were being treated, with an average monthly consumption of 550l of larvicide, and at an average monthly cost of US$ 48,904.32, of which 25.71% represented the price of the larvicide. The fact that consumption did not diminish, despite a considerable reduction in the number of breeding sites, was due to a decision to increase the number of treatment points. This increase was necessary because of variations in the topography of the breeding sites, most of which had low levels of water-flow. With the initial operational difficulties successfully resolved, the full inplementation of the Bti program had now been achieved. Since then, the density of *S. pertinax* females has remained within acceptable limits.

Although the use of entomopathogenic bacteria in the routine simuliid control program has given satisfactory results, further studies on a large scale are necessary in order to perfect this control method and identify possible problems and deficiencies, and also to assess the environmental impact of continuous and prolonged use of the larvicide. Such data are indispensable for a full evaluation of the cost/benefit relationship represented by Bti vector control.

With the aim of determining one aspect of the cost/benefit relationship, a study was initiated in 1994 on the direct and indirect impact of continuous use of Bti on fauna inhabiting lotic environments along the edge of the Serra do Mar. Although the use of biological rather than chemical agents clearly represents a technical advance in terms of controlling larvae in lotic environments, is important to avoid an error common to vector-control evaluation studies: namely, the extrapolation of long-term and immutable "maxims" from an initial set of satisfactory results. The adoption of new methods on a large scale for routine operations should occur only when all the relevant criteria have been rigorously tested and analyzed, thereby avoiding incalculable enviromental risks and uncertain results in terms of control.

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